SLOVAK REPUBLIC

NATIONAL INVENTORY REPORT 2013

Greenhouse gas emission inventory 1990 – 2011

Submission under the UNFCCC including reporting elements under the Kyoto Protocol

Slovak Hydrometeorological Institute

Ministry of the Environment of the Slovak Republic

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The National Inventory Report was prepared in accordance with UNFCCC related to *FCCC/CP/2002/8* from March 28 2003 – UNFCCC Guidelines on Reporting and Review and in accordance with reporting guidelines under Article 7 (decision 15/CMP.1) with the respect of the Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol.

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PREFACE

National Inventory Report of the Slovak Republic (NIR) under the UNFCCC (United Nations Framework Convention on Climate Change) and the Kyoto Protocol (in accordance with the decision 15/CMP.1) contains the following parts:

- National greenhouse gas emission inventory report of the Slovak Republic 1990 – 2011 (NIR) prepared using the reporting guidelines (UNFCCC 2006) and relevant parts of the Guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol. IPCC and other methods applied to the calculation of the emissions are described, as well as the changes to the previous submission. Several summary tables and graphs of the emission data and emission trends for the years 1990 – 2011 are included.
- CRF data tables of the Slovak Republic's greenhouse gas emissions for the years 1990 – 2011. The CFR tables are compiled with the latest UNFCCC CRF Reporter software (version 3.6.2), xml file with the databases, country specific variables and unit's lists.
- SEF tables for reporting of Kyoto units (AAU, ERU, CER, t-CER. l-CER, RMU) in the registry as of 31st December 2012 and transfers of the units during the year 2012.

The Inter-ministerial High Level Committee on the Coordination of the Climate Change, the Ministry of Environment (the MZP) – (the Department of Climate Change Policy), the Slovak Hydrometeorological Institute (the SHMU) – (the Department of Emissions and Air Quality Monitoring), 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 MoA SR), the Transport Research Institute Žilina with the cooperation of the Ministry of Transport, Construction and Regional Development of the Slovak Republic, the Slovak Agricultural University Nitra, the Research Institute on Soil Protection Bratislava, 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 Energy Agency, the Slovak Environmental Agency, the Statistical Office of the Slovak Republic (the SO SR), the Slovak Cooling and Air Conditions Association, the SPIRIT Information Systems and the Waste Management Centre Bratislava are directly involved in the process of development of this report and have made the inventory calculations, as well as the description of the methodologies and other information included in this National Inventory Report.

During the process of changes in the organizational structure of the SHMU (to increase efficiency and to save financial resources) the Department of Emissions was merged with the Department of Air Quality on 1st December 2010. The new unit is named the Department of Emissions and Air Quality Monitoring (OMEaKO) and serves also as the Single National Entity (SNE) while providing all activities connected with coordination of the National Inventory System for the KP under the Article 5.1. This change has had no practical impact on the function of the SNE. 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. It currently comprises 3.5 experts working on inventory tasks as a full time job. Composition of SNE is: NIS Coordinator, Deputy NIS Coordinator, Data Manager and Quality Manager (for a half time job). The Department of Emissions and Air Quality Monitoring is the coordinator of the National Inventory System with the 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 journal: Vestnik, Ministry of Environment, XV, 3, 2007, page 19.

All relevant documents have to be approved by the National Focal Point to the UNFCCC, which is the Department of Climate Change Policy of the Ministry of Environment of the Slovak Republic headed by Helena Princová (helena.princova@enviro.gov.sk) and by the Inter-ministerial High Level Committee on the Coordination of the Climate Change. The Slovak NIR as well as the CRF tables and other relevant documents can be downloaded from the link: http://ghg-inventory.shmu.sk/ after 15 April 2013. The NIS coordinator, Janka Szemesová (janka.szemesova@shmu.sk) is the contact person at the SHMU for the GHG emission inventory preparation.

EXECUTIVE SUMMARY

ES.1 Background information on greenhouse gas inventories and climate change

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

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 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 Slovak Republic committed itself to an 8% reduction of emissions compared to the base year 1990. The Slovak Republic and the former EU Member States ratified the Kyoto Protocol on 31st May 2002.[1]

Current UNFCCC negotiation process is focused on wide co-operation of developed and developing countries to achieve global goal of 2 °C.

According to global climatologic classification, the Slovak Republic is in the mild climate zone category with precipitation uniformly distributed over the whole year. The Atlantic Ocean impacts the west part of the Slovak Republic, while a continental influence is typical for the east part. A regular rotation of four seasons and variable weather throughout the year are typical for this country.

The Slovak Republic has 5.404322 million inhabitants (as of 31st December 2011). The average population density is 110.2 inhabitants per km². The population is concentrated in cities in lowlands and the main basins. Mountain areas are randomly populated. Labour force activity rate in the Slovak Republic is 58.74% in average during 1998 – 2011 (according to the Eurostat 2012). The largest city is Bratislava with 411 228 inhabitants (as of 31st December 2011). It is the capital of the Slovak Republic.

The Ministry of Environment of the Slovak Republic (http://www.minzp.sk/) is responsible for development and implementation of national environmental policy including climate change and air

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

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 fulfillment 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 from 19 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 will replace 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 the 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.

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 following tasks:

- reviewing and providing comments to the emission indicators calculated as obligatory part of the Annual Report 2013 prepared according to the Article 3(1) of Decision No 280/2004/EC (January 2013),
- providing documents for relevant strategies, policies and measures to prepare 6th National Communication on Climate Change,
- drafting the Adaptation Strategy of the Slovak Republic,
- drafting the Low Carbon Strategy of the Slovak Republic up to 2030.

Supporting institutions, founded by the Ministry of the Environment to perform specific tasks linked to the inventory activities, play an important role. These include the Slovak Hydrometeorological Institute (www.shmu.sk), 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 with the cooperation of the Ministry of Agriculture and Rural Development of the Slovak Republic, the Transport Research Institute Žilina with the cooperation of the Ministry of Transport, Construction and Regional Development of the Slovak Republic, the Slovak Agricultural University Nitra, the Research Institute on Soil Protection Bratislava, 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 Energy Agency, the Slovak Environmental Agency, the Statistical Office of the Slovak Republic, the Slovak Cooling and Air Conditions Association, the SPIRIT Information Systems, the Waste Management Centre Bratislava, the Slovak Innovation and Energy Agency (SEIA) or Detox – company for research in solvent use) are involved in the process of data collection and other inventory related task.

The in-country review of the 2011 submission of the Slovak Republic to the UNFCCC took place in Bratislava from 22nd to 27th August 2011. The Annual Review Report 2011 identified two area for adjustments (in F-gases consumption and in road transport sectors) and question of implementation for the national system. The agreement between the ERT and the Slovak Republic was not found, so the issue was shifted to the Compliance Committee – Enforcement Branch. The Compliance Committee EB adopted in accordance with the "Procedures and mechanisms relating to compliance under the Kyoto Protocol" contained in the annex to decision 27/CMP.1 and the "Rules of procedure of the Compliance Committee of the Kyoto Protocol" on August 17, 2012 the Final Decision (reference CC-2012-1-9/Slovakia/EB) confirming its preliminary finding from July 14, 2012, which dealt with allocated question of implementation in the Report of the individual review of the Slovakia's annual submission 2011. On September 20, 2012, Slovakia submitted its Plan and the Progress Report to present adopted measures addressing its non-compliance status, which also included an analysis of reasons for non-compliance and evaluation of achieved progress on its implementation.

The First Plan and Progress Report was presented by the Slovak delegation during the 21st meeting of the enforcement branch in October 2012 in the structure following a two-fold logic, i.e. not only to non-compliance issues but also the time schedule of implemented remedies. We divided presented measures under three time periods:

- Response measures implemented in the period from the in-country review of the Slovakia's 2011 annual submission (August 2011) to the 20th meeting of the enforcement branch in July 2012;
- Response measures implemented from the 20th meeting of the enforcement branch in July 2012 to the in-country review of the Slovakia's 2012 annual submission in October 2012;
- Response measures which were to be implemented after October 2012.

The enforcement branch reviewed and assessed the Plan and the Progress Report submitted by Slovakia and adopted the Decision on the review and assessment of the plan submitted under paragraph 2 of section XV (reference CC_2012-1-12/Slovakia/EB). In the part IV, paragraph 10 (a) (b) of this decision enforcement branch concluded that the Plan sets out and adequately addresses the relevant requirements and, if implemented in accordance with this decision, is expected to remedy the non-compliance. The branch also concluded that the receipt of the report of the review of Slovakia's 2012 annual submission is required for it to determine whether all the questions of implementation have been resolved.

The in-country review of the 2012 submission of the Slovak Republic to the UNFCCC took place in Bratislava from 1st to 6th October 2012. The Expert Review Team (ERT) during the in-country review has reviewed the implementation of measures announced in the Plan and Progress Report and identified a number of questions for relevant IPCC sectors. During the review week, most of the questions were answered and accepted by the review team, however Slovakia received the "Saturday paper" document at the end of the review week (Potential Problems and Further Questions from the ERT formulated in the course of the 2012 review of the GHG inventories of Party submitted in 2012). The "Saturday Paper" included two technical questions – in F-gases consumption (complete categories 2.F.1, 2.F.2 and 2.F.3) and in agricultural sector (correct categories 4.D.1.2 and 4.D.3.1). During the 6 weeks period Slovakia has prepared answers to these specific technical questions /Table ES.1). In due time on 16 November, 2012 we sent The Responses to the Potential Problems and Further Questions from the ERT formulated in the course of the 2012 review of the GHG inventories of Slovakia submitted in 2012. The corrected estimates were accepted by the ERT and Slovakia resubmitted the GHG emission inventory 2012 on December 7, 2012.

However, the draft of the ARR 2012 was not delivered; Slovakia has prepared the Second Plan and Progress Report and sent it to the Compliance Committee EB for the consideration on March 15, 2013. The Second Plan and Progress Report of the Slovak Republic presents information on the current status of implementation for all proposed measures to enhance functioning of the national system in accordance with provisions of Decision 19/CMP.1. Besides this, Second Plan and Progress

Report includes information on additional implemented measure which was not a part of the First Progress Report, but enhancing the whole national system.

Table ES.1: *The proposed plan of actions*

CRF	Issue Identified by the ERT	Slovakia responses
2. INDUSTRIAL PROCESSES **2.F.1, 2.F.2 and 2.F.3 consumption of halocarbons and SF_6**	The ERT noted that the methodology applied by Slovakia does not follow the IPCC good practice guidance (section 3.7) for tier 2 for the reported categories refrigeration and air conditioning equipment (2.F.1), foam blowing (2.F.2) and fire extinguishers (2.F.3). The reported emission estimates do not include the following contributions: ▪ (i) equipment operation emissions for subcategory fire extinguishers (2.F.3); ▪ (ii) equipment disposal emissions for subcategories refrigeration and air conditioning equipment (2.F.1), foam blowing (2.F.2) and fire extinguishers (2.F.3); and are thus potentially underestimated. In the category refrigeration and air conditioning equipment (2.F.1), only total emissions by substance for the category are reported, no details are presented according to the structure of the CRF tables 2(II).Fs1 and 2.	New estimation of actual emissions for all used HFCs and SF_6 in the categories 2.F.1, 2.F.2, 2.F.3, 2.F.4 and 2.F.8 were provided with the description of new methodology. New estimations of potential emissions of HFCs and SF_6 were provided. The disaggregation of actual emissions into 2.F.1 - subcategories was added according to the IPCC methodology.
4. AGRICULTURE 4.D.1.2, 4.D.3.1	Reporting in subcategory 4.D.1.2: The NIR states that the IPCC tier 1 method is used for estimation of this category, and provides the assumption that 20 per cent of nitrogen (N) is evaporated to the atmosphere in subcategory animal manure applied to soils (4.D.1.2). This percentage is consistent with the IPCC default FracGASM (0.2 kg NH3-N+NOX–N/kg of nitrogen excreted by livestock). This implies a value of 80 per cent for N included in faeces from animal waste management systems (AWMS). However, Slovakia reports a value of 70 per cent for N included in faeces from AWMS in subcategory 4.D.1.2 (Table 6.16 of the NIR and CRF table 4.D). This would mean that 30 per cent of the N was evaporated, and the ERT noted that this is inconsistent with the description in the NIR.	In response to the potential problem, the revised emission estimation in these categories was provided according to the IPCC 2000 GPG default methodology and the coefficient of 20% of nitrogen lost by evaporation was used.

ES.2 Summary of trends in national emissions and removals

The GHG emissions presented in the National Inventory Report 2013 were updated and recalculated using the last updated methods, national conditions and data published by the Statistical Office of the Slovak Republic. According to the recommendations of the ERT from the last in-country review (2012), several recalculations and reallocations were performed and reflected in the 2013 submission with the impacts on the previous inventory years 1991 – 2010 and the base year 1990. Due to the late delivery of the draft ARR 2012, the National Inventory System of the Slovak republic was not able to reflect all recommendations as identified in the ARR 2012.

Total GHG emissions were 45 296.96 Gg of CO_2 equivalents in 2011 (without LULUCF). This represents a reduction by 36.9% against the base year 1990. In comparison with 2010, the emissions decreased by 1.3%. The decrease in total emissions of 2011 compared to 2010 was due to decrease in energy and industrial processes sectors in the reaction to lower foreign trade and demand.

Latest OECD Environmental Performance Review of the Slovak Republic summaries 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".[2]

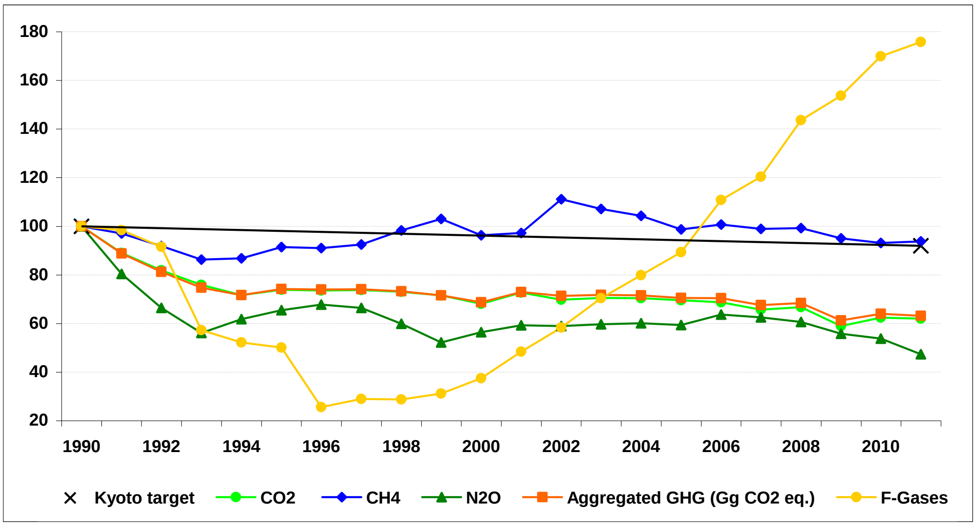
Similarly, ETC/ACM Technical paper states that:

"*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."*[3]

It is expected further increase in the transport category and in consumption of F-gases (mainly HFCs and SF_6) emissions. Unexpected increase occurred in agriculture and waste sectors, which can be explained by the later increase in economic activity after recession year 2009.

Total GHG emissions excluding LULUCF sector have continued to decrease from the base year with the moderate rate in the recent years. Significant changes in methodologies and emission factors were implemented to ensure consistency with the European Emission Trading Scheme (EU ETS), which represent significant progress in quality of estimation through comparison with the verified emissions for all installation included in the EU ETS. Table ES.2 shows the aggregated GHG emissions expressed in CO_2 equivalents and according to the gases. In the period 1990 – 2011, 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 target (92%) in relative expression. The emissions of F-gases are only gases which have increasing trend since 1990 due to the increasing use in industry.

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



GHG emissions without LULUCF; emissions are determined as of 15.04.2013

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 after EU membership) and also by temporary changes in production intensity (driven by global and EU markets). Transport (mostly the

[2] *OECD Environmental Performance Reviews, Slovak Republic, 2011*

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

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).

ES.3 Overview of source and sink category

The energy sector (including transport) with the share of 55.53% was the main contributor to total GHG emissions in 2011. Within this sector, transport with 14.08% share contributes significantly to the GHG emissions and it shows the most increasing trend. The share of transport in total emissions has increased by 11.46% since 1990. 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 was the second important sector in 2011 with its 18.21% share in total GHG emissions, producing mainly technological emissions from processing mineral products, chemical production and steel and iron production. The reduction of emissions from technological processes is very costly and there exist specific technical limits, therefore the emissions have not been changed since the reference year as significantly as for other categories. Their level is influenced mostly by the production volume in industrial processes. The most growing emissions within the IP 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 2011, the share of agriculture sector on total GHG emissions was 6.88% and the trend in decrease of 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. Sector waste contributed by 4.92% to total GHG emissions in 2011. Using of more exact methodology for the evaluation of methane emissions from solid waste disposal on sites 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. Sector solvents use is the least significant sector with respect to the generation of GHG emissions in the Slovak Republic. Its contribution to the total GHG emissions was less than 1%. 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 sector energy are noticeable. Combustion and transformation of fossil fuels, which account for about 95% of the total CO_2 emissions in the Slovak Republic, represent most important anthropogenic source of CO_2 emissions (Figure ES.2, Table ES.3).

Table ES.2: *Total anthropogenic greenhouse gas emissions by gases in 1990 – 2011*

GREENHOUSE GAS EMISSIONS	Base year 1990	1991	1992	1993	1994	1995	1996	1997
	CO_2 equivalent (Gg)							
CO_2 emissions including net CO_2 from LULUCF	50 606.13	42 846.80	36 794.56	34 023.64	32 340.05	34 021.90	34 004.24	34 344.26
CO_2 emissions excluding net CO_2 from LULUCF	60 745.23	54 091.96	49 749.76	46 078.75	43 526.70	44 879.11	44 699.10	44 811.47
CH_4 emissions including CH_4 from LULUCF	4 428.26	4 292.00	4 062.63	3 817.26	3 839.07	4 046.77	4 026.74	4 091.44
CH_4 emissions excluding CH_4 from LULUCF	4 414.17	4 283.03	4 054.61	3 809.15	3 830.55	4 037.22	4 016.51	4 080.17
N_2O emissions including N_2O from LULUCF	6 456.94	5 197.81	4 329.69	3 675.73	4 006.55	4 228.79	4 371.70	4 274.31
N_2O emissions excluding N_2O from LULUCF	6 351.04	5 104.12	4 218.54	3 561.90	3 924.94	4 159.70	4 302.24	4 217.93
HFCs	NA.NO	NA.NO	NA.NO	NA.NO	0.17	11.65	24.06	32.60
PFCs	271.37	266.94	248.42	155.42	132.06	114.32	34.51	34.62
SF_6	0.03	0.03	0.04	0.07	9.27	9.91	10.76	11.34
Total (including LULUCF)	**61 762.74**	**52 603.58**	**45 435.34**	**41 672.11**	**40 327.18**	**42 433.35**	**42 472.01**	**42 788.57**
Total (excluding LULUCF)	**71 781.85**	**63 746.08**	**58 271.38**	**53 605.29**	**51 423.69**	**53 211.91**	**53 087.19**	**53 188.12**

GREENHOUSE GAS EMISSIONS	Base year (1990)	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (Gg)							
CO_2 emissions including net CO_2 from LULUCF	50 606.13	33 273.25	32 272.36	30 568.03	33 612.48	31 597.53	32 553.92	33 063.62
CO_2 emissions excluding net CO_2 from LULUCF	60 745.23	44 324.34	43 434.62	41 367.41	44 168.53	42 405.42	42 836.47	42 742.09
CH_4 emissions including CH_4 from LULUCF	4 428.26	4 348.13	4 559.22	4 259.44	4 306.51	4 916.43	4 744.24	4 621.02
CH_4 emissions excluding CH_4 from LULUCF	4 414.17	4 336.85	4 546.42	4 247.68	4 292.24	4 902.38	4 729.13	4 603.82
N_2O emissions including N_2O from LULUCF	6 456.94	3 852.79	3 360.44	3 655.53	3 797.05	3 767.80	3 817.86	3 841.75
N_2O emissions excluding N_2O from LULUCF	6 351.04	3 804.04	3 312.30	3 581.79	3 762.96	3 739.18	3 787.70	3 813.82
HFCs	NA.NO	40.42	58.18	77.01	102.30	130.12	154.22	181.34
PFCs	271.37	25.40	13.60	11.65	15.59	13.75	21.65	19.91
SF_6	0.03	12.24	12.68	13.11	13.48	14.42	15.03	15.53
Total (including LULUCF)	**61 762.74**	**41 552.24**	**40 276.49**	**38 584.76**	**41 847.42**	**40 440.06**	**41 306.91**	**41 743.17**
Total (excluding LULUCF)	**71 781.85**	**52 543.30**	**51 377.81**	**49 298.65**	**52 355.10**	**51 205.27**	**51 544.20**	**51 376.51**

GREENHOUSE GAS EMISSIONS	Base year (1990)	2005	2006	2007	2008	2009	2010	2011
	CO_2 equivalent (Gg)							
CO_2 emissions including net CO_2 from LULUCF	50 606.13	36 073.08	33 219.48	31 716.37	33 237.73	28 323.37	30 955.22	30 164.19
CO_2 emissions excluding net CO_2 from LULUCF	60 745.23	42 224.47	41 718.12	39 857.26	40 492.91	35 802.01	37 911.16	37 671.87
CH_4 emissions including CH_4 from LULUCF	4 428.26	4 379.95	4 462.55	4 383.55	4 399.99	4 216.17	4 130.63	4 161.08
CH_4 emissions excluding CH_4 from LULUCF	4 414.17	4 357.51	4 443.65	4 364.81	4 378.94	4 195.41	4 107.72	4 138.49
N_2O emissions including N_2O from LULUCF	6 456.94	3 797.90	4 061.74	3 995.57	3 867.57	3 561.90	3 434.16	3 027.19
N_2O emissions excluding N_2O from LULUCF	6 351.04	3 771.85	4 040.35	3 970.84	3 852.08	3 541.50	3 416.27	3 009.36
HFCs	NA.NO	205.96	248.14	284.44	335.17	380.08	420.16	439.50
PFCs	271.37	20.25	35.82	24.88	36.16	17.76	21.15	17.00
SF_6	0.03	16.27	16.81	17.44	18.51	19.39	19.90	20.74
Total (including LULUCF)	**61 762.74**	**44 493.41**	**42 044.54**	**40 422.25**	**41 895.13**	**36 518.68**	**38 981.23**	**37 829.71**
Total (excluding LULUCF)	**71 781.85**	**50 596.32**	**50 502.89**	**48 519.67**	**49 113.78**	**43 956.15**	**45 896.36**	**45 296.96**

Table ES.3: *Total anthropogenic greenhouse gas emissions by sectors*

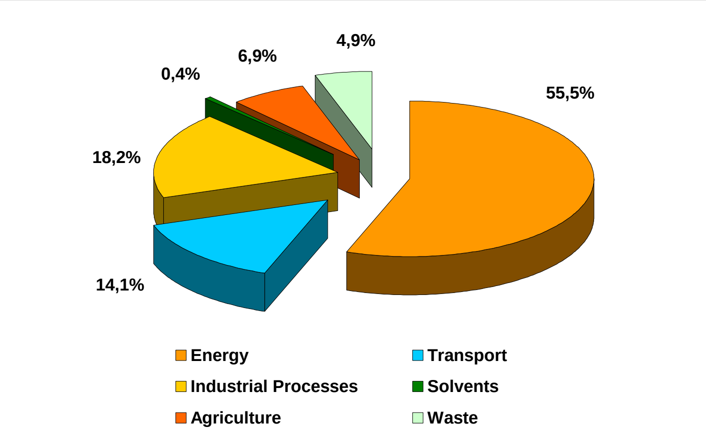
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997
	CO_2 equivalent (Gg)							
1. Energy	53 875.84	48 694.21	44 578.88	40 793.10	37 934.98	38 947.71	38 929.38	38 805.77
2. Industrial Processes	9 543.26	7 737.66	7 400.44	7 242.93	8 023.03	8 552.32	8 547.54	8 759.58
3. Solvent and Other Product Use	147.15	126.64	110.00	101.65	102.96	121.53	115.50	97.62
4. Agriculture	7 124.26	6 081.67	5 072.08	4 348.57	4 187.69	4 357.64	4 201.16	4 040.70
5. Land Use, Land-Use Change and Forestry	-10 019.11	-11 142.50	-12 836.04	-11 933.17	-11 096.51	-10 778.56	-10 615.18	-10 399.55
6. Waste	1 091.33	1 105.90	1 109.98	1 119.03	1 175.03	1 232.71	1 293.62	1 484.45
7. Other	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)	**61 762.74**	**52 603.58**	**45 435.34**	**41 672.11**	**40 327.18**	**42 433.35**	**42 472.01**	**42 788.57**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (Gg)							
1. Energy	53 875.84	37 941.63	36 856.98	35 646.59	38 132.84	35 854.22	36 521.34	35 439.92
2. Industrial Processes	9 543.26	8 954.24	8 874.59	8 293.99	8 770.08	9 152.43	9 021.00	10 131.28
3. Solvent and Other Product Use	147.15	94.45	90.52	85.04	99.74	131.92	137.35	163.49
4. Agriculture	7 124.26	3 724.15	3 462.98	3 495.99	3 541.59	3 482.24	3 362.62	3 174.53
5. Land Use, Land-Use Change and Forestry	-10 019.11	-10 991.06	-11 049.45	-10 713.89	-10 507.68	-10 765.22	-10 237.28	-9 633.33
6. Waste	1 091.33	1 828.83	2 092.74	1 777.04	1 810.85	2 584.46	2 501.90	2 467.29
7. Other	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)	**61 762.74**	**41 552.24**	**40 328.36**	**38 584.76**	**41 847.42**	**40 440.06**	**41 306.91**	**41 743.17**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	2005	2006	2007	2008	2009	2010	2011
	CO_2 equivalent (Gg)							
1. Energy	53 875.84	35 500.64	34 432.40	32 749.51	33 546.07	30 200.64	31 789.70	31 533.37
2. Industrial Processes	9 543.26	9 407.00	10 251.98	10 010.10	9 901.67	8 374.69	8 621.23	8 248.22
3. Solvent and Other Product Use	147.15	171.54	170.59	166.25	166.59	164.38	164.35	170.54
4. Agriculture	7 124.26	3 171.01	3 115.33	3 231.22	3 129.46	3 052.37	3 098.29	3 117.52
5. Land Use, Land-Use Change and Forestry	-10 019.11	-6 102.90	-8 458.35	-8 097.42	-7 218.64	-7 437.46	-6 915.13	-7 467.26
6. Waste	1 091.33	2 346.13	2 532.60	2 362.59	2 369.99	2 164.06	2 222.79	2 227.32
7. Other	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)	**61 762.74**	**44 493.41**	**42 044.54**	**40 422.25**	**41 895.13**	**36 518.68**	**38 981.23**	**37 829.71**

Total aggregated GHGs emission, emissions are determined as of 15.04.2013

Figure ES.2: *GHG emissions share by sectors in 2011 (%) in the Slovak Republic*



Sector/Category	CO_2 *eq.* (Gg)
Energy	25 153.35
Transport	6 380.02
Industrial Processes	8 248.22
Solvents	170.54
Agriculture	3 117.52
Waste	2 227.32

Emissions are determined as of 15.04.2013

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 would be applicable also for reporting, under Article 3.4. However, the Slovak Republic has decided not to use Article 3.4 activities to meet its commitments under the first 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 decided not to use any activities under Article 3.4 (forest management, cropland management, grazing land management and revegetation) to meet its commitment under the first commitment period of the Kyoto Protocol. The Slovak Republic has chosen to account for the activities under Article 3.3 (afforestation, reforestation and deforestation) for the whole commitment period.

In 2011, total CO_2 removals from afforestation/reforestation activities were -527.85 Gg of CO_2 (changes in 34.16 kha to the end of 2011). Total CO_2 emissions from deforestation were 38.53 Gg of CO_2 (changes in 7.85 kha to the end of 2011). In 2011, total removals under the Article 3.3 of the KP were 489.33 Gg with the changed area of 42.01 kha.

Table ES.4: *Emissions and removals resulting from the activities under Article 3.3 of the KP*

Activities	2008	2009	2010	2011	Total
	Net CO_2 (Gg)				
A. Article 3.3 activities	-318.75	-257.39	-371.23	-489.33	**-1 436.71**
A.1. Afforestation and Reforestation	-453.55	-469.73	-512.43	-527.85	**-1 963.56**
A.1.1. Units of land not harvested since the beginning of the commitment period	-453.55	-469.73	-512.43	-527.85	**-1 963.56**
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	NA	**NA**
A.2. Deforestation	134.80	212.34	141.19	38.53	**526.86**

The recalculations followed the changes in methodology and land-use categorizations were provided in KP LULUCF for the years 2008 – 2010.

ES.5 Indirect greenhouse gases

A major source of SO_2, NO_x and CO emissions is power and heat generation. Contribution of transport to NO_x and CO emissions is still growing. Metallurgy is an important source of CO emissions. Emissions of NM VOC are regularly monitored by the National Program of NM VOC Emissions Reduction in the Slovak Republic. Within this Program, the emission factors for asphalt paving and residential plants combustion were revised (total decrease in emissions due this revaluation of EFs was about 45% in 1990). The year 1990 was used as a starting point and updating was carried out for the years 1993, 1996 – 1999 and 2000 – 2011. NM VOC emissions occur from the use of solvents, transport, refinery/storage and transport of crude oil and petrol. The categories of emission sources in the National Emission Information System (NEIS) are based on provisions of Act No 318/2012 Coll. amending the Act No 137/2010 Coll. on Air and they do not correspond exactly to the structure of sources according to the CRF requirements. Therefore, it is technically very complicated to provide information on emissions and emission factors according to the classification as required by standard tables. NM VOC emissions have slightly increased in the sector solvent and other product use as result of increased industrial production, especially in engineering, but also due to increasing consumption of print’s ink and import of solvent paints. New emission factors respect that asphalt mixture contains 5.5% of asphalt.

Emission inventory of NM VOC for the Slovak Republic is elaborated according to the EMEP/EEA Air Pollutant Emission Inventory Guidebook and in coincidence with requirements of the respective of working group for emission inventory (UN ECE Task Force on Emission Inventory). In the sense of the requirements for the NFR reporting, the NFR sectors were assigned to the individual sectors upon the base of SNAP nomenclature. Emission factors for the estimation of emissions have been taken over from the literature, secondly comes from the measurements on sources in the Slovak Republic, in some cases are recommended by sectoral experts. NFR category 3.A.3 includes SNAP 0601, emission estimation is based on paints and glues consumption and on information about content of particular types of VOC in these products.[4] The EFs are specific for every year, depends on average content of VOC in products. Category 3.B.1 includes SNAP 060202, emission estimation is based on particular solvents consumption (total amount of produced and imported solvents – exported solvents and used in category 3.A.3 to avoid double counting). The estimation is based on VOC content in particular solvent.[4] Category 3.C includes SNAP 060408. The EF is 1.55 kg/inhabitants (Atmospheric Emission Inventory Guidebook, October 2003). Emissions from this category are estimated according to the number of population. Category 3.D.3 includes SNAP 060404.

The last update of the emission inventory and projections was performed in 2013. Major recalculations were made for all pollutants in road transport. The recalculation of the emissions from road transport for the period of 1990 – 2009 was based on the updated model COPERT IV. Model COPERT IV was used also for the calculation of emissions in 2010. Minor recalculations for NO_x, NM VOC, heavy metal emissions from stationary sources were performed in 2010 (only for sector energy – category 1A1a), due to the changes in operators´ statistics in the database of NEIS (National Emission Information System). The recalculations regarding solid waste disposal on landfills and waste incineration (hospital waste, industrial waste and municipal waste) were performed back to the year 1990. NMVOC and heavy metals (HMs) were recalculated back to year 2000 due to the corrections of activity data. Recalculations for $PM_{2.5}$ and PM_{10} emissions were done for stationary sources in 2007 (only for sector energy – category 1A1a), due to the change in the plant statistics of operators in the database NEIS. The recalculation was also done for sector agriculture in category synthetic N-fertilizers for NH_3 emissions up to year 2000.

No recalculation for NMVOC took place in 2012 submission. The last extent recalculation was done in year 2008, when the NFR sector 3.B.1 Degreasing and dry cleaning was recalculated, due to the

[4] *The National Program for Reducing Emissions of NMVOC Pollutants, 2nd stage; K. Magulova, 2000*

revision of activity data back to the base year 1990. The total NMVOC emissions have strongly decreased from 1990 to 1999 and slightly increased after 2000 according to the balance, but even though are below 1990 in 2011. However, the preliminary results of NMVOC emissions in 2011 show increase in the comparison of the previous year. This increase was caused by the increasing import of solvents, namely acetone used in machinery industry as a degreasing agent.

The NMVOC emissions have increased after 2000 especially in the NFR category 3.A.3 by about 34% since 2000 because of increasing industrial activity in Slovakia. The expansion in automotive industry in Slovakia occurred in years 2004 and 2005, many of paint shops were opened and so the consumption of paints has increased. The import of print's ink and solvent paints has increased, too. The Council Directive 1999/13/EC entered into force since 2007, with which operators had to adjust to emission limits. Slovakia adopted several decrees that led to a reduction in VOC emissions in solvents sector (Decree of the Ministry of Environment of the Slovak Republic No 409/2003 which established emission limits, technical requirements and operating conditions for sources in which the organic solvents are used as amended by the Decree No 457/2007 and the Decree No 133/2006 on requirements on emission limits for VOC from using organic solvents in regulated products, since 2009 according to the Decree No 30/2009).

Table ES.5: *Anthropogenic emissions of NO_x, CO, NM VOC and SO_2 in 1990 – 2011*

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	Gg of NOx										
Total NOx	**226.59**	**204.42**	**190.54**	**181.54**	**171.31**	**179.07**	**135.53**	**127.44**	**132.79**	**120.62**	**107.75**
Energy	160.46	150.21	141.73	135.26	122.39	128.01	89.42	82.10	86.43	77.41	70.32
Transport	61.48	50.72	45.65	43.59	44.84	46.59	45.62	44.84	45.89	42.72	36.89
Industry	4.31	3.22	2.93	2.46	3.87	4.25	0.24	0.23	0.21	0.19	0.21
Solvent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other*	0.35	0.28	0.23	0.24	0.20	0.23	0.25	0.27	0.26	0.30	0.33
Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
	Gg of NOx										
Total NOx	**108.10**	**100.54**	**98.16**	**99.45**	**102.39**	**96.80**	**96.05**	**94.23**	**83.42**	**89.14**	**85.55**
Energy	67.58	59.70	58.37	56.51	55.39	52.09	46.84	45.79	41.08	42.69	42.75
Transport	39.97	40.30	39.22	42.30	46.20	43.99	48.49	47.69	41.53	45.57	41.88
Industry	0.21	0.20	0.21	0.24	0.27	0.28	0.27	0.26	0.32	0.34	0.38
Solvent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other*	0.33	0.33	0.36	0.40	0.53	0.45	0.45	0.49	0.50	0.54	0.53
Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
	Gg of CO										
Total CO	**521.38**	**497.08**	**455.31**	**466.57**	**442.15**	**426.85**	**366.48**	**364.31**	**347.37**	**334.93**	**305.91**
Energy	351.26	340.23	299.99	301.05	272.63	258.90	208.18	205.61	187.61	185.36	185.16
Transport	164.00	151.87	151.29	161.36	165.92	163.93	153.84	153.97	155.12	144.22	114.89
Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.02
Solvent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other*	6.12	4.97	4.03	4.16	3.60	4.02	4.46	4.74	4.64	5.36	5.84
Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
	Gg of CO										
Total CO	**310.49**	**295.85**	**298.40**	**299.34**	**281.40**	**280.42**	**252.04**	**253.67**	**217.90**	**230.45**	**236.57**
Energy	175.59	165.14	184.20	189.56	181.39	193.51	183.33	178.41	148.23	165.87	179.00
Transport	128.97	124.86	107.73	102.67	90.64	78.97	60.78	66.55	60.93	55.03	48.16
Industry	0.04	0.05	0.05	0.04	0.01	0.04	0.004	0.004	0.004	0.004	0.005
Solvent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other*	5.88	5.80	6.42	7.07	9.35	7.90	7.93	8.70	8.73	9.55	9.41
Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
	Gg of NMVOC										
Total NMVOC	**133.60**	**58.96**	**53.48**	**102.47**	**51.83**	**91.10**	**86.95**	**80.84**	**74.72**	**68.01**	**67.09**
Energy	41.02	NO	NO	34.43	NO	27.52	28.30	27.28	24.09	22.85	21.97
Transport	25.73	22.96	23.98	25.44	24.13	22.99	21.59	21.01	18.21	14.61	16.14
Industry	8.79	NO	NO	5.87	NO	2.82	2.68	2.67	1.58	1.51	1.37
Solvent	52.87	36.00	29.50	34.97	27.70	37.07	33.80	29.29	30.18	28.41	26.98
Other*	5.19	NO	NO	1.77	NO	0.69	0.58	0.59	0.66	0.62	0.63

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
						Gg of NMVOC					
Total NMVOC	**68.75**	**66.89**	**68.78**	**70.48**	**71.46**	**68.74**	**67.24**	**65.60**	**64.28**	**62.40**	**68.29**
Energy	22.48	20.29	21.33	23.00	24.87	22.77	22.25	22.12	21.37	21.51	22.42
Transport	15.66	13.62	12.92	12.44	10.85	9.16	9.31	7.77	7.73	7.11	6.84
Industry	1.32	1.39	1.68	1.69	1.59	1.56	1.53	1.38	1.26	1.25	1.52
Solvent	28.72	31.02	32.27	32.76	33.56	34.63	33.58	33.78	33.33	31.86	36.90
Other*	0.56	0.56	0.57	0.59	0.58	0.62	0.57	0.56	0.57	0.67	0.61

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
						Gg of SO_2					
Total SO_2	**524.13**	**443.93**	**388.27**	**326.96**	**243.88**	**244.84**	**229.12**	**203.20**	**182.55**	**172.96**	**126.95**
Energy	522.69	442.77	387.24	326.04	242.91	243.80	228.06	202.14	181.39	171.88	126.08
Transport	1.44	1.16	1.03	0.92	0.97	1.04	1.06	1.06	1.16	1.09	0.86
Industry	IE.NA	IE.NA	IE.NA	IE.NA	IE.NA	IE.NA	IE.NA	IE.NA	IE.NA	IE.NA	0.02
Solvent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other*	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
						Gg of SO_2					
Total SO_2	**131.11**	**103.35**	**105.50**	**96.19**	**89.01**	**87.75**	**70.56**	**69.41**	**64.08**	**69.39**	**68.48**
Energy	130.23	102.53	105.26	95.95	88.77	87.53	70.30	69.14	63.84	69.11	68.26
Transport	0.87	0.79	0.21	0.22	0.24	0.22	0.25	0.26	0.24	0.26	0.22
Industry	0.01	0.02	0.03	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Solvent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other*	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

**Biomass burning and forest fires, emissions are determined as of 15.04.2013.*

PART 1:
Annual Inventory Submission

CHAPTER 1: INTRODUCTION

1.1 Background information on greenhouse gas inventories and climate change

1.1.1 Climate change

From 1881 to the present days, the average annual air temperature in Slovakia increased by about 1.6 °C (more in the season from January to August) and the annual atmospheric precipitation in totals decreased by about 3.4% (in the south of the territory the decrease was more than 10%; in the north and northeast of the territory the increase up to 3% has occurred temporarily). A significant decrease in the relative air humidity was recorded (in the south of the territory by about 5% from 1900 and less than 5% elsewhere in the Slovak Republic), as well as the decrease in snow cover at the altitude up to 1 000 m almost over the whole territory (the increase in higher altitude). Also the characteristics of potential and actual evapotranspiration, soil humidity and net radiation confirm a gradual desertification, in particular in the south of Slovakia (the increase in potential evapotranspiration and the decrease in soil moisture). However, characteristics of sun radiation have not been changed significantly (except for a transitional decrease in the period from 1965 to 1985). Similar trend continues also after 2000.[5]

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.

Whilst mentioning the emissions of greenhouse gases, we must also include CO_2, CH_4 N_2O and F-gases, as they are defined in the Kyoto Protocol. Though they belong to natural components of the ambient air, their present content in the atmosphere is significantly affected by human activity. The growth in concentrations of greenhouse gases in the atmosphere (caused by anthropogenic emission) leads to the strengthening of the greenhouse gas effect and thus to the additional warming of the

[5] *The Fifth National Communication of the Slovak Republic on Climate Change, 2009*

atmosphere. Concentrations of greenhouse gases in the atmosphere are formed by the difference between their emission (release into the atmosphere) and sink. It follows then that the increase of their content in the atmosphere operates by two mechanisms:

- Emissions into the atmosphere.
- Weakening of natural sink mechanisms.

Globally (Climate Change, 1995) the annual anthropogenic emission of carbon dioxide ranges between 4-8 billion tons of carbon (about 4 t of CO_2 per capita in the globe). Fossil fuel combustion and cement production are the most important sources of "new" carbon dioxide. CO_2 is also released from the soil (deforestation, forest fires and conversion of grasslands into agricultural soil), but this contribution is more difficult to quantify. Carbon dioxide is very stable in the atmosphere; its residence time is tens of years (60-200 years.) and is removed from the atmosphere by a complex of natural sink mechanisms. It is expected that 40% of carbon dioxide presently emitted will be absorbed by the oceans. Photosynthesis by vegetation and sea plankton is another important sink mechanism, though only a transitional one, because after the death (eating) of a plant, carbon dioxide is released again. The level of methane in the ambient air is affected by human activity in more ways. Land transformation into an agricultural one (mainly rice fields), animal husbandry, coal mining, natural gas mining, its transport and use as well as the biomass burning, these all are the anthropogenic activities. The natural methane sources have not been fully investigated yet and thus the role of methane in the climate change mechanism is not quite clear. As distinct from CO_2, the disintegration of methane in the atmosphere is via chemical reactions (by OH radical). Residence time of methane in the atmosphere is 10-12 years. At present, the annual total anthropogenic methane emission is said to be approximately 0.4 billion tons, emission from natural sources is about 0.16 billion tons (IPCC[6] 1995). PFCs, HCFCs, HFCs (perfluorocarbons, hydrochloroflourocarbons, hydrofluorocarbons, etc.) and SF_6 are entering the atmosphere only because of human activity. They are used as carrier gases for sprays, fillings in cooling and extinguishing systems, as insulating substances, as solvents at the production of semiconductors etc. Apart from the fact that they attack atmospheric ozone, they are very "high-powered" inert greenhouse gases having a residence time e.g. perfluoromethane (CF_4) of 50 000 years. It means that even minor emissions have a great negative effect. The ground level ozone concentrations are growing as a consequence of CO, NO_x and NM VOC emissions. They have very important source in exhaust gases, fossil fuel combustion and as far as NM VOCs are considered, the use of solvents, as well. N_2O enters the atmosphere from several small sources. The most important source seems to be the emission from soil (nitrogen surpluses because of intensive fertilizing and inconvenient agriculture-technical procedures). Fuel combustion, some industrial technologies, large-scale livestock breeding and sewage are the sources of N_2O emissions. Global anthropogenic emission is estimated to be 3-7 million tons of nitrogen per year. Natural sources are approximately twice as large as anthropogenic ones. The N_2O is disintegrated mainly photo chemically in the stratosphere.

1.1.2 Greenhouse gas inventories

According to the emission inventory submitted in April, 15 2013, in 2011 the Slovak Republic total anthropogenic emissions of greenhouse gasses expressed as CO_2 equivalent decreased by 36.9% without LULUCF, if compared with 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.

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[6] *Intergovernmental panel was established in 1988 commonly by ECE (UNEP) and the World Meteorological Organisation (WMO). Its task is to reach the authoritative international consensus in the scientific opinions on climate change. The working groups of IPCC prepare regular updated information for COP, where the latest knowledge in association with the global warming is included.*

- 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).

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.*" However, the share of greenhouse gasses per capita still remains one of the highest in Europe.

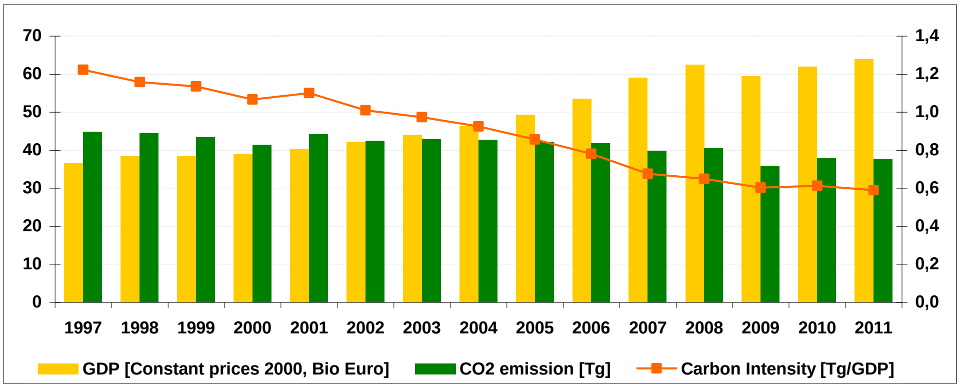
In May 2004, the Slovak Republic joined the European Union. Relevant European legislation has brought additional positive direct and indirect effects to the reduction of GHG emissions, mainly in energy sector. The introduction of emission trading scheme will allow the implementation of further reduction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

Table 1.1: *Carbon intensity per GDP from 1997 in the Slovak Republic*

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005
GDP [Constant prices 2000. Bio Euro]	36.68	38.27	38.29	38.81	40.16	42.01	44.01	46.24	49.31
CO_2 emission [Tg]	44.81	44.32	43.43	41.37	44.17	42.41	42.84	42.74	42.22
Carbon Intensity [Tg/GDP]	1.22	1.16	1.13	1.07	1.10	1.01	0.97	0.92	0.86
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**			
GDP [Constant prices 2000. Bio Euro]	53.43	59.04	62.43	59.35	61.95	63.95			
CO_2 emission [Tg]	41.72	39.86	40.49	35.80	37.91	37.67			
Carbon Intensity [Tg/GDP]	0.78	0.68	0.65	0.60	0.61	0.59			

The values are absolute, GDP after recalculation in 2010 up to 1997, data before 1997 are not available in the same methodology

Figure 1.1: *Comparison of CO_2 emissions per GDP (carbon intensity)*



Statistical Office of the Slovak Republic recalculated GDP and Value Added according to the NACErev.2 methodology only back to the year 1997

1.1.3 International agreements

The instrument to tackle climate change is the UN Framework Convention on Climate Change adopted in 1992. The aim of the Convention is to stabilize the atmospheric concentrations of greenhouse gases to a safe level that enables adapting of ecosystems. Currently UNFCCC covers 195 countries or international communities, including the Slovak Republic, and the EU which is also the Party to the Convention. The Convention requires adoption of mitigation measures to reduce GHG emission in developed countries by 25-40 % by 2020 compared to 1990.

The Framework Convention on Climate Change (UNFCCC) – the basic international legal instrument to protect global climate was adopted at the UN Conference on the Environment and Development (Rio de Janeiro, 1992). The final goal of the Convention is to achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that would not cause any dangerous interference in the climate system. 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, is to prepare and submit to the UNFCCC secretariat greenhouse gas emission inventory on yearly base.

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 1990. The Slovak Republic and the former EU Member States ratified the Kyoto Protocol on 31st May 2002.[7]

Current UNFCCC negotiation process is focused on wide co-operation of developed and developing countries to achieve global goal of 2 °C.

After joining the European Union (May 1st, 2004) by the Slovak Republic, set of new environmental legislative requirements have been adopted, including climate change and air protection. The European Union (EU) considers climate change as one of the four environmental priorities.[8] 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 Decision No 280/2004/EC of the European Parliament and of the Council concerning a mechanism for monitoring Community GHG emissions and for implementing the Kyoto Protocol.[9] Basic objectives of the Decision are:

- 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.

The European Commission asses the preliminary data submitted in the Annual Report of the Slovak Republic on March 15, 2013.

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

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

[9] *OJ L 49, 19.2.2004, p. 1*

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.

1.2 Brief description of the institutional arrangements for inventory preparation

1.2.1 National Inventory System of the Slovak Republic for GHG inventory

Articles 4 and 12 of the UNFCCC require that Parties to the UNFCCC develop, periodically update, publish, and make available to the Conference of the Parties 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 estimating emissions and removals as a part of ensuring that Parties are in compliance with emission limits, that they have a national system for estimating 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 fulfill 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 (http://ghg-inventory.shmu.sk/) has been established and officially announced by Decision of the Ministry of the Environment of the Slovak Republic on 1st January 2007 in the official bulletin: Vestnik, Ministry of Environment, XV, 3, 2007.[10] In agreement with paragraph 30(f) of Annex to decision 19/CMP.1 which gives the definitions of all qualitative parameters for the 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 Ministry of the Environment of the Slovak Republic (MZP) (http://www.minzp.sk/) 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.

The Ministry of the Environment of the Slovak Republic is the main body to ensure conditions and to monitor progress of Slovakia in fulfilment of all commitments and obligations in climate change and adaptation policy.

According to the Governmental Resolution No 821/2011 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 will replace 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, the Ministry of Transport, Construction and Regional Development, the Ministry of Education, Science, Research and Sport, the Ministry of Health, the Ministry of Finance, the Ministry of Foreign Affairs and the Head of the Regulatory Office for the Network Industries.

Main objectives of inter-ministerial body are to develop and implement national strategy on mitigation and adaptation and to ensure cost-effective meeting of reduction commitments both in middle and long-term frame. Committee will play an important role also in process of evaluation of fulfilment for our climate change objectives and commitments and will regularly submit report on progress in achievement to be considered by the Slovak Government.

District and regional environmental offices are decision-making bodies according to Act No 525/2003 Coll. These are located at 8 regional and 46 district administration offices. Inspection and enforcement activities are carried out by the 4 inspectorates of the Slovak Environmental Inspection. According to the Act No 137/2010 Coll. on Air Protection, competencies and decision-making process concerning large, medium and small pollution sources are given to regional and district levels and municipalities.

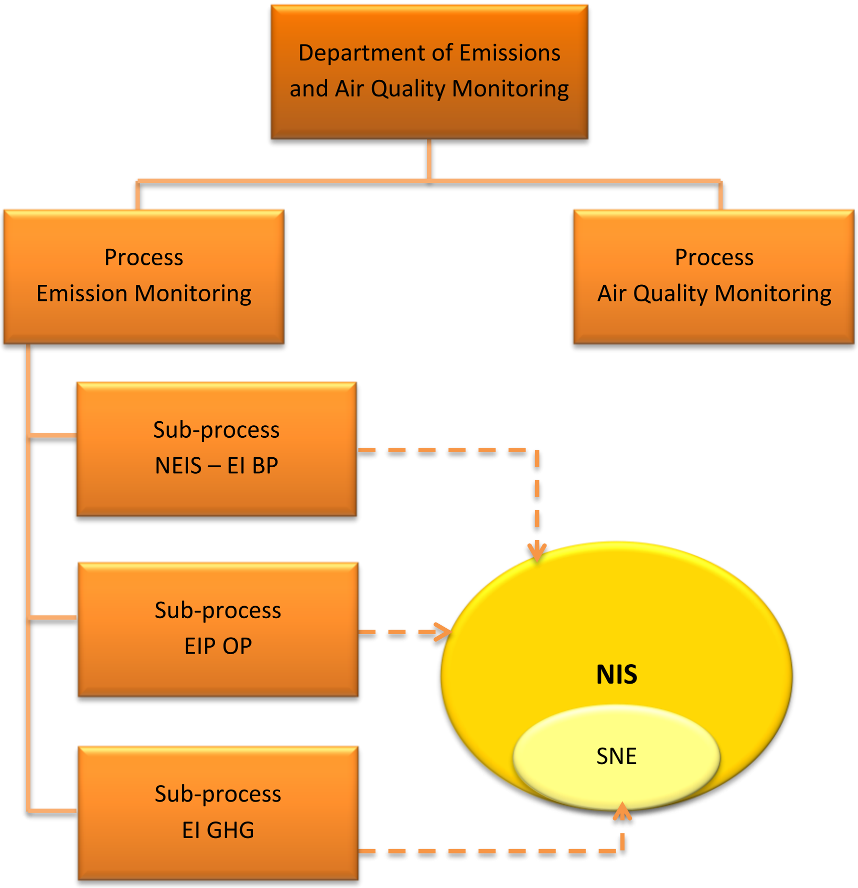
Act No 572/2004 Coll. as amended on Emission Allowance Trading is the first legal instrument directly oriented towards the control of GHG emissions. According to this Act, competencies with respect to emission allowance trading are given to the Ministry of Environment and the regional and district environmental offices.

The Slovak Hydrometeorological Institute (SHMU) www.shmu.sk is authorised by the Ministry of the Environment of the Slovak Republic to provide environmental services, including annual GHG

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

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 after approval published at the website of the SHMU http://www.shmu.sk/File/SHMU_Kontrakt_2012.pdf. Deadline for the approval of this plan by the ministry is 31st December each year.

Figure 1.2: *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 (OMEaKO) as the Single National Entity with delegated responsibilities. The process of preparing and management of emission inventories is the main workload of the OMEaKO. Permanent staff of emission experts working at the Department is complemented by several external experts from relevant institutions working on annual contracts renewed each year.

Contracts with external institutions and sectoral experts are fully in competence of the SHMU after previous approval by the Ministry of Environment. The Department of Emissions and Air Quality Monitoring is fulfilling inventory tasks fully in line with approved Plan of Main Tasks and with financial resources allocated by the ministry. The Department of Emissions and Air Quality Monitoring has usually three main projects per year: Emission Inventory of GHGs, Emission Inventory of Other

Pollutants and National Emission Information System. From the 1st January until 15th February at the latest the external contracts between the SHMU and co-operating institutions or experts are signed.

To specify main objectives for given year, kick-off workshop with participation of ministry, SHMÚ and external co-operating bodies and experts is organised regularly, usually at the beginning of February. 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 SHMU is responsible for developing and maintaining the National Emission Information System (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.spirit.sk/en/index.php). The NEIS software product is constructed as a multi-module system, corresponding fully to the requirements of current legislation. The NEIS database contains also some technical information about the sources like fuel consumption and use for the estimation of sectoral approach.

The SHMU updates annually the incoming information and activity data using the corresponding statistical information from the Statistical Office of the Slovak Republic and other national statistics.

The Department of Emissions and Air Quality Monitoring at the SHMU is responsible for the coordination of the National Inventory System for the KP under Article 5.1 as the Single National Entity. The Department of Emissions and Air Quality Monitoring has 30 full-time experts, 6.5 experts for emissions tasks. The emission experts are responsible for the following activities:

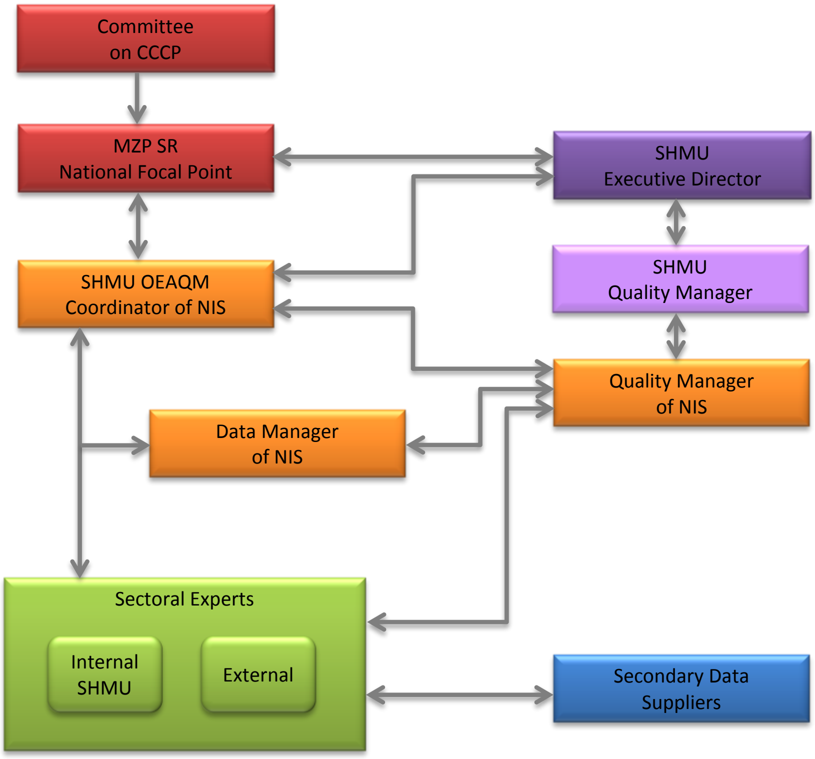
- *GHG emissions estimation and reporting (UNFCCC, KP).*
- *Emission projections evaluation and reporting.*
- *Basic and other pollutants estimation and reporting (CLRTAP).*
- *Reporting under EU requirements (NECD, LCP, VOCD, ePRTR, IPPC).*
- *National Focal Point to the EEA (air and climate change).*
- *National reporting for other institutions at national level.*

The cooperation with the Transport Research Centre in Brno is based on the consultations in road transport issues (recalculations COPERT V, disaggregation of vehicles, emission factors). SNE co-operates closely also with the Research Institute of Transport in Žilina and ensures communication among both institutions. The sectoral expert for LULUCF in cooperation with the National Forest Centre in Zvolen is responsible for the Kyoto Protocol reporting requirements under Article 3.3. Unlike in the previous period, Ministry of Agriculture and Rural Development will directly guarantee for some of the activities under the reporting obligation for the LULUCF sector in the year 2012 on the basis of contract with the National Forest Centre with defined scope and approved budget.

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

Institution	Name	Responsibility
External experts/institutions		
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. Jiri Balajka	Consultations in energy and emission projections
National Forest Centre Zvolen	Mr. Tibor Priwitzer	GHG inventory in LULUCF and KP LULUCF
Ministry of Agriculture and Rural Development of the Slovak Republic		Data provider in LULUCF sector
Motran Research – company for transport research	Mr. Jiri Dufek	GHG inventory in transport sector
Transport Research Institute Žilina		Data provider in transport sector
Ministry of Transport, Construction and Regional Development of the Slovak Republic		
Slovak Agricultural University Nitra	Mr. Bernard Šiška	GHG inventory in agriculture
Research Institute on Soil Protection Bratislava	Mr. Jozef Takáč	Data provider in agriculture sector
Department of Chemical and Environmental Engineering and the	Mr. Vladimir Danielik	GHG inventory in industrial processes and solvent use sectors
Department of Inorganic Chemistry of the Faculty of Chemical Technology of the Slovak Technical University Bratislava	Mr. Juraj Labovský	Consultation in fuel balance
Faculty of Mathematics, Physics & Informatics of the Comenius University Bratislava	Mr. Martin Gera	Uncertainty analyses
Slovak Environmental Agency -	Ms. Alena Bodíková	GHG inventory in waste sector
Waste Management Centre Bratislava	Mr. Alexander Jančárik	Data provider in waste sector
veQ – company for waste management research	Mr. Juraj Farkaš	
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	Mr. Peter Tomlein	GHG inventory in F-gases
SPIRIT Information Systems – IT services, NEIS databases provider	Mr. Jozef Skákala	NEIS provider, consultation on the NACE classification of sources
Prima Banka Slovakia	Mr. Miroslav Hrobák	National Registry focal point
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	Ms. Janka Szemesová	NIS coordinator
Dept. of Emissions and Air Quality Monitoring	Mr. Miroslav Mikovec	Deputy of NIS coordinator, energy sector coordinator
Dept. of Emissions and Air Quality Monitoring	Ms. Lýdia Ostradická	Data Manager of NIS, other pollutants expert
Dept. of Emissions and Air Quality Monitoring	Ms. Silvia Šrenkelová	Quality manager for NIS
Dept. of Emissions and Air Quality Monitoring	Mr. Marcel Zemko	Emission projections, other pollutant expert
Dept. of Emissions and Air Quality Monitoring	Mr. Jozef Uhík	NEIS 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

Figure 1.3: *Structure and responsibilities of the National Inventory System of the Slovak Republic*



1.2.2 National Registry of the Slovak Republic

Slovakia operates its national registry (NR SR) in a consolidated manner with the EU Member States who are also Parties to Kyoto Protocol (25) 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. Internet address of the registry changed to co2.primabanka.sk in January 2012. Following the change of organization designated as registry system administrator in January 2013 to ICZ Slovakia, a.s. and the email address has further changed to emisie@icz.sk. These changes occurred after the end of the reported period and were reported to the UNFCCC through Slovak National Focal Point. They will be reported in the next submission. More information on changes in the national registry is provided in the 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 Trencin, Slovakia
Phone & Fax number:	Phone: +421 32 6563 730, Fax: +421 32 6563 754
E-mail:	emisie@icz.sk
Web site address:	www.emisie.icz.sk
Contact person:	Ing. Miroslav Hrobák
Position:	Emission Registry Manager
E-mail address:	miroslav.hrobak@icz.sk

1.3 Brief description of inventory preparation and planning

1.3.1 Inventory planning

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 updating annually after the regular UNFCCC review take 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 No 525/2013/EC in spring every year. These outcomes and recommendations are included in the improvement plan, too. After preparation of the improvement plan, the prioritisation of the tasks is done. The improvement plan is delivered divided by sectors to the sectoral experts for consideration and first prioritisation of planned activities for the next inventory cycle. The ranking of tasks is then summed up and prepared for the final approval of the planned activities to the NFP on the Ministry of Environment. The approval is depending on the actual capacity situation and the review recommendations. The approved activities are included in the SHMU annual contract and the contracts of the sectoral experts (see Chapter 1.2.1).

Currently, the prioritisation of the improvement plan is focused on the energy sector and the harmonisation of different data sources for energy balance.

1.3.2 Inventory preparation

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 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 database NEIS is the most important source of emission data on fuels and other characteristics of stationary air pollution sources. NEIS is operated by the Department of Emissions and Air Quality Monitoring of the SHMU. Collected input data are compared with 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 model COPERT).

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.

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/plyn/o-zemnom-plyne/emisie/), hard coal (energetic, cooking coal, blast furnace coal), lignite, brown coal of various origin, gaseous fuels and other 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. 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.1 Fuel combustion in energy and transport, 6.A Municipal waste disposal sites, sector 2 Industrial processes and sector 3 Solvent use). The results are published annually in papers and in the National Inventory Report to the emission inventory.

The emission balances prepared by the external experts for individual sectors are gathered at the Department of Emissions and Air Quality Monitoring of the SHMU, where they are checked, reported and archived. Members of the Committee for the Climate Change Policy should comment on the emission inventory each year.

According to the COP decision 7/CP.11 the countries of Annex I are obliged to use the program CRF Reporter in reporting GHG emission inventory. The Slovak Republic uses the actual version of the program and reports the emissions according to approved methodology.

1.3.3 Inventory archiving

Archiving of inventory documents and database is in the competence of the quality and data managers of the NIS. 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's 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 Department of Emissions and Air Quality Monitoring.

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 electronic archiving of documents needed for the quality management systems are archived in electronic form at the webpage of the SHMU (intranet). Printed documents are archiving in central archive of the SHMU and at the Department of Emissions and Air Quality Monitoring.

1.4 Brief general description of methodologies and data sources used

The deadlines and responsibilities are described in the QA/QC external plan. A comprehensive description of the inventory preparation for GHG emissions is described in methodologies for individual sectors. The methodologies are updated annually within the QA/QC plan and they are archived after formal approval at the web page of the National Inventory System http://ghg-inventory.shmu.sk/.

The methodologies used for the preparation of greenhouse gas inventory in the Slovak Republic are consistent with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1997) and the IPCC Good Practice Guidance (IPCC 2000) and the IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry (IPCC 2003). 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 Guidelines. Detailed descriptions of used methodologies can be found as sector specific ones in Chapters 3 to 9.

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
Industrial Processes	Association of cement and lime producers, Association of refrigeration and air conditioning engineers, Association of paper producers
Solvent Use	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, http://www.land.gov.sk/sk/index.php?navID=122&id=1964
LULUCF	Green Report of the Ministry of Agriculture of the SR - Forest, http://www.land.gov.sk/sk/index.php?navID=123&id=2102
Waste	Dbase RISO http://www.sazp.sk/slovak/struktura/COH/oim/data/index.htm

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 and PETROCHEMA a.s. Dubová*: 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.*

1.5 Brief description of key categories

Key categories were assessed by the level of emissions and the trend in emissions with and without LULUCF and those key categories have been chosen, whose cumulative contribution is less than 95% of total GHGs and are enclosed followed the Good Practice Guidance (IPCC, 2000 and 2003). Using tables 7.1 and 5.4.1 of IPCC (2000) and IPCC (2003) as a basis, the key category analysis consists of a hundred of category-gas combinations. The identification includes all reported greenhouse gases CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 and all IPCC source categories with or without LULUCF performed with the detailed categorization of the CRF categories. The detailed key source analyses were assessed based on the recommendation of the ERT during in-country review on annual inventory 2010.

In 2011, the Slovak Republic determined using the tier 1 methodology (quantitative) according to the IPCC GPG (2000), section 7.2.1.1, 28 key source categories by the level assessment with LULUCF and 25 key source categories without LULUCF. The trend assessment determined 35 key source categories with LULUCF and 31 key source categories without LULUCF in 2011. The most important key source categories are fuel combustion, road transport, forest land, direct N_2O emissions from agricultural soil or methane emissions from SWDS (Tables 1.5 and 1.6).

A more sophisticated tier 2 method was used to identify key categories in qualitative analyses. This method combines tier 1 level key categories with the tier 1 uncertainty assumption developed by using error propagation equation to combine emission factor and activity data uncertainties. The results of this exercise is providing in the Table 1.7. Only emissions were taking into consideration (not removals), the most important key categories are comparable with the categories indentified by tier 1 with some exception (for example other land category is key in level tier 2 assessment).

Tables with the key categories assessment are provided in the Annex 1 to this report.

Table 1.5: *Summary of the key categories with LULUCF identifying by tier 1 level and trend assessment in 2011*

IPCC Source Categories	Direct GHG	Key Source Category	Criteria for Identification
ENERGY SECTOR			
1.A.1 Energy Industries - solid	CO_2	yes	Level, Trend
1.A.1 Energy Industries - gaseous	CO_2	yes	Level, Trend
1.A.1 Energy Industries - liquid	CO_2	yes	Level, Trend
1.A.2 Manufacturing Industries and Construction - solid	CO_2	yes	Level, Trend
1.A.2 Manufacturing Industries and Construction - gaseous	CO_2	yes	Level, Trend
1.A.2 Manufacturing Industries and Construction - liquid	CO_2	yes	Level, Trend
1.A.4 Other sector - gaseous	CO_2	yes	Level, Trend
1.A.4 Other sector - solid	CO_2	yes	Trend
1.A.3.b Transport - Road Transportation - liquid	CO_2	yes	Level, Trend
1.A.5.a Other non-specified - gaseous	CO_2	yes	Level, Trend
1.B.1.a Coal Mining and Handling	CH_4	yes	Level, Trend
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	CH_4	yes	Level, Trend
INDUSTRIAL SECTOR			
2(I).A.1 Cement Production	CO_2	yes	Level, Trend
2(I).A.2 Lime Production	CO_2	yes	Level, Trend
2(I).A.3 Limestone and Dolomite Use	CO_2	yes	Level, Trend
2(I).A.7 Magnesite Production	CO_2	yes	Level, Trend
2(I).B.1 Ammonia Production	CO_2	yes	Level, Trend
2(I).B.2 Nitric Acid Production	N_2O	yes	Level, Trend
2(I).B.4 Calcium Carbide Production	CO_2	yes	Trend
2(I).C.1.1 Steel Production	CO_2	yes	Level, Trend
2(I).C.2 Ferroalloys Production	CO_2	yes	Trend
2(I).C.3 Aluminium Production	CO_2	yes	Trend
2(I).F HFCs emissions	HFCs	yes	Level, Trend
AGRICULTURE SECTOR			
4.A Enteric Fermentation - Cattle	CH_4	yes	Level, Trend
4.B Manure Management	N_2O	yes	Level, Trend
4.D Agricultural Soils - indirect	N_2O	yes	Level, Trend
4.D Agricultural Soils - direct	N_2O	yes	Level, Trend
LULUCF SECTOR			
5.A Forest Land	CO_2	yes	Level, Trend
5.B Cropland	CO_2	yes	Level, Trend
5.C Grassland	CO_2	yes	Level, Trend
5.E Other Land	CO_2	yes	Trend
WASTE SECTOR			
6.A Solid Waste Disposal on Land	CH_4	yes	Level, Trend
6.B Wastewater Handling	CH_4	yes	Level, Trend
6.D Waste Composting	N_2O	yes	Trend
6.D Waste Composting	CH_4	yes	Trend

Table 1.6: *Summary of the key categories without LULUCF identifying by tier 1 level and trend assessment in 2011*

IPCC Source Categories	Direct GHG	Key Source Category	Criteria for Identification
ENERGY SECTOR			
1.A.1 Energy Industries - solid	CO_2	yes	Level, Trend
1.A.1 Energy Industries - gaseous	CO_2	yes	Level, Trend
1.A.1 Energy Industries - liquid	CO_2	yes	Level, Trend
1.A.2 Manufacturing Industries and Construction - solid	CO_2	yes	Level, Trend
1.A.2 Manufacturing Industries and Construction - gaseous	CO_2	yes	Level, Trend
1.A.2 Manufacturing Industries and Construction - liquid	CO_2	yes	Level, Trend
1.A.4 Other sector - gaseous	CO_2	yes	Level, Trend
1.A.4 Other sector - solid	CO_2	yes	Trend
1.A.3.b Transport - Road Transportation - liquid	CO_2	yes	Level, Trend
1.A.5.a Other non-specified - gaseous	CO_2	yes	Level, Trend
1.B.1.a Coal Mining and Handling	CH_4	yes	Level, Trend
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	CH_4	yes	Level, Trend
INDUSTRIAL SECTOR			
2(I).A.1 Cement Production	CO_2	yes	Level, Trend
2(I).A.2 Lime Production	CO_2	yes	Level, Trend
2(I).A.3 Limestone and Dolomite Use	CO_2	yes	Level, Trend
2(I).A.7 Magnesite Production	CO_2	yes	Level, Trend
2(I).B.1 Ammonia Production	CO_2	yes	Level, Trend
2(I).B.2 Nitric Acid Production	N_2O	yes	Level, Trend
2(I).B.4 Calcium Carbide Production	CO_2	yes	Trend
2(I).C.1.1 Steel Production	CO_2	yes	Level, Trend
2(I).C.2 Ferroalloys Production	CO_2	yes	Trend
2(I).C.3 Aluminium Production	CO_2	yes	Trend
2(I).F HFCs emissions	HFCs	yes	Level, Trend
AGRICULTURE SECTOR			
4.A Enteric Fermentation - Cattle	CH_4	yes	Level, Trend
4.B Manure Management	N_2O	yes	Level, Trend
4.D Agricultural Soils - indirect	N_2O	yes	Level, Trend
4.D Agricultural Soils - direct	N_2O	yes	Level, Trend
WASTE SECTOR			
6.A Solid Waste Disposal on Land	CH_4	yes	Level, Trend
6.B Wastewater Handling	CH_4	yes	Level, Trend
6.D Waste Composting	N_2O	yes	Trend
6.D Waste Composting	CH_4	yes	Trend

Table 1.7: Summary of the key sources with LULUCF identifying by tier 2 level assessment in 2011

IPCC Source Categories	Direct GHG	Key Source Category	Criteria for Identification
ENERGY SECTOR			
1.A.1 Energy Industries - solid	CO_2	yes	Level
1.A.1 Energy Industries - gaseous	CO_2	yes	Level
1.A.1 Energy Industries - liquid	CO_2	yes	Level
1.A.2 Manufacturing Industries and Construction - solid	CO_2	yes	Level
1.A.2 Manufacturing Industries and Construction - gaseous	CO_2	yes	Level
1.A.2 Manufacturing Industries and Construction - liquid	CO_2	yes	Level
1.A.4 Other sector - gaseous	CO_2	yes	Level
1.A.3.b Transport - Road Transportation - liquid	CO_2	yes	Level
1.A.5.a Other non-specified - gaseous	CO_2	yes	Level
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	CH_4	yes	Level
1.B.1.a Coal Mining and Handling	CH_4	yes	Level
INDUSTRIAL SECTOR			
2(I).A.1 Cement Production	CO_2	yes	Level
2(I).A.2 Lime Production	CO_2	yes	Level
2(I).A.3 Limestone and Dolomite Use	CO_2	yes	Level
2(I).A.7 Magnesite Production	CO_2	yes	Level
2(I).B.1 Ammonia Production	CO_2	yes	Level
2(I).B.2 Nitric Acid Production	N_2O	yes	Level
2(I).C.1.1 Steel Production	CO_2	yes	Level
2(I).F HFCs emissions	HFCs	yes	Level
AGRICULTURE SECTOR			
4.A Enteric Fermentation - Cattle	CH_4	yes	Level
4.B Manure Management	N_2O	yes	Level
4.D Agricultural Soils - indirect	N_2O	yes	Level
4.D Agricultural Soils - direct	N_2O	yes	Level
LULUCF SECTOR			
5.E Other Land	CO_2	yes	Level
WASTE SECTOR			
6.A Solid Waste Disposal on Land	CH_4	yes	Level
6.B Wastewater Handling	CH_4	yes	Level
6.D Waste Composting	CH_4	yes	Level

1.6 Information on the QA/QC plan including verification

The Ministry of the 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 QA/QC plan for sectors will be updated and evaluated annually by the quality manager of NIS. The project was finalized at the meeting and workshop for the experts involved in the National Inventory System on 13th January 2010.

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 sending 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 it is planned to create a website forum.

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 steps in QA/QC activities are managed and documented in several protocols (verification protocol, recalculation protocol, contracts or sectoral reports) which are in full compliance with internal documentation. All documents are approved and archived. Verification procedures are provided by competent authorities in several steps. The quality manager has the overall responsibility for documentation, formal contact with sectoral experts and approval activities, taking over the sectoral reports and archiving them. The results of the check are recorded in a verification protocol, which are parts of the management system. The sectoral experts shall fill out the first article, sign and shall respond to the comments, specify the actions taken in response to the comments (if necessary, correct the data, calculation methodology or the report accordingly). Quality manager shall fill out the second article, check and sign. NIS coordinator shall fill out the third article, check, sign and return the verification protocol for archiving.

The QA/QC plans (external and internal), proposed and approved in the phase of preparation for the certification, are included in Tables 1.8 and 1.9. Detailed information about QA/QC plan and activities inside sectors are included in the Chapters 3 – 9.

1.6.1 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 introducing 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 Department of Emissions and Air Quality Monitoring formally fulfills 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 and Air Quality Monitoring in Slovak language. The quality manager has completed several trainings regarding the QMS.

1.6.2 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 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, calculation methods, etc.

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.

1.6.3 Quality assurance process

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 takes place.
- **Data transference:** All checking 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. 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
- Inventory completeness

- F-gases
- QA/QC plan and Improvement plan
- Verification

1.6.4 Verification activities

Figure 1.4 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 National Inventory System are nominated by the National Focal Point. Nomination letters are included in the list of controlled documentation and administrated by the quality manager of NIS.

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

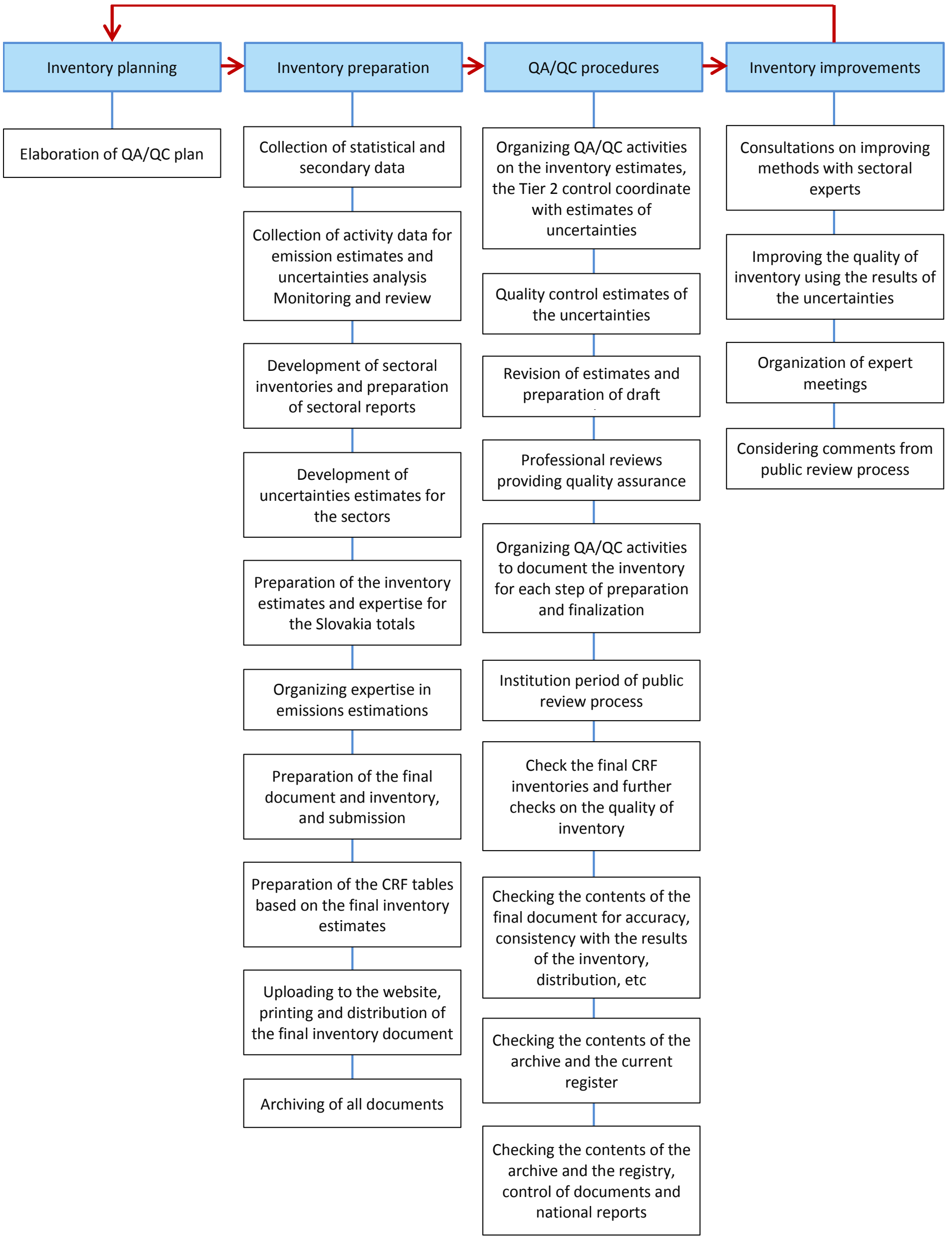


Table 1.8: *Quality Assurance/Quality Control Plan – External*

Procedural step		Who	Check-in	Time schedule	Record
1.	Annual Report submission 280/2004/EC, Article 3.1 (a)-(k): a) Emission GHG inventory for year X-2 b) National Inventory System information c) Annual Report for year X-2.	NIS coordinator	Ministry of Environment (NFP)	15. January	CDR (Central Data Repository) upload: http://cdr.eionet.europa.eu/sk/eu
2.	Inter-ministerial annotation of GHG inventory and NIR for year X-2: a) Publishing of draft on website, b) Assessment and revising	NIS coordinator	Ministry of Environment (NFP) Expert group CEP	15. January - 15. March	Comments Final version of NIR
3.	Biennial Report submission 280/2004/EC, Article 3.2 (a)-(d): a) Biennial Report b) GHG emission projections	NIS coordinator	Ministry of Environment (NFP)	15. March	CDR upload
4.	Annual Report submission 280/2004/EC, Article 3.1: a) Emission GHG inventory for year X-2 b) National Inventory Report for year X-2	NIS coordinator	Ministry of Environment (NFP)	15. March	CDR upload
5.	Submission to the secretariat UNFCCC: a) Emission GHG inventory for year X-2 b) National Inventory Report for year X-2 c) Key source and uncertainty analyses d) KP – LULUCF for year X-2 e) National Registry information for year X-1.	NIS coordinator National Registry	Ministry of Environment (NFP)	15. April	UNFCCC submission upload: https://unfccc.int/submissionportal/webportal/SubmissionStatusComponent.jsp
6.	National GHG emission inventory publishing on the official website of the NIS.	NIS coordinator	Ministry of Environment (NFP)	30. April	NIS website upload: http://ghg-inventory.shmu.sk/
7.	Revising based on findings in UNFCCC (Annual Status Report)	NIS coordinator	Ministry of Environment (NFP)	27. May	Resubmission ASR UNFCCC
8.	Uploading emission information to the Statistical Office of the SR. Publishing of the NIR for the year X-2 to the relevant national institutions. Preparing of the Report on air quality and climate change (SHMU).	NIS coordinator	Ministry of Environment (NFP) Expert group CEP Statistical Office SHMU	31. August	Statistical report Emission inventory Report on air quality and climate change (SHMU)

9.	UNFCCC review.	NIS coordinator Sectoral experts of NIS	Ministry of Environment (NFP)	July - October	Comments to UNFCCC Annual Review Report UNFCCC
10.	Sectoral improvement plan for increasing quality of the inventory process (based on the results of UNFCCC review).	NIS coordinator Sectoral experts of NIS	NIS coordinator Expert group CEP	30. June - 30. November	Assessment, improvements steps
11.	Submission of National Communication UNFCCC 10/CP.13	NIS coordinator Sectoral experts of NIS	Ministry of Environment (NFP)	31. December	Publishing on UNFCCC website.

Table 1.9: *Quality Assurance/Quality Control Plan - Internal*

Procedural step		Who	Check-in	Time schedule	Record
1.	Tasks and financial plan of NIS - preparation	NIS coordinator	Ministry of Environment (NFP)	24.1.2013	Information on budget, capacity (personal, external, internal), training plan, meetings and business trips plan, plan of QA/QC activities, etc.
2.	Sectoral contracts negotiations	NIS coordinator Deputy of NIS coordinator Quality manager	Ministry of Environment (NFP) SHMU director	15.2.2013	Frame contracts with the sectoral experts Specification of tasks for given year (improvement plan) Nomination letters for sectoral experts
3.	Plan of QA/QC activities on overall and sectoral level	Sectoral experts	Quality manager NIS coordinator	15.3.2013	Description of the sectoral QA/QC activities in the sectoral reports
4.	Key sources and uncertainty management on sectoral level	Sectoral expert for uncertainty NIS coordinator	NIS coordinator Deputy NIS coordinator	15.3.2013	Report on key sources and uncertainty evaluation Template for the key sources and uncertainty evaluation
5.	Final evaluation of emission data in sectoral level based on the QA/QC management from external audit of the European Commission.	Sectoral experts NIS coordinator Data manager	Deputy of NIS coordinator Quality manager Ministry of Environment (NFP)	15.3.2013	Verification protocols Description of changes, updated sectoral report Updated sectoral database
6.	Responsibility matrix update Responsibility matrix on sectoral level	Sectoral experts Deputy of NIS coordinator	NIS coordinator, Quality manager Deputy of NIS coordinator Ministry of Environment (NFP)	15.2.2013	Responsibility matrix Description of tasks responsibility
7.	Attendance on the audits, cooperation in the final statements for the assessment reports	Sectoral experts	NIS coordinator Deputy of NIS coordinator Quality manager	all year	Sectoral assessment report

8.	Review day for the status of preparation of the emission inventories on sectoral level.	Sectoral experts	NIS coordinator Deputy of NIS coordinator Quality manager Ministry of Environment (NFP)	30.5.2013 31.10.2013	Report from the meeting Tasks for further evaluation
9.	Methodological updates, recalculations list on sectoral level.	Sectoral experts	NIS coordinator Deputy NIS coordinator Quality manager	30.11.2013	Draft of sectoral reports
10.	Sectoral reports delivery	Sectoral experts	NIS coordinator Deputy NIS coordinator Quality manager	30.11.2013	Delivery protocol Sectoral reports
11.	Workshop – meeting of experts, stakeholders, ministries Program: evaluation of results, findings from the reviews, proposals for improvement, proposal for the inventory plan for next year.	Sectoral experts NIS coordinator Deputy NIS coordinator	Ministry of Environment (NFP) – Quality manager	April 2013 September 2013 December 2013	Minutes from the meeting
12.	Improvement plan	Sectoral experts NIS coordinator Deputy NIS coordinator	Quality manager Ministry of Environment (NFP)	April 2013	Improvement plan - tables
13.	Preparation of unified software for data management.	Data manager Ministry of Environment (NFP)	Quality manager Ministry of Environment (NFP)	31.12.2013	Electronic system - proposal Training of sectoral experts

1.7 General uncertainty evaluation

The uncertainty assessment by tier 1 is enclosed in an Annex 5 to this report. Quantification of emissions uncertainty by level and trend assessment was calculated by using tier 1 method published in Good Practice Guidance (IPCC, 2000). The tier 1 estimated the 12.9% level uncertainty and the 4.4% trend uncertainty in 2011.

The uncertainty assessment by using the more sophisticated tier 2 Monte Carlo method was prepared with cooperation with the Faculty of Mathematics, Physics & Informatics. According to the most recent results, the tier 2 uncertainty for methane emissions from solid waste disposal sites in waste sector was estimated in the range of confidence interval (-76%; +72%) in 2011.

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 (-2.25%; +2.76%) in 2011.

The tier 2 uncertainty analyses for industrial processes sector including solvent and other product use sector according to the technological emissions was estimated in the range of confidence interval (-4.17%; +4.19%) in 2011.

Results of the Monte Carlo method to estimate uncertainty were published in following papers[11,12] and detailed descripted in Chapters 3 – 9 of this report.

1.8 General assessment of the completeness

1.8.1 Completeness by source and sink categories and gases

The Slovak Republic reports in the 2013 submission all significant IPCC source and sink categories according to the detailed CRF classification. Estimates are provided for the following gases: CO_2, N_2O CH_4, F-gases (HFC, PFC and SF_6), NMVOC, NO_x, CO and SO_2.

In the GHG national inventory submission 2013 reports the Slovak Republic gases or source/sink categories that are not estimated (NE) and categories, that are included elsewhere (IE), as they are explained in Tables 9(a) CRF. The notation keys “NO”, “NA” and “IE” are used to fill in the blanks in all the tables in the CRF. Notation keys used in the NIR are consistent with those reported in the CRF. Notation keys are used according to the UNFCCC guidelines on reporting and review (FCCC/CP/2002/8). Several categories were not estimated due to lack of appropriate methodology or if emissions are below the measurement threshold.

The additional GHG emissions are reported in the CRF Table 9(b). These HFCs gases are not included into national inventory due to the absence of the GWP in the IPCC Second Assessment Report, the GWP were taken from the IPCC Fourth Assessment Report.

GHG	Source category	Emissions (Gg)	Estimated GWP value (100-year horizon)	Emissions CO_2 equivalent (Gg)	Reference to the source of GWP value
HFC 245fa	Hard Foam	0.52	1 030.00	533.15	4AR IPCC, Chapter 2, WGI
HFC 365mfc	Soft Foam	0.38	794.00	300.95	4AR IPCC, Chapter 2, WGI

In accordance with the IPCC Guidelines, international aviation fuel emissions are not included in national totals. Emissions from water transportation on Danube River are exclusively included in international bunkers because of international character of the river transportation through the Slovak territory (transit). According to the recommendations of the ERT during the in-country review for the

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

[12] *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*

annual GHG inventory submission 2011 several categories were completed which were not reported in the previous submission and which are the following:

- Foam Blowing agents and category 2.F.4 – Aerosols.
- N_2O emissions from disturbance associated with land-use conversion to cropland;
- N_2O from human sewage.

1.8.2 Completeness by geographical coverage

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.

1.8.3 Completeness by timely coverage

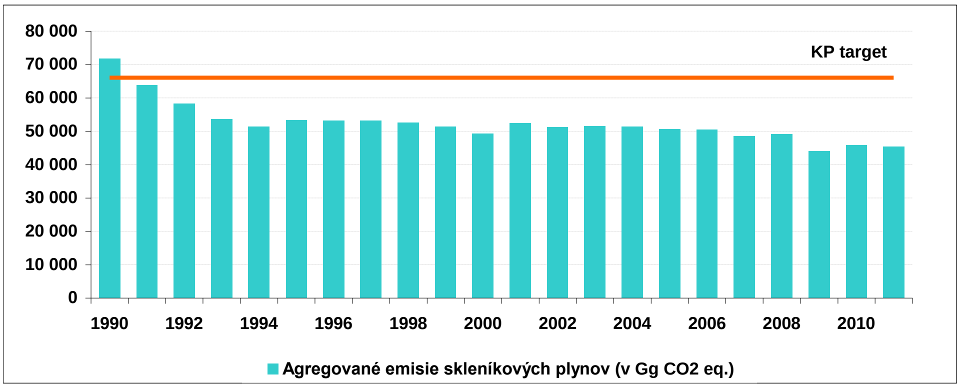
A complete set of CRF tables are provided for all years and the estimates are calculated in a consistent manner. The detail information is provided in Annex 4.

CHAPTER 2: TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Description and interpretation of emission trends for aggregated greenhouse gas emissions

The GHG emissions presented in the National Inventory Report 2013 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 recommendations of the Expert Review Team from the last in-country review of the Slovak Republic were taken into account only partly by the inventory compilation 2013 because of no delivery of the draft Annual Review Report 2012. Total GHG emissions were 45 296.96 Gg in 2011 (without LULUCF). This represents a reduction by 36.9% in comparison with the reference (base) year 1990. In comparison with 2010, the emissions decreased by 1.3%. Total GHG emissions in the Slovak Republic slightly decreased in 2011 in comparison with the previous year, which was probably influence by the international trade (lower export of products), but in general the recovery of economy after the economic and financial crises in 2009 and gas and oil crises in delivery from the Ukraine at the beginning of 2009 is finished. Total GHG emissions excluding LULUCF sector have been decreasing continually from the base year with the 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 Trade System (ETS). Table 2.1 shows the aggregated GHG emissions. In the period 1990 – 2011, 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 (92%) in relative expression.

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



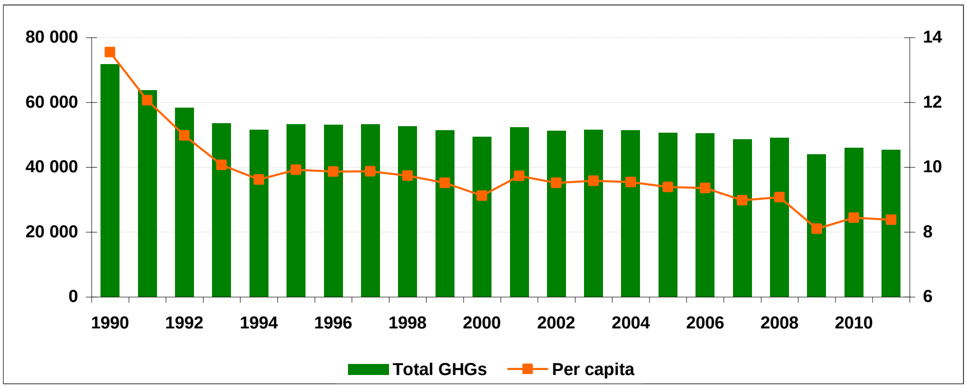
Aggregated GHG emissions without LULUCF; emissions are determined as of 15.04.2013

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 the 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 – 2011 are depicted in the Table ES.2 in this report.

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 just 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 per capita in 1990 – 2011*



2.2 Description and interpretation of emission trends by gas

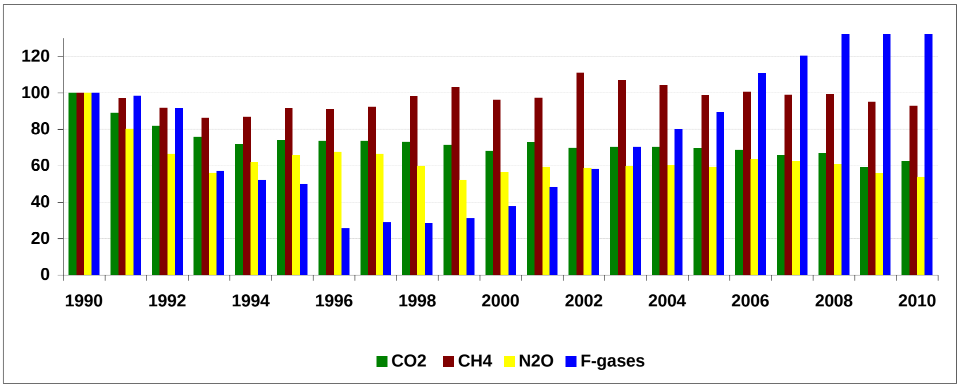
Total anthropogenic emissions of carbon dioxide excluding LULUCF have decreased by 37.98% in 2011 compared to the base year (1990). Nowadays the amount is 37 671.87 Gg of CO_2. Compared to the previous inventory year 2010, the minor decrease is visible. The reason for the decrease in CO_2 emissions in 2011 is caused mainly by decreasing CO_2 emissions in energy and industrial processes sectors. In 2011, CO_2 emissions including LULUCF sector decreased by 40.39% compared to the base year, and they decreased by approximately 800 Gg compared to the previous year. In 2011, CO_2 emissions decreased mainly due to the increase of removals in LULUCF.

Total anthropogenic emissions of methane without LULUCF decreased compared to the base year (1990) by 6.25% and currently the emissions are 4 138.49 Gg of CO_2 equivalents. In absolute value, CH_4 emissions were 197.07 Gg without LULUCF. Methane emissions from LULUCF sector are 1.08 Gg of CH_4 caused by forest fires. The trend has been relatively stable during the last years with a slight decrease in the last year due to the emission decrease from category energy and industrial processes sectors. 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 52.62% and currently the emissions are 3 009.36 Gg of CO_2 equivalents. Emissions of N_2O in absolute value were 9.71 Gg without LULUCF. Emissions of N_2O from LULUCF sector are 0.06 Gg from forest fires and cropland. Emissions decreased compared to the previous year 2010 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 439.50 Gg of HFCs, 17.0 Gg of PFCs and 20.74 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 substances. Emission trend of PFCs is decreasing and emissions of SF_6 are slightly increasing due to the increasing consumption in industry.

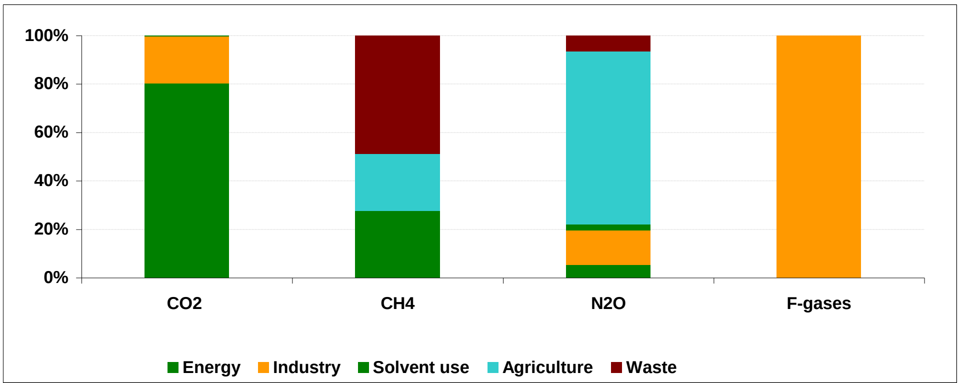
Figure 2.3: *Emission trends by gas for the years 2000 – 2011 relative to the 1990 level (100%)*



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 80.22% share from the total carbon dioxide emissions in 2011 inventory, 19.50% of CO_2 is produced in industrial processes and negligible amount is produced in waste (0.03%) and solvent use sectors (0.25%). The energy related CO_2 emissions from waste incineration are included in energy sector. The 48.92% of CH_4 emissions is produced in waste sector (SWDS), 27.73% of methane emissions is produced in energy sector and 23.30% in agriculture sector. More than 71.55% of N_2O emissions are produced in agriculture sector (nitrogen from soils), 14.01% in industrial processes sector (nitric acid production), 6.43% in wastewaters and 5.05% 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 2011*



Aggregated GHG emissions from energy sector based on sectoral approach data in 2011 were estimated to be 31 533.37 Gg of CO_2 equivalents including transport emissions (6 380.02 Gg of CO_2 equivalents), which represent the decrease by 41.47% compared to the base year and 0.8% decrease in comparison with 2010. Transport sub-sector decreased by 4% compared to 2010 and in comparison with the base year it raised by 21.3%.

Total emissions from industrial processes sector were 8 248.22 Gg of CO_2 equivalents in 2011, which was decreased by 13.57% compared to the base year and the increased by 4.3% compared to the previous year. Intensive increase of industrial production has caused the increase in emissions. Total emissions from sector of solvent use were estimated to be 170.54 Gg of CO_2 equivalents, which is the increased by about 15.89% compared to the base year. The time series have been completed, but the period of 1990 – 1993 (before the Slovak Republic formation) is has not been covered by statistical data sufficiency (the lack of the national statistics data). Based on expert judgment, the constant values for this period were reported.

Emissions from agriculture sector were estimated to be 3 117.52 Gg of CO_2 equivalents. It is 56.24% decrease in comparison with the base year and 0.6% increase 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.

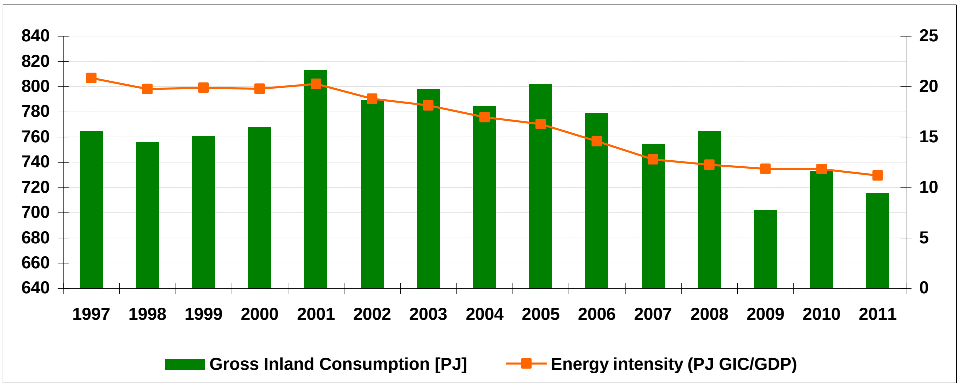
Emissions from waste sector were estimated to be 2 227.32 Gg of CO_2 equivalents. The increase is 0.2% compared to the previous inventory year and the time series are stable for last years. Compared to the base year, the increase was more 104%, because of increased methane emissions from solid waste disposal sites. The emissions from waste incineration with energy use are included into energy sector, category 1.A.1a – energy industries, other fuels. The reallocation of methane emissions from waste incineration was the main driving force for the trend of changes in the last submissions.

Structural changes in sector energy 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 – 2011 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 2011. 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 – 2011 (estimated by the revised statistical approach NACErev.2)*



Transport is a significant source of emissions in sector energy, 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 8.1. 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.

Sector of industrial processes includes all GHG emissions generated from technological processes producing raw materials and products with the 27% 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 stochiometric coefficients to CO_2 emissions.

Sector agriculture with 3% 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 earlier 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.[13] 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 sector waste.

2.4 Description and interpretation of emission trends for indirect greenhouse gases and SO_2

A major source of SO_2, NO_x and CO emissions is power and heat generation. Contribution of transport to NO_x and CO emissions is still growing. Metallurgy is an important source of CO emissions. Emissions of NM VOC are regularly monitored by the National Program of NM VOC Emissions Reduction in the Slovak Republic. Within this Program, the emission factors for asphalt paving and

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[13] 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

residential plants combustion were revised (total decrease in emissions due this revaluation of EFs was about 45% in 1990). The year 1990 was used as a starting point and updating was carried out for the years 1993, 1996 – 1999 and 2000 – 2011. NM VOC emissions occur from the use of solvents, transport, refinery/storage and transport of crude oil and petrol. The categories of emission sources in the National Emission Information System (NEIS) are based on provisions of Act No 318/2012 Coll. amending the Act No 137/2010 Coll. on Air and they do not correspond exactly to the structure of sources according to the CRF requirements. Therefore, it is technically very complicated to provide information on emissions and emission factors according to the classification as required by standard tables. NM VOC emissions have slightly increased in the sector solvent and other product use as result of increased industrial production, especially in engineering, but also due to increasing consumption of print's ink and import of solvent paints. New emission factors respect that asphalt mixture contains 5.5% of asphalt.

Emission inventory of NM VOC for the Slovak Republic is elaborated according to the EMEP/EEA Air Pollutant Emission Inventory Guidebook and in coincidence with requirements of the respective of working group for emission inventory (UN ECE Task Force on Emission Inventory). In the sense of the requirements for the NFR reporting, the NFR sectors were assigned to the individual sectors upon the base of SNAP nomenclature. Emission factors for the estimation of emissions have been taken over from the literature, secondly comes from the measurements on sources in the Slovak Republic, in some cases are recommended by sectoral experts. NFR category 3.A.3 includes SNAP 0601, emission estimation is based on paints and glues consumption and on information about content of particular types of VOC in these products.[14] The EFs are specific for every year, depends on average content of VOC in products. Category 3.B.1 includes SNAP 060202, emission estimation is based on particular solvents consumption (total amount of produced and imported solvents – exported solvents and used in category 3.A.3 to avoid double counting). The estimation is based on VOC content in particular solvent.[4] Category 3.C includes SNAP 060408. The EF is 1.55 kg/inhabitants (Atmospheric Emission Inventory Guidebook, October 2003). Emissions from this category are estimated according to the number of population. Category 3.D.3 includes SNAP 060404.

The last update of the emission inventory and projections was performed in 2013. Major recalculations were made for all pollutants in road transport. The recalculation of the emissions from road transport for the period of 1990 – 2009 was based on the updated model COPERT IV. Model COPERT IV was used also for the calculation of emissions in 2010. Minor recalculations for NO_x, NM VOC, heavy metal emissions from stationary sources were performed in 2010 (only for sector energy – category 1A1a), due to the changes in operators´ statistics in the database of NEIS (National Emission Information System). The recalculations regarding solid waste disposal on landfills and waste incineration (hospital waste, industrial waste and municipal waste) were performed back to the year 1990. NMVOC and heavy metals (HMs) were recalculated back to year 2000 due to the corrections of activity data. Recalculations for $PM_{2.5}$ and PM_{10} emissions were done for stationary sources in 2007 (only for sector energy – category 1A1a), due to the change in the plant statistics of operators in the database NEIS. The recalculation was also done for sector agriculture in category synthetic N-fertilizers for NH_3 emissions up to year 2000. No recalculation for NMVOC took place in 2012 submission. The last extent recalculation was done in year 2008, when the NFR sector 3.B.1 Degreasing and dry cleaning was recalculated, due to the revision of activity data back to the base year 1990. The total NMVOC emissions have strongly decreased from 1990 to 1999 and slightly increased after 2000 according to the balance, but even though are below 1990 in 2011. However, the preliminary results of NMVOC emissions in 2011 show increase in the comparison of the previous year. This increase was caused by the increasing import of solvents, namely acetone used in machinery industry as a degreasing agent.

[14] *The National Program for Reducing Emissions of NMVOC Pollutants, 2nd stage; K. Magulova, 2000*

The NMVOC emissions have increased after 2000 especially in the NFR category 3.A.3 by about 34% since 2000 because of increasing industrial activity in Slovakia. The expansion in automotive industry in Slovakia occurred in years 2004 and 2005, many of paint shops were opened and so the consumption of paints has increased. The import of print's ink and solvent paints has increased, too. The Council Directive 1999/13/EC entered into force since 2007, with which operators had to adjust to emission limits. Slovakia adopted several decrees that led to a reduction in VOC emissions in solvents sector (Decree of the Ministry of Environment of the Slovak Republic No 409/2003 which established emission limits, technical requirements and operating conditions for sources in which the organic solvents are used as amended by the Decree No 457/2007 and the Decree No 133/2006 on requirements on emission limits for VOC from using organic solvents in regulated products, since 2009 according to the Decree No 30/2009).

Although air quality management programs are focused on the reduction of basic pollutants, they contribute significantly also to the decrease in GHG emissions. Currently, there are 18 air quality management areas in 2 agglomerations and 8 specially observed zones due to the air quality in the Slovak Republic. Exceeding of daily limit value for sulphur dioxide has occurred in the district of Prievidza, exceeding of limit values for nitrogen oxide has occurred in Bratislava – the capital of the Slovak Republic. Both areas belong to the air quality management areas. For all these areas programs on air quality management have been developed with clearly specified measures for individual sources to improve local air quality. All programs are published at the internet web page of the Ministry of Environment (http://www.minzp.sk/).

Total indirect GHG emissions by sectors in the years 1990 – 2011 are depicted in the Table ES.5 in this report. According to the comparison with the CLRTAP reporting data, several discrepancies occurred in NMVOC emissions. The differences were mostly in transport and other sectors and are results of the different methodologies in air transport and waste incineration used for NMVOC emissions estimation. Further measures will be considered in the future to harmonize these reporting obligations.

Table 2.1: *Comparison of the CLRTAP and UNFCCC totals of indirect GHG emissions and SO_2*

NMVOC	**Year**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Energy	CLRTAP	21.97	22.48	20.29	21.33	23.00	24.87
	UNFCCC	21.97	22.48	20.29	21.33	23.00	24.87
Transport	CLRTAP	14.57	16.13	15.64	13.58	12.93	12.46
	UNFCCC	16.14	15.66	13.62	12.92	12.44	10.85
Industry	CLRTAP	1.37	1.32	1.39	1.68	1.69	1.59
	UNFCCC	1.37	1.32	1.39	1.68	1.69	1.59
Solvents	CLRTAP	26.98	28.72	31.02	32.27	32.76	33.56
	UNFCCC	26.98	28.72	31.02	32.27	32.76	33.56
Others	CLRTAP	1.24	0.68	0.62	0.62	0.64	0.67
	UNFCCC	0.63	0.56	0.56	0.57	0.59	0.58
Total	CLRTAP	66.14	69.34	68.96	69.48	71.02	73.15
	UNFCCC	67.09	68.74	66.88	68.77	70.48	71.45
NMVOC	**Year**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Energy	CLRTAP	22.77	22.27	22.12	21.37	21.51	22.42
	UNFCCC	22.77	22.27	22.12	21.37	21.51	22.42
Transport	CLRTAP	10.81	9.19	9.29	7.74	7.11	6.84
	UNFCCC	9.16	9.31	7.77	7.73	7.11	6.84
Industry	CLRTAP	1.56	1.53	1.38	1.26	1.25	1.52
	UNFCCC	1.56	1.53	1.38	1.26	1.25	1.52
Solvents	CLRTAP	34.63	33.58	33.96	33.33	31.86	36.90
	UNFCCC	34.63	33.58	33.96	33.33	31.86	36.90
Others	CLRTAP	0.67	0.65	0.61	0.59	0.67	0.61
	UNFCCC	0.62	0.57	0.56	0.57	0.67	0.61
Total	CLRTAP	70.44	67.22	67.36	64.30	62.40	68.29
	UNFCCC	68.74	67.24	65.61	64.26	62.40	68.29

2.5 Description and interpretation of emission trends for KP-LULUCF inventory

National GHG emission inventory for the year 2011 includes information required by the Kyoto Protocol – Land use, land use change and forestry, Article 3.3 and this information is included in the set of the CRF tables.

According to the *"Report on the estimation of assigned amounts 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 unstuck areas are included (forest regeneration areas). For linear formations, a minimum width of 20 m is applied. This definition would be applicable also for reporting, under Article 3.4. However, the Slovak Republic has decided not to use Article 3.4 activities to meet its commitments under the first 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 decided not to use any activities under Article 3.4 (forest management, cropland management, grazing land management and revegetation) to meet its commitment under the first commitment period of the Kyoto Protocol.

The Slovak Republic has chosen to account for the activities under Article 3.3 (afforestation, reforestation and deforestation) for the whole commitment period.

In 2011, total CO_2 removals from afforestation/reforestation activities were -527.85 Gg of CO_2 (changes in 34.16 kha to the end of 2011). Total CO_2 emissions from deforestation were 38.53 Gg of CO_2 (changes in 7.85 kha to the end of 2011). In 2011, total removals under the Article 3.3 of the KP were 489.33 Gg with the changed area of 42.01 kha.

Table 2.2: *Emissions and removals resulting from the activities under Article 3.3 of the KP*

Activities	2008	2009	2010	2011	Total
	Net CO_2 (Gg)				
A. Article 3.3 activities	-318.75	-257.39	-371.23	-489.33	**-1 436.71**
A.1. Afforestation and Reforestation	-453.55	-469.73	-512.43	-527.85	**-1 963.56**
A.1.1. Units of land not harvested since the beginning of the commitment period	-453.55	-469.73	-512.43	-527.85	**-1 963.56**
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	NA	**NA**
A.2. Deforestation	134.80	212.34	141.19	38.53	**526.86**

The recalculations followed the changes in methodology and land-use categorizations were provided in KP LULUCF for the years 2008 – 2010.

Table 2.3: *Total areas and changes in 2011*

		Article 3.3 activities		Other	Total area at the beginning of the current inventory year
		AR	DEF		
		(kha)			
Article 3.3 activities	**AR**	32.99	NO		32.99
	DEF		7.77		7.77
Other		1.17	0.09	4 861.51	4 862.77
Total area at the end of the current inventory year		34.16	7.85	4 861.51	4 903.52

AR = Afforestation and Reforestation, DEF = Deforestation, Emissions are determined as of 15.04.2013

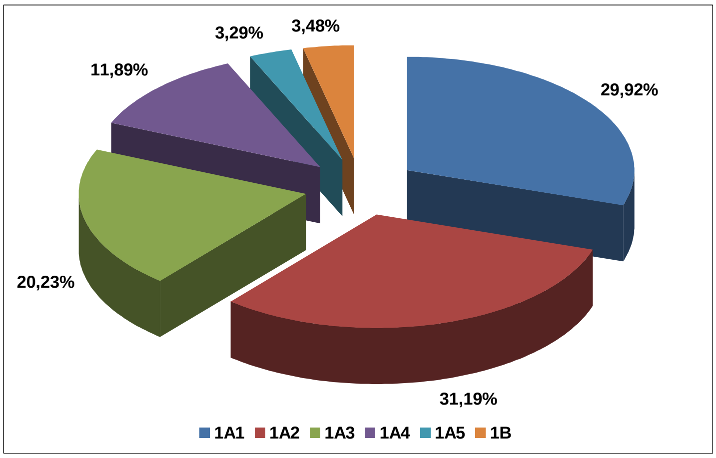
CHAPTER 3: ENERGY (CRF 1)

3.1 Overview of sector (CRF 1)

Energy sector is the main contributor to overall GHG emissions with its share of 83.4% and 31 533.37 Gg of CO_2 equivalents in 2011. Within this sector, transport contributes 20.2% to GHG emissions (in CO_2 equivalents) and it shows increasing trend since 2000. 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 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.A) 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 (NO_x, 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 emissions by categories within energy sector in 2011*



Category	CO_2 eq. (Gg)
Energy Industries	9 434,34
Manufacturing Industries and Construction	9 836,21
Transport	6 380,02
Other Sectors	3 748,93
Other	1 037,18
Fugitive Emissions from Fuels	1 096,68

Figure 3.2: *Trend in aggregated emissions by categories within energy sector in 1990 – 2011 (in Gg of CO_2 eq.)*

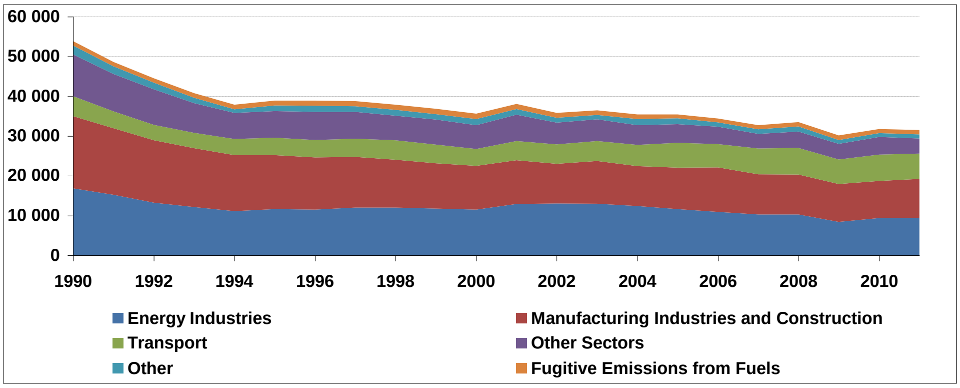


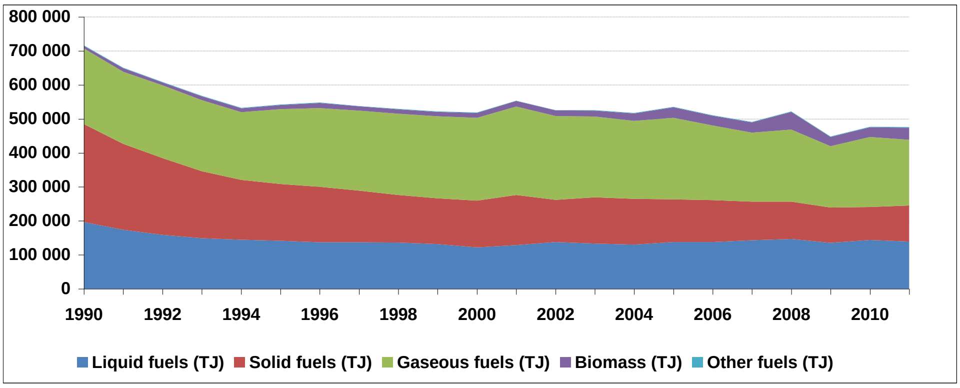
Table 3.1: *GHG emissions by categories within sector 1 Energy in 1990 – 2011*

Year	CO_2 Emissions			CH_4 Emissions			N_2O Emissions		
	(Gg)								
	1 Energy	1.A	1.B	1 Energy	1.A	1.B	1 Energy	1.A	1.B
1990	52 469.54	52 469.39	0.15	54.53	2.88	51.65	0.84	0.84	0.000020
1991	47 281.95	47 281.82	0.13	56.54	2.75	53.79	0.73	0.73	0.000014
1992	43 188.95	43 188.82	0.13	56.79	2.61	54.18	0.64	0.64	0.000013
1993	39 427.20	39 427.06	0.13	56.37	2.67	53.70	0.59	0.59	0.000012
1994	36 517.87	36 517.73	0.14	59.15	2.65	56.50	0.56	0.56	0.000013
1995	37 476.77	37 476.62	0.15	61.57	2.73	58.83	0.57	0.57	0.000016
1996	37 432.82	37 432.66	0.16	62.61	2.81	59.80	0.59	0.59	0.000014
1997	37 297.95	37 297.79	0.16	63.33	2.74	60.59	0.57	0.57	0.000013
1998	36 381.72	36 381.55	0.17	65.94	2.76	63.18	0.57	0.57	0.000012
1999	35 337.47	35 337.30	0.17	64.18	2.69	61.49	0.55	0.55	0.000010
2000	34 107.55	34 107.37	0.18	65.44	2.56	62.88	0.53	0.53	0.000008
2001	36 609.42	36 609.23	0.19	63.98	2.79	61.19	0.58	0.58	0.000009
2002	34 379.25	34 379.07	0.18	62.07	2.64	59.44	0.55	0.55	0.000008
2003	35 088.44	35 088.25	0.19	59.68	2.63	57.04	0.58	0.58	0.000011
2004	34 076.10	34 075.92	0.18	56.80	2.71	54.09	0.55	0.55	0.000008
2005	34 239.54	34 239.37	0.17	51.08	2.95	48.13	0.61	0.61	0.000007
2006	33 215.65	33 215.47	0.17	49.54	2.74	46.80	0.57	0.57	0.000009
2007	31 499.35	31 499.20	0.15	51.59	2.63	48.96	0.54	0.54	0.000006
2008	32 203.61	32 203.47	0.15	54.18	3.32	50.86	0.66	0.66	0.000005
2009	28 845.56	28 845.32	0.24	57.04	2.35	54.69	0.51	0.51	0.000005
2010	30 535.99	30 535.80	0.19	52.31	2.40	49.91	0.50	0.50	0.000005
2011	30 220.23	30 219.99	0.24	54.65	2.44	52.21	0.53	0.53	0.000006

In 2011, the consumption of brown coal was only 6% of its consumption in 1990, light fuel oil consumption decreased by 92% and heavy fuel oil by 72% compared to 1990. An example of the Slovak Republic is as follows: the production of liquid steel increased by 27.7% from 1990 to 2005, while the consumption of coal energy production decreased by 2.3%. Carbon intensity per metric ton of liquid steel has been improved by 5.2% during the same period. There is a lot of further technological and innovation steps made by individual operators to increase production intensity and to meet strict environmental requirements.

The most indicative trend in emissions and GDP decoupling is visible in sector energy in fossil fuel consumption. The decrease in the consumption of solid fuels is more than 63.4% in comparison with the base year 1990. The consumption of liquid fuels decreased by almost 29.1% and the decline in gaseous fuels is 13.1%. By comparison, the consumption of biomass was 5 times higher in 2011 than in 1990. General trend in total consumption of fossil fuels is declining due to the increase in energy efficiency. The emissions from municipal and industrial waste incineration with energy use and methane cogeneration from mines are included in other fuels category.

Figure 3.3: *Trend in fuels consumption within energy sector in 1990 – 2011*



3.1.1 Emissions from fuel combustion (CRF 1.A)

Fossil fuels combustion in energy (including transport) and industry sectors is the most important source of emissions in the Slovak Republic. The emissions represent more than 80% share of total GHGs emissions in CO_2 equivalents. It is especially public energy provided for power and heat supplies, industrial energy – energy production for technological processes, road transport and last but not the least district heating – heat supply for block of flats and dwelling houses, public equipment and services and objects of non-productive sphere.

Total aggregated emissions from fuel combustion, including transport, based on sectoral approach methodology represented 30 436.69 Gg of CO_2 equivalents in 2011. The following sub-sectors of the IPCC categories according to the IPCC 1996 Guidelines are relevant for the Slovak Republic in sectoral approach.

High level of dependency on import of primary energy sources (PES) is a limiting factor for the energy sector and subsequently for the whole economic development. 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 almost twice that high than the EU average. In January 2004, the transitional period for price subsidies ended and the Regulatory Office for Network Industries terminated provision of the subsidies for electricity, gas and heat for industry and households, in order to change energy consumption pattern.

In 2001, the Slovak Republic started transformation and privatization of regional distribution companies. In 2002, the biggest producer of electricity, Slovenské elektrárne – a member of ENEL group was transformed and split up (http://www.seas.sk/en).

Since then, the Slovak electricity transmission system, Plc. (Slovenská elektrizačná prenosová sústava, a.s.) has been registered and it acts as the transmission system operator including also the energy dispatch (http://www.sepsas.sk/seps/en_index.asp).

The Slovak Republic makes use of the sectoral approach based on bottom-up methodology for emission estimation as the most appropriate method for energy balance. The sectoral approach is based on direct information from stationary sources of pollution from every district in the country. The information about fuels, technology used, parameters of fuels and other important information are stored in robust database system – the National Emission Information System (NEIS). 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 values by the Statistical Office.

Table 3.2: *Reported emissions in category fuel combustion within energy sector in 2011*

Category		Description	Emissions reported
1.A.1	**Energy industry**		
1.A.1.a	Public Electricity and Heat Production	electricity, combined heat and power generation	CO_2, CH_4, N_2O
1.A.1.b	Petroleum Refining	refineries, petrochemical oil processing	CO_2, CH_4, N_2O
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries	coke production, coal manufacturing, charcoal production	CO_2, CH_4, N_2O
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, CH_4, N_2O
1.A.2.b	Non-Ferrous Metals	non ferrous metals production, casting	CO_2, CH_4, N_2O
1.A.2.c	Chemicals	chemical products manufacturing and production	CO_2, CH_4, N_2O
1.A.2.d	Pulp, Paper and Print	Paper and pulp production, printing,	CO_2, CH_4, N_2O
1.A.2.e	Food Processing, Beverages and Tobacco	food industry	CO_2, CH_4, N_2O
1.A.2.f	Other	glass, cement, lime and magnesite production, wood manufacturing, brickworks, asphalt mixing plant, bating and electroplating	CO_2, CH_4, N_2O
1.A.3	**Transport**		
1.A.3.a	Civil Aviation	domestic aviation	CO_2, CH_4, N_2O
1.A.3.b	Road Transportation		CO_2, CH_4, N_2O
1.A.3.c	Railways		CO_2, CH_4, N_2O
1.A.3.d	Navigation	domestic navigation	CO_2, CH_4, N_2O
1.A.3.e	Other Transportation		NO
1.A.4	**Other Sectors**		
1.A.4.a	Commercial/Institutional	commercial and institutional building, hospitals, schools,	CO_2, CH_4, N_2O
1.A.4.b	Residential	sale fuels for households	CO_2, CH_4, N_2O
1.A.4.c	Agriculture/Forestry/Fisheries	farms and forest organisations, slaughters	CO_2, CH_4, N_2O
1.A.5	**Other**		
1.A.5.a	Stationary	compress and petrol stations, paint shops, wastewater treatment plants, crematory	CO_2, CH_4, N_2O
1.A.5.b	Mobile	military aviation	CO_2, CH_4, N_2O

Table 3.3: *GHG emissions by categories within category 1.AA Fuel Combustion – Sectoral approach in 1990 – 2011*

Year	1.AA			1.AA.1 Energy Industries	1.AA.2 Man. Ind. and Construc.	1.AA.3 Transport	1.AA.4 Other Sectors	1.AA.5 Other
	CH_4	N_2O	CO_2					
	(Gg)			CO_2 (Gg)				
1990	**2.88**	**0.84**	**52 469.39**	16 819.21	18 093.02	4 887.55	10 442.83	2 226.78
1991	**2.75**	**0.73**	**47 281.82**	15 167.46	16 723.76	4 110.96	9 341.97	1 937.67
1992	**2.61**	**0.64**	**43 188.82**	13 211.30	15 622.08	3 785.04	8 920.19	1 650.22
1993	**2.67**	**0.59**	**39 427.06**	12 101.97	14 794.51	3 759.55	7 402.49	1 368.55
1994	**2.65**	**0.56**	**36 517.73**	11 080.10	14 048.16	3 999.84	6 524.30	865.33
1995	**2.73**	**0.57**	**37 476.62**	11 601.22	13 572.67	4 243.22	6 686.12	1 373.39
1996	**2.81**	**0.59**	**37 432.66**	11 486.22	13 071.35	4 296.17	7 034.10	1 544.83
1997	**2.74**	**0.57**	**37 297.79**	12 019.12	12 659.27	4 461.78	6 720.25	1 437.38
1998	**2.76**	**0.57**	**36 381.55**	12 011.79	12 009.63	4 740.28	6 174.19	1 445.67
1999	**2.69**	**0.55**	**35 337.30**	11 728.70	11 363.39	4 627.67	6 216.82	1 400.72
2000	**2.56**	**0.53**	**34 107.37**	11 489.80	10 991.22	4 150.29	5 921.59	1 554.47
2001	**2.79**	**0.58**	**36 609.23**	12 883.26	10 982.18	4 700.11	6 623.83	1 419.84
2002	**2.64**	**0.55**	**34 379.07**	13 039.90	9 910.30	4 834.42	5 406.36	1 188.09
2003	**2.63**	**0.58**	**35 088.25**	12 941.81	10 717.79	4 947.98	5 387.75	1 092.92
2004	**2.71**	**0.55**	**34 075.92**	12 351.99	10 050.81	5 209.39	4 932.64	1 531.09
2005	**2.95**	**0.61**	**34 239.37**	11 628.39	10 358.91	6 162.49	4 660.26	1 429.32
2006	**2.74**	**0.57**	**33 215.47**	10 872.25	11 229.22	5 761.50	4 301.56	1 050.94
2007	**2.63**	**0.54**	**31 499.20**	10 245.89	10 087.79	6 422.66	3 602.80	1 140.06
2008	**3.32**	**0.66**	**32 203.47**	10 281.76	9 995.29	6 614.20	4 007.89	1 304.32
2009	**2.35**	**0.51**	**28 845.32**	8 386.65	9 519.18	6 080.96	3 879.12	979.40
2010	**2.40**	**0.50**	**30 535.80**	9 356.29	9 290.95	6 557.09	4 395.90	935.56
2011	**2.44**	**0.53**	**30 219.99**	9 394.51	9 805.17	6 287.64	3 698.14	1 034.52

3.1.2 Fugitive emissions from fuels (CRF 1.B)

Fugitive emissions from the 1.B.1 Solid fuel (coal mining and handling) and 1.B.2 Oil and natural gas, as key categories, are important sources of methane emissions in the national GHGs inventory. Only emissions of NMVOC from coke production are included in the category 1.B.1.B Solid fuel transformation.

In 2011, total aggregated fugitive emissions in the category 1.B represented 1 096.68 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 extraction 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 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 – 2011 were calculated based on the coal production from underground mines, obtained from the official statistical sources and 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 1996 Guidelines, the following sub-sectors of the IPCC categories are relevant for the Slovak Republic in category 1.B.

Table 3.4: *Reported emissions in category fugitive emissions within energy sector in 2011*

Category		**Description**	**Emissions reported**
1.B.1	**Solid Fuels**		
1.B.1.A	Coal Mining and Handling - 1.B.1.A.1.1 Mining activities	underground mines for brown coal	CH_4
	Coal Mining and Handling - 1.B.1.A.1.2 Post-mining activities	brown coal processing	CH_4
1.B.2	**Oil and natural Gas**		
1.B.2.A	Oil - 1.B.2.A.1 Exploration	Not occurring in the SR	NO
	Oil - 1.B.2.A.2 Production		CO_2, CH_4
	Oil - 1.B.2.A.3 Transport		CO_2, CH_4
	Oil - 1.B.2.A.4 Refining/Storage		CO_2, CH_4
	Oil - 1.B.2.A.5 Distribution of Oil Products	Not occurring in the SR	NO
	Oil - 1.B.2.A.6 Other	Not occurring in the SR	NO
1.B.2.B	Natural Gas - 1.B.2.B.1 Exploration	Not occurring in the SR	NO
	Natural Gas - 1.B.2.B.2 Production / Processing		CO_2, CH_4
	Natural Gas - 1.B.2.B.3 Transmission		CO_2, CH_4
	Natural Gas - 1.B.2.B.4 Distribution		CO_2, CH_4
	Natural Gas - 1.B.2.B.5 Other Leakage	included in Transmission and Distribution	IE
1.B.2.C	Venting and Flaring - 1.B.2.C.1.1 Venting of Oil		CO_2, CH_4
	Venting and Flaring - 1.B.2.C.1.2 Venting of NG		CO_2, CH_4
	Venting and Flaring - 1.B.2.C.1.3 Combined	Not occurring in the SR	NO
	Venting and Flaring - 1.B.2.C.2.1 Flaring of Oil		CO_2, CH_4
	Venting and Flaring - 1.B.2.C.2.2 Flaring of NG		CO_2, CH_4
	Venting and Flaring - 1.B.2.C.2.3 Combined	Not occurring in the SR	NO
1.B.2.D	Other - Storage of Natural Gas		CO_2, CH_4, N_2O

According to several recommendations of the ERT during previous in-country reviews under UNFCCC in 2009 and 2011, the estimation of CH_4 fugitive emissions followed 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 – 2011*

	CH_4 (Gg)			
Year	**1.B.1.A.1 Underground Mines**	**1.B.1.A.1.1 Mining Activities**	**1.B.1.A.1.1 Mining CH_4 recovery**	**1.B.1.A.1.2 Post-Mining Activities**
1990	**27.1976**	25.1137	NO	2.0840
1991	**28.8267**	26.6179	NO	2.2088
1992	**29.9324**	27.6388	NO	2.2935
1993	**28.6121**	26.4327	NO	2.1794
1994	**29.9119**	27.6538	NO	2.2581
1995	**29.7041**	27.4374	NO	2.2667
1996	**30.0758**	27.7602	NO	2.3156
1997	**30.6130**	28.2527	NO	2.3603
1998	**31.1677**	28.7852	NO	2.3825
1999	**29.4960**	27.2007	NO	2.2953
2000	**28.8208**	26.6203	NO	2.2005
2001	**26.3301**	24.2654	NO	2.0647
2002	**25.6938**	23.6430	NO	2.0508
2003	**21.1140**	19.2597	NO	1.8544
2004	**19.7726**	17.9926	NO	1.7800
2005	**16.1726**	14.6584	NO	1.5142
2006	**14.6709**	13.3405	NO	1.3304
2007	**13.5181**	12.2732	0.2259	1.2449
2008	**15.9487**	14.4876	0.1825	1.4611
2009	**16.9240**	15.3731	0.1057	1.5509
2010	**15.2250**	13.7959	0.0322	1.4291
2011	**16.1782**	14.7486	0.0621	1.4296

Table 3.6: *GHG emissions by categories within category 1.B.2 Oil and natural gas in 1990 – 2011*

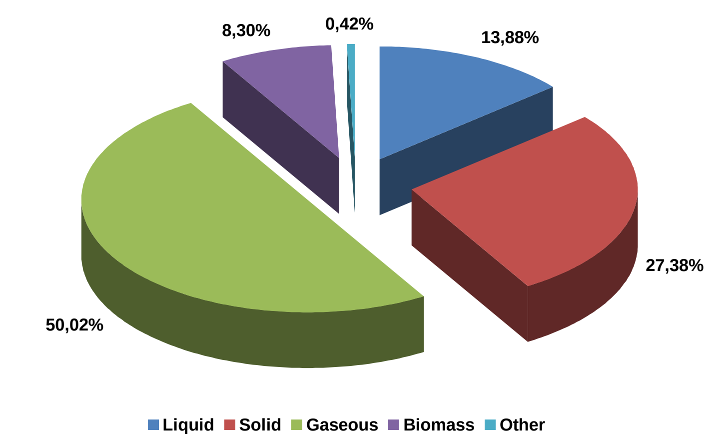
Year	**1.B.2**			**1.B.2.A Oil**	**1.B.2.B Natural gas**	**1.B.2.C.1 Venting**	**1.B.2.C.2 Flaring**	**1.B.2.D Storage**
	CO_2	**N_2O**	**CH_4**					
	(t)		(Gg)	CH_4 (Gg)				
1990	**145.684**	**0.020**	**24.452**	0.217	21.355	2.741	0.135	0.004
1991	**132.597**	**0.014**	**24.966**	0.208	21.859	2.741	0.154	0.004
1992	**128.760**	**0.013**	**24.243**	0.189	21.176	2.738	0.136	0.004
1993	**133.245**	**0.012**	**25.088**	0.198	22.019	2.740	0.127	0.004
1994	**141.190**	**0.013**	**26.584**	0.200	23.201	2.740	0.142	0.300
1995	**154.698**	**0.016**	**29.127**	0.209	25.339	2.742	0.168	0.669
1996	**157.882**	**0.014**	**29.726**	0.204	25.968	2.741	0.154	0.659
1997	**159.223**	**0.013**	**29.979**	0.185	26.617	2.739	0.142	0.297
1998	**170.030**	**0.012**	**32.014**	0.179	28.376	2.738	0.128	0.592
1999	**169.905**	**0.010**	**31.990**	0.184	28.544	2.739	0.109	0.413
2000	**180.905**	**0.008**	**34.061**	0.168	28.864	2.738	0.090	2.202
2001	**185.242**	**0.009**	**34.860**	0.164	30.035	2.736	0.099	1.826
2002	**179.316**	**0.008**	**33.744**	0.159	30.008	2.736	0.079	0.762
2003	**190.917**	**0.011**	**35.929**	0.147	32.784	2.733	0.128	0.137
2004	**182.385**	**0.008**	**34.318**	0.144	29.757	2.732	0.035	1.651
2005	**169.696**	**0.007**	**31.957**	0.134	28.868	2.732	0.012	0.210
2006	**174.750**	**0.009**	**32.128**	0.133	29.154	2.732	0.063	0.046
2007	**149.661**	**0.006**	**35.446**	0.132	32.427	2.732	0.155	NO
2008	**147.388**	**0.005**	**34.908**	0.117	31.421	2.729	0.112	0.529
2009	**241.095**	**0.005**	**37.766**	0.111	32.425	2.728	0.112	2.390
2010	**187.843**	**0.005**	**34.682**	0.103	31.307	2.728	0.111	0.433
2011	**241.256**	**0.006**	**36.033**	0.109	31.439	2.728	0.098	1.659

3.2 Energy industries (CRF 1.AA.1), Manufacturing industries and combustion (CRF 1.AA.2), Other sectors (CRF 1.AA.4) and Other (CRF 1.AA.5)

3.2.1 Source category description

Energy industries (CRF 1.AA.1), Manufacturing industries and construction (CRF 1.AA.2), Other sectors (CRF 1.AA.4) and Other (CRF 1.AA.5) categories include emissions from fuel combustion in large and medium point sources in energy production and industrial sectors (power plants, boilers and industrial plants with boilers and/or other combustion installations). The emissions according to the relevant subcategories and gases in 1990 – 2011 are presented in Table 3.7.

Figure 3.4: *The share of different fuels consumption within energy sector's categories in 2011*



1.AA Fuel Combustion without Transport	Fuel (TJ)
Liquid	53 543.71
Solid	105 639.87
Gaseous	193 010.95
Biomass	32 021.76
Other	1 619.58
Total	**385 835.87**

The share of fuel consumption within subsectors 1.AA.1, 1.AA.2, 1.AA.4 and 1.AA.5 in total fuel consumption of sectoral approach balance was more than 81% in 2011. The highest share represents category CRF 1.AA.1.A – Public electricity and heat production followed by category 1.AA.2.A – Iron and Steel and category 1.AA.4.B – Residential. Detailed emission trends by gases and categories are presented in Table 3.7.

Table 3.7: *GHG emissions by categories within category 1.AA Fuels Combustion – Sectoral approach in 1990 – 2011*

Year	1.AA.1 – Energy Industry			1.AA.2 – Manufacturing Industries and Construction			
	1.AA.1.A	1.AA.1.B	1.AA.1.C	1.AA.2.A	1.AA.2.B	1.AA.2.C	1.AA.2.D
	CO_2 (Gg)						
1990	14 834.84	665.42	1 318.95	2 681.61	1 239.04	4 907.45	2 329.29
1991	12 548.98	1 302.62	1 315.86	2 369.54	1 044.58	5 182.35	2 028.64
1992	10 968.68	929.84	1 312.77	2 240.26	877.26	5 311.97	1 769.91
1993	9 808.63	983.66	1 309.68	2 304.47	734.64	5 315.69	1 549.28
1994	8 778.27	995.24	1 306.60	2 373.69	614.59	5 211.82	1 363.23
1995	8 508.14	1 789.57	1 303.51	2 447.40	514.98	5 018.65	1 208.18
1996	8 460.54	1 725.25	1 300.42	2 525.09	433.67	4 754.48	1 080.60
1997	8 292.69	2 429.09	1 297.33	2 613.85	368.52	4 437.61	1 028.49
1998	8 398.30	2 319.24	1 294.25	2 690.39	317.39	4 086.33	893.64
1999	8 532.32	1 905.22	1 291.16	2 776.99	278.14	3 718.95	827.15
2000	9 022.50	1 218.71	1 248.60	2 774.13	269.91	3 397.34	690.70
2001	9 988.80	1 697.72	1 196.74	3 072.76	260.48	3 130.08	604.30
2002	9 266.36	2 509.09	1 264.46	2 934.72	261.94	2 471.94	628.67
2003	9 755.73	1 828.57	1 357.51	3 321.40	226.09	2 417.71	599.33
2004	9 638.07	1 490.77	1 223.14	3 165.26	182.65	2 419.74	534.21
2005	8 650.19	1 629.71	1 348.49	3 387.00	172.49	2 874.59	528.88
2006	8 006.62	1 503.83	1 361.80	3 911.82	170.77	2 892.84	521.33
2007	7 337.64	1 532.85	1 375.41	3 392.14	158.04	2 715.69	485.60
2008	7 414.92	1 600.31	1 266.53	3 583.81	171.92	2 829.98	518.61
2009	6 495.36	688.92	1 202.37	3 637.47	142.83	2 692.88	622.36
2010	6 216.51	1 831.59	1 308.20	3 742.43	183.96	2 596.77	396.20
2011	6 372.56	1 745.17	1 276.78	4 773.44	231.36	2 045.10	368.48

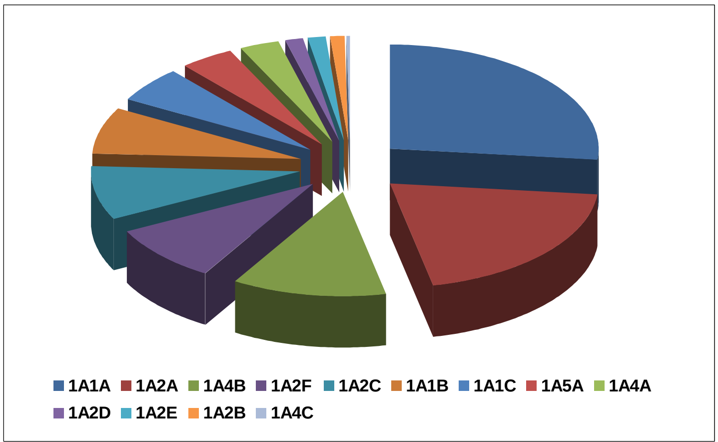
Table 3.7 cont.: *GHG emissions by categories within category 1.AA Fuels Combustion – Sectoral approach in 1990 – 2011*

Year	1.AA.2		1.AA.4 – Other Sectors			1.AA.5 - Other	
	1.AA.2.E	1.AA.2.F	1.AA.4.A	1.AA.4.B	1.AA.4.C	1.AA.5.A	1.AA.5.B
	CO_2 (Gg)						
1990	1 140.36	5 795.28	3 327.77	7 069.81	45.24	2 219.78	7.00
1991	1 040.56	5 058.08	2 922.07	6 377.87	42.03	1 931.68	6.00
1992	953.95	4 468.74	2 567.66	6 310.66	41.88	1 645.13	5.09
1993	879.12	4 011.30	2 260.38	5 097.59	44.52	1 362.43	6.11
1994	814.83	3 670.01	1 996.51	4 478.26	49.53	859.13	6.20
1995	759.84	3 623.62	1 772.33	4 857.32	56.47	1 366.98	6.41
1996	712.93	3 564.57	1 584.12	5 385.07	64.91	1 539.27	5.56
1997	695.67	3 515.13	1 428.16	5 217.67	74.43	1 434.67	2.71
1998	638.39	3 383.48	1 300.72	4 788.89	84.58	1 443.65	2.03
1999	608.30	3 153.86	1 198.09	4 923.79	94.94	1 399.39	1.33
2000	569.22	3 289.92	1 012.22	4 806.14	103.23	1 552.79	1.68
2001	559.53	3 355.03	1 085.57	5 424.05	114.21	1 417.24	2.60
2002	551.05	3 061.98	1 004.07	4 283.55	118.75	1 185.45	2.64
2003	495.88	3 657.38	926.87	4 358.84	102.04	1 091.33	1.58
2004	478.85	3 270.10	836.88	3 983.26	112.50	1 529.55	1.54
2005	436.19	2 959.77	834.24	3 706.78	119.25	1 427.46	1.86
2006	416.82	3 315.65	822.39	3 370.66	108.51	1 049.08	1.86
2007	359.35	2 976.97	688.98	2 824.52	89.30	1 137.66	2.40
2008	335.11	2 555.86	806.09	3 099.29	102.51	1 302.25	2.07
2009	303.73	2 119.91	753.55	3 026.61	98.95	977.87	1.54
2010	306.00	2 065.59	769.73	3 517.75	108.42	934.02	1.54
2011	312.03	2 074.76	721.74	2 884.35	92.05	1 032.94	1.59

Comments: transport emissions from the category 1.AA.3 are reported in the Chapter 3.3

According to the detail analyses of the categories, the major share of emissions is represented by category 1.AA.1.A – Electricity and heat production (26.6%) followed by the categories 1.AA.2.A (19.9%) and 1.AA.4.B with the share of 12.2%. The category 1.AA.2.F Other represents 8.7% share of emissions. The categories among transport are not included in this analysis, but the road transportation is the most important key source with the one of the highest share of emissions from energy sector.

Figure 3.5: *The share of emissions in CO_2 eq. on different categories within energy sector in 2011*



IPCC Category	GHG (CO_2 eq.)	Share
1.AA.1.A	6 409.84	26.64%
1.AA.2.A	4 784.91	19.89%
1.AA.4.B	2 929.96	12.18%
1.AA.2.F	2 084.59	8.67%
1.AA.2.C	2 050.94	8.53%
1.AA.1.B	1 747.35	7.26%
1.AA.1.C	1 277.16	5.31%
1.AA.5.A	1 035.54	4.30%
1.AA.4.A	726.62	3.02%
1.AA.2.D	370.41	1.54%
1.AA.2.E	312.89	1.30%
1.AA.2.B	232.46	0.97%
1.AA.4.C	92.36	0.38%
1.AA.5.B	1.645	0.01%

3.2.2 Methodological issues – methods

There are 3 main sources of activity data and other parameters for GHG emissions estimation:

- National Energy Statistics (NES) – energy balance based on the data from the Statistical Office of the Slovak Republic which is used mainly for the Reference Approach (RA) inventory, but is taken into consideration also during the Sectoral Approach (SA) preparation;
- National Emission Information System (NEIS) – national database of stationary sources of air pollution;
- ETS reports from operators and verifiers included in the National Allocation Plan I and II for the years 2005 – 2011.

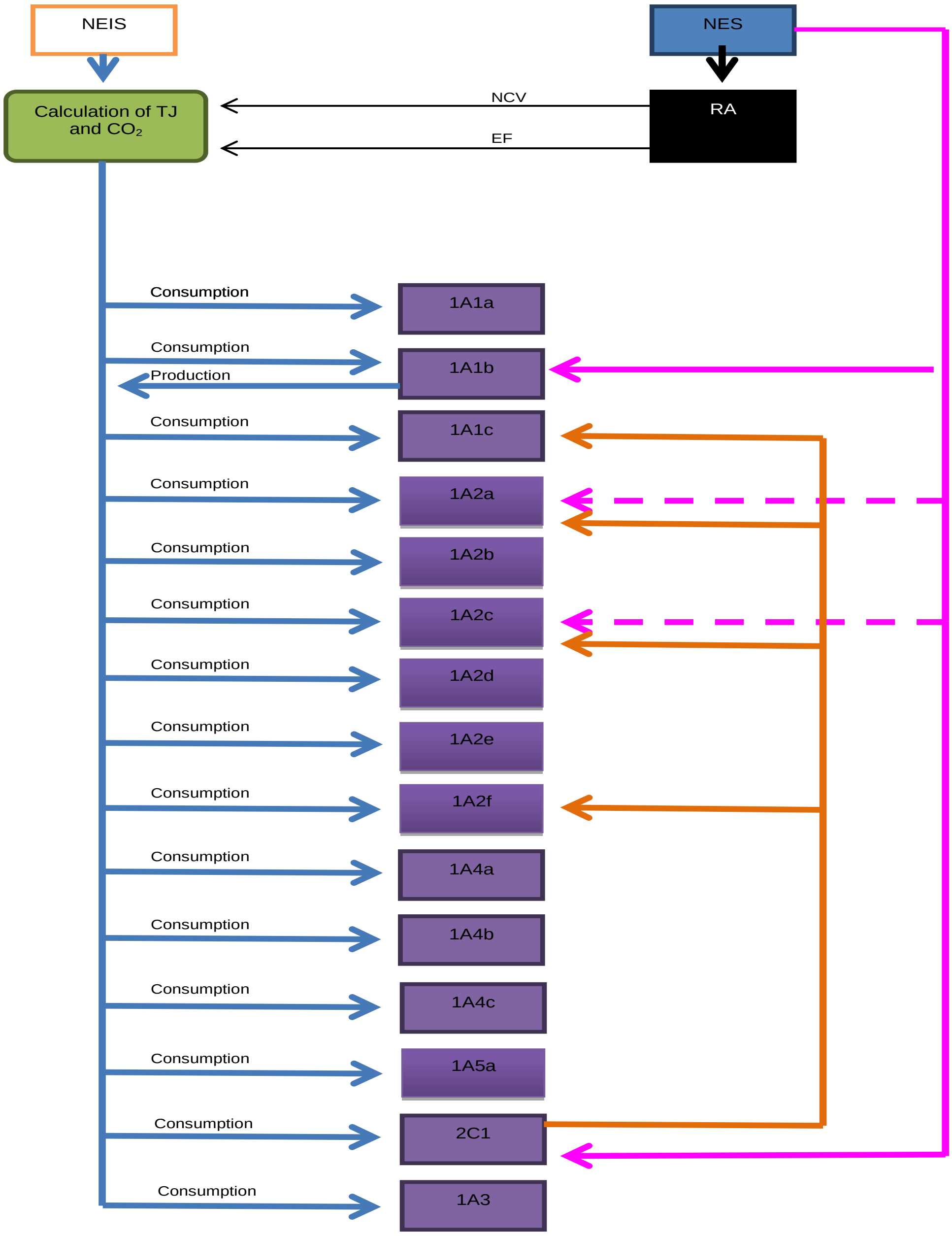
Although top-down approach enables to follow total national balance as the black box, in some categories it is impossible to split these data by the detail IPCC CRF categories (e.g. category other fuels consists also from the fuels recognised by the IPCC methodology). On the other side, this approach is used as the standard and there is assured that any data of fuel consumption are omitted. In the RA, some secondary fuels as heating oil, refinery gas, coking gas, blast furnace gas and convertory gas are not available since they are included in primary fuels crude oil and coking coal and therefore comparison is difficult at this level.

Bottom-up approach using primary data from the NEIS such as fuel consumption according to the different types of fuel enables to split this consumption by the detail IPCC CRF categories. On the other hand, in some cases double counting can arise. It is the case of metallurgical data where the coking coal conversion is included in coke and technical gases. Coke consumption in blast furnace is included in database together with blast furnace gas, arising from coking coal conversion. Usage of both data can cause the double counting. There are other similar cases in other sectors. The other case is the oil refineries. Both, crude oil and coking coal are not included in the NEIS database because are not used for combustion (therefore no basic pollutants emissions are produced). In order to avoid the above mentioned mistakes following QA/QC activities for the SA were elaborated:

- Using the data of NCV and EF, the fuel consumption in metrics unit [kt, mil. m^3] was converted into energy ones [TJ].
- The apparent consumption of fuel in individual sectors was calculated as the difference of input – output. It was the case of CRF categories were the apparent consumption was calculated as the consumption – production of refinery products. The consumption of primary fuels as were crude oil and natural gas had to be added as the main refinery input. In other sectors practically only fuel consumptions were used.
- In some cases the NEIS does not cover all fuel consumption. As mentioned above it was the case of hard coal and/or coke in metallurgy, and NG in chemistry (fuels not used for heating or electricity production). Therefore the harmonisation of its consumption was done by adding the difference of consumption from the NES and the NEIS.
- Special case represents the metallurgy production, sector 2.C.1 which is described in the IP chapter. This sector is using coking coal, and is producing the technical gases such as blast furnace gas and coking gas, used in sectors 1.AA.1c, 1.AA.2a, 1.AA.2c and 1.AA.2f.

The categories 1.AA.1, 1.AA.2, 1.AA.4 and 1.AA.5 are balanced in one approach by using tier 2 methodology and country specific emission factors and NCV. The oxidation factors are IPCC default.

Figure 3.6: *Scheme illustrates the SA inventory process*



Data from the NEIS database	blue arrow
Data from the NES crude oil, coking coal, refinery products etc.	magenta arrow
Backward flow of blast furnace gas and coking gas from 2C1 sector	orange arrow
Harmonisation of coal and NG consumption with the NES	dashed magenta arrow

3.2.2.1 Description of the NEIS

The National Emission Information System (NEIS) (www.air.sk and in the report http://www.shmu.sk/sk/?page=997) is the database of stationary sources, which collects the data on fuel consumptions from the major sources of air pollution in the Slovak Republic. These data are available in consistent series since 2000, when the system NEIS was put in operation. It replaced an old system EAPSI (Emission and Air Pollution Source Inventory) system. These systems are comparable only at the national level. The comparison of individual parts of EAPSI (EAPSI 1 and EAPSI 2) with the NEIS module (large and medium-size sources), or the comparison of individual sources in both systems is difficult. According to the Act No 137/2010 Coll. (article 33, paragraph 3, letters g, m) as amended, district environmental offices are obliged to elaborate yearly reports about operational characteristics of air pollution sources in their districts and provide them to the SHMU central database in electronic form (in the NEIS BU format) for the next processing. The SHMU is authorized by the Ministry of Environment to manage the database NEIS CU and to process the data at the national level (Decree No 357/2010). The first collection and processing of data by module NEIS was realized in 2001 at the SHMU. In 2011, the new system contained 863 (712 of it in operation) large point sources collected from the 79 partially NEIS district databases. The sources of 50 MW and above are included to the registration of large point sources. In year 2011, the NEIS system registered 12 921 (10 885 of it in operation) medium sources of the heating output of 0.3-50 MW. The emission balances in 2000 – 2011 were processed in the NEIS CU module by the same calculation. The input data (fuel amounts, according to the types, sold for households and retail consumers, and quality marks) necessary for the emission balance were collected from the regional offices by means of the NEIS BU module. The sources below 0.3 MW (category 1.AA.4.B – Residential) are qualified as small sources and the emission balance is processed within the NEIS CU system and is based on the data on the sales of solid fuels from retailers to households (in 2001 – 2003 according to Decree No 144/2000, since 2004 according to Decree No 53/2004), the consumption of natural gas for the inhabitants and its annually specified emission factors. Liquid fuels are not used in this category. Local furnaces are assessed as local sources at the level of district. In 2004, the emission balance of small sources was revised and therefore emission recalculation since 1990 has been performed. Within the revision, the emission factors were updated (in conformity with the effective legislation on air protection), together with qualitative features of solid fuels (in sense of standard OTN ZP 2008). Wood combustion emissions were additionally recalculated as its consumption was not included in the balance before 2004. In the past, the balances were not carried out regularly (EAPSI 3 system had been updated annually only until 1997), the data for the missing years were estimated additionally. In such way, the consistent data time series since 1990 have been obtained. The statistics has been completed by the consumption of natural gas for inhabitants (from the records of the Slovak Gas Industry LtD.) and corresponding emission factors. The changes occurred in context with the revision of the codebook of fuels in accordance with the approved legislation (Regulation of the Ministry of Environment No 706/2002, Regulation of the Ministry of Environment No 129/2004 amending Regulation of the Ministry of Environment No 284/2001 Coll. on Waste Catalogue and Directive No 2000/76/EC on Waste Incineration).

The NEIS contains following modules:

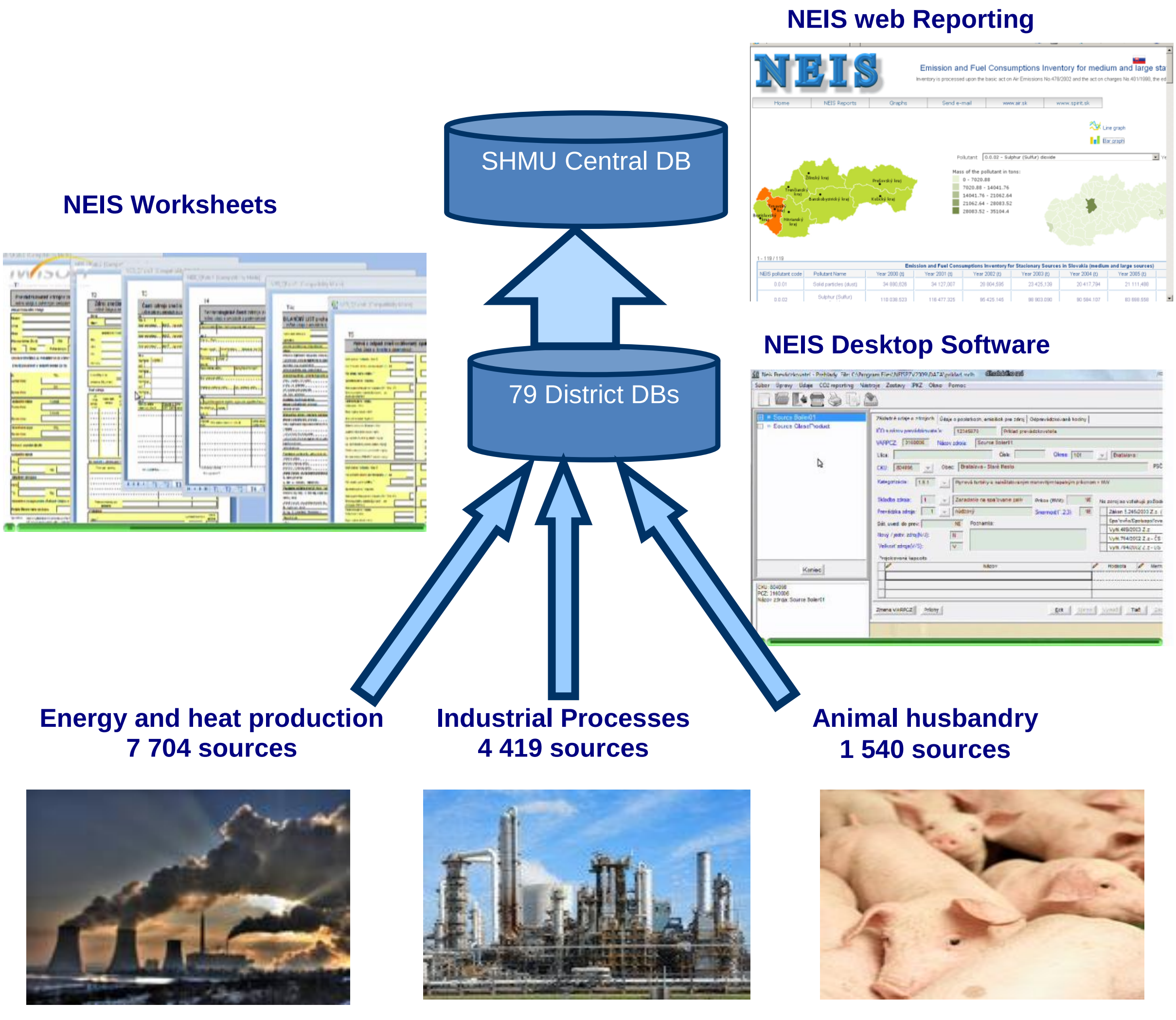
- NEIS QF printed questionnaire form for air pollution sources reporting (used by 6 300 operators);
- NEIS PZ electronic questionnaire form for air pollution sources reporting (used by 160 operators);
- NEIS BU basic unit – the module for district offices in relation to data collection, data processing, data verifying and preparing “decisions on air polluting fees”;
- NEIS CU central unit – the central database module of the SHMU for importing district databases, data verifying, statistical and inventory exports, joining IPPC databases and the export to the internet;
- NEIS WEB presentation module – large data sets at local, regional and national level, including all pollutants, and individual reports;
- NEIS documents are archived at the website: http://www.air.sk.

Special program runs inside of the database NEIS developed for reporting requirements under the UNFCCC for the estimation of emissions by a bottom-up methodology. The program was designed in the cooperation with IT experts to ensure easier allocation of individual sources into CRF categories.

The allocation of all large and medium sources within the current year is performed on the base of NACE codes. The production activity of installations and operators of sources is available at the NEIS CU unit. After automatic allocation of sources, the manual verification and check-in by competent expert take place. The NACE rev.2 classification codes are compared with IPCC CRF categories and included into NEIS database and checked annually for new or renamed sources (Table 3.2). The special convertor for the NACE and CRF classification was developed in the frame of the grant supported by Eurostat and implemented by the SHMU. Activity data (the quantity of burned fuel in physical units) included in each CRF category, collected in the NEIS database for the actual year are provided in mass units (thousands of m^3 or tons) with corresponding calorific values (GJ/thous.m^3 or GJ/t) and other characteristics of the fuel. Operators are under the state control and they guarantee the quality assurance and the data control.

The outputs from a special program under NEIS database are verified by the database administrator of the SHMU and forwarded in a special report to the sectoral expert for energy. Then the emission estimation is performed in excel sheets according to the IPCC 2000 GPG. In the bottom-up sectoral energy balance the IPCC more detailed method Tier 2 and national plant specific (CO_2) or default emission factors (mostly for non-CO_2 gases) are applied. The consumption of biomass is not included in the total CO_2 emission balance, but it is provided. Information provided by operators was allocated according to the IPCC methodology into appropriate categories. Several sources were divided into more than one category due to the types of production or technological equipments.

Figure 3.7: *The structure of NEIS database and data flows*



3.2.3 Methodological issues – emission factors and other parameters

The country specific calorific values of the fuels are announced annually by the Statistical Office. The variations depend on fuel characteristics, which are published in the Statistical Yearbook annually. If an operator uses the plant specific calorific values, he has the obligation to provide the 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 ETS reports. The inventory experts used NCV from the NES calculated as country specific average (annual weighted average NCV):

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

According to the direct information on the quantity of combusted fuels (in thous. of tons or mil. m^3) and their specific net calorific values, the calculation of fuel consumption in energy unit (TJ) is provided. For each fuel 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 emission factors for the non-CO_2 are default (IPCC 2006 GL). The emission factors for CO_2 are country or plant 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. Carbon emission factors may vary considerably both among and within primary fuel types. National emission factors for CO_2 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 IPCC categories. The emission factors for natural gas and other important fuels are based on precise measurements and calculation published every month by Slovak Gas Industry Ltd, Slovak Energy Industry LtD., refinery plant Slovnaft for liquid fuels, a.s. and U.S. Steel Company for iron and steel production. These EFs are in use for the installations under the Emission Trading Scheme and for the requirements of the Ministry of Environment of the Slovak Republic. Carbon content per unit of energy is usually lesser for light refined products, such as gasoline, than for heavier products such as residual fuel oil. The list of actually used EFs is presented in the Table 3.8.

Carbon emission factors are recalculated to CO_2 emission factors and considered by the oxidation factors according to the type of fuel group (0.99 for liquid, 0.98 for solid and 0.995 for gaseous fuels).

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 include also small quantities of ethane, propane, butane, and heavier hydrocarbons). Natural gas flared at the production site is usually "wet", i.e., it contains much more non-methane hydrocarbons. Identically, the carbon emission factor is correspondingly different. In the Slovak Republic, the emission factors for natural gas (of the Russian origin) are based on precise measurements and calculations published every month by Slovak Gas Industry since 1st January 2000. Nowadays, these EFs are used for the installations covered by the ETS that comply with the requirements of the Ministry of Environment of the Slovak Republic. The emission factors are published monthly at the http://www.spp.sk/sk/velki-zakaznici/zemny-plyn/emisie/ (Tables 3.9, 3.10). Weighted averages are calculated based on monthly announced consumption by the Slovak Gas Industry. Despite the fact, that the Slovak Gas Industry was not exclusive natural gas supplier, the parameters of the NG are consistent in all consumers due to the common origin of natural gas distributed by the Slovak Gas Industry – Distribution. The complete set of consumptions, emission factors, NCVs and emissions (CO_2, CH_4 and N_2O) by allocation of fuels according to the IPCC categories are included in the chapter 3.2.4 and partly in Annex 3 of this report.

Table 3.8: *Overview of the country or plant specific emission factors in energy for CO_2 in 2011*

Fuel			EF	Unit	NCV	Unit
Liquid	Primary	Crude Oil	20.47	t C/TJ	41.996	TJ/1 000t
		Natural Gas Liquids	17.20	t C/TJ	37.000	TJ/1 000t
	Secondary	Gasoline	19.73	t C/TJ	43.780	TJ/1 000t
		Jet Kerosene	20.09	t C/TJ	43.300	TJ/1 000t
		Other Kerosene	20.09	t C/TJ	43.000	TJ/1 000t
		Gas / Diesel Oil	20.28	t C/TJ	42.206	TJ/1 000t
		Residual Fuel Oil	22.03	t C/TJ	40.404	TJ/1 000t
		LVO	22.03	t C/TJ	40.404	TJ/1 000t
		LPG	17.56	t C/TJ	46.000	TJ/1 000t
		Ethane	16.80	t C/TJ	47.400	TJ/1 000t
		Naphtha	20.00	t C/TJ	43.600	TJ/1 000t
		Bitumen	21.83	t C/TJ	40.080	TJ/1 000t
		Lubricants	20.00	t C/TJ	42.115	TJ/1 000t
		Refinery gas	18.20	t C/TJ	43.860	TJ/1 000t
		Petroleum Coke	27.51	t C/TJ	34.057	TJ/1 000t
		Refinery Feedstock	18.20	t C/TJ	43.860	TJ/1 000t
		Other Oil	19.82	t C/TJ	30.000	TJ/1 000t
Solid	Primary	Anthracite (2)	26.43	t C/TJ	27.425	TJ/1 000t
		Coking Coal	26.05	t C/TJ	29.594	TJ/1 000t
		Other Bit. Coal	26.71	t C/TJ	26.139	TJ/1 000t
		Lignite	28.48	t C/TJ	10.264	TJ/1 000t
	Secondary	BKB & Patent Fuel	25.16	t C/TJ	26.417	TJ/1 000t
		Coking gas	12.92	t C/TJ	17.222	$TJ/mil.m^3$
		Blast furnace gas	71.24	t C/TJ	3.150	$TJ/mil.m^3$
		Coke Oven/Gas Coke	29.75	t C/TJ	28.049	TJ/1 000t
Gaseous		Natural Gas (Dry)	15.11	t C/TJ	34.510	$TJ/mil.m^3$
Biomass		Solid Biomass (wood)	27.59	t C/TJ	11.454	TJ/1 000t
		Liquid Biomass	20.00	t C/TJ	30.586	TJ/1 000t
		Gaseous Biomass (biogas)	23.84	t C/TJ	19.224	$TJ/mil.m^3$
Other		Waste Municipal	8.05	t C/TJ	8.71	TJ/1 000t
		Waste Industrial	69.25	t C/TJ	-	-
		Methane Cogeneration	15.11	t C/TJ	34.510	$TJ/mil.m^3$

Table 3.9: *Parameters of natural gas published by the Slovak Gas Industry on-line in 2011*

2011	Natural gas (mol %)									
Month	CH_4	C_2H_6	C_3H_8	$i\text{-}C_4H_{10}$	$n\text{-}C_4H_{10}$	$i\text{-}C_5H_{12}$	$n\text{-}C_5H_{12}$	C_6H_{14}	CO_2	N_2
I.	96.77	1.52	0.46	0.07	0.07	0.02	0.01	0.02	0.22	0.84
II.	96.63	1.58	0.48	0.07	0.08	0.02	0.01	0.02	0.25	0.86
III.	96.73	1.53	0.46	0.07	0.07	0.02	0.01	0.02	0.25	0.85
IV.	96.99	1.41	0.43	0.06	0.07	0.01	0.01	0.01	0.19	0.81
V.	97.07	1.38	0.43	0.06	0.07	0.01	0.01	0.01	0.16	0.80
VI.	96.85	1.46	0.45	0.07	0.07	0.02	0.01	0.01	0.22	0.84
VII.	96.52	1.68	0.51	0.08	0.08	0.02	0.01	0.02	0.24	0.84
VIII.	95.91	2.01	0.59	0.08	0.10	0.02	0.02	0.02	0.37	0.88
IX.	96.24	1.83	0.56	0.08	0.09	0.02	0.01	0.02	0.30	0.85
X.	96.77	1.54	0.47	0.07	0.08	0.02	0.01	0.01	0.21	0.82
XI.	96.68	1.58	0.47	0.07	0.07	0.02	0.01	0.01	0.25	0.83
XII.	96.78	1.53	0.46	0.07	0.07	0.02	0.01	0.01	0.22	0.82
Average	**96.66**	**1.59**	**0.48**	**0.07**	**0.08**	**0.02**	**0.01**	**0.02**	**0.24**	**0.84**

Table 3.10: *Overview of EF CO_2 and NCV for natural gas [15 °C; 101,325 kPa]*

2011	**Natural gas**						
Month	**Relative Density**	**Density**	**NCV**	**Combustion Heat**	**Wobbe Number**	**Sulphur Content**	**EF CO_2**
	(mol %)	($kg.m^{-3}$)	($kWh.m^{-3}$)	($kWh.m^{-3}$)	($kWh.m^{-3}$)	($mg.m^{-3}$)	(tCO_2/TJ])
I.	0.5753	0.7042	9.630	10.614	13.99	0.10	55.06
II.	0.5763	0.7062	9.580	10.619	13.99	0.11	55.40
III.	0.5756	0.7053	9.569	10.609	13.98	0.08	55.40
IV.	0.5737	0.7030	9.563	10.603	13.98	0.10	55.34
V.	0.5731	0.7023	9.562	10.602	14.00	0.07	55.32
VI.	0.5748	0.7043	9.567	10.608	14.00	0.16	55.37
VII.	0.5771	0.7071	9.595	10.638	14.00	0.13	55.44
VIII.	0.5813	0.7024	9.623	10.667	13.99	0.17	55.59
IX.	0.5791	0.7096	9.611	10.665	14.00	0.17	55.51
X.	0.5753	0.7049	9.578	10.619	14.00	0.11	55.39
XI.	0.5759	0.7054	9.577	10.619	13.99	0.10	55.41
XII.	0.5751	0.7048	9.575	10.616	14.00	0.16	55.38
Average	**0.5761**	**0.7050**	**9.586**	**10.623**	**13.99**	**0.12**	**55.38**

3.2.4 Activity data

Activity data on emission factors, NCVs, fuel consumption and emissions are collected from several official sources. Main source of activity is still the NEIS central database where the information from stationary sources is allocated according to the NACE categorization based on identification number of installation. The basic information from the NEIS database are compared with the information provided by the Statistical Office of the Slovak Republic (energy statistics) and with the information provided in the ETS Reports for those installations which are included in the NAP II. In the questionable cases (if the activity data are not corresponding), direct request for clarification is directed to the operators. The systems are better harmonized from year to year and only several cases for clarification are occurred in 2011. Major issue for clarification was iron and steel industry, ammonia producers and natural gas supplier in 2011.

Since 2011, the harmonization process between NEIS economical classification of sources and statistical classification based on NACE Rev.2 is ongoing in line with the Regulation (EU) 691/2011 of the European Parliament and of the Council of 6th July 2011 on European Environmental Economic Accounts. The project is evaluated in cooperation with the SHMU and the Statistical Office of the Slovak Republic. Based on the Manual provided by the Eurostat, the classification is associated with this SNAP-NRF/CRF-NACE correspondence table as a matrix of coefficients that provides the user a key to convert data from inventories to NACE activities. This matrix will be handed out during the data collection phase later this year. The fuels according to the basic categories in the sectoral approach are listed in Table 3.8.

Biomass balance is based on direct information from NEIS database and includes biogas and wood consumption directly reported by producers.

3.2.4.1 Category 1.AA.1.A – Public electricity and heat production

Total volume of fuels in this category represented 88 490.71 TJ in 2011. Total CO_2 emissions were 6 372.56 Gg, total CH_4 emissions were 0.26 Gg and total N_2O emissions were 0.10 Gg. The fuels are allocated among solid, liquid and gaseous fuels, biomass and other fuels categories.

1.AA.1a	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	79.79	Gas / Diesel Oil	20.28	0.99	73.62
		Residual Fuel Oil	22.03	0.99	79.95
Solid	100.49	Other Bit. Coal	26.71	0.98	95.98
		Lignite	28.48	0.98	102.33
		Coke Oven/Gas Coke	29.75	0.98	106.89
Gaseous	55.11	Natural Gas	15.11	0.995	55.11
Biomass	100.67	solid - wood	27.59	0.98	99.14
		gaseous - biogas	23.84	0.995	86.98
Other	39.17	Methane cogeneration	15.11	0.995	55.11
	29.51	MSW	8.05	-	29.51
	IE	ISW	69.25	-	253.93

The other fuel category consists of three different sources of emissions that are used for electricity and heat production (Table 3.12):

- 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).

The measurements of the methane content in cogeneration gas are not representative and well documented and therefore the country specific NG´s emission factor and NCV was used. Activity data for industrial waste incineration are included in waste category 6.C.2 due to no information on NCV of the waste composed from different type of materials. Methane emissions from waste incineration do not occur in these categories.

Table 3.11: *The activities included in category 1.AA.1.A other fuel in 2011*

Year	Cogeneration (mining)				MSW Incineration			IW Incineration		
	Fuel	CO_2	CH_4	N_2O	Fuel	CO_2	N_2O	Fuel	CO_2	N_2O
	(TJ)	(t)			(TJ)	(Gg)	(t)	(TJ)	(Gg)	(t)
1990	NO	NO	NO	NO	1 307.04	43.00	4.60	IE	127.30	11.20
1991	NO	NO	NO	NO	1 307.04	43.00	4.60	IE	127.30	11.20
1992	NO	NO	NO	NO	1 503.09	44.36	4.00	IE	127.30	11.20
1993	NO	NO	NO	NO	1 614.28	47.64	4.64	IE	127.30	11.20
1994	NO	NO	NO	NO	1 409.03	41.58	3.50	IE	127.30	11.20
1995	NO	NO	NO	NO	1 314.20	38.78	3.10	IE	127.30	11.20
1996	NO	NO	NO	NO	1 289.15	38.04	3.05	IE	127.30	11.20
1997	NO	NO	NO	NO	1 404.66	41.45	3.35	IE	91.70	9.80
1998	NO	NO	NO	NO	1 567.06	46.25	3.69	IE	184.90	9.90
1999	NO	NO	NO	NO	1 520.48	44.87	3.59	IE	128.80	10.70
2000	NO	NO	NO	NO	1 816.22	53.60	4.27	IE	127.20	9.80
2001	NO	NO	NO	NO	1 142.09	33.70	2.71	IE	105.80	10.90
2002	NO	NO	NO	NO	1 363.66	40.24	3.20	IE	85.70	38.10
2003	NO	NO	NO	NO	1 416.04	41.79	2.54	IE	70.15	56.80
2004	NO	NO	NO	NO	1 604.26	47.34	2.79	IE	51.57	22.80
2005	NO	NO	NO	NO	1 593.28	47.02	2.26	IE	16.16	30.40
2006	NO	NO	NO	NO	1 655.52	48.86	2.43	IE	15.35	26.50
2007	11.59	639.53	0.0116	0.0012	1 570.34	46.34	2.26	IE	17.89	16.20
2008	9.36	514.89	0.0094	0.0009	1 370.62	40.45	1.91	IE	20.79	42.90
2009	5.44	300.40	0.0054	0.0005	1 548.82	45.71	2.26	IE	22.89	16.90
2010	1.66	91.79	0.0017	0.0002	1 597.02	47.13	2.29	IE	11.56	8.39
2011	3.21	176.68	0.0032	0.0003	1 616.38	47.70	2.41	IE	15.55	12.20

3.2.4.2 Category 1.AA.1.B – Petroleum refining

Total volume of fuels in this category expressed in energy units represented 64 983.84 TJ in 2011. Total CO_2 emissions were 1 745.17 Gg, total CH_4 emissions were 0.04 Gg and total N_2O emissions were 0.004 Gg in this category. The fuels are allocated among solid, liquid and gaseous fuels categories. No biomass is combusted in this category.

1.AA.1b	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	7.66	Refinery Gas	18.20	0.99	66.07
		Petroleum Coke	27.51	0.99	99.86
Solid	106.89	Coke Oven/Gas Coke	29.75	0.98	106.89
Gaseous	55.11	Natural Gas	15.10	0.995	55.11

Within category 1.AA.1b main source of fuel balance are oil and natural gas, which are used for heating and as source of hydrogen for processing of oil products (hydrocracking). Fuel refinery gas for which country specific NCV and EF are used is a mixture of various gases of different quality. Refinery gas is within secondary fuels used in refinery technology i.e. in category 1.AA.1b and in category 1.AA.2c (chemical industry). Production of secondary liquid fuels (gasoline, gas/diesel oil, LGP and others) is a balance of production, import, export, stock change and reflux of products back to the process within 1.AA.1b and within other categories (mainly transport).

CRF	Fuel	Unit	Consumption	Production
1.AA.1a	Gas / Diesel Oil	1 000 t	0.17	
1.AA.1b	Gas / Diesel Oil	1 000 t	0.00	**Total = 3 041.58**
1.AA.1c	Gas / Diesel Oil	1 000 t	0.00	
1.AA.2a	Gas / Diesel Oil	1 000 t	0.00	
1.AA.2b	Gas / Diesel Oil	1 000 t	0.00	
1.AA.2c	Gas / Diesel Oil	1 000 t	0.00	
1.AA.2d	Gas / Diesel Oil	1 000 t	0.00	
1.AA.2e	Gas / Diesel Oil	1 000 t	0.00	
1.AA.2f	Gas / Diesel Oil	1 000 t	0.15	
1.AA.4a	Gas / Diesel Oil	1 000 t	0.90	
1.AA.4c	Gas / Diesel Oil	1 000 t	0.05	
1.AA.5a	Gas / Diesel Oil	1 000 t	0.04	
2.C.1	Gas / Diesel Oil	1 000 t	0.00	
1.AA.4b	Gas / Diesel Oil	1 000 t	0.00	
1.A.3	Gas / Diesel Oil	1 000 t	1 435.26	

Implied emission factor for liquid fuels is aggregated emission factor and was automatically calculated by dividing actual CO_2 emissions and apparent consumption in TJ. The result of this calculation is not real value of EF (liquid) (7.66 t CO_2/TJ) because the apparent consumption is influenced by the input-output carbon balance, and is different in individual years, so unexpected fluctuations of IEF are caused. It is a consequence of high share of secondary fuels allocating to other categories. Balance of liquid fuels in category 1.AA.1b as well as CO_2 emissions are calculated directly from amount of fuels produced (products + reflux), in which reflux back to the production process is included. Direct consumption of fuels is used for calculation of CH_4 and N_2O emissions. Weighted plant specific value of EF for liquid fuels is 66.07 tCO_2/TJ in 1.AA.1b category is fully in relation with value for this type of fuels (in the IPCC range). Similarly as in other categories this calculation process avoids inconsistencies between RA and SA.

3.2.4.3 Category 1.AA.1.C – Manufacture of solid fuels and other energy industries

The total volume of fuels in this category expressed in energy units represented 7 190.87 TJ in 2011. Total CO_2 emissions were 1 276.78 Gg, total CH_4 emissions were 0.01 Gg and total N_2O emissions were 0.0007 Gg in this category. The fuels are allocated among liquid, solid, gaseous and biomass fuels categories.

1.AA.1c	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	73.62	Gas / Diesel Oil	20.28	0.99	73.62
Solid	193.10	Coking Gas	12.92	0.98	46.41
		Lignite	28.48	0.98	102.33
		Blast-Furnace Gas	71.24	0.98	256.00
Gaseous	55.11	Natural Gas	15.10	0.995	55.11
Biomass	87.41	Biogas	23.84	0.995	87.41

When allocating amounts of fuels consumed in category 1.AA.1c, only direct consumption of secondary fuels as product of coke ovens – coking gas and from blast furnace – blast furnace gas were included.

Other fuels are balanced in category 2.C.1. Consumption of coking coal was allocated in this category due to technological character of this fuel. Following table demonstrates the allocation in case of fuel coking gas of this fuel produced from coking coal in category 2.C.1 into other categories.

CRF	Fuel	Unit	Consumption	Production
1.AA.1a	Coking gas	mil.m^3	0.00	0.00
1.AA.1b	Coking gas	mil.m^3	0.00	0.00
1.AA.1c	Coking gas	mil.m^3	110.53	0.00
1.AA.2a	Coking gas	mil.m^3	265.24	0.00
1.AA.2b	Coking gas	mil.m^3	0.00	0.00
1.AA.2c	Coking gas	mil.m^3	0.00	0.00
1.AA.2d	Coking gas	mil.m^3	0.00	0.00
1.AA.2e	Coking gas	mil.m^3	0.00	0.00
1.AA.2f	Coking gas	mil.m^3	269.52	0.00
1.AA.4a	Coking gas	mil.m^3	0.00	0.00
1.AA.4c	Coking gas	mil.m^3	0.00	0.00
1.AA.5a	Coking gas	mil.m^3	0.00	0.00
2.C.1	Coking gas	mil.m^3	89.36	**Total = 734.64**

3.2.4.4 Category 1.AA.2.A – Iron and steel

Total volume of fuels in this category expressed in energy units represented 40 365.10 TJ in 2011. Total CO_2 emissions were 4 773.44 Gg, total CH_4 emissions were 0.05 Gg and total N_2O emissions were 0.03 Gg in this category. The fuels are allocated among liquid, solid and gaseous fuels categories. No biomass is combusted in this category.

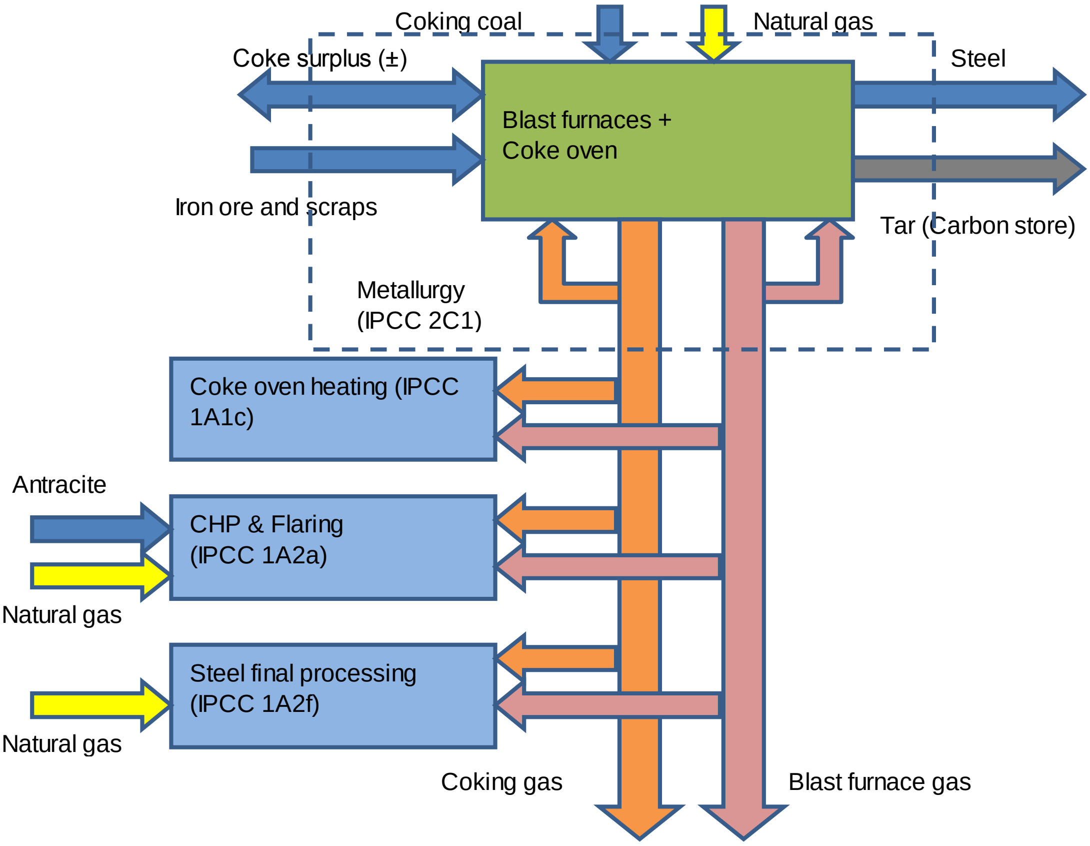
1.AA.2a	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	65.06	LPG	17.56	0.99	63.74
		Residual Fuel Oil	22.03	0.99	79.95
Solid	121.38	Anthracite	26.43	0.98	94.97
		Coking Gas	12.92	0.98	46.41
		Blast-Furnace Gas	71.24	0.98	256.00
		Coke Oven/Gas Coke	29.75	0.98	106.89
Gaseous	55.11	Natural Gas	15.10	0.995	55.11

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 sectoral expert on IP sector. The estimation includes and compares information from the iron and steel industry based on the ETS report of the biggest iron and steel company in the Slovak Republic (U.S. Steel). Methodology for emission estimation in this category is described on the Figure 3.8 and in Annex 3 of this report.

The material balance in this category was compared with the direct material balance reported by plants in the ETS. Such comparison was possible for the years 2005 – 2011. The study could be conducted because of the availability of data from ETS, directly from the operators included in the National Allocation Plan I for period 2005 – 2007 and in the National Allocation Plan II for period 2008 – 2011. For the completeness of calculation, the emissions from limestone are included in the category 2.A.3 (limestone and dolomite used) and technological emissions from steel production are included in category 2.C.1 (iron and steel production) according to the technology.

Consumption of coking coal used for technological process was relocated to category 2.C.1. Coking coal is source of carbon in secondary fuels Coke Oven/Gas coke, Blast furnace gas and Coking gas and production of these fuels is balanced within input-output analysis of category 2.C.1.

Figure 3.8: *Schematic demonstration of carbon balance in the iron and steel industry*



3.2.4.5 Category 1.AA.2.B – Non-ferrous metals

Total volume of fuels in this category expressed in energy units represented 3 169.68 TJ in 2011. Total CO_2 emissions were 231.36 Gg, total CH_4 emissions were 0.01 Gg and total N_2O emissions were 0.003 Gg in this category. The fuels are allocated among solid, liquid, gaseous and biomass fuels categories.

1.AA.2b	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	64.80	LPG	17.56	0.99	63.74
		Other Oil	19.82	0.99	71.95
Solid	97.34	Other Bit. Coal	26.71	0.98	95.98
		Lignite	28.48	0.98	102.33
		Coke Oven/Gas Coke	29.75	0.98	106.89
Gaseous	55.11	Natural Gas	15.10	0.995	55.11
Biomass	101.16	Wood	27.59	0.98	101.16

3.2.4.6 Category 1.AA.2.C – Chemicals

Total volume of fuels in this category expressed in energy units represented 31 579.05 TJ in 2011. Total CO_2 emissions were 2 045.10 Gg, total CH_4 emissions were 0.13 Gg and total N_2O emissions were 0.01 Gg in this category. The fuels are allocated among solid, liquid, gaseous and biomass.

1.AA.2c	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	79.70	Residual Fuel Oil	22.03	0.99	79.95
		LPG	17.56	0.99	63.74
		Refinery Gas	18.20	0.99	66.07
		Other Oil	19.82	0.99	71.95
Solid	95.26	Anthracite	26.43	0.98	94.97
		Lignite	28.48	0.98	102.33
Gaseous	55.11	Natural Gas	15.10	0.995	55.11
Biomass	78.75	Wood	27.59	0.98	101.16
		Black Liquor	20.00	0.99	73.33

3.2.4.7 Category 1.AA.2.D – Pulp, paper and print

Total volume of fuels in this category expressed in energy units 4 908.74 TJ in 2011. Total CO_2 emissions were 368.48 Gg, total CH_4 emissions were 0.02 Gg and total N_2O emissions were 0.005 Gg in this category. The fuels are allocated among solid, liquid, gaseous and biomass fuels categories.

1.AA.2d	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	79.95	Residual Fuel Oil	22.03	0.99	79.95
Solid	102.33	Other Bit. Coal	26.71	0.98	95.98
		Lignite	28.48	0.98	102.33
Gaseous	55.11	Natural Gas	15.10	0.995	55.11
Biomass	101.16	Wood	27.59	0.98	101.16

3.2.4.8 Category 1.AA.2.E – Food processing, beverage and tobacco

Total volume of fuels in this category expressed in energy units represented 5 357.36 TJ in 2011. Total CO_2 emissions were 312.03 Gg, total CH_4 emissions were 0.03 Gg and total N_2O emissions were 0.001 Gg in this category. The fuels are allocated among solid, liquid, gaseous and biomass fuels categories.

1.AA.2e	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	63.92	Gas / Diesel Oil	20.28	0.99	73.62
		LPG	17.56	0.99	63.74
Solid	102.33	Lignite	28.48	0.98	102.33
Gaseous	55.11	Natural Gas	15.10	0.995	55.11
Biomass	89.10	Wood	27.59	0.98	101.16
		Biogas	23.84	0.995	87.41

3.2.4.9 Category 1.AA.2.F – Other

The remaining emissions from fuel combustion in industries described in the Table 3.2 are reported in this category. Total volume of fuels in this category expressed in energy units represented 32 611.12 TJ in 2011. Total CO_2 emissions were 2 074.76 Gg, total CH_4 emissions were 0.17 Gg and total N_2O emissions were 0.02 Gg in this category. The fuels are allocated among solid, liquid, gaseous and biomass fuels categories.

1.AA.2f	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	66.70	Gas / Diesel Oil	20.28	0.99	73.62
		Residual Fuel Oil	22.03	0.99	79.95
		LPG	17.56	0.99	63.74
Solid	90.18	Anthracite	26.43	0.98	94.97
		Other Bit. Coal	26.71	0.98	95.98
		Lignite	28.48	0.98	102.33
		Coking Gas	12.92	0.98	46.41
		Blast-Furnace Gas	71.24	0.98	256.00
		Coke Oven/Gas Coke	29.75	0.98	106.89
Gaseous	55.11	Natural Gas	15.10	0.995	55.11
Biomass	101.16	Wood	27.59	0.98	101.16

3.2.4.10 Category 1.AA.4.A – Commercial/Institutional

Total volume of fuels in this category expressed in energy units represented 14 813.02 TJ in 2011. Total CO_2 emissions were 721.74 Gg, total CH_4 emissions were 0.11 Gg and total N_2O emissions in this category were 0.01 Gg in this category. The fuels are allocated among solid, liquid, gaseous and biomass fuels categories.

1.AA.4a	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	71.38	Gas / Diesel Oil	20.28	0.99	73.62
		Residual Fuel Oil	22.03	0.99	79.95
		LPG	17.56	0.99	63.74
		Other Oil	19.82	0.99	71.95
Solid	99.25	Other Bit. Coal	26.71	0.98	95.98
		Lignite	28.48	0.98	102.33
		Coke Oven/Gas Coke	29.75	0.98	106.89
Gaseous	55.11	Natural Gas	15.10	0.995	55.11
Biomass	97.90	Wood	27.59	0.98	101.16
		Biogas	23.84	0.995	87.41

3.2.4.11 Category 1.AA.4.B – Residential

Total volume of fuels in this category expressed in energy units represented 71 329.72 TJ in 2011. Total CO_2 emissions were 2 884.35 Gg, total CH_4 emissions were 0.86 Gg and total N_2O emissions were 0.09 Gg in this category. The fuels are allocated among solid (coal, coke, brown coal, and briquettes), gaseous (NG) and biomass (wood) fuels categories. No liquid fuel is reported in this category.

The activity data collected in this category are summarized in the NEIS central database as small sources according to the information about the sales of solid fuels to households from retailers. The consumption of natural gas for inhabitants is periodically announced by Slovak Gas Industry (SPP, a.s.). The activity data are verified by the information collected in the Statistical questionnaires. This comparison is available since the year 2001 and the results are provided in the Table 3.12.

1.AA.4b	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Solid	98.13	Other Bit. Coal	26.71	0.98	95.98
		Lignite	28.48	0.98	102.33
		BKB & Patent Fuel	25.16	0.98	90.41
		Coke Oven/Gas Coke	29.75	0.98	106.89
Gaseous	55.11	Natural Gas	15.10	0.995	55.11
Biomass	101.16	Wood	27.59	0.98	101.16

Table 3.12: *Comparison of the household fuel combustion in the category 1.AA.4b between the NEIS data (used in inventory) and NES data (SO SR)*

Fuel Consumption Source		Year Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total	NEIS	PJ	102.17	88.36	90.69	88.81	92.52	84.34	73.64	101.2	71.79	77.55	71.33
	NES	PJ	73.66	73.21	71.06	68.06	62.84	57.36	50.41	54.13	54.69	60.19	53.13
	Diff.	%	139	121	128	130	147	147	146	187	131	129	134
Solid	NEIS	PJ	16.80	5.67	6.30	6.00	4.63	4.03	2.60	1.95	2.58	4.72	1.80
	NES	PJ	3.02	5.21	3.27	4.25	1.75	1.87	1.77	2.41	1.77	2.06	1.89
	Diff.	%	556	109	192	141	265	215	147	81	146	229	95
NG	NEIS	PJ	70.07	67.80	68.08	62.24	59.23	53.85	46.47	52.76	50.33	55.63	49.13
	NES	PJ	70.62	68.00	67.79	62.51	59.67	54.42	46.99	50.23	51.31	56.33	49.38
	Diff.	%	99	100	100	100	99	99	99	105	98	99	100
Bio-mass	NEIS	TJ	15.30	14.90	16.31	20.57	28.66	26.46	24.56	46.45	18.88	17.19	20.40
	NES	TJ	0.02	0.00	0.00	1.30	1.42	1.07	1.64	1.49	1.62	1.80	1.86
	Diff.	%	-	-	-	1 586	2 021	2 468	1 495	3 126	1 166	958	1 096

According to the information provided in the Table 3.12 it is visible, that the completeness of the information on fuels consumption provided by the Statistical Office of the Slovak Republic which was allocated in the category residential heating is strongly underestimated. Mostly in biomass consumption the reporting of the SO SR is incomplete (wood consumption). The opposite situation is in the solid fuels, where the consumption provided by the SO SR is higher that in the NEIS databases. This is caused by the including solid fuels, which cannot be incinerated in households (such as hard coal with the NCV corresponded to the energetic coal used in electricity production). In total, fuels consumption reported in the CRF table 1.AA.4b is 134% higher than the consumption reported in the energy balance of the SO SR. The NG consumption is similar due to one data provider, which is the company Slovak Gas Industry both to the NEIS and to the NES of the SO SR.

3.2.4.12 Category 1.AA.4.C – Agriculture, forestry and fisheries

Total volume of fuels in this category expressed in energy units represented 1 948.53 TJ in 2011. Total CO_2 emissions were 92.05 Gg, total CH_4 emissions were 0.01 Gg and total N_2O emissions were 0.0004 Gg in this category. The fuels are allocated among solid, liquid, gaseous and biomass fuels categories.

1.AA.4c	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	65.70	Gas / Diesel Oil	20.28	0.99	73.62
		Residual Fuel Oil	22.03	0.99	79.95
		LPG	17.56	0.99	63.74
Solid	102.32	Other Bit. Coal	26.71	0.98	95.98
		Lignite	28.48	0.98	102.33
		BKB & Patent Fuel	25.16	0.98	90.41
		Coke Oven/Gas Coke	29.75	0.98	106.89
Gaseous	55.11	Natural Gas	15.10	0.995	55.11
Biomass	89.12	Wood	27.59	0.98	101.16
		Biogas	23.84	0.995	87.41

3.2.4.13 Category 1.AA.5.A – Other stationary

Total volume of fuels in this category expressed in energy units represented 19 066.41 TJ in 2011. Total CO_2 emissions were 1 032.94 Gg, total CH_4 emissions were 0.09 Gg and total N_2O emissions were 0.002 Gg in this category. The fuels are allocated among solid, liquid, gaseous and biomass fuels categories.

1.AA.5a	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	77.17	Gas / Diesel Oil	20.28	0.99	73.62
		Residual Fuel Oil	22.03	0.99	79.95
		LPG	17.56	0.99	63.74
Solid	101.64	Other Bit. Coal	26.71	0.98	95.98
		Lignite	28.48	0.98	102.33
		Coke Oven/Gas Coke	29.75	0.98	106.89
Gaseous	55.11	Natural Gas	15.10	0.995	55.11
Biomass	87.96	Wood	27.59	0.98	101.16
		Biogas	23.84	0.995	87.41

3.2.4.14 Category 1.AA.5.B – Mobile (Military aviation)

Total volume of fuels in this category expressed in energy units represented 21.73 TJ in 2011. Total CO_2 emissions were 1.59 Gg, total CH_4 emissions were 0.13 Gg and total N_2O emissions were 0.18 Gg in this category. The jet kerosene from military aviation is reported in this category in liquid fuel. These emissions were reallocated from the category 1.AA.3e based on the ERT´s recommendation from previous review.

1.AA.5b	Weighted EF (CO_2) t/TJ	Fuel type	EF (C) t/TJ	Oxidation Factor	EF (CO_2) t/TJ
Liquid	73.05	Jet Kerosene	19.92	0.99	73.05

GHG emissions from military aviation, i.e. jet kerosene consumption, have been included into the category 1.AA.5.B Mobile since 1990. The information is directly from the Ministry of Defense of the Slovak Republic. The methodology is comparable with the methodology for the estimation of emissions from civil aviation, based on fuel consumption in military service multiplied by the default emission factor for jet kerosene. The emissions are not key source. No recalculation was provided in this category, the only change is reallocation from the category 1.AA.3.E to the category 1.AA.5.B.

3.2.5 Uncertainties and time-series consistency

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 (IPCC, 1996) and default emission factors consistent with previous reporting. These categories are not key sources. For emission uncertainty assessment AD, caloric value, EF and their uncertainties are available in the energy sector. The expression of EFs changed from CO_2 to C in t/TJ in this inventory calculation. The conversion factor was used in formula. Additional important changes were entering new subsectors to Monte Carlo simulation: Civil Aviation, Road Transportation, Railways, Navigation and Military Aviation.

From expert analysis, the predetermined values for uncertainty are known. It helps us to verify the rightness of computation of aggregated uncertainty. From the background data structure, the differences between the Tier 1 and the Tier 2 method for uncertainty estimation are concentrated to the correlation among input parameters; formulas which are applied in the Tier 2 method use only multiplication and additional operation. The Tier 2 method is computed without correlation dependency; therefore Tier 1 and Tier 2 are well comparable. The Tier 2 method offers more reliable statistical results; it shows more information about statistical structure of analyzed 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 1A1, 1A2, 1A4 and 1A5. 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 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. Aggregate uncertainty is computed from partial uncertainties. For energy sector (fuel combustion) the combination of AD, EF and caloric values are utilized. Emission for specific source is computed:

$$Em_i=AD_i*NCV_i*EF_i/1000 \qquad (1)$$

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:

$$Emn_i=(AD_i+a\delta_i)*(NCV_i+n\delta_i)*(EF_i+e\delta_i)/1000 \qquad (2)$$

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 utilized. 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 follow suggestions and we play with normal, triangular and lognormal analytical distributions. An input data empirical PDF has been applied only in the problematic cases. Consecutive, the aggregate uncertainty is computed as the sum of partial emission uncertainties.

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

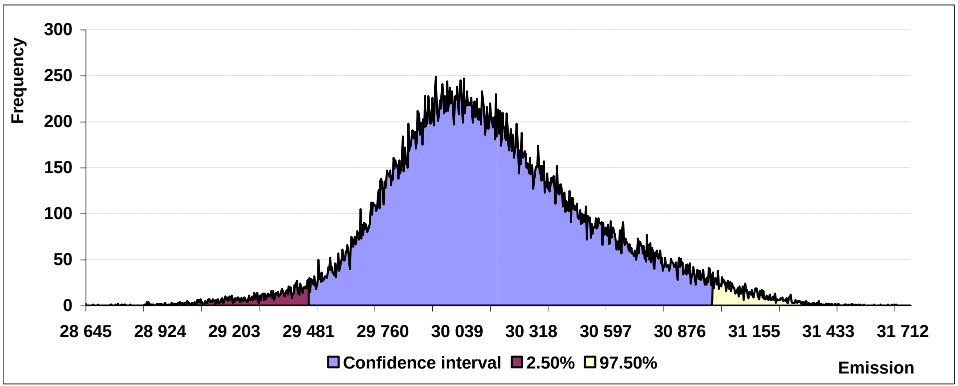
where *Z* represents the number of source inputs. The results for every category are generated from 60 000 trials, with random number generator of random numbers for adequate PDF.

From presented results obtained by Monte Carlo simulation (60 000 trials) it seems that the mean value is 30 164 853.99 t. Confidence interval (95%) is within the range: <29 485.85; 30 998.64>, which represents the uncertainty by relative values to the mean value: -2.25%; +2.76%. Following tables and graphs describe calculated results of uncertainty analyses.

Table 3.13: *Selected statistical characteristics for energy sector, 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
30 123.77	**30 164.85**	379.91	28 644.86	31 743.24	-2.25%	2.76%

Figure 3.9: *Probability density function for energy sector – sectoral approach in kt of CO_2*



The average mean value of GHG emissions for the Energy sector obtained by the Monte Carlo simulation is 30 164 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 30 220 kt. Comparison of tier 1 and tier 2 approaches for uncertainty estimation described above, can be found in the following tables.

Table 3.14: *Comparison of tier 2 and tier 1 (without CO_2 storage), emissions are in t per year*

Approach	Energy	1.A.1a	1.A.1b	1.A.1c	1.A.2a
Tier 2	30 164 853.9938	6 404 075.1774	1 454 958.6919	1 302 305.5224	4 869 700.3940
Tier 1	30 155 820.4842	6 403 803.9456	1 447 726.2854	1 302 152.8879	4 869 240.5446
Deviation tier 2-tier 1	9 033.5097	271.2318	7 232.4065	152.6345	459.8493

Approach	1.A.2b	1.A.2c	1.A.2d	1.A.2e	1.A.2f
Tier 2	234 767.7632	2 061 282.8303	374 008.3812	314 199.6609	2 101 283.7216
Tier 1	234 760.0396	2 061 148.9190	373 949.7652	314 179.1448	2 101 251.6238
Deviation tier 2-tier 1	7.7236	133.9112	58.6160	20.5161	32.0978

Approach	1.A.3a	1.A.3b	1.A.3c	1.A.3d
Tier 2	5 795.3565	6 197 591.8708	84 731.7868	30.3790
Tier 1	5 794.5431	6 197 075.4711	84 739.0614	30.3869
Deviation tier 2-tier 1	0.8134	516.3998	-7.2747	-0.0079

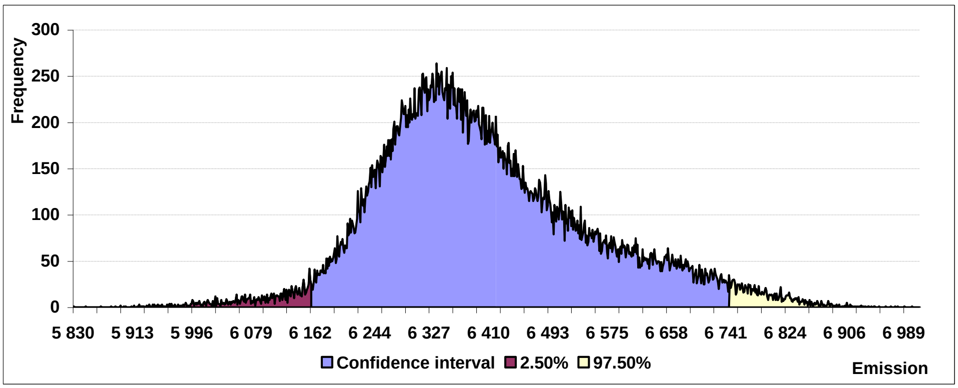
Approach	1.A.4a	1.A.4b	1.A.4c	1.A.5a	1.A.5b
Tier 2	726 155.2452	2 901 550.1919	92 544.8703	1 038 284.8920	1 587.2586
Tier 1	726 080.7629	2 901 555.7594	92 546.7486	1 038 197.1919	1 587.4028
Deviation tier 2-tier 1	74.4822	-5.5676	-1.8783	87.7001	-0.1443

The average mean value of GHG emissions for the 1.A.1a category obtained by the Monte Carlo simulation is 6 404 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 6 273 kt. Confidence interval (95%) is within the range: <6 163.18; 6 746.69>, which represents the uncertainty by relative values to the mean value: -3.76%; +5.35%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.15: *Selected statistical characteristics for 1.A.1a, 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
6 379.28	**6 404.08**	149.18	5 830.46	7 012.78	-3.76%	5.35%

Figure 3.10: *Probability density function for 1.A.1a in kt of CO_2*

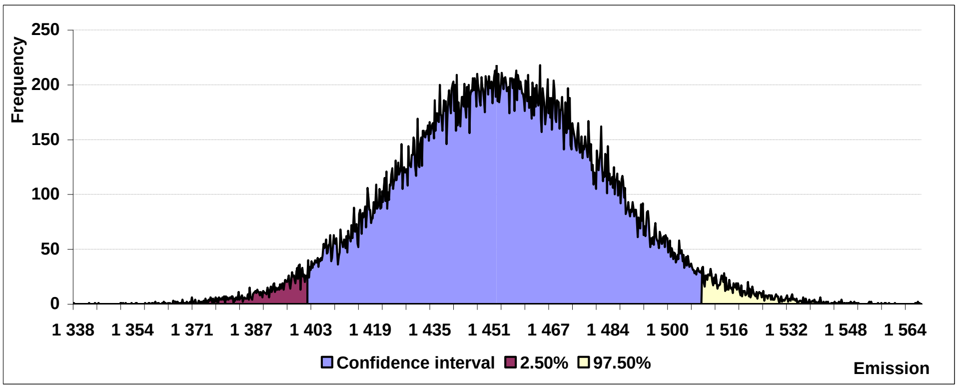


The average mean value of GHG emissions for the 1.A.1b category obtained by the Monte Carlo simulation is 1 455 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 745 kt. Confidence interval (95%) is within the range: <1 401.99; 1 509.17>, which represents the uncertainty by relative values to the mean value: -3.64%; +3.73%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.16: *Selected statistical characteristics for 1.A.1b, 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
1 454.82	**1 454.96**	27.46	1 338.23	1 569.05	-3.64%	3.73%

Figure 3.11: *Probability density function for 1.A.1b in kt of CO_2*

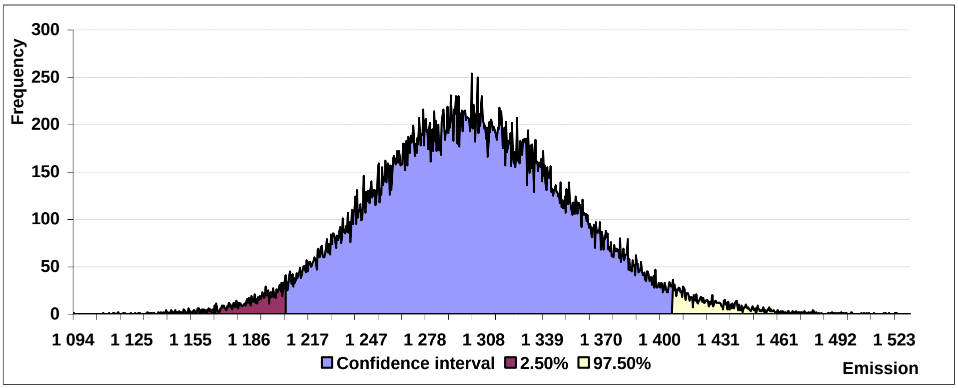


The average mean value of GHG emissions for the 1.A.1c category obtained by the Monte Carlo simulation is 1 302 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 277 kt. Confidence interval (95%) is within the range: <1 205.71; 1 407.21>, which represents the uncertainty by relative values to the mean value: -7.42%; +8.06%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.17: *Selected statistical characteristics for 1.A.1c, 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
1 300.96	**1 302.31**	51.33	1 094.28	1 531.37	-7.42%	8.06%

Figure 3.12: *Probability density function for 1.A.1c in kt of CO_2*

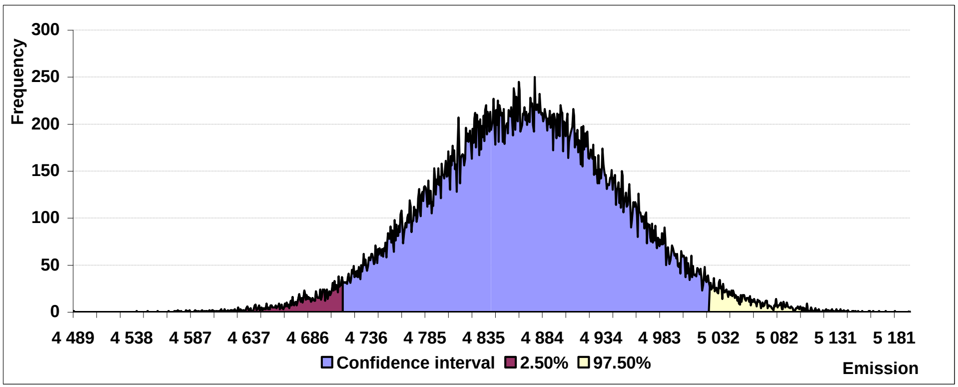


The average mean value of GHG emissions for the 1.A.2a category obtained by the Monte Carlo simulation is 4 870 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 4 773 kt. Confidence interval (95%) is within the range: <4 716.05; 5 025.06>, which represents the uncertainty by relative values to the mean value: -3.16%; +3.19%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.18: *Selected statistical characteristics for 1.A.2a, 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
4 869.49	**4 869.70**	79.07	4 488.56	5 194.88	-3.16%	3.19%

Figure 3.13: *Probability density function for 1.A.2a in kt of CO_2*

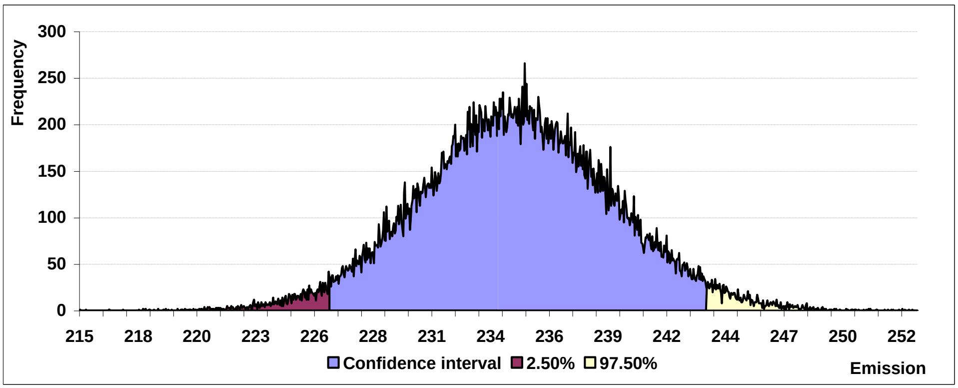


The average mean value of GHG emissions for the 1.A.2b category obtained by the Monte Carlo simulation is 235 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 231 kt. Confidence interval (95%) is within the range: <226.34; 243.38>, which represents the uncertainty by relative values to the mean value: -3.59%; +3.67%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.19: *Selected statistical characteristics for 1.A.2b, 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
234.73	**234.77**	4.35	215.05	252.92	-3.59%	3.67%

__Figure 3.14:__ Probability density function for 1.A.2b in kt of CO_2

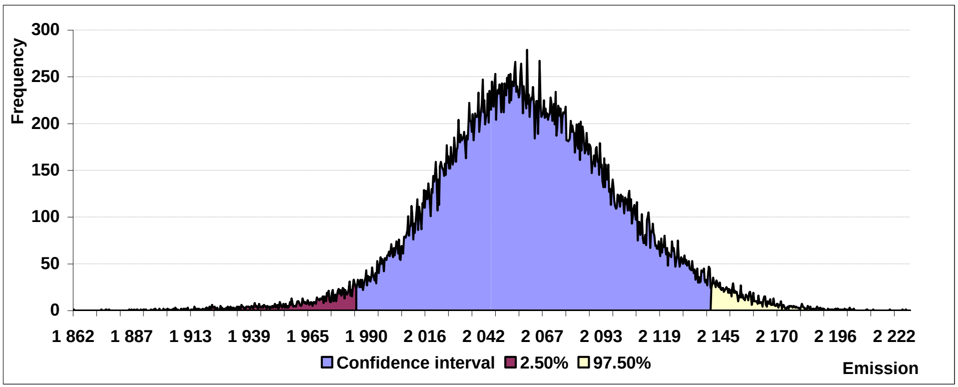


The average mean value of GHG emissions for the 1.A.2c category obtained by the Monte Carlo simulation is 2 061 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 2 045 kt. Confidence interval (95%) is within the range: <1 985.91; 2 141.52>, which represents the uncertainty by relative values to the mean value: -3.66%; +3.89%. Following table and graph describe calculated results of uncertainty analyses.

__Table 3.20:__ Selected statistical characteristics for 1.A.2c, 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
2 059.78	**2 061.28**	39.45	1 861.63	2 229.14	-3.66%	3.89%

__Figure 3.15:__ Probability density function for 1.A.2c in kt of CO_2

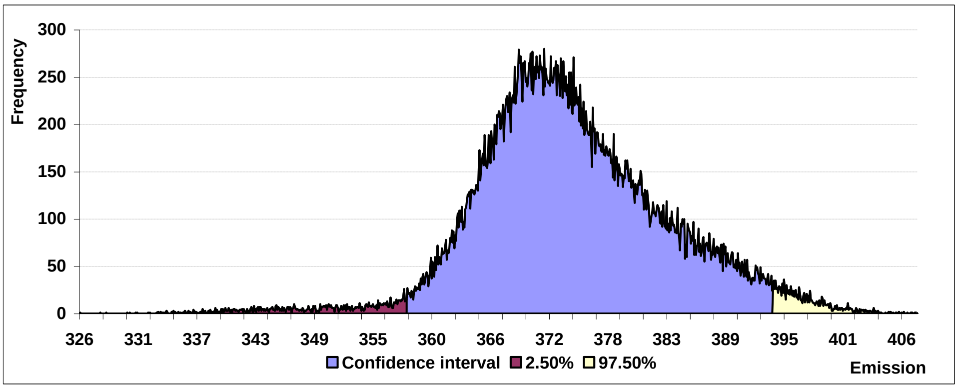


The average mean value of GHG emissions for the 1.A.2d category obtained by the Monte Carlo simulation is 374 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 368 kt. Confidence interval (95%) is within the range: <357.84; 393.80>, which represents the uncertainty by relative values to the mean value: -4.32%; +5.28%. Following table and graph describe calculated results of uncertainty analyses.

__Table 3.21:__ Selected statistical characteristics for 1.A.2d, 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
373.03	**374.01**	9.27	325.74	408.00	-4.32%	5.28%

Figure 3.16: Probability density function for 1.A.2d in kt of CO_2

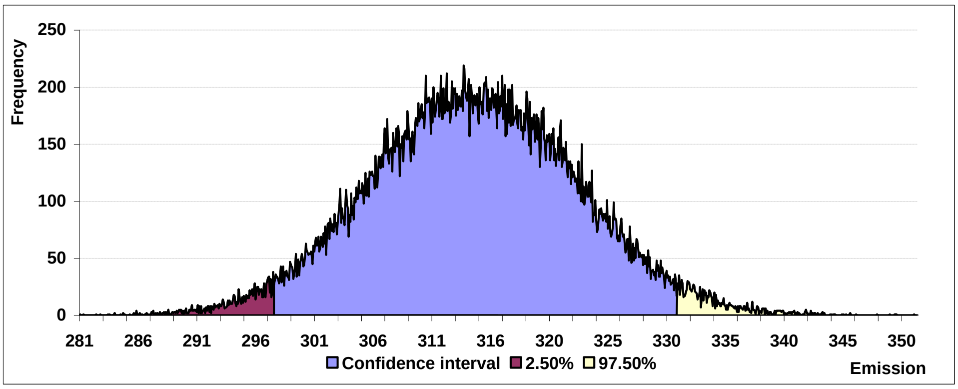


The average mean value of GHG emissions for the 1.A.2e category obtained by the Monte Carlo simulation is 314 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 312 kt. Confidence interval (95%) is within the range: <297.64; 331.10>, which represents the uncertainty by relative values to the mean value: -5.27%; +5.38%. Following table and graph described calculate results of uncertainty analyses.

Table 3.22: *Selected statistical characteristics for 1.A.2e, 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
314.14	**314.20**	8.55	281.39	351.19	-5.27%	5.38%

Figure 3.17: *Probability density function for 1.A.2e in kt of CO_2*

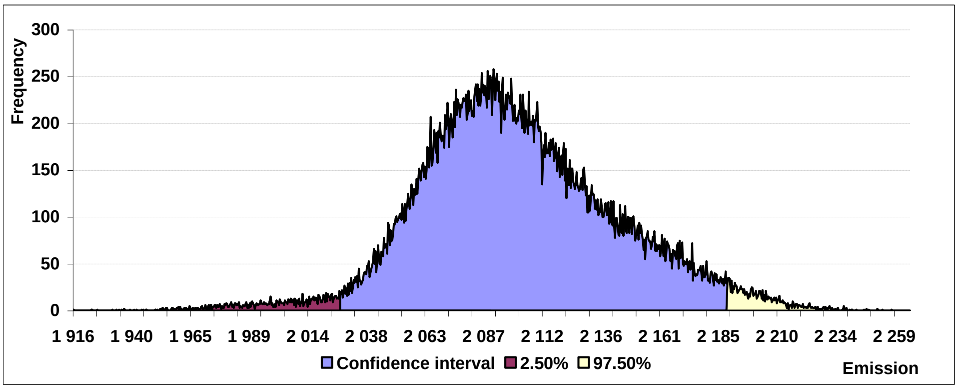


The average mean value of GHG emissions for the 1.A.2f category obtained by the Monte Carlo simulation is 2 101 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 2 075 kt. Confidence interval (95%) is within the range: <2 027.42; 2 188.72>, which represents the uncertainty by relative values to the mean value: -3.52%; +4.16%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.23: *Selected statistical characteristics for 1.A.2f, 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
2 097.36	**2 101.28**	40.93	1 915.64	2 265.61	-3.52%	4.16%

Figure 3.18: *Probability density function for 1.A.2f in kt of CO_2*

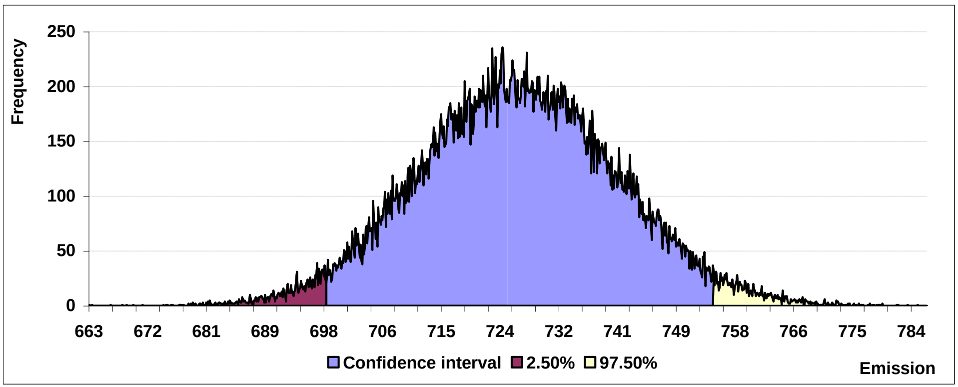


The average mean value of GHG emissions for the 1.A.4a category obtained by the Monte Carlo simulation is 726 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 722 kt. Confidence interval (95%) is within the range: <698.16; 754.74>, which represents the uncertainty by relative values to the mean value: -3.86%; +3.94%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.24: *Selected statistical characteristics for 1.A.4a, 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
726.03	**726.16**	14.48	663.46	786.07	-3.86%	3.94%

Figure 3.19: *Probability density function for 1.A.4a in kt of CO_2*

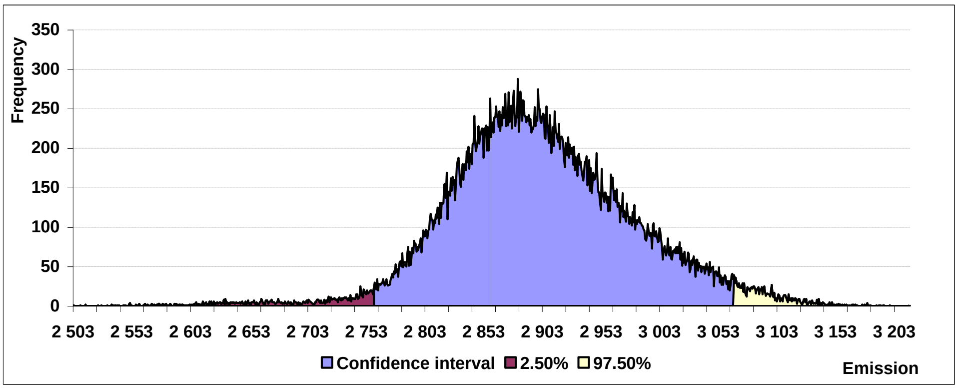


The average mean value of GHG emissions for the 1.A.4b category obtained by the Monte Carlo simulation is 2 902 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 2 885 kt. Confidence interval (95%) is within the range: <2 760.32; 3 066.39>, which represents the uncertainty by relative values to the mean value: -4.87%; +5.68%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.25: *Selected statistical characteristics for 1.A.4b, 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
2 896.27	**2 901.55**	78.68	2 503.37	3 217.44	-4.87%	5.68%

Figure 3.20: *Probability density function for 1.A.4b in kt of CO_2*

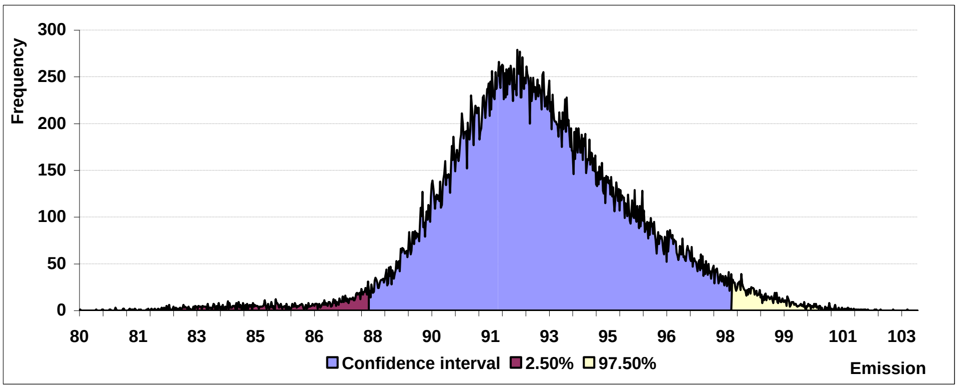


The average mean value of GHG emissions for the 1.A.4c category obtained by the Monte Carlo simulation is 93 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 92 kt. Confidence interval (95%) is within the range: <87.84; 98.00>, which represents the uncertainty by relative values to the mean value: -5.08%; +5.89%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.26: *Selected statistical characteristics for 1.A.4c, 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
92.36	**92.54**	2.60	79.72	103.22	-5.08%	5.89%

Figure 3.21: *Probability density function for 1.A.4c in kt of CO_2*

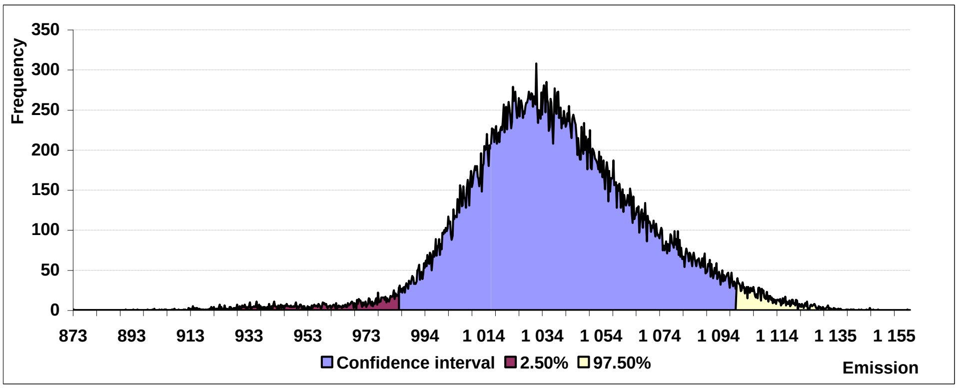


The average mean value of GHG emissions for the 1.A.5a category obtained by the Monte Carlo simulation is 1 038 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 033 kt. Confidence interval (95%) is within the range: <984.89; 1 100.43>, which represents the uncertainty by relative values to the mean value: -5.14%; +5.99%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.27: *Selected statistical characteristics for 1.A.5a, 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
1 036.24	**1 038.28**	29.73	872.72	1 160.42	-5.14%	5.99%

Figure 3.22: Probability density function for 1.A.5a in kt of CO_2

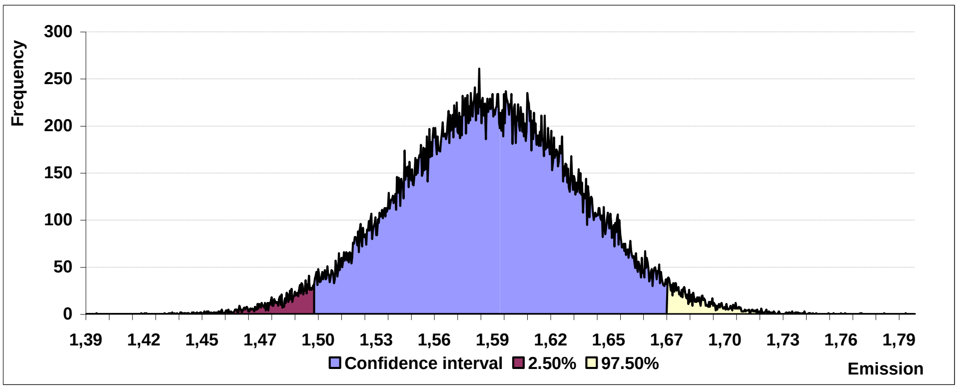


The average mean value of GHG emissions for the 1.A.5b category obtained by the Monte Carlo simulation is 1.59 kt per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1.59 kt. Confidence interval (95%) is within the range: <1.50; 1.67>, which represents the uncertainty by relative values to the mean value: -5.45%; +5.49%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.28: *Selected statistical characteristics for 1.A.5b, 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
1.59	**1.59**	0.04	1.39	1.79	-5.45%	5.49%

Figure 3.23: Probability density function for 1.A.5b in kt of CO_2



The emission inventory in the energy sector – sectoral approach is based on activity data directly provided by producers in the NEIS database since 2000. Time series is consistent in all aspects since 2000 (methodological approach, country specific EFs and oxidation factor used, fuel characteristics, etc.) to the detailed level of disaggregation (on plant specific level). Chapter 3.1.3.3 of this Report described in detail the data source for emission estimation before 2000. The database system REZZO, used in the sectoral approach emission estimation as main source for activity data and emission factors in 1990 – 1999, was based on different aggregation level and therefore the activity data are not possible to be allocated in the same way in the detailed CRF categories as was done after the year 2000. This disaggregation was made manually and in some categories also regression was used to reconstruct consistent time series 1990 – 1999. The regression was used mostly for estimation of mixed CO_2 emission factors in the solid and liquid fuel categories before 2000. It is important to emphasized, that the aggregated sum of fuels consumption in the individual categories 1.A.1, 1.A.2, 1.A.4 and 1.A.5 is based on the data provided in the REZZO database (from the producers and the national statistics). Emission factors of non-CO_2 gases were used according to the default values of the IPCC 2000 GPG for the all time series.

Since 2000, complete time series have been evaluated 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 ETS (from 2005 – 2007 and 2008 – 2011). Overall, methodologies and data sources are as consistent as possible at this stage.

3.2.6 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:

- 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.

Emission balance in energy made for sectoral approach was prepared in the model calculation taking into consideration also emission balance in transport and industrial processes sectors. The sector specific QC activities were performed directly during emission balance preparation. Several data sources were compared and checked. The differences were consulted with the SO SR, the NEIS experts and operators (or verifiers).

The QC activities directly provided during data collection in the NEIS database are running at two levels. The first level is represented by 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 for the data of X-1 year. After closing the QC activities, the verification process returns back to the operators of installations. They receive decisions issued according to effective legislation on payments for the emissions of basic pollutants. 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.

The QA activities are performed after finishing the energy balance and include comparison with other data sources and several automatic calculations. The most important QA activities are verification of emissions calculation with emissions provided in the ETS reports. Since 2005, the energy balances from the most significant sources of air pollution have been included in the National Allocation Plan and monitored according to the Directive No 2003/87/EC establishing a scheme for GHG emission allowances trading, which was transposed into Act No 527/2004 Coll. on emission trading scheme (ETS) amended by the Act No 414/2012 Coll. In order to comply with the quality management criteria and data harmonization between ETS and the national emission balance at sectoral level, emission factors of the most important fuels have been re-evaluated and new methods have been implemented at the level of source operators. By comparison and correct allocation of CO_2 emissions in sector energy, it can be concluded that the balance is in a good compliance with the emissions verified within ETS. The comparison of the years 2005 – 2007 was carried out based on the National Allocation Plan I and the comparison of years 2008 – 2011 were carried out based on the National Allocation Plan II. The results are shown in Figure 3.24. The trend of differences was increasing during the first NAP (2005 – 2007) (-0.56%, -3.17%, -5.59%), while in the second NAP (2008 – 2011), the difference was stabilized with slight increase for the last year (-2.21%, -2.16%, -0.80%, 3.67%). It can be explained by non-compatibility of source allocation, different definitions of technological and energy emissions and allocation of polluting sources according to the IPCC methodology in the NAP I. The improvement in the NAP II depended also on the revision of the directive 2003/87/EC. The comparison was provided for most important sources (energy and technology) (Table 3.29), but also only for energy sources (Figure 3.24). For the comparison study, 26 biggest emitters were taken, which represent more than 90% of all allocated emissions in the Slovak Republic.

Figure 3.24: *Comparison of CO_2 emissions from energy sources (in Gg) allocated in ETS and estimated by sectoral approach from the NEIS database for 2005 – 2011*

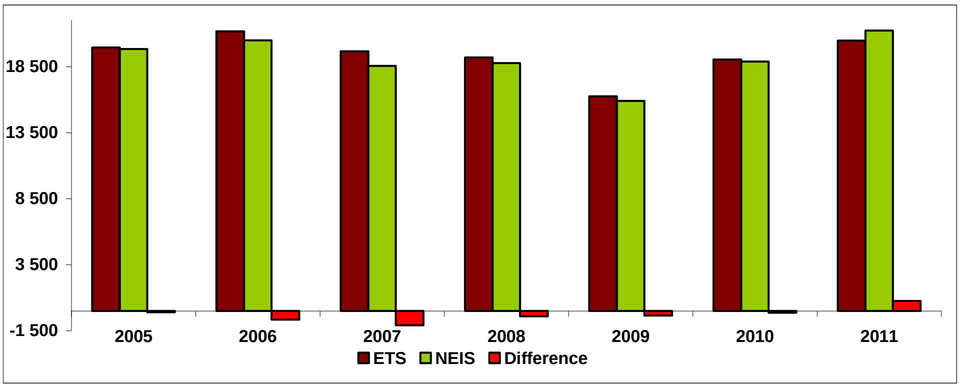


Table 3.29: *Comparison of CO_2 emissions (in Gg) allocated in ETS and estimated by sectoral approach from NEIS database for 2005 – 2011*

Energy + Technology (CO_2 Gg)							
NAP	**NAP I**			**NAP II**			
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
ETS	21 487.27	22 684.75	21 033.72	20 567.60	17 916.09	21 698.63	22 222.53
NEIS	19 825.35	20 496.39	18 554.39	18 772.50	15 900.96	18 876.83	21 228.91
Difference	-1 661.93	-2 188.36	-2 479.33	-1 795.10	-2 015.12	-2 821.79	-993.63
Difference	***-7.73%***	***-9.65%***	***-11.79%***	***-8.73%***	***-11.25%***	***-13.00%***	***-4.47%***
Energy (CO_2 Gg)							
NAP	**NAP I**			**NAP II**			
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
ETS	19 937.20	21 166.72	19 652.88	19 197.17	16 251.32	19 029.13	20 478.36
NEIS	19 825.35	20 496.39	18 554.39	18 772.50	15 900.96	18 876.83	21 228.91
Difference	-111.85	-670.33	-1 098.49	-424.66	-350.35	-152.30	750.54
Difference	***-0.56%***	***-3.17%***	***-5.59%***	***-2.21%***	***-2.16%***	***-0.80%***	***3.67%***

3.2.7 Source specific recalculations

Recalculations are summarized in the table 8(b) in the CRF tables 1990 – 2010. The recalculations were performed for the time series back to the base year in line with the QA/QC improvement plan. Detailed description of recalculations is in Table 10.1 in the Chapter 10 of this Report. The following recalculations were made in 2013 submission in sectoral approach:

- The correction of carbon emission factor for natural gas in the category 1.A.4b – Residential in the year 2008 led to the correction of CO_2 emissions in this category. The corrected EF(CO_2) is 54.75 t/TJ (previously incorrect was 56.95 t/TJ). Corrected CO_2 emissions = 2 888.29 Gg. This caused CO_2 emissions decrease in this source category by 4%.
- Improvement of emission factors for biomass in the categories 1.A.4a, 1.A.4b, 1.A.4c and 1.A.5a, the IPCC 2006 default EF for biomass (solid, liquid, gaseous) were used instead of one average EF and therefore the time series were recalculated back to the year 2000. The corrections occurred also in consumption of biomass mostly caused by the NCVs corrections.

- The CO_2 emissions of the Industrial Solid Waste Incineration with energy use allocated in the category 1.A.1a – other fuels were recalculated based on reconstructed time series for the quantity of waste incinerated with energy use. This was based on the ERT recommendations.
- Improvement of the CH_4 and N_2O emission factors in the categories 1.A.1a and 1.A.4a-c based on the IPCC 2000 GPG. Default EFs were used directly to the individual fuels and the time series was recalculated. Total impact of these changes on the emission level is negligible.
- The reallocation of emissions from military aviation into category 1.A.5b influenced total emissions from this category also for previous years.

Since the draft of ARR 2012 was not available before April 2013 submission, the Slovak National Inventory System was not in position to include improvements for all recommendations identified in the ARR 2012. The manager of NIS will summarize and evaluate in terms of QA/QC system the list of recommendations made by ERT and implement further steps in line with the IPCC 2000 GPG in the next submission.

3.2.8 Source specific planned improvements

Based on agreement between the Ministry of Environment, SHMU and the SO SR, disaggregated data for 2011 on energy balance were provided in November 2012. These data were decoded according to the item codes provided in yearly reports of the SO SR (report on production of liquid fuels from crude oil and report on sources and division of fuels and energy). From these, energy balance of fuels in form of input output analysis was performed. First analysis was focused on Refinery Slovnaft, Slovnaft Petrochemicals and heating plant CM European power Slovakia. Resulting flows and their summaries were compared with the NEIS database. Potential ways for harmonization of data gathering were discussed with the SO SR. The plan is to continue with this exercise also in this year and to compare bottom up and top down data also for other enterprises and explore possibilities for harmonization and QA/QC compliance. Then disaggregated data from the SO SR can be potentially used instead of data from the NEIS in order to safeguard more comparable data sets.

The category 1.A.2f now includes all other industries not included in other categories. According to the recommendations of the EU review process, next improvement will be focused on the disaggregation of industrial sources in the individual subcategories among 1.A.2f.

There is a plan to improve reporting of carbon stored balance and apparent consumption reporting. According to the analysis of the detailed data provided by the SO SR, carbon stored in iron and steel industry (mostly coking coal) is not reported as carbon stored in their database, therefore, the comparison of the SA and RA approach is not consistent. Due to the methodology used in the SA, the fuel used in technology step of iron and steel production is deducted from the SA balance and reported in the IP sector. The apparent consumption will be improved this way, too.

There are also following improvements planned based on the ARR 2012 (included in the plan):

- Regarding the Para 70 of the ARR 2012:

As noted by the ERT average composition of natural gas combusted in the country is consistent with CO_2 EF of about 55.0 t CO_2/TJ. Differences in CO_2 IEFs in the years (1990 – 1999) raised from the performed backward regression based on the country specific EFs based on the Slovak Gas Industry available since the year 2000. This regression analysis was performed in the year 2004 based on the ERT recommendations. Carbon content of natural gas imported to Slovakia from Russia is lower because of its higher methane content. Especially since the year 2000 till 2004 carbon content of natural gas had had decreasing trend and extrapolation based on this trend resulted in relatively higher IEFs since the base year.

- Regarding the Para 67 and 68 of the ARR 2012:

The planned improvements are that in next steps for selected key sources emissions will be compared based on the National Energy Statistics and the EU ETS Registry. In case of sources where transformation of fuels from primary to secondary occurs (coking battery, metallurgy, oil refinery) emissions will be compared based on the amount of combusted fuel as well as input-output carbon balance. CO_2, CH_4, N_2O emissions in petroleum refining will be reported in amount of fuel combusted, nevertheless CO_2 balance will be compared under carbon input-output.

- Regarding the Para 62 and 65 of the ARR 2012:

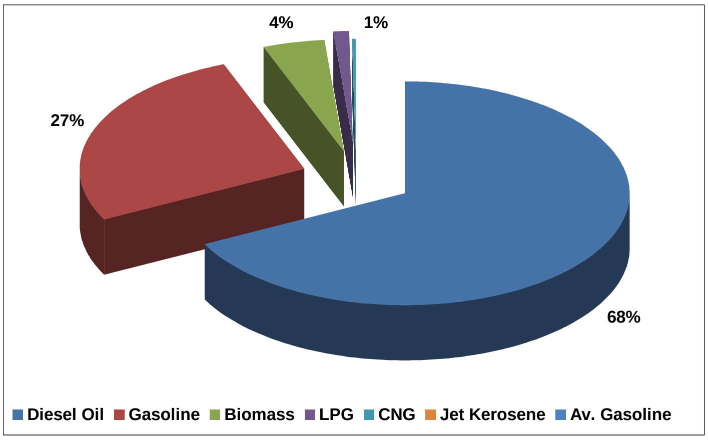
Applying IPCC 2000 GPG the equivalent of fuel consumption and corresponding CO_2 emissions will be reallocated into relevant categories of the IPPU sector.

3.3 Transport (CRF 1.AA.3)

3.3.1 Source category description

The emissions from category 1.A.3 Transport include the Civil aviation (1.A.3a), the Road transportation (1.A.3b), the Railways (1.A.3c) and the inland Navigation (1.A.3d) sources in the Slovak Republic in year 2011. The emissions from road and non-road transport were calculated by using models and default methods and the consistent data series from 1990 to 2011 are presented in CRF tables. The GHG emission inventory of category transport 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) and greenhouse gases (CO_2, CH_4, N_2O) emitted in the Slovak Republic in year 2011. The balance of pollutant and heavy metal emissions was evaluated according to the EMEP/CORINAIR Emission Inventory Guidebook methodology and by using the software product COPERT IV version 8.1. The emissions from road transport were recalculated from the base year 1990 year by using updated version COPERT IV version 8.1 to receive consistent time series in the previous submission (2011). Total GHG emissions in the category transport were 6 380.02 Gg of CO_2 equivalents in 2011. The CO_2 emissions were 6 287.64 Gg which represents 98.55% share on total transport emissions, CH_4 emissions were 13.56 Gg of CO_2 eq. with the 0.21% share and N_2O emission were 78.82 Gg of CO_2 eq. with the 1.24% share on total transport emissions. The share of road transportation was 98.4%, railways 1.5%, civil aviation represents 0.1% and navigation 0.001%. Total energy consumption was 90 241 TJ of fuels in category transport. In terms of fuels, the most important are liquid fuels (diesel oil – 68%, gasoline – 27% and LPG – 1%, followed by jet kerosene – 0.08%, aviation gasoline - 0.004% and biomass – 4%) and gaseous fuel (CNG – 0.3%). No solid fuels are used in category transport. The complete time series of GHG emissions are presented in Table 3.30. All emissions from inland transport on Danube River are transit and included in international bunkers.

Figure 3.25: *The share of fuels in CO_2 eq. on different categories within transport in 2011*



Fuel	Consumption (TJ)	Share (%)
Diesel Oil	60 976.84	67.571%
Gasoline	24 058.63	26.660%
Biomass	4 006.84	4.440%
LPG	835.83	0.926%
CNG	283.43	0.314%
Jet Kerosene	75.72	0.084%
Av. Gasoline	3.88	0.004%

Table 3.30: *Fuel consumption and GHG emissions in transport subcategories in 1990 – 2011*

Year	Civil Aviation				Road Transportation			
	Consum.	CO_2	CH_4	N_2O	Consum.	CO_2	CH_4	N_2O
	(TJ)	(t)			(TJ)	(Gg)	(t)	
1990	105.83	7 736.80	1.00	0.80	61 454.90	4 503.02	1 165.44	189.15
1991	98.39	7 192.90	0.93	0.75	52 195.27	3 820.33	1 079.91	155.00
1992	90.95	6 649.10	0.86	0.69	48 477.38	3 544.54	1 076.88	137.43
1993	88.56	6 473.70	0.82	0.67	48 646.05	3 552.31	1 159.28	135.79
1994	75.17	5 495.50	0.71	0.57	52 121.92	3 804.83	1 218.39	151.11
1995	75.03	5 484.70	0.69	0.57	55 265.15	4 033.64	1 232.35	168.13
1996	87.94	6 427.90	0.79	0.67	56 058.64	4 089.46	1 180.20	177.45
1997	77.90	5 694.50	0.70	0.60	58 568.07	4 267.88	1 167.29	195.15
1998	71.60	5 233.50	0.63	0.55	62 665.18	4 562.40	1 192.33	211.87
1999	72.58	5 305.70	0.65	0.55	61 401.25	4 464.32	1 114.90	212.46
2000	75.21	5 498.50	0.73	0.57	54 925.45	3 989.01	958.55	185.23
2001	71.52	5 228.80	0.72	0.54	62 618.11	4 541.25	1 055.87	214.04
2002	74.58	5 453.20	0.76	0.56	64 548.80	4 686.24	999.67	198.88
2003	95.59	6 987.50	0.88	0.73	66 571.99	4 826.84	981.70	201.34
2004	124.11	9 069.50	0.95	0.97	70 094.16	5 090.84	950.28	193.90
2005	144.16	10 534.90	1.11	1.13	83 180.62	6 045.33	935.20	218.92
2006	160.68	11 741.71	1.20	1.26	77 519.59	5 636.49	859.18	201.08
2007	184.85	13 507.06	1.32	1.46	88 455.08	6 300.45	834.26	199.22
2008	206.50	15 087.88	1.39	1.65	91 417.67	6 499.33	826.18	216.52
2009	85.78	6 244.02	0.68	0.67	84 501.16	5 988.78	732.60	207.64
2010	80.16	5 836.28	0.67	0.62	91 735.56	6 463.41	716.28	218.54
2011	79.61	5 794.54	0.61	0.62	89 031.48	6 197.08	639.95	217.22
Year	**Railways**				**Inland Water Transport**			
	Consum.	**CO_2**	**CH_4**	**N_2O**	**Consum.**	**CO_2**	**CH_4**	**N_2O**
	(TJ)	(t)			(TJ)	(t)		
1990	5 022.82	376 770.60	29.50	161.91	0.303	22.751	0.001	0.009
1991	3 778.29	283 416.40	22.20	121.79	0.259	19.435	0.001	0.008
1992	3 117.25	233 830.20	18.30	100.49	0.242	18.129	0.001	0.007
1993	2 676.24	200 749.40	15.70	86.27	0.246	18.473	0.001	0.007
1994	2 526.24	189 497.90	11.30	81.40	0.262	19.620	0.001	0.008
1995	2 720.51	204 070.26	12.20	87.70	0.277	20.766	0.001	0.008
1996	2 669.71	200 259.50	11.90	86.10	0.296	22.208	0.001	0.009
1997	2 508.63	188 176.80	11.20	80.90	0.309	23.180	0.001	0.009
1998	2 301.29	172 623.70	10.30	74.20	0.323	24.198	0.001	0.010
1999	2 106.64	158 023.10	9.40	67.90	0.323	24.205	0.001	0.010
2000	2 076.36	155 751.50	9.30	66.90	0.327	24.534	0.001	0.010
2001	2 047.83	153 611.50	9.20	66.00	0.338	25.369	0.001	0.010
2002	1 902.30	142 694.80	8.50	61.30	0.354	26.574	0.001	0.011
2003	1 521.51	114 130.70	6.80	49.00	0.371	27.832	0.001	0.011
2004	1 459.14	109 452.32	6.52	47.04	0.390	29.267	0.002	0.012
2005	1 420.98	106 590.00	6.00	46.00	0.416	31.183	0.002	0.013
2006	1 509.61	113 238.58	6.75	48.66	0.451	33.832	0.002	0.014
2007	1 448.70	108 669.63	6.48	46.70	0.498	37.358	0.002	0.015
2008	1 329.78	99 749.60	5.94	42.87	0.545	40.876	0.002	0.017
2009	1 145.21	85 903.85	5.12	36.92	0.519	38.921	0.002	0.016
2010	1 170.54	87 804.08	5.23	37.73	0.540	40.488	0.002	0.016
2011	1 129.68	84 739.06	5.05	36.42	0.405	30.387	0.002	0.012

3.3.2 Source subcategory description – Civil aviation (CRF 1.AA.3.A)

The inventory evaluation of GHG emissions in subcategory of civil 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 number of LTO cycles is available and summary information from the Eurocontrol database) and according to the recommendations of ERT final findings in 2008, followed by IPCC GPG 2000, the emission estimation was based on the fuel sold to national and international civil flights (Tier 1 method). The estimation of GHG emissions was based on the fuel sold at the important Slovak airports (Bratislava, Košice, Poprad, Sliač, Piešťany and Žilina). The sale of fuels decreased in the period 1990 – 2011 by 20%. Compared to the previous year the decreasing trend was stabilized in 2010/2011. Total GHG emissions from domestic aviation represented 6.0 Gg of CO_2 equivalents in 2011. The increasing trend of emissions was visible in 2000 – 2008. The airports are managed by the Slovak Management of Airports, except for the airport in Žilina, where exercises with light aircrafts of the Žilina University predominate. Other smaller civil airports (Nitra, Prievidza, Ružomberok, Lučenec) are operated by aero-clubs with predominating character of sport flights. Currently, the extensive reconstruction and rebuilding of terminals of Bratislava airport were finished in 2012 and the increase of LTO is expected since this year.

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 Košice 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.

3.3.2.1 Methodological issues – methods

The Slovak Republic has used the tier 1 methodology for the estimation of emissions from aviation, both for aviation gasoline and jet kerosene, based on sold fuels. These categories are not key sources. The information on LTO cycles are known (26 069) and they have been used for air pollutants inventory, not divided into national and international flights. The emission estimation is based on fuel sale and the international rule for national and international flights based on expert judgment was evaluated.

Statistic methodology for the airport traffic is determined only by the origin of air operator for domestic and international flights. It means that no direct information about numbers of domestic and internationally operated flights is known from this data source. The average division of consumed fuel was executed by an expert estimation and verified by the information provided in the Eurocontrol database. The estimation was also discussed and explained during the in-country review 2012. Total jet kerosene for domestic consumption was estimated to be 5% and the international consumption was 95% from total quantity of sold fuel. 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) are consumed jet kerosene. In opposite, the aviation gasoline is mostly consumed by smaller aircrafts (operated on national flights - Bratislava – Poprad, Bratislava – Košice).

Emission estimation is calculated on the individual airports based on detailed statistics on LTO cycles, aircrafts type, their weights and fuel consumption and type of engines.

3.3.2.2 Methodological issues – emission factors and other parameters

Emission factors for CO_2 (jet kerosene and aviation gasoline) are constant values taken from EMEP/CORINAIR EIG. 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 Annexes of EMEP/CORINAIR EIG, are used for the determination of emission factors.

Table 3.31: *Starting conditions for the estimation of mixed EFs in civil aviation for jet kerosene*

Parameter	International Flight	National Flight
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 3.32: *Mixed emission factors for the GHG emission balance in civil aviation according Tier 1 method based on fuel consumption*

Parameter	Emission Factor (g/kg of fuel)	
	International Flight	National Flight
Emission	**Jet Kerosene**	
CO_2	3 150	3 150
CH_4	0.104	0.35
N_2O	0.05	0.25
Emission	**Aviation Gasoline**	
CO_2	3 150	
CH_4	0.1	
N_2O	1.9	

It is generally known, that in the period 1990 – 2011 the technological development of aircraft industry took place and the emissions were decreasing from air traffic per one LTO cycles and per fuel consumption. The use of mixed EFs based on recent knowledge on parameters of aircrafts could cause the underestimation of emissions in the previous period and the base year. It is historically proved, that in the earlier 90-ties, the obsolete aircrafts were used. Because no relevant information estimating time series is known from the previous period, the problem cannot be solved satisfactorily.

3.3.2.3 Activity data

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 emission estimation from civil aviation. The aircrafts are divided into two weight categories: under 5.7 t and over 5.7 t. The innovated method uses the emission factors for the each aircraft type and weight category. The number of the LTO cycles was 26 069 cycles in the inventory year 2011. Total consumption of jet kerosene was 1 748.79 t and the consumption of aviation gasoline was 90.75 t on national flights.

Table 3.33: *The quantity of fuels sold at the Slovak airports and GHG emissions during 1990 – 2011 for national flights*

Year	Aviation Gasoline					Jet Kerosene				
	Consumption		CO_2	CH_4	N_2O	Consumption		CO_2	CH_4	N_2O
	(TJ)	(t)	(t)			(TJ)	(t)	(t)		
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	7.14	166.87	525.700	0.317	0.017	137.02	3 177.53	10 009.20	0.79	1.11
2006	7.01	163.89	516.255	0.311	0.016	153.66	3 563.64	11 225.46	0.89	1.25
2007	6.37	148.88	468.965	0.283	0.015	178.48	4 139.08	13 038.10	1.03	1.45
2008	4.90	114.51	360.702	0.218	0.011	201.60	4 675.29	14 727.18	1.17	1.64
2009	4.89	114.36	360.243	0.217	0.011	80.88	1 867.87	5 883.78	0.47	0.65
2010	5.35	125.09	394.040	0.238	0.013	74.81	1 727.70	5 442.24	0.43	0.60
2011	3.88	90.75	285.864	0.172	0.009	75.72	1 748.79	5 508.68	0.44	0.61

The overview of fuel sale according to the type (aviation gasoline and jet kerosene) during 1990 – 2011 is shown in Table 3.33. For the period 1994 – 2011 the data came directly from the airport statistics processing information on annual basis. The data of fuel sale for the period 1990 – 1993 are based on the expert estimation according the real LTO cycles in this period. The overview of fuels quantity sold (filled in) at the Slovak airports during 1990 – 2011 is shown in Table 3.33.

3.3.2.4 Uncertainties and time-series consistency

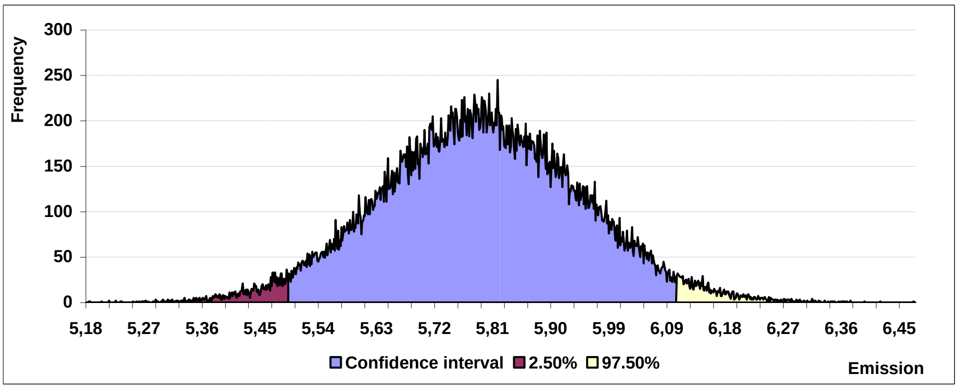
The Tier 1 uncertainties analysis was performed according to the IPCC 2000 GPG. Tier 2 uncertainty estimation was performed according to the methodology described in the Chapter 3.2.5 of this Report.

From presented results obtained by Monte Carlo simulation (60 000 trials) for the 1.A.3a category it seems that the mean value is 5.80 kt. The average mean value is comparable with the real result of the CO_2 emissions, which is 5.79 kt. Confidence interval (95%) is within the range: <5.49; 6.10>, which represents the uncertainty by relative values to the mean value: -5.19%; +5.27%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.34: *Selected statistical characteristics for 1.A.3a, 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
5.79	**5.80**	0.15	5.18	6.47	-5.19%	5.27%

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



Since 2002, the development of civil aviation in the Slovak Republic has been influenced by fast entering of low-cost airlines on market (mostly Ryan Air and Sky Europe Airlines). The Sky Europe Airlines finished its activity in 2008 and afterwards the sharp decrease in emissions is visible in time series. The airports Bratislava and Košice are the busiest airports. Other airports have only local character for domestic and sport flights.

In the period 1990 – 2011, the sale of aviation fuels at Slovak airports was influenced mostly by prices and other conditions on fuel market at neighboring airports. The consistency of time series is well ensured by comparing data flight numbers, fuel sale and LTO cycles with the Eurocontrol database.

3.3.2.5 Source specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. The emission inventory of civil aviation was determined by the SHMU in cooperation with external experts from the Centrum of Transport Research in Brno (the Czech Republic) and the Transport Research Institute in Žilina (with the cooperation of the Ministry of Transport and Regional Development). Several bilateral meetings were made between the Ministry of Environment and 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, the EC is preformed annual comparison of aviation fuel consumption and emissions data with Eurocontrol AEM model calculations. The comparison of Eurocontrol and the UNFCCC reporting data in aviation is provided by 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 EU works towards making data from Eurocontrol available to EU MS on a regular basis for quality check, however this information is not possible to make public available. Based on this comparison, the difference between national and Eurocontrol data on fuel consumption by domestic aviation (1.A.3a) in 2011 was 6% higher in Eurocontrol database. Difference in fuel split between domestic and international aviation according to national and Eurocontrol data was in good agreement (below 1%) and higher share for domestic aviation was reported in national estimation. Finally, the difference between national and Eurocontrol data on CO_2 emissions by domestic aviation (1.A.3a) in 2011 was again 6% higher in Eurocontrol database. Implied CO_2 emission factors for jet kerosene combustion in domestic aviation (1.A.3a) in Mg CO_2/TJ was in total agreement but the Implied CO_2 emission factors for aviation gasoline combustion in domestic aviation (1.A.3a) in Mg CO_2/TJ was higher in national estimate.

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 and Regional Development. The background documents are archived by sectoral experts in the central archiving system at the SHMU. The responsibility for the verification, approval of process and archiving lies on quality manager of SNE.

3.3.2.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

3.3.2.7 Source specific planned improvements

Differences between Eurocontrol and national reported data are larger for domestic aviation than when considering total aviation fuel consumption (domestic and international). When considering that Eurocontrol has detailed information on the origin-destination of most European flights, there seems to be room for improvement. According to the Eurocontrol methodology description, the use of ICAO default taxi-times could lead to overestimation of fuel consumption for the LTO phase. This can be also reason for 6% higher emissions estimated by the Eurocontrol. The implementation of tier 2 methodology will be done in the next submission based on the date from Eurocontrol database. Next steps include the evaluation of time series of civil and international aviation emissions. Time series calculated by Eurocontrol are expected in fall of 2013. Based on the experience gained during this QA/QC process recommendations will be made to Eurocontrol to safeguard and improve time-series calculations.

3.3.3 Source subcategory description – Road Transportation (CRF 1.AA.3.B)

During the review of Slovakia's 2011 annual submission, the ERT identified underestimations in some of Slovakia's emission estimates. It recommended nine adjustments in the energy sector for 2008 and 2009. With regard to the estimates of emissions from road transportation, the ERT written in the ARR 2012 that Slovakia did not provide an explanation of the values used in the COPERT IV (COmputer Programme to calculate Emissions from Road Transport) model for setting and calculating the emission factors and the corresponding emissions as requested by the ERT. In accordance with paragraph 19 of the annex to decision 20/CMP.1, the ERT initiated an adjustment procedure on the ground that the information provided by Slovakia was not sufficiently transparent.

During the adjustment process, Slovakia prepared the written submission and expressed disagreement with the ERT's views and reasoning for the recommended adjustments. Upon the national presentation of further information on the values used for setting and calculating the emission factors and the corresponding emissions in the COPERT IV model and the justifications for their application, the experts indicated that, in view of the updated information provided by Slovakia at the hearing in the front of the Compliance Committee, the nine adjustments recommended by the ERT with respect to the emissions from road transportation were no longer necessary.

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, quality of road network and interconnection of all municipalities. In recent 10 years, road transport has expanded significantly in the transport of goods and persons. In 2011, the transport network included 419 km of highways, 234 km of motorways and 3 312 km of the category I roads. Total roads network included 18 044 km of roads in the Slovak Republic in 2011. Road transportation is the most important category within transport sector with the highest share of emissions and increasing trend. Total aggregated emissions from road transportation reached 6 277.85 Gg of CO_2 equivalents in 2011. The decrease is by 4% compared to 2010, but the 27% increase compared to the base year is significant. The major share belongs to duty vehicles and passenger cars. Total blended emissions of CO_2 were 6 197.08 Gg in 2011. After separation of biomass content, the final CO_2 balance was 6 491.01 Gg. The biomass content is increasing and actual represented 293.93 Gg of CO_2.

Table 3.35: *Overview of total GHG emission balance according to the type of vehicles without separation of fossil and biomass contents in fuels in 2011*

Category of Road Vehicles	Emissions			Category of Road Vehicles	Emissions		
	CO_2	CH_4	N_2O		CO_2	CH_4	N_2O
	(t)				(t)		
Passenger Cars	**2 654 828**	**341.88**	**120.18**	diesel >32 t	28 468	0.56	0.80
gasoline <1.4 l	895 141	197.63	49.82	diesel 14-20 t	250 436	21.06	7.25
gasoline 1.4 l–2.0 l	576 654	90.97	30.47	diesel 20-28 t	292 194	20.52	6.71
gasoline >2.0 l	141 964	19.79	5.33	diesel 28-34 t	163 063	10.90	4.93
diesel <2.0 l	764 779	16.50	26.63	diesel 34-40 t	163 670	4.31	4.75
diesel >2.0 l	221 957	4.03	5.77	**Buses**	**484 500**	**81.06**	**4.92**
LPG	54 273	12.96	2.16	City buses CNG	16 301	48.71	0.00
Two stroke engine	60	0.01	0.00	City buses Midi <=15t	27 418	2.29	0.34
Light Duty Vehicles	**668 322**	**18.62**	**20.80**	City buses Stand. 15-18t	153 189	10.09	1.42
gasoline <3.5 t	133 306	12.40	7.39	City buses >18t	83 989	4.29	0.61
diesel <3.5 t	535 016	6.21	13.41	Long-line buses	203 602	15.67	2.55
Heavy Duty Vehicles	**2 674 564**	**187.44**	**71.10**	**Motorcycles**	**8 789**	**10.95**	**0.19**
diesel <=7.5 t	655 404	51.67	23.16	<50 cm^3 (mopeds)	1 094	2.13	0.02
diesel 7.5-12 t	134 923	6.69	2.47	Two stroke engine >50 cm^3	3 912	4.24	0.09
diesel 12- 4 t	61 956	2.77	1.68	Four stroke engine <250 cm^3	892	1.59	0.03
diesel 14-20 t	311 174	27.78	6.97	Four stroke engine 250-750 cm^3	1 170	1.64	0.02
diesel 20-26 t	267 886	20.05	4.96	Four stroke engine >750 cm^3	1 720	1.35	0.03
diesel 26-28 t	160 131	10.52	3.04	**Total Road Transport**	**6 491 002**	**639.95**	**217.22**
diesel 28-32 t	185 258	10.59	4.37	***Total Blended Emissions***	***6 197 075***	***639.95***	***217.22***

3.3.3.1 Methodological issues – methods

The calculation of GHG emissions in the annual inventory 2011 was made according to the EMEP/CORINAIR EIG methodology, with the software product COPERT IV version 8.1. Therefore, it is often referred to the name of the methodology consistently with the name of the program (methodology “COPERT”). Road transport emissions have been recalculated since 1990 by COPERT IV version 8.1 software in the previous submissions. The fuel based approach is used for the calculation of CO_2 emissions from road transport. CO_2 is 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 solid vehicles are further divided by weight into 8 subgroups and articulated into 6 subgroups. This methodology for the calculation of emissions used the technical parameters on the types of vehicles and the country characteristics, for example, 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 types of input data:

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

Based on these input parameters and additional information (the age of automobiles) the emissions can be estimated. Information about the vehicle fleet is based on database operated by the Police Presidium. 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. COPERT IV version 8.1 includes new EFs for hot emissions in category motorcycles. The EFs are based on project ARTEMIS experimental results. The EFs for Euro 3-6 for LPG and gasoline were updated in the category passenger cars. These improvements followed improvements in catalytic systems in vehicles. Emission factors which have been used in the version 8.0 were upgraded. COPERT IV version 8.1 software fixed some bugs in the model, determining a recalculation of emission estimates. The annual update of the model emission factors is based on the availability of new measurements and studies regarding road transport emissions.

Table 3.36: *Overview of input data in COPERT IV version 8.1 program*

Category of Road Vehicles	Activity data		
	Number	**Average consumption (l/100km)**	**Average mileage (km/veh.)**
Passenger Cars	**1 749 348.00**	**8.68**	**6 413.55**
gasoline < 1.4 l	740 186.00	7.21	6 337.82
gasoline 1.4 l–2.0 l	393 476.00	8.36	6 500.27
gasoline > 2.0 l	52 736.00	10.13	10 064.82
diesel < 2.0 l	455 962.00	6.19	9 915.31
diesel > 2.0 l	106 898.00	7.98	9 511.21
LPG	0.00	10.00	0.00
Two stroke engine	90.00	10.90	2 565.44
Light Duty Vehicles	**178 205.00**	**10.79**	**12 823.64**
gasoline < 3.5 t	43 014.00	12.21	10 389.92
diesel < 3.5 t	135 191.00	9.36	15 257.36
Heavy Duty Vehicles	**113 764.00**	**25.03**	**57 001.95**
diesel <=7.5 t	54 400.00	13.23	36 625.54
diesel 7.5 - 12 t	7 681.00	19.05	35 915.90
diesel 12 - 14 t	3 180.00	20.54	37 453.46
diesel 14 - 20 t	10 390.00	23.72	48 886.62
diesel 20 - 26 t	5 699.00	26.28	63 769.45
diesel 26 - 28 t	3 419.00	27.90	65 740.68
diesel 28 - 32 t	3 419.00	32.02	65 937.80
diesel >32 t	883.00	30.65	65 050.75
diesel 14 - 20 t	12 970.00	21.80	35 580.79
diesel 20 - 28 t	6 235.00	26.71	69 170.63
diesel 28 - 34 t	2 994.00	27.65	76 286.79
diesel 34 - 40 t	2 494.00	30.82	83 605.00

Category of Road Vehicles	Activity data		
	Number	Average consumption (l/100km)	Average mileage (km/veh.)
Buses	**9 011.00**	**32.93**	**59 536.66**
City buses CNG	225.00	49.00	51 625.91
City buses Midi <=15 t	878.00	21.95	52 986.79
City buese Stand. 15-18 t	3 075.00	29.40	62 898.16
City buses >18 t	1 318.00	37.83	62 708.92
Long - line buses	3 515.00	26.46	67 463.54
Motorcycles	**81 851.00**	**3.93**	**1 856.15**
< 50 cm^3 (mopeds)	26 418.00	2.59	783.08
Two stroke engine > 50 cm^3	40 279.00	3.74	1 182.75
Four stroke engine < 250 cm^3	5 800.00	3.63	2 102.92
Four stroke engine 250 - 750 cm^3	4 474.00	4.21	2 460.77
Four stroke engine > 750 cm^3	4 880.00	5.49	2 751.23
Total Road Transport	**2 132 179.00**	**16.27**	**137 631.95**

3.3.3.2 Methodological issues – emission factors and other parameters

The EFs values for CH_4 and N_2O in COPERT IV version 8.1 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 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.

3.3.3.3 Activity data

The accurate and more actual data on other distance-based values and parameter values that are necessary to run the COPERT IV model, particularly kilometers (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 the estimation of shares on urban, rural and highway driving is the Traffic Census of Slovakia done 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 and they are outcomes of the experimental studies.

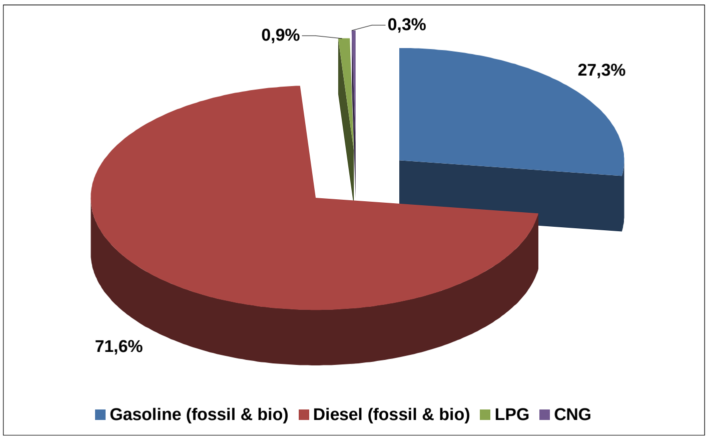
The emissions from this sector have an increasing tendency every year and they are the key source in level and trend assessment for uncertainty management. The revision of EF for CNG according to the EMEP/CORINAIR EIG 2008 and new disaggregation of buses to the EURO categories was provided in 2011. The emission inventory of road transport in 2011 included 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 from the year 2000. It is assumed, that before year 2000 the use of CNG 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 fulfill 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 fulfill the EEV requirements, while older buses were usually registered as Euro II or Euro III, Euro IV.

Table 3.37: *Results from COPERT IV in distribution for agglomeration mode (CO_2 emissions are from blended fuels with bio-component) in 2011*

Traffic	Emissions (t)		
	CO_2	CH_4	N_2O
City	2 765 995	420.25	106.22
Road	2 781 858	187.30	89.80
Highway	943 149	32.40	21.20
Total SR	**6 491 002**	**639.95**	**217.22**

Important information about the import, production, distribution and sale of gasoline and diesel oil were received from domestic producers of fuels – Slovnaft Ltd. Bratislava and Petrochema Ltd. Dubová, 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 gaseous fuels (LPG and CNG) were obtained from exclusive dealers and Slovak Gas Industry Ltd. All materials are in Slovak language and they are official. The statistical information about fuels sold in the Slovak Republic is checked by the results of the COPERT IV model and the differences are not higher than 2%. According to the statistical information the diesel oil represents the major share in fuel with 72% share, followed by gasoline with 27% share. The minor consumptions were balanced for LPG (1%) and CNG (0.3%).

Figure 3.27: *Fuels balance from statistics and COPERT IV model results in 2011*



Fuel	Consumption (t)	Share (%)
Gasoline (fossil & bio)	564 629.13	27.3
Diesel (fossil & bio)	1 480 176.82	71.6
LPG	17 950.14	0.9
CNG	5 904.71	0.3

3.3.3.4 Biomass consumption, blending

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 recalculated. The information was obtained from Slovnaft Ltd. Bratislava, which is one of the biggest distributors of fuels in the Slovak Republic. In terms of implementing Directive No 2003/30/EC on the replacement of fossil fuels with bio-component:

- In 2005 and 2006, the content of bio-component in fuel was value near 0%.
- In 2007, it was 1.53% for gasoline and 3.13% for diesel.
- In 2008, it was 0.83% for gasoline and 3.63% for diesel.
- In 2009, it was 1.71% for gasoline and 3.80% for diesel.
- In 2010, it was 2.34% for gasoline and 4.41% for diesel.
- In 2011, it was 2.66% for gasoline and 5.30% for diesel.

__Table 3.38:__ Estimated activity data and emissions from biomass share in 2007 – 2011

Biomass TJ Total				
2007	**2008**	**2009**	**2010**	**2011**
2 267.30	2 438.74	2 571.21	3 417.60	4 006.84
CO_2 emissions (Gg)				
166.88	180.15	189.45	251.81	293.93
CH_4 emissions (Gg)				
0.017	0.015	0.016	0.021	0.022
N_2O emissions (Gg)				
0.0047	0.0044	0.0053	0.0075	0.0089

In 2011, the target of 4.45% of all the energy equivalent of gasoline and diesel oil was achieved in the Slovak Republic. 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 15376. The report is prepared by the Ministry of Economy of the Slovak Republic with the cooperation of the Customs Administration and the Ministry of Environment.

__Table 3.39:__ Estimated activity data of gasoline and diesel oil with their emissions and biomass share

Gasoline Blended (TJ)					Diesel Oil Blended (TJ)				
2007	**2008**	**2009**	**2010**	**2011**	**2007**	**2008**	**2009**	**2010**	**2011**
28 879.36	29 321.86	27 950.00	26 886.60	24 716.08	58 321.03	60 478.51	55 086.04	63 230.35	63 196.13
Biomass share									
1.53%	0.83%	1.71%	2.34%	2.66%	3.13%	3.63%	3.80%	4.41%	5.30%
Biomass (TJ)									
441.85	243.37	477.95	629.15	657.45	1 825.45	2 195.37	2 093.27	2 788.46	3 349.39
Gasoline Fossil (TJ)					**Diesel Oil Fossil (TJ)**				
28 437.50	29 078.49	27 472.06	26 257.45	24 058.63	56 495.58	58 283.14	52 992.77	60 441.89	59 846.75
CO_2 Gasoline Blended (Gg)					**CO_2 Diesel Oil Blended (Gg)**				
2007	**2008**	**2009**	**2010**	**2011**	**2007**	**2008**	**2009**	**2010**	**2011**
2 065.96	2 092.16	2 000.04	1 923.13	1 755.92	4 321.79	4 484.51	4 085.52	4 689.56	4 664.52
Biomass share									
1.53%	0.83%	1.71%	2.34%	2.66%	3.13%	3.63%	3.80%	4.41%	5.30%
BiomassCO_2 (Gg)									
31.61	17.36	34.20	45.00	46.71	135.27	162.79	155.25	206.81	247.22
CO_2 Gasoline Fossil (Gg)					**CO_2 Diesel Oil Fossil (Gg)**				
2 034.35	2 074.79	1 965.83	1 878.13	1 709.21	4 186.52	4 321.73	3 930.27	4 482.75	4 417.30
CH_4 Gasoline Blended (Gg)					**CH_4 Diesel Oil Blended (Gg)**				
2007	**2008**	**2009**	**2010**	**2011**	**2007**	**2008**	**2009**	**2010**	**2011**
0.42	0.47	0.42	0.37	0.33	0.34	0.29	0.24	0.27	0.24
Biomass share									
1.53%	0.83%	1.71%	2.34%	2.66%	3.13%	3.63%	3.80%	4.41%	5.30%
Biomass CH_4 (Gg)									
0.006	0.004	0.007	0.009	0.010	0.011	0.011	0.009	0.012	0.131
CH_4 Gasoline Fossil (Gg)					**CH_4 Diesel Oil Fossil (Gg)**				
0.42	0.47	0.41	0.36	0.32	0.33	0.28	0.23	0.26	0.23
N_2O Gasoline Blended (Gg)					**N_2O Diesel Oil Blended (Gg)**				
2007	**2008**	**2009**	**2010**	**2011**	**2007**	**2008**	**2009**	**2010**	**2011**
0.09	0.12	0.12	0.10	0.09	0.10	0.09	0.09	0.12	0.12
Biomass share									
1.53%	0.83%	1.71%	2.34%	2.66%	3.13%	3.63%	3.80%	4.41%	5.30%
N_2O Biomass (Gg)									
0.001	0.001	0.002	0.002	0.000	0.003	0.003	0.003	0.005	0.010
N_2O Gasoline Fossil (Gg)					**N_2O Diesel Oil Fossil (Gg)**				
0.09	0.12	0.11	0.10	0.09	0.10	0.09	0.08	0.11	0.12

3.3.3.5 *Uncertainties and time-series consistency*

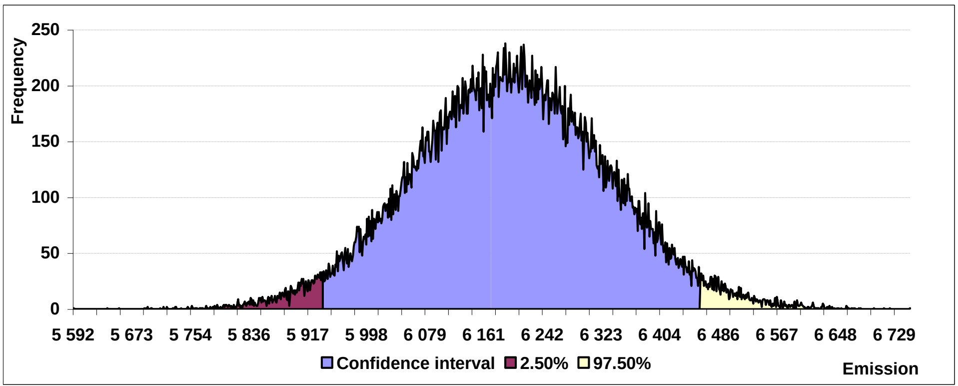
The Tier 1 uncertainties analysis was performed according to the IPCC 2000 GPG. Tier 2 uncertainty estimation was performed according to the methodology described in the Chapter 3.2.5 of this Report.

From presented results obtained by Monte Carlo simulation (60 000 trials) for the 1.A.3b category it seems that the mean value is 6 198 kt. The average mean value is comparable with the real result of the CO_2 emissions, which is 6 197 kt. Confidence interval (95%) is within the range: <3 938.34; 6 460.15>, which represents the uncertainty by relative values to the mean value: -4.18%; +4.24%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.40: *Selected statistical characteristics for 1.A.3b, 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
6 196.93	**6 197.59**	132.94	5 591.84	6 752.63	-4.18%	4.24%

Figure 3.28: *Probability density function for 1.A.3b in kt of CO_2*



The trend in the production of CO_2 and N_2O emissions from road transportation corresponds with the consumption of the fuels. Emission factors are different in individual years. The variability is caused by inputs for emission calculation: modifying vehicle fleet and varying fuel consumption. In the period 2007 – 2008 gasoline consumption increased by 1.3% and diesel consumption also increased by 3.1%. This was caused by the variation of fuel prices, 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 2011, the number of new cars with engines over 2 000 cm^3 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. It can be concluded that CH_4 emission production slightly increased by 0.55% compared to the previous year. 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 kilometers.
- 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 model. COPERT IV version 8.1 was used from 1990 – 2011.

3.3.3.6 Source specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. The emission inventory of Road transportation was determined by the SHMU sectoral expert for transport emission inventory and projections Mgr. Jiří Dufek from the Research Institute of Transport in Brno (Czech Republic).

The 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 institution. 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 expert. The Transport Research Institute is responsible for the data collection from different subjects (see below). Data manager of the SNE is responsible for the verification of these input parameters. Transport sectoral expert is responsible for the emission estimation by COPERT model.

The preliminary results of emission inventory are sent to other subjects (SNE, Transport Research Institute, Ministry of Transport and Regional Development) for checking 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.

Table 3.41: *The QA exercise comparison of statistical data and calculated data on consumption of different fuels in road transport*

Fuel	Statistical (t)	Calculated (t)	Deviation (%)
Gasoline (fossil & bio)	564 627.67	564 629.13	-0.00026%
Diesel (fossil & bio)	1 480 177.21	1 480 176.82	0.00003%
LPG	17 962.98	17 950.14	0.07148%
CNG	5 904.71	5 904.71	0.00000%

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 COPERT IV model. The background documents are archived by sectoral experts and in central archiving system of SNE at SHMU. The list of data providers is included in QA/QC plan:

- Slovnaft Ltd. Bratislava – provide data concerning production and selling of gasoline and diesel fuel.
- Statistical Office of the Slovak Republic – provides data concerning import and export of gasoline and diesel fuel from the EU Member States.

- Customs Directorate of the Slovak Republic – provides data concerning import and export of gasoline and diesel fuel from countries that are not the EU Member States.
- Probugas Ltd. Bratislava, Progas Ltd. Bratislava, Flaga Slovplyn Ltd. Pezinok, Flavia Ltd. Vranov nad Topľou, Slovnaft Ltd. Bratislava, Autoplyn Žilina – provide data concerning selling of LPG for road vehicles delivered into net of gas stations.
- Slovak Gas Trading Company SPP Inc. – provides data concerning selling of compressed natural gas – CNG at gas stations in the Slovak Republic.
- SAD Ltd. Zvolen, SAD Ltd. Nitra, SAD Ltd. Michalovce, DP mesta Košice Ltd. Košice, DPMB Ltd. Bratislava – bus transportation companies providing data concerning CNG consumption of gas driven busses.
- Presidium of the Police Force of the Slovak Republic, the Department of Documents and Registration– provides data concerning numbers of new registrations, changes of the registration and/or deregistration of road vehicles at the end of the year.
- Association of car industry of the Slovak Republic –detailed data concerning structure of all types of cars sold in the Slovak Republic during actual year can be found in its statistical yearbook.

3.3.3.7 Source specific recalculations

According to the recommendations of the ERT described in the Para 71 of the ARR 2012, the following improvements have been implemented:

- Correction of the EF (N_2O) for LPG in the year 2010 and the recalculation of the N_2O emission using the EF (N_2O) = 2.46 t/TJ. The new estimated N_2O emissions = 3.14 t in 2010.
- Correction of the NCV for the CNG used in the years 2000 – 2010 and the recalculation of N_2O emissions with the using of EF (N_2O) = 0.1 kg/TJ.

3.3.3.8 Source specific planned improvements

No specific improvements are planned for the next submission. According to the information provided by the Transport Research Institute, the project on estimation of new mileages for the individual vehicles categories is in the preparation and the results can be obtained in the 2014. These new input data can improve the model calculation in the next submissions.

3.3.4 Source subcategory description – Railways (CRF 1.AA.3.C)

Rail transport will be modernised with the support of 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 will result in the increase of operational speed to 160 km/h and increased safety of passengers. In 2011, the length of managed railways was 3 624 km of which the length of electric railways was 1 578 km (http://portal.statistics.sk/showdoc.do?docid=23751).

The railways transport is the second important source of emissions in transport subsector, the decreasing character of this transport mode. The decreasing trend was stabilized in 2003 and it occurs mostly in freight transportation. Total emissions from railways transport reached 96.13 Gg of CO_2 equivalents in 2011 and they decreased by 3% compared to 2010 and decreased several times compared to the base year. The reason behind is in the increase of railways efficiency and modernization of infrastructure and decreasing of fuel consumption by technical parameters (new locomotives and wagons).

Table 3.42: *Overview of GHG emission inventory in railways in 2011*

	Diesel Oil Consumption		Emissions (t)		
	(TJ)	(t)	CO_2	CH_4	N_2O
EFs for the motor locomotives and wagons kg/t diesel oil			*3 188*	*0.19*	*1.37*
Košice	291.72	6 864	21 882.37	9.40	1.30
Žilina	98.65	2 321	7 400.05	3.18	0.44
Zvolen	491.36	11 561	36 857.83	15.84	2.20
Bratislava	247.95	5 834	18 598.81	7.99	1.11
Public	*486.09*	*11 437*	*36 462.14*	*15.67*	*2.17*
CARGO	*643.59*	*15 143*	*48 276.93*	*20.75*	*2.88*
Total SR	**1 129.68**	**26 581**	**84 739.06**	**36.42**	**5.05**

3.3.4.1 Methodological issues – methods

The railways transport represents the operation of diesel traction using the simple methodology Tier 1 according to the IPCC 2000 GPG. The emissions of greenhouse gases are calculated from the weight of consumed fuel by diesel rail traction multiplied by emission factor.

3.3.4.2 Methodological issues – emission factors and other parameters

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 list of used emission factors is in Table 3.40.

3.3.4.3 Activity data

The consumption of diesel oil for the motor traction in the Slovak Republic was obtained from the statistic of the Railways Company, Ltd. for the whole time series. It is assumed that the consumption of the 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 (RC SR). 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, Žilina and Košice). Table 3.39 shows basic activity data and statistical information for inventory preparation and Figure 3.27 shows the information on diesel oil consumption.

Table 3.43: *Overview of activity data used in GHG inventory for railways transport in 2011*

Traction 70+80, CARGO + Public 2011							
Year run	**Košice**	**Žilina**	**Zvolen**	**Bratislava**	***Total public***	***Total CARGO***	**Total SR**
Number of loco	224	102	172	150	***260***	***388***	**648**
(km per year)	405 841 618	2 997 212	5 454 815	4 219 387	***10 958 050***	***6 529 982***	**17 488 032**
Operations (hrtkm)x1 000	401 025	172 666	1 787 237	542 787	***1 054 973***	***1 848 742***	**2 903 715**
Consumption (l)	8 171 407	2 763 357	13 763 605	6 945 243	***13 615 842***	***18 027 770***	**31 643 612**
Consumption (t)	6 864	2 321	11 561	5 834	***11 437***	***15 143***	**26 581**

Figure 3.29: *Overview of diesel oil consumption for railways transport in 1990 – 2011*

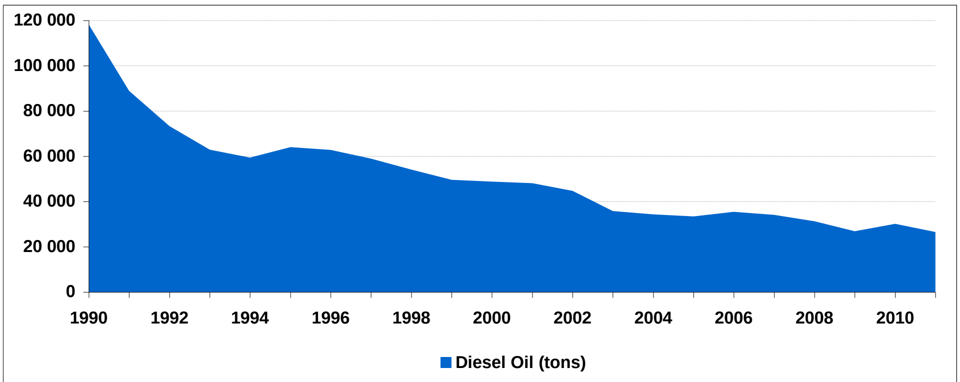


Table 3.44: *Overview of emission factors used in GHG inventory for railways transport*

Year	Number of Loco	Annual Mileage	Emissions (t)			Electricity Consumption
	piece	(km)	CO_2	CH_4	N_2O	(kWhour)
EFs for the motor locomotives and wagons kg/t diesel oil			***3 188***	***0.25***	***1.37***	
1990	1 192	63 432 669	376 771	29.50	161.91	988 025 749
EFs for the motor locomotives and wagons kg/t diesel oil			***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
EFs for the motor locomotives and wagons kg/t diesel oil			***3 188***	***0.19***	***1.37***	
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	108 670	6.48	46.70	680 115 929
2008	677	25 950 301	99 750	5.94	42.87	591 114 612
2009	653	32 078 886	85 904	5.12	36.92	526 693 646
2010	619	21 223 547	87 804	5.23	37.73	564 500 847
2011	648	26 581 000	84 739	5.05	36.42	621 626 121

3.3.4.4 Uncertainties and time-series consistency

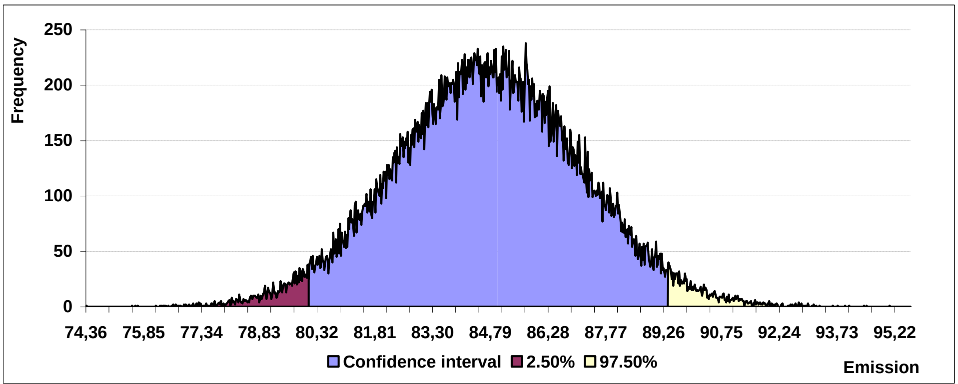
The Tier 1 uncertainties analysis was performed according to the IPCC 2000 GPG. Tier 2 uncertainty estimation was performed according to the methodology described in the Chapter 3.2.5 of this Report.

From presented results obtained by Monte Carlo simulation (60 000 trials) for the 1.A.3c category it seems that the mean value is 84.73 kt. The average mean value is comparable with the real result of the CO_2 emissions, which is 84.74 kt. Confidence interval (95%) is within the range: <80.11; 89.38>, which represents the uncertainty by relative values to the mean value: -5.45%; +5.49%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.45: *Selected statistical characteristics for 1.A.3c, 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
84.72	**84.73**	2.36	74.37	95.64	-5.45%	5.49%

Figure 3.30: *Probability density function for 1.A.3c in kt of CO_2*



The inter-annual decrease in diesel oil consumption in motor traction of railways is caused by the reduction of realised operations number in passenger and freight railways transport (decreases: 2007/2008 1.7%, 2006/2007 4.1%, 2005/2006 6.2%, 2004/2005 2.6%, 2003/2004 4.1%, 2002/2003 20%, 2001/2002 7.1%, 2000/2001 0.98%, 1999/2000 1.5%, 1998/1999 8.5%. The Railways Company, Ltd. adopted a new economic and effective policy in the operation of railways transport. The extensive reconstruction of railways transport infrastructure takes place in order to fulfill international requirements and caused increase of electricity consumption in 2011. The methodology, activity data collection and used emission factors for diesel oil are consistent in time series.

3.3.4.5 Source specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. The emission inventory of railways was determined by the sectoral expert for transport emission inventory and projections Mr. Jiří Dufek from the Research Institute of Transport in Brno (the Czech Republic).

The verification process is based on cross-checking of the input data from the Railways Company Ltd. and the Statistical Office of the Slovak Republic.

Two fundamental changes were made in the values of emission factor for the motor traction in the GHGs emission inventory during the previous submission. Based on the legislation (Regulation of the Ministry of Environment No. 144/2001 Coll.) about the requirements for the quality of fuels, the EFs for diesel oil were revised in the years 1994 and 2002. The emissions and the actual EFs are shown in Table 3.44. Since 1995, the emissions have been divided according to the types of railways operations (passenger, freight and service transport).

3.3.4.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

3.3.4.7 Source specific planned improvements

The information on fuel consumption in the international public transport corridors will be verified during the future inventory years.

3.3.5 Source subcategory description – Navigation (CRF 1.AA.3.D)

Major share of emissions from inland shipping in Slovakia are realized as transit on Danube River. Therefore are included in category 1.C1B Memo items – International bunkers (no movements are realized between the Gabčíkovo and Komárno ports on the Slovak territory). 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.

Other inland shipping transportation on small lakes in the Slovak Republic is negligible and only for tourist purposes, but was estimated for 2013 submission. This type of transport will be described in more detail in this chapter.

Total aggregated emissions from inland shipping excluding international navigation (on Danube River) reached 34.23 t of CO_2 equivalents in 2011, the slight decrease was recognized compared to the previous year 2010 and compared to the base year, it is approximately a double increase. Overview of activity data and emission is in the Table 3.46.

3.3.5.1 Methodological issues – methods

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 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 Basins in the Slovak Republic is registered. The emissions of greenhouse gases are calculated from the weight of consumed fuel by diesel motor boats multiplied by emission factor.

3.3.5.2 Methodological issues – emission factors and other parameters

Emission factors and other parameters are given in the Table 3.47.

Table 3.46: *Overview of GHG emission inventory in inland shipping in 1990 – 2011*

Year	Total Consumption	Total Consumption	CO_2 Emissions	CH_4 Emissions	N_2O Emissions	Total
	(kg/year)	(TJ/year)		(kg/year)		(t CO_2 *eq.*)
1990	7 136.35	0.30	22 750.68	1.21	9.21	**25.63**
1991	6 096.28	0.26	19 434.93	1.04	7.86	**21.89**
1992	5 686.54	0.24	18 128.68	0.97	7.34	**20.42**
1993	5 794.69	0.25	18 473.48	0.99	7.48	**20.81**
1994	6 154.25	0.26	19 619.76	1.05	7.94	**22.10**
1995	6 513.81	0.28	20 766.04	1.11	8.40	**23.39**
1996	6 966.06	0.30	22 207.79	1.18	8.99	**25.02**
1997	7 270.89	0.31	23 179.60	1.24	9.38	**26.11**
1998	7 590.28	0.32	24 197.82	1.29	9.79	**27.26**
1999	7 592.62	0.32	24 205.28	1.29	9.79	**27.27**
2000	7 695.71	0.33	24 533.92	1.31	9.93	**27.64**
2001	7 957.51	0.34	25 368.55	1.35	10.27	**28.58**
2002	8 335.66	0.35	26 574.09	1.42	10.75	**29.94**
2003	8 730.32	0.37	27 832.26	1.48	11.26	**31.35**
2004	9 180.36	0.39	29 266.98	1.56	11.84	**32.97**
2005	9 781.31	0.42	31 182.83	1.66	12.62	**35.13**
2006	10 612.36	0.45	33 832.20	1.80	13.69	**38.11**
2007	11 718.47	0.50	37 358.47	1.99	15.12	**42.09**
2008	12 821.76	0.54	40 875.77	2.18	16.54	**46.05**
2009	12 208.65	0.52	38 921.17	2.08	15.75	**43.85**
2010	12 700.01	0.54	40 487.63	2.16	16.38	**45.61**
2011	11 347.20	0.41	30 386.89	1.62	12.30	**34.23**

3.3.5.3 Activity data

The inland shipping occurrs in the Slovak Republic, however in limited extend. There are three relevant shipping routes in the Slovak Republic, but these activities were not included in the emission inventory:

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

While the public and tourist shipping activities in the Slovak Republic are not very frequent and have expanded only in the recent years, 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 liters 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 IPCC GL 1996, Reference Manual, Table I-40: EF (CO_2) is 3 188 g/kg.

Table 3.47: *The emission estimation for domestic navigation (CRF 1.A.3d) in 2011*

2011	Location							Total SR
Activity Data	**Piestany long trip**	**Piestany short trip**	**Trencin**	**Liptovska Mara**	**Oravska Priehrada short trip**	**Oravska Priehrada long trip**	**Zemplinska Sirava**	
Number of Trips (per year)	196	68	24	240	102	84	240	**954**
Duration of Trip (hours)	1.42	0.92	0.35	1.00	0.50	1.50	0.75	**6**
Total Duration (per year)	277.67	62.33	8.40	240.00	51.00	126.00	180.00	**945**
Fuel Consumption (l/hour)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Total Consumption (l/year)	3 332.00	748.00	100.80	2 880.00	612.00	1 512.00	2 160.00	**11 345**
Total Consumption (kg/year)	2 798.88	628.32	84.67	2 419.20	514.08	1 270.08	1 814.40	**9 530**
EF CO_2 (g/kg)	***3 188***							
CO_2 Emissions (kg/year)	8 922.83	2 003.08	269.93	7 712.41	1 638.89	4 049.02	5 784.31	**30 39**
EF CH_4 (g/kg)	***0.17***							
CH_4 Emissions (kg/year)	0.48	0.11	0.01	0.41	0.09	0.22	0.31	**1.62**
EF N_2O (g/kg)	***1.29***							
N_2O Emissions (kg/year)	3.61	0.81	0.11	3.12	0.66	1.64	2.34	**12.29**
Total GHG in CO_2 eq. (t/year)	**10.05**	**2.26**	**0.30**	**8.69**	**1.85**	**4.56**	**6.52**	**34.23**

3.3.5.4 Uncertainties and time-series consistency

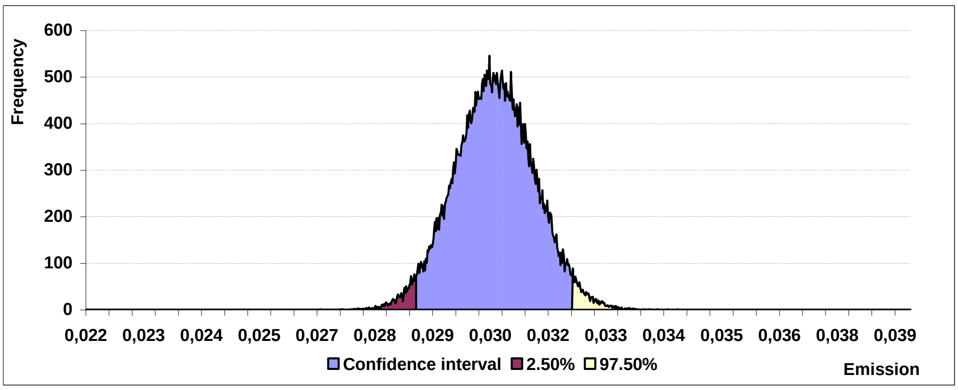
The Tier 1 uncertainties analysis was performed according to the IPCC 2000 GPG. Tier 2 uncertainty estimation was performed according to the methodology described in the Chapter 3.2.5 of this Report.

From presented results obtained by Monte Carlo simulation (60 000 trials) for the 1.A.3d category it seems that the mean value is 0.030 kt. The average mean value is comparable with the real result of the CO_2 emissions, which is 0.030 kt. Confidence interval (95%) is within the range: <0.029; 0.032>, which represents the uncertainty by relative values to the mean value: -5.45%; +5.49%. Following table and graph describe calculated results of uncertainty analyses.

Table 3.48: *Selected statistical characteristics for 1.A.3d, 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
0.030	**0.030**	0.001	0.027	0.034	-5.45%	5.49%

Figure 3.31: *Probability density function for 1.A.3d in kt of CO_2*



The time series are consistent and emission inventory was performed based on GDP information with the consistent methodology, activity data collection and using default emission factors for diesel oil fuel and vessels.

3.3.5.4 Source specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. The emission inventory of railways was determined by the sectoral expert for transport emission inventory and projections Mr. Jiří Dufek from the Research Institute of Transport in Brno (the Czech Republic). The 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.

3.3.5.5 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

3.3.5.6 Source specific planned improvements

The information about inland tourists shipping in the Slovak Republic can be collected and updated from several lakes and small rivers.

3.4 Fuel combustion – reference approach (CRF 1.AB)

3.4.1 Source category description

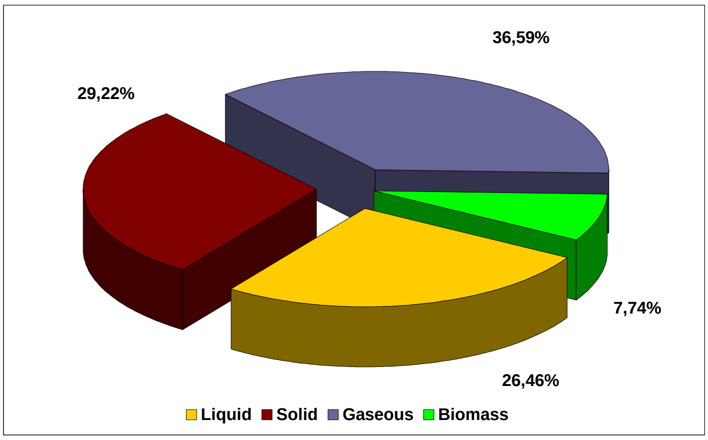
Data gathered and processed by the Statistical Office of the Slovak Republic every year (the annual energy statistic balance) is the base for the calculation of reference approach. Therefore the data is official energy balance data. Company Profing Ltd. Bratislava has prepared preliminary and final energy balances based on documents published by the Statistical Office of the Slovak Republic (http://portal.statistics.sk/files/Sekcie/sek_500/energetika/archiv2012_pdf/puben11_def.pdf, December 2012). The reference approach balance includes emissions from fuel combustion differentiated according to the gaseous, liquid, solid and biomass categories. The emissions according to the relevant subcategories and gases in 1990 – 2011 are presented in Table 3.49.

Table 3.49: *GHG emissions within reference approach in 1990 – 2011*

CO_2 (Gg)									
Year	**Fuel Combustion (RA)**	**Liquid Fuels**	**Carbon Stored Liquid**	**Solid Fuels**	**Carbon Stored Solid**	**Gaseous Fuels**	**Carbon Stored Gaseous**	**Biomass**	**Feedst. Total**
1990	**56 377.11**	10 596.11	-4 038.47	33 418.32	-313.86	12 362.68	-323.91	1 685.70	**-4 676.24**
1991	**49 719.54**	9 230.58	-3 502.13	28 711.40	-288.39	11 777.55	-215.01	1 381.72	**-4 005.54**
1992	**44 939.84**	7 845.45	-3 340.35	25 319.65	-266.87	11 774.73	-241.45	1 253.17	**-3 848.67**
1993	**42 859.62**	6 599.91	-2 515.24	24 768.15	-261.95	11 491.56	-180.60	720.37	**-2 957.78**
1994	**39 738.23**	6 966.86	-3 066.12	21 921.45	-271.75	10 849.91	-256.56	717.30	**-3 594.43**
1995	**40 881.10**	7 284.38	-3 553.00	21 599.21	-273.68	11 997.52	-276.51	325.72	**-4 103.20**
1996	**41 379.14**	7 348.46	-3 353.99	21 477.73	-280.93	12 552.95	-347.06	303.00	**-3 981.98**
1997	**41 478.84**	8 281.41	-3 011.58	20 411.79	-258.91	12 785.64	-272.51	348.69	**-3 543.00**
1998	**39 684.99**	8 001.86	-2 932.80	18 719.50	-230.37	12 963.62	-277.21	302.67	**-3 440.38**
1999	**38 562.21**	7 338.67	-2 544.61	18 123.30	-307.01	13 100.24	-277.21	269.48	**-3 128.83**
2000	**36 392.99**	6 279.16	-2 904.96	16 943.79	-273.43	13 170.04	-277.30	263.17	**-3 455.69**
2001	**38 645.78**	7 007.61	-2 655.86	17 492.38	-297.60	14 145.79	-198.26	1 126.72	**-3 151.71**
2002	**38 234.07**	7 634.68	-2 750.10	16 964.23	0.00	13 635.16	0.00	4 191.31	**-2 750.10**
2003	**38 882.81**	7 386.06	-2 802.14	18 274.85	0.00	13 221.90	0.00	1 474.73	**-2 802.14**
2004	**38 149.01**	7 378.39	-2 831.66	18 133.55	0.00	12 637.07	0.00	593.05	**-2 831.66**
2005	**37 644.68**	7 419.56	-3 215.92	16 937.60	-169.07	13 287.53	-294.10	1 459.56	**-3 679.10**
2006	**37 042.28**	7 283.89	-3 293.81	17 592.00	-163.86	12 166.39	-245.65	1 880.20	**-3 703.32**
2007	**35 268.77**	7 565.36	-3 283.65	16 369.87	-163.25	11 333.55	-375.44	3 360.48	**-3 822.34**
2008	**35 994.57**	8 444.72	-2 713.45	15 931.19	-163.94	11 618.66	-221.56	2 419.99	**-3 098.95**
2009	**32 437.58**	7 272.40	-3 012.93	15 182.33	-138.52	9 982.85	-224.12	3 194.62	**-3 375.57**
2010	**34 615.50**	7 948.59	-2 888.77	15 258.67	-136.06	11 408.24	-161.05	3 209.10	**-3 185.88**
2011	**32 897.29**	7 631.32	-3 035.39	14 849.48	-143.93	10 416.49	-293.32	3 874.92	**-3 472.65**

The major share (37%) was represented by natural gas consumption, followed by solid fuels (29%) and liquid fuels (26%) in 2011. The share of biomass consumption increased and is approximately 8% in total consumption in the Slovak Republic. Total CO_2 emissions in reference approach was 32 897.29 Gg of CO_2 in 2011. Other emissions were not estimated. Total CO_2 emissions are without CO_2 emissions stored in feedstock and other products (section 3.6).

Figure 3.32: *The share of different fuels consumption within reference approach in 2011*



Reference Approach Fuels	TJ	Share (%)
Liquid	140 509.09	26.46%
Solid	155 178.91	29.22%
Gaseous	194 291.84	36.59%
Biomass	41 086.86	7.74%

3.4.2 Methodological issues – methods

Upper level of emissions and sinks of CO_2 from fuel use is determined by using of summary inventory data of the Slovak Republic in form of reference approach table 1.AB (this table provides data on fuel consumption by type of fuel, their low heating values, emission and oxidation factors). This method is called also the top down or the upstream method and is characterized by the minimum requirements for the input data. The reference approach provides only CO_2 emissions estimates by fuel type distinguishing between primary and secondary fuels. The top-down approach used in reference approach estimates means that stationary combustion emissions cannot be distinguished from mobile combustion emissions. The method is applied also as the quickest control and confirmation method. It is necessary to state, that this method does not include so called fugitive emissions, i.e. uncontrolled emissions from mining and post-mining treatment, from transport and other use of fuels.

The reference approach of the Slovak Republic estimates direct CO_2 emissions from the following groups of fuels combusted in energy sector:

- Liquid fuels – primary fuels (Crude Oil, Natural Gas Liquids); secondary fuels (Gasoline, Jet Kerosene, Other Kerosene, Gas/Diesel Oil, Residual Fuel Oil, LPG, Naphtha, Bitumen, Lubricants, Petroleum Coke, Refinery Feedstock, Other Oil).
- Solid fuels – primary fuels (Anthracite, Coking Coal, Other Bit. Coal, Lignite); secondary fuels (BKB & Patent Fuel, Coke Oven/Gas Coke).
- Gaseous fuels – primary fuels (Natural Gas).
- Biomass (solid, liquid, gaseous).

3.4.3 Methodological issues – emission factors and other parameters

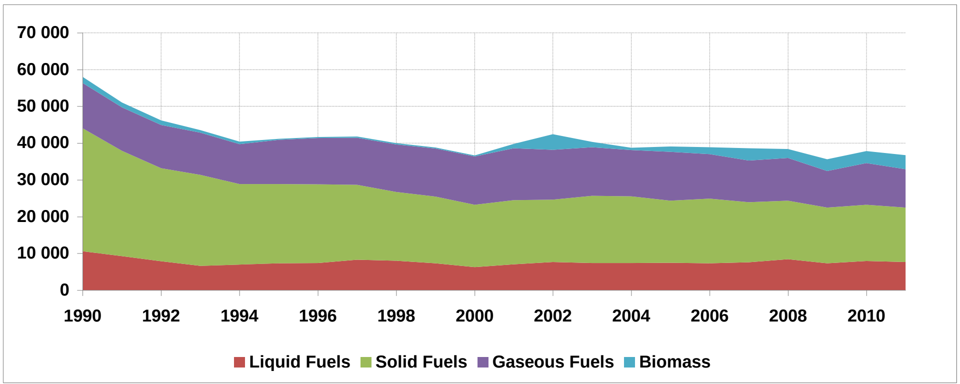
The emission factors of several important fuels were used according to national circumstances and according to the direct measurements by sources included in ETS. The CO_2 EF for natural gas, coal, coke, brown coal, lignite and coke oven gas were revised and the values are described in section 1.AA – sectoral approach. The consistency is strictly kept between EFs used in sectoral and reference approach.

3.4.4 Activity data

The emission inventory based on the reference approach is periodically included into the annual inventory for comparison and verification reasons. The data for preparation of the preliminary energy balance is obtained from the Statistical Office of the Slovak Republic, which is the authority officially organizing and yearly performing statistical findings. Reporting duty to fill out the statistical forms is issued by Act No 322/1992 Coll., § 27 on the National Statistic, as amended. The Statistical Office of the Slovak Republic performs yearly statistical findings to monitor the consumption of fuels for electricity and heat generation, fuel enrichment processes, the amount of electricity and heat production, sales and distribution of fuels, etc. The results of these findings are used for energy balance calculation as well as for international statistics. Collection of data is performed by using of the following annual statistical forms:

- 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.

Figure 3.33: *The share of different fuels consumption within reference approach in 1990 – 2011*



3.4.5 Uncertainties and time-series consistency

Reference approach uncertainties are determined by the methodology of the Statistical Office of the Slovak Republic. The Monte Carlo method was not applied for the CO_2 emissions estimated by reference approach methodology. The methodology is consistent during time series across of the main types of fuels. The most visible characteristics in the trend are decreasing of carbon intensive fuels (mostly solid and liquid) and increase of natural gas and biomass consumption. These changes are connected with the overall trends in the economical and industrial development.

3.4.6 Source specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. Results of energy statistic that are used for GHG emission inventories are yearly issued in the Statistical Yearbooks and in the publications on energy statistics in physical and caloric values The first preliminary data on the balances of liquid, solid, gaseous fuels and biomass from the previous year in the Slovak Republic are available at the beginning of October. These data are verified by Profing Ltd. Bratislava (comparing the consumption of fuels and production of heat and electricity, discussion with the main producers of heat and electricity and suppliers of fuels, etc.) and used for reference approach.

Profing Ltd. Bratislava (the company for energy research) executed the preliminary energy balance based on the documents published by the Statistical Office. Profing Ltd. Bratislava namely Dr. Ján Judák, the director, is the sectoral expert for energy and the external consultant for energy questions in the Slovak NIS. He is responsible for the preparation of reference approach balance, the fugitive emissions balance from mines, oil and gas industry. The reference approach determines the apparent consumption of individual types of fuels (primary, secondary and biomass) for which the inventory is being prepared. This information is available in energy (TJ) and mass (Gg) units.

The reference approach balance is compared with the fuel balance (in metric units) published by Eurostat and by the International Energy Statistics. The results are included in Annex 2.1 of this report.

The IEA database includes information for gaseous fuels expressed only in energy units (TJ). The Statistical Office of the SR provides information based on gross calorific values and therefore consumptions are provided in the IEA statistics lower by the coefficient 1.11 (recalculation of GCV to NCV). After recalculation to natural units, no differences were found between IEA, RA and the SO SR data (Annex 2.1).

The differences in oil consumption between IEA, RA and the SO SR data were not found (Annex 2.1).

3.4.7 Source specific recalculations

During QA/QC procedures of the statistical information comparison, the disagreement (357 kt) between Reference approach data and IEA statistics was found in solid fuels – coking coal for the year 2010. Imported value of coking coal was corrected (increasing from 2 115 kt to 2 472 kt) by the Statistical Office of the Slovak Republic (information provided by official letter). The Statistical Office of the Slovak Republic corrected previous reported value published in December 2011 by increasing coking coal import. This change was not reflected in the reference approach prepared for the submission 2012, but the value 2 115 kt was used for 2010 inventory preparation. The recalculation is incorporated in the current submission.

The import and stocks of briquettes (BKB) was corrected by the Statistical Office of the Slovak Republic to Eurostat in January 2013. The corrected values of import are 43 kt and for stock change 2 kt for the year 2010. The CO_2 emissions in this category increased to 97.92 Gg, what is a four-fold increase compared to the previous submission. However, the total CO_2 emissions from BKB & patent fuels are very low in comparison with emissions of solid fuels (0.6% in 2010).

3.4.8 Source specific planned improvements

The official frame contract was signed between the Statistical Office of the Slovak Republic and the Ministry of the Environment to ensure direct responsibility for provision of information about any changes, recalculations or reporting of the SO SR to the National Inventory System coordinator. This measure will avoid the late implementation of changes and ensures direct cooperation between the experts of the SHMU and the SO SR in the field of the energy balance. The cooperation is now established on the official level and the ongoing discussion on removing discrepancies between the several statistics (NEIS, SO SR, ETS) is in place.

Regarding the ARR 2012 recommendation in the Para 51, the correction of amounts of carbon stored for solid and gaseous fuels in the period 2002 – 2004 will be improved based on data obtained from different sources (producers, IEA):

Non-energy use of coal tars and NG for the period 2002 – 2004:			
Coal tars	**2002**	**2003**	**2004**
Productions (kt)	78.318	75.360	73.919
Source: producer			
NG non-energy use	**2002**	**2003**	**2004**
IEA (TJ-gross)	16 113	14 441	16 595
Gross Hv ($MJ.m^{-3}$)	38.033	37.622	38.063
NG ($mil.m^3$)	423.658	383.844	435.987
Source: IEA			

3.5 Difference – sectoral and reference approach (CRF 1.AC)

3.5.1 Source category description

Complete time series of CO_2, CH_4 and N_2O emissions for reference and sectoral approaches have been estimated since the base year. The higher difference between sectoral and reference approach in the older submissions is caused by the complicated situation in the national database NEIS, the changes in the legislation in air protection and different classification of fuel types in statistical collection of data and national legislation in large combustion plants and other stationary sources. The previous recalculations of sectoral approach were based on the reallocation of the fuel consumption into the separate CRF categories for the years 1991 – 1999 according to appropriate IPCC methodology. The revised EFs for natural gas, coal, brown coal, coke and coke gas were used. Total difference between reference and sectoral approach in CO_2 balance was 8.86% in 2011. The difference in fuel consumption (in PJ) was 11.35% in 2011.

Figure 3.34: *The difference between reference and sectoral approaches of CO_2 emissions in 1990 – 2011*

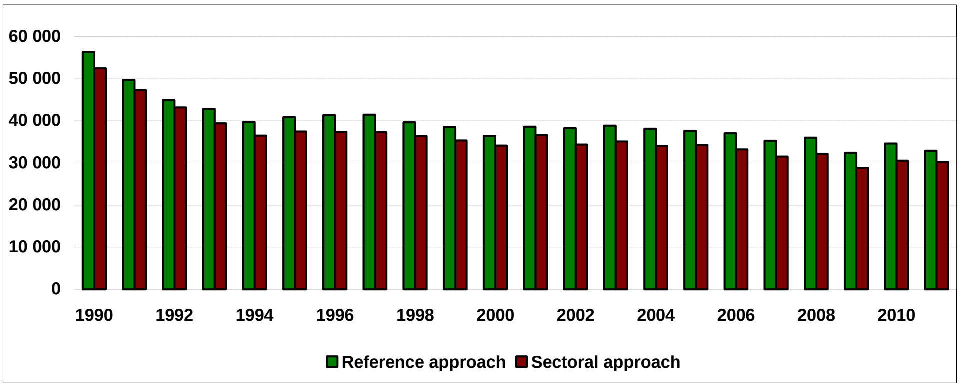
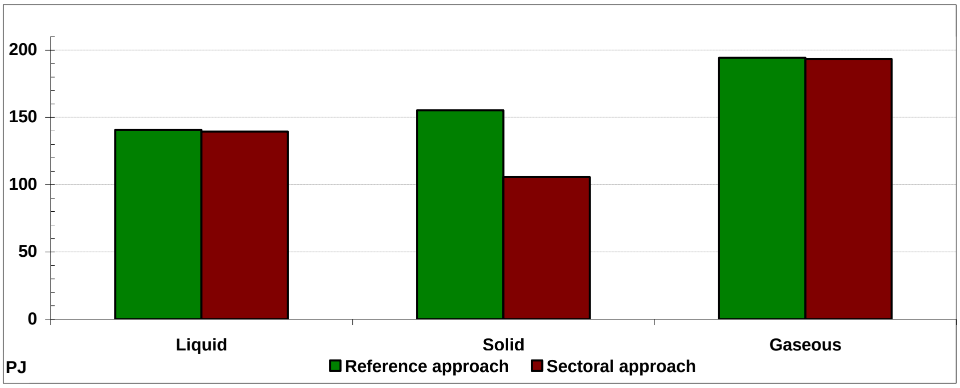
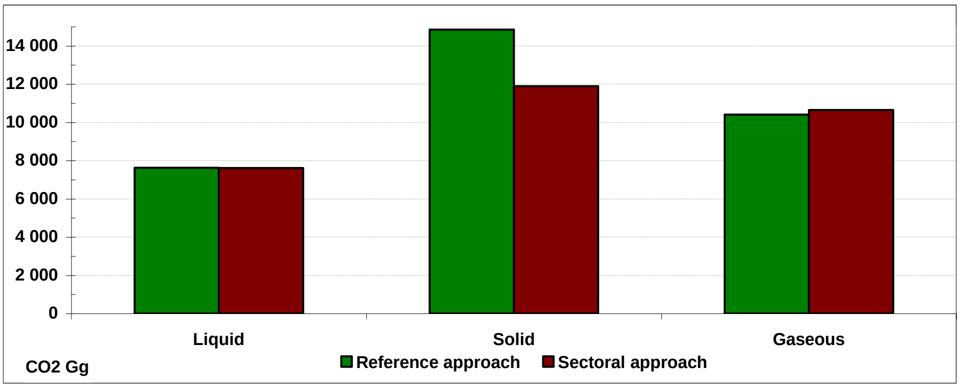


Figure 3.35: *The difference between reference and sectoral approaches of fuel consumption in PJ and for CO_2 emissions in Gg in 2011*





3.5.2 Methodological issues – methods

Reference and sectoral approaches are estimated on fully independent data sets, whereby obtained differences are significant compared to the previous methodology. After recalculation of category 1.A.2a iron and steel production (see Chapter 3.2.4.4) the difference between the top down and the bottom up energy balance was recalculated to the base year. The differences in fuel consumption between these two approaches were caused by the reallocation of the major share of fuels to the industrial processes sector.

The following reallocation of technological fuels from iron and steel production and their emissions was performed in 2012 submission:

- Reallocation of CO_2 emissions from coking coal from category iron and steel 1.A.2a (energy sector) to category iron and steel production 2.C.1 (IP sector).

Including solid fuels in sectoral approach balance since the base year (only for comparison reason), the estimation and comparison with reference approach was more representative and the differences are shown in the following tables and figures. The difference in 2011 was estimated as -1.58% for CO_2 emissions.

Table 3.50: *The comparison of RA and SA with the inclusion of emissions from technology (reallocated into IP sector) in 1990 – 2011 for CO_2 emissions*

Year	RA	SA	Difference	Cooking Coal in 2.C.1	SA + 2.C.1	Difference
	CO_2 (Gg)		RA/SA in %	CO_2 (Gg)		RA/SA in %
1990	56 377.11	52 469.39	7.45%	4 095.73	56 565.12	**-0.33%**
1991	49 719.54	47 281.82	5.16%	3 479.74	50 761.56	**-2.10%**
1992	44 939.84	43 188.82	4.05%	3 188.59	46 377.41	**-3.20%**
1993	42 859.62	39 427.06	8.71%	3 686.21	43 113.27	**-0.59%**
1994	39 738.23	36 517.73	8.82%	3 663.44	40 181.17	**-1.11%**
1995	40 881.10	37 476.62	9.08%	3 848.88	41 325.50	**-1.09%**
1996	41 379.14	37 432.66	10.54%	3 650.00	41 082.66	**0.72%**
1997	41 478.84	37 297.79	11.21%	3 840.38	41 138.17	**0.82%**
1998	39 684.99	36 381.55	9.08%	3 565.00	39 946.55	**-0.66%**
1999	38 562.21	35 337.30	9.13%	3 762.00	39 099.30	**-1.39%**
2000	36 392.99	34 107.37	6.70%	3 414.39	37 521.76	**-3.10%**
2001	38 645.78	36 609.23	5.56%	3 639.29	40 248.53	**-4.15%**
2002	38 234.07	34 379.07	11.21%	3 980.10	38 359.17	**-0.33%**
2003	38 882.81	35 088.25	10.81%	4 076.12	39 164.37	**-0.72%**
2004	38 149.01	34 075.92	11.95%	4 067.45	38 143.37	**0.01%**
2005	37 644.68	34 239.37	9.95%	3 528.99	37 768.36	**-0.33%**
2006	37 042.28	33 215.47	11.52%	4 047.71	37 263.18	**-0.60%**
2007	35 268.77	31 499.20	11.97%	3 873.91	35 373.12	**-0.30%**
2008	35 994.57	32 203.47	11.77%	3 788.59	35 992.05	**0.01%**
2009	32 437.58	28 845.32	12.45%	3 251.17	32 096.48	**1.05%**
2010	34 615.50	30 535.80	13.36%	3 790.16	34 325.96	**0.84%**
2011	32 897.29	30 219.99	8.86%	3 197.53	33 417.52	**-1.58%**

Considering the results of analyses, minor inconsistencies in the trend can be observed. The plant specific information for the previous years is not always possible to obtain in sufficient extent. The expert interpolation took place in several industrial categories in order to produce parameters and emission factors. The consistency is ensured by using the same methodology for the estimation of fuel consumption and emissions. The following figures show the trend in time series of differences in fuels and emissions between sectoral and reference approach including the allocation of fuels from IP sector. The difference in 2011 was estimated as 0.09% for fuel consumption.

Table 3.51: *The comparison of RA and SA with the inclusion of emissions from technology (reallocated into IP sector) in 1990 – 2011 for fuel consumption*

Year	RA	SA	Difference	Cooking Coal in 2.C.1	SA + 2.C.1	Difference
	Fuel consumption (PJ)		RA/SA in %	Fuel consumption (PJ)		RA/SA in %
1990	763.91	708.55	8.00%	51.78	760.33	**0.47%**
1991	679.15	640.05	6.31%	45.99	686.04	**-1.01%**
1992	625.19	600.48	4.37%	42.92	643.40	**-2.91%**
1993	586.82	556.97	5.65%	46.60	603.57	**-2.85%**
1994	561.52	521.51	7.94%	48.42	569.93	**-1.50%**
1995	590.98	530.51	11.65%	46.63	577.14	**2.34%**
1996	599.39	533.67	12.56%	42.57	576.24	**3.86%**
1997	600.08	525.62	14.43%	44.67	570.29	**4.96%**
1998	582.02	517.13	12.85%	40.07	557.20	**4.26%**
1999	565.85	509.67	11.32%	43.43	553.10	**2.25%**
2000	545.41	505.04	8.35%	46.04	551.08	**-1.04%**
2001	574.89	537.44	7.18%	47.32	584.76	**-1.72%**
2002	562.96	510.11	10.63%	51.37	561.48	**0.26%**
2003	565.57	508.36	11.53%	56.60	564.96	**0.11%**
2004	553.56	496.11	11.90%	54.75	550.86	**0.49%**
2005	565.00	505.29	12.13%	53.46	558.75	**1.11%**
2006	549.20	482.71	14.12%	63.52	546.23	**0.54%**
2007	528.99	461.51	14.96%	59.01	520.52	**1.60%**
2008	531.29	469.94	13.35%	57.08	527.02	**0.80%**
2009	480.51	421.87	14.27%	49.17	471.04	**1.97%**
2010	512.96	448.29	14.78%	56.98	505.27	**1.50%**
2011	489.98	440.05	11.71%	49.51	489.56	**0.09%**

Figure 3.36: *The difference between RA and SA for CO_2 emissions with the inclusion of emissions from cooking coal used in iron and steel production (IP sector) in 1990 – 2011*

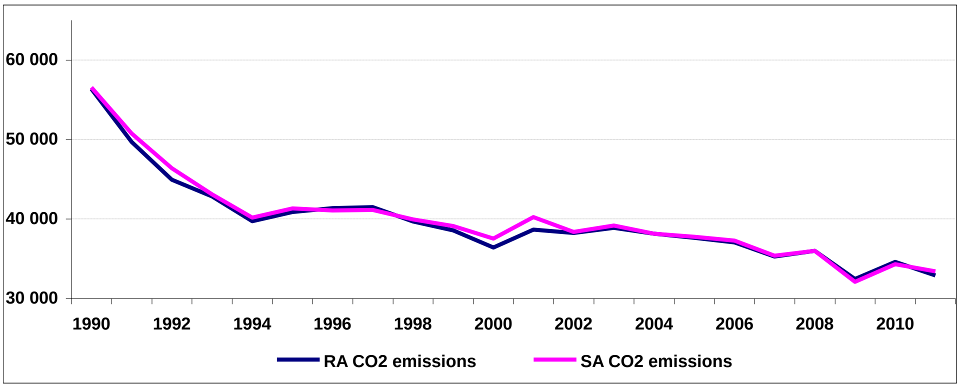
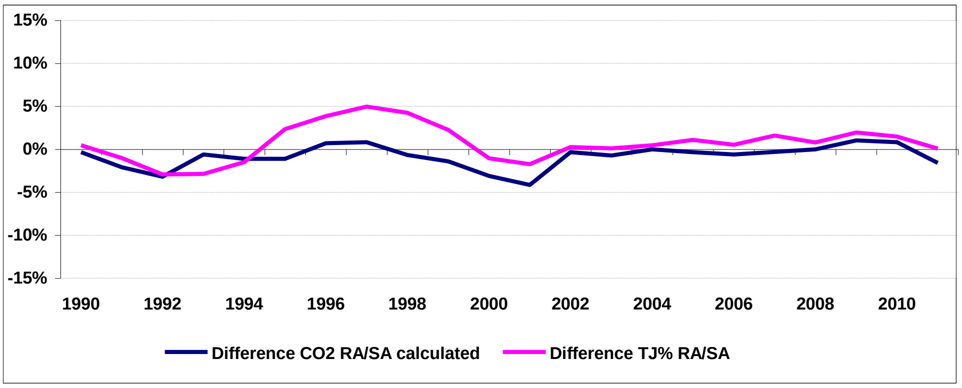


Figure 3.37: *Trend in difference between RA and SA for CO_2 emissions and for fuels consumption with the inclusion of emissions from technology (reallocated in IP sector) in 1990 – 2011*



3.5.3 Methodological issues – emission factors and other parameters

The information on the emission factors is presented in sections on sectoral and reference approach. The minor differences were caused by the use of average NCVs (net calorific values) in reference approach and fuel specific NCVs in sectoral approach. In sectoral approach, the quantities of fuels used in blast furnace (IPCC category 1.AA.2.A – solid fuels and gaseous fuels) were excluded from energy balance and the quantities of residual carbon from combustion, witch stayed in products, were excluded from energy balance (IPCC categories 1.AA.1.C – other fuels and 1.AA.2.C – liquid and gaseous fuels). Since 1990, total fuel combustion decreased significantly and the share of natural gas as an alternatively fuel type increased. After the medium increase in solid fuels in 2001, the decreasing trend in 2002 – 2007 appeared in energy balance. In the last inventory year 2011 the increasing trend was recognized. The balance of solid fuels consumption is complicated due to the calculation of the stock change. The Statistical Office of the Slovak Republic annually updates the fuel categories and methodology for fuel stock. The quality of data used for bottom-up approach is higher, because this data is checked more times (by operators, providers of NEIS database, sectoral expert and SNE).

3.5.4 Activity data

The information on activity data is presented in sections on sectoral and reference approaches. The comparison is shown in Table 3.52.

Table 3.52: *Comparison of fuel consumption by fuel type and CO_2 emissions within reference and sectoral approaches in 2011*

Fuel	Liquid	Solid	Gaseous	Other	Total
Fuel Consumption (PJ)					
Reference approach	140.51	155.18	194.29	NA	**489.98**
Sectoral approach	139.49	105.64	193.29	1.62	**440.05**
Difference	*0.73*	*46.89*	*0.52*	*0.00*	***11.71***
Apparent energy consumption (excluding non-energy use and feedstocks)	140.51	155.18	194.29	1.62	**491.60**
CO_2 Emissions (Gg)					
Reference approach	7 631.32	14 849.48	10 416.49	NA	**32 897.29**
Sectoral approach	7 607.38	11 895.12	10 654.05	63.43	**30 219.99**
Difference	*0.31*	*24.84*	*-2.23*	*-100.00*	***8.86***

3.5.5 Uncertainties and time-series consistency

For the uncertainty analysis and time-series consistency see sections on sectoral and reference approaches.

3.5.6 Source specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. For the source specific QA/QC and verification see sections on sectoral and reference approaches.

3.5.7 Source specific recalculations

For the source specific recalculation see sections on sectoral and reference approaches.

3.5.8 Source specific planned improvements

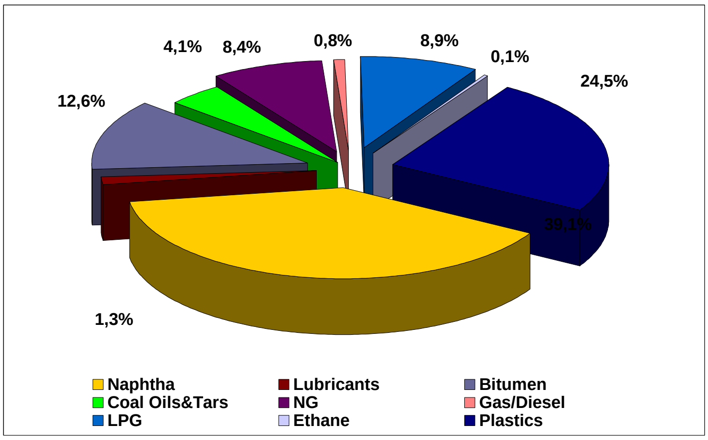
For the planned improvements see sections on sectoral and reference approaches. The improvements are described in the improvement plan and will be focused on the correction in reporting of reference approach, carbon stored and apparent consumption. The main reason is streamlining these data sources and removing discrepancies in reporting, which are difficult to explain in the CRF Tables in the present submission.

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

3.6.1 Source category description

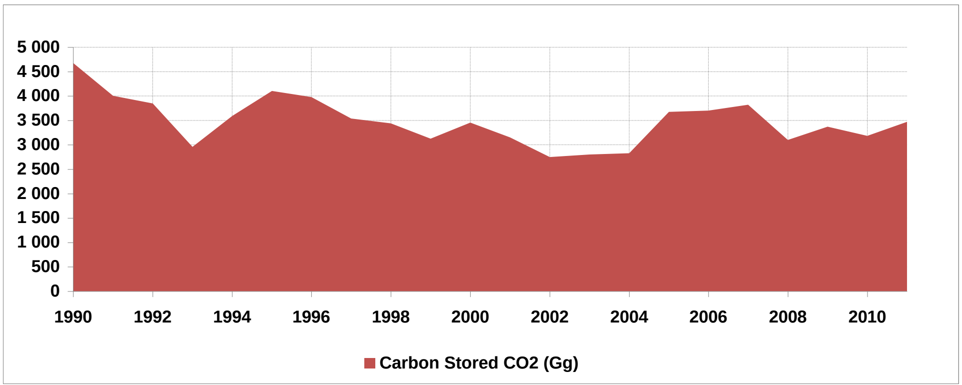
Used of the IPCC methodology (IPCC, 1996), the quantity of residual carbon from combustion which stayed in products (carbon fixed in tar and tar's oils occurring by carbonisation and in petrochemical oil products such as polyethylene, polypropylene, asphalts and lubricants etc., carbon bound in fertilizers) was estimated. Total carbon stored in products was 3 472.65 Gg of CO_2 (947.09 Gg C) in 2011.

Figure 3.38: *The share of different fuel types with the share of carbon stored in 2011*



Fuel Type	Carbon Stored (Gg of C)	Share (%)
Naphtha	370.43	39.11%
Lubricants	12.63	1.33%
Bitumen	118.99	12.56%
Coal Oils & Tars	39.25	4.14%
NG	80.00	8.45%
Gas/Diesel	8.03	0.85%
LPG	84.65	8.94%
Ethane	0.64	0.07%
Plastics	232.46	24.54%
Total	**947.09**	**100.00%**

Figure 3.39: *Overview of CO_2 emissions from carbon stored in 1990 – 2011*



3.6.2 Methodological issues – methods

Liquid fuels (ethane, gas oil, liquefied petroleum gas (LPG), naphtha and other fuels), solid fuels (coking coal) and natural gas are used as feedstocks in Slovakia. In addition, other non-energy use is associated with bitumen and lubricants. Default values from the Revised 1996 IPCC Guidelines are used to estimate the fraction of carbon stored under the reference approach. Default values are consistent with the country-specific data estimated on the basis of plant-specific information and expert judgment. The Tier 1 method was applied for the estimation of carbon stored.

Table 3.53: *Overview of carbon stocks in fuels in 2011*

Fuel Type	Fuel quantity (TJ)	Fraction of carbon stored	EFs (tC/TJ)
Naphtha	23 151.60	0.80	20.00
Lubricants	1 263.45	0.50	20.00
Bitumen	5 450.88	1.00	21.83
Coal Oils & Tars	2 009.46	0.75	26.05
NG	16 046.85	0.33	15.11
Gas/Diesel	506.47	0.80	19.82
LPG	6 026.00	0.80	17.56
Ethane	47.40	0.80	16.80
Plastics	14 528.80	0.80	20.00

3.6.3 Methodological issues – emission factors and other parameters

The most important criterion for EF and fraction of stored carbon is the consistency with parameters used in reference approach. The IPCC default values for the fractions of stored carbon are used mostly in the inventory.

3.6.4 Activity data

The following fuel types were balanced in the Slovak Republic in 2011 (Table 3.54):

- Fuels used as feed stocks type – Naphtha, Lubricants, Bitumen, Coal Oils and Tars (from Coking Coal), Natural Gas, Gas/Diesel Oil, LPG, Ethane and Plastics under other fuels.

Table 3.54: *Overview of quantity and CO_2 stocks in fuels in the period 1990 – 2011*

Fuel / Year	Naphtha (1.A.2c)	Lubricants (1.A.1c)	Bitumen (1.A.1c)	Coal Oils & Tars (1.A.1c)	NG (1.A.2c)	Gas/Diesel (1.A.1b)	LPG (1.A.2c)	Ethane (1.A.1b)	Plastics (1.A.2c)
1990	440.82	121.53	1 197.42	313.86	323.91	554.05	58.49	1 666.16	NO
1991	422.97	81.81	955.93	288.39	215.01	468.66	47.08	1 525.69	NO
1992	444.60	68.36	888.84	266.87	241.45	391.56	40.70	1 506.29	NO
1993	225.37	49.48	479.64	261.95	180.60	388.48	37.75	1 334.51	NO
1994	256.19	49.86	764.74	271.75	256.56	420.56	43.84	1 530.94	NO
1995	252.99	57.22	972.70	273.68	276.51	518.29	49.20	1 702.60	NO
1996	276.10	59.93	670.82	280.93	347.06	533.10	50.03	1 764.01	NO
1997	276.60	63.80	566.85	258.91	272.51	552.01	49.42	1 502.90	NO
1998	186.64	66.31	546.93	230.37	277.21	585.19	49.93	1 497.80	NO
1999	186.64	55.92	649.82	307.01	277.21	571.02	25.91	1 055.31	NO
2000	415.63	63.11	546.93	273.43	277.30	631.16	50.18	1 197.96	NO
2001	1 095.84	109.40	321.72	297.60	198.26	884.88	192.52	51.49	NO
2002	863.32	100.98	382.85	NO	NO	294.37	174.25	44.47	889.88
2003	885.40	97.03	307.86	NO	NO	280.84	331.54	44.00	855.46
2004	1 479.10	NO	NO	NO	NO	36.63	367.06	34.74	914.12
2005	1 438.36	68.97	275.40	169.07	294.10	36.81	338.65	9.35	1 048.37
2006	1 332.88	102.67	336.27	163.86	245.65	36.81	324.61	32.70	1 127.88
2007	1 442.64	104.91	330.87	163.25	375.44	34.36	367.26	28.03	975.58
2008	961.76	66.51	429.78	163.94	221.56	27.00	329.35	23.36	875.70
2009	1 457.98	30.99	391.25	138.52	224.12	27.00	338.83	4.67	762.21
2010	1 376.13	46.49	389.49	136.06	161.05	27.00	279.59	2.34	767.73
2011	1 358.23	46.33	436.31	143.93	293.32	29.45	310.40	2.34	852.36

3.6.5 Uncertainties and time-series consistency

The Tier 1 uncertainties analysis was performed according to the IPCC 2000 GPG. The Tier 2 uncertainty estimation has not been provided for the subcategory of civil aviation. The lack of input data is the most facing issue. The methodology is consistent during time series across the main types of fuels.

3.6.6 Source specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. The results of energy statistics that are used for GHG emission inventories are yearly issued in the Statistical yearbooks and in energy publications in physical and caloric values. The first preliminary data related to the liquid, solid, gaseous and biomass fuels balance for previous year in the Slovak Republic are available at the beginning of October. These data are verified by Profing Ltd. Bratislava (comparison of the consumption of fuels and the production of heat and electricity, the discussion with the main producers of heat and electricity and suppliers of fuels, etc.) and they are used for reference approach.

3.6.7 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

3.6.8 Source specific planned improvements

The previous review report indicated that the fuel quantity of natural gas used as feedstock in ammonia synthesis is reported as "NO" in CRF table 1.A(d) for the period 2002 – 2004. These data are not reported in the national energy statistics for this particular period. The filling this gap will be possible by using data provided by the ammonia producer. This activity is included in the improvement plan and will be improved in the next submission.

3.7 Fugitive emissions from coal mining and handling (CRF 1.B.1.A) and oil and natural gas (CRF 1.B.2)

3.7.1 Source subcategory description

Detail description of the source category 1.B is included in the Chapter 3.1.2 of this Report.

3.7.2 Source subcategory description - Coal mining and handling (CRF 1.B.1.A)

The Slovak Republic mined 2 371 kt of brown coal from underground mines in 2011 mostly for domestic consumption (industry and households). Total methane emissions from the underground coal mining in 2011 was estimated to be 16.18 Gg (14.75 Gg of CH_4 from mining activities, 1.43 Gg of CH_4 from post-mining activity and 0.18 Gg of CO_2 equivalents from methane cogeneration (category 1.A.1a electricity and heat production – other fuels) with recovery of 0.06 Gg of CH_4.

3.7.2.1 Methodological issues – methods

Total emissions from fugitive sources in coal mining industry can be calculated by the following formula: methane emissions = underground mining emissions + post-mining activity emissions - recovery or flared methane with cogeneration with Tier 2 methodology and the country specific EFs. The amount of mined brown coal (in the raw form) is the most important activity data. The fugitive methane emissions from underground coal mining and post-mining activities in the Slovak Republic were estimated in accordance with Tier 2 methodology from the IPCC 2000 GPG.

Table 3.55: *Overview of fugitive emissions from mining and post-mining activities in 1990 – 2011*

Year	Brown Coal	CH_4 Emissions from Mining	CH_4 Recovery from Mining	CH_4 Emissions from Post-Mining	CH_4 Emissions Total
	(kt)	(Gg)			
1990	3 456.00	25.114	0.000	2.084	**27.198**
1991	3 663.00	26.618	0.000	2.209	**28.827**
1992	3 803.50	27.639	0.000	2.294	**29.932**
1993	3 614.30	26.433	0.000	2.179	**28.612**
1994	3 744.80	27.654	0.000	2.258	**29.912**
1995	3 759.10	27.437	0.000	2.267	**29.704**
1996	3 840.10	27.760	0.000	2.316	**30.076**
1997	3 914.20	28.253	0.000	2.360	**30.613**
1998	3 951.00	28.785	0.000	2.382	**31.168**
1999	3 806.50	27.201	0.000	2.295	**29.496**
2000	3 649.30	26.620	0.000	2.201	**28.821**
2001	3 424.00	24.265	0.000	2.065	**26.330**
2002	3 401.00	23.643	0.000	2.051	**25.694**
2003	3 075.23	19.260	0.000	1.854	**21.114**
2004	2 951.87	17.993	0.000	1.780	**19.773**
2005	2 511.20	14.658	0.000	1.514	**16.173**
2006	2 206.28	13.340	0.000	1.330	**14.671**
2007	2 064.48	12.273	0.226	1.245	**13.518**
2008	2 423.07	14.488	0.182	1.461	**15.949**
2009	2 571.90	15.373	0.106	1.551	**16.924**
2010	2 370.00	13.796	0.032	1.429	**15.225**
2011	2 370.80	14.749	0.062	1.430	**16.178**

3.7.2.2 Methodological issues – emission factors and other parameters

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

- IPCC 1996 Guidance for National Greenhouse Gas Inventories, Fugitive sources, 1.4 Methane Emissions from Coal Mining and Handling Activities.
- IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories page 2.70, 2.6 Fugitive Emissions from Coal Mining and Handling.
- International Energy Agency – CIAB Global Methane and the Coal Industry (http://spider.iea.org/ciab/).
- Estimation of EF (CH_4) specified of mines operator – HBP Prievidza.

According to the IPCC 1996 Guidance 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 factor measured by the mine operators of HBP Prievidza on the base of concentration values of the methane in the air ventilation was assigned for one single mine according to the suggestion of the operators. The emission factors for post–mining activities were used from IPCC 2000 GPG for mining without drainage with known gas amount (in the coal after mining is present 30% of gas and 10% of gas for mines with pre-drainage). Overview of emission factors is presented in Table 3.56.

Based on the judgment of sectoral expert, it was decided to calculate fugitive methane emissions in the period 1990 – 2011 on the base of coal production from underground mines obtained from official sources and emission factors according to the methodology IEA-CIAB Global Methane and the Coal Industry selected for the depth of the mines (Table 3.56, point 2).

Table 3.56: *Coal production, characteristics of mine and the availability of emission factors for mining and post-mining assigned to single mines in the Slovak Republic in 2011*

Mine	Mine Novaky	Mine Novaky 6^{th} Logging Place	Mine Cigel	Mine Cigel 7^{th} Logging Place	Mine Handlova	Mine Handlova East Shaft	Mine Dolina	Mine Cary
Coal Production (kt)	1 245	0	0	583	0	252	172.504	118.298
Depth of Mine (m)	200	200	500	500	500-1500	500-1500	600	400
EF CH_4 (m^3/t)								
1. IPCC 1996 GL								
IPCC Mining Tier 1	10	10	10	10	10	10	10	10
IPCC Post-Mining	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
2. IEA - CIAB Global Methane and the Coal Industry								
CIAB Mining	6	6	13	13	13	13	13	13
CIAB Post-Mining	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
3. Measurements of HBP. a.s.								
HPB Mining	0.92	4.17	0	4.17	0	4.17	0.02	0.02
HPB Post-Mining	0.39	0.46	0	0.46	0	0.46	0.01	0.01

The calculation used the assumption that fugitive methane emissions were partly used for electricity and heat cogeneration since 2007 in the east shaft of mine Handlová and it continued also in 2011. The amount of cogenerated methane was 92 893 m^3 in 2011. The calculation is based on the measurement of gaseous mixture and concentration of methane. The emissions of GHGs from cogeneration are included into category 1.AA.1.A – other fuel (methane cogeneration (mining)) and represent 0.18 Gg of CO_2 equivalents in 2011. 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 2011. 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 emissions from mines. The average methane EF for methane from mining was 6.85 kg/t in 2011.

Table 3.57: *Cogeneration of methane from Mine Handlová, the east shaft during 2007 – 2012* (*predictions)*

Methane cogenerated in Mine Handlova East Shaft		**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Mixture Methane + Air	m^3	1 022 730	910 560	925 000	150 590	290 290	134 482
Average Concentration of CH_4	%	33.06	30.00	17.10	32.00	32.00	35.00
Quantity of CH_4	m^3	338 115	273 168	158 175	48 189	92 893	47 069
Density of CH_4 (20 °C)	kg/m^3	0.67	0.67	0.67	0.67	0.67	0.67
Quantity of Flared CH_4	t	225.86	182.48	105.66	32.19	62.05	31.44

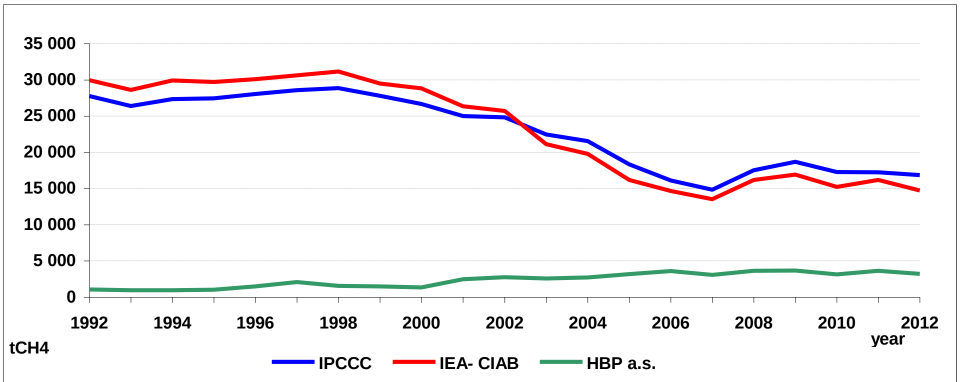
3.7.2.3 Activity data

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), Baňa Dolina Veľký Krtíš (BD) and Baňa Čáry (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 Cígeľ – non-gaseous (except 7th logging place)
  - Mine Handlová – gaseous
  - Mine Nováky – gaseous
- Baňa Čáry Holíč – gaseous
- Baňa Dolina Veľký Krtíš – gaseous

Figure 3.40 shows the comparison of trends in estimated CH_4 emissions in the Slovak Republic in years 1990 – 2011 (2012 predictions) according to different emission factors of IPCC GPG 2000, IEA-CIAB methodology and EF(CH_4) measured by HBP, a.s. Prievidza. In case of emissions calculation with use of IPCC emission factors, the trend of fugitive emissions CH_4 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 in the mines. 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 good practice, because measurements are not certified and they are not carried out continuously. The emissions can be underestimated.

Figure 3.40: *Comparison of trends in CH_4 emissions in the Slovak Republic in years 1990 – 2012* (*predictions)*



CH_4 emissions from post-mining activities represent the second part of gaseous methane, which is present in mined coal. This source of emissions releases the methane into the atmosphere during the manipulation and storage of coal. The measurement of these emissions are not realised so the emission must be estimated with the default emission factors. 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 estimation of emission from post-mining activities based on IEA-CIAB methodology is 0.9 m^3/t (0.603 kg/t).

3.7.2.4 Uncertainties and time-series consistency

The Tier 1 uncertainty analysis was performed according to the IPCC 2000 GPG. The Tier 2 uncertainty estimation was not provided for subcategory civil aviation for the present. Lack of input data availability is the most facing issue. The methodology is consistent during time series across of the main types of fuels.

The amount of methane from underground mining is naturally variable. The direct measurements of the CH_4 emissions from the ventilated air are made with the ±20% accuracy depending on the measurement's installation. The repeatability of the measurements increases the accuracy up to ±5%. For the continual measurement the uncertainty is in the range of ±10-15% for the two weeks repeating.

The emission 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 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.

3.7.2.5 Source 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 Profing Ltd. (Mr. Jan Judak is the sectoral expert for energy and fugitive emissions) prepared emission 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 and the Statistical Office of the Slovak Republic. The background documents are archived by sectoral experts and in central archiving system of SNE at the SHMÚ.

Regarding the recommendation from Para 53 of the ARR 2012 to include explanation for not reporting CO_2 emissions from coal mining and handling in the Slovak GHG inventory it can be resumed, that these emissions are negligible. The brown coal/lignite is mined in deep underground mines. Coal is energy poor (NCV 9-10 MJ/kg, carbon content 28%) and is directly combusted in the power plant Nováky located at the same area. Relatively short contact time of the coal with the air is not appropriate for oxidation and generation of CO_2 and the CO_2 volume in fugitive gases is under measurement threshold close to zero. Therefore, Slovakia reports CO_2 emissions from coal mining and handling (1.B.1a) as not occurring ("NO").

3.7.2.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

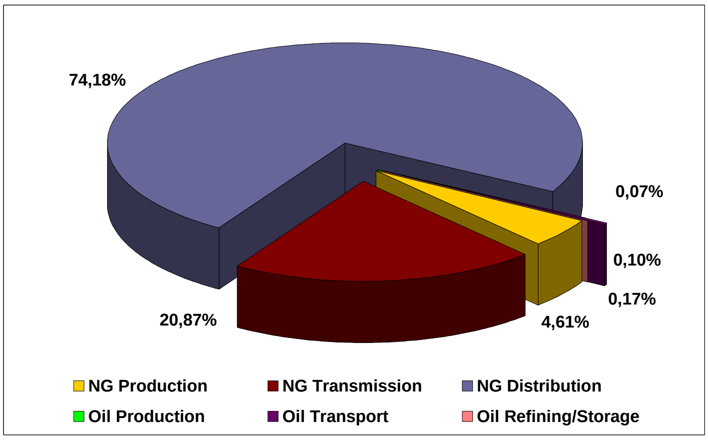
3.7.2.7 Source specific planned improvements

The Slovak Republic uses EFs from the international methodology IEA-CIAB, the improvements can be found in the implementation of EFs measured directly from the mines. According to the present measurements, the information about the gas released is not sufficiently accurate and measurements are not continual. Greater effort could be invested into the determination of appropriate national EFs for mining and post-mining activities in the Slovak Republic.

3.7.3 Source subcategory description – Oil and natural gas (CRF 1.B.2)

The production of oil and natural gas from domestic sources are negligible in the Slovak Republic and the major share of these stocks comes from import. These categories are important key sources in level and trend assessment. Total aggregated emissions represented 756.94 Gg of CO_2 equivalents (36.03 Gg CH_4) in 2011. Total CO_2 emissions were 0.241 Gg in 2011 and the estimation was based on the composition of natural gas and carbon content. Total N_2O emissions were 5.6 kg in 2011. The major share belongs to the NG distribution (74%) and NG transmission (21%). Production of natural gas is decreasing and represented 5% from the total fugitive emissions from oil and NG activities.

Figure 3.41: *The share of individual activities in fugitive emissions of oil and natural gas*



IPCC Category	GHG (CO_2 *eq.*)	Share (%)
NG Production	30.55	4.61%
NG Transmission	138.29	20.87%
NG Distribution	491.59	74.18%
Oil Production	0.47	0.07%
Oil Transport	1.13	0.17%
Oil Ref./Storage	0.68	0.10%

Total emission from oil activities (1.B.2A) were 2.28 Gg of CO_2 equivalents (0.73 t of CO_2 and 108.59 t of CH_4) in 2011. Total emissions are decreasing continuously since the base year due to decrease in production and storage (Table 3.58).

Table 3.58: *Trend in fugitive emissions from oil activities in 1990 – 2011*

Year	Oil Production			Oil Transport			Oil Refining/Storage		
	Production	CO_2	CH_4	Production	CO_2	CH_4	Production	CO_2	CH_4
	(TJ)	(t)		(PJ)	(t)		(PJ)	(t)	
1990	3 046.01	0.58	109.71	565.62	0.39	73.34	259.99	0.18	33.71
1991	2 978.22	0.57	107.27	565.57	0.39	73.34	209.05	0.14	27.11
1992	2 561.61	0.49	92.27	565.55	0.39	73.34	182.50	0.13	23.67
1993	2 769.25	0.53	99.75	565.55	0.39	73.34	190.26	0.13	24.67
1994	2 803.88	0.54	100.82	565.65	0.39	73.34	200.86	0.14	26.05
1995	3 091.86	0.59	111.37	522.75	0.36	67.66	227.97	0.16	29.51
1996	2 970.39	0.57	107.00	522.75	0.36	67.66	224.63	0.15	29.13
1997	2 665.14	0.51	96.00	461.79	0.32	59.89	222.11	0.15	28.80
1998	2 490.25	0.48	90.00	461.79	0.32	59.89	227.48	0.16	29.60
1999	2 739.38	0.53	99.00	431.66	0.30	56.16	224.63	0.16	29.22
2000	2 448.76	0.47	88.50	385.95	0.27	50.22	223.60	0.15	29.10
2001	2 290.75	0.44	82.50	397.80	0.27	51.58	228.30	0.16	29.48
2002	2 132.00	0.41	78.00	387.29	0.27	51.01	229.81	0.16	30.27
2003	1 747.20	0.33	63.00	413.07	0.28	53.62	234.46	0.16	30.43
2004	1 581.00	0.30	57.00	429.57	0.30	55.75	239.41	0.17	31.07
2005	1 277.20	0.25	46.50	439.29	0.31	57.58	228.33	0.16	29.93
2006	1 162.00	0.23	42.00	462.54	0.33	60.19	238.58	0.17	31.04
2007	1 162.00	0.18	42.00	441.44	0.24	57.44	252.86	0.14	32.90
2008	747.00	0.11	27.00	442.25	0.24	57.55	245.68	0.13	31.97
2009	622.50	0.14	22.50	443.44	0.37	57.70	237.34	0.20	30.88
2010	539.50	0.11	19.50	418.13	0.29	54.41	226.30	0.16	29.45
2011	629.94	0.15	22.50	416.59	0.36	53.57	252.90	0.22	32.52

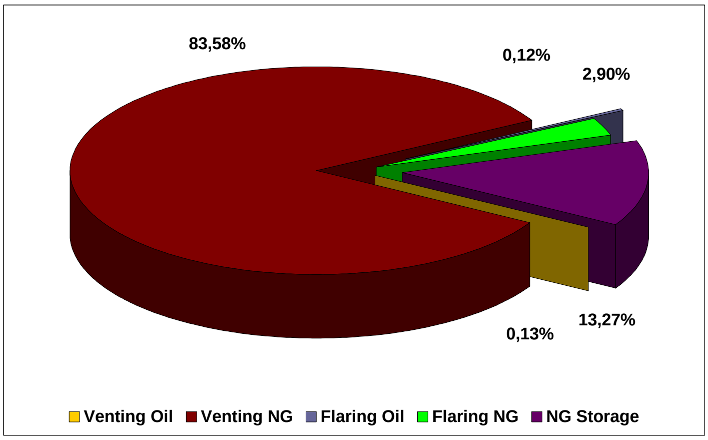
Total emissions from natural gas (1.B.2B) activities were 660.43 Gg of CO_2 equivalents (210 t of CO_2 and 31.44 Gg of CH_4) in 2011. Since 2003 total emissions fluctuated due to the changes in production and storage. Other leakages at industrial plants and power stations and in residential and commercial sectors are included in transmission and distribution categories and balance according to the length of pipeline (Table 3.59).

Table 3.59: *Trend in fugitive emissions from NG activities in 1990 – 2011*

Year	NG Production			NG Transmission			NG Distribution		
	Production	CO_2	CH_4	Transmission	CO_2	CH_4	Distribution	CO_2	CH_4
	(TJ)	(t)		(km)	(t)		(km)	(t)	
1990	14 905.08	43.50	5 288.99	2 268	34.93	6 577.20	13 364	50.39	9 488.44
1991	10 691.70	30.77	5 792.90	2 268	34.93	6 577.20	13 364	50.39	9 488.44
1992	9 429.08	27.14	5 110.30	2 268	34.93	6 577.20	13 364	50.39	9 488.44
1993	8 602.98	24.89	4 685.98	2 268	34.93	6 577.20	15 149	57.13	10 755.79
1994	9 675.72	28.32	5 331.68	2 268	34.93	6 577.20	15 905	59.98	11 292.55
1995	11 702.88	33.71	6 346.36	2 268	34.93	6 577.20	17 487	65.94	12 415.77
1996	10 704.26	30.77	5 792.90	2 268	34.93	6 577.20	19 152	72.22	13 597.92
1997	9 837.56	28.32	5 331.68	2 268	34.93	6 577.20	20 716	78.12	14 708.36
1998	8 850.40	25.48	4 796.67	2 268	34.93	6 577.20	23 947	90.30	17 002.37
1999	7 274.01	20.87	3 929.58	2 268	34.93	6 577.20	25 404	95.80	18 036.84
2000	5 921.79	16.95	3 191.63	2 268	34.93	6 577.20	26 894	101.42	19 094.74
2001	6 699.28	19.20	3 615.95	2 268	34.93	6 577.20	27 946	105.38	19 841.66
2002	6 049.86	15.07	2 836.90	2 268	34.93	6 577.20	29 006	109.38	20 594.26
2003	8 368.07	25.94	4 883.48	2 268	34.93	6 577.20	30 033	113.25	21 323.43
2004	6 603.00	7.97	1 500.31	2 268	34.93	6 577.20	30 534	115.14	21 679.14
2005	5 288.80	3.10	583.59	2 270	34.93	6 583.00	30 566	115.26	21 701.86
2006	7 368.12	4.73	869.46	2 270	35.81	6 583.00	30 566	118.04	21 701.86
2007	4 550.40	14.58	3 453.15	2 270	27.79	6 583.00	31 537	94.54	22 391.27
2008	4 479.30	8.96	2 122.29	2 270	27.79	6 583.00	31 994	95.91	22 715.74
2009	3 669.90	17.64	2 763.16	2 270	42.03	6 583.00	32 506	147.34	23 079.26
2010	3 697.20	7.79	1 437.76	2 270	35.65	6 583.00	32 798	126.12	23 286.58
2011	4 303.12	9.74	1 454.45	2 270	44.08	6 583.00	32 960	156.68	23 401.60

Total emissions from flaring and venting activities (1.B.2C) were 59.38 Gg of CO_2 equivalents (18.92 t of CO_2, 2.83 Gg of CH_4 and 2.55 kg of N_2O) in 2011 (Table 3.60). Emissions from the category other (1.B.2D) includes emissions from storage of natural gas and were 34.85 Gg of CO_2 equivalents (11.11 t of CO_2, 1.66 Gg of CH_4 and 3.03 kg of N_2O) (Table 3.61). Fugitive emissions from flaring and venting of oil and natural gas and from the storage of natural gas are estimated separately. Total emissions have been decreased since 2003 due decreasing production and storage. The emissions in category 1.B.2.B5 Other leakages at industrial plants and power stations and in residential and commercial sectors are included in transmission and distribution categories and balance according to the length of pipeline. Activity data are consistent with activity data used by oil and NG estimation.

Figure 3.42: *The share of individual activities of venting, flaring and storage of NG in 2011*



IPCC Category	GHG (CO_2 *eq.*)	Share (%)
Venting Oil	0.09	0.13%
Venting NG	57.23	83.58%
Flaring Oil	0.09	0.12%
Flaring NG	1.98	2.90%
NG Storage	9.09	13.27%

Total emissions from storage of natural gas are presented in Table 3.61 and are allocated in category 1.B.2D other leakages. The major share is distributed between NG storage (13%) and NG venting

(84%), the venting and flaring of oil and NG flaring represented 3% from the total fugitive emissions from venting, flaring and storage of oil and NG in 2011 (Figure 3.42).

Table 3.60: *Trend in fugitive emissions from venting and flaring activities in 1990 – 2011*

Year	Venting Oil		Venting NG		Flaring Oil			Flaring NG		
	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
	Emissions (t)									
1990	0.105	19.747	14.455	2 721.6	0.105	19.747	0.00005	1.014	115.519	0.009
1991	0.102	19.309	14.455	2 721.6	0.103	19.309	0.00005	0.717	135.000	0.007
1992	0.088	16.609	14.455	2 721.6	0.088	16.609	0.00004	0.633	119.120	0.006
1993	0.095	17.955	14.455	2 721.6	0.095	17.955	0.00004	0.580	109.229	0.005
1994	0.096	18.147	14.455	2 721.6	0.096	18.147	0.00004	0.660	124.280	0.006
1995	0.106	20.047	14.455	2 721.6	0.106	20.047	0.00005	0.786	147.932	0.007
1996	0.102	19.259	14.455	2 721.6	0.102	19.259	0.00005	0.717	135.031	0.007
1997	0.092	17.280	14.455	2 721.6	0.092	17.280	0.00004	0.660	124.280	0.006
1998	0.086	16.200	14.455	2 721.6	0.086	16.200	0.00004	0.594	111.809	0.005
1999	0.095	17.820	14.455	2 721.6	0.095	17.820	0.00004	0.486	91.597	0.004
2000	0.085	15.930	14.455	2 721.6	0.085	15.930	0.00004	0.395	74.396	0.004
2001	0.079	14.850	14.549	2 721.6	0.079	14.850	0.00004	0.448	84.287	0.004
2002	0.075	14.040	14.549	2 721.6	0.075	14.040	0.00003	0.344	64.815	0.004
2003	0.060	11.340	14.549	2 721.6	0.060	11.340	0.00003	0.619	116.542	0.005
2004	0.054	10.260	14.549	2 721.6	0.054	10.260	0.00002	0.144	25.006	0.003
2005	0.044	8.370	14.468	2 724.0	0.044	8.370	0.00002	0.019	3.530	0.003
2006	0.041	7.560	14.816	2 724.0	0.041	7.560	0.00002	0.302	55.472	0.004
2007	0.032	7.560	11.501	2 724.0	0.032	7.560	0.00002	0.623	147.576	0.003
2008	0.021	4.860	11.501	2 724.0	0.021	4.860	0.00001	0.454	107.636	0.002
2009	0.026	4.050	17.390	2 724.0	0.026	4.050	0.00001	0.686	107.457	0.002
2010	0.019	3.510	14.754	2 724.0	0.019	3.510	0.00001	0.582	107.470	0.002
2011	0.027	4.050	18.238	2 724.0	0.027	4.050	0.00001	0.632	94.426	0.003

Table 3.61: *Trend in fugitive emissions from storage of NG in 1990 – 2011*

Year	NG Storage			
	Storage	CO_2 Emissions	CH_4 Emissions	N_2O Emissions
	(TJ)	(t)		
1990	33.570	0.022	4.200	0.011
1991	34.050	0.022	4.200	0.008
1992	34.040	0.022	4.200	0.007
1993	33.870	0.022	4.200	0.006
1994	2 390.472	1.593	299.880	0.007
1995	5 422.787	3.556	669.480	0.009
1996	5 352.130	3.502	659.400	0.008
1997	2 403.224	1.575	296.520	0.007
1998	4 799.640	3.145	592.200	0.007
1999	3 360.389	2.195	413.280	0.005
2000	17 946.789	11.696	2 202.060	0.004
2001	14 861.464	9.699	1 826.160	0.005
2002	6 203.670	4.049	762.300	0.004
2003	1 101.872	0.726	136.676	0.006
2004	13 463.001	8.777	1 650.600	0.004
2005	1 709.700	1.114	210.000	0.004
2006	377.410	0.251	46.200	0.005
2007	NO	NO	NO	NO
2008	4 558.176	2.234	529.200	0.003
2009	19 529.446	15.256	2 389.800	0.003
2010	3 539.842	2.343	432.600	0.003
2011	13 621.338	11.108	1 659.000	0.003

3.7.3.1 Methodological issues – methods

The fugitive emissions of CH_4 from the transport and the distribution of natural gas in the Slovak Republic were calculated with IPCC Tier 1 default methodology. The methodology is based on the IPCC 2000 GPG and using new refined emissions factors for methane in Tier 1, based on North America data – IPCC 2000 Good Practice Guidelines, table 2-16 with the applications of high level emission factors (conservative principle). The emissions of CO_2 were estimated based on analyses of content of natural gas in 2011 (prepared by monthly analyses) with the recalculation value of 6.7 grams CO_2 per kg CH_4.

3.7.3.2 Methodological issues – emission factors and other parameters

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

- IPCC 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories 2.7 Fugitive Emissions from Oil and gas operation, Table 3 gives of EF used for calculation.

Table 3.62: *Activity data, EFs and fugitive emissions from oil and NG production, transport and refining/storage in 2011*

Activity	Oil		EF CO_2	EF CH_4	EF N_2O	CO_2	CH_4	N_2O
	(t)	(PJ)	(g/kg CH_4)	(Gg/t)	(g/kg)		(t)	
Oil Production	15 000	0.630	6.7	1.50E-03	0.00	0.151	22.50	0.00
Oil Transport	9 919 730	416.589	6.7	5.40E-06	0.00	0.359	53.57	0.00
Oil Ref./Storage	6 022 000	252.900	6.7	5.40E-06	0.00	0.218	32.52	0.00
Oil Venting	15 000	0.630	6.7	2.70E-04	0.00	0.027	4.05	0.00
Oil Flaring	15 000	0.630	6.7	2.70E-04	6.40E-07	0.027	4.05	9.60E-09
Activity	**NG**		**EF CO_2**	**EF CH_4**	**EF N_2O**	**CO_2**	**CH_4**	**N_2O**
	(m^3)	(PJ)	(g/kg CH_4	(Gg/t)	(g/kg)		(t)	
NG Production	121 000	4.303	6.7	2.90E-03	0.00	9.74	1 454.45	0.00
NG Transmits.	2 270	km	6.7	2.90E-03	0.00	44.08	6 583.00	0.00
NG Distribution	32 960	km	6.7	7.10E-04	0.00	156.68	23 401.60	0.00
NG Venting	2 270	km	6.7	1.20E-03	0.00	18.24	2 724.00	0.00
NG Flaring	121 000	4.303	6.7	1.30E-05	2.10E-08	0.63	94.43	2.54E-06
NG Storage	395 000	13.621	6.7	4.20E-03	2.50E-08	11.11	1 659.00	3.03E-06

3.7.3.3 Activity data

Activity data of oil production, transport and refining/storage are from 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 of the Slovak Statistical Office. Activity data of natural gas were obtained from the Slovak Gas Industry, LtD., the Ministry of the Economy of the Slovak Republic and the Statistical Office of the Slovak Republic.

Table 3.63: *Activity data for production, export and import of NG in the Slovak Republic in 2011*

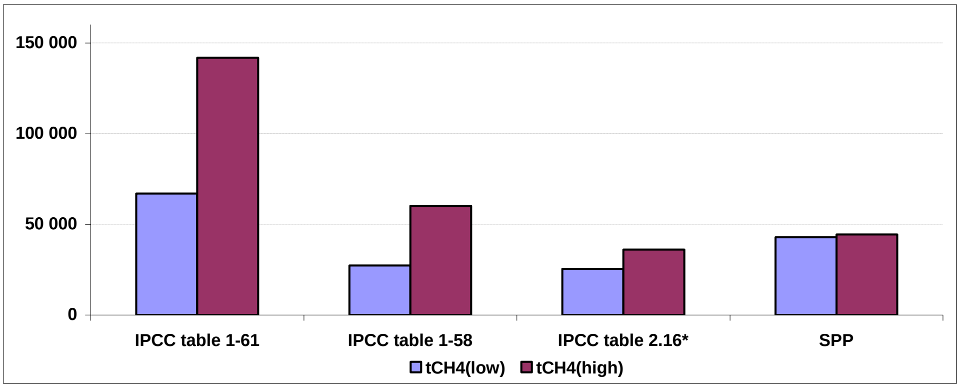
Activity	Natural Gas	Natural Gas	NCV
	(m^3)	(PJ)	(PJ/m^3)
Indigenous Production	121 000 000	4.303	35.563
Associated Gas	14 000 000	0.498	35.563
Non-associated Gas	107 000 000	3.805	35.563
Stock Changes	-395 000 000	-13.621	34.484
Gas Vented	2 000 000	0.069	34.319
Gas Flared	7 000 000	0.240	34.345
Export	3 000 000.000	0.103	34.484
Import	5 907 000 000	203.566	34.462
Inland Consumption	**5 630 000 000**	**194.147**	**34.484**

The results of the calculated fugitive methane emissions show, that disaggregating of gas and oil industry to main- and sub-categories according to the principles of „good practice“ improved the quality of balances. The results received from the calculation of methane emissions with the applications of new refined EF (CH_4) (high) for Tier 1, based on the North America data are the most real values. The trend of fugitive emissions CH_4 from transport and distribution of natural gas in the Slovak Republic is increasing. It is due to the expansion of distribution system and the growth of NG consumption. The emissions of CO_2 were estimated based on analyses of the content of natural gas in 2011 (prepared by monthly analyses) with the recalculation value of 6.7 grams CO_2 per kg CH_4. The natural gas production category was estimated on the values of fugitive and flaring methane emissions reported data of vented NG – 2 mills. m^3 and flared NG – 7 mills. m^3 (the Statistical Office of the Slovak Republic, 2011).

3.7.3.4 Uncertainties and time-series consistency

The Tier 1 uncertainties analyses were performed according to the IPCC 2000 GPG. The Tier 2 uncertainty estimation was not provided for fugitive emissions from oil and natural gas. Lack of input data is the most facing issue. The methodology is consistent during time series across the activities. The trend of fugitive emissions of CH_4 from transport and distribution of natural gas in the Slovak Republic is increasing due to the expansion of the distribution system and the growth of NG consumption in the Slovak Republic. The fugitive CO_2 emissions from transport and distribution of natural gas were calculated on the base of natural gas composition. The average value of CO_2 content in natural gas was 0.24% mol in 2011. The application of IPCC default EFs for fugitive emissions from NG for the regions of the former USSR and Eastern Europe (IPCC Guidelines, Reference Manual Table I-49) gives too high results (66 971 – 141 770 t CH_4). For the balance of the fugitive methane emissions from transport and distribution of natural gas in the Slovak Republic it was recommend to use values calculated by the applications of new refined EF based on North America data with the conservative approach (using high range of EFs).

Figure 3.43: *The comparison between the methodologies used for the calculation (national approach according to the Slovak Gas Industry, LtD. and IPCC) of fugitive methane emissions from transport and distribution of natural gas in the Slovak Republic (IPCC table 2.16 - reported emissions)*



3.7.3.5 Source 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 Profing Ltd. Company (Mr. Jan Judak is the sectoral expert for energy and fugitive emissions) 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 Transpetrol Company (oil) and the Slovak Gas Company (NG) and the comparison of them 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 the central archiving system of 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 6.7 grams CO_2 per Gg of CH_4.

3.7.3.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

3.7.3.7 Source specific planned improvements

The Slovak Republic used EFs from the international methodology IEA-CIAB, the improvements can be found in the implementation of EFs measured directly from the companies. According to the present measurements, the information about the natural gas is not sufficiently accurate and measurements are not continual; the measurements are not carried out at the distribution places. Greater effort could be invested into the determination of appropriate national EFs for fugitive emissions from oil and natural gas production, processing and distribution in the Slovak Republic.

3.8 International bunkers (CRF 1.C1), Multilateral operation (CRF 1.C2) and Emissions from biomass CRF 1.C3)

3.8.1 Source category description

Emission inventory from category 1.C Memo items includes emissions from international aviation (1.C.1A), international navigation (1.C.1B) and biomass (1.C.3). Multilateral operations (1.C.2) do not occur in the Slovak Republic. The emissions are not included in national totals inventory.

3.8.2 Source subcategory description – International aviation (CRF 1.C.1.A)

Since 1990, the Slovak Republic has been estimating the emissions from international aviation based on the expert judgment and according to the information about LTO cycles and fuel consumption. The international aviation occurs more frequently than the national aviation.

The estimation of GHG emissions was performed based on the total sale of fuels at the important Slovak airports (Bratislava, Košice, Poprad, Sliač, Piešťany and Žilina) in the period 1990 – 2011 and the expert estimation of the share in total national fuels. In 2011, the emissions from international civil aviation decreased back to the level of 2006 and represented 105.80 Gg of CO_2 equivalents. The interannual decreasing of emissions is explained by recession of economy and canceling of many regular flight operated by foreign companies at Bratislava Airport in 2011. According to the recent projections the increasing trend will continue after 2012.

3.8.2.1 Methodological issues – methods

See methodology for civil aviation in Chapter 3.3.2 of this Report.

The Slovak Republic has used Tier 1 methodology based on sold fuels for the estimation of emissions from aviation transport, both for aviation gasoline and jet kerosene.

Based on the expert estimation oft total sale of jet kerosene it is stated that the international aviation represented 95% from the total sale of the fuel at the airports. The approximately opposite ration is applied for the consumption of aviation gasoline (5% on international flights). The expert estimation was corrected in 2009 and increased by 5% for jet kerosene. The ratio for aviation gasoline did not change and is 90% for national flights and 10% for international flights.

3.8.2.2 Methodological issues – emission factors and other parameters

See the emission factors for jet kerosene and aviation gasoline in section civil aviation in Chapter 3.3.2 of this Report.

3.8.2.3 Activity data

The number of realized LTO cycles during the year at monitored airports, the types of aircrafts and the carrying capacity of the airports are basic input information used for the estimation of emissions from civil aviation. The aircrafts are divided into two weight categories up to 5.7 t and over 5.7 t. The innovated method uses emission factors for each aircraft type and weight category. The number of total LTO cycles was 26 069 cycles in 2011. Total consumption of jet kerosene was 33 227 t and the consumption of aviation gasoline by international flights was 10.08 t.

The overall view of the sale of aviation fuels according to the types (aviation gasoline and jet kerosene) during 1990 – 2011 was estimated. For the period 1994 – 2011 the data came directly from the airport statistical processing information based on annual bases. The data on the sale of fuels in the period 1990 – 1993 are based on the expert estimation according to the real LTO cycles in this period. The overview of fuels quantity sold (fill in) at the Slovak airports during 1990 – 2011 is shown in Table 3.64.

Table 3.64: *Fuel quantities sold at the Slovak airports and GHG emissions during 1990 – 2011 for international flights*

Year	Aviation Gasoline					Jet Kerosene				
	Consumption		**CO_2**	**CH_4**	**N_2O**	**Consumption**		**CO_2**	**CH_4**	**N_2O**
	(TJ)	(t)	(t)			(TJ)	(t)	(t)		
1990	1.11	25.90	81.60	0.05	0.003	862.70	20 007.00	63 022.10	1.00	2.08
1991	1.03	24.05	75.80	0.05	0.002	802.16	18 603.00	58 599.50	0.93	1.94
1992	0.95	22.20	69.90	0.04	0.002	741.62	17 199.00	54 176.90	0.86	1.79
1993	0.87	20.35	64.10	0.04	0.002	726.49	16 848.00	53 071.20	0.84	1.75
1994	0.80	18.59	58.60	0.04	0.002	612.13	14 195.85	44 716.90	0.71	1.48
1995	0.73	17.14	54.00	0.03	0.002	615.85	14 282.23	44 989.00	0.71	1.49
1996	0.80	18.62	58.70	0.04	0.002	726.86	16 856.76	53 098.80	0.84	1.75
1997	0.71	16.55	52.10	0.03	0.002	643.77	14 929.80	47 028.90	0.75	1.55
1998	0.63	14.64	46.10	0.03	0.001	593.62	13 766.62	43 364.90	0.69	1.43
1999	0.67	15.66	49.30	0.03	0.002	598.96	13 890.60	43 755.40	0.70	1.45
2000	0.85	19.75	62.20	0.04	0.002	608.45	14 110.69	44 448.70	0.71	1.47
2001	0.88	20.61	64.90	0.04	0.002	572.18	13 269.57	41 799.20	0.66	1.38
2002	0.95	22.28	70.20	0.04	0.002	594.01	13 840.34	43 393.70	0.69	1.43
2003	0.92	21.56	67.90	0.04	0.002	785.58	18 218.41	57 388.00	0.91	1.90
2004	0.67	15.65	49.30	0.03	0.002	1 062.70	24 645.09	77 632.00	1.23	2.56
2005	0.79	18.54	58.40	0.04	0.002	1 233.14	28 597.79	90 083.00	1.43	2.97
2006	0.78	18.21	57.36	0.03	0.002	1 382.98	32 072.73	101 029.10	1.60	3.34
2007	0.71	16.54	52.11	0.03	0.002	1 606.29	37 251.71	117 342.88	1.86	3.87
2008	0.54	12.72	40.08	0.02	0.001	1 814.39	42 077.65	132 544.59	2.10	4.38
2009	0.54	12.71	40.03	0.02	0.001	1 536.73	35 489.44	111 791.75	1.77	3.69
2010	0.59	13.90	43.79	0.03	0.001	1 421.41	32 826.22	103 402.59	1.64	3.41
2011	0.43	10.08	31.76	0.02	0.001	1 438.76	33 226.96	104 664.91	1.66	3.46

3.8.2.4 Uncertainties and time-series consistency

See uncertainty and time series consistency for civil aviation in Chapter 3.3.2 of this Report. Tier 1 uncertainty was included in total assessment. Time series consistency is ensured.

3.8.2.5 Source specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6 and in the Chapter 3.3.2 of this Report.

3.8.2.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

3.8.2.7 Source specific planned improvements

The implementation of Tier 2 methodology is in preparation. The discussions on the first estimation are going on with the Ministry of Transport and Regional Development – the Department of Civil Aviation and the Bratislava airport. The initiative aimed at the development of a new methodology for including aviation in emission trading system after 2012 has also increased. The first preliminary results show, that the expert judgment introducing the differentiation of the flights into national and international ones was correct.

3.8.3 Source subcategory description – International navigation (CRF 1.C.1.B)

GHG emission inventory of navigation transport in the Slovak Republic is aimed at the calculation of CO_2, CH_4 and N_2O emissions from shipping activities in the Slovak section of the Danube River. The inventory of GHG emissions from inland shipping transport has no direct methodological support in the IPCC 2000 GPG. For this reason and in view of the relationship between 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 in the Slovak section 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 33.84 Gg of CO_2 equivalents in 2011, the decrease is more than 11% compared to the previous year 2010 but compared to the base year, the decrease is significant.

Table 3.65: *Overview of GHG emission inventory in inland shipping in 2011*

Activity	Diesel Oil Sale		Emissions (t)		
	(TJ)	(kt)	CO_2	CH_4	N_2O
EFs for the boats in kg/t diesel oil			***3 188 t/t***	***0.19 t/t***	***1.37 t/t***
Slovak Shipping and Ports Bratislava	338.94	7 975.00	25 424.30	1.52	10.93
State Shipping Administration	11.82	278.00	886.26	0.05	0.38
International Shipping Companies	46.92	1 104.00	3 519.55	0.21	1.51
Total SR	**397.67**	**9 357.00**	**29 830.12**	**1.78**	**12.82**

3.8.3.1 Methodological issues – methods

The Slovak Republic used Tier 1 methodology based on transportation model (fuel consumption by transit transport) for the estimation of emission from inland shipping on the Danube River. National shipping activities did not occur (except of few tourist sightseeing journeys during summer months). According to the recommendations of ERT final findings and IPCC 2000 GPG, 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.

3.8.3.2 Methodological issues – emission factors and other parameters

The GHG emissions from the diesel oil consumption sold in the Slovak Republic in important ports Bratislava and Komárno were balanced in the period 1990 – 2011. Table 3.61 shows the emission balance using EFs for the different type of ships known in the time of estimation for diesel fuel, which is more realistic way of emission estimation and is recommended by sectoral expert.

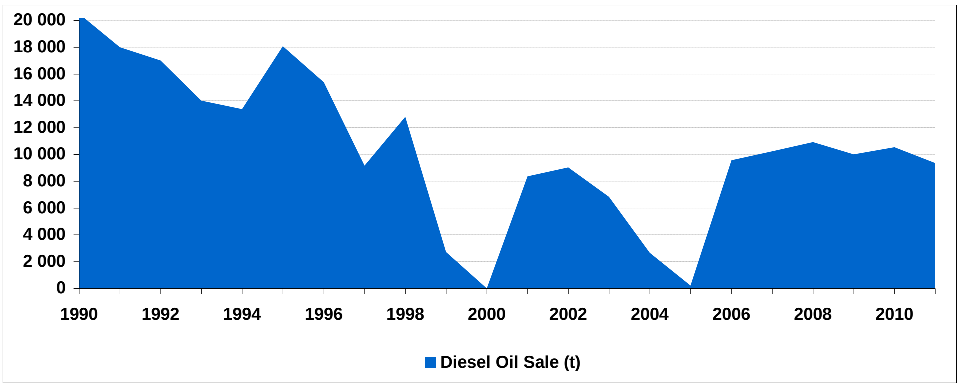
3.8.3.3 Activity data

Bratislava and Komárno are two relevant ports on the Danube River taken into consideration for the emission estimation in the Slovak inland international transport. The sources of activity data for the period 1994 – 2011 are the Slovak Shipping and Ports in Bratislava, the State Shipping Administration and other international shipping companies in accordance with the annual providing 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. Emissions for the year 2000 were estimated to be negligible, because of increasing prices of diesel oil fuel in the Slovak Republic and decreasing prices of fuels in the neighboring countries (market discrepancies).

Table 3.66: *Emission balance of GHGs from diesel oil sold for shipping companies in the Slovak Republic in 1990 – 2011 based on historical EFs in that time*

Year	Emissions (t)			Diesel Oil Sale
	CO_2	CH_4	N_2O	(kt)
EFs for the boats in kg/t diesel oil	***3 188***	***0.25***	***0.10***	
1990	65 354.00	5.13	2.05	20 500
EFs for the boats in kg/t diesel oil	***3 188***	***0.20***	***1.37***	
1995	57 594.40	3.61	24.75	18 066
2000	NO	NO	NO	0
2001	26 670.81	1.67	11.46	8 366
EFs for the boats in kg/t diesel oil	***3 188***	***0.19***	***1.37***	
2002	28 778.71	1.72	12.37	9 027
2003	21 793.17	1.30	9.37	6 836
2004	8 483.17	0.51	3.65	2 661
2005	682.23	0.04	0.29	214
2006	30 505.97	1.82	13.11	9 569
2007	32 617.19	1.94	14.02	10 231
2008	34 822.52	2.08	14.96	10 923
2009	31 905.50	1.90	13.71	10 008
2010	33 607.90	2.00	14.44	10 542
2011	29 830.12	1.78	12.82	9 357

Figure 3.44: *Overview of diesel oil consumption for shipping transport in 1990 – 2011*



3.8.3.4 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 in the Slovak territory. This 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.

3.8.3.5 Source specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6 and in the Chapter 3.3.2 of this Report. The verification of activity data on fuels sold for shipping activities was performed by the sectoral expert and compared with the statistical information.

3.8.3.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

3.8.3.7 Source specific planned improvements

The information about on inland tourists shipping in the Slovak Republic can be collected from several lakes and small rivers. These emissions will be included into the national shipping transportation in the next submission.

3.8.4 Source subcategory description – Emissions from biomass (CRF 1.C.3)

The information on the biomass consumption is included in sectoral approach allocated in appropriate category. CO_2 emissions from biomass are not included in national totals, but they have been estimated since the base year. Total CO_2 emissions have increasing trend and in 2011, they represented 3 513.69 Gg of CO_2 (36 028.60 TJ). This is the increase by 24% compared to the previous year 2010. The fluctuations in trend are expected also in the future due to the household consumption and price policy.

Figure 3.45: *Trend of CO_2 emissions from biomass in 1990 – 2011*

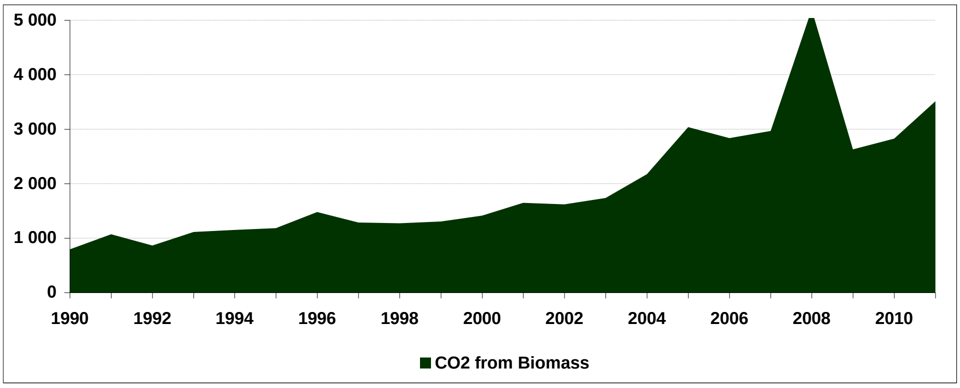


Table 3.67: *Trend of emissions from biomass in 1990 – 2011*

Year	Consumption	CO_2	CH_4	N_2O
	(TJ)	(Gg)	(t)	
1990	7 910.86	793.83	232.37	31.64
1991	10 654.83	1 069.08	315.05	42.58
1992	8 619.12	865.31	254.32	34.49
1993	11 067.05	1 110.96	328.06	44.29
1994	11 456.18	1 150.16	339.99	45.87
1995	11 783.40	1 183.10	350.01	47.12
1996	14 711.43	1 476.75	437.98	58.80
1997	12 828.54	1 288.07	381.52	51.32
1998	12 677.14	1 272.97	376.93	50.75
1999	12 981.49	1 303.57	385.91	51.95
2000	14 185.55	1 412.60	419.37	55.93
2001	16 539.23	1 646.58	479.76	64.05
2002	16 193.17	1 618.73	476.16	63.53
2003	17 373.25	1 734.85	509.34	67.97
2004	21 740.26	2 175.16	642.30	85.69
2005	30 355.29	3 036.58	897.54	119.75
2006	28 361.11	2 836.65	837.40	111.74
2007	30 266.93	2 969.09	844.63	115.08
2008	52 528.84	5 197.49	1 503.39	203.14
2009	26 952.97	2 629.21	732.94	101.09
2010	29 188.04	2 826.04	764.23	106.99
2011	36 028.60	3 513.69	942.39	131.63

3.8.4.1 Methodological issues – methods

See methodology for sectoral approach in section 3.2.

3.8.4.2 Methodological issues – emission factors and other parameters

See emission factors and other parameters for sectoral approach in section 3.2.

3.8.4.3 Activity data

See collection of activity data for sectoral approach in section 3.2.

3.8.4.4 Uncertainties and time-series consistency

See the section sectoral approach 3.2. The Tier 1 uncertainty was included in total assessment. Time series consistency is ensured.

3.8.4.5 Source specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. See the section sectoral approach 3.2. The Tier 1 uncertainty was included in total assessment. Time series consistency is ensured.

3.8.4.6 Source specific recalculations

Recalculations are connected with the corrections in biomass consumption for years 1997 – 2010 and corrections of the emission factors based on the IPCC 2000 GPG. Corrections are presented in the following Table 3.68.

Table 3.68: *Recalculations of fuels and emissions from biomass in 1997 – 2010*

Year	CO_2 (Gg)		Consumption (TJ)		Difference 2012/2013
	Submission				
	2013	2012	2013	2012	
1997	1 288.07	1 288.09	12 828.54	12 828.54	100.00%
1998	1 272.97	1 273.01	12 677.14	12 677.14	100.00%
1999	1 303.57	1 303.63	12 981.49	12 981.49	100.00%
2000	1 412.60	1 425.71	14 185.55	14 196.80	99.08%
2001	1 646.58	1 632.20	16 539.23	16 248.71	100.88%
2002	1 618.73	1 622.36	16 193.17	16 150.68	99.78%
2003	1 734.85	1 733.71	17 373.25	17 259.51	100.07%
2004	2 175.16	2 182.95	21 740.26	21 737.21	99.64%
2005	3 036.58	3 044.58	30 355.29	30 324.66	99.74%
2006	2 836.65	2 843.16	28 361.11	28 315.48	99.77%
2007	2 969.09	2 982.94	30 266.93	30 305.23	99.54%
2008	5 197.49	5 266.71	52 528.84	53 118.09	98.69%
2009	2 629.21	2 640.93	26 952.97	26 964.11	99.56%
2010	2 826.04	2 820.17	29 188.04	28 953.14	100.21%

3.8.4.7 Source specific planned improvements

No further improvements are planned for the next submission.

CHAPTER 4: INDUSTRIAL PROCESSES (CRF 2)

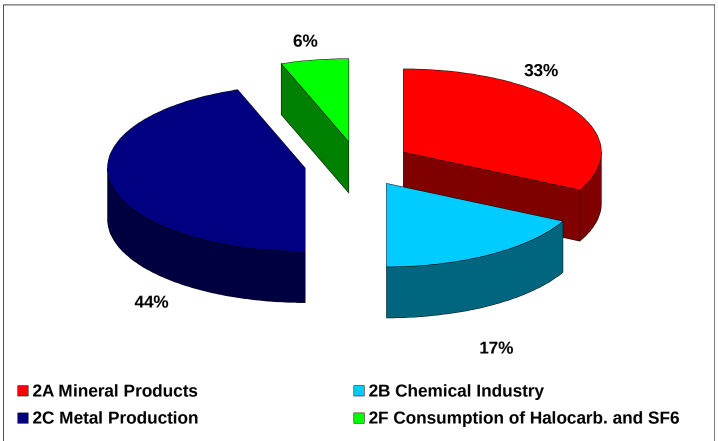
4.1 Overview of sector (CRF 2)

Sector of industrial processes includes all GHG emissions generated from technological processes producing raw materials and products. 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.

In 2011, total aggregated GHG emissions from industrial processes were 8 248.22 Gg of CO_2 equivalents and they decreased compared to the previous year by 4%. Compared to the reference year 1990 the emissions decreased by 13.6%. CO_2 is the most important gas with the share of 89%, followed by N_2O and HFCs emissions with 5% shares. The most important source of GHG emissions are metal production (44%), mineral products (33%), chemical industry (17%) and consumption of halocarbons and SF_6 (6%). The emissions of CO_2 from iron and steel production were reallocated from sector energy (category 1.A.2a) during the previous year and consequently, the time series were revaluated. The most important source of N_2O emissions is nitric acid production, which contributes by 14%, given in CO_2 equivalents, to total N_2O emissions.

The IP sector covers emissions from technological processes in mineral products industry (CRF 2.A), chemical industry (CRF 2.B), metal production (CRF 2.C), other production (CRF 2.D) (not occurring in the Slovak Republic) and emissions from production (not occurring in the Slovak Republic) and consumption of halocarbons and SF_6 (CRF 2.E and 2.F). The inventory of emissions from 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), as well as the emissions of SO_2.

Figure 4.1: *The share in emissions of individual categories in industrial processes in 2011*



Category	CO_2 eq. (Gg)
2.A Mineral Products	2 681.10
2.B Chemical Industry	1 440.48
2.C Metal Production	3 666.40
2.F Consumption of Halocarb. and SF_6	460.24

The internal structure of Slovak industry has been stabilised after the implementation of significant changes prior to the EU membership. The share of mining, distribution of electricity, gas and water has been reduced in the generation of value added and today it is comparable with other developed countries. In 2011, the industrial production indicated a moderate increase in the dynamics of growth in comparison with the base year. This trend has resulted from the increased production in pulp and paper industry, production of plastics and rubber products and predominantly, in car production, with the dynamics of increase above 9%. 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, coke, oil products 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 represents in general almost 20% reduction compared to previous 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 emission in ammonia production. The decrease in mineral product industry is 24%, in chemical industry 10% and in metal industry 16%. The re-start-up of economy is visible in 2010, but according to the current results, the recovery of industrial production was not fully finished and the decrease in productivity is visible also in 2011.

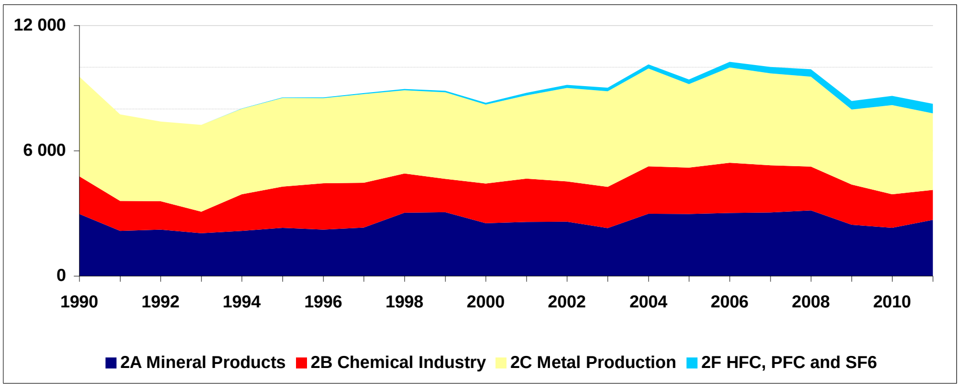
Table 4.1: *GHG emissions in individual categories in industrial processes in 1990 – 2011*

Year	Industrial Processes in CO_2 *eq.* (Gg)			Categories CO_2 *eq.* (Gg)			
	CO_2 emissions	CH_4 emissions	N_2O emissions	2.A Mineral Products	2.B Chemical Industry	2.C Metal Production	2.F HFC, PFC and SF_6
1990	8 082.89	1.14	1 187.84	2 966.48	1 805.94	4 770.81	0.03
1991	6 637.71	1.13	831.84	2 153.64	1 441.40	4 142.58	0.03
1992	6 405.17	1.10	745.71	2 215.94	1 368.35	3 816.12	0.04
1993	6 504.26	0.66	582.53	2 054.09	1 025.42	4 163.36	0.07
1994	6 859.98	1.11	1 020.43	2 157.58	1 751.39	4 104.62	9.44
1995	7 249.10	1.23	1 166.11	2 305.05	1 975.89	4 249.82	21.56
1996	7 121.30	1.32	1 355.59	2 218.56	2 223.17	4 070.99	34.82
1997	7 397.52	1.31	1 282.20	2 315.29	2 155.85	4 243.31	45.14
1998	7 778.25	1.35	1 096.58	3 032.97	1 876.52	3 989.32	55.43
1999	7 965.32	1.45	823.35	3 058.24	1 589.71	4 153.52	73.12
2000	7 132.15	1.46	1 058.61	2 523.66	1 906.56	3 773.40	90.36
2001	7 437.14	1.43	1 200.13	2 585.60	2 080.86	3 983.68	119.94
2002	7 926.80	1.94	1 065.40	2 599.01	1 927.53	4 479.01	146.88
2003	7 643.51	2.01	1 184.58	2 296.73	1 969.32	4 584.92	170.03
2004	8 554.78	2.04	1 357.67	2 978.96	2 275.82	4 679.04	197.45
2005	7 877.88	1.72	1 284.91	2 969.73	2 214.55	4 000.28	222.43
2006	8 365.83	1.48	1 583.89	3 018.57	2 404.11	4 564.34	264.96
2007	8 264.09	1.35	1 417.90	3 049.01	2 254.30	4 404.92	301.87
2008	8 195.92	1.29	1 314.62	3 144.79	2 100.16	4 303.03	353.68
2009	6 864.42	1.27	1 091.76	2 456.00	1 925.12	3 594.10	399.47
2010	7 254.52	1.47	904.03	2 303.17	1 608.70	4 269.30	440.06
2011	7 347.38	2.11	421.49	2 681.10	1 440.48	3 666.40	460.24

Energy intensity of industry in the Slovak Republic has been decreasing slowly, but it is still relatively high in comparison with the average of EU-15 countries. Regarding the final consumption of energy, industry has got the highest share (including construction). The trend in the final consumption of energy in this sector is positive and is characterised by the decrease in total energy consumption. The following branches of industrial sector contribute 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.

Whereas the N_2O emissions come from the nitric acid production only (this category is the key source by level and trend assessment), the cement, lime, limestone and dolomite use and iron & steel production are very important key sources of CO_2 emissions.

Figure 4.2: *Emission trend of individual categories in industrial processes in 1990 – 2011*



4.2 Sector specific QA/QC procedures

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 of GHG emissions inventory of the IP sector was obtained from different data sources:

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

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

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

Further QC activities are provided in the sectoral inventory preparation step:

- outliers checking with developed automated tool,
- comparison of IEFs with default EFs and IEFs of neighboring countries (where possible).

Any discrepancies are directly discussed with subject or data providers. Draft of the sectoral GHG inventory is prepared annually in the middle of November. Quality assurance activities are performed on the draft of the sectoral inventory and sectoral report. The draft is checked up with the person from the Slovak University of Technology which is not involved in inventory preparation (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 preparation, the methodology, EFs and other parameters are verified again. Final sectoral inventory is prepared at the end of December and it is approved during the January of the next year. 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.

4.3 Uncertainty analyses

Aggregated uncertainty is computed from partial uncertainties. Every subsector is computed from disaggregated data. The data are split by factory or by technology processes. Computed uncertainties are aggregated consecutively to the total uncertainty. The results for every subsector 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 method used 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 impressions.

Figure 4.3: *Probability density function for IP sector in t of CO_2 eq.*

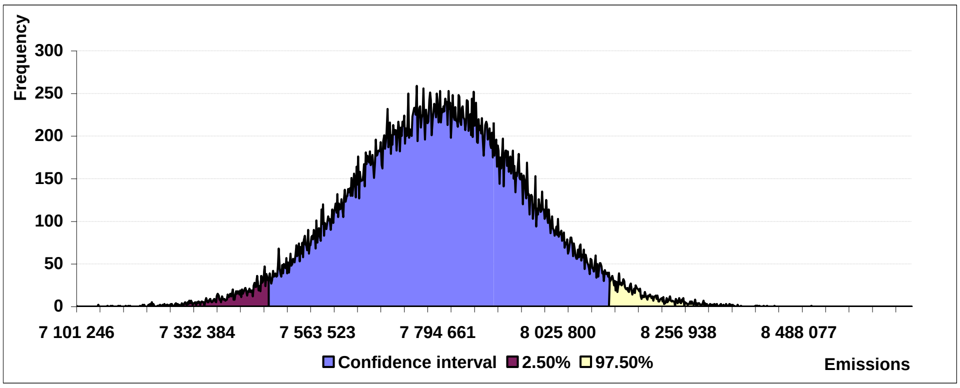


Table 4.2: *Selected statistical characteristics for IP sector, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
7 797 358.799	**7 797 092.030**	166 290.187	7 101 245.926	8 706 374.491	-4.17%	4.19%

Several uncertainties for EF are country specific and were used in the overall tier 2 uncertainty preparation. The average mean value of GHG emissions (except F-gases) for the Industrial Processes sector obtained by the Monte Carlo simulation is 7 797 kt per year (excluding Solvents sector). The average mean value is comparable with the real result of the GHG emissions expressed in CO_2 equivalents, which is 7 771 kt. Confidence interval (95%) is represented by the relative values to the mean: (-4.17%; +4.19%). 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. The following updates were implemented in analyses in 2011 (more details can be found in the specific category description):

- update of correction factors in cement production for producers (Cemmac and VSH) caused the increase of uncertainties for these factors,
- update (increase) of correction factor in lime production for producer Calmit caused the decrease of MgO and CaO contents uncertainties,
- decrease of the uncertainty of supply amounts in glass production for producer Vetropack,
- change in tier 2 methodology in ammonia production caused change of uncertainty for results,
- use of consistent methodology in iron and steel production with the energy sector followed mass balance approach caused changes in uncertainty results.

4.4 Mineral products (CRF 2.A)

4.4.1 Source category description

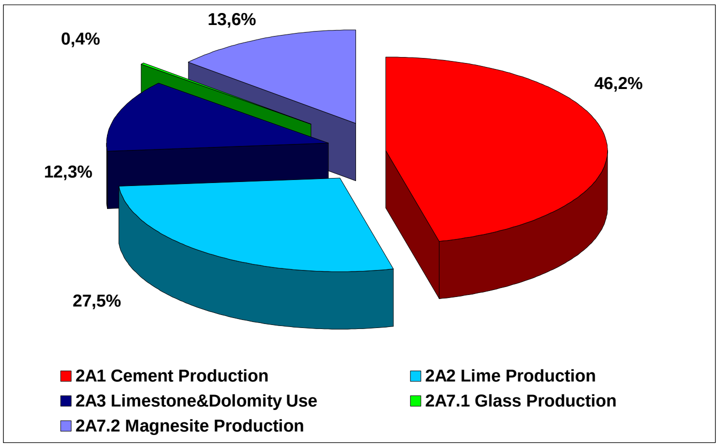
The major share of CO_2 emissions comes from the production and transformation of mineral products. Total emissions were 2 681.10 Gg of CO_2 in 2011 (only CO_2 emissions are reported from this subcategory), higher approximately by 16% compared to the previous year. Major increase is in cement production category (nearly 50% increase of production compared to 2010). It is caused by reopening of one cement plant after renovation. Compared to 1990, the decrease in mineral products GHG emissions is approximately 10%.

The major share (46.2%) of emissions belongs to cement production, 27.5% belongs to lime production and 13.6% to magnesite production. The limestone and dolomite use shared 12.3% and glass production was only 0.4%.

Table 4.3: *GHG emissions in individual subcategories of the 2.A category in 1990 – 2011*

	Category 2.A - CO_2 emissions (Gg)				
Year	2.A.1 Cement Production	2.A.2 Lime Production	2.A.3 Limestone & Dolomite Use	2.A.7.1 Glass Production	2.A.7.2 Magnesite Production
1990	1 438.01	770.42	318.23	7.88	431.94
1991	1 019.27	586.40	280.78	9.95	257.24
1992	1 283.22	441.06	260.13	12.03	219.50
1993	1 010.14	520.53	283.09	14.65	225.67
1994	1 094.96	547.74	294.27	16.31	204.31
1995	1 133.75	574.95	284.31	18.01	294.03
1996	1 080.50	547.02	269.85	20.06	301.12
1997	1 192.70	490.46	301.97	19.92	310.25
1998	1 789.44	532.65	315.39	18.99	376.51
1999	1 794.34	543.75	306.16	19.15	394.85
2000	1 168.88	539.57	382.56	22.82	409.82
2001	1 187.43	584.22	359.24	23.08	431.63
2002	1 144.19	657.99	336.89	21.42	438.52
2003	904.99	573.17	346.18	22.44	449.95
2004	1 194.84	672.16	587.92	24.37	499.67
2005	1 233.51	785.83	441.37	33.04	476.00
2006	1 363.98	854.02	427.90	32.06	340.62
2007	1 458.01	897.06	348.76	41.18	304.00
2008	1 581.87	860.18	302.09	23.44	377.22
2009	1 198.66	689.43	289.03	13.19	265.69
2010	844.58	728.80	340.31	13.15	376.34
2011	1 238.93	737.77	328.72	11.83	363.85

Figure 4.4: *The share in CO_2 emissions of individual subcategories within 2.A in 2011*



Category	CO_2 *eq.* (Gg)
2.A.1 Cement Production	1 238.93
2.A.2 Lime Production	737.77
2.A.3 Limestone & Dolomite	328.72
2.A.7.1 Glass Production	11.83
2.A.7.2 Magnesite Production	363.85

4.4.2 Source category description – Cement Production (CRF 2.A.1)

According to the IPCC 2000 GPG, it is a good practice that CO_2 emissions are estimated from the mass of produced cement clinker. However, in the Statistical Yearbook only Portland cement clinker is published. The cement plants in the Slovak Republic (4 plants), where cement clinker is produced, are included into the ETS and they were used for the verification of data reported in questionnaires by producers. Production of cement from clinker is based on milling the clinker with solid additives. Therefore it is meaningful to balance only clinker production. Total CO_2 emissions from cement production were 1 238.93 Gg in 2011 and increased comparable to the previous year by 47%, which was caused by one cement plant reopening after its renovation together with increasing production in others plants.

Table 4.4: *Activity data and CO_2 emissions in 1990 – 2011*

Category 2.A.1 Cement Production			
Year	**Cement Clink Production**	**CO_2 emissions**	**CaO Content**
	(kt)	(Gg)	(%)
1990	2 835.75	1 438.01	64.60
1991	2 010.00	1 019.27	64.60
1992	2 530.50	1 283.22	64.60
1993	1 992.00	1 010.14	64.60
1994	2 159.25	1 094.96	64.60
1995	2 235.75	1 133.75	64.60
1996	2 130.75	1 080.50	64.60
1997	2 352.00	1 192.70	64.60
1998	3 528.77	1 789.44	64.60
1999	3 538.43	1 794.34	64.60
2000	2 313.71	1 168.88	64.36
2001	2 367.29	1 187.43	63.90
2002	2 259.79	1 144.19	64.50
2003	1 754.73	904.99	65.70
2004	2 271.13	1 194.84	67.02
2005	2 352.68	1 233.51	66.78
2006	2 589.08	1 363.98	67.11
2007	2 825.32	1 458.01	65.74
2008	3 045.25	1 581.87	65.74
2009	2 348.07	1 198.66	65.87
2010	1 635.59	844.58	66.07
2011	2 433.86	1 238.93	65.89

4.4.2.1 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). Based on the plant specific information provided in questionnaires and verified in ETS reports, tier 2 methodology according to the IPCC 2000 Good Practice Guidance has been applied since 2002. The calculations provided by the cement clinker producers in the 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 4.5 (C = confidential, *weighted average).

Table 4.5: *The data necessary for the estimation of CO_2 emissions in 2011*

Plant	**Cement clink**	**CaO content**	**MgO content**	**Corr. Factor**	**CO_2**
	(kt)	(%)	(%)		(Gg)
Cemmac	C	65.07	1.93	0.9712	204.54
VSH	C	64.49	4.18	0.6961	179.80
Holcim – Portland	C	65.88	2.40	1.0000	475.85
Holcim – white	C	68.31	1.99	1.0000	60.74
Považská cementáreň	C	67.13	1.50	1.0000	318.00
Total SR	**2 433.86**	**0.6589***	**0.0243***	**0.9369***	**1 238.93**

4.4.2.2 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 EF is expressed as weighted average and is based on the specific content of CaO in cement clinker in each producer and varies over the years. The content varies from 64.49% to 68.31% according to the plant specifications with the value of weighted average 65.89% in 2011. The content of MgO in cement clinker varies from 1.50% to 4.18% with the weighted average of 2.43% in 2011. The implied CO_2 emission factor is 0.7509 t CO_2/t of cement clink in 2011. Correction factors provided in Table 4.5 are related to the amount of non-carbonate origin of CaO and MgO (ground granulated blast-furnace slag). The correction factor includes also the CKD factor. All producers have modern technology with complete capturing of dust. The dust is returned to the kiln, then. According to the verification experiments made in one plant, efficiency of capturing dust is 99.9992%.

4.4.2.3 Activity data

Based on data supplied by plants and ETS reports, total CO_2 emissions from cement production were 1 238.93 Gg and IEF was 0.509 t/t of clinker. Total production of cement clinker interannual (2010/2011) increased by 49% and was 2 433.86 kt in 2011. Increase in production is caused by reopening of one cement plant after its renovation (the plant did not produce cement clink in 2010, in 2011 nearly 400 kt of cement clink was produced in that plant) together with increased production in the others plants due to renewal of construction and building industry.

4.4.2.4 Uncertainties and time-series consistency

In the period 1990 – 2000 the average CaO content in the cement clinker was very close to the default IPCC value of content. 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 then. This is the reason of higher CaO content and IEF since 2002. 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.

Default value of cement clink mass uncertainty (2.5%) and country specific value of cement clink composition uncertainty (2%) were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the uncertainty of EF (per clink) is 1% and the overall uncertainty of CO_2 emissions was calculated in interval (-3.87%; +3.93%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented in formula by symbol Δ):

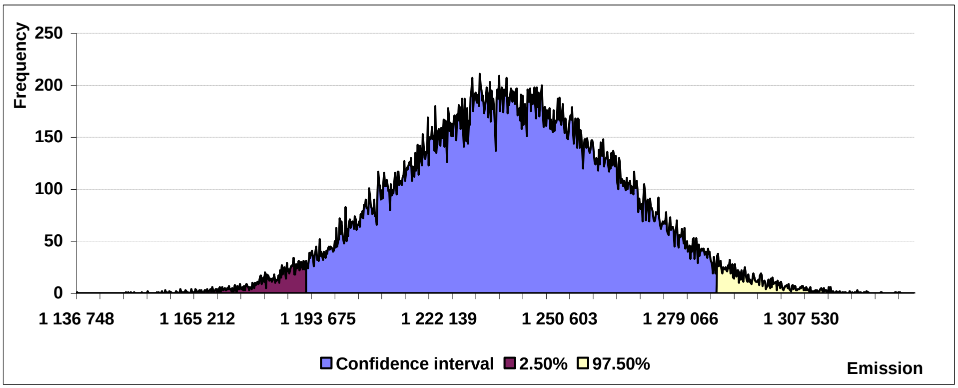
$$\text{Emissions} = \sum_{I} [(\text{clinker} \pm \Delta\text{clinker})*(\text{content of CaO} \pm \Delta\text{CaO})*(\text{EFCaO} \pm \Delta\text{EFCaO}) + (\text{clinker} \pm \Delta\text{clinker})*(\text{content of MgO} \pm \Delta\text{MgO})*(EF_{MgO} \pm \Delta EF_{MgO})]*\text{cor\_f}$$

The emissions of five sources from four 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 could not exceed the value 1 in cement clink. This correlation is integrated to the computation procedure. The average mean value of GHG emissions in the category 2.A.1 obtained by the Monte Carlo simulation is 1 239.0 kt per year. The average mean value is comparable with the real CO_2 emissions in this category, which is 1 238.9 kt.

Table 4.6: *Selected statistical characteristics for category 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
1 238 836.14	**1 239 013.55**	24 834.57	1 136 748.14	1 334 412.20	-3.87	3.93

Figure 4.5: *Probability density function for category 2.A.1 in 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 Chapter 4.2 of this report. Activity data are verified with ETS reports data and information provided by the Slovak Association of Cement Producers.

4.4.2.6 Source specific recalculations

No recalculations focused on the base year 1990 or the other inventory years were provided in the submission 2013.

4.4.2.7 Source specific planned improvements

Correction of CRF tables tier method indication will be provided. The CRF tables include tier 3 methodology shortcut since 2002. However, tier 3 is described in the IPCC 2006 GL not in the IPCC 2000 GPG. Therefore, CRF tables will be corrected to tier 2. No further methodological improvements are planned for this category for the next submission.

4.4.3 Source category description – Lime production (CRF 2.A.2)

From a chemical point of view, lime is calcium oxide (CaO). It is produced by the thermal decomposition of limestone at the temperatures of 1 040 °C-1 300 °C. Carbon dioxide is produced according to the same reaction scheme as shown above in the case of cement production. Total CO_2 emissions from lime production were 737.77 Gg in 2011 and remained almost stable in comparison with previous year.

Table 4.7: *Activity data and CO_2 emissions in 1990 – 2000*

Category 2.A.2 Lime Production 1990 – 2000				
Year	**Lime Production** (kt)	**CO_2 emissions** (Gg)	**EF** (t/t)	**CaO Content** (%)
1990	1 076.00	770.42	0.716	91.20
1991	819.00	586.40	0.716	91.20
1992	616.00	441.06	0.716	91.20
1993	727.00	520.53	0.716	91.20
1994	765.00	547.74	0.716	91.20
1995	803.00	574.95	0.716	91.20
1996	764.00	547.02	0.716	91.20
1997	685.00	490.46	0.716	91.20
1998	743.92	532.65	0.716	91.20
1999	759.43	543.75	0.716	91.20
2000	753.59	539.57	0.716	91.20

Table 4.7 cont.: *Activity data and CO_2 emissions in 2001 – 2011*

Category 2.A.2 Lime Production 2001 – 2011						
Year	**Lime Production**	**CO_2 emissions**	**EF**	**CaO Content**	**MgO Content**	**"Hypothetic" CaO Content**
	(kt)	(Gg)	(t/t)	(%)	(%)	(%)
2001	815.96	584.22	0.716	90.56	0.47	91.20
2002	918.99	657.99	0.716	90.28	0.66	91.20
2003	781.69	573.17	0.733	90.21	2.30	93.41
2004	908.94	672.16	0.740	90.47	2.69	94.21
2005	1 041.71	785.83	0.754	89.91	4.45	96.10
2006	1 131.24	854.02	0.755	89.61	4.72	96.17
2007	1 158.07	897.06	0.775	89.44	6.64	98.68
2008	1 120.33	860.18	0.768	88.50	6.48	97.51
2009	916.77	689.43	0.752	92.50	2.37	95.80
2010	952.60	728.80	0.765	87.71	7.01	97.46
2011	971.62	737.77	0.759	86.72	7.19	96.73

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

4.4.3.1 Methodological issues – methods

In Table 4.7 the "hypothetic" CaO content is presented. It includes data on the CaO and MgO contents on the basis of stoichiometry. This approach is used because no distinguished data are available 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 the lime is (91.2 ± 0.2%) in the period 1990 – 2002. Tier 2 according to the IPCC 2000 GPG has been applied for time series (until 2001 extrapolation was made) with the combination of plant specific activity data and emission factors estimated for each plant. The calculations are based on the data provided by the lime producers in questionnaires and in the ETS reports (produced lime and CaO and MgO contents). The data required for CO_2 emissions calculation are summarized in Table 4.8.

4.4.3.2 Methodological issues – emission factors and other parameters

Based on availability of information, the plant specific emission factors were used since 2001. The annual estimation of overall EF is expressed as weighted average and is based on the purity of lime in each producer and varies over the years. The implied CO_2 emission factor is 0.759 t CO_2/t of lime in 2011. Total CO_2 emissions increased and were 737.77 Gg in 2011. Correction factor in Table 4.8 represents the fraction of carbonate calcinations (it is determined by analysis of CO_2 in the product).

4.4.3.3 Activity data

Total quantity of produced lime was 971.62 kt in Slovakia in 2011. Activity data are summarized in Tables 4.7 and 4.8.

Table 4.8: *The data necessary for the CO_2 emissions estimation in 2011*

Plant	**Lime Production**	**CaO Content**	**MgO Content**	**Correction Factor**	**CO_2 Emissions**
	(kt)	(%)	(%)		(Gg)
Calmit	C	93.05%	1.33%	1.00	92.21
Dolvap Varín	C	86.20%	11.00%	1.00	118.03
Carmeuse Slavec	C	93.72%	1.40%	1.00	166.65
Carmeuse Košice	C	78.65%	13.10%	1.00	275.31
Others**	C	92.50%	1.20%	1.00	85.57
Total SR	**971.62**	**86.72%***	**7.19%***	**1.00**	**737.77**

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

4.4.3.4 Uncertainties and time-series consistency

Time series consistency is assured by using the "hypothetic" CaO content in the lime in the period 1990 – 2000 as it is explained in details in the text above. The 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 that. Because of the dolomitic lime production the IEF increased since that time, as well. Till 2010, the lime production from small lime producers that are not covered in the EU ETS was reported as aggregated data and assigned to the biggest one of them. Lime produced by sugar producers was included there, as well. For increased transparency, the same aggregated data are used with the label “Others” since 2011 (as presented in Table 4.8).

Default value of lime mass uncertainty (2%) 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 (-2.94%; +3.01%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF represent in formula symbol Δ):

$$Emissions = \sum_{I} [(lime \pm \Delta lime) * (content of CaO \pm \Delta CaO) * (EFCaO \pm \Delta EFCaO) +$$

$$+ (lime \pm \Delta lime) * (content of MgO \pm \Delta MgO) * (EF_{MgO} \pm \Delta EF_{MgO})] * cor\_f$$

The emissions from six sources from four lime producers enter the formula. During the uncertainty computation, the relation between content of CaO ($CaCO_3$) and content of MgO ($MgCO_3$) is verified again. It means that the sum of CaO ($CaCO_3$) and MgO ($MgCO_3$) contents could not exceed the value 1 in lime. This correlation is integrated to the computational procedure. The average mean value of GHG emissions in the category 2.A.2 obtained by the Monte Carlo simulation is 738.76 kt per year. The average mean value is comparable with real CO_2 emissions in this category, which is 738.77 kt.

Figure 4.6: *Probability density function for category 2.A.2 in t of CO_2*

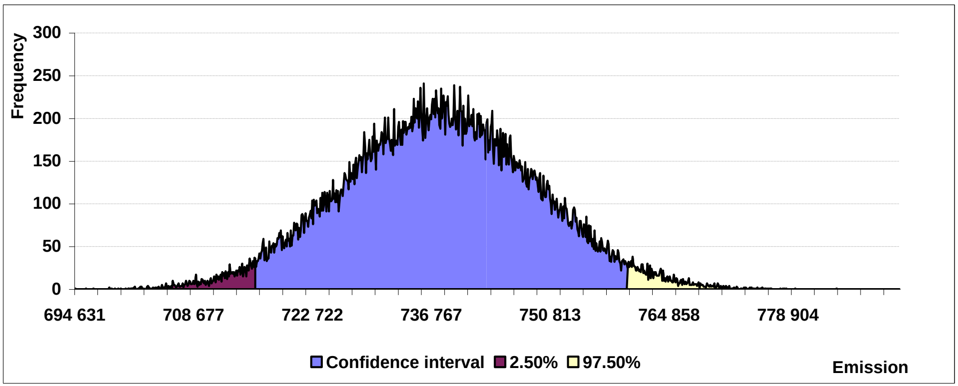


Table 4.9: *Selected statistical characteristics for category 2.A.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
737 729.59	**737 756.54**	11 264.38	694 631.22	792 168.62	-2.94	3.01

4.4.3.5 Source specific QA/QC and verification

Performed sector specific QA/QC activities are described in Chapter 4.2 of this report. Activity data are verified with the ETS reports and compared with the information from the Statistical Office of the Slovak Republic on lime production.

4.4.3.6 Source specific recalculations

No recalculations focused on the base year 1990 or the other inventory years were provided in the submission 2013.

4.4.3.7 Source specific planned improvements

Correction of CRF tables tier method indication will be provided. The CRF tables include tier 3 methodology shortcut since 2002. However, tier 3 is described in the IPCC 2006 GL not in the IPCC 2000 GPG. Therefore, CRF tables will be corrected to tier 2. Also correction of indication of plant specific EFs for the years 2001 and 2002 will take place (before country specific indication was used for these years). No further methodological improvements are planned for this category for the next submission.

4.4.4 Source category description – Limestone and dolomite use (CRF 2.A.3)

Carbon dioxide is produced at thermal decomposition or chemical reactions of limestone to clink. 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 values in IPCC 2000 GPG. The estimation is based on volume of consumed limestone in industrial processes except consumption in cement and lime industry. The CO_2 emissions estimated in this source category is based on limestone consumed in different industrial processes (iron and steel production, desulphurization of coal and ceramics).

4.4.4.1 Methodological issues – methods

The limestone used in Slovak industry often contains a small amount of $MgCO_3$. Emissions are estimated using tier 2 method according to the IPCC 2000 GPG on the basis of carbonates and the plant specific emission factors. The volumes of consumed limestone according to the different sources and CO_2 emissions in the period 1990 – 2011 are summarized in Table 4.10.

4.4.4.2 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 the stoichiometry of limestone and dolomite in the mixtures in each producer and varies over the years. Implied emission factor was 0.441 t/t of used carbonates mixture in 2011.

4.4.4.3 Activity data

Total volume of used limestone and dolomite in industry was 745.30 kt, the activity data are summarized in Table 4.10. Total CO_2 emissions decreased by 3% compared to 2010. The small decrease was caused by the decreased production of iron and steel. Total CO_2 emissions estimated in this category was 328.72 Gg.

Table 4.10: *Total carbonates used and CO_2 emissions in 1990 – 2011*

Category 2.A.3 Limestone and Dolomite Use							
Year	**$CaCO_3$ from Iron and Steel**	**Desulphu-risation ($CaCO_3$)**	**Desulphu-risation ($MgCO_3$)**	**Ceramics ($CaCO_3$)**	**Ceramics ($MgCO_3$)**	**Total Carbonates**	**CO_2 emissions**
	(kt)						(Gg)
1990	689.64	0.00	0.00	25.41	6.92	721.97	**318.23**
1991	612.55	0.00	0.00	18.35	6.10	637.00	**280.78**
1992	571.69	0.00	0.00	12.12	6.24	590.05	**260.13**
1993	620.68	0.00	0.00	14.98	6.52	642.18	**283.09**
1994	644.89	0.00	0.00	16.66	6.11	667.66	**294.27**
1995	621.07	0.00	0.00	17.19	6.66	644.92	**284.31**
1996	565.42	23.48	0.44	15.69	6.90	611.93	**269.85**
1997	594.91	68.54	1.20	13.56	6.62	684.83	**301.97**
1998	600.27	91.26	1.69	15.08	6.89	715.19	**315.39**
1999	578.39	91.71	1.67	16.38	6.20	694.35	**306.16**
2000	755.18	88.86	1.58	15.79	6.54	867.95	**382.56**
2001	697.98	91.00	1.66	18.38	6.00	815.02	**359.24**
2002	642.12	92.89	1.63	21.51	6.08	764.23	**336.89**
2003	669.71	91.66	1.69	16.09	6.16	785.31	**346.18**
2004	1 228.71	92.49	1.73	6.55	5.37	1 334.85	**587.92**
2005	876.85	94.52	1.73	21.80	6.64	1 001.54	**441.37**
2006	840.71	92.84	1.75	30.65	5.25	971.20	**427.90**
2007	674.12	72.59	1.24	36.31	6.87	791.12	**348.76**
2008	522.00	69.75	1.02	72.47	17.82	683.05	**302.09**
2009	543.56	85.82	0.00	19.01	7.16	655.55	**289.03**
2010	682.78	60.49	0.99	18.95	8.46	771.67	**340.31**
2011	634.63	84.46	1.28	16.61	8.32	745.30	**328.72**

4.4.4.4 Uncertainties and time-series consistency

The same tier approach is used for the time period 1990 – 2011. 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 producers with the limit to economic aspects of the building industry in Slovakia (they served as the boundary conditions of interpolation or extrapolation). The decrease in consumption of limestone for desulphurization in 2010 was caused by using of bought lime from lime producer. 15 654 t of bought lime was used 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 allocated and are reported in lime production category (2.A.2). In 2011, no use of bought lime was reported.

Default value of used limestone and dolomite uncertainty (2%) and country specific value of their composition uncertainty in CaO and MgO (3%) were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-1.57%; +1.57%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF represent in formula symbol Δ):

$$Emissions = \sum_{I} [(carbonateamount \pm \Delta carbonate) * (EFCarb \pm \Delta EFCarb)$$

The emissions of three processes (desulphurization, ceramics and iron&steel production) enter to the calculation. Accumulated uncertainty and statistical characteristics for subsector limestone and dolomite use are presented in the following figure and table. The average mean value of GHG emissions in the category 2.A.3 obtained by the Monte Carlo simulation is 328.8 kt per year. The average mean value is comparable with the real CO_2 emissions in this category, which is 328.7 kt.

Figure 4.7: *Probability density function for category 2.A.3 in t of CO_2*

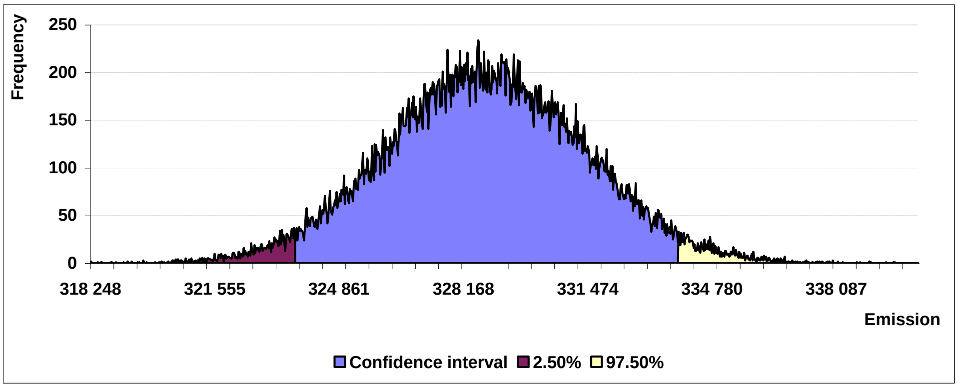


Table 4.11: *Selected statistical characteristics for category 2.A.3, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
328 734.39	**328 751.49**	2 632.91	318 248.27	340 291.06	-1.57	1.57

4.4.4.5 Source specific QA/QC and verification

Performed sector specific QA/QC activities are described in Chapter 4.2 of this report. Activity data are verified with the ETS reports and compared with the information from the Statistical Office of the Slovak Republic on industrial production.

4.4.4.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

4.4.4.7 Source specific planned improvements

Correction of CRF tables tier method indication will be providing. The CRF tables include tier 3 methodology shortcut since 2002. However, tier 3 is described in the IPCC 2006 GL not in the IPCC

2000 GPG. Therefore, CRF tables will be corrected to tier 2. No further methodological improvements are planned for this category for the next submission.

4.4.5 Source category description – Soda ash production and use (CRF 2.A.4)

Soda ash is not produced in the Slovak Republic. The use of soda ash is included in the category 2.A.7.1 Glass production.

4.4.6 Source category description – Asphalt roofing (CRF 2.A.5)

Asphalt blowing is a part of asphalt roofing production. It is the process of polymerizing and stabilizing asphalt to improve its weathering characteristics. Emissions of CO and NMVOC from this category are included in category in energy sector category 1.A.2f and notation key "IE" was used. The CO_2 emissions in this category were not estimated due to the not availability of methodology and therefore notation key "NA" was used for time series.

The emissions originating from asphalt roofing production are NMVOC and CO. According to the IPCC 1996 Guidelines the CO emission factor is 0.0095 kg CO/t of asphalt. In the company Icopal, a.s. Štúrovo, asphalt roofing is produced by saturation without spray (by rolling). Default NMVOC emission factor according to the IPCC is in the range from 0.046 to 0.049 kg/t of asphalt. The inventory has assumed the higher value. In the case of afterburner, the emission factor of NMVOC according to the IPCC Guidelines is 0.1 kg/t of asphalt at asphalt blowing. According to the data supplied by Icopal, a.s. Štúrovo, 28.102 kt of asphalt were used in the production of asphalt roofing in 2011. It follows that the emissions of CO and NMVOC were 0.267 t and 4.187 t, respectively. These emissions were allocated in the 1.A.2f category according to the methodology applied in the CLRTAP inventory.

4.4.7 Source category description – Road paving with asphalt (CRF 2.A.6)

The emissions of NMVOC from road paving with asphalt were estimated in this category based on the EMEP/ CORINAIR methodology. The CO_2 emissions in this category were not estimated due to the not availability of methodology and therefore notation key "NA" was used for time series.

Total amount of asphalt used for paving the road was 121 kt in 2011. The emission factor for NMVOC was estimated at 0.00647 kg/t and total emissions of NMVOC included in this category were 0.796 t. The emissions of NO_x, SO_2 and CO are included in the energy sector, category 1.A.2f and notation key "IE" was used.

4.4.8 Source category description – Glass production (CRF 2.A.7.1)

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 coloring agents are used in glass production. NMVOC and CO_2 are the most important emissions but are not reported in this category (notation key "IE" was used). These emissions are allocated in the category 1.A.2f. Only CO_2 emissions were estimated in this category and were 11.83 kt in 2011. CH_4 and N_2O emissions are not estimated due to lack of appropriate methodology and therefore notation key "NA" was used for time series.

4.4.8.1 Methodological issues – methods

The emissions of CO_2 from glass production were reallocated from the category 2.A.3 limestone and dolomite use. The CO_2 emissions from the used carbonates were calculated by tier 2 methodology on the stoichiometry principle. The same approach was used for the calculation of default factors in the IPCC 2000 GPG.

4.4.8.2 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 the stoichiometry of carbonates and CO_2 and varies over the years. Implied emission factor was 0.430 t/t of used carbonates mixture in 2011.

4.4.8.3 Activity data

Glass production based on information from the producers in the Slovak Republic was as follows: 65 000 t of white glass, 74 320 t of green glass, 117 936 t of crystal glass and 989 t of leaded glass in 2011. Total amount of produced glass was 258 245 t. $SrCO_3$ and Li_2CO_3 were not used for glass production. Total amounts of used carbonates were 27.52 kt in 2011 and time series is presented in Table 4.12.

Table 4.12: *Total amounts of used carbonates in 1990 – 2011*

Category 2.A.7.1 Glass Production									
Year	**$CaCO_3$**	**K_2CO_3**	**Na_2CO_3**	**$BaCO_3$**	**$MgCO_3$**	**$SrCO_3$**	**Li_2CO_3**	**Total**	**CO_2**
	(t)								(Gg)
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	0.00	0.00	0.00	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	0.00	95.36	**41.183**
2008	29.43	1.72	21.27	0.83	1.78	0.00	0.00	55.03	**23.440**
2009	15.05	1.43	13.45	1.49	0.39	0.00	0.00	31.81	**13.193**
2010	15.89	0.48	13.62	1.52	0.01	0.00	0.00	31.52	**13.145**
2011	15.17	0.30	11.49	0.01	0.54	0.00	0.00	27.52	**11.825**

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

4.4.8.4 Uncertainties and time-series consistency

Detail statistics on carbonates for the period 1990 – 2003 is not available and therefore, total carbonates are included in the form of calcium carbonate based on stoichiometry. Thus, only one carbonate could be calculated from that data. New production of white glass started in 2005 and the emissions increased since that year adequately. Since 2008, colemanite and calumite slag are widely used in the biggest glass plant in order to replace carbonates.

Default value of used carbonates uncertainty (2.5%) and country specific value of their emission factors uncertainty (1%) were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-1.52%; +1.52%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF represent in formula symbol Δ):

$$\text{Emissions} = \sum_I \left[(\text{carbonateamount} \pm \Delta\text{carbonate}) * (\text{EFCarb} \pm \Delta\text{EFCarb}) \right)$$

The emissions from glass production from four producers are contributed to the calculation procedure (in the formula subscript "*I*" represent 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 category 2.A.7.1 obtained by the Monte Carlo simulation is 11.825 kt per year. The average mean value is comparable with the real CO_2 emissions in this category, which is 11.825 kt.

Figure 4.8: *Probability density function for category 2.A.7.1 in t of CO_2*

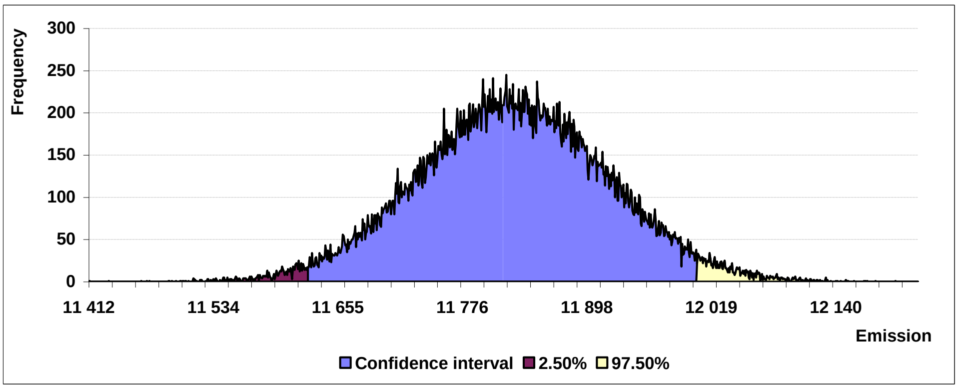


Table 4.13: *Selected statistical characteristics for category 2.A.7.1, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
11 824.571	**11 825.068**	91.682	11 412.364	12 220.959	-1.52%	1.52%

4.4.8.5 Source specific QA/QC and verification

Performed sector specific QA/QC activities are described in Chapter 4.2 of this report. Activity data are verified with the ETS reports and compared with the information from the Statistical Office of the Slovak Republic on glass production.

4.4.8.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

4.4.8.7 Source specific planned improvements

Correction of CRF tables tier method indication will be provided. The CRF tables include tier 3 methodology shortcut since 2002. However, tier 3 is described in the IPCC 2006 GL not in the IPCC 2000 GPG. Therefore, CRF tables will be corrected to tier 2. No further methodological improvements are planned for this category for the next submission.

4.4.9 Source category description – Magnesite production (CRF 2.A.7.2)

Carbon dioxide is produced from thermal decomposition of magnesite. The chemical reaction scheme of the thermal decomposition is $MgCO_3 = MgO + CO_2$. Total CO_2 emissions from magnesite production were 363.85 Gg in 2011. They are approximately at the same level as in 2010.

4.4.9.1 Methodological issues – methods

Magnesite clinker produced in the Slovak Republic contains a small amount of $CaCO_3$. Emissions are calculated on the basis of carbonates by using tier 2 method according to the IPCC 2000 GPG and the plant specific emission factors. The amounts of magnesite clinker and emissions of CO_2 in the period of 1990 – 2011 are summarized in Table 4.14. CH_4 and N_2O emissions are not estimated due to lack of appropriate methodology and therefore notation key “NA” was used for time series.

4.4.9.2 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 the stoichiometry of MgO and CaO and varies over the years. Implied emission factor as weighted average of EFs of MgO (1.092 t/t of MgO) and CaO (0.785 t/t of CaO) was 0.946 t/t of magnesite clinker in 2011.

4.4.9.3 Activity data

Total amount of magnesite clinker produced in the Slovak Republic was 384.58 kt in 2011. The purity of magnesite in the Slovak Republic varies mainly from 82% to 94%. It should be noted that CaO content which can be presented in some magnesite clinkers was recalculated to the hypothetical "MgO content" on the basis of stoichiometry for the purity presented above.

Table 4.14: *Magnesite clinker production and CO_2 emissions in 2000 – 2011*

Category 2.A.7.2 Magnesite Production			
Year	**Magnesite Clinker Production** (kt)	**CO_2 emissions** (Gg)	**IEF** (t/t)
1990	460.05	431.94	0.939
1991	273.98	257.24	0.939
1992	233.79	219.50	0.939
1993	240.36	225.67	0.939
1994	217.61	204.31	0.939
1995	313.17	294.03	0.939
1996	320.72	301.12	0.939
1997	330.44	310.25	0.939
1998	401.01	376.51	0.939
1999	420.54	394.85	0.939
2000	436.49	409.82	0.939
2001	459.71	431.63	0.939
2002	467.06	438.52	0.939
2003	479.23	449.95	0.939
2004	524.93	499.67	0.952
2005	481.88	476.00	0.988
2006	346.49	340.62	0.983
2007	320.05	304.00	0.950
2008	404.18	377.22	0.933
2009	283.43	265.69	0.937
2010	399.34	376.34	0.942
2011	384.58	363.85	0.946

4.4.9.4 Uncertainties and time-series consistency

The same tier 2 is used for the whole time period 1990 – 2011. New production of high purity magnesite clinker (for refractory materials) started in Slovakia in 2004 and ended in 2007.

Default value of magnesite clink uncertainty (2%) and country specific value of MgO and CaO contents uncertainty (3%) 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 (-2.85%; +2.89%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented in formula by symbol Δ):

$$Emissions = \sum_{I} [(clinker \pm \Delta clinker) * (content of\ CaO \pm \Delta CaO) * (EFCaO \pm \Delta EFCaO) + (clinker \pm$$

$$\pm \Delta clinker) * (content\ of\ MgO \pm \Delta MgO) * (EF_{Mg} \pm \Delta EF_{Mg})]$$

Emissions from three producers contributed to the computations of overall uncertainty. The relation between the content of $CaCO_3$ and MgO is verified during calculation. It means that the sum of $CaCO_3$ and MgO contents could not exceed the value 1 in clinker (the recommended value is 0.95). This correlation is integrated to the procedure. 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 category 2.A.7.2 obtained by the Monte Carlo simulation is 363.86 kt per year. The average mean value is comparable with the real CO_2 emissions in this category, which is 363.85 kt.

Figure 4.9: *Probability density function for category 2.A.7.2 in t of CO_2*

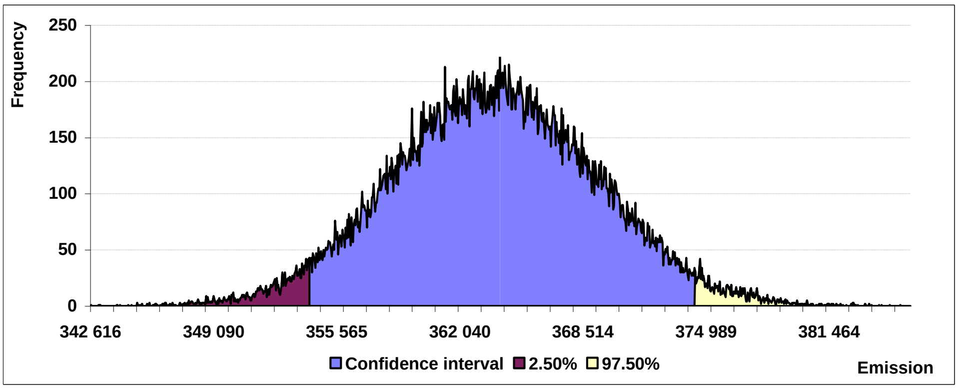


Table 4.15: *Selected statistical characteristics for category 2.A.7.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
363 852.04	**363 864.73**	5 358.98	342 615.77	385 780.00	-2.85	2.89

4.4.9.5 Source specific QA/QC and verification

Performed sector specific QA/QC activities are described in Chapter 4.2 of this report. Activity data are verified with the ETS reports and compared with the information from the Statistical Office of the Slovak Republic on magnesite production.

4.4.9.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

4.4.9.7 Source specific planned improvements

Correction of CRF tables tier method indication will be provided. The CRF tables include tier 3 methodology shortcut since 2002. However, tier 3 is described in the IPCC 2006 GL not in the IPCC 2000 GPG. Therefore, CRF tables will be corrected to tier 2. No further methodological improvements are planned for this category for the next submission.

4.5 Chemical industry (CRF 2.B)

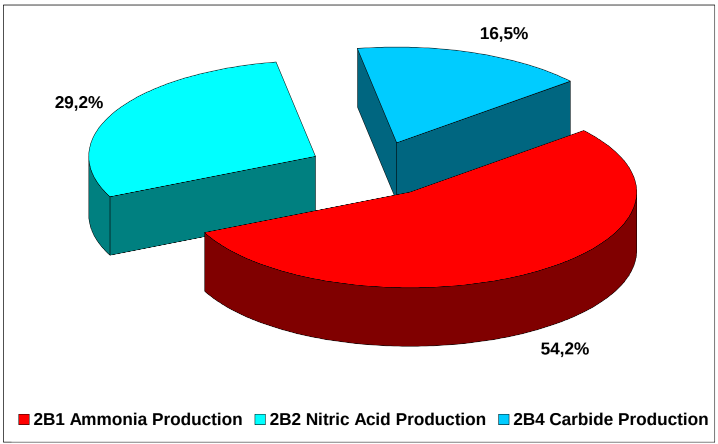
4.5.1 Source category description

The major share of CO_2 emissions in this category comes from ammonia production and major share of N_2O emissions are from nitric acid production. Total GHG emissions were 1 440.48 Gg of CO_2 equivalents in 2011, the decrease by more than 10% compared to the previous year. The continual increasing trend since base year was interrupted in 2006 and the decrease reached 20% in 2011 comparable to the base year. The significant decrease is visible in nitric acid production where using of secondary YARA catalyst fully reflected in 2011. The major share (54.2%) in emissions belongs to ammonia production, 29.2% belongs to nitric acid production and 16.5% to carbide production.

Table 4.16: *GHG emissions in individual subcategories of the 2.B category in 1990 – 2011*

Category 2.B - CO_2 emissions equivalents (Gg)				
Year	**2.B.1 Ammonia Production**	**2.B.2 Nitric Acid Production**	**2.B.4 Carbide Production**	**2.B Total**
1990	618.44	1 187.50	NO	**1 805.94**
1991	609.89	831.51	NO	**1 441.40**
1992	594.19	745.39	28.77	**1 368.35**
1993	354.23	582.34	88.85	**1 025.42**
1994	596.60	1 020.10	134.68	**1 751.39**
1995	655.73	1 165.74	154.42	**1 975.89**
1996	702.54	1 355.20	165.43	**2 223.17**
1997	697.06	1 281.81	176.97	**2 155.85**
1998	617.89	1 096.23	162.39	**1 876.52**
1999	618.56	823.01	148.15	**1 589.71**
2000	685.53	1 058.23	162.81	**1 906.56**
2001	698.56	1 199.74	182.57	**2 080.86**
2002	679.08	1 065.02	183.44	**1 927.53**
2003	600.97	1 184.24	184.11	**1 969.32**
2004	692.44	1 357.29	226.10	**2 275.82**
2005	723.17	1 284.51	206.87	**2 214.55**
2006	604.14	1 583.55	216.42	**2 404.11**
2007	616.03	1 417.56	220.71	**2 254.30**
2008	557.94	1 314.31	227.91	**2 100.16**
2009	619.93	1 091.41	213.78	**1 925.12**
2010	485.84	903.75	219.10	**1 608.70**
2011	781.34	421.05	238.09	**1 440.48**

Figure 4.10: *The share in CO_2 emissions of individual subcategories of the 2.B in 2011*



Category	**CO_2 eq. (Gg)**
2.B.1 Ammonia Production	781.34
2.B.2 Nitric Acid Production	421.05
2.B.4 Carbide Production	238.09

4.5.2 Source category 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 are summarized in Table 4.17.

4.5.2.1 Methodological issues – methods

Tier 2 methodology according to the IPCC 2000 GPG was applied to category 2.B.1 Ammonia production and the plant specific emission factors were used for time series. The information on ammonia production and natural gas consumption for its production was provided directly by the company. The measured values of natural gas consumption from the plant were used for CO_2 emissions estimation and calculated according to the relationship:

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

where: FR is consumption of natural gas as raw material in Nm^3; CF is conversion factor in MJ/m^3 (34.51 in 2011); CCF is content of carbon in the fuel in t/TJ (15.107 in 2011) and OF is oxidation factor of the fuel (1).

4.5.2.2 Methodological issues – emission factors and other parameters

The average emission factor is 1.711 t CO_2 per 1 t of ammonia produced in 2011 and is based on plant specific data. The EF was calculated annually by chemical reaction directly on the produced ammonia. The methane and N_2O emission factors are IPCC default: 5 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 in Table 4.17.

4.5.2.3 Activity data

The produced quantity of ammonia was 455.783 kt in 2011. Production of ammonia increased in 2011 by 95% in comparison with 2010. The increase in 2011 is only relative because the ammonia was not produced for 3.5 months in the year 2010 (due to the malfunction in the plant). In 2011, the production was similar to that in 2005. Based on data supplied by the producer consumption of natural gas for ammonia production was 407 736 380 m^3 in 2011. The presented data are based on direct measurements in plant.

Table 4.17: *Ammonia production and GHG emissions in 1990 – 2011*

Category 2.B.1 Ammonia Production							
Year	**Ammonia Production**	**CO_2 emissions**	**CH_4 emissions**	**N_2O emissions**	**NG Consumption**		**EF CO_2**
	(kt)	(Gg)	(t)		(mil. m^3)	(TJ)	(t/t NH_3)
1990	360.00	616.97	54.14	1.08	322.54	10 827.83	1.7138
1991	351.60	608.44	53.63	1.07	315.02	10 726.39	1.7305
1992	344.20	592.76	52.49	1.05	308.39	10 497.55	1.7221
1993	206.90	353.38	31.39	0.63	185.37	6 278.60	1.7080
1994	353.90	595.16	53.08	1.06	317.08	10 615.82	1.6817
1995	383.80	654.14	58.49	1.17	343.87	11 698.41	1.7044
1996	411.70	700.83	62.87	1.26	368.87	12 574.63	1.7023
1997	409.90	695.36	62.51	1.25	367.25	12 501.29	1.6964
1998	364.30	616.38	55.55	1.11	326.40	11 110.57	1.6919
1999	364.00	617.04	55.69	1.11	326.13	11 137.29	1.6952
2000	403.00	683.85	61.80	1.24	361.07	12 359.46	1.6969
2001	411.80	696.84	63.05	1.26	368.96	12 610.98	1.6922
2002	400.00	677.41	61.34	1.23	358.38	12 267.45	1.6935
2003	353.68	599.49	54.28	1.09	316.88	10 856.39	1.6950
2004	407.90	690.73	62.59	1.25	365.46	12 517.07	1.6934
2005	426.35	721.40	65.32	1.31	381.99	13 064.02	1.6920
2006	354.56	602.65	54.50	1.09	317.67	10 899.22	1.6997
2007	362.44	614.52	55.64	1.11	324.73	11 128.53	1.6955
2008	328.20	556.57	50.40	1.01	293.94	10 079.12	1.6958
2009	344.40	618.40	55.97	1.12	325.39	11 194.45	1.7956
2010	233.56	484.65	43.77	0.88	254.31	8 753.49	2.0751
2011	455.48	779.42	70.35	1.41	407.74	14 070.98	1.7112

4.5.2.4 Uncertainties and time-series consistency

The same tier 2 method is used for whole time period 1990 – 2011. Higher emission factors in 2009 and 2010 were caused by the malfunctions in the 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 malfunction. To ensure transparency, the consumption of natural gas was recalculated for 2009 and 2010. In those years the volume of natural gas was related to 0 °C while in the other years to 15 °C. Although the calorific value of the natural gas was used for the right temperature, the comparability of the results was not fully ensured. Risk of errors in the calculation of CH_4 and N_2O emissions was increased, as well, as it occurred in 2010 emissions. The recalculation resulted in changed volume of used natural gas (depends on the used temperature) in 2009 and 2010; and in changed emission estimates of CH_4 and N_2O in 2010. CO_2 emissions were not recalculated for these years.

The uncertainty estimation used several input parameters such as natural gas consumption, gas caloric value, oxidation factor, their emission factors and their default uncertainties according to the IPCC 2000 GPG. 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 (-6.39%; +7.05%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented in formula by symbol Δ):

$$\text{Emissions} = (\text{gas} \pm \Delta\text{gas}) * (\text{caloric} \pm \Delta\text{caloric}) * (\text{oxid.fact} \pm \Delta\text{oxid.fact}) * \frac{44}{12} / 1000 +$$

$$+ \sum_{I} (\text{gas} \pm \Delta\text{gas}) * (\text{g\_density} \pm \Delta\text{g\_density}) * (EF_i \pm \Delta EF_i) * CF_i$$

In the formula subscript "I" represents CH_4 and N_2O emission contribution to total emission uncertainty. 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 category 2.B.1 obtained by the Monte Carlo simulation is 781.16 kt per year. The average mean value is comparable with the real GHG emissions in this category, which is 781.34 kt.

Figure 4.11: *Probability density function for category 2.B.1 in t of CO_2 equivalents*

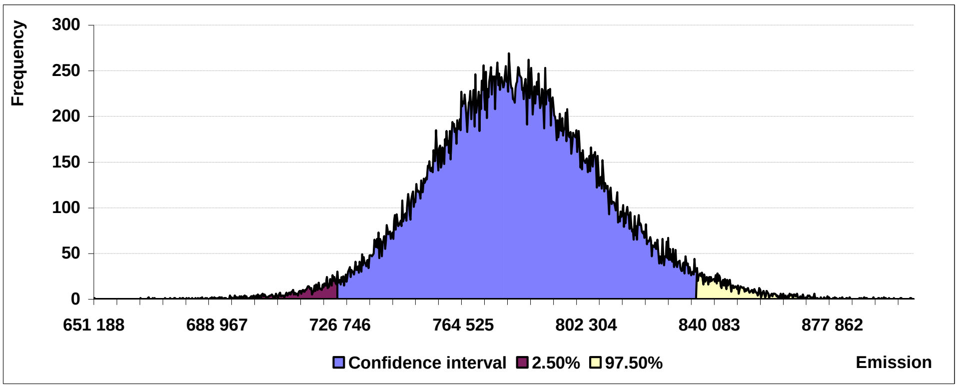


Table 4.18: *Selected statistical characteristics for category 2.B.1, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
780 286.999	**781 163.701**	26 478.065	651 187.750	903 047.768	-6.39%	7.05%

4.5.2.5 Source specific QA/QC and verification

General QA/QC activities are described in Chapter 4.2 of this report. As ammonia production is one of the largest CO_2 emissions sources and key category (from industrial processes), a significant attention was paid to the validation of the 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 synthesis gas production) was developed and the results were compared with measurement data provided by producer. Furthermore, the activity data were compared with information provided by the Statistical Office of the Slovak Republic, NEIS database and the ETS report. Finally, the emission factors were compared with the published EFs from adjacent country, where similar technology is used.

4.5.2.6 Source specific recalculations

The recalculation was provided in methane and N_2O emissions together with corrections in NG consumption back to 2009. In 2009 and 2010 the volume of natural gas used was related to 0°C while in the other years to 15 °C. Although the calorific value of the natural gas was used for the right temperature, the results were not fully comparable. Risk of errors in the CH_4 and N_2O emissions increased, as well as it occurred in 2010 emissions. The recalculation resulted in changes in natural gas consumption in 2009 and 2010; and in changes in CH_4 and N_2O emissions in 2010. CO_2 emissions were not changed (Table 4.19). Total impact of recalculation on CO_2 emissions equivalents in ammonia production was 5.32% increase in 2010.

Table 4.19: *The recalculations changes and comparison of the submissions 2012 and 2013*

Year	Submission 2012				Submission 2013				Changes 2012/13
	NG Consumption		CH_4	N_2O	NG Consumption		CH_4	N_2O	
	(mil. m^3)	(TJ)	(t)		(mil. m^3)	(TJ)	(t)		(%)
2009	308.455	11 194	55.97	1.12	325.392	11 194	55.97	1.12	**0.00**
2010	241.077	8 298	41.49	0.83	254.307	8 753	43.77	0.88	**5.32**

4.5.2.7 Source specific planned improvements

Carbon dioxide emissions from ammonia production reflect the use of natural gas for both energy and feedstock applications. At present, this category includes the non-fuel emissions from ammonia production and the portion of natural gas used as fuel is included in the energy sector. According to the analyses of prioritization improvements in the national inventory, it is planned to fully harmonize our procedures of CO_2 emission estimation with the IPCC 2006 GL in the next submission. Total quantities of natural gas used in the process of ammonia production (fuel + feedstock) will be allocated in the IPPU sector, category 2.B.1.

Principally, a portion of carbon dioxide emissions arising from the production of ammonia is recovered for the use in the production of urea. In accordance with the IPCC 1996 GL, it is assumed that this carbon will only be stored for a short time and therefore, intermediate binding of CO_2 downstream the manufacturing processes does not have to be considered. According to the IPCC 2006 GL, the quantity of CO_2 recovered for downstream use in the urea production can be subtracted from the total quantity of CO_2 generated and CO_2 emissions from the urea use will be allocated in corresponding sectors. This approach is planned implement for the next submission along with the compilation of information on urea production.

4.5.3 Source category 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 significantly increased interannual (2010/2011) by 16%. However, the followed N_2O emissions decreased by 53% in 2011 in comparison with 2010. The reason of that decrease is in use of technology with the second YARA catalyst. This approach resulted in N_2O emissions decrease. This new technology was in operation thorough 2011.

4.5.3.1 Methodological issues – methods

Since 2005, emissions of N_2O and NO_x are continuously monitored by the nitric acid producer. Tier 2 methodology according to the IPCC 2000 GPG was used for time series in this category with the combination of plant specific emission factors.

4.5.3.2 Methodological issues – emission factors and other parameters

The nitric acid is produced by two providers in Slovakia. One of them produces nitric acid by two technologies: medium-pressure and high-pressure. The N_2O emissions are directly measured during these processes. According to that information the emission factors were estimated annually, based on certified measurements in this plant.

- Medium-pressure EFs:

According to the measured data, the EFs were 10.332 kg N_2O/1 t of HNO_3 for medium-pressure plant in 2006 and 2007; and 7.3; 7.6 and 7.5 kg/t in 2005, 2008 and 2009, respectively (reg. No.: SNAS 230/S-189). In 2006 – 2007, there was a malfunction that resulted in higher N_2O emissions. The average value of this emission factor (7.5 kg/1 t of HNO_3) observed in the years 2005, 2008 and 2009 is used for medium pressure plant for the period 1990 – 2004, as well. The same value was also measured before technological change in 2010 took place. According to the ERT recommendation, the same EF should be used also for the other producer in the Slovak Republic. The used medium-pressure technologies are very similar.

- High-pressure EFs:

The emissions factor of N_2O in high-pressure plant was measured to be 9.02 kg N_2O/1 t of HNO_3 in 2006 and 2007. This value is used for 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 with medium-pressure and high-pressure plant introduced the technology with secondary YARA catalyst. It resulted in significant decrease of N_2O emissions.

The overall EF 2.29 kg N_2O/t of HNO_3 in 2011 was estimated as weighted average. N_2O emissions were 1 358.22 t in 2011. The detailed information on the calculation is in Tables 4.20 and 4.21.

Table 4.20: *Estimated N_2O emissions and weighted EFs N_2O in 1990 – 2011*

Category 2.B.2 Nitric Acid Production							
Year	**Nitric Acid Production**	**EF N_2O**	**N_2O atmospheric**	**N_2O medium pressure**	**N_2O high pressure**	**N_2O emissions**	**NO_x emissions**
	(kt)	(t/t HNO_3)			(t)		
1990	400.54	0.00956	1 953.77	1 876.88	0.00	3 830.65	4 310.94
1991	301.83	0.00889	989.37	1 692.92	0.00	2 682.28	3 216.50
1992	278.44	0.00864	747.36	1 657.12	0.00	2 404.47	2 927.93
1993	233.62	0.00804	298.74	1 579.76	0.00	1 878.50	2 457.62
1994	360.82	0.00912	1 381.64	1 909.01	0.00	3 290.65	3 870.12
1995	398.80	0.00943	1 818.70	1 941.77	0.00	3 760.47	4 250.00
1996	446.78	0.00978	2 412.67	1 958.94	0.00	4 371.61	236.80
1997	421.33	0.00981	2 304.38	1 830.50	0.00	4 134.88	229.67
1998	377.35	0.00937	1 668.94	1 867.30	0.00	3 536.24	208.88
1999	306.51	0.00866	554.58	1 371.88	728.40	2 654.86	185.26
2000	407.22	0.00838	0.00	1 256.58	2 157.06	3 413.64	202.78
2001	464.35	0.00833	0.00	1 545.02	2 325.11	3 870.14	202.04
2002	403.84	0.00851	0.00	995.28	2 440.26	3 435.54	189.15
2003	454.64	0.00840	0.00	1 357.93	2 462.20	3 820.13	193.76
2004	524.82	0.00834	0.00	1 725.29	2 653.06	4 378.34	230.38
2005	497.68	0.00833	0.00	1 584.29	2 559.28	4 143.57	265.15
2006	564.00	0.00906	0.00	2 470.33	2 637.90	5 108.23	252.46
2007	489.22	0.00935	0.00	1 934.70	2 638.07	4 572.77	228.32
2008	509.26	0.00833	0.00	1 845.09	2 394.62	4 239.71	215.00
2009	418.62	0.00841	0.00	1 259.34	2 261.35	3 520.69	287.14
2010	510.97	0.00571	0.00	1 393.18	1 522.15	2 915.33	331.26
2011	593.75	0.00229	0.00	739.54	618.68	1 358.22	371.14

Table 4.21: *Detailed information on N_2O concentrations in 2011*

Year 2011	**medium pressure plant**		**high pressure plant**	
	N_2O concentration	**N_2O EF**	**N_2O concentration**	**N_2O EF**
	(ppm)	(kg/t)	(ppm)	(kg/t)
Weighted average EF	377.66	1.20	607.60	2.02

4.5.3.3 Activity data

Total production of nitric acid was 593.75 kt and the emissions of NO_x were 371.137 t in 2011. Activity data and emissions are presented in Table 4.20.

4.5.3.4 Uncertainties and time-series consistency

Two producers of nitric acid are operated in Slovakia. One of them produces nitric acid in medium- and high-pressure plants. The second producer produces nitric acid only in medium-pressure plant. Until 1999, also atmospheric-pressure plant was operated in Slovakia.

The plant specific emission factors are used for medium- and high-pressure technologies since 1990. The IPCC default 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 of 2006 and 2007. According to the measured N_2O emissions in 2006 – 2007, the EF was 10.332 kg/1 t of HNO_3 (malfunction in the plant). The emissions 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 in one producer. The secondary YARA catalyst is introduced, which resulted in significant decrease of N_2O emissions in 2011. The second producer is still using un-modified technology and EF equaled 7.5 kg/1 t of HNO_3.

Default value of nitric acid volume uncertainty (2%) and default value EFs uncertainty (10%) based on the IPCC 2000 GPG were used for both plants in uncertainty analyses by Monte Carlo method for this category. It follows that the uncertainty of EF is 5.9% and the uncertainty of N_2O emissions is 8.6% for each plant. The production process generates N_2O emissions. Based on calculation, the overall uncertainty of CO_2 emissions (in equivalents) was calculated in interval (-3.92%; +3.93%). Following formula Monte Carlo simulation was used (uncertainties for AD and EF are represented by symbol Δ):

$$Emissions = \sum_i \left[(HNO_3 \text{ amount} \pm \Delta \text{amount}) * (EF \pm \Delta EF) * CF_i / 1000 \right.$$

Three sources from 2 producers entered the calculating procedure. 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 category 2.B.2 obtained by the Monte Carlo simulation is 420.79 kt per year. The average mean value is comparable with the real GHG emissions in this category, which is 421.05 kt.

Figure 4.12: *Probability density function for category 2.B.2 in t of CO_2 equivalents*

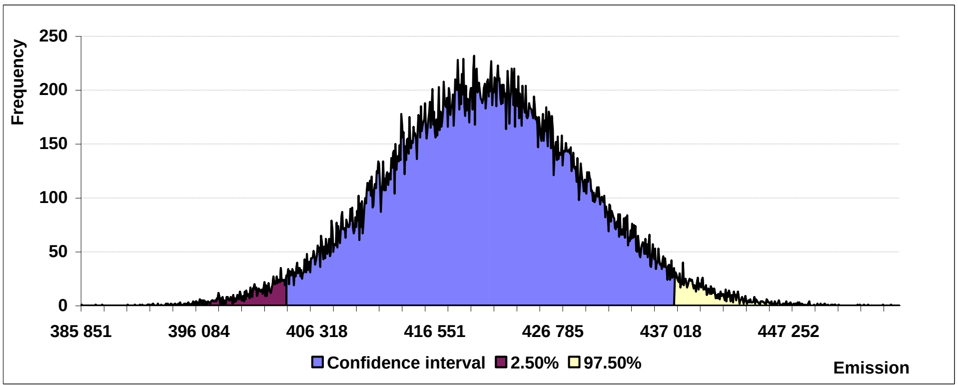


Table 4.22: *Selected statistical characteristics for category 2.B.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
420 776.730	**420 785.152**	84 22.945	385 850.845	456 916.640	-3.92%	3.93%

4.5.3.5 Source specific QA/QC and verification

Performed sector specific QA/QC activities are described in Chapter 4.2 of this report. Activity data are verified with the ETS reports and compared with the measurements protocols on N_2O concentration in output gases.

4.5.3.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

4.5.3.7 Source specific planned improvements

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

4.5.4 Source category 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 category.

4.5.5 Source category description – Carbide production (CRF 2.B.4)

4.5.5.1 Silicon Carbide (CRF 2.B.4.1)

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

4.5.5.2 Calcium Carbide (CRF 2.B.4.2)

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. Recently this plant was modernized in order to decrease emissions. The final CO_2 emissions are influenced by export of carbide and limestone use. The production is stable since 2004 and total CO_2 emissions reached 238.09 Gg of CO_2 in 2011.

4.5.5.3 Methodological issues – methods

Tier 2 methodology according to the IPCC 2000 GPG was used for CO_2 emission estimation in this category with the combination of country specific emission factors (which are at the same time also plant specific because only one producer operates in Slovakia). These EFs are updated annually and are comparable to IPCC default EFs. The CO_2 emissions are calculated from the coke consumption (reduction step), limestone use and products use. Results of CO_2 emissions from non-exported production are summarized in Table 4.23.

Table 4.23: *Estimated CO_2 emissions, carbide production and carbide export in 1990 – 2011*

Category 2.B.4.2 - Calcium Carbide Production								
Year	**CaC_2 Produc.**	**CaC_2 Export**	**$CaCO_3$ Consum.**	**CO_2 (reduction step)**	**CO_2 (product use)**	**CO_2 ($CaCO_3$ use)**	**IEF CO_2**	**Total CO_2**
	(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	NO	15.61	10.90	11.00	6.87	2.88	**28.77**
1993	50.00	50.00	78.07	54.50	0.00	34.35	1.78	**88.85**
1994	73.50	69.80	114.76	80.12	4.07	50.50	1.83	**134.68**
1995	84.30	80.10	131.63	91.89	4.62	57.92	1.83	**154.42**
1996	90.00	85.00	140.53	98.10	5.50	61.83	1.84	**165.43**
1997	96.60	91.77	150.83	105.29	5.31	66.37	1.83	**176.97**
1998	88.60	84.10	138.34	96.57	4.95	60.87	1.83	**162.39**
1999	80.87	76.82	126.26	88.14	4.45	55.56	1.83	**148.15**
2000	88.82	84.30	138.68	96.81	4.97	61.02	1.83	**162.81**
2001	99.65	94.67	155.60	108.62	5.48	68.46	1.83	**182.57**
2002	100.13	95.12	156.34	109.14	5.51	68.79	1.83	**183.44**
2003	100.44	95.32	156.82	109.48	5.63	69.00	1.83	**184.11**
2004	100.00	56.00	156.14	109.00	48.40	68.70	2.26	**226.10**
2005	97.03	65.71	151.50	105.76	34.45	66.66	2.13	**206.87**
2006	97.26	57.62	151.86	106.01	43.60	66.82	2.23	**216.42**
2007	101.22	64.08	158.04	110.32	40.85	69.54	2.18	**220.71**
2008	107.52	74.04	167.90	117.20	36.83	73.88	2.12	**227.91**
2009	97.50	62.56	156.95	106.28	38.44	69.06	2.19	**213.78**
2010	98.26	59.72	158.17	107.11	42.40	69.60	2.23	**219.10**
2011	107.40	66.54	172.89	117.07	44.95	76.07	2.22	**238.09**

4.5.5.4 Methodological issues – emission factors and other parameters

Implied CO_2 emission factors are updated annually and calculated as weighted average of the country specific partial EFs for 0.44 t CO_2/t of $CaCO_3$ from the decomposition of limestone, 1.09 t CO_2 /t of carbide from the reduction and 1.1 t CO_2/t of carbide from using the product. Actual 2011 implied CO_2 emission factor was 2.22 t CO_2/t of produced CaC_2. Based on the previous ERT recommendation also the CO_2 emissions from the decomposition of limestone are included in this category.

4.5.5.5 Activity data

Total CaC_2 (calcium carbide) production was 107.4 kt in 2011. According to the data supplied by the producers, 66 541 t of produced calcium carbide was exported from the Slovak Republic. The rest was used for acetylene production (conservative approach).

4.5.5.6 Uncertainties and time-series consistency

Consistent methodology and tier method was used for the whole time series since 1992 when the production of carbide started in the Slovak Republic. Outliers in emissions and emission factors are caused by different amounts of exported calcium carbide (Table 4.23).

Default value of calcium carbide volume uncertainty (2.5%) and default value EFs uncertainty (10%) based on the IPCC 2000 GPG 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 (-6.11%; +6.17%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented in formula by symbol Δ):

Emission = (carbide production ± Δ(carbide production))*(EFcarb ± ΔEFcarb)+((carbide production ± ± Δ(carbide production))-(exported carbide ± Δ(exported carbide))*(EFcarb ± ΔEFcarb)

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 category 2.B.4.2 obtained by the Monte Carlo simulation is 238.10 kt per year. The average mean value is comparable with the real CO_2 emissions in this category, which is 238.09 kt.

Figure 4.13: *Probability density function for category 2.B.4.2 in t of CO_2*

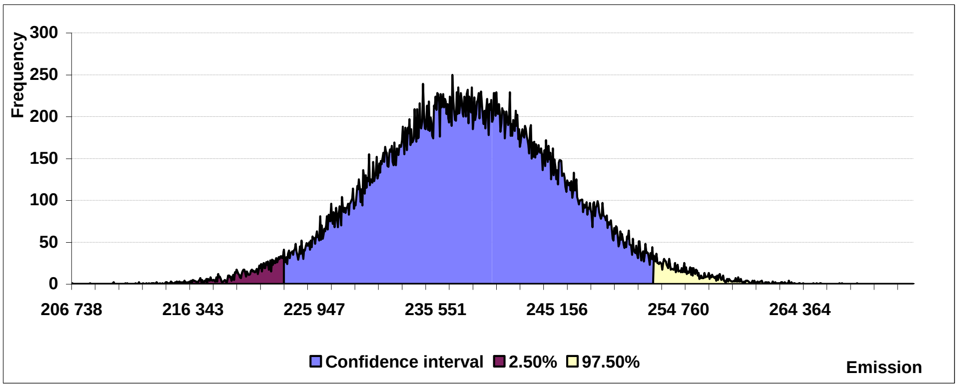


Table 4.24: *Selected statistical characteristics for category 2.B.4.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
238 035.287	**238 100.219**	7 420.340	206 738.416	273 434.947	-6.11%	6.17%

4.5.5.7 Source specific QA/QC and verification

Performed sector specific QA/QC activities are described in Chapter 4.2 of this report.

4.5.5.8 Source specific recalculations

No recalculations were provided in the submission 2013 focused on the base year 1990 or the other inventory years.

4.5.5.9 Source specific planned improvements

Thorough survey of calcium carbide use is planned for the next submissions. Using of calcium carbide that not results in CO_2 emissions will be identified. Data will be reported when the whole time series are available.

4.6 Metal production (CRF 2.C)

4.6.1 Source category description

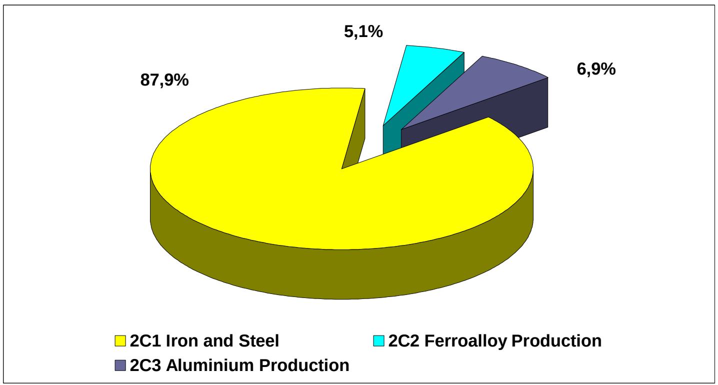
This category produces emissions of CO_2, CH_4 and PFCs emissions from aluminium production. Total emissions in 2011 were 3 666.41 Gg of CO_2 equivalents and decreased by 14% compared to the previous year. Comparing to the base year, the decrease is more than 23%. This strong decrease is mostly caused by the decrease in CO_2 emissions from iron and steel production. The emissions of NMVOC emissions are also included in iron and steel, emissions of other indirect GHG are reported in energy sector.

Table 4.25: *GHG emissions in individual subcategories in the 2.C category in 1990 – 2011*

Category 2.C - CO_2 emissions equivalents (Gg)				
Year	**2.C.1 Iron and Steel**	**2.C.2 Ferroalloy Production**	**2.C.3 Aluminium Production**	**2.C Total**
1990	4 113.88	264.24	392.69	**4 770.81**
1991	3 498.40	257.89	386.28	**4 142.58**
1992	3 206.40	250.24	359.48	**3 816.12**
1993	3 703.91	234.55	224.90	**4 163.36**
1994	3 681.89	231.63	191.10	**4 104.62**
1995	3 867.09	209.72	173.00	**4 249.82**
1996	3 668.12	201.26	201.61	**4 070.99**
1997	3 858.65	185.95	198.71	**4 243.31**
1998	3 583.22	221.47	184.64	**3 989.32**
1999	3 780.40	197.97	175.14	**4 153.52**
2000	3 432.88	164.39	176.13	**3 773.40**
2001	3 657.82	149.34	176.53	**3 983.68**
2002	3 998.08	304.80	176.13	**4 479.01**
2003	4 094.73	301.88	188.30	**4 584.92**
2004	4 085.13	339.25	254.67	**4 679.04**
2005	3 542.45	207.09	250.75	**4 000.28**
2006	4 061.46	250.10	252.78	**4 564.34**
2007	3 894.46	271.86	238.60	**4 404.92**
2008	3 809.42	237.89	255.71	**4 303.03**
2009	3 268.82	104.51	220.77	**3 594.10**
2010	3 807.76	201.01	260.53	**4 269.30**
2011	3 224.50	187.70	254.20	**3 666.40**

The major share (88%) in emissions belongs to the iron and steel production, 5% belongs to the ferroalloy production and 7% to the aluminum production.

Figure 4.14: *The share in GHG emissions of individual subcategories of the 2.C in 2011*

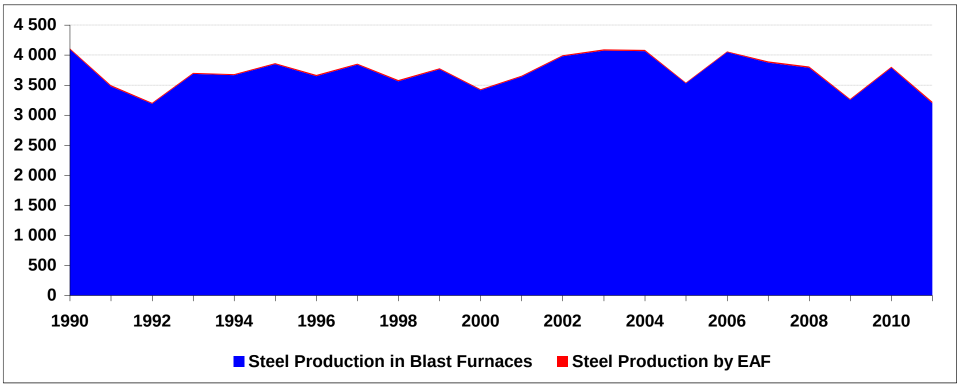


Category	**CO_2 *eq.* (Gg)**
2.C.1 Iron and Steel	3 224.50
2.C.2 Ferroalloy Production	187.70
2.C.3 Aluminium Production	254.20

4.6.2 Source category description – Iron and steel production (CRF 2.C.1)

Total CO_2 emissions were 3 224.50 Gg in 2011, decrease in comparison with 2010 was 15%. Comparing with the base year, the decrease is approximately 22%. Pig iron is produced by the reduction of iron ore by coke in a blast furnace, the main emission is CO_2. 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 CO emissions, the most of which is burned to CO_2. Iron ore was processed to pig iron. Category iron and steel production includes processes steel production (2.C.1.1), pig iron production (2.C.1.2), sinter production (2.C.1.3) and steel production in electric arc furnaces (2.C.1.5). The CO_2 emissions from coke and sinter production were allocated according to the IPCC 2000 GPG in energy sector, category iron and steel production (1.A.2.a). Therefore notation key "IE" was used in these categories. Major share of technological CO_2 emissions represents pig iron and steel production in blast furnaces. Due to the difficult determination between emissions originated from pig iron and from steel production, total CO_2 emissions from this production were included directly in steel production category. Therefore the notation key "IE" in pig iron production category was used. The CO_2 emissions from EAF steel production are reported in the 2.C.5 category (Figure 4.15).

Figure 4.15: *The trend of individual categories in emissions (in CO_2 eq.) in category 2.C.1 iron and steel production in 2011*



4.6.2.1 Methodological issues – methods

Previously used country specific methodology was revised in previous submission 2012. 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 discussion with plant operators, simplified scheme of the plant in order to carbon balance was proposed (Figure 4.16).

All the streams were recalculated based on conversion unit and carbon EF used in energy sector (category 1.A.2a) or on the basis of content of carbon in iron ore and steel to total carbon. Carbon balance of the iron and steel production is described in full details in Annex 3.

The CO_2 emissions can be calculated by using following equation:

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

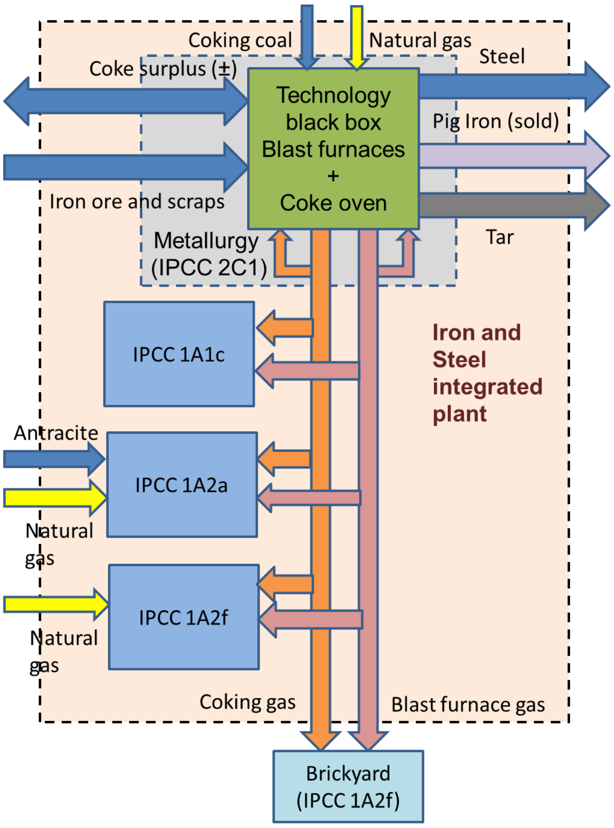
$$E(\text{steel EAF}) = EF(\text{steel in EAF}) \cdot \text{mass of Steel produced in EAF}$$

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

However, the data necessary for this new approach are available only for the time period 2005 – 2011. The older data has been be recalculated in previous submission by using alternative recalculation techniques (overlap method) described in the Chapter 7.3.2.2 of the IPCC 2000 GPG.

The technological emissions from pig iron (2.C.1.2), steel (2.C.1.1) and emissions from coke electrodes used by EAF steel production (2.C.1.5) are included in the category 2.C.1 iron and steel production. The CO_2 emissions originated from coke production in iron and steel industry and emissions originated from sinter production are included in the category 1.A.2a of energy sector. The CO_2 emissions from limestone consumption were reallocated into the category 2.A.3 limestone and dolomite use as it is *good practice* described in the IPCC 2000 GPG.

Figure 4.16: *The simplified calculation and distribution scheme of pig iron and steel production*



4.6.2.2 Methodological issues – emission factors and other parameters

It should be noted that the EFs differ and are estimated annually on plant level which is equal to country specific level in this case. Differences between annual emission factors are caused by the different amounts of iron scrap added to the charge in steel making process and different amounts of gas fuels produced in blast furnaces. The content of carbon in iron ore was 0.530 kg/t, in pig iron was 43.6 kg/t and in steel the content was 0.747 kg/t (data supplied by the plants). Emission factors and other parameters are summarized in Tables 4.26 – 4.28.

4.6.2.3 Activity data

Iron and steel is produced by several plants (U.S.Steel Kosice, a.s., UNEX, Prakovce, Metalurg and by ironworks Železiarne Podbrezová, a.s.). The manufacturers of iron and steel in blast furnaces (integrated production of iron and steel) produced totally 19.55 kt of pig iron (which was sold) and 3 961.02 kt of steel from 2 810.39 kt of iron ore in 2011. Total production of steel produced by EAF was 374 215 t in 2011. The plant UNEX, Prakovce did not produced steel in 2011.

Activity data for sinter production are based on written information supplied by the producers (VSS, a.s. Košice, Zlieváreň SEZ, a.s. Krompachy, Strojchem Chemosvit, SJT Moldava, UNEX, Prakovce, Zlieváreň, s.r.o. Trnava, ZLH, a.s. Hronec, GML Casting, SMZ Kunová Teplica, s.r.o., Eurocast Košice and Compel Metal Martin). Total production of cast iron in the Slovak Republic was 51 905 t in 2011.

Table 4.26: *Activity data, emission factors and CO_2 emissions in integrated iron and steel production in 2005 – 2011*

Year	Coking coal consum.	Coke saldo	NG consum.	Coking gas output	BFG output	Steel produc.	Tar output	CO_2	CO_2 IEF
	(kt)		(mil. m^3)	(kt)				(Gg)	(t/t)
2005	2 594.52	-20.00	30.67	626.30	3 622.84	4 238.12	71.00	**3 528.99**	0.833
2006	2 853.64	179.00	37.68	670.28	4 665.12	4 836.49	69.00	**4 047.71**	0.837
2007	2 960.17	-147.00	26.31	682.77	3 838.94	4 784.81	69.00	**3 873.91**	0.810
2008	2 867.21	-152.00	22.11	668.56	3 693.60	4 229.40	62.00	**3 788.59**	0.896
2009	2 455.88	-85.00	20.27	592.13	3 378.26	3 642.28	58.00	**3 251.17**	0.893
2010	2 516.80	327.63	36.14	657.13	4 227.88	4 401.78	57.00	**3 790.16**	0.861
2011	2 503.00	-27.00	28.90	645.28	4 025.42	3 961.02	0.00	**3 197.53**	0.807

BFG – blast furnace gas, Tar output is zero in 2011, the produced tar was consumed in plant

Table 4.27: *Data used in integrated iron and steel production in 1990 – 2004*

Year	Steel production	CO_2 Emissions	IEF (CO_2)
	(kt)	(Gg)	(t/t)
1990	3 561.50	**4 095.73**	1.150
1991	3 163.40	**3 479.74**	1.100
1992	2 952.40	**3 188.59**	1.080
1993	3 205.40	**3 686.21**	1.150
1994	3 330.40	**3 663.44**	1.100
1995	3 207.40	**3 848.88**	1.200
1996	2 920.00	**3 650.00**	1.250
1997	3 072.30	**3 840.38**	1.250
1998	3 100.00	**3 565.00**	1.150
1999	3 420.00	**3 762.00**	1.100
2000	3 519.99	**3 414.39**	0.970
2001	3 751.85	**3 639.29**	0.970
2002	4 103.20	**3 980.10**	0.970
2003	4 382.92	**4 076.12**	0.930
2004	4 421.14	**4 067.45**	0.920

Table 4.28: *Activity data, emission factors and CO_2 emissions in individual plants for EAF steel production in 1990 – 2011*

Year	Železiarne Podbrezová			Metalurg Steel			UNEX. Prakovce		Total		
	Steel	Carbon	CO_2	Steel	Carbon	CO_2	EAF	CO_2	EAF	CO_2	IEF
	(t)										(t/t)
1990	C	3 810	13 970	C	1 096.6	4 021	C	162	310 729	18 153	0.0584
1991	C	3 928	14 403	C	1 117.4	4 097	C	162	319 963	18 662	0.0583
1992	C	3 735	13 695	C	1 076.5	3 947	C	161	304 644	17 803	0.0584
1993	C	3 729	13 673	C	1 053.5	3 863	C	166	303 750	17 702	0.0583
1994	C	3 884	14 241	C	1 102.4	4 042	C	166	316 433	18 449	0.0583
1995	C	3 878	14 219	C	1 044.3	3 829	C	164	314 641	18 212	0.0579
1996	C	3 797	13 922	C	1 102.1	4 041	C	160	309 851	18 123	0.0585
1997	C	3 841	14 084	C	1 097.7	4 025	C	167	313 155	18 276	0.0584
1998	C	3 876	14 212	C	1 047.8	3 842	C	166	314 601	18 220	0.0579
1999	C	3 952	14 491	C	1 022.7	3 750	C	159	319 660	18 400	0.0576
2000	C	3 879	14 223.	C	1 117.1	4 096	C	167	316 358	18 486	0.0584
2001	C	3 900	14 300.	C	1 105.9	4 055	C	166	317 710	18 521	0.0583
2002	C	3 765	13 805.	C	1 091.5	4 002	C	171	307 356	17 978	0.0585
2003	C	3 953	14 494	C	1 088.5	3 991	C	134	320 863	18 619	0.0580
2004	C	4 583	16 804	C	226.1	829	C	46	347 605	17 679	0.0509
2005	C	3 409	12 490	C	242.2	888	C	83	356 900	13 461	0.0377
2006	C	3 232	11 843	C	495.0	1 815	C	94	376 581	13 752	0.0365
2007	C	4 982	18 254	C	604.9	2 218	C	69	389 435	20 541	0.0527
2008	C	4 986	18 269	C	684.0	2 508	C	62	382 609	20 839	0.0545
2009	C	4 597	16 856	C	211.6	776	C	23	348 065	17 655	0.0507
2010	C	4 465	16 372	C	335.2	1 229	0.00	0.00	331 248	17 601	0.0531
2011	C	7 058	25 879	C	297.3	1 090	0.00	0.00	374 215	26 969	0.0721

4.6.2.4 Uncertainties and time-series consistency

The time series consistency was respected in the highest degree due to the high share of emissions in this specific category. However, some remarks should be mentioned:

- Iron and steel production in blast furnaces:

Natural gas was also used for heating of blast furnaces since 2000. Therefore the CO_2 IEF decreased from that year. The detailed data for country specific methodology described above are directly available for the time period 2005 – 2010. Therefore, the overlap recalculation method was used for the years 1990 – 2004. The EU ETS reports are available since 2005, but no detailed data for fuel consumption or CO_2 emissions are presented in the reports. The methodology used by plant operator in the EU ETS report is based on mass balance and was used for comparison during QA/QC process.

- EAF steel production:

Emission estimation is based on the available country specific data and following assumptions

- <u>Železiarne Podbrezová:</u> EU ETS reports are available since 2005. According to the questionnaires sent by the producer for the period 2000 – 2004, the average value of 13.4 kg of carbon (in all material inputs) for production of 1 t of produced steel was used.
- <u>Metalurg Steel:</u> EU ETS reports are available since 2005. Until 2006, the CO_2 emission factor was determined on the value 0.165 t per 1 t of produced steel. This approach is based on the carbon balance made by the plant. Since 2007, direct consumption of carbon is available. From data directly reported in the period 2007 – 2011, carbon consumption was extrapolated using driver methodology (steel production) back to 1990. The EF = 0.165 t/t was verified during this exercise.
- <u>UNEX Prakovce:</u> The plant is not included in the EU ETS. The default CO_2 emission factor was used (0.08 t/t) for produced steel.

The abovementioned assumptions were used for the CO_2 emission estimation in the period 1990 – 1999, as well. Wide range of EFs for EAF steel production is based on the content of carbon in the scraps. One of the plant is using low carbon scraps (<0.1% of C). On the other hand, the other plant is using high carbon iron scraps (ca 4% of C). Content of carbon in produced steel is approximately 1%. The unequal carbon content results in significant different EFs.

The uncertainty analyses in this category were prepared in consistency with the methodology used in energy sector. Estimation is based on materials properties, carbon balance and default values for uncertainty of production, NCV and EFs. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-9.01%; +9.09%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented in formula by symbol Δ):

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

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 category 2.C.1 obtained by the Monte Carlo simulation is 3 235 kt per year. The average mean value is comparable with the real CO_2 emissions in this category, which is 2 225 kt. 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.

Figure 4.17: Probability density function for category 2.C.1 in t of CO_2

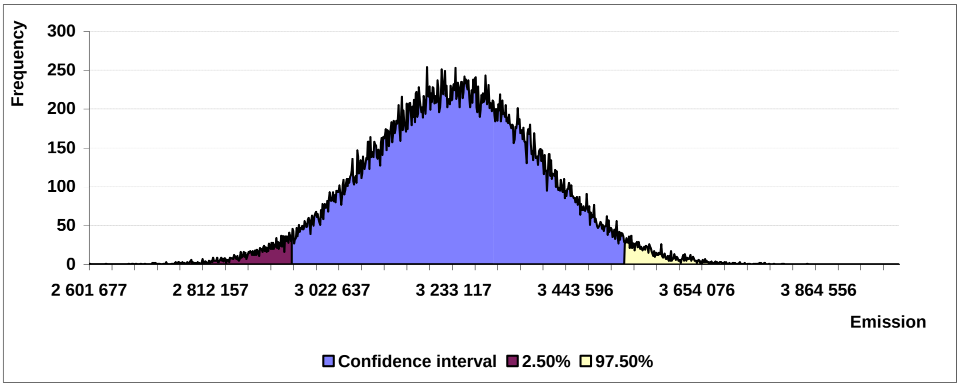


***Table 4.29:** Selected statistical characteristics for category 2.C.1, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
3 234 696.743	**3 234 521.333**	149 304.125	2 601 677.093	4 004 876.006	-9.01%	9.09%

4.6.2.5 Source specific QA/QC and verification

Performed sector specific QA/QC activities are described in Chapter 4.2 of this report. In addition, 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 carbon balance methodology without differentiation among IPCC categories presented in this chapter. The difference between the emissions calculated from these two approaches data was 0.2%, this exercise was a part of the QA process.

4.6.2.6 Source specific recalculations

No recalculations were provided in the submission 2013 focused on the base year 1990 or the other inventory years.

4.6.2.7 Source specific planned improvements

No improvements of the used approach are planned in the next submission. However, the estimation of the results for 1990 – 2004 will be checked and verified in the next submission.

4.6.3 Source category description – Ferroalloys production (CRF 2.C.2)

Ferroalloys are produced in arc furnaces, submerged arc furnaces by the reduction of the mixture of iron ore, and added metal and/or metalloid (Si) oxides. Technological CO_2 and CH_4 (only from FeSi alloys) emissions from ferroalloys production were reallocated from energy sector in previous submissions and according to the methodology used in 2013 submission were 187.07 Gg of CO_2 and 30.29 t of CH_4.

4.6.3.1 Methodological issues – methods

The CO_2 emission estimation for the period 1990 – 2011 was based on tier 2 approach by using the plant specific data. Since 2002, more detailed information on ferroalloys production are known and therefore CRF tables informed on tier 3 method for the period 2002 – 2011 (based on the IPCC 2006 GL). Before that, the simple data aggregation into ferroalloys based on Cr, Mn and Si was used. The production of FeSi started in 1998. Further information is provided in Tables 4.30 and 4.31.

4.6.3.2 Methodological issues – emission factors and other parameters

In the previous inventory submission (2010) the thorough survey on CO_2 emissions was done in the cooperation with producers. This survey was recommended by the ERT. Plant specific emission factors were estimated (on the basis of carbon balance) annually and they are summarized in Table 4.30. Methane emission factor was not changed and the default value 1 kg CH_4/1 t of FeSi ferroalloys was used for time series.

Table 4.30: *Plant specific CO_2 emission factors in t of CO_2 per 1 t of ferroalloy in 2011*

Ferroalloy	$FeSi_{75}$	$FeSi_{65}$	$FeSi_{45}$	FeSiMn	FeMnC	FeCr	FeSiCa
EF (CO_2) t/t of ferroalloy	3.155	3.030	3.030	1.734	1.629	1.300	4.800

4.6.3.3 Activity data

Information on activity data was taken directly from the producers of ferroalloys questionnaires in the Slovak Republic and they are summarized in Table 4.32.

Table 4.31: *Activity data, emission factors and CO_2 in ferroalloys production in 1990 – 2001*

Year	Ferroalloys				Total CO_2	EF (CO_2)	Total CH_4
	Based on Cr	Based on Mn	Based on Si	Total			
	(t)				(t)	(t/t)	(t)
1990	53 000	116 000	0	169 000	264 244.00	1.564	**0.00**
1991	52 000	113 000	0	165 000	257 892.00	1.563	**0.00**
1992	50 000	110 000	0	160 000	250 240.00	1.564	**0.00**
1993	47 000	103 000	0	150 000	234 552.00	1.564	**0.00**
1994	34 000	111 300	0	145 300	231 629.20	1.594	**0.00**
1995	45 000	89 800	0	134 800	209 723.20	1.556	**0.00**
1996	46 000	84 000	0	130 000	201 256.00	1.548	**0.00**
1997	42 000	78 000	0	120 000	185 952.00	1.550	**0.00**
1998	44 000	81 000	8 666	133 666	221 283.20	1.655	**8.67**
1999	46 700	56 300	13 205	116 205	197 695.97	1.701	**13.21**
2000	17 658	69 458	7 611	94 727	164 232.21	1.734	**7.61**
2001	12 140	69 380	5 200	86 720	149 226.72	1.721	**5.20**

Table 4.32: *Activity data, emission factors and CO_2 for ferroalloys production in 2002 – 2011*

Year	Ferroalloys							
	$FeSi_{75}$	$FeSi_{65}$	$FeSi_{45}$	FeSiMn	FeMnC	FeCr	FeSiCa	Total
	(t)							
2002	31 208	0	0	62 084	56 297	3 521	364	**153 474**
2003	41 539	0	0	52 773	43 434	1 654	1 155	**140 555**
2004	34 684	0	0	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	0	0	**134 674**
2007	8 417	112	0	71 587	74 065	0	0	**154 181**
2008	9 510	941	393	59 940	61 194	0	0	**131 978**
2009	4 241	118	278	32 102	20 976	0	0	**57 715**
2010	16 274	9 519	626	34 960	35 449	0	0	**96 828**
2011	22 079	7 174	1 039	25 023	18 180	0	4 066	**77 561**

Year	Total CO_2	EF (CO_2)	Total CH_4
	(t)	(t/t)	(t)
2002	304 147.20	1.982	**31.21**
2003	301 012.10	2.142	**41.54**
2004	338 522.10	2.000	**34.68**
2005	206 742.10	1.902	**16.51**
2006	249 765.40	1.855	**16.16**
2007	271 678.70	1.762	**8.58**
2008	237 667.10	1.801	**10.84**
2009	104 415.00	1.809	**4.64**
2010	200 451.00	2.070	**26.42**
2011	187 066.50	2.412	**30.29**

4.6.3.4 Uncertainties and time-series consistency

In the previous inventory submission (2010) the thorough survey on CO_2 emissions was done in the cooperation with producers. This survey was recommended by the ERT. The detailed data on the individual ferroalloys were obtained and the respective EFs are summarized in Table 4.30. However, before 2002 different aggregation of production data is available. The CO_2 emission factors in the period 1990 – 2001 were 1.734 t/t of ferroalloys based on Mn, 1.3 t/t of ferroalloys based on Cr and

3.155 t/t of ferroalloys based on Si. This methodology was not fully consistent in terms of time series, therefore the recalculation as described in the IPCC 2000 GPG was made (ERT recommendation during in-country review in 2011). The Overlap method described in Chapter 7 of the IPCC 2000 GPG was adopted and new EFs for the period 1990 – 2001 were calculated to be 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 was made with the same aggregation of production data for the period 2002 – 2010 and the difference in the emissions did not exceed 0.6% (see Annex 2.2, Figures A2.1 and A2.2). Significant increase in emissions since 2002 is caused by change of the plant owner and new market situation.

Following input parameters were applied for the uncertainty analyses in this category: the production of FeSi, FeSiMn, FeMnC, 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 have been included. The emission factors and uncertainty for both AD and EF (in formula represented by symbol Δ) were used for uncertainty estimation. The uncertainty of CO_2 emissions (in equivalents) is in interval (-2.90%; +2.88%). Formula can be written in the following form:

$$Emission = \sum_{I} (ferroalloy \pm \Delta ferroalloy) * (EF\_Ferroall \pm \Delta EF\_Ferroalloy)$$

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 category 2.C.2 obtained by the Monte Carlo simulation is 187.72 kt per year. The average mean value is comparable with the real CO_2 emissions in this category, which is 187.70 kt.

Figure 4.18: *Probability density function for category 2.C.2 in t of CO_2 equivalents*

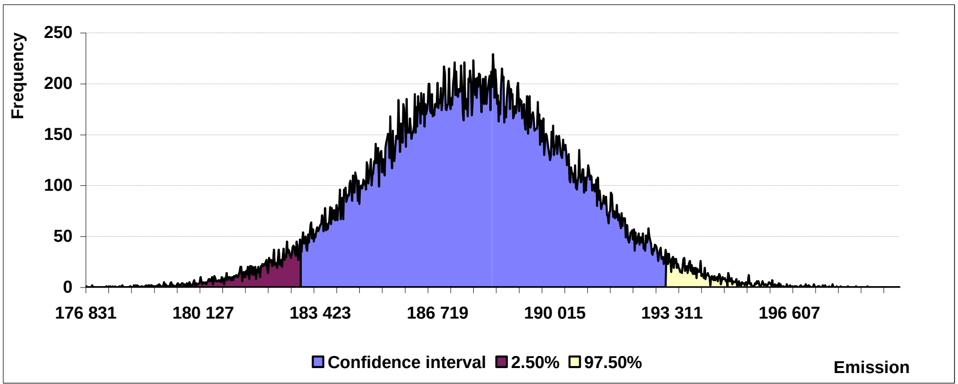


Table 4.33: *Selected statistical characteristics for category 2.C.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2 equivalents)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
187 721.651	**187 716.455**	2 773.578	176 831.356	199 720.399	-2.90%	2.88%

4.6.3.5 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 of information is U.S. Geological Survey (www.usgs.gov). The data for the time period 1990 – 2009 were available and were compared with the results of national inventory. The consistency of the whole time series was checked, as well. The results are presented in Annex 2.2.

4.6.3.6 Source specific recalculations

No recalculations were provided in the submission 2013 focused on the base year 1990 or the other inventory years.

4.6.3.7 Source specific planned improvements

More attention will be laid down to improve methane emissions estimation in this particular category.

4.6.4 Source category 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. The most interesting for emission estimation is the content of AlF_3. The Slovak plants for aluminium production use a modern technology where the majority of HF and other fluorides escaping from the electrolytic cells are 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 Soederberg 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 per month.

4.6.4.1 Methodological issues – methods

Tier 3 methodology based on plant specific emission factors and activity data has been applied since 2004 in CO_2 and PFCs emissions estimation. According to the information from producers, 68 821 t of graphite anodes were used in 2011 with the carbon content 94%. The CO_2 emissions were estimated based on the IPCC 2000 GPG multiplying volume of used anodes by carbon content and 44/12 (237.20 Gg CO_2 in 2011). The total PFC emission was 2.521 t (17 Gg of CO_2 *eq.*) in 2011 and it was calculated according to the Slope method.

4.6.4.2 Methodological issues – emission factors and other parameters

The CO_2 emission factors are based on plant specific data and are updated annually since 2005. Before 2005, overall EF = 1.5 t/t for 1996 – 2004 and EF = 1.8 t/t for 1990 – 1995 were used. The emission factors of PFCs (CF_4, C_2F_6) were calculated according to the Tabereaux's equation (version of the Slope method):

$$EF(PFC) = const \cdot \frac{x}{\eta} \cdot AE \cdot AED$$

Where *const* is a constant for emission factor of CF_4 = 1.698, for emission factor of C_2F_6 = 0.1698 in 2011 and it equals to:

- *x* is the mole fraction of PFC. For the plants with pre-baked anodes it is 0.08;
  η is the current efficiency (fraction).
- *AE* is the number of anode effects per pot day.
- *AED* equals to the anode effect duration in minutes.

4.6.4.3 Activity data

According to the data from plant operator, the average current efficiency was 92.67% in 2011, the number of anode effects per pot day equals to 0.10 and their average duration was 0.96 min. It follows that the emission factors were 0.0141 kg CF_4/t of aluminium and 0.0014 kg C_2F_6/t of aluminium, respectively. 162 84 t of aluminium were produced in 2011. SF_6 is not used in aluminium castings in the Slovak Republic since 2004.

4.6.4.4 Uncertainties and time-series consistency

In 1996 the technology was changed from Søderberg to prebaked technology. It results in significant decrease of CO_2 and PFC emissions. The CO_2 emissions were calculated by using tier 2 methodology in the period 1990 – 1995 due to lack of detailed data. The plant owner was changed since that time and higher tier methodology can be implemented since 2004. According to the questionnaire, the significant progress in control of the electrolysis was achieved in 2009 (background of the progress is confidential but information can be provided during review as well as the reason of CO_2 IEF decrease). The progress results in decrease of PFC emissions since 2009.

Table 4.34: *The overview of emissions and EFs in aluminium production in 1990 – 2011*

Year	Aluminium Production	CO_2 EF	CO_2	CF_4	CF_4 EF	C_2F_6	C_2F_6 EF	Total PFC Emissions
	(kt)	(t/t)	(Gg)	(t)	(t/t)	(t)	(t/t)	Gg CO_2 eq.
1990	67.40	1.8000	121.32	36.60	0.5430	3.64	0.0540	**271.37**
1991	66.30	1.8000	119.34	36.00	0.5430	3.58	0.0540	**266.94**
1992	61.70	1.8000	111.06	33.50	0.5430	3.33	0.0540	**248.42**
1993	38.60	1.8000	69.48	20.96	0.5430	2.08	0.0540	**155.42**
1994	32.80	1.8000	59.04	17.81	0.5430	1.77	0.0540	**132.06**
1995	32.60	1.8000	58.68	15.42	0.4730	1.53	0.0470	**114.32**
1996	111.40	1.5000	167.10	4.68	0.0420	0.45	0.0040	**34.51**
1997	110.19	1.5000	165.29	4.52	0.0410	0.44	0.0040	**33.42**
1998	108.00	1.5000	162.00	3.02	0.0280	0.32	0.0030	**22.64**
1999	109.20	1.5000	163.80	1.53	0.0140	0.15	0.0014	**11.34**
2000	109.81	1.5000	164.72	1.54	0.0140	0.15	0.0014	**11.41**
2001	110.06	1.5000	165.09	1.54	0.0140	0.15	0.0014	**11.43**
2002	109.81	1.5000	164.72	1.54	0.0140	0.15	0.0014	**11.41**
2003	111.62	1.5000	167.43	2.81	0.0252	0.28	0.0025	**20.87**
2004	156.89	1.5000	235.34	2.60	0.0166	0.26	0.0017	**19.32**
2005	159.20	1.4490	230.69	2.70	0.0170	0.27	0.0017	**20.06**
2006	158.29	1.3706	216.95	4.83	0.0305	0.48	0.0031	**35.82**
2007	160.46	1.3319	213.72	3.35	0.0209	0.34	0.0021	**24.88**
2008	163.00	1.3470	219.55	4.87	0.0299	0.49	0.0030	**36.16**
2009	149.60	1.3570	203.01	2.39	0.0160	0.24	0.0016	**17.76**
2010	163.00	1.4686	239.38	2.85	0.0175	0.29	0.0018	**21.15**
2011	162.84	1.4567	237.20	2.29	0.0141	0.23	0.0014	**17.00**

The uncertainties in the mass of produced aluminium (2%), the amount of anodes, carbon content in anodes, the mole fraction of PFC, 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 (-3.70%; +3.75%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented in formula bysymbol Δ):

$$\text{Emission} = (\text{amountof Anodes} \pm \Delta\text{Anode}) * (\text{contentof C} \pm \Delta\_\text{contentof C}) * \frac{44}{12} +$$

$$+ \sum_{I} \left(\text{constant} * (\text{PFCcontent} \pm \Delta\text{PFCcontent}) * (\text{anodeeffects} \pm \Delta\text{anodeeffects}) \right) *$$

$$* \frac{(\text{durationof Anodes} \pm \Delta\text{durationof Anode})}{(\text{current eff} \pm \Delta\_\text{current eff})} / 1000$$

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 category 2.C.3 obtained by the Monte Carlo simulation is 253.6 kt per year. The average mean value is comparable with the real CO_2 emissions in this category, which is 254.2 kt.

Figure 4.19: *Probability density function for category 2.C.3 in t of CO_2 equivalents*

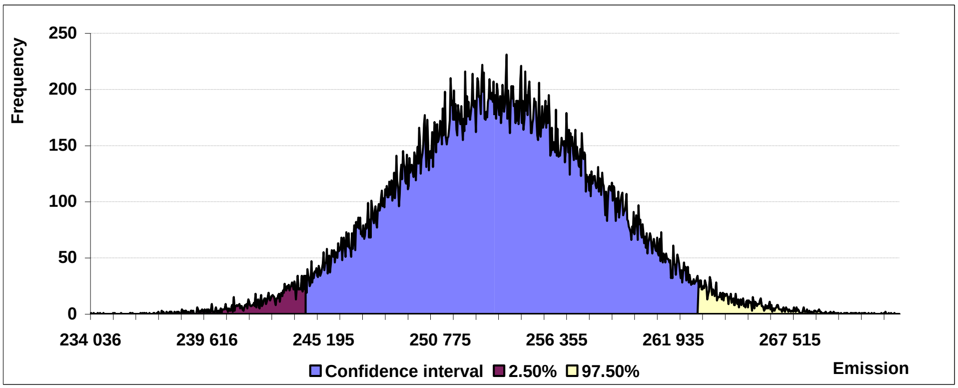


Table 4.35: *Selected statistical characteristics for category 2.C.3, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2 equivalents)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
253 548.258	**253 593.795**	4 845.315	234 035.684	272 784.974	-3.70%	3.75%

4.6.4.5 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 by the theoretical thermodynamic calculation provided at the Slovak University of Technology, Faculty of Chemical and Food Technology.

4.6.4.6 Source specific recalculations

No recalculations were provided in the submission 2013 focused on the base year 1990 or the other inventory years.

4.6.4.7 Source specific planned improvements

Thorough survey of carbon content in anodes is planned for the time period 1995 – 2004.

4.6.5 Source category description – Aluminium Magnesium Foundries (CRF 2.C.4)

This production does not occur in the Slovak Republic, therefore the notation key “NO” was used for time series in this category.

4.7 Other production (CRF 2.D)

No GHGs emissions from the technology of paper and pulp and food industry were estimated. Therefore notation key “NO” was used in these categories. The emissions of SO_2 from paper and pulp production were not occurring in 2011 and NMVOC emissions from food industry were 296 t.

4.8 Production of halocarbons and SF_6 (CRF 2.E)

No halocarbons or SF_6 were produced in the Slovak Republic in 1990 – 2011, therefore notation key “NO” was used in these categories.

4.9 Consumption of halocarbons and SF_6 (CRF 2.F)

4.9.1 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 they were not considered in the GHG emission 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);

- 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 category 2.C.3 – Aluminium production. The inventory of F-gases is complicated due to a high number of substances HFCs, PFCs a SF_6. They are components of different mixtures used in more than 15 different applications. Each application has its own development of consumption and trend of emission development. To ensure environmental integrity, the post-2012 agreement should include 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. The GWPs from the IPCC Fourth Assessment Report were used to estimate emissions in CO_2 equivalents from these gases.

During the last two years, the emission inventory of F-gases in the CRF category 2.F was completely revaluated, recalculated and improved. These changes led to the increase of completeness, transparency, accuracy, consistency and comparability of inventory. The time series was recalculated back to base year. The emissions of used F-gases were disaggregated into the IPCC subcategories based on the ERT recommendations from the previous reviews. The inventory is based on the national database system, which was put into operation in 2010. Based on the information from this electronic database system, detailed data are available directly from the industry and services companies. The overview of the F-gases actual and potential emissions is presented in the following table.

Table 4.36: *The overview of actual and potential HFCs, PFCs and SF_6 emissions in 1990 – 2011*

Category 2.F Consumption of HFCs, PFCs and SF_6									
Year	**Actual HFCs** (CO_2 eq.)	**Potential HFCs**	**Ratio A/P**	**Actual PFCs** (CO_2 eq.)	**Potential PFCs**	**Ratio A/P**	**Actual SF_6** (t)	**Potential SF_6**	**Ratio A/P**
1990	NO	NO	NO	NO	NO	NO	0.001	0.013	9.946
1991	NO	NO	NO	NO	NO	NO	0.001	0.012	8.874
1992	NO	NO	NO	NO	NO	NO	0.002	0.025	15.259
1993	NO	NO	NO	NO	NO	NO	0.003	0.118	42.865
1994	0.17	3.08	17.79	NO	NO	NO	0.388	3.890	10.030
1995	11.65	119.57	10.27	NO	NO	NO	0.415	3.484	8.402
1996	24.06	147.66	6.14	NO	NO	NO	0.450	4.405	9.788
1997	32.60	147.62	4.53	1.20	1.20	1.00	0.474	3.354	7.072
1998	40.42	163.52	4.05	2.77	2.81	1.01	0.512	4.766	9.307
1999	58.18	266.56	4.58	2.26	2.28	1.01	0.531	2.903	5.469
2000	77.01	341.02	4.43	0.24	0.24	1.00	0.549	2.880	5.248
2001	102.30	413.64	4.04	4.16	4.16	1.00	0.564	2.633	4.669
2002	130.12	486.15	3.74	2.34	2.34	1.00	0.603	5.097	8.450
2003	154.22	499.00	3.24	0.78	0.78	1.00	0.629	3.782	6.015
2004	181.34	565.43	3.12	0.59	0.59	1.00	0.650	3.369	5.185
2005	205.96	586.19	2.85	0.20	0.20	1.00	0.681	4.451	6.537
2006	248.14	695.76	2.80	NO	NO	NO	0.703	3.644	5.181
2007	284.44	694.63	2.44	NO	NO	NO	0.730	4.053	5.554
2008	335.17	878.22	2.62	NO	NO	NO	0.775	5.995	7.740
2009	380.08	956.03	2.52	NO	NO	NO	0.811	5.256	6.479
2010	420.16	820.79	1.95	NO	NO	NO	0.833	3.794	4.556
2011	439.50	856.54	1.95	NO	NO	NO	0.868	5.223	6.018

The actual HFCs emissions in category 2.F Consumption of halocarbons were 439.50 Gg of CO_2 equivalents in 2011 and they have increased by more than 4% compared to the previous year. Strong increasing trend is visible since base year caused by supplying PFCs gases by the HFCs. The potential emissions of HFCs represented 856.54 Gg of CO_2 equivalents in 2011. The emissions have increased by more than 4% compared to the previous year. The ratio of potential/actual HFCs emissions was 1.95 in 2011 and the trend of ratio started to decrease.

The actual emissions of PFCs in the category 2.F did not occur in 2011.

Actual emissions of SF_6 reached 0.87 t in 2011 and increased by 5% compared to the previous inventory year. The potential emissions of SF_6 reached 5.22 t and increased by 37% compared to the previous year. The ratio of potential/actual emissions of SF_6 was 6.02 in 2011.

Total aggregated emissions estimated in the category 2.F were 460.24 Gg of CO_2 equivalents in 2011. Emissions were increased in comparison with the previous year by 4.5% and the increasing trend is visible since 1994.

4.9.2 Activity data

Before year 2009, the activity data were collected via the 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 doubt, received data were verified by the provider and they were summarized in the tables according to the way of use. Since the year 2009 data have been reported through the electronic system. Tables used since 1990 were also used in the latest inventory for data storage and archiving in order to retain the continuity of observing the trends of sent data.

The implemented electronic system on www.szchkt.org consists of:

- Yearly reporting of F-gases (new charges and leakages) by certified companies;
- Yearly reporting of F-gases imported in bulks by certified companies;
- Yearly 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 certification.

Advantages of electronic data logging and reporting are in the possibilities of automatic analysis, fault detection and comparison, 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 4.20).

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 authorised 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.

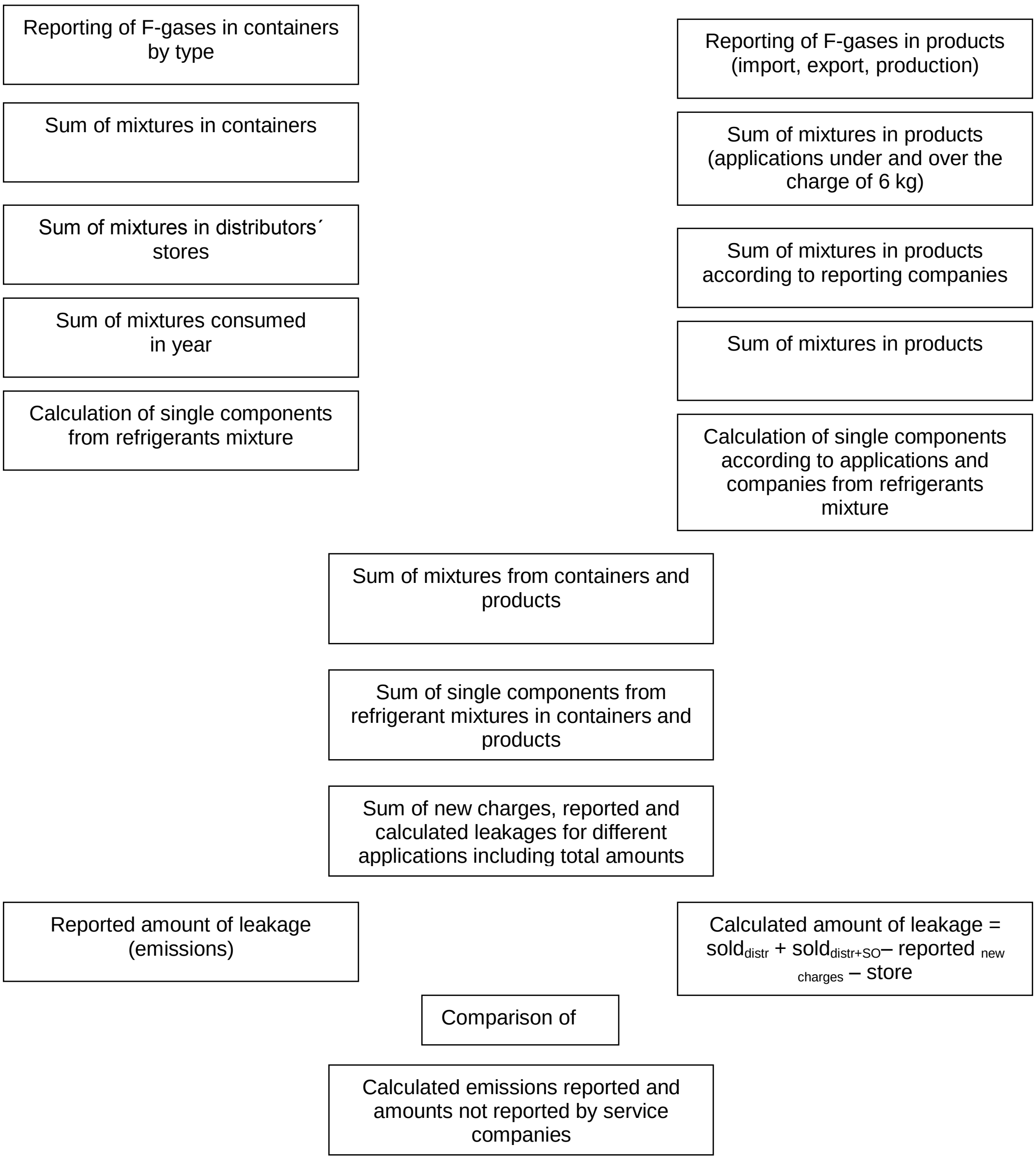
Slovak Republic reports emissions of HFCs, PFCs and SF_6 (use of substances) in the Industrial Processes sector in the following subcategories of the 2.F IPCC category:

- 2.F.1 Refrigeration and Air Conditioning Equipment
- 2.F.2 Foam Bowing
- 2.F.3 Fire Extinguisher
- 2.F.4 Aerosols and Metered Dose Inhalers
- 2.F.8 Electrical Equipment – only SF_6 is reported in this category

In the following subcategories are emissions not reported and the notation key “NO” was used:

- 2.F. 5 Solvent – no gases occur in this category
- 2.F.6 Other Application Using ODS substitute – no gases occur in this category
- 2.F.7 Semiconductor Manufacture – no gases occur in this category
- 2.F.9 Other – no gases occur in this category

Figure 4.20: *The diagram of data flow in electronic system*



4.9.3 Emission factors

Emission factors were evaluated in each subcategory for each individual product (or use of gas) to ensure the best available accuracy of inventory. EFs are described in each subcategory chapter.

4.9.4 Methodological issues – methods

The actual emission estimation of time series was performed by tier 2 methodology that accounts for the time lag between the consumption and the emissions. The method of potential emission estimation (tier 1) assumes that the emissions occur during the year in which the chemical is produced or sold to particular end-use sector. Detailed description of methodology is provided in the reported subcategories.

Some general methodological procedures are described in the following text:

Methodology for F-gases imported in bulks:

Refrigerant and other F-gases movement reporting is required according to legal instruments in the EU. Electronic system is based on the certification of companies which shall restore its certificate annually. Company has to enter the web site of electronic system with its name and password and declare the competencies of the employees, possession of technical equipment, regular checking of electronic detectors, and movement of refrigerant from the previous year. The confirmed data are saved and sent to the Notified Body till the end of January. After receiving the report, the Notified Body will restore the certificate. Certified companies and competent persons are on the web site of notified body. The declarations of certified companies with the legal requirements of the EU are notified on the website.

Reporting of F-gases imported in products:

Refrigerant and other F-gases movement reporting is required according to legal instruments in the EU. Electronic system collects the movement of refrigerant and other F-gases in products from the previous year. The confirmed data are saved and sent to the Notified Body till the end of January. After receiving the report, data are automatically processed. Reporting of importers, producers and exporters of F-gases movement in products (such as extinguishing equipment's, cooling and AC equipment's, foams, transport cooling, mobile AC, heat pumps, equipment's filled with SF_6 and others) are on the web site. Producers have to confirm, that they filled the gases into products only from certified companies (bought in Slovakia or own import). In this way double counting of reported amounts from products and containers is avoided. All reported data are available for the reporting organization and companies. The Slovak electronic system includes historical development in all monitored refrigerants and other F-gases according to the categories. List of companies dealing the products is on http://www.szchkt.org/a/databaza/vyrobky?locale=en_GB.

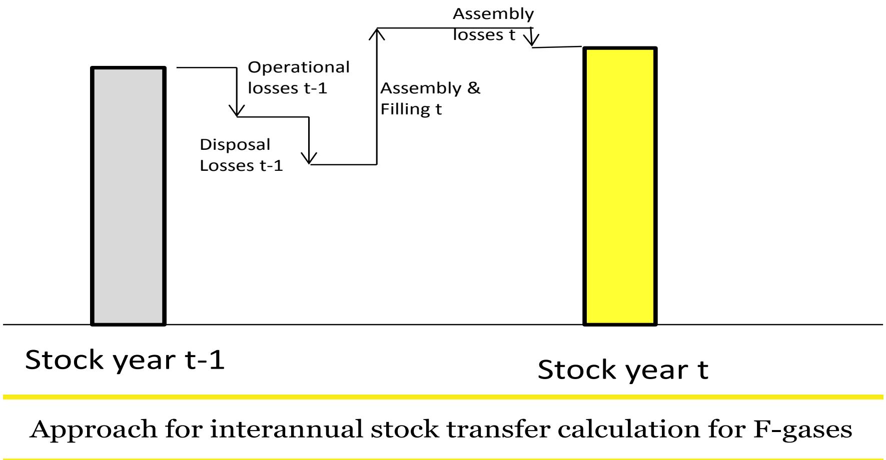
Calculation of HFCs amount in operation (stock):

The emission calculation of HFCs in stock is according to following equation:

$$\text{Stock}_{\text{year t}} = \text{Stock}_{\text{t-1}} - \text{HFC}_{\text{emitted t-1}} - \text{Disposal}_{\text{losses t-1}} + \text{Assembly}_{\text{filling t}} - \text{Assembly}_{\text{losses t}}$$

These stocks are obtained as sum of final stocks of the previous year (t-1) and of the current year (t) minus emissions; summation is carried out from the first year of application on. The result is the accumulated stocks for year t. The calculation includes amounts in bulk and in products and foreign trade. The same equation graphically expressed on following Figure 4.21.

Figure 4.21: *Scheme of emission estimation in 2011*



4.9.5 Source specific QA/QC and verification

Slovakia has a unique reporting system of F-gases in bulks and in products. Data processing system is done automatically on 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 for the reporting organizations,
- 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.

The evaluation of sent and processed data on the sources and emissions of the substances in the Slovak Republic is realized on the basis of country-specific emission factors. All country-specific emission factors are in the range recommended by the IPCC 2000 Good Practice Guidance. Some of the used emission factors are default values.

The new internet reporting system has been running since 2009 on the legal basis of the 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 increased knowledge of the companies to get more precise data. Then it can then be expected that the improvements in the completeness and accuracy of the reported data will take place.

4.9.6 Uncertainties and time-series consistency

Monte Carlo method for the uncertainty analyses has not been implemented for F-gases yet. The overall uncertainty in this category (2.F) is determined by the characteristics of the web electronic system. The IPCC default values for uncertainty of activity data and emission factors were used. There are two collection systems in the time series of F-gases:

1. 1990 – 2008: system was based on questionnaires;
2. Since the year 2009: electronic system in place.

Up to the year 2008 the reporting was based on questionnaires sent to the companies included in the Catalogue of RAC Companies. The companies were trained by the SZ CHKT which was authorized by the Ministry of Environment for training and certification. Addressed companies filled the questionnaires on the base of their documentation and so the reported data corresponded to the reality.

Since the year 2009 electronic system on internet platform has been in place. This system started operation in the year 2010. This system introduced new solution for:

- comfort of data sending with self-control of their reliability,
- history of sent data,
- possibility of mass communication,
- automatic data processing.

To ensure the time series consistency the recalculation of stock was made according to the discussion with the ERT during six weeks period after in-country review in 2012. The recalculation is described in detail in Chapter 4.9.7.

The uncertainties of actual and potential emissions are influence by preciseness and completeness of reported data. Potential emissions have correlation to economic development in the SR and are dependent on time (years). Trend in potential emissions has fluctuating, mainly increasing tendency, which will be decreasing due to implementation of alternative natural refrigerants in the future.

Nowadays, the development is given mainly by the fact that HFCs substances are substituting CFCs and HCFCs substances excluded from usage by Montreal Protocol.

The nonsymmetrical error distribution in reported data in the range from -5% to +15% was assumed. This error was lowered since the year 2009. The emission factor uncertainty is gradually decreasing during the years 1994 – 2011. The emission factor is starting to be influenced by amortization, end of life of equipment's. Refrigerant recovery from eliminated equipment is important, but these are eliminated often, because the refrigerant has leaked. Due to this fact the decrease of emission factor is slower. The lowest emission factors are on the products completed in the factories mainly in domestic refrigerators, chillers and similar. Higher emission factors are in cooling circuits assembled on the place of application for example commercial, agricultural, industrial or transport refrigeration. The uncertainty of emission factors in car air conditioning is over 20%. From this assessment is expected emission factor uncertainty in all applications in the range from 8% to 25%.

4.9.7 Source specific recalculations

Based on the Potential Problems document formulated by the ERT in the course of the 2012 in-country review, the recalculations in CRF categories 2.F.1 – 2.F.6 were prepared for the whole time series. The resubmission was uploaded in November 2012. The emissions in the category 2.F.1 – Refrigerants were allocated according to the subcategories (domestic, commercial …) and as a sum of amounts (new, filled, on stock …) with the corresponding EF. Calculation formulas were implemented to get the time series methodology consistent and the data itself, too. Year 2010 was chosen as a year of the best and most accurate data up to now because of web reporting. EFs are based on real web-reported data in 2010.

The disaggregated data for subcategories refrigeration and air conditioning equipment (2.F.1), foam blowing (2.F.2) and fire extinguishers (2.F.3) were not available before 2009. However, when new reporting system started through web server, all necessary data were available for the year 2010. Activity data and real EFs were obtained from electronic system in complete and very detailed way in 2010. The recalculation of emissions before 2009 was made on the following assumptions:

- Stock was calculated according to the formula which is in line with the IPCC 2000 Good Practice Guidance (see Chapter 4.5.4).
- Activity data for stock, new fillings (assembly) and disposal have been disaggregated into subcategories (refrigeration and air conditioning equipment (2.F.1), foam blowing (2.F.2) and fire extinguishers (2.F.3)) for 2010.
- Equipment operation emissions for subcategory fire extinguishers (2.F.3) were added based on the electronic database system, as well.
- Disposal emissions for subcategories refrigeration and air conditioning equipment (2.F.1), foam blowing (2.F.2) and fire extinguishers (2.F.3) were included from the data available in electronic database system.
- Formula for stock mentioned above was used back to base year for the whole time series.
- Extrapolation for new fillings and disposals back to the base year was made on the basis of the national share of new fillings, stocks and disposals for 2010. This method is very similar to the surrogate recalculation method that is described in Chapter 7 of the IPCC 2000 Good Practice Guidance. Stock data were used as surrogate parameter.
- EFs were assumed to be the same as obtained in 2010.
- The approach described above was used for each gas in each subcategory.

Use of this revised methodology for the whole time series ensured time series consistency in methods. Some minor inconsistency in activity data disaggregation in individual subcategories mostly in refrigeration category (2.F.1) for stock can occur by using this methodology. It was caused by the used extrapolation method to the individual subcategories. Stock depends on the new fillings and disposals that were extrapolated by using the stock as surrogate parameter.

Extrapolated values changed the stock data then and little inconsistency may occur. Two ways were available to solve this problem: (i) a proportional disaggregation or (ii) use of the modified formula for stock as follows:

Stock(t-1) = [stock(t) - new filling(t) + filling losses(t) + removal(t-1)]/(1-EF life time (t-1)/100)

(i): Deviations of cumulative actual and potential emissions compared with previously (2011) reported data (old) without proportional disaggregation based on the shares of reported data in year 2010 with disaggregated back to the year 1995 (new) were up to 0.1% for actual emissions and 0.17% for potential emissions in the year 2011.

(ii): The modified formula for stock(t-1) as presented above was introduced in order to avoid these small deviations. The allocation of new fillings and removals was kept according to 2010 shares and the basic stock formula where all the terms are known was tried to inverse. According to the thorough analysis it seems that the 2010 data (mainly the ratio of new fillings and emissions) were not appropriate allocated between commercial and industrial cooling. The border between these two subcategories is very sensitive. Methodology used dependencies among variables and this resulted in larger data inconsistencies than in previous approach (i). From this reason the proportional disaggregation was use for allocation of emissions in individual subcategories in 2.F.1. Using of the modified formula for stock(t-1) can be followed in the future and due to more reliable reporting we can expect that disaggregation deviations will be lower.

4.9.8 Source specific planned improvements

The improvements will focus on ensuring continuity in reporting of the activity data of all involved organizations (the Ministry of Environment, the Slovak Environmental Inspection, reporting companies, notified bodies).

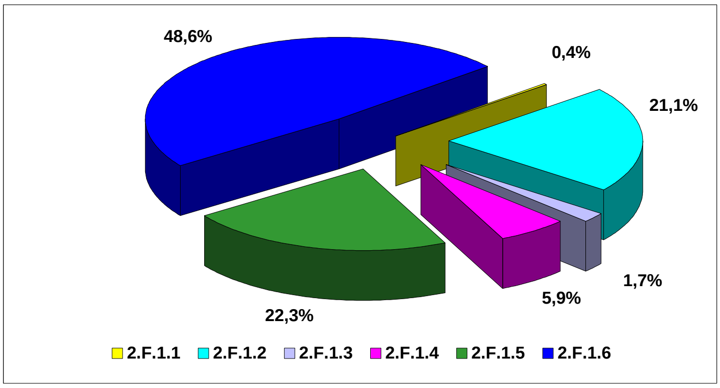
4.9.9 Source category description – Refrigeration and Air Conditioning Equipment (CRF 2.F.21)

The emissions originated from refrigeration and AC equipments represent more than 90% of emissions from 2.F category. Total actual emissions of HFCs were 415.28 Gg of CO_2 equivalents and they increased from the previous year by 4%, the potential emissions of HFCs were 794.04 Gg of CO_2 equivalents in 2011, they increased by 1% compared to the previous inventory year. The emissions of PFCs and SF_6 do not occur in this category. The following gases and subcategories are reported in this category 2.F.1:

- HFC-134a in 2.F.1.1 - Domestic refrigeration
- HFC-23, HFC-125, HFC-134a, HFC-143a and HFC-152a in 2.F.1.2 - Commercial refrigeration
- HFC-125, HFC-134a, HFC-143a and HFC-32 in 2.F.1.3 - Transport refrigeration
- HFC-32, HFC-125, HFC-134a and HFC-143a in 2.F.1.4 - Industrial refrigeration
- HFC-125, HFC-134a, HFC-143a and HFC-32 in 2.F.1.5 - Stationary AC
- HFC-134a in 2.F.1.6 - Mobile AC

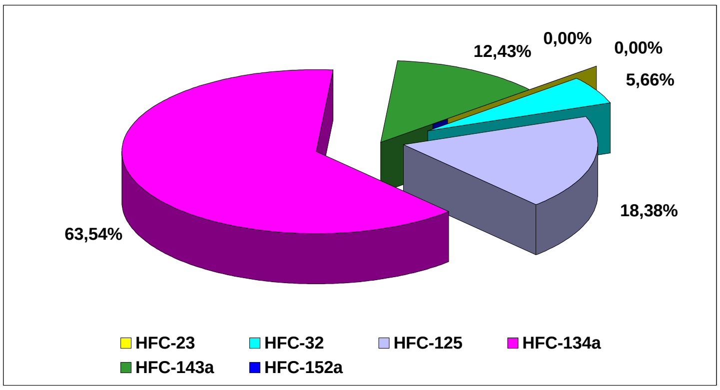
Up to the year 1998 the products designed for coolants R22, R134a and R404A were usually imported. Only in 1999 the indications of import of products containing coolants R407C and R410A are emerging. Because of the entry into force of the Act No. 76/1998 on the Protection of the Ozone Layer of the Earth on April 1, 1998, the year 1998 was the year of making the supplies of coolant R22. Consumption of alternative coolants R401A and R409A for R12 started to decrease in the year 2002. Coolants R407C and R410A shows the increase since 1999. Coolant R134a shows continuing increasing trend mainly because of rising import of cars with AC. After 2011 we can expect slight decrease of R134a consumption.

Figure 4.22: *The share of individual subcategories in 2.F.1 in 2011*



Category	F-gases (t)
2.F.1.1	0.84
2.F.1.2	46.46
2.F.1.3	3.77
2.F.1.4	13.06
2.F.1.5	49.14
2.F.1.6	106.89

Figure 4.23: *The share of individual gases consumption in 2.F.1 in 2011*



Category	F-gases (t)
HFC-23	0.001
HFC-32	12.462
HFC-125	40.455
HFC-134a	139.881
HFC-143a	27.355

In general, almost 50% of total F-gases emissions are allocated in the subcategory 2.F.6 – Mobile Air Conditioning (HFC-134a) in 2011(Figure 4.22). This is in agreement with the total HFC-134a consumption in the category 2.F.1 which is almost 64% (Figure 4.23). This is connected with the high share of automotive industry on Slovak economy in last years. About 20% shares of emissions are allocated in the subcategories 2.F.2 – Commercial Refrigeration and 2.F.5 – Stationary AC. Subcategory 2.F.1 – Domestic Refrigeration has the share below 1%.

The time series development of F-gases consumption in the category 2.F.1 is summarized in the Table 4.37 and on the Figure 4.24. The consumption of HFCs in refrigerants and AC equipments increased in the agreement with the increasing trend of GDP. Gradual substitution of HCFC coolants by HFC (HC) coolants, especially by coolant R134a or coolants R125 and R143a as components in mixtures of coolants R 404A, R407C, R410 and the CFCs is occurring.

Figure 4.24: *Time series development of the individual gases in the category 2.F.1 in 1995 – 2011*

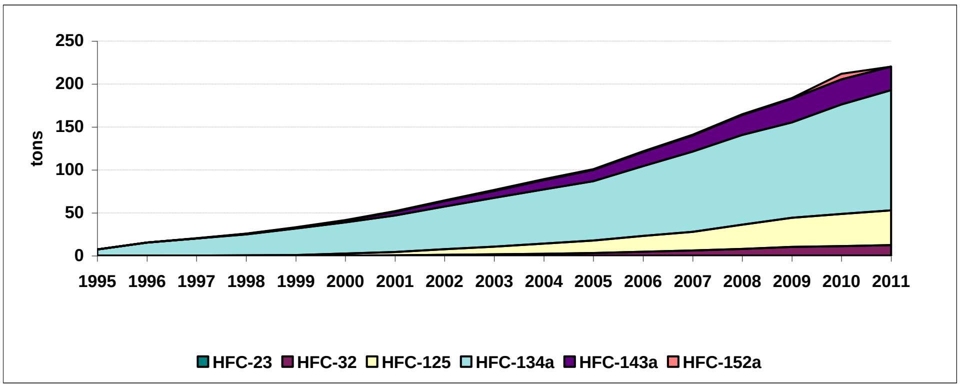


Table 4.37: *HFCs actual emissions according to the subcategories in 2.F.1 in 1990 – 2011*

Year	2.F.1.1 HFC-134a	2.F.1.2 HFC-23	HFC-125	HFC-134a	HFC-143a	HFC-152a
	(t)					
1990	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO
1995	NO	0.001	0.003	0.502	NO	NO
1996	NO	0.035	0.031	1.034	0.070	0.001
1997	NO	0.031	0.094	1.347	0.186	0.074
1998	0.050	0.032	0.280	1.650	0.451	0.282
1999	0.102	0.033	0.494	2.084	0.791	0.531
2000	0.132	0.034	1.242	2.449	1.908	0.666
2001	0.154	0.033	2.165	2.879	3.429	0.784
2002	0.163	0.034	3.653	3.351	5.310	0.893
2003	0.171	0.049	4.986	3.849	6.840	0.959
2004	0.174	0.052	6.541	4.277	9.087	1.022
2005	0.177	0.047	8.006	4.674	11.079	0.920
2006	1.446	0.050	10.228	5.391	14.027	0.828
2007	1.297	0.103	11.995	6.225	15.887	0.746
2008	1.163	0.103	15.585	6.961	19.386	0.890
2009	1.044	0.102	18.860	7.375	23.029	1.096
2010	0.936	0.059	20.833	7.261	24.744	6.674
2011	0.840	0.001	18.668	5.494	22.298	0.003

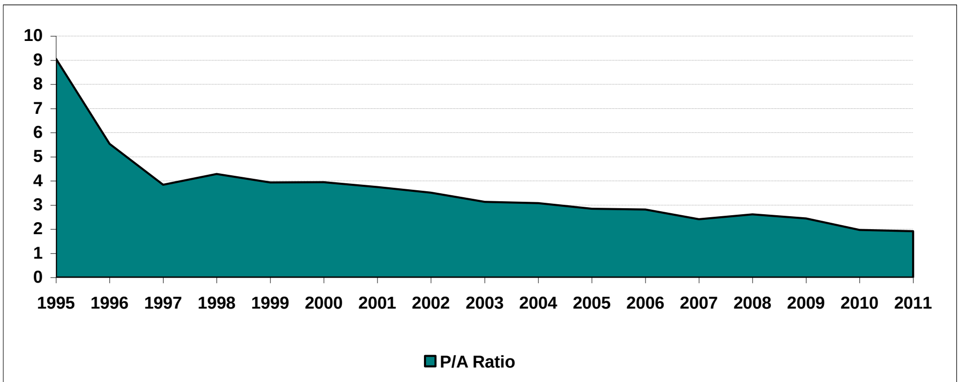
Year	2.F.1.3 HFC-125	HFC-134a	HFC-143a	HFC-32	2.F.1.4 HFC-32	HFC-125	HFC-134a	HFC-143a
	(t)							
1990	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO	NO
1995	0.000	0.195	NO	NO	NO	0.001	0.098	NO
1996	0.001	0.400	0.003	0.000	0.000	0.005	0.180	0.012
1997	0.003	0.520	0.007	0.002	0.001	0.016	0.221	0.031
1998	0.010	0.637	0.017	0.001	0.000	0.046	0.268	0.073
1999	0.018	0.804	0.029	0.002	0.001	0.078	0.337	0.123
2000	0.046	0.945	0.070	0.008	0.003	0.203	0.394	0.308
2001	0.079	1.111	0.125	0.014	0.005	0.342	0.463	0.537
2002	0.133	1.293	0.192	0.029	0.010	0.575	0.535	0.815
2003	0.179	1.485	0.246	0.046	0.016	0.764	0.613	1.018
2004	0.235	1.650	0.328	0.066	0.022	0.996	0.680	1.359
2005	0.287	1.803	0.398	0.092	0.031	1.205	0.740	1.632
2006	0.367	2.058	0.505	0.133	0.045	1.550	0.850	2.080
2007	0.428	2.350	0.569	0.176	0.059	1.792	0.978	2.303
2008	0.559	2.605	0.696	0.229	0.077	2.366	1.094	2.849
2009	0.673	2.731	0.824	0.293	0.098	2.830	1.162	3.366
2010	0.739	2.676	0.879	0.320	0.107	3.076	1.138	3.538
2011	0.696	2.240	0.831	NO	0.348	5.595	2.897	4.223

Year	2.F.1.5				2.F.1.6
	HFC-125	HFC-134a	HFC-143a	HFC-32	HFC-134a
	(t)				
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	0.002	1.602	NO	NO	5.102
1996	0.020	3.257	0.000	0.009	10.450
1997	0.060	4.218	0.000	0.054	13.585
1998	0.178	5.161	0.001	0.048	16.633
1999	0.311	6.515	0.001	0.072	21.004
2000	0.789	7.655	0.003	0.266	24.687
2001	1.362	8.996	0.006	0.481	29.013
2002	2.296	10.467	0.009	0.998	33.768
2003	3.112	12.018	0.012	1.548	38.778
2004	4.076	13.351	0.016	2.226	43.084
2005	4.974	14.584	0.019	3.090	47.077
2006	6.365	16.816	0.025	4.486	54.542
2007	7.437	19.411	0.028	5.936	63.262
2008	9.703	21.709	0.034	7.729	71.031
2009	11.707	23.003	0.040	9.864	75.592
2010	12.877	22.638	0.043	10.771	92.666
2011	15.497	21.523	0.003	12.114	106.888

The level of import in products has been increasing continually since 1995. The import of R134a in cars and comfort air conditioning systems up to 20 kW with the refrigerant R410A is influencing the trend in this category. Import of these products is expected to decrease because higher prices due to eco-design requirements.

The trend in P/A ratio in the category 2.F.1 is decreasing since 1995 (Figure 4.25). The ratio of potential and actual emissions or ratio of potential_{cum} and actual_{cum} emissions is declining. The actual emissions are raising nearly adequately to the cumulative amount of these HFCs substances in operating systems. The above analysis shows that in the year 2008 was reached faster application of HFCs because the HCFCs applications have been completely abandoned in new installations by the Act No 76/1998 Z.z. in version No 408/2000 Z.z. in the year 2004. Despite raising amounts of refrigerant consumption after 2009, the amounts of potential emissions are balanced after 2009 due to consumption of refrigerants with lower GWP.

Figure 4.25: *The ratio of potential and actual HFCs emissions in the category 2.F.1 in 1995 – 2011*



4.9.9.1 Activity data

Consumption data was obtained directly from the most important importers, retailers and service companies of refrigerants since 2009 through web reporting. Emissions from stocks were calculated equal to the amounts refilled as reported by the companies corrected by the amount sold on the market but not reported as new charge or emission. This leads to an implied product life factor that ranges between 9% and 17%.

4.9.9.2 Emission factors and other parameters

Individual data collected for calculation of HFC emissions from the subcategories of refrigeration and stationary air conditioning systems with the refrigerant models are used. Any refrigerant models used are described in connection with the relevant method. The emission factors are based on expert surveys or calculated (e.g. EF from stock can be calculated on the basis of the service refilling of existing installations). Disposal emissions in all subcategories first occurred in 2006.

4.9.9.3 2IIA.F.1.1 – Domestic refrigeration

The gas HFC-134a is used as refrigerant in refrigerators (fridges and freezers) for domestic use. HFC-134a as refrigerant was introduced at the end of 1995 as replacement of the gas CFC-12. Since 1999 it was gradually replaced by the gas R600a (isobutane). Import of refrigerators with the gas R134a was stopped by the end of 2007. Lifetime of domestic refrigeration equipment is calculated for 9-12 years. This is a conservative lifetime selected from the range given by the IPCC 2000 GPG, Table 3.22 (12-15 years). Since 2006 onwards emissions of HFC-134a remaining in products at decommissioning equal the amount of refrigerant in operating system (10%). Current HFCs emissions from household refrigerators and freezers from stocks are estimated on the level 0.3% per year with the agreement of the range given by the IPCC 2000 GPG (0.1-0.5%). The emissions from disposal were calculated with 21% disposal loss factor. This factor is based on the expert judgment with consideration of results of recycling factory in Slovenská Lupča using formula 3.43 and values given by the IPCC 2000 GPG in Table 3.22:

4.9.9.4 2IIA.F.1.2 – Commercial refrigeration

This sector includes emissions from manufacturing, assembly, installation of small refrigeration equipment mostly for export *("stand-alone" commercial application including also some equipment for domestic refrigeration*), emissions from refrigeration in Supermarkets and other Commercial Refrigeration.

Slovakia has one company manufacturing smaller "*stand-alone*" equipment for commercial and refrigeration (*fridges, freezers*) with HFC R-134a and R-404A as cooling agents. The equipments are mostly exported. Companies communicate their data on F-gases consumption through web reporter.

Emissions from commercial refrigeration manufacturing, assembly, installation are estimated to equal 1%. No detailed figure on the equipment installed 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.

The gases R-134a, R-402A, R-404A and R-507 are used as refrigerants in this particular subcategory. Refrigerants of less importance are R-407C, R-410A R-23, R-401A, R-402A R-417A and R-422D. Emissions from manufacturing, assembly, installation were estimated to equal 1%. Lifetime of supermarket refrigeration is calculated to be 9-12 years and emissions from disposal equal to 49%. Emissions from stocks were equal to the amounts refilled as reported by the companies. This leads to an implied product life factor that ranged between 10% and 15%.

The other commercial refrigeration is very heterogeneous and no detailed data on equipments installed is available. This sector can be considered the residual sector of 2.F.1 because it contains refrigeration in small and non-industrial commercial sectors (*inosculating with industrial refrigeration*), in the private and public service sector, and food trade other than supermarkets. Data on consumption for new systems and refilling were through import and retail figures, the stocks were calculated accordingly.

Except for EF disposal, the used emission factors are based on expert surveys and literature. The refrigeration filling systems produce only small emissions. Table 3.22 of the IPCC 2000 GPG gives a range 0.5-3% of the initial filling quantity. The country-specific EF is 1%. Ongoing HFC emissions from stationary refrigeration systems in the commercial refrigeration category vary widely in keeping with the type of system concerned. Refrigerant losses range from 1.5% for individual appliances (*except for those in food sales*) to 17% for old devices. Those values lie within the lower value ranges given in Table 3.22 (1 to 10% for individual appliances and 10 to 30% for commercial refrigeration systems).

The average stocks are obtained as a sum of final stocks of the previous year (t-1) and of the current year (t) minus emissions. Summation is carried out from the first year of application on. The new additions for a given year consist of the new domestic consumption for that year, minus production, assembly emissions and losses from removals. The pertinent number of equipment operators, and the types of refrigeration equipment (i.e. as sets) commonly involved, has been generally assessed by experts who have carried out direct surveys of equipment suppliers and users (Havelsky, Tomlein et al, 1993). The specification "average refrigeration fills, in kg per kW of refrigeration output" has been determined semi-empirically by experts, with the help of technical literature. Since 2009, these data are compared by web reporting.

4.9.9.5 2IIA.F.1.3 – Transport refrigeration

This group includes refrigerated road vehicles (*vans, trucks, trailers*). Recently, the most important refrigerants are R-404A and R-134a. Refrigerants of less importance: 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. Statistical data on refrigerated road vehicles are not available. Hence experts from the main furnishers of refrigeration units provided the relevant activity data (*stock data, refilling of the refrigeration units*). The lifetime of the equipment is estimated with 9 years and emissions from disposal equal 40%. Product life factor is estimated to equal in the range from 10 to 17%.

4.9.9.6 2IIA.F.1.4 – Industrial refrigeration

In this subcategory 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. The equipments are mostly not pre-manufactured but constructed on site. In contrast to commercial refrigeration, in the industrial sector not only HFC/HCFC refrigerants play the major role, but also NH_3. The refrigeration systems are normally served 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 equipments.

Emissions from manufacturing, assembly were estimated to equal 1%. Lifetime of industrial refrigeration equipments are calculated with 9 and 12 years and emissions from disposal are 49%. Emissions from stocks were set equal to the amounts refilled as reported by the companies. This leads to an implied product life factor that range between 8% and 16%.

4.9.9.7 2IIA.F.1.5 – Stationary Air Conditioning

This subcategory includes stationary air conditioning, room air conditioning and heat pumps. Stationary air conditioning includes large equipments >20 kW. Data on consumption for new systems and refilling are provided by service companies since 2009 through web reporting, the stocks are calculated accordingly.

Room AC systems include small mobile and compact equipments installed at windows or walls, fixed split- and multi-split systems up to 20 kW and larger Variable Refrigerant Flow (VRF) or Multi Air Conditioning systems. Small equipment, split- and multi-split systems and VRF systems are imported already charged with refrigerant and they are not manufactured within the country. Refrigerants used are R-407C and R-410A.

The installation of heat pumps with HFC started in Slovakia in 2004. The stock of equipment in 2011 was estimated to be in total more than 3 000 units. Heat pumps are manufactured in Slovakia too, but mostly imported. F-gases used here are R-134a, R-404A, R-407C and R-410A. In Slovakia the share of heat pumps for heating of water for domestic use is comparably small.

Emissions from manufacturing, assembly were estimated to equal 1%. Lifetime of air conditioning equipments and Heat pumps is calculated to be 12 years and emissions from disposal are 49%. Emissions from stocks were set equal to the amounts refilled as reported by the companies. This leads to an implied product life factor that ranges between 7% and 15%.

4.9.9.8 2IIA.F.1.6 – Mobile Air Conditioning

In Slovakia 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.

Web reporting is used for calculation of emissions since 2010. Before 2010 operating emissions were calculated as 10-15% from stocks, emissions from manufacturing as 1% and emissions from disposal with 49% assuming a life time of 9-12 years. For trucks, buses, railways, tramways and agricultural machines a similar model was used.

4.9.9.9 Source specific recalculations

Based on the recommendations provided during previous reviews, the complete recalculations were provided for the category 2.F.1 back to the year 1995. The recalculated emissions were distributed and reallocated into prescribed subcategories back to 1995 based on their distribution in the year 2010. The way of recalculation is described in details in Chapter 4.9.7 of this report. The new data are summarized in the Table 4.37. Previously reported data are not comparable with new estimation due newly estimated emissions from manufacturing, stock and disposal based on the IPCC 2000 GPG methodology.

4.9.9.10 Source specific planned improvements

The general planned improvement in F-gases category is described in the Chapters 4.9.7 and 4.9.8. The consistent way of operation the web electronic system will ensure consistency, completeness, transparency and accuracy of the reporting figures.

4.9.10 Source category description – Foam Blowing (CRF 2.F.2)

This category includes F-gases used in industry as follow:

- PUR foam appliances (transferred from blowing agent R141b directly to cyclopentane in 1998).
- Injected PUR foams in commercial cooling (started in 1999 and transferred from blowing agent R134a to water in 2007).

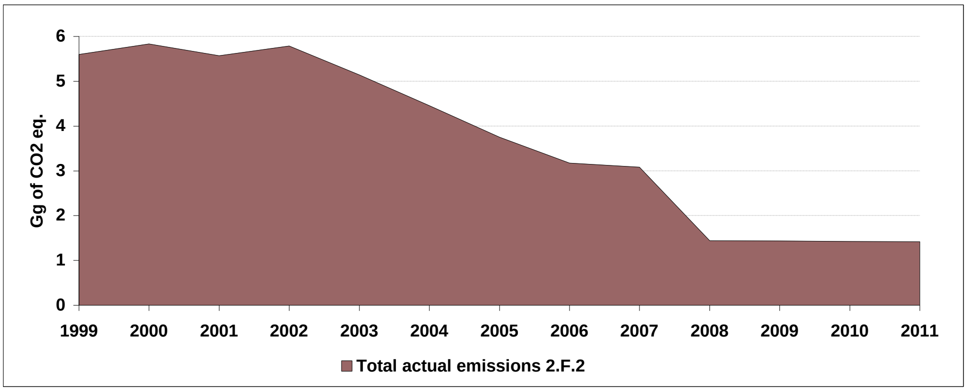
This blowing agent remains longer in foam; the half life time is calculated with >20 years and depends on the panel's thickness. HFC-134a emissions from stocks are calculated based on producers' information with a product life factor 0.5%. Emissions from assembly were equal to 10% according to the IPCC 2000 GPG default value for first year losses. Sprayed PUR foams for roofs (transferred directly from ODS to HFC245fa and 365mfc. Fluorinated gases HFC-245fa and HFC-365mfc are used in Slovakia since 2002. Big importers trade only with hydrocarbons panels and water blowing agents, smaller importers (in open market) imported from 1999 up to 2007 panels with R134a, which is only gas reported in this category. In the main application areas hard foam (rigid foam insulating panels, flexibly coated; rigidly faced sandwich panels) hydrocarbons are usually used as blowing agent. In the area of insulating foam for pipes HFC-245fa and HFC-365mfc cover a small share of the market whilst pentane is dominating. These gases are reported under category "Information on additional GHGs" and are not including into national totals. The consumption of gases in foam blowing category in Slovakia is the lowest comparable to neighboring countries. According to the findings of ERT in 2011 in-country review, the survey of national circumstances was done. The reporting of HFC134a was completed based on information from the BASF Company for the years 1999 to 2011. Emissions from stocks are calculated with a product life factor of 0.5%, based on information from producers. Emissions from assembly were firstly assumed to equal 7.5%, later corrected for whole time series to

10% according to the IPCC 2000 GPG default value for the first year of losses. Total actual emissions in this category were 1.42 Gg of CO_2 equivalents in 2011. Total potential emissions in this category were equal to the actual emissions. Time series since 1999 is presented in the following figure. Emissions before 1999 were not occurring in this category. Activity data and emissions of the category 2.F.2 are summarized in the following table. The additional GHG emissions of HFC-245fa and HFC-365mfc are summarized in the Table 9.1 of this report.

Table 4.38: *Activity data and HFC134a emissions in the category 2.F.2 in 1999 – 2011*

2.F.2.1 Hard Foam - HFC134a				
Year	new products	in operation	Actual emissions from manufacturing	Actual emissions from stock
	(t)			
1999	41.200	37.080	4.120	0.185
2000	41.200	73.975	4.120	0.370
2001	37.500	106.985	3.750	0.535
2002	37.500	140.200	3.750	0.701
2003	31.200	166.949	3.120	0.835
2004	24.900	187.894	2.490	0.939
2005	18.700	203.165	1.870	1.016
2006	13.700	213.979	1.370	1.070
2007	12.500	224.039	1.250	1.120
2008	NO	221.669	NO	1.108
2009	NO	220.560	NO	1.103
2010	NO	219.458	NO	1.097
2011	NO	218.360	NO	1.092

Figure 4.26: *Time series development of HFC134a emissions in the category 2.F.2 in 1999 – 2011*



4.9.10.1 Source specific QA/QC and verification

General description of QA/QC activities applied also in this category is included in the Chapter 4.9.5 of this report. The verification process is a part of the web based system introduced since 2010.

4.9.10.2 Uncertainties and time-series consistency

General description of uncertainties is included in the Chapter 4.9.6 of this report. The time series of the HFC134a used as hard foam is consistent since the year 1999. The reporting system is based on the same methodology, data collection and factors applied. New filling decreased since 1999 and ended in 2007, on the other hand gas in operating systems increased sharply until 2007 and after this year the trend is stable. This trend is observed also for emissions in this particular subcategory. The reason is in introducing new gases and continually decommissioning of old fillings.

4.9.10.3 Source specific recalculations

Brief summary of recalculations made in this subcategory are described in the Chapter 4.9.7 of this report. The major change was in using new conservative product manufacturing factor 10% and recalculated emissions since 1999 with using this factor. Emissions were estimated using equation providing in the Chapter 4.9.7. Gases HFC245fa and HFC365mfc used in the subcategory soft foams were reallocated into CRF table 9 and therefore are not included into national totals.

4.9.10.4 Source specific planned improvements

The general planned improvement in F-gases category is described in the Chapters 4.9.7 and 4.9.8. The consistent way of operation the web electronic system will ensure consistency, completeness, transparency and accuracy of the reporting figures.

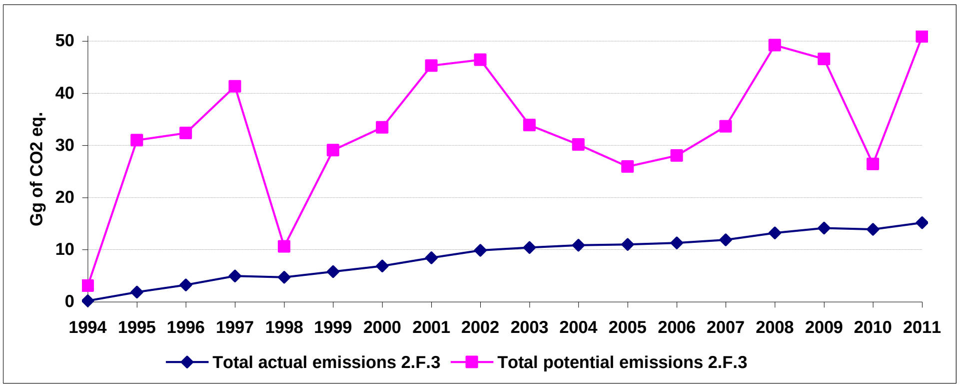
4.9.11 Source category description – Fire Extinguishing (CRF 2.F.3)

This category includes F-gases used in industry as follows:

- 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 stabile extinguishing equipment's since 2004. After 1993, halons are not imported into Slovakia.
- HFC 236fa (*FE36*) started to be used for transportable extinguishing equipment since the year 2000.
- PFCs extinguishing media are not imported to Slovakia. PFC 410 and PFC 614 have never been 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 HFC. HFC-227ea in fire extinguishers was first introduced to the Slovak market in 1994. F-gases for firefighting are imported in cylinders and filled in fixed installed systems. Detailed data on consumption for new equipment, the stock in existing fixed flooding systems, annual losses (refilling) and recovered F-gases for 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 to 12 years (given by producer). After this time extinguishing media are recovered, recycled and used again. No emissions from disposal are reported. In systems with working pressure 25, or 40 bar the lifetime of pressure vessels is supposed to be at least up to 25 years. HFC emissions occur from filling in fixed systems, from the bank (*in case of false alarm, fire, leakage, accidents etc.*) and from disposal. Test flooding, in former times an important source of emissions, did not take 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%. Both figures are in agreement with references and were consulted with the fire protection companies. Used emission factors are within the range provided in the IPCC 2006 GL, chapter 7.6.2.2 (p. 7.63) for installed flooding systems (up to 5% per year). Total actual emissions in this category were 15.19 Gg of CO_2 equivalents in 2011. Total potential emissions in this category were 50.98 Gg of CO_2 equivalents. Time series since 1994 is presented on the following figure. Before 1994 emissions in this category were not occurring.

Figure 4.27: *Time series development of actual and potential emissions in 2.F.3 in 1994 – 2011*



Activity data and emissions of the category 2.F.3 are summarized in the following table.

Table 4.39: *Activity data and emissions in the category 2.F.3 in 1994 – 2011*

Year	new products			in operation		
	HFC227ea	HFC134a	HFC236fa	HFC227ea	HFC134a	HFC236fa
	(t)					
1994	1.000	0.007	NO	0.990	0.007	NO
1995	10.050	NO	NO	10.890	0.007	NO
1996	10.050	NO	NO	20.295	0.006	NO
1997	12.540	NO	NO	31.695	0.006	NO
1998	2.040	NO	NO	32.130	0.006	NO
1999	8.025	NO	NO	38.468	0.005	NO
2000	8.000	NO	0.540	44.465	0.005	0.535
2001	8.000	NO	2.160	50.161	0.005	2.646
2002	4.400	NO	3.780	52.009	0.005	6.256
2003	3.320	NO	2.200	52.696	0.004	8.121
2004	1.228	NO	2.500	51.277	0.004	10.190
2005	0.302	NO	2.236	49.012	0.004	11.894
2006	1.088	NO	2.160	47.638	0.004	13.438
2007	1.000	NO	3.000	46.246	0.004	15.736
2008	1.000	NO	5.257	44.924	0.003	20.154
2009	3.971	NO	3.320	46.609	0.003	22.430
2010	2.550	NO	0.820	46.803	0.003	22.123
2011	11.440	NO	0.400	55.789	0.003	21.413
Year	**Actual emissions from manufacturing**			**Actual emissions from stock**		
	HFC227ea	**HFC134a**	**HFC236fa**	**HFC227ea**	**HFC134a**	**HFC236fa**
	(t)					
1994	0.010	0.00007	NO	0.050	0.00035	NO
1995	0.101	NO	NO	0.545	0.00033	NO
1996	0.101	NO	NO	1.015	0.00032	NO
1997	0.125	NO	NO	1.585	0.00030	NO
1998	0.020	NO	NO	1.606	0.00029	NO
1999	0.080	NO	NO	1.923	0.00027	NO
2000	0.080	NO	0.005	2.223	0.00026	0.027
2001	0.080	NO	0.022	2.508	0.00024	0.132
2002	0.044	NO	0.038	2.600	0.00023	0.313
2003	0.033	NO	0.022	2.635	0.00022	0.406
2004	0.012	NO	0.025	2.564	0.00021	0.510
2005	0.003	NO	0.022	2.451	0.00020	0.595
2006	0.011	NO	0.022	2.382	0.00019	0.672
2007	0.010	NO	0.030	2.312	0.00018	0.787
2008	0.010	NO	0.053	2.246	0.00017	1.008
2009	0.040	NO	0.033	2.330	0.00016	1.122
2010	0.026	NO	0.008	2.340	0.00015	1.106
2011	0.114	NO	0.004	2.789	0.00015	1.071

4.9.11.1 Source specific QA/QC and verification

General description of QA/QC activities applied also in this category is included in the Chapter 4.9.5 of this report. The verification process is a part of the web based system introduced since 2010.

4.9.11.2 Uncertainties and time-series consistency

General description of uncertainties is included in the Chapter 4.9.6 of this report. The time series of the F-gases used as fire extinguishers is consistent since the year 1994. The reporting system is based on the same methodology, data collection and factors applied. Trend in actual emissions from HFC227ea and HFC236fa is increasing and is influencing with the trade demand. Trend of new fillings is fluctuating. Trend in total actual emissions is increasing since 1994. Trend in potential emissions is fluctuating and influenced by the economical activities in this area. The purchase of new fire extinguishers depends mostly on the building of new server rooms.

4.9.11.3 Source specific recalculations

Brief summary of recalculations made in this subcategory are described in the Chapter 4.9.7 of this report. Emissions were estimated using equation provided in the Chapter 4.9.7.

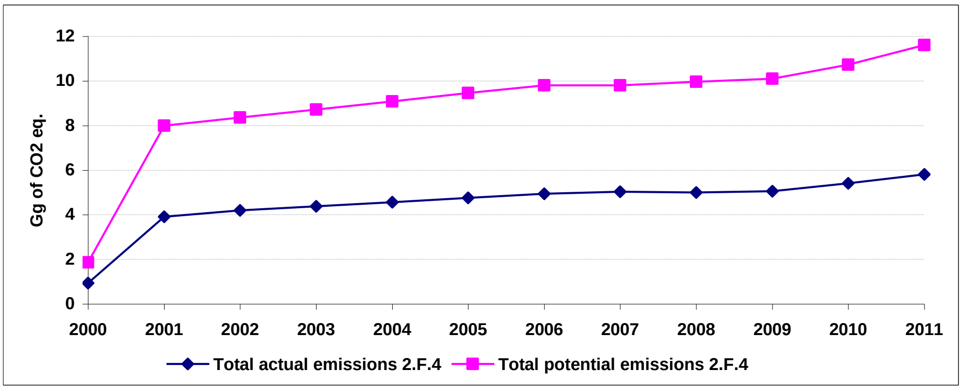
4.9.11.4 Source specific planned improvements

The general planned improvement in F-gases category is described in the Chapters 4.9.7 and 4.9.8. System of import F-gases in the bulk and products is in place via the web electronic system. There are no further principal improvements planned in this activity. The information on fillings and recycling 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. The Association is obliged to provide information to the SZCHKT from all members. Incorporation of this data source directly into the web electronic database will be task for future activities of the Ministry of Environment in this area.

4.9.12 Source category description – Aerosols/Metered Dose inhalers (CRF 2.F.4)

The group of aerosol gases includes medical aerosols, i.e. Metered Dose Inhalers (MDIs). The HFC-134a and HFC227ea are used as propellant for such aerosols in Slovakia. As the consumption of the product follows in general the purchase immediately, annual stock and annual emissions are equal. Emissions from manufacturing are not occurring and emissions from stock are calculated using product life factor = 100% during 2 years. In 1990, producers of aerosols in Slovakia changed directly from ODS to mechanical principles and use of hydrocarbons and dimethylether. The HFCs gases used in this activity were only imported as MDIs and were not reported up to 2010 in the previous submissions. Based on the recommendations of the ERT during and after 2011 in-country review, revision of the national circumstances and inventory of available sources were performed. The State Institute for Drug Control of Slovakia was in the position to provide to the NIS SR the number of containers with aerosols imported to Slovakia. Data are available since 2000 and based on the statement of the experts of the State Institute for Drug Control, no MDIs were imported to Slovakia before this year. First approach on reported charge per container was set on the basis of expert estimates and was reviewed afterwards. The recalculation was made according to the chosen cluster of countries with similar circumstances for the whole time series. This approach was proposed by the ERT and can be found in the previous reports (ARR2011 and answers to the Saturday Paper 2011). Extreme values of the countries like Poland or Czech Republic were removed from the average. These countries have production of containers with aerosols and therefore they represent statistical outliers that are inappropriate for Slovakia (no production). The average value of the charge per container was calculated 1.36 GgCO_2/inhabitant. Total actual emissions in this category were 5.81 Gg of CO_2 equivalents in 2011. Total potential emissions in this category were 0.02 Gg of CO_2 equivalents. Time series for actual emissions since 2000 and time series for potential emissions since 2008 are presented on the following figure. Before 2000 emissions in this category were not occurring.

Figure 4.28: *Time series development of actual and potential emissions in 2.F.4 in 2000 – 2011*



Activity data and emissions of the category 2.F.4 are summarized in the following table.

Table 4.40: *Activity data and emissions in the category 2.F.4 in 2000 – 2011*

Year	new products		in operation		Actual emissions from stock	
	HFC227ea	HFC134a	HFC227ea	HFC134a	HFC227ea	HFC134a
	(t)					
2000	NO	3.730	NO	1.865	NO	0.933
2001	NO	4.100	NO	2.050	NO	3.915
2002	NO	4.290	NO	2.145	NO	4.195
2003	NO	4.470	NO	2.235	NO	4.380
2004	NO	4.660	NO	2.330	NO	4.565
2005	NO	4.850	NO	2.425	NO	4.755
2006	NO	5.030	NO	2.515	NO	4.940
2007	NO	5.030	NO	2.515	NO	5.030
2008	0.042	4.978	0.020	2.490	0.010	5.000
2009	0.025	5.148	0.013	2.570	0.030	5.060
2010	0.025	5.671	0.013	2.840	0.030	5.410
2011	0.019	5.945	0.099	2.970	0.020	5.810

4.9.12.1 Source specific QA/QC and verification

General description of QA/QC activities applied also in this category is included in the Chapter 4.9.5 of this report. The verification process is a part of the web based system introduced since 2010.

4.9.12.2 Uncertainties and time-series consistency

General description of uncertainties is included in the Chapter 4.9.6 of this report. The time series of the F-gases used as MDI is consistent since the year 2000. The reporting system is based on the same methodology, data collection and factors applied. Trend in actual emissions from HFC227ea and HFC134a is increasing and is influencing with the trade demand. Trend in total actual and potential emissions is increasing which was caused by the introducing HFC134a since 2001 (substitution for R12).

4.9.12.3 Source specific recalculations

Brief summary of recalculations made in this subcategory are described in the Chapter 4.9.7 of this report.

4.9.12.4 Source specific planned improvements

The general planned improvement in F-gases category is described in the Chapters 4.9.7 and 4.9.8. The information on the MDI is realized with the cooperation of the State Institute for Drug Control (http://www.sukl.sk/en?page_id=256) based on the Act No 286/2010 Coll. The Institute is obliged to provide information to the SZCHKT from MDI users. Incorporation of this data source directly into the web electronic database will be task for future activities of the Ministry of Environment and the Slovak Environmental Inspection in this area.

4.9.13 Source category description – Solvents (CRF 2.F.5)

Emissions in this category are not occurring for the time series 1990 – 2011.

There is no import of F-solvents to Slovakia because they are rather expensive. SP-255, which contains distilled oil and methylacetate, is used as a flushing material. Slovakia uses solvents L113 and S316 which are not obliged to include in the inventory. HFCs as solvents are not used in cleaning machines for flushing refrigeration circuits.

PFC14 use in solvents was replaced with SF_6 in 2007. Due to technological results no PFC or SF_6 emissions are occurring from this source in 2011. Used amounts are very low up to 0.2 t. PFC14 actual and potential emissions from the solvents use are reported for the period 1997 – 2005, potential emissions are allocated in the category 2.P.

Table 4.41: *Actual and potential PFC14 emissions in the category 2.F.5 in 1997 – 2005*

PFC14/Year	1997	1998	1999	2000	2001	2002	2003	2004	2005
Actual emissions in t	0.184	0.426	0.347	0.037	0.640	0.360	0.120	0.090	0.030
Potential emissions in Gg of CO_2 *eq.*	1.196	2.808	2.275	0.239	4.160	2.340	0.780	0.585	0.195

In the production process, 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 byproducts go into special washing tank with NaOH where HF is neutralized.

According to 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.

4.9.14 Source category description – Other applications using ODS substitutes (CRF 2.F.6)

Emissions in this category are not occurring for the time series 1990 – 2011.

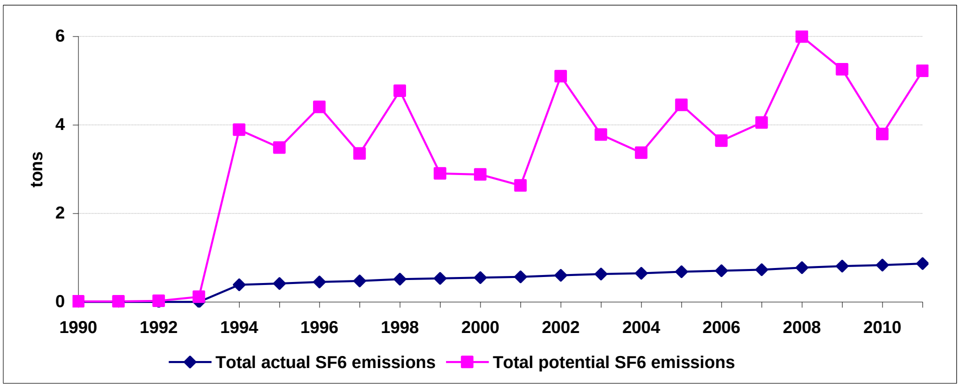
4.9.15 Source category description – Semiconductor Manufacture (CRF 2.F.7)

Emissions in this category are not occurring for the time series 1990 – 2011.

4.9.16 Source category description – Electrical Equipment (CRF 2.F.7)

Emissions of SF_6 from the thermal insulation of windows and from the high voltage switchgears are reported in this category. Total actual emissions of SF_6 were 0.87 t and total potential emissions were 5.22 t in 2011. Emissions were estimated based on total SF_6 emissions used in the Slovak Reporting. Trend of actual and potential emissions since 1990 is presented on the following figure.

Figure 4.29: *Time series development of actual and potential SF_6 emissions in the category 2.F.8 in 1990 – 2011*



The lifetime of SF_6 in atmosphere is up to 3 200 years. GWP (*at lifetime 100 years*) is 23 900 kg CO_2/kg. This gas is 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 in the Slovak industry. Shoes and tires with F-gas cushions are not manufactured or imported to Slovakia. Most of its use is as insulation media in high and low voltage electric equipments because of higher safety level and reducing dimension. Use in the surface treatment of metals is not occurring. 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 medium-voltage GIS (MV GIS). These operate with lower overpressure and small gas quantities of only some kg/system. They are already charged with SF_6 when imported and are hermetically closed ("sealed for life"). Both categories of equipment have lifetimes of 30 years. Up to thousands kg of SF_6 can be in one interrupter of high voltage. The EF of HV- and MV-GIS corresponds to the default emission factors of the IPCC 2006 GL. The product life factor is 1%. Highly toxic products originate at temperatures over 400 °C. Alternatives at low voltage are vacuum and air. Novec™612 (fluorinated ketone) ($C_3F_7C(O)C_2F_5$) is in development.

Company Nitrasklo Ltd. used SF_6 since 1994 for anti-noise and thermal isolation into windows. It was mixed with argon in rate 30:70 thus its consumption is decreased, production is more cost-effective. It was filled in close cycles without emissions from production Consumption of SF_6 in Nitrasklo Ltd. was decreasing and was phased out in the year 2002. Amount stored in windows in the Slovak Republic was 10 kg yearly from 80 kg filled into windows yearly (70 kg were exported in windows). SF_6 was used as isolating gas in windows till the end of 2004. Emissions are calculated together with isolating gas in high voltage switchers. For the stock of gas remaining inside, an annual leakage rate is 1%.

Isolating gas in high voltage switchgears is used by the electricity company Slovenské elektrárne with supposed release 1% of amount on stock per year. Filling is dimension for 30 years without refilling. SF_6 as isolation gas in HV circuit breakers is reported in Slovakia since 1990.

Activity data and emissions of the category 2.F.8 are summarized in the following table.

Table 4.42: *Activity data and SF_6 emissions in the category 2.F.8 in 1990 – 2011*

Year	new products	in operation	Actual emissions from stock
	(t) of SF_6		
1990	0.128	0.130	0.001
1991	0.011	0.140	0.001
1992	0.023	0.161	0.002
1993	0.115	0.275	0.003
1994	38.509	38.781	0.388
1995	3.069	41.462	0.415
1996	3.955	45.003	0.450
1997	2.880	47.432	0.474
1998	4.254	51.212	0.512
1999	2.372	53.072	0.531
2000	2.331	54.872	0.549
2001	2.069	56.393	0.564
2002	4.494	60.323	0.603
2003	3.153	62.872	0.629
2004	2.719	64.963	0.650
2005	3.770	68.083	0.681
2006	2.941	70.343	0.703
2007	3.323	72.963	0.730
2008	5.220	77.453	0.775
2009	4.445	81.124	0.811
2010	2.961	83.273	0.833
2011	4.354	86.795	0.868

4.9.16.1 Source specific QA/QC and verification

General description of QA/QC activities applied also in this category is included in the Chapter 4.9.5 of this report. The verification process is a part of the web based system introduced since 2010.

4.9.16.2 Uncertainties and time-series consistency

General description of uncertainties is included in the Chapter 4.9.6 of this report. The time series of SF_6 used in this category is consistent since the year 1990. The reporting system is based on the same methodology, data collection and factors applied. Trend in actual SF_6 emissions is influencing by the start of windows production in the company Nitrasklo Ltd. in 1994. Since this year the consumption of SF_6 is increasing continually. Trend in potential SF_6 emissions is influenced by the economic activities.

4.9.16.3 Source specific recalculations

Brief summary of recalculations made in this subcategory are described in the Chapter 4.9.7 of this report.

4.9.16.4 Source specific planned improvements

The general planned improvement in F-gases category is described in the Chapters 4.9.7 and 4.9.8. The consistent way of operation of the web electronic system will ensure consistency, completeness, transparency and accuracy of the reporting figures.

4.9.17 Source category description – Other (CRF 2.F.8)

Emissions in this category are not occurring for the time series 1990 – 2011.

4.10 Consumption of halocarbons and SF_6 potential emissions (CRF 2.F.P)

The method of estimation of potential emissions assumes that the emissions occur during the year in which the chemical is produced or sold into a particular end-use sector. Conditions for the evaluation of retrospective and perspective of the trend of consumption of HFC were thus prepared using the total sums of purchased and cumulated CFC, HCFC and HFC coolants. Total potential emissions of F-gases from industry sector are from the import in bulk. In 2011, the potential emissions of HFCs from the consumption were 856.54 Gg of CO_2 equivalents and no emissions of PFCs. Total potential emissions of SF_6 were 5.22 t. Potential emissions of HFCs gases are estimated based on the subcategories of the 2.F category and summarized according to the gases. Potential emissions of HFCs – hydrofluorocarbons (23, 32, 125, 134a, 152a, 143a, 227ea, 236fa) and SF_6 – sulphur hexafluoride are reported in this category. Potential PFC14 emissions were reported in this category for the period 1997 – 2005 (Table 4.41). Time series of HFCs and SF_6 potential emissions according to the individual gases reported as imported in bulk is presented in the following figure and table.

Figure 4.30: *Time series development of HFCs potential emissions in the category 2.P in 1994 – 2011*

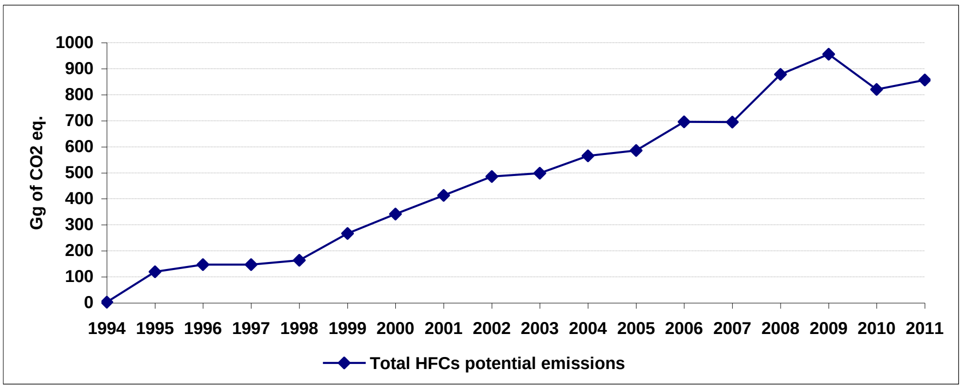


Table 4.43: *Potential emissions of HFCs and SF_6 in the category 2F.P2.1 2.P in 1990 – 2011*

Year	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-152a	HFC-143a	HFC-227ea	HFC-236fa	HFCs total	SF_6
	(t)								Gg of CO_2 eq.	(t)
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.01
1991	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.01
1992	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.02
1993	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.12
1994	NO	NO	NO	0.01	NO	NO	1.06	NO	3.08	3.89
1995	0.00	NO	0.06	68.00	NO	NO	10.70	NO	119.57	3.48
1996	0.04	0.10	0.44	85.32	0.00	0.70	11.17	NO	147.66	4.41
1997	0.03	0.54	1.12	74.84	0.07	1.36	14.25	NO	147.62	3.35
1998	0.03	0.11	3.21	101.12	0.28	3.14	3.67	NO	163.52	4.77
1999	0.03	0.37	4.20	160.32	0.53	4.36	10.03	NO	266.56	2.90
2000	0.03	2.30	12.98	169.79	0.67	12.76	10.30	0.57	341.02	2.88
2001	0.03	3.09	18.18	185.96	0.78	19.27	10.59	2.31	413.64	2.63
2002	0.03	6.89	29.74	194.05	0.89	26.10	7.04	4.13	486.15	5.10
2003	0.05	8.60	32.30	205.47	0.96	26.64	5.99	2.63	499.00	3.78
2004	0.05	11.21	39.85	212.21	1.02	36.79	3.80	3.03	565.43	3.37
2005	0.05	14.81	43.47	215.01	0.92	39.13	2.76	2.85	586.19	4.45
2006	0.05	22.66	59.51	219.72	0.83	52.64	3.48	2.85	695.76	3.64
2007	0.06	26.55	59.61	226.61	0.74	47.72	3.32	3.82	694.63	4.05
2008	0.06	33.02	92.07	226.88	2.19	66.77	3.27	6.32	878.22	5.99
2009	0.05	41.33	97.61	249.88	1.17	74.59	6.42	4.47	956.03	5.26
2010	0.01	32.38	86.93	226.86	6.04	61.55	4.98	1.93	820.79	3.79
2011	0.00	35.88	88.19	252.56	0.00	54.41	14.44	1.47	856.54	5.22

4.10.1 Methodological issues – methods

Potential emissions are estimated in consistency with the actual emission estimation. The web electronic database is used since 2009 (see also data flow on Figure 4.20). Potential emissions are estimated based on simplified scheme Production + Import – Export – Decommissioning. More information was provided in the Chapter 4.9.4 of this report.

4.10.2 Methodological issues – emission factors and other parameters

Summarized amounts of mixtures imported in bulks and products are followed by the conversion of mixtures to the single substances. The results have been evaluated since 1990 and summarized for the actual inventory year.

4.10.3 Activity data

The same activity data was used as described in the Chapter 4.9.2 of this report.

4.10.4 Uncertainties and time-series consistency

General description of uncertainties is included in the Chapter 4.9.6 of this report.

4.10.5 Source specific QA/QC and verification

General description of QA/QC activities applied also in this category is included in the Chapter 4.9.5 of this report. The verification process is a part of the web based system introduced since 2010.

4.10.6 Source specific recalculations

Brief summary of recalculations made in this subcategory are described in the Chapter 4.9.7 of this report.

4.10.7 Source specific planned improvements

There are no further planned improvements in this category.

4.11 Other (CRF 2.G)

No emissions are included in the category 2.G Other in the Slovak Republic in 1990 – 2011.

CHAPTER 5: SOLVENT AND OTHER PRODUCTS USE (CRF 3)

5.1 Overview of sector (CRF 3)

This category includes the emissions of CO_2, N_2O and NMVOC (photochemical smog) from solvent and other product use according to the national methodology. In 2013 submission, the primary attention regarding the inventory was put on CO_2 emissions calculation in the categories 3.A and 3.B and N_2O emissions in the category 3.D. It should be noted, that CO_2 emissions represent only potential emissions which originate from the oxidation of NMVOC emissions. The most important issue was collection of all available inputs of solvents used in industry. The official statistical information in this area was insufficient, so it was decided to request directly the producers, importers, distributors and users of solvents and other products. This inventory was prepared in the streamlining process with the CLRTAP inventory preparation.

Total NMVOC emissions from solvent and other products use were estimated in the frame of the National Program for Emission Reduction of Non-Methane Volatile Organic Compounds in the Slovak Republic.

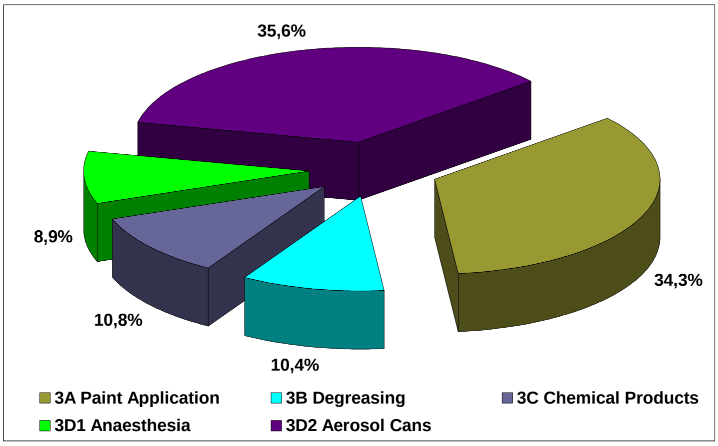
Total GHG emissions in this sector were 170.54 Gg of CO_2 equivalents in 2011. Emissions increased by almost 4% in the comparison with previous year (2010) and increased by almost 16% in the comparison with the base year. This increase was caused by the increase in N_2O fugitive emissions used in medicine and food industry. Total NMVOC emissions were 36.897 kt and SO_2 emissions were 7 grams in 2011. Following Table 5.1 summarized CO_2, N_2O and NMVOC emissions in the particular categories within the sector.

Table 5.1: *GHG emissions in individual categories in the solvent use sector in 1990 – 2011*

Year	Total NMVOC	Total CO_2			Total N_2O	
		3.A Paint Application	3.B Degreasing	3.C Chemical Products	3.D.1 Anaesthesia	3.D.2 Aerosol Cans
	(Gg)					
1990	52.8746	94.4398	17.5544	18.1105	0.0550	NO
1991	36.0000	77.7141	13.7382	18.1410	0.0550	NO
1992	29.5000	63.3225	11.4485	18.1753	0.0550	NO
1993	34.9653	55.6922	10.7083	18.1958	0.0550	NO
1994	27.7000	58.1415	9.7614	18.2435	0.0542	NO
1995	37.0661	59.5433	12.6912	18.3049	0.1000	NO
1996	33.7997	55.0388	8.8991	18.3424	0.1072	NO
1997	29.2943	45.0553	7.2742	18.3731	0.0868	NO
1998	30.1764	46.1538	8.7253	18.3901	0.0683	NO
1999	28.4143	41.3469	8.8746	18.4094	0.0706	NO
2000	26.9782	38.0339	8.4501	18.4227	0.0650	NO
2001	28.7247	40.3683	11.0628	18.3422	0.0810	0.0157
2002	31.0199	43.4912	12.8260	18.3429	0.0762	0.1085
2003	32.2721	47.1150	12.6351	18.3460	0.0733	0.1178
2004	32.7597	53.1247	11.7148	18.3622	0.0706	0.1884
2005	33.5612	54.4514	12.3650	18.3771	0.0656	0.2129
2006	34.6342	56.1531	13.6149	18.3923	0.0598	0.2061
2007	33.5792	57.7098	10.1701	18.4173	0.0609	0.1970
2008	33.7841	58.5344	10.6761	18.4567	0.0522	0.2024
2009	33.3316	59.0474	9.4419	18.4990	0.0476	0.2020
2010	31.8599	58.8830	6.1446	18.5343	0.0528	0.2078
2011	36.8971	58.5800	17.6819	18.4287	0.0490	0.1957

The major share (36%) in sector solvent use is represented by N_2O emissions from aerosol cans used in food industry. The second large share (34%) belongs to CO_2 emissions in paint application, 11% share represent CO_2 emissions chemical products, 10% share represent CO_2 emissions from degreasing in industry and 9% N_2O emissions used in pharmacology.

Figure 5.1: *The share of individual categories of sector 3 in CO_2 emissions eq. in 2011*



Category	CO_2 eq. (Gg)
3.A Paint Application	58.58
3.B Degreasing	17.68
3.C Chemical Products	18.43
3.D.1 Anaesthesia	15.19
3.D.2 Aerosol Cans	60.67

5.2 Uncertainties and time-series consistency

Consistent methodology and tier method was used for the whole time series. To ensure the time series consistency in 3A category Paint, different aggregation of data (before and after 2006) was handled by the Overlap method as described in Chapter 7 of the IPCC 2000 GPG.

Content of carbon in NMVOC emissions was used for the uncertainty analyses in the sector solvent and other products use according to the individual categories. The emission factors and uncertainty for both AD and EF (in formula represented by symbol Δ) were used for uncertainty estimation. The uncertainty of CO_2 emissions (in equivalents) is in interval (-19.50%; +19.85%). Formula can be written in the following form:

$$\text{Emission} = \sum_{I} (\text{NMVOC} \pm \Delta\text{NMVOC}) * (\text{content of C} \pm \Delta\_\text{content of C}) * \frac{44}{12} + \\ + \sum_{I} (\text{constant} * (\text{N2O} \pm \Delta\text{N2O}))$$

First row of formula is related to CO_2 emissions, second row is related to N_2O emissions in CO_2 equivalent. The accumulated uncertainty and statistical characteristics for solvent are presented in 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 the sector 3 obtained by the Monte Carlo simulation is 170.6 kt per year. The average mean value is comparable with the real CO_2 emissions in equivalents in this category, which is 170.5 kt.

Figure 5.2: *Probability density function for sector Solvent use in t of CO_2 equivalents*

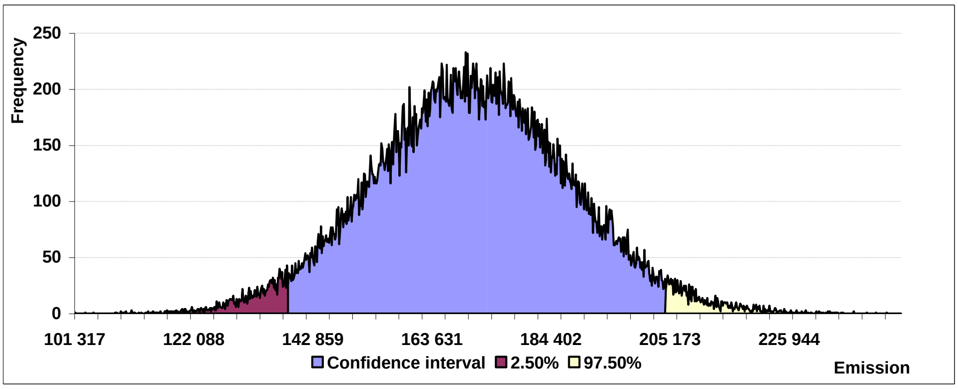


Table 5.2: *Selected statistical characteristics for sector 3, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2 equivalents)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
170 470.182	**170 592.985**	170 14.014	101 316.788	245 561.754	-19.50%	19.85%

5.3 Source specific QA/QC and verification

Due to the lack of appropriate statistical information and methodological advises in the sector of solvents use, inputs were taken directly from questionnaires sent to operators and producers of solvents in the Slovak Republic. The first preliminary data related to the production and the quality of products for the previous year in the Slovak Republic will be available at the beginning of October. These data are used for the emissions estimation and are verified in the cooperation of sectoral expert, the Slovak University of Technology in Bratislava, the Faculty of Chemical and Food Technology and the Slovak Union of Paint Producers. The emission inventory is prepared in the consistency with the emission inventory of the Industrial Processes sector, so the sector specific QA/QC activities are streamlined as it is described in the Chapter 4.2.

5.4 Source specific recalculations

No recalculations were provided in the submission 2013 focused on the base year 1990 or the other inventory years.

5.5 Source specific planned improvements

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

5.6 Paint application (CRF 3.A)

The CO_2 emissions estimation is based on the NMVOC emissions in this category. The indirect (potential) CO_2 emissions from paint application were calculated since the base year 1990 (Table 5.1). Thorough survey of the used solvents was done 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 contents of carbon in each class are summarized in Table 5.3. In the later period (2006 – 2011) the more detailed information was available and the appropriate carbon contents are listed in Table 5.4. The carbon contents were verified by the Overlap method described in Chapter 7 of the IPCC 2000 GPG. The results of NMVOC and CO_2 emissions estimated are summarized in Tables 5.5 and 5.6. Total CO_2 emissions in the category paint application were 58.58 Gg and total NMVOC emissions were 20.25 kt in this category. Activity data in this category represents the amount of used paints and glues.

Table 5.3: *The carbon contents in solvent classes for the 3.A category 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	0.6

Table 5.4: *The carbon contents in solvent classes for the 3.A category in 2006 – 2011*

Solvent	**Solvent Naphtha**	**Xylene**	**Toluene**	**Styrene**	**Ethyl-acetate**	**Butyl-acetate**	**Methyl-acetate**	**Metoxy-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

Table 5.5: *NMVOC and CO_2 emissions (in t) in 3.A category in 1990 – 2005*

Year	Activity Data	NMVOC emissions (t)							
		Solvent naphtha	Aromatics	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
1991	56 907	9 801.00	8 370.00	5 130.00	2 295.00	999.00	54.00	216.00	135.00
1992	56 907	7 986.00	6 820.00	4 180.00	1 870.00	814.00	44.00	176.00	110.00
1993	35 306	7 023.70	5 998.20	3 676.30	1 644.70	715.90	38.70	154.80	96.70
1994	36 306	7 332.60	6 262.00	3 838.00	1 717.00	747.40	40.40	161.60	101.00
1995	38 462	7 509.40	6 413.00	3 930.50	1 758.40	765.40	41.40	165.50	103.40
1996	35 406	6 941.30	5 927.80	3 633.20	1 625.40	707.50	38.20	153.00	95.60
1997	31 122	5 682.20	4 852.60	2 974.10	1 330.50	579.20	31.30	125.20	78.30
1998	28 951	5 820.70	4 970.90	3 046.70	1 363.00	593.30	32.10	128.30	80.20
1999	24 937	5 214.50	4 453.20	2 729.40	1 221.00	531.50	28.70	114.90	71.80
2000	24 642	4 796.70	4 096.30	2 510.70	1 123.20	488.90	26.40	105.70	66.10
2001	25 356	5 091.10	4 347.80	2 664.80	1 192.10	518.90	28.10	112.20	70.10
2002	26 971	5 484.90	4 684.10	2 870.90	1 284.40	559.10	30.20	120.90	75.60
2003	29 533	5 941.90	5 074.40	3 110.10	1 391.40	605.70	32.70	131.00	81.80
2004	32 612	6 699.90	5 721.70	3 506.80	1 568.80	682.90	36.90	147.70	92.30
2005	34 064	6 867.20	5 864.60	3 594.40	1 608.00	700.00	37.80	151.30	94.60

Table 5.6: *NMVOC and CO_2 emissions (in t) in 3.A category in 2006 – 2011*

Year		2006	2007	2008	2009	2010	2011
Activity data		35 562	36 405	36 690	36 805	36 830	36 930
NMVOC emissions (t)	**Total**	**19 522**	**20 003**	**20 205**	**20 367**	**20 279**	**20 251**
	Solvent Naphtha	7 223	7 232	7 183	7 386	7 383	7 391
	Xylene	2 310	2 774	2 889	2 817	2 840	2 588
	Toluene	2 789	2 725	2 987	3 035	3 028	3 036
	Styrene	872	849	825	816	810	801
	Ethyl acetate	1 110	1 131	1 122	1 144	1 131	1 122
	Butyl acetate	2 135	2 155	2 185	2 110	2 100	2 117
	Methyl acetate	262	243	230	236	237	233
	Metoxypropylacetate	192	201	168	121	104	106
	Ethyl alcohol	696	917	919	929	928	926
	Butyl alcohol	310	232	250	307	262	466
	Isopropanol	193	185	148	154	148	151
	Isobutanol	426	410	388	394	407	404
	Acetone	702	741	760	763	769	774
	Dichloromethane	39	39	31	34	22	25
	Cyclohexane	164	42	45	46	45	46
	Others	99	127	75	75	65	65
CO_2 emissions (t)		**56 153.1**	**57 709.8**	**58 534.4**	**59 047.4**	**58 883.0**	**58 580.0**

5.7 Degreasing and Dry Cleaning (CRF 3.B)

The indirect (potential) CO_2 emissions from degreasing and dry cleaning have been estimated since the base year 1990 (Table 5.1). The calculation of the CO_2 emissions is based on the NMVOC emissions. In this category the solvents are divided into 4 classes. The carbon contents are summarized in Table 5.7. NMVOC and CO_2 emissions are listed in Table 5.8. NMVOC emissions from degreasing and dry cleaning use in industry and services were 8.1 kt and CO_2 emissions were estimated to be 17.68 Gg in 2011. The interannual increase is caused by significantly higher import of acetone to Slovakia. Activity data in this category are direct volume of used solvents; therefore "NA" notation key was used in the inventory.

Table 5.7: *Carbon contents in solvent classes for the 3.B category since 1990*

Solvent	Trichloroethylene	Tetrachloroethylene	Acetone	Isopropanol
Carbon Content	0.183	0.145	0.620	0.600

Table 5.8: *NMVOC and CO_2 emissions in solvent classes for the 3.B category since 1990*

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

5.8 Chemical Products, Manufactured and Processing (CRF 3.C)

The indirect (potential) CO_2 emissions from chemical products, manufactured and processing have been estimated since the base year 1990 (Table 5.1). The calculation of the CO_2 emissions is based on the NMVOC emissions. The NMVOC emissions from chemical products, manufactured and processing were 8.38 kt. The EF for NMVOC is based on number of inhabitants (5 435 273) in accordance with the applied EMEP/CORINAIR methodology. It was assumed that the average content of carbon in solvents was 60% and CO_2 emissions were estimated to be 18.43 Gg in 2011.

5.9 Other (CRF 3.D) (3.D.1 Use of N_2O for Anaesthesia, 3.D.3 N_2O from Aerosol Cans)

N_2O emissions in the sector solvent and other product use are estimated in the medicine (anaesthesia) and food industry (aerosol cans). There is also the consumption of N_2O for analytical purposes, but the gas is burned after the use, so this source is not included into the total inventory. Total N_2O emissions from aerosol cans were 0.1957 Gg and total N_2O emissions from anaesthesia were 0.0486 Gg in 2011.

5.9.1 Methodological issues – methods

The methodology is based on tier 1 followed default approach because solvent use sector is not key category. The final N_2O emissions from these sources are equal to the consumed gas in medicine and food industry. The time series was reconstructed based on statistical data on production. The N_2O emissions according to the categories are summarized in Table 5.1.

The estimation of NMVOC emissions from processing of vegetable fat and oil were estimated in the category 3.D.5 Other and were 168.64 t in 2011. They slightly increased compared to the previous inventory due to the increase in production.

5.9.2 Methodological issues – emission factors and other parameters

N_2O emission factors used in the emission estimations 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.

5.9.3 Activity data

The activity data in the categories 3.D.1 and 3.D.3 come from the four major 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 gas distributors.

CHAPTER 6: AGRICULTURE (CRF 4)

6.1 Overview of sector (CRF 4)

In comparison with other sectors, the generation of emissions and sinks of greenhouse gases in agriculture have 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 increase their greenhouse effect as well as the acidity of environment. Despite of the fact that water vapour and CO_2 are the gases of the highest importance sharing 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 analyzed according to revised IPCC 1996 GL and IPCC 2006 GL methodologies when principles of good practice in GHGs inventory in agriculture were taking 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 are accepted in agricultural practice. Effective measures have been 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 only 4 893 ha 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 23% of total methane and more than 62% of total nitrous oxide emissions in the Slovak Republic.

By the end of 2011, the primary soil fund (arable land) of the Slovak Republic was 1 358 423 ha from the total agricultural land 1 929 698 ha. The importance of agriculture in economy shows a long-lasting decrease, as regards either the share in GDP or employment. In 2011, the area of seeded soil slightly increased by 3.3% in comparison with 2010. The areas of following plants increased: sugar-beet (2.3%), maize (8.3%), soya been (52%), oilseed rape (3.1%) cultivated flax (48%) and sunflower (5.4%). The area of N-fixing crops has increased after three-years decreasing in total by 36%. This was reaction on the price situation on EU agricultural commodity market. The decreasing of soil seeded with potatoes (9.6%), vegetables (21%) and rape seed (23%) was reaction on situation low prices and demand on the market. However, Act No 77/2009 Coll. changing and amending Act No 139/1998 Coll. on narcotics and psychotropic substances, which has been effective since March 2009, allows growing of technical cannabis. In case of sugar-beet, the reform of sugar regime goes on and its growing has been reduced. Potatoes growing have been influenced in the long term by several factors, like climate change, the decrease in human and animal consumption and the absence of companies processing potatoes. Increased interest of producers in oilseed rape was caused by increasing demands on the production of methyl ester and a higher average price.[15]

[15] http://www.mpsr.sk/sk/index.php?navID=122&id=6916

Table 6.1: *GHG emissions in individual categories in the agriculture sector in 1990 – 2011*

Year	Sector 4 Agriculture		Categories			
	CH_4	N_2O	4.A Enteric Fermentation CH_4	4.B Manure Management CH_4	4.B Manure Management N_2O	4.D Agricultural Soil N_2O
	(Gg)		(t)			
1990	113.46	15.30	95 901.46	17 555.08	3 465.54	11 830.16
1991	104.22	12.56	87 893.20	16 324.44	3 144.52	9 413.88
1992	92.31	10.11	77 493.54	14 816.71	2 704.39	7 403.89
1993	80.49	8.58	66 869.22	13 617.34	2 343.28	6 232.06
1994	76.05	8.36	63 140.71	12 905.62	2 188.72	6 168.43
1995	80.96	8.57	67 708.71	13 253.17	2 306.57	6 265.83
1996	76.06	8.40	63 464.46	12 597.28	2 127.34	6 272.21
1997	68.44	8.40	56 883.36	11 559.48	1 948.65	6 449.43
1998	63.74	7.70	53 529.47	10 210.04	1 717.66	5 977.88
1999	61.29	7.02	51 421.00	9 869.61	1 636.33	5 382.64
2000	60.34	7.19	50 819.56	9 519.76	1 601.25	5 588.63
2001	61.67	7.25	52 039.26	9 634.41	1 548.33	5 698.25
2002	60.12	7.16	50 378.48	9 742.34	1 531.67	5 628.66
2003	57.52	6.95	48 259.54	9 262.14	1 487.71	5 462.82
2004	52.87	6.66	45 023.89	7 842.90	1 386.13	5 272.98
2005	53.19	6.63	45 530.58	7 660.82	1 339.54	5 286.23
2006	52.28	6.51	44 793.29	7 489.05	1 309.46	5 198.28
2007	51.36	6.94	44 514.04	6 844.36	1 284.46	5 659.72
2008	48.98	6.78	43 131.54	5 853.10	1 239.11	5 537.59
2009	47.15	6.65	41 202.94	5 943.25	1 216.14	5 436.44
2010	46.48	6.85	40 813.39	5 667.45	1 207.88	5 637.89
2011	45.92	6.95	40 824.83	5 098.54	1 191.17	5 754.40

In animal production, the problems persist with the nutrition, feeding techniques and care of animals that result in ineffective production. A long-lasting decrease in the number of cattle is accompanied with changes in breed structure. This brings a higher share of milk production with a lower number of dairy cows. Free stabling of animals is the most important technological change in animal production. Production of pigs is stagnant; however, it does not cover domestic consumption. Trend in poultry breeding is positive.

Sector agriculture with its share of 6.9% (without LULUCF) with 3 117.52 Gg of CO_2 equivalents 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 and Rural Development of the Slovak Republic issued annual statistics “Green Report”, part agriculture and food industry on a yearly basis.

The trend in GHG emissions has been mildly decreasing 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, which produced 40.82 Gg (89%) of methane within sector in 2011, in particular in category of cattle. Regarding N_2O emissions, direct emissions from fertilization of agricultural soils were the most important sources, and they produced 4.15 Gg N_2O (60%) within sector in 2011.

The major emission source in the sector agriculture is category 4.D – Agricultural Soils with the share 57%, followed by the category 4.A – Enteric Fermentation with the share 28%. The category 4.B – Manure Management represents 15% from the total sector emissions.

Figure 6.1: *Trend in aggregated emissions (Gg) by categories within agriculture sector in 1990 – 2011*

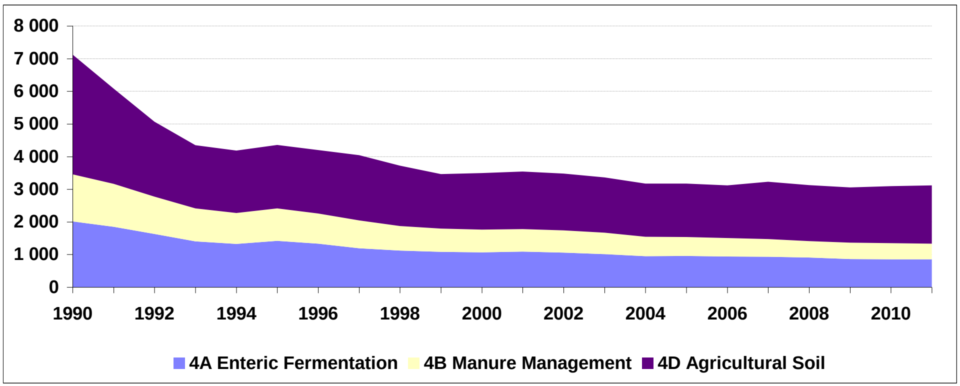
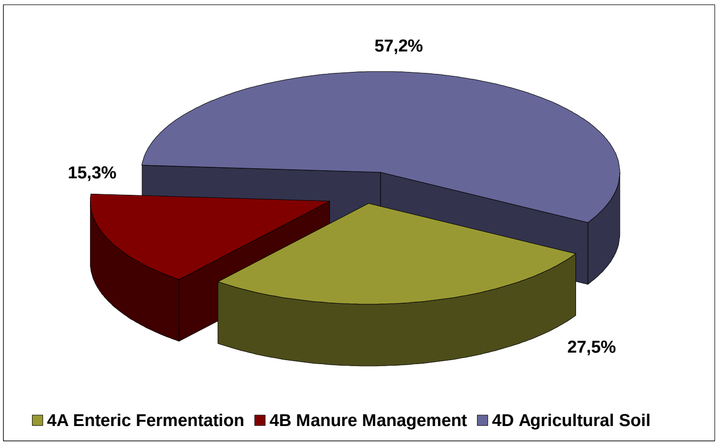


Figure 6.2: *The share of aggregated emissions by categories within agriculture sector in 2011*



Category	CO_2 eq. (Gg)
4.A Enteric Fermentation	857 321.50
4.B Manure Management	476 332.76
4.D Agricultural Soil	1 783 863.15

6.2 Enteric fermentation (CRF 4.A)

6.2.1 Source category description

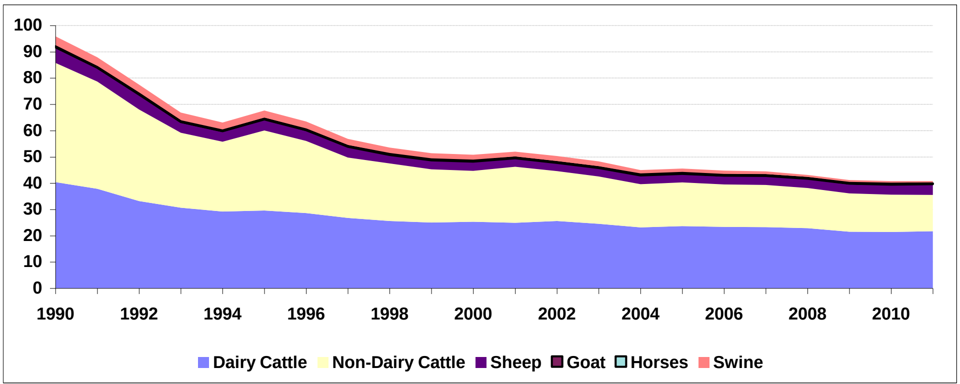
Among all domestic livestock the cattle is the most important producer of methane due to its digestive tract, weight and a relatively high number compared with other population of livestock in the Slovak Republic. Therefore, the trends in total CH_4 emissions reflect a number of animals in this category. The number of dairy cows as well as other cattle has decreased by more than a half during the evaluated period. Except for domestic livestock category 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.

Methane emissions from enteric fermentation are dominant emissions from animal husbandry and from agriculture. The cattle produce more than 90% of these emissions and dairy cattle give nearly half of emissions in the category. Less than 10% of emissions are produced by other categories of domestic livestock. An intensification of animal husbandry increased also methane emissions to the level of 100 kg CH_4 per head and per year. 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 source categories according to level and trend assessment for the base year and for 2011. Total methane emissions from enteric fermentation decreased from 95.90 Gg in 1990 to 40.82 Gg in 2011, what is the decrease by more than 57%. 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 what is less than one third of emissions of 1990. From the following Figures is visible that the diary and non-dairy cattle are the key categories within the enteric fermentation.

Table 6.2: *Methane emissions from enteric fermentation according to the livestock in 1990 – 2011*

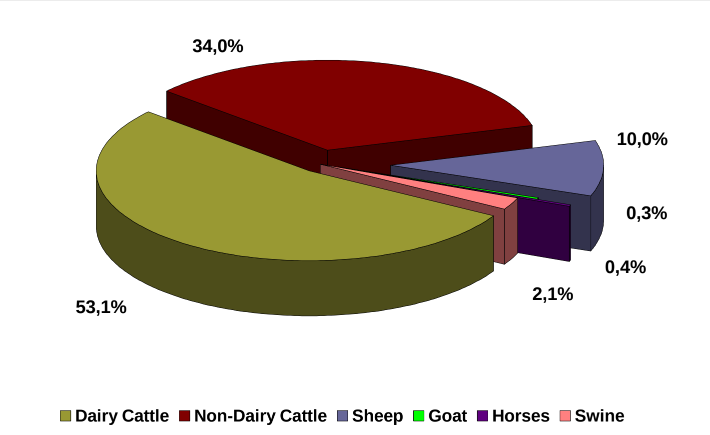
Category 4.A Enteric Fermentation - CH_4 (Gg)						
Year	**Dairy Cattle**	**Non-Dairy Cattle**	**Sheep**	**Goat**	**Horses**	**Swine**
1990	40.368	45.443	5.932	0.1250	0.2520	3.7815
1991	37.832	40.811	5.250	0.1250	0.2340	3.6420
1992	33.245	34.849	5.655	0.1250	0.2160	3.4035
1993	30.678	28.537	4.063	0.1250	0.1980	3.2685
1994	29.243	26.594	3.925	0.1250	0.1980	3.0555
1995	29.638	30.420	4.230	0.1250	0.1820	3.1146
1996	28.650	27.390	4.141	0.1305	0.1750	2.9778
1997	26.746	22.991	4.126	0.1339	0.1716	2.7148
1998	25.648	21.842	3.225	0.2545	0.1719	2.3889
1999	25.041	20.248	3.365	0.2554	0.1682	2.3432
2000	25.343	19.375	3.440	0.2571	0.1713	2.2327
2001	24.883	21.409	3.127	0.2019	0.1419	2.2759
2002	25.613	18.963	3.124	0.2010	0.1462	2.3308
2003	24.529	18.005	3.218	0.1961	0.1461	2.1645
2004	23.216	16.368	3.374	0.1951	0.1478	1.7239
2005	23.642	16.690	3.188	0.1978	0.1499	1.6624
2006	23.328	16.221	3.247	0.1918	0.1480	1.6572
2007	23.236	16.144	3.373	0.1894	0.1443	1.4280
2008	22.861	15.274	3.537	0.1854	0.1516	1.1228
2009	21.550	14.536	3.697	0.1793	0.1296	1.1113
2010	21.406	14.224	3.848	0.1765	0.1280	1.0309
2011	21.690	13.889	4.080	0.1703	0.1249	0.8706

Figure 6.3: *Trend in methane emissions (Gg) by categories within enteric fermentation in 1990 – 2011*



Dairy and non-dairy cattle methane emissions represent the major share of enteric fermentation emissions (53% and 34%). Almost 10% belongs to sheep methane emissions. These sources are significant and key sources in enteric fermentation category are estimated by tier 2 methodology. Other not so significant animal categories are estimated with tier 1 methodology.

Figure 6.4: *The share of aggregated emissions by categories within enteric fermentation in 2011*



Category	CO_2 eq. (Gg)
Dairy Cattle	455.49
Non-Dairy Cattle	291.68
Sheep	85.67
Goat	3.58
Horses	2.62

6.2.2 Methodological issues – methods

The Slovak Republic used a methodology based on national data about animal number in detailed categories (for other non-dairy cattle) and more advanced characteristic about feed and milk conditions for category dairy cattle and sheep. Detailed input data are available from 1997 up to the present. The datasets are published in the Green Reports of the Slovak Republic (www.land.gov.sk) and verified by district offices of statistical farm information (bottom-up approach). Methane emissions from enteric fermentation for dairy cattle, non-dairy cattle and sheep are based on tier 2 approach. The bottom-up regional input data about the number of animals, feeding situation, weight, milk production, average gross energy intake and other information are available since 1997 (sheep since 2004). The time series 1990 – 1996 was evaluated with the extrapolation methodology for dairy and non-dairy cattle and for sheep (1990 – 2004). The complete time series is consistent with the recommendations of the IPCC 2000 GPG. Tier 1 methodology is used for goats, horses and swine because these categories are not key sources.

6.2.3 Methodological issues – emission factors and other parameters

Emission factors for dairy cattle, non-dairy cattle and sheep were estimated on the basis of milk production, average gross energy intake and they are specific for the Slovak Republic. Methane emissions from enteric fermentation of dairy cattle reflect milk production from 1997. For the estimation of emission factor for methane emissions from enteric fermentation of dairy and non-dairy cattle, the extrapolation, linear function was used back to the base year 1990. The time series of EFs is based on average gross energy intake (AGEI) and detailed analysis of cattle categories. Direct activity data are available from the national statistics since 1990. Other input parameters such as milk production, fat of milk (3.93%) average gross energy intake and detailed population statistics according to the age of cattle are available since the year 1997 in regional disaggregation form (from eight districts). The time series back to the base year was completed by extrapolation method from 1997 back to 1990. The average methane conversion rate was 6% for cattle (dairy and non-dairy) and 7% for sheep for the time series 1990 – 2011. Average weight was 550 kg for cattle (dairy and non-dairy) and 54.2 kg for sheep in 2011. The average digestibility of feed was 60% for cattle and sheep and constant in time series. The average pregnancy for dairy cattle was 90% and constant in time series. AGEI for sheep is constant value (24.78 kg/head/day) and constant value for milk yield is 0.12 kg/head/day for sheep category (Table 6.3). Emission factor for dairy cattle was increased reflecting the increase in milk yield and average gross energy intake in 2011 (Table 6.4).

Table 6.3: *Activity data and methane emissions for dairy cattle in 1990 – 2011*

Activity Data for Dairy Cattle in Enteric Fermentation					
Year	**Population**	**Milk production**	**AGEI**	**EF (CH_4)**	**CH_4**
	1 000 head	kg/day	MJ/head/day	kg/head/year	Gg
1990	549.000	6.340	211.117	73.530	**40.3681**
1991	501.000	6.860	216.771	75.512	**37.8315**
1992	429.000	7.380	222.424	77.494	**33.2448**
1993	386.000	7.910	228.078	79.476	**30.6776**
1994	359.000	8.430	233.732	81.457	**29.2432**
1995	355.200	8.950	239.386	83.439	**29.6376**
1996	335.400	9.480	245.040	85.421	**28.6502**
1997	309.742	9.650	246.935	86.350	**26.7461**
1998	284.165	10.650	258.983	90.256	**25.6475**
1999	274.065	10.940	262.219	91.370	**25.0414**
2000	271.184	11.990	266.456	93.453	**25.3430**
2001	259.269	12.430	274.997	95.975	**24.8834**
2002	259.873	13.070	282.506	98.559	**25.6129**
2003	245.802	13.320	286.210	99.793	**24.5294**
2004	231.874	13.450	286.093	100.122	**23.2157**
2005	229.607	14.240	295.402	102.969	**23.6424**
2006	218.653	15.604	306.598	106.691	**23.3284**
2007	215.659	16.300	304.373	107.742	**23.2355**
2008	211.185	16.500	304.373	108.250	**22.8609**
2009	204.133	15.800	303.777	105.569	**21.5501**
2010	204.386	15.671	300.854	104.735	**21.4064**
2011	201.307	16.200	310.678	107.746	**21.6901**

Table 6.4: *The overview of used country specific parameters for dairy cattle in 2011*

Activity Data	**Population**	**Milk Production**		**Energy Intake**	**EF (CH_4)**	**CH_4**
District	heads	l/day	in kg/day	MJ/head/day	kg/head/year	t
Bratislava	6 787	21.73	21.30	361.92	142.43	869.99
Trnava	31 060	20.71	20.30	351.67	138.39	3 868.68
Trencin	18 857	17.75	17.40	321.95	126.70	2 150.23
Nitra	25 838	19.58	19.20	340.40	133.96	3 115.08
Zilina	30 037	13.57	13.30	279.93	110.16	2 978.03
Banska Bystrica	31 445	13.46	13.20	278.91	109.76	3 106.21
Presov	37 495	13.36	13.10	277.88	109.35	3 690.23
Kosice	19 788	12.85	12.60	272.76	107.34	1 911.61
Weighted Average (SR)	**201 307**	**16.52**	**16.20**	**310.68**	**107.75**	**21 690.05**

Total methane emissions from enteric fermentation of non-dairy cattle were estimated based on detailed classification of animals to the following categories: young males, young females (0-8 M, 8M-1yr), males, females (1-2 yr), fattening cattle and bulls. The country specific EFs are estimated annually as an average based on AGEI and other parameters specific for each category (Table 6.5).

Total methane emissions from enteric fermentation of sheep were estimated on the basis of detailed classification of animals to three categories: ewes, lambs and other sheep. The country specific data are available since 2004. The emission factors are calculated as weight average from these three categories based on gross energy intake, milk productivity, average methane conversion rate and other country specific information (Table 6.5). Time series back to the base year was completed based on extrapolation method using tier 2 methodology.

Emission factors for goats, horses and swine in enteric fermentation are constant default parameters based on IPCC 2000 GPG. EF for goats is 5 kg/head/year (default value), emission factor for horses is 18 kg/head/year (default value) and emission factor for category swine is 1.5 kg/head/year (Table 6.6).

Table 6.5: *Activity data and methane emissions for non-dairy cattle and sheep in 1990 – 2011*

Year	Non-Dairy Cattle in Enteric Fermentation				Sheep in Enteric Fermentation			
	Population	**AGEI**	**EF (CH_4)**	**CH_4**	**Population**	**AGEI**	**EF (CH_4)**	**CH_4**
	1000 heads	MJ/head/day	kg/head/year	Gg	1000 heads	MJ/head/day	kg/head/year	Gg
1990	1 014.000	122.035	44.816	45.443	600.000	21.533	9.886	5.932
1991	896.000	123.049	45.548	40.811	531.000	21.533	9.886	5.250
1992	753.000	124.063	46.280	34.849	572.000	21.533	9.886	5.655
1993	607.000	125.077	47.013	28.537	411.000	21.533	9.886	4.063
1994	557.000	126.092	47.745	26.594	397.000	21.533	9.886	3.925
1995	627.500	127.106	48.478	30.420	427.844	21.533	9.886	4.230
1996	556.600	128.120	49.210	27.390	418.823	21.533	9.886	4.141
1997	493.656	131.395	46.573	22.991	417.337	21.533	9.886	4.126
1998	420.627	130.198	51.927	21.842	326.199	21.533	9.886	3.225
1999	390.990	130.198	51.787	20.248	340.346	21.533	9.886	3.365
2000	374.964	131.387	51.672	19.375	347.983	21.533	9.886	3.440
2001	365.921	133.647	58.507	21.409	316.302	21.533	9.886	3.127
2002	347.944	130.906	54.501	18.963	316.028	21.533	9.886	3.124
2003	347.380	135.861	51.831	18.005	325.521	21.533	9.886	3.218
2004	308.272	134.317	53.095	16.368	321.227	22.876	10.503	3.374
2005	298.282	140.808	55.953	16.690	320.487	21.667	9.948	3.188
2006	289.167	140.808	56.095	16.221	332.571	21.266	9.764	3.247
2007	286.158	141.266	56.416	16.144	347.179	21.162	9.716	3.373
2008	277.252	139.326	55.091	15.274	361.634	21.302	9.780	3.537
2009	267.834	139.143	54.272	14.536	376.978	21.359	9.807	3.697
2010	262.739	139.992	54.136	14.224	394.175	21.263	9.762	3.848
2011	262.051	135.476	53.003	13.889	393.927	22.556	10.356	4.080

Table 6.6: *Activity data and methane emissions for other animal in 1990 – 2011*

Year	Goat		Horses		Swine		
	Population	**CH_4**	**Population**	**CH_4**	**Population**	**CH_4**	**EF (CH_4)**
	heads	Gg	heads	Gg	heads	Gg	kg/head/year
1990	25.000	0.125	14.000	0.252	2 035	3.782	1.858
1991	25.000	0.125	13.000	0.234	1 942	3.642	1.875
1992	25.000	0.125	12.000	0.216	1 799	3.404	1.892
1993	25.000	0.125	11.000	0.198	1 731	3.269	1.888
1994	25.000	0.125	11.000	0.198	1 613	3.056	1.894
1995	25.000	0.125	10.109	0.182	1 644	3.115	1.894
1996	26.100	0.131	9.722	0.175	1 575	2.978	1.891
1997	26.778	0.134	9.533	0.172	1 435	2.715	1.892
1998	50.905	0.255	9.550	0.172	1 220	2.389	1.958
1999	51.075	0.255	9.342	0.168	1 192	2.343	1.966
2000	51.419	0.257	9.516	0.171	1 099	2.233	2.031
2001	40.386	0.202	7.883	0.142	1 116	2.276	2.040
2002	40.194	0.201	8.122	0.146	1 237	2.331	1.884
2003	39.225	0.196	8.114	0.146	1 184	2.165	1.828
2004	39.012	0.195	8.209	0.148	1 149	1.724	1.500
2005	39.566	0.198	8.328	0.150	1 045	1.662	1.591
2006	38.352	0.192	8.222	0.148	1 105	1.657	1.500
2007	37.873	0.189	8.017	0.144	952	1.428	1.500
2008	37.088	0.185	8.421	0.152	749	1.123	1.500
2009	35.866	0.179	7.199	0.130	741	1.111	1.500
2010	35.292	0.176	7.111	0.128	687	1.031	1.500
2011	34.053	0.170	6.937	0.125	580	0.871	1.500

6.2.4 Activity data

The Slovak Agricultural University in Nitra, namely Dr. B. Šiška has taken responsibility for inventory of emissions from agriculture sector. Methodology used also the results of research institutions sharing 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.
- Green report of the Slovak Republic 1998 – 2012, the Ministry of Agriculture of the Slovak Republic.
- Statistical Yearbook 1990 – 2012, the Statistical Office of the Slovak Republic.

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. 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. Activity data used for methane emission estimation of dairy cattle are summarized in Table 6.4. Detailed statistical information is available at the district level and emissions are estimated by bottom-up tier 2 methodology.

Activity data for non-dairy cattle are available for detailed animal categories (Table 6.7) such as young male (below 6 months, 6 m – 1 year), young female (below 6 months, 6 m – 1 year), males (1-2 years), females (1-2 years), fattening cattle (males, females) and bulls.

Table 6.7: *The overview of used country specific parameters for non-dairy cattle in 2011*

Activity Data	**Population**	***from total Bulls***	***from total Fattening***	***from total Young***	**Energy Intake**	**EF (CH_4)**	**CH_4**
District	heads				MJ/head/day	kg/head/year	t
Bratislava	6 979	0	1 207	5 772	135.59	58.34	410.50
Trnava	46 568	7	4 424	42 137	150.03	64.10	3 003.83
Trencin	24 609	3	3 296	21 310	145.10	61.81	1 514.37
Nitra	40 313	0	3 132	37 181	126.89	53.41	2 093.16
Zilina	36 053	251	6 139	29 663	111.76	46.46	1 603.94
Banska Bystrica	40 931	20	7 489	33 422	126.61	53.28	2 113.13
Presov	41 820	20	7 448	34 352	122.63	51.45	2 036.59
Kosice	24 778	3	3 945	20 830	115.69	48.27	1 113.90
Weighted Average (SR)	**262 051**	***304***	***37 080***	***224 667***	**135.48**	**53.00**	**13 889.41**

Activity data for sheep are available for detailed categories (Table 6.8) such as ram, lambs and ewes.

Table 6.8: *The overview of used country specific parameters for sheep in 2011*

Activity Data	**Population**	**Milk Production**		**Energy Intake**	**EF (CH_4)**	**CH_4**
	heads	l/day	kg/day	MJ/head/day	kg/head/year	t
Bratislava	664	0.122	0.120	24.78	10.33	6.86
Trnava	2 237	0.122	0.120	24.78	10.12	22.64
Trencin	33 290	0.122	0.120	24.78	10.49	349.10
Nitra	10 202	0.122	0.120	24.78	9.95	101.53
Zilina	85 546	0.122	0.120	24.78	10.41	890.27
Banska Bystrica	133 835	0.122	0.120	24.78	10.33	1 382.42
Presov	80 270	0.122	0.120	24.78	10.43	837.31
Kosice	47 883	0.122	0.120	24.78	10.22	489.53
Weighted Average (SR)	**393 927**	**0.122**	**0.120**	**24.78**	**10.36**	**4 079.65**

6.2.5 Uncertainties and time-series consistency

Data on number of domestic livestock according to 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 in this study were published in:

- Green Report of the Slovak Republic.
- Statistical Yearbook of the Slovak Republic.

Data published in the Green Report of the Slovak Republic, as well as in the Statistical Yearbook can differ slightly, especially if the number of animals in some category is very low. Round up or down if the numbers of domestic livestock are given in thousands of head can cause differences up to 3%. However, the differences are not of high importance. Subcategories of domestic livestock can be estimated according to Annual census of domestic livestock in the Slovak Republic. Data from this publication are issued relatively soon after the end of previous year but many times they are different in comparison with data from Green Report or Statistical Yearbook. 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 uncertainty was included in total assessment. Time series consistency is ensured.

6.2.6 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 the in-country review 2012. The Ministry of Environment and the Ministry of Agriculture and Rural Development agreed 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 (Mr. Bernard Siska) 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 of the Slovak Republic (Green Reports). The information used for the preparation of this report is archived by the author and by SNE.

6.2.7 Source specific recalculations

Two minor recalculations were provided in the 2013 submission in reflection to improve consistency and transparency of the inventory (ARR 2012, Para 97 – 99). The average gross energy intake for dairy cattle in the year 2010 was corrected based on improve data from regional statistics. This change had no impact on emissions.

Correction of methane EF (default 5 kg/head/year) for goats led to the small correction of methane emissions (increase by 0.5%) in the year 2009.

6.2.8 Source specific planned improvements

Several important methodological changes occurred during last inventory submission in enteric fermentation. The recalculation was based by using tier 2 methodology for the estimation of methane emissions (cattle, sheep). The data provided by regional statistics are more precise and detailed. The estimations were recalculated since 1997. The time series were calculated back to the base year using linear regression and expert judgment for cattle. Productivity of different categories of domestic livestock varies in the conditions of the Slovak Republic significantly depending upon the scale and production level of farm.

6.3 Manure management (CRF 4.B(a)) – CH_4 emissions

6.3.1 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 higher part of total methane emission will create emissions 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 2011.

Methane emissions from this source decreased from 17.56 Gg in 1990 to 5.10 Gg in 2011. 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 economical reason (low prices of meat on the market) during recent years what consequently influenced methane emissions from manure management. Emissions decreased by more than 71% in this category, however swine stay key source. Next decrease is supposed also for the future. Methane emissions can drop by about 10% up to year 2015 because of continuing decrease in cattle population.

Table 6.9: *Methane emissions from manure management according to the animals in 1990 – 2011*

Category 4.B Manure Management - CH_4 (Gg)							
Year	**Dairy Cattle**	**Non-Dairy Cattle**	**Sheep**	**Goat**	**Horses**	**Swine**	**Poultry**
1990	2.196	3.853	0.114	0.0030	0.0196	10.0840	1.2853
1991	2.004	3.405	0.101	0.0030	0.0182	9.7120	1.0815
1992	1.716	2.861	0.109	0.0030	0.0168	9.0760	1.0348
1993	1.544	2.307	0.078	0.0030	0.0154	8.7160	0.9543
1994	1.436	2.117	0.075	0.0030	0.0154	8.1480	1.1112
1995	1.421	2.385	0.081	0.0030	0.0142	8.3056	1.0438
1996	1.342	2.115	0.080	0.0031	0.0136	7.9408	1.1035
1997	1.239	1.876	0.079	0.0032	0.0133	7.2395	1.1093
1998	1.137	1.598	0.062	0.0061	0.0134	6.3704	1.0231
1999	1.096	1.486	0.065	0.0061	0.0131	6.2484	0.9553
2000	1.085	1.425	0.066	0.0062	0.0133	5.9538	0.9708
2001	1.037	1.390	0.060	0.0048	0.0110	6.0691	1.0617
2002	1.039	1.322	0.060	0.0048	0.0114	6.2155	1.0888
2003	0.983	1.320	0.062	0.0047	0.0114	5.7721	1.1089
2004	0.927	1.171	0.061	0.0047	0.0115	4.5971	1.0696
2005	0.918	1.133	0.061	0.0047	0.0117	4.4331	1.0986
2006	0.875	1.099	0.063	0.0046	0.0115	4.4193	1.0170
2007	0.863	1.087	0.066	0.0045	0.0112	3.8080	1.0050
2008	0.845	1.054	0.069	0.0045	0.0118	2.9941	0.8758
2009	0.817	1.018	0.072	0.0043	0.0101	2.9634	1.0595
2010	0.818	0.998	0.075	0.0042	0.0100	2.7490	1.0134
2011	0.805	0.996	0.075	0.0041	0.0097	2.3216	0.8873

Figure 6.5 shows the decrease in swine and non-dairy cattle methane emissions from manure management category.

Figure 6.5: *Trend in CH_4 emissions (in Gg) by categories within manure management in 1990 – 2011*

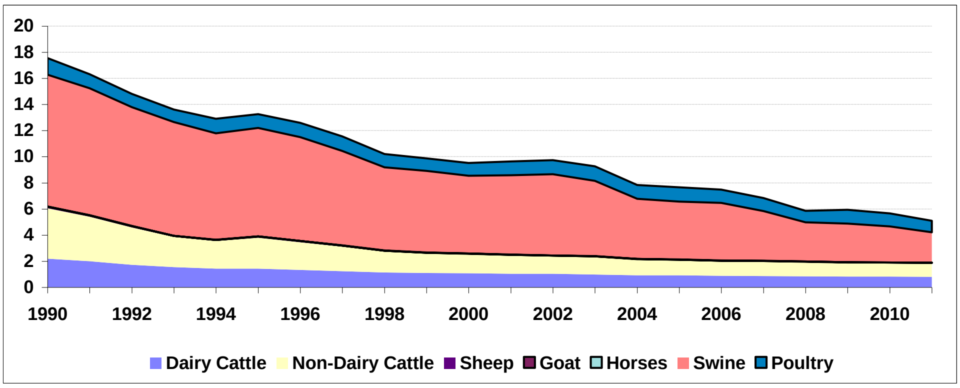
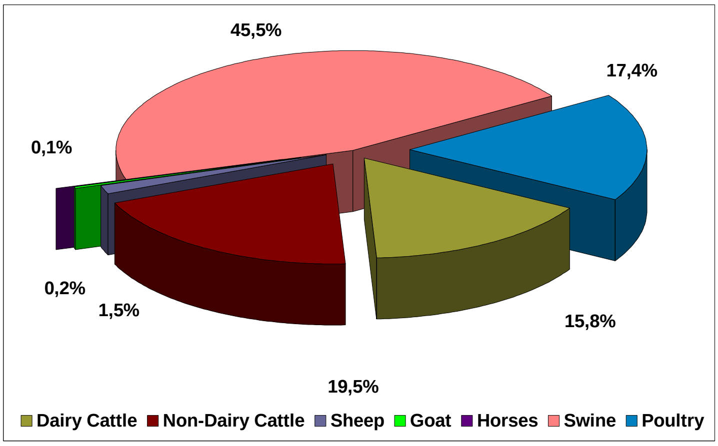


Figure 6.6 shows the share of individual categories in the production of manure methane emissions. The share of swine category is 46% which is in compliance with the methodology.

Figure 6.6: *The share of aggregated emissions by categories within manure management in 2011*



Category	CH_4 (Gg)
Dairy Cattle	0.8052
Non-Dairy Cattle	0.9958
Sheep	0.0748
Goat	0.0041
Horses	0.0097
Swine	2.3216
Poultry	0.8873

6.3.2 Methodological issues – methods

The methodology based on the national data was evaluated for the estimation of methane emission in manure management. The national approach is based on the number of animals per regions, the calculation of volatile solid excretion (VS) and methane conversion factor (MCF) as inputs to the formula for the estimation of national EFs. This approach will be used in the next submission. The methodology used for the estimation in manure management is based on tier 1 IPCC methodology using the country specific parameters and activity data.

6.3.3 Methodological issues – emission factors and other parameters

Methane emissions from manure management are base on country specific emission factors used constantly during time series. Table 6.10 shows emission factors for different animal categories.

Table 6.10: *EF for methane emissions in manure management in 2011*

Category	EF CH_4 (Gg)
Dairy Cattle	4.000
Non-Dairy Cattle	3.800
Sheep	0.190
Goat	0.120
Horses	1.400
Swine	4.000
Poultry	0.078

6.3.4 Activity data

Decreasing number of domestic livestock, especially in categories pigs (as mentioned above) and dairy cows, produce lower amount of nitrogen. 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 is divided into four subcategories (sows, sows up to 50 kg, young sows over 50 kg and fattening pigs), poultry category is divided into ducks & turkey, laying hens and broilers categories.

6.3.5 Uncertainties and time-series consistency

Tier 1 uncertainty was included in total assessment. Time series consistency is ensured.

6.3.6 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 6.2.6 of this Report.

6.3.7 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

6.3.8 Source specific planned improvements

Methane emissions from manure management are not key source by level or trend assessment, the improvements in emission factors are planned, but it is not a high priority.

6.4 Manure management (CRF 4.B(b)) – N_2O emissions

6.4.1 Source category description

Because domestic livestock produce different kinds of nitrogen inputs (liquid or dry) 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 also plays certain role. The production of nitrogen in category cattle is 90 kg per head per year and for dairy cows with milk productivity higher than 4 500 l is 100 kg N per head per year (CORINAIR, 2003). Some differences are also in category other cattle, where for intensive animal husbandry the higher production of nitrogen (60 kg N pre head per year instead of 56 kg N per head per year) was used. Direct measurements of nitrogen produced by domestic livestock in the Czech Republic showed that real amounts could be much higher than the values of produced nitrogen recommended in methodologies what influenced directly also N_2O emissions. The applied animal fertilizers lost the definite amount of nitrogen by volatilization and N-NO_x conversion. This amount is 20% for animal fertilizers, what means that only 80% of total amount applied synthetic fertilizers remains for the conversion of N to N_2O. Solid and liquid systems are the most often form for the storage of excreta in manure management (especially sows and pigs) 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. Input of nitrogen oxide from manure management was 1.19 Gg of N_2O in 2011 and total decrease was about 66% compared to the base year.

Table 6.11: *N_2O and N emissions in manure management according to the animal categories and AWMS in 1990 – 2011*

Category 4.B Manure Management										
	N_2O (Gg)			**N - Excretion (kt)**						
Year	**Liquid System**	**Solid Storage and Dry Lot**	**Total**	**Dairy Cattle**	**Non-Dairy Cattle**	**Sheep**	**Goat**	**Horses**	**Swine**	**Poultry**
1990	0.063	3.402	**3.4655**	54.900	60.840	9.600	0.400	0.350	33.055	12.229
1991	0.058	3.087	**3.1445**	50.100	53.760	8.496	0.400	0.325	31.747	10.641
1992	0.054	2.650	**2.7044**	42.900	45.180	9.152	0.400	0.300	29.591	9.966
1993	0.050	2.293	**2.3433**	38.600	36.420	6.576	0.400	0.275	28.432	9.447
1994	0.049	2.140	**2.1887**	35.900	33.420	6.352	0.400	0.275	26.555	10.685
1995	0.049	2.258	**2.3066**	35.520	37.650	6.846	0.400	0.253	27.069	10.286
1996	0.048	2.079	**2.1273**	33.540	33.396	6.701	0.418	0.243	25.893	10.561
1997	0.045	1.904	**1.9486**	30.974	29.619	6.677	0.428	0.238	23.602	10.662
1998	0.040	1.678	**1.7177**	28.417	25.238	5.219	0.814	0.239	20.558	9.831
1999	0.038	1.598	**1.6363**	27.407	23.459	5.446	0.817	0.234	20.139	9.217
2000	0.037	1.565	**1.6012**	27.118	22.498	5.568	0.823	0.238	18.725	9.365
2001	0.038	1.510	**1.5483**	25.927	21.955	5.061	0.646	0.197	18.918	10.062
2002	0.040	1.492	**1.5317**	25.987	20.878	5.056	0.643	0.203	20.291	10.346
2003	0.039	1.449	**1.4877**	24.580	20.843	5.208	0.628	0.203	19.265	10.484
2004	0.037	1.349	**1.3861**	23.187	18.496	5.140	0.624	0.205	18.594	10.160
2005	0.036	1.304	**1.3395**	22.961	17.897	5.128	0.633	0.208	16.863	10.296
2006	0.036	1.273	**1.3095**	21.865	17.350	5.321	0.614	0.206	17.777	9.793
2007	0.032	1.252	**1.2845**	21.566	17.169	5.555	0.606	0.200	15.196	9.721
2008	0.026	1.213	**1.2391**	21.119	16.635	5.786	0.593	0.211	11.725	8.367
2009	0.028	1.188	**1.2161**	20.413	16.070	6.032	0.574	0.180	11.722	9.868
2010	0.026	1.182	**1.2079**	20.439	15.764	6.307	0.565	0.178	10.898	9.507
2011	0.022	1.169	**1.1912**	20.131	15.723	6.303	0.545	0.173	9.280	8.512

Figure 6.7: *Trend in nitrogen excretion (kt) by categories within manure management in 1990 – 2011*

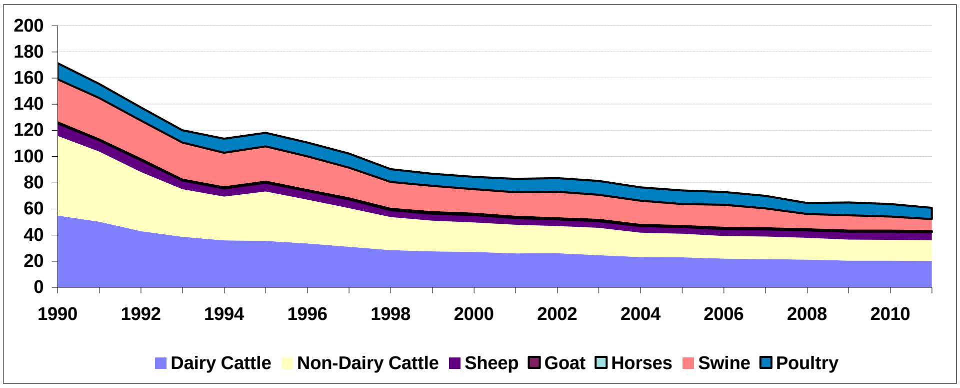
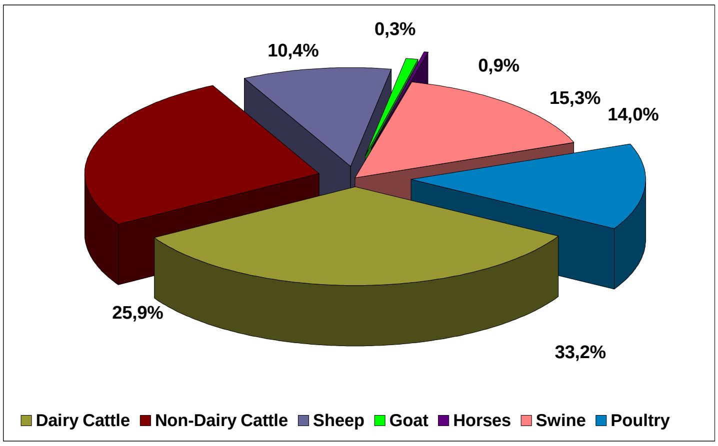


Figure 6.8: *The share of aggregated emissions by categories within manure management in 2011*



Category	N (kt per year)
Dairy Cattle	20.131
Non-Dairy Cattle	15.723
Sheep	6.303
Goat	0.545
Horses	0.173
Swine	9.280
Poultry	8.512

6.4.2 Methodological issues – methods

Information on animal housing, pasture and production of manures and slurries was collected on the base of questioners published in national papers. Some additional information was based on expert estimation. Duration of pasture is limited by climatic conditions. According to the IPCC methodology the Animal Waste Management Systems (AWMS) were recognized for evaluation in the Slovak Republic as follows:

- Liquid system,
- Solid storage and dry lot,
- Pasture range and paddock.

Solid storage of manure was found as the most frequent AMWS in the conditions of the Slovak Republic. Liquid storage of slurries is also frequently used especially in category pigs. Housing on grasslands since April to October is frequent for sheep, goats and horses. The methodology used for the estimation of manure management is based on tier 2 IPCC methodology using country specific parameters and activity data.

6.4.3 Methodological issues – emission factors and other parameters

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 of Animal Production in Nitra. It is supposed that sheep, goats and horses can stay on pasture 200 days a year, 40% of dairy cattle only 150 days especially in mountainous regions. During winter period sheep and goats produce 9% of waste as slurry and 91% as manure (Brestenský et al., 1998).

Table 6.12: *N production (kg/head/year) for different domestic livestock and share in AWMS in 2011*

Category	N	Liquid System	Solid System	Pasture
	kg/head/year	Share (%)		
Dairy Cattle	100.00	5.00%	0.75%	0.20%
Non-Dairy Cattle	60.00	0.05%	0.85%	0.10%
Sheep	16.00	0.04%	0.41%	0.55%
Horses	25.00	0.00%	0.45%	0.55%
Goats	16.00	4.00%	41.00%	55.00%
Sows	*36.00*	*41.60%*	*58.40%*	*0.00%*
Sows up to 50 kg	*15.00*	*91.00%*	*9.00%*	*0.00%*
Young Sows over 50 kg	*16.00*	*41.60%*	*58.40%*	*0.00%*
Fattening pigs	*14.00*	*91.00%*	*9.00%*	*0.00%*
Swine	15.99	86.40%	13.60%	0.00%
Laying hens	*0.80*	*2.20%*	*97.80%*	*0.00%*
Broilers	*0.60*	*98.20%*	*1.80%*	*0.00%*
Turkeys and Ducks	*2.00*	*100.00%*	*0.00%*	*0.00%*
Poultry	0.75	46.07%	53.93%	0.00%

Allocation according to the climate conditions is 100% for cool climate for all animals based on IPCC methodology. Methane conversion factor is 1.

Nitrogen excretion per animal category is constant for given years; the fluctuation in swine and poultry categories is done only by the changes in animal heads numbers inside the category. The weighted averages of the nitrogen excretion are calculated annually for swine and poultry (see Table 6.12).

6.4.4 Activity data

Some trends in the use of animal housing and consequently animal waste management system can be seen. The Ministry of Agriculture and Rural Development of the Slovak Republic is the second source of data on animal housing, pasture and production of manures and slurries. Figures are given in the table below as the alternative source of data for the calculation of emissions. Therefore the calculations were done in two variants.

6.4.5 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 emission from leaching and deposition of ammonia and NO_x. Tier 1 uncertainty was included in total assessment. Time series consistency is ensured. 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.

In the Slovak Republic, both the extensive and intensive farming system in animal husbandry can be found. Nitrogen production from dairy cows is in the range of 60 – 140 kg per head per year. Nitrogen inputs from animal excreta differ depending on used methodology and therefore two variants of calculation were applied in this study:

- Nitrogen input was calculated for animal categories of domestic livestock according to the IPCC methodology: cattle (dairy cattle – 90 kg of N per head and others with the production of 56 N per head), pigs, sheep, goats, horses and poultry.
- More detailed figures for the calculation of NH_3 emissions were used, when the categories of domestic livestock were separated according to the weight to subcategories and the production of 100 kg N per year for dairy cattle and 60 kg N for other cattle was supposed.

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.

6.4.6 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 6.2.6 of this Report.

6.4.7 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

6.4.8 Source specific planned improvements

Tier 2 methodology and national N-excretion values are planned to be improved in the next submission.

6.5 Rice Cultivation (CRF 4.C)

No emissions from rise cultivation were estimated in this category because no rice was cultivated in the Slovak Republic in 1990 – 2011.

6.6 Agricultural Soils (CRF 4.D)

6.6.1 Source category description

The applied amounts of synthetic fertilizers into cultivated soils have been very low for 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 available on the base of applied nitrogen fertilizers. Emissions also depend on the type of fertilizers, soil parameters (pH), meteorological conditions, time of application in relation to crop development. Applied nitrogen fertilizers were calculated on the base of FAO materials for the Slovak Republic (Bielek, 1998). The selection of emission coefficients reflect climatic and soil conditions of the Slovak Republic, when the climate in Central Europe was defined as cool (ECOTEC, 1994) with prevailing acidic soils. ECOTEC coefficients are lower than those published by Assman in 1992 or the coefficients for non-defined climatic conditions (simple methodology). Emissions of ammonia from cultivated soil can be higher by 6–20% depending on applied methodology.

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 5.75 Gg of N_2O. The emissions have been increasing by 2% in comparison with 2010 and decreased by 51% in comparison with the base year. 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 and the manure from pasture, the range and paddocks which corresponds with the decrease in the number of animals. Small interannual increase was caused by higher utilization of synthetic fertilizers in 2011 in the comparison with the previous year.

Table 6.13: *N_2O emissions from agricultural soils according to the subcategories in 1990 – 2011*

Category 4.D N_2O (Gg) from Agricultural Soils								
Year	4.D.1 Direct Emissions					4.D.2	4.D.3 Indirect Emissions	
	4.D.1.1	4.D.1.2	4.D.1.3	4.D.1.4	4.D.1.5	PRP	4.D.3.1	4.D.3.2
1990	3.929	2.161	0.620	1.195	NO	0.715	0.888	2.323
1991	2.587	2.121	0.606	1.208	NO	0.643	0.719	1.529
1992	1.594	1.870	0.612	1.230	NO	0.582	0.574	0.942
1993	1.146	1.647	0.634	1.165	NO	0.482	0.480	0.678
1994	1.214	1.559	0.574	1.187	NO	0.452	0.465	0.718
1995	1.230	1.619	0.507	1.231	NO	0.471	0.480	0.727
1996	1.316	1.519	0.464	1.286	NO	0.443	0.465	0.778
1997	1.556	1.399	0.418	1.282	NO	0.415	0.460	0.920
1998	1.447	1.232	0.370	1.294	NO	0.366	0.412	0.855
1999	1.156	1.174	0.353	1.283	NO	0.358	0.375	0.683
2000	1.284	1.136	0.345	1.330	NO	0.356	0.379	0.759
2001	1.438	1.151	0.309	1.292	NO	0.334	0.380	0.795
2002	1.560	0.817	0.287	1.310	NO	0.331	0.401	0.922
2003	1.437	0.861	0.278	1.330	NO	0.324	0.383	0.850
2004	1.413	0.758	0.281	1.314	NO	0.307	0.366	0.835
2005	1.438	0.748	0.278	1.308	NO	0.304	0.360	0.850
2006	1.391	0.720	0.312	1.302	NO	0.298	0.353	0.822
2007	1.572	0.714	0.446	1.339	NO	0.299	0.360	0.929
2008	1.551	0.681	0.379	1.370	NO	0.299	0.340	0.917
2009	1.362	0.871	0.400	1.377	NO	0.296	0.325	0.805
2010	1.536	0.850	0.383	1.324	NO	0.300	0.337	0.908
2011	1.644	0.805	0.367	1.334	NO	0.297	0.337	0.972

Figure 6.9: *Trend in nitrogen excretion (kt) by categories within agricultural soils in 1990 – 2011*

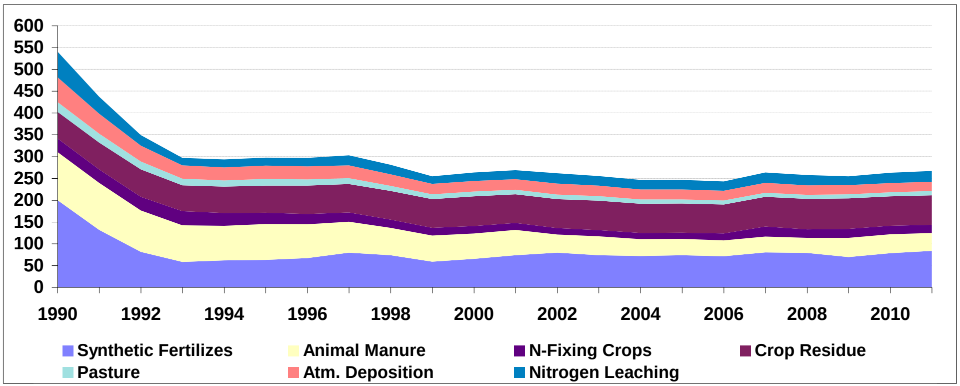
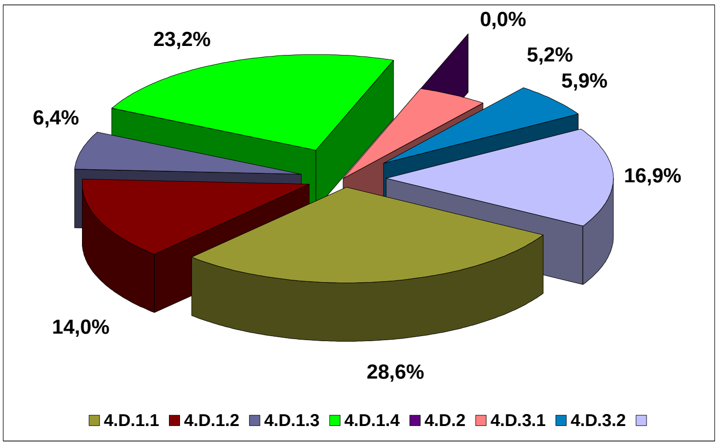


Figure 6.10: *The share of aggregated emissions by categories within agricultural soils in 2011*



Category	N_2O (Gg)
Synthetic Fertilizes	1.644
Animal Manure	0.805
N-Fixing Crops	0.367
Crop Residue	1.334
Pasture	0.297
At. Deposition	0.337
N Leaching & Run-off	0.972

The major share belongs to synthetic fertilizers use (29%) and crop residue (23%). Animal manure use (14%) and nitrogen leaching and run-off (17%) are influenced by manure management and the number of animals.

6.6.2 Source category description – Synthetic fertilizers (CRF 4.D.1.1)

The consumption of synthetic fertilizers decreased during last decade of 20th century, from 222 kt in 1990 to 84 kt in 2011. The synthetic fertilizers were applied on 60.7% of area of arable soils and only on 62.3% of sowing area of cereals in 2011. 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 in 2006 – 2011 by about 20% compared with 2000. Because of decreasing numbers of domestic livestock in some categories (producing still less nitrogen in wastes), this trend in higher consumption of synthetic fertilizers should continue if the present level of yields of field crops is accepted (Green Report, 2012).

6.6.2.1 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 (90% of 92 969 t N is 83 672 t N in 2011). Having used the IPCC default emission factor 0.0125 kg N_2O–N/kg N, total emissions of N_2O from using the synthetic fertilizers were 1.64 Gg in 2011. Tier 2 methodology was applied in combination with IPCC default EF and other parameters.

6.6.2.2 Methodological issues – emission factors and other parameters

Nitrogen inputs from applied fertilizers are published annually in the Green Report. The loss by volatilization is 10% and default emission factor 0.0125 kg N_2O-N/kg N was used for the calculation.

Table 6.14: *Input parameters and EF in category 4.D.1.1 Synthetic fertilizers in 1990 – 2011*

Category 4.D.1.1 Synthetic Fertilizers				
Year	**N-input in fertilizers**	**N-input to the soil**	**EF (N_2O)**	**N_2O Emissions**
	(kg/year)	(kg/year)	(kg N_2O-N/kg N)	(Gg)
1990	222 255 000	200 029 500	0.0125	**3.929**
1991	146 341 000	131 706 900	0.0125	**2.587**
1992	90 186 000	81 167 400	0.0125	**1.594**
1993	64 852 000	58 366 800	0.0125	**1.146**
1994	68 669 000	61 802 100	0.0125	**1.214**
1995	69 587 000	62 628 300	0.0125	**1.230**
1996	74 464 000	67 017 600	0.0125	**1.316**
1997	88 017 000	79 215 300	0.0125	**1.556**
1998	81 843 000	73 658 700	0.0125	**1.447**
1999	65 393 000	58 853 700	0.0125	**1.156**
2000	72 653 000	65 387 700	0.0125	**1.284**
2001	81 345 000	73 210 500	0.0125	**1.438**
2002	88 260 000	79 434 000	0.0125	**1.560**
2003	81 300 000	73 170 000	0.0125	**1.437**
2004	79 911 000	71 919 900	0.0125	**1.413**
2005	81 317 000	73 185 300	0.0125	**1.438**
2006	78 681 120	70 813 008	0.0125	**1.391**
2007	88 935 400	80 041 860	0.0125	**1.572**
2008	87 736 950	78 963 255	0.0125	**1.551**
2009	77 058 450	69 352 605	0.0125	**1.362**
2010	86 873 000	78 185 700	0.0125	**1.536**
2011	92 969 000	83 672 100	0.0125	**1.644**

6.6.2.3 Activity data

Activity data are summarized in Table 6.14.

6.6.2.4 Uncertainties and time-series consistency

Tier 1 uncertainty was included in total uncertainty assessment. Time series consistency is ensured. 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. Great 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 preliminary. 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 the case of cultivated soils (soils with fertilizers). More exact data on NH_3 and N_2O emissions from cultivated soils can be reached by modeling 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.

6.6.2.5 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 6.2.6 of this Report.

6.6.2.6 Source specific recalculations

According to the findings of the ERT during the in-country review 2012, correction of error in formula calculated the nitrogen fraction applied to soil from synthetic fertilizers was realized in the previous resubmission (ARR 2012, Para 103 - 106). The N_2O emissions for the entire time series 1997 – 2005 were increased. In line with the IPCC 2000 GPG, the inconsistencies were eliminated in calculation and revised estimation of the N_2O emissions was provided. The synthetic fertilizers use in agriculture is based on information from the Statistical Office of the Slovak Republic. The quantity of nitrogen applied to soil is based on the formula: SF x (1-0.1) x 1000 (SF= synthetic fertilizer in t of nitrogen). The revised time series with the comparison is shown in Table 6.15.

Table 6.15: *The revised emission estimation in the category 4.D.1.1 as submitted on 15 November 2012 and the comparison with the previous submission (April 2012)*

Year	Synthetic fertilizers	N applied to soil		Emissions		Diff.
	Statistics	Submission 2013	Submission 2012	Submission 2013	Submission 2012	
	(t N)	(kg N)		(Gg N_2O)		%
1990	222 255.00	200 029 500.00	200 029 500.00	3.93	3.93	100.00
1991	146 341.00	131 706 900.00	131 706 900.00	2.59	2.59	100.00
1992	90 186.00	81 167 400.00	81 167 400.00	1.59	1.59	100.00
1993	64 852.00	58 366 800.00	58 366 800.00	1.15	1.15	100.00
1994	68 669.00	61 802 100.00	61 802 100.00	1.21	1.21	100.00
1995	69 587.00	62 628 300.00	62 628 300.00	1.23	1.23	100.00
1996	74 464.00	67 017 600.00	67 017 600.00	1.32	1.32	100.00
1997	88 017.00	79 215 300.00	79 215 012.00	1.56	1.56	100.000
1998	81 843.00	73 658 700.00	73 658 268.00	1.45	1.45	99.999
1999	65 393.00	58 853 700.00	58 853 358.00	1.16	1.16	99.999
2000	72 653.00	65 387 700.00	65 388 114.00	1.28	1.28	100.001
2001	81 345.00	73 210 500.00	68 428 638.00	1.44	1.34	93.468
2002	88 260.00	79 434 000.00	79 433 712.00	1.56	1.56	100.000
2003	81 300.00	73 170 000.00	73 169 622.00	1.44	1.44	99.999
2004	79 911.00	71 919 900.00	71 919 729.00	1.41	1.41	100.000
2005	81 317.00	73 185 300.00	73 184 904.00	1.44	1.44	99.999
2006	78 681.12	70 813 008.00	70 813 008.00	1.39	1.39	100.00
2007	88 935.40	80 041 860.00	80 041 860.00	1.57	1.57	100.00
2008	87 736.95	78 963 255.00	78 963 255.00	1.55	1.55	100.00
2009	77 058.45	69 352 605.00	69 352 605.00	1.36	1.36	100.00
2010	86 873.00	78 185 700.00	78 185 700.00	1.54	1.54	100.00

6.6.2.7 Source specific planned improvements

The planned improvements for the next submission are in the direct soil emissions of N_2O and the N_2O emissions from manure management. The share of animal waste management system according to animal categories will be updated with using the information from regional statistics. The direct N_2O emissions from soils will be recalculated according to new research knowledge in agro-climatic regionalisation in the Slovak Republic. Based on this approach, the first outputs from the DNDC model are known. The direct measurements of N_2O soil emissions to adjust model are planned for the international project of the Agricultural University in Nitra (Slovak Republic).

6.6.3 Source category description – Animal manure applied to soil (CRF 4.D.1.2)

As domestic livestock produce different kind of nitrogen inputs (liquid or dry) 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.

6.6.3.1 Methodological issues – methods

The direct inputs of nitrogen slightly vary according to the applied methodology. Based on the IPCC GL 1996 (Method A)[16] higher inputs of nitrogen from animal excreta can be estimated (in average higher by about 5%) as compared with detailed method based on the IPCC GPG 2000 (Method B).[17]

Total nitrogen excretion per liquid (14 006 t/N/year) and solid system (37 201 t/N/year) in manure management in 2011 were used for the estimation of total nitrogen input of manure applied to soils.

6.6.3.2 Methodological issues – emission factors and other parameters

Calculated amount of nitrogen input from animal waste applied to soils was 40 965.20 t/N/year (liquid and solid systems) and default EF was 0.0125 kg N_2O-N/kgN. Total amount of N_2O emissions from animal excreta applied to soils was 0.80 Gg in 2011.

Table 6.16: *Input parameters and EF in category 4.D.1.2 Animal manure applied to soils in 1990 – 2011*

Category 4.D.1.2 Animal Manure Applied to Soils					
Year	**N-input from Liquid System**	**N-input from Solid System**	**N-input from Manure to Soils**	**EF (N_2O)**	**N_2O Emissions**
	(kg/year)	(kg/year)	(kg/year)	(kg N_2O-N/kg N)	(Gg)
1990	40 369 536	97 131 911	110 001 157	0.0125	**2.161**
1991	36 787 859	98 213 383	108 000 993	0.0125	**2.121**
1992	34 656 493	84 315 964	95 177 965	0.0125	**1.870**
1993	31 832 436	72 967 375	83 839 849	0.0125	**1.647**
1994	31 114 025	68 085 495	79 359 616	0.0125	**1.559**
1995	31 198 641	71 831 044	82 423 747	0.0125	**1.619**
1996	30 491 919	66 163 432	77 324 281	0.0125	**1.519**
1997	28 425 135	60 628 361	71 242 797	0.0125	**1.399**
1998	25 268 331	53 158 440	62 741 417	0.0125	**1.232**
1999	24 477 446	50 245 947	59 778 715	0.0125	**1.174**
2000	23 227 965	49 039 452	57 813 934	0.0125	**1.136**
2001	24 077 041	49 142 386	58 575 542	0.0125	**1.151**
2002	25 408 785	26 604 866	41 610 921	0.0125	**0.817**
2003	24 792 408	29 975 692	43 814 480	0.0125	**0.861**
2004	23 717 970	24 510 805	38 583 020	0.0125	**0.758**
2005	22 841 385	24 785 599	38 101 587	0.0125	**0.748**
2006	22 920 857	22 919 858	36 672 572	0.0125	**0.720**
2007	20 648 769	24 792 386	36 352 923	0.0125	**0.714**
2008	16 313 083	27 002 747	34 652 664	0.0125	**0.681**
2009	17 622 793	37 814 372	44 349 732	0.0125	**0.871**
2010	16 508 501	37 607 276	43 292 622	0.0125	**0.850**
2011	14 005 848	37 200 656	40 965 203	0.0125	**0.805**

6.6.3.3 Activity data

Activity data are summarized in Table 6.16.

[16] Method A: nitrogen input was calculated for animal categories of domestic livestock according to IPCC Methodology[12] cattle (dairy and others), pigs, sheep, goats, horses, and poultry, 1996.

[17] Method B: the more detailed values for calculation of N_2O emissions were used, when categories of domestic livestock per year for other cattle were supposed.

6.6.3.4 Uncertainties and time-series consistency

Tier 1 uncertainty was included in total uncertainty assessment. Time series consistency is ensured.

6.6.3.5 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 6.2.6 of this Report.

6.6.3.6 Source specific recalculations

In previous submission Slovakia reported a value of 70% for amount of nitrogen input to soil from AWMS in the subcategory 4.D.1.2 (Table 6.16 of the NIR and CRF table 4.D). This approach was based on the national methodology, which assumes the 20% of nitrogen lost by evaporation (according to IPCC methodology) and additional 10% of nitrogen lost by leaching during the winter period. Because of shortage of storage capacities, those manures are applied onto soils out of growing season (especially during late autumn, winter and early spring) without plugging or injection into soil. This practice leads to increased surface outflow of nitrogen (leading to eutrophication of water). Therefore, the nitrogen from manure management coming into soil is reduced by about additional 10 % (Bielek, P.: Dusík v poľnohospodárskych pôdach Slovenska, Bratislava 1998, 256s). Therefore the fraction coming into soil was not 0.8, but 0.7.

During the period available for preparing our response to the Saturday Paper it was not enough time to discuss this issue in deep with our waste sector experts and detailed scientific evidence of our national methodology. Therefore, for revised emission estimation in this category we have applied the IPCC 2000 GPG default methodology and the coefficient of 20% of nitrogen lost by evaporation. Revised emission estimates are given in the Table 6.17. This is improvement implemented based on the recommendation of the ERT (ARR 2012, Para 103 - 106).

Table 6.17: *The revised emission estimation in the category 4.D.1.2 as submitted on 15 November 2012 and the comparison with the previous submission (April 2012)*

Year	N applied to soil		Emissions	
	Submission 2012	Submission 2013	Submission 2012	Submission 2013
	(kg N)		(Gg N_2O)	
1990	104 032 772.67	110 001 157.33	2.04	2.16
1991	94 500 869.17	108 000 993.33	1.86	2.12
1992	83 280 719.67	95 177 965.33	1.64	1.87
1993	73 359 868.17	83 839 849.33	1.44	1.65
1994	69 439 664.00	79 359 616.00	1.36	1.56
1995	72 120 779.02	82 423 747.45	1.42	1.62
1996	67 658 745.68	77 324 280.77	1.33	1.52
1997	62 304 378.44	71 242 797.33	1.22	1.40
1998	55 060 511.54	62 741 416.67	1.08	1.23
1999	52 722 925.29	59 778 714.80	1.04	1.17
2000	51 110 797.78	57 813 934.00	1.00	1.14
2001	50 496 740.95	58 575 542.00	0.99	1.15
2002	51 011 336.67	41 610 920.88	1.00	0.82
2003	49 622 205.43	43 814 479.76	0.97	0.86
2004	46 645 444.19	38 583 020.11	0.92	0.76
2005	45 024 778.79	38 101 586.85	0.88	0.75
2006	44 407 616.33	36 672 571.94	0.87	0.72
2007	42 339 911.08	36 352 923.38	0.83	0.71
2008	38 446 651.78	34 652 664.28	0.76	0.68
2009	38 806 015.89	44 349 732.44	0.76	0.87
2010	37 881 044.15	43 292 621.88	0.74	0.85

6.6.3.7 Source specific planned improvements

Further research and development of national emission factors are included in the list of the improvements for the next submissions.

6.6.4 Source category description – N-Fixing crops (CRF 4.D.1.3)

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 620.0 Gg in 1990 to 500.0 Gg in 1995). During recent years the inputs of nitrogen into soils were stabilized on the level of 350.0 Gg per year.

6.6.4.1 Methodological issues – methods

Country-specific methodology is used for this emission source based on the national research study and therefore no Frac parameter is used (notation key NA is used in the CRF). Nitrogen inputs from symbiotic fixation are within the range of 20 – 30 kg/ha (Bielek 1998), but there are enough reasons to accept an experimental value 26 kg N/ha. Details for the estimation of total input of nitrogen from N-fixing residuals were recalculated according to the data obtained from direct measurement (Jurcova, 2000) at national conditions and recalculated for the growing areas of N-fixing crops and average harvest.

6.6.4.2 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 decreased and were 85 600 ha in 2010 due to decreasing of area of peas, been, soya and lens. On the other hand, the area of fodder N-fixing crops increased. The direct inputs of nitrogen from N-fixing crops (lower than in previous year) were 18 686 t N in 2011. The crop residuals from the previous year were the base 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 0.0125 kg N_2O-N/kg N and total N_2O emissions from N-fixing crops were 0.37 Gg including biologic fixation in 2011.

6.6.4.3 Activity data

Total N_2O emissions from N–fixing crops (residuals + biologic fixation) were 0.37 Gg in 2011. 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 (approximately 0.35 Gg). This fact documents an abnormal intake of nutrients from soils what 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 6.18: *Crops characteristics in category 4.D.1.3 N-Fixing crops in 2011*

Crop	Area of N-Fixing Crops	Harvested Residuals	Content of N in Dry Matter	Nitrogen in Soil	Nitrogen Fixed
	(ha)	(t/ha)	(%)	(kg/ha)	Total (kg)
Peas	3 771.52	6.51	1.66	0.11	407.57
Lens	690.59	7.00	2.42	0.17	116.99
Beans	298.73	7.00	2.96	0.21	61.90
Mix of fodder beans and cereals	3 649.61	10.94	2.96	0.32	1 181.83
Soybeans	19 838.58	3.44	4.19	0.14	2 859.45
Alfalfa	49 461.31	7.00	2.42	0.17	8 378.75
Clover	7 890.05	6.00	1.97	0.12	932.60
Other Fodder Crops*	40 156.21	6.00	1.97	0.12	4 746.46
Total SR	**85 600.39**				**18 685.55**

**permanent (not including in total harvested area)*

Table 6.19: *Input parameters and EF in category 4.D.1.3 N-Fixing crops in 1990 – 2011*

Category 4.D.1.3 N-Fixing Crops				
Year	**Area of N-Fixing Crops**	**Nitrogen Fixed by N-Fixing Crops**	**EF (N_2O)**	**N_2O Emissions**
	(ha)	(kg/year)	(kg N_2O-N/kg N)	(Gg)
1990	193 412	31 551 835	0.0125	**0.620**
1991	200 889	30 843 953	0.0125	**0.606**
1992	215 542	31 138 436	0.0125	**0.612**
1993	198 563	32 272 384	0.0125	**0.634**
1994	172 386	29 211 274	0.0125	**0.574**
1995	156 809	25 815 160	0.0125	**0.507**
1996	140 056	23 645 793	0.0125	**0.464**
1997	124 154	21 255 833	0.0125	**0.418**
1998	112 960	18 837 557	0.0125	**0.370**
1999	112 793	17 952 705	0.0125	**0.353**
2000	100 886	17 542 586	0.0125	**0.345**
2001	94 616	15 732 782	0.0125	**0.309**
2002	92 572	14 511 772	0.0125	**0.287**
2003	92 028	14 169 250	0.0125	**0.278**
2004	88 371	14 285 517	0.0125	**0.281**
2005	90 577	14 163 138	0.0125	**0.278**
2006	81 036	15 884 972	0.0125	**0.312**
2007	99 136	22 711 071	0.0125	**0.446**
2008	82 893	19 305 014	0.0125	**0.379**
2009	88 717	20 344 762	0.0125	**0.400**
2010	89 716	19 508 495	0.0125	**0.383**
2011	85 600	18 685 555	0.0125	**0.367**

6.6.4.4 Uncertainties and time-series consistency

Tier 1 uncertainty was included in total uncertainty assessment. Time series consistency is ensured.

6.6.4.5 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 6.2.6 of this Report.

6.6.4.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

6.6.4.7 Source specific planned improvements

No improvements are planned at the moment.

6.6.5 Source category description – Crop residue (CRF 4.D.1.4)

Directly after incorporation of the crop residuals into the soil, the multilateral interactions between organic compounds and nutrients presented in the residuals with the mineral and organic components of soil take place. The knowledge of nutrient potential in crop residuals by crop rotation are mostly actual in the in the present requirements of biologicalisation in plant production.

6.6.5.1 Methodological issues – methods

Country-specific methodology is used for this emission source based on the national research study and therefore no Frac parameter is used (notation key NA is used in the CRF). During the period of 1986 – 1997, the crop and root residuals 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 residuals were abstracted from the same field as root residuals directly after root take off. According to the applied methodology, crop residuals as well as symbiotic fixation depend on the acreage of field crops and leguminous. Nitrogen input from crop residuals varies round about the value of 70 kt per year. Nitrogen in crop residuals of different categories was determined from the results of field trial of the Research Institute of Plant Production (Jurcova, 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 residuals fluctuates mostly upon the dependence of genetic plant attributes and the level of agro technique in primary fertilization. The content of nitrogen can differ in the residuals 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 residuals and root residuals 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 residuals 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 6.20 and 6.21 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 residuals 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 GPG 2000, the basic information on nitrogen input into soil from crop residuals 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 other) 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 is only crop yield taking into account they are not included into the calculation of N_2O emissions. Therefore, the acreage of field crops and the national data on nitrogen content in crop residuals 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.

6.6.5.2 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) was decreased again in comparison with the previous year and was 1 100 327 ha in 2010 and the direct inputs of nitrogen from crop residuals were 67 037 t in 2011. The crops residuals from previous year (2010) were the base for the calculation of N_2O emissions in current inventory year (according to the country specific methodology). The used default emission factor was 0.0125 kg N_2O-N/kg N and total N_2O emissions from crops residuals were 1.33 Gg in 2011.

Table 6.20: *Growing areas and total nitrogen amount of crops and leguminous in 2011*

Crop		Average nitrient potential of crop residuals	Area of Crops	Nitrogen Fixed Total
		(kg N/ha)	(ha)	(t)
Cereals	**Wheat**	52.50	364 047.17	16 513.18
	Ray	45.00	13 357.65	368.78
	Barley	44.00	136 324.98	4 925.01
	Oat	55.00	16 157.77	630.15
	Maize	39.00	193 813.36	9 171.25
Potato		59.00	10 406.25	708.42
Sugar beet		20.00	18 100.00	305.38
Oil plants		107.00	261 638.96	28 780.29
Tobacco		45.00	16.41	1.09
Fodder crops		59.00	405.33	6.84
Maize for silage		55.00	86 059.15	5 626.55
Total SR			**1 100 327.03**	**67 036.93**

Table 6.21: *Input parameters and EF in category 4.D.1.4 Crop residue in 1990 – 2011*

Category 4.D.1.4 Crop Residue				
Year	**Cropland Acreage**	**Nitrogen in Crop Residues Returned to Soils**	**EF (N_2O)**	**N_2O Emissions**
	(ha)	(kg/year)	(kg N_2O-N/kg N)	(Gg)
1990	1 184 531	60 830 021	0.0125	**1.195**
1991	1 188 937	61 516 525	0.0125	**1.208**
1992	1 183 686	62 622 894	0.0125	**1.230**
1993	1 153 657	59 315 948	0.0125	**1.165**
1994	1 159 134	60 438 162	0.0125	**1.187**
1995	1 184 530	62 660 737	0.0125	**1.231**
1996	1 196 868	65 478 104	0.0125	**1.286**
1997	1 185 919	65 288 400	0.0125	**1.282**
1998	1 202 413	65 901 472	0.0125	**1.294**
1999	1 179 262	65 304 595	0.0125	**1.283**
2000	1 139 329	67 699 850	0.0125	**1.330**
2001	1 149 184	65 794 680	0.0125	**1.292**
2002	1 152 764	66 682 980	0.0125	**1.310**
2003	1 156 021	67 689 915	0.0125	**1.330**
2004	1 144 607	66 891 845	0.0125	**1.314**
2005	1 149 857	66 599 880	0.0125	**1.308**
2006	1 116 456	66 271 980	0.0125	**1.302**
2007	1 139 880	68 148 673	0.0125	**1.339**
2008	1 150 765	69 769 371	0.0125	**1.370**
2009	1 135 231	70 104 998	0.0125	**1.377**
2010	1 086 340	67 415 585	0.0125	**1.324**
2011	1 100 327	67 036 931	0.0125	**1.334**

6.6.5.3 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 been, 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 residuals started in 1989 because of mineralization rate. It is supposed that crop residuals 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 is only crop yield taking into account they are not included into the calculation of N_2O emissions. Therefore the acreage of field crops and national data about nitrogen content in crop residuals look as more representative data for calculation procedure,
- 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 6.22: Nutrition potential in crop residuals in kg of nitrogen per hectare according to the study of the Research Institute of Plant Production (Jurcova, 2000)

Crop	**Average nitrient potential of crop residuals** (kg N/ha)	**Crop**	**Average nitrient potential of crop residuals** (kg N/ha)	**Crop**	**Average nitrient potential of crop residuals** (kg N/ha)	**Crop**	**Average nitrient potential of crop residuals** (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 Peas	115 112	Maize for Silage	55	Grassland in 2nd year	113	Spring Barley	60

6.6.5.4 Uncertainties and time-series consistency

Tier 1 uncertainty was included in total uncertainty assessment. Time series consistency is ensured.

6.6.5.5 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 6.2.6 of this Report.

6.6.5.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

6.6.5.7 Source specific planned improvements

No improvements are planned at the moment.

6.6.6 Source category description – Cultivation of histosols (CRF 4.D.1.5)

No emissions from the category 4.D.1.5 Cultivation of histosols occurred in the Slovak Republic in 2010. The total area of protected histosols is 4 893 ha.

6.6.7 Source category description – Pasture, range and paddock manure (CRF 4.D.2)

Production of slurries is typical for domestic livestock in category pig. 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 of Animal Production in Nitra (Brestenský, 1998).

6.6.7.1 Methodological issues – methods

It is supposed that sheep, goats and horses can stay at pasture 200 days a year, 40% of dairy cattle stay only 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 since April to October is frequent for sheep, goats and horses. The duration of grazing period can vary significantly depending on weather conditions in different part of the Slovak Republic. Reliable data for statistical evaluation is not available, but significant differences can be found in this regard.

6.6.7.2 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 and N_{ex} per AWMS estimated by manure management category. Total nitrogen from animals in AWMS was 9 460 t in 2011. Total emissions of N_2O from pasture of animals were 0.297 Gg of N_2O in 2011. The trend of pasture, range and paddocks is almost stable from 1998.

6.6.7.3 Activity data

Activity data in this category are in consistency with the activity data in category 4B(b) Manure management (Table 6.11). Table 6.23 shows time series of parameters and emissions.

Table 6.23: *Input parameters and EF in category 4.D.2 Pasture, range and paddock in 1990 – 2011*

Category 4.D.2 Pasture. Range and Paddock Manure			
Year	**N Excretion on Pasture**	**EF (N_2O)**	**N_2O Emissions**
	(kg)	(kg N_2O-N/kg N)	(Gg)
1990	22 756 500	0.020	**0.715**
1991	20 467 550	0.020	**0.643**
1992	18 516 600	0.020	**0.582**
1993	15 350 050	0.020	**0.482**
1994	14 386 850	0.020	**0.452**
1995	14 993 026	0.020	**0.471**
1996	14 096 600	0.020	**0.443**
1997	13 196 067	0.020	**0.415**
1998	11 656 914	0.020	**0.366**
1999	11 400 197	0.020	**0.358**
2000	11 319 047	0.020	**0.356**
2001	10 628 152	0.020	**0.334**
2002	10 531 663	0.020	**0.331**
2003	10 321 652	0.020	**0.324**
2004	9 770 089	0.020	**0.307**
2005	9 664 808	0.020	**0.304**
2006	9 485 237	0.020	**0.298**
2007	9 528 819	0.020	**0.299**
2008	9 511 754	0.020	**0.299**
2009	9 421 677	0.020	**0.296**
2010	9 541 240	0.020	**0.300**
2011	9 460 054	0.020	**0.297**

6.6.7.4 Uncertainties and time-series consistency

Tier 1 uncertainty was included in total uncertainty assessment. Time series consistency is ensured.

6.6.7.5 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 6.2.6 of this Report.

6.6.7.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

6.6.7.7 Source specific planned improvements

Further research and development of national emission factors are included in the list of improvements for the next submissions.

6.6.8 Source category description – Atmospheric deposition (CRF 4.D.3.1)

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 0.337 Gg in 2011 which is more than 60% below 1990.

6.6.8.1 Methodological issues – methods

IPCC default methodology tier 1 and default emissions factors were used for estimation indirect N_2O emissions from atmospheric deposition.

6.6.8.2 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 (0.01 kg N_2O-N/kg N) was used during the time series. It was assumed, that 10% of nitrogen input from synthetic fertilizers is applied to volatilize (NH_3 and NO_x) in soil and 20% of nitrogen from manure is volatilized in soils.

6.6.8.3 Activity data

Volatized nitrogen (NH_3 and NO_x) from synthetic fertilizers and animal wastes was 21 430 t N in 2011. Activity data in this category are in consistency with the activity data in categories synthetic fertilizers and animal manure applied to soil 4.D.1.1 and 4.D.1.2. Table 6.24 shows the time series of parameters and emissions.

Table 6.24: *Input parameters and EF in category 4.D.3.1 Atmospheric deposition in 1990 – 2011*

Category 4.D.3.1 Atmospheric Deposition					
Year	**Volatilized N from Synthetic Fertilizers**	**Volatilized N from Animal Manure**	**Total Volatilized N**	**EF (N_2O)**	**N_2O Emissions**
	(kg)	(kg)	(kg)	(kg N_2O-N/kg N)	(Gg)
1990	22 225 500	34 274 949	56 500 449	0.010	**0.888**
1991	14 634 100	31 093 758	45 727 858	0.010	**0.719**
1992	9 018 600	27 497 811	36 516 411	0.010	**0.574**
1993	6 485 200	24 029 972	30 515 172	0.010	**0.480**
1994	6 866 900	22 717 274	29 584 174	0.010	**0.465**
1995	6 958 700	23 604 542	30 563 242	0.010	**0.480**
1996	7 446 400	22 150 390	29 596 790	0.010	**0.465**
1997	8 801 668	20 440 464	29 242 132	0.010	**0.460**
1998	8 184 252	18 062 957	26 247 209	0.010	**0.412**
1999	6 539 262	17 343 732	23 882 994	0.010	**0.375**
2000	7 265 346	16 866 894	24 132 240	0.010	**0.379**
2001	7 603 182	16 553 271	24 156 453	0.010	**0.380**
2002	8 825 968	16 681 000	25 506 968	0.010	**0.401**
2003	8 129 958	16 242 103	24 372 061	0.010	**0.383**
2004	7 991 081	15 281 288	23 272 369	0.010	**0.366**
2005	8 131 656	14 797 184	22 928 840	0.010	**0.360**
2006	7 868 112	14 584 938	22 453 050	0.010	**0.353**
2007	8 893 540	14 002 881	22 896 421	0.010	**0.360**
2008	8 773 695	12 887 109	21 660 804	0.010	**0.340**
2009	7 705 845	12 971 769	20 677 614	0.010	**0.325**
2010	8 687 300	12 731 403	21 418 703	0.010	**0.337**
2011	9 296 900	12 133 312	21 430 212	0.010	**0.337**

6.6.8.4 Uncertainties and time-series consistency

Tier 1 uncertainty was included in total uncertainty assessment. Time series consistency is ensured.

6.6.8.5 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 6.2.6 of this Report.

6.6.8.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

6.6.8.7 Source specific planned improvements

Further research and development of national emission factors are included in the list of improvements for the next submissions.

6.6.9 Source category description – Nitrogen leaching and Run-off (CRF 4.D.3.2)

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 0.97 Gg in 2011 which is more than 50% below 1990.

6.6.9.1 Methodological issues – methods

IPCC default methodology tier 1 and default emissions factors were used for the estimation of indirect N_2O emissions from nitrogen leaching and run-off

6.6.9.2 Methodological issues – emission factors and other parameters

The IPCC default emission factor (0.025 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.

6.6.9.3 Activity data

Lost nitrogen (NH_3 and NO_x) from synthetic fertilizers and animal wastes through leaching and run-off was 24 730 t N in 2011. Activity data in this category are in consistency with the activity data in categories synthetic fertilizers and animal manure applied to soil 4.D.1.1 and 4.D.1.2. Table 6.25 shows time series of parameters and emissions.

Table 6.25: *Input parameters and EF in category 4.D.3.2 Nitrogen leaching and Run-off in 1990 – 2011*

Category 4.D.3.2 Nitrogen Leaching and Run-off					
Year	**Lost N from Synthetic Fertilizers**	**Lost N from Animal Manure**	**Total Lost N**	**EF (N_2O)**	**N_2O Emissions**
	(kg)	(kg)	(kg)	(kg N_2O-N/kg N)	(Gg)
1990	31 115 700	28 004 130	59 119 830	0.025	**2.323**
1991	20 487 740	18 438 966	38 926 706	0.025	**1.529**
1992	12 626 040	11 363 436	23 989 476	0.025	**0.942**
1993	9 079 280	8 171 352	17 250 632	0.025	**0.678**
1994	9 613 660	8 652 294	18 265 954	0.025	**0.718**
1995	9 742 180	8 767 962	18 510 142	0.025	**0.727**
1996	10 424 960	9 382 464	19 807 424	0.025	**0.778**
1997	12 322 335	11 090 102	23 412 437	0.025	**0.920**
1998	11 457 953	10 312 158	21 770 110	0.025	**0.855**
1999	9 154 967	8 239 470	17 394 437	0.025	**0.683**
2000	10 171 484	9 154 336	19 325 820	0.025	**0.759**
2001	10 644 455	9 580 009	20 224 464	0.025	**0.795**
2002	12 356 355	11 120 720	23 477 075	0.025	**0.922**
2003	11 381 941	10 243 747	21 625 688	0.025	**0.850**
2004	11 187 513	10 068 762	21 256 275	0.025	**0.835**
2005	11 384 318	10 245 887	21 630 205	0.025	**0.850**
2006	11 015 357	9 913 821	20 929 178	0.025	**0.822**
2007	12 450 956	11 205 860	23 656 816	0.025	**0.929**
2008	12 283 173	11 054 856	23 338 029	0.025	**0.917**
2009	10 788 183	9 709 365	20 497 548	0.025	**0.805**
2010	12 162 220	8 911 982	21 074 202	0.025	**0.908**
2011	13 015 660	8 493 318	24 729 754	0.025	**0.972**

6.6.9.4 Uncertainties and time-series consistency

Tier 1 uncertainty was included in total uncertainty assessment. Time series consistency is ensured.

6.6.9.5 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 6.2.6 of this Report.

6.6.9.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

6.6.9.7 Source specific planned improvements

Further research and development of national emission factors are included in the list of improvements for the next submissions.

6.7 Prescribed Burning of Savannas (CRF 4.E)

The category Prescribed burning of savannas 4.E is not occurring in the Slovak Republic.

6.8 Field Burning of Agricultural Residues (CRF 4.F)

This form of cultivation is strictly prohibited by law in the Slovak Republic. No emissions from this category were estimated.

CHAPTER 7: LULUCF (CRF 5)

7.1 Overview of sector (CRF 5)

The Forestry and Land use sector covers the wide range of biological and technical processes within the landscape, which influence 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. 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 most importance due to their coverage of the Slovak territory which represents more than 90% of the whole territory. These processes connected with 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 landscape. This category covers all three main GHGs and basic pollutants. Beside this the inventory covers the estimation of CO_2 emissions from the agricultural lime application.

The LULUCF sector with net removals -7 467.26 Gg of CO_2 equivalents in 2011 is very important sector and comprises several key categories. The major share represents CO_2 removals (-7 507.68 Gg) with the contributions of following categories: Forest land with removals of -6 567.96 Gg CO_2, Cropland with removals of -758.15 Gg CO_2, Grassland with removals of -384.27 Gg CO_2, Settlements with the emissions of 81.02 Gg CO_2 and Other land with the emissions of 121.68 Gg CO_2. Total methane emissions were 1.08 Gg and total N_2O emissions were 0.06 Gg from LULUCF sector in 2011. N_2O emissions from the disturbance associated with the land-use conversion to Cropland were reported for the first time in this submission. The emissions of other pollutants originate from forest fires and controlled burning of forest. The estimated amount of NOx emissions was 0.53 Gg and the estimated amount of CO emissions was 9.41 Gg in 2011.

Table 7.1: *Summary of total emissions and removals according to the categories in 2011*

	Net CO_2		CH_4	N_2O	NO_x	CO
	Emissions/Removals		Emissions			
	(Gg)					
5. LULUCF	**NO**	**-7 507.68**	**1.08**	**0.06**	**0.53**	**9.41**
A. Forest Land	NO	-6 567.96	1.08	0.01	0.53	9.41
B. Cropland	NO	-758.15	NO	0.04	NO	NO
C. Grassland	NO	-384.27	NO	NO	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO
E. Settlements	81.02	NO	NO	NO	NO	NO
F. Other Land	121.68	NO	NO	NO	NO	NO

Figure 7.1: *CO_2 emission and removal balance (in Gg) according to the LULUCF land use categories except Forest Land in 1990 – 2011*

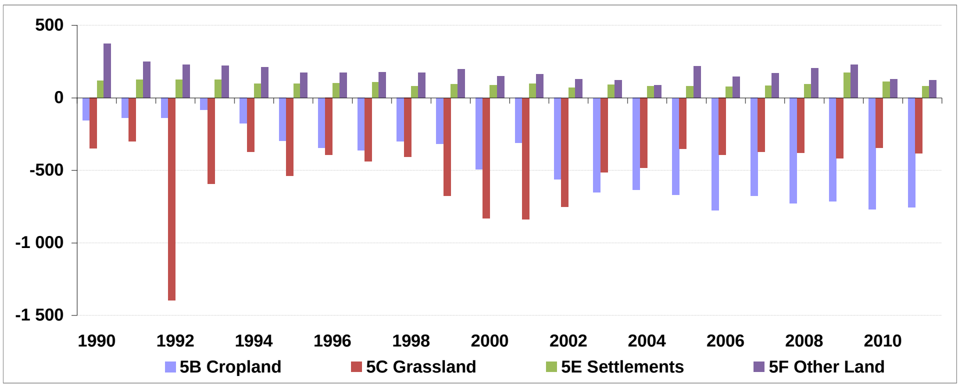
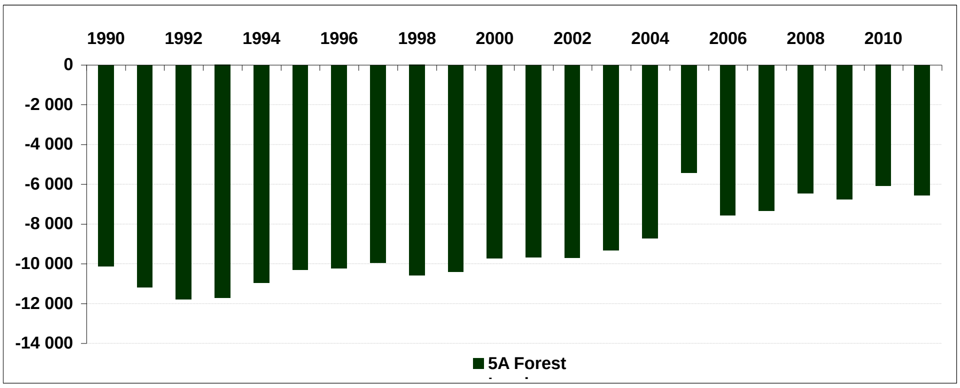


Table 7.2: *Summary of GHG emissions and removals (in Gg) according to the categories in 1990 – 2011*

Year	Net CO_2						CH_4	N_2O
	(Gg)							
	Forest land	Cropland	Grassland	Settlements	Other land	LULUCF		
1990	-10 128.02	-154.70	-350.08	119.66	374.05	-10 139.10	0.6710	0.3416
1991	-11 180.20	-140.61	-298.22	124.62	249.26	-11 245.16	0.4270	0.3022
1992	-11 771.60	-139.91	-1 397.74	124.91	229.14	-12 955.21	0.3820	0.3585
1993	-11 726.31	-81.52	-594.09	124.13	222.68	-12 055.11	0.3860	0.3672
1994	-10 946.08	-178.11	-370.99	96.75	211.78	-11 186.65	0.4060	0.2633
1995	-10 289.48	-298.65	-538.52	96.18	173.26	-10 857.21	0.4550	0.2229
1996	-10 229.65	-344.15	-394.43	101.30	172.07	-10 694.86	0.4870	0.2241
1997	-9 950.97	-364.15	-438.38	108.60	177.69	-10 467.21	0.5370	0.1819
1998	-10 591.65	-302.89	-408.03	77.78	173.71	-11 051.09	0.5370	0.1573
1999	-10 410.79	-316.09	-674.64	92.88	198.25	-11 110.39	0.6097	0.1553
2000	-9 709.10	-495.41	-831.65	87.55	149.23	-10 799.38	0.5597	0.2379
2001	-9 668.77	-312.12	-836.66	97.87	163.63	-10 556.05	0.6797	0.1100
2002	-9 691.76	-563.46	-752.22	70.52	129.03	-10 807.89	0.6687	0.0923
2003	-9 326.20	-651.65	-514.51	89.29	120.53	-10 282.55	0.7197	0.0973
2004	-8 724.02	-636.05	-484.44	78.17	87.87	-9 678.47	0.8190	0.0901
2005	-5 425.88	-669.68	-352.10	78.51	217.76	-6 151.39	1.0685	0.0840
2006	-7 552.28	-775.30	-393.92	76.45	146.39	-8 498.64	0.9000	0.0690
2007	-7 340.48	-678.55	-373.10	82.31	168.93	-8 140.88	0.8922	0.0798
2008	-6 445.05	-728.83	-377.76	91.94	204.51	-7 255.18	1.0025	0.0500
2009	-6 749.11	-715.67	-417.04	172.67	230.52	-7 478.64	0.9888	0.0658
2010	-6 083.18	-768.31	-344.35	111.65	128.25	-6 955.94	1.0911	0.0577
2011	-6 567.96	-758.15	-384.27	81.02	121.68	-7 507.68	1.0754	0.0575

Figure 7.2: *CO_2 removal balance (in Gg) of the Forest Land category in 1990 – 2011*



7.2 Activity data

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 LULUCF sector have remained at the level of 8-10% of total GHG emissions. Historically stable trend was disrupted in 2004 by the wind calamity in the High Tatras, which resulted in increased harvest of wood damaged by the calamity and pests and consequently in the decrease of total sinks to the half of previous volumes. The identification of land-use categories is based on key data source represented by areas data from the Geodesy, Cartography and Cadastre Authority of the Slovak Republic (GCCA). This institute 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 http://www.skgeodesy.sk/sk/ugkk/kataster-nehnutelnosti/sumarne-udaje-katastra-podnom-fonde/. The GCCA database distinguishes ten land categories, six of them belonging to 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 IPCC GPG for LULUCF 2003 and in the IPCC GL for AFOLU 2006. The Slovak Republic used for the reporting of GHG emissions and removals in the LULUCF sector following land use definitions:

Forest Land

This category includes the land covered by all tree species serving for the fulfillment 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 timber land.

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 into 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 arable land. This category also includes fallow land which is arable land left for regeneration for one growing season. During this period there were not sown another crops or just crops for green manure, eventually it is covered by spontaneous vegetation, which would be used as a mess or plough under.

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

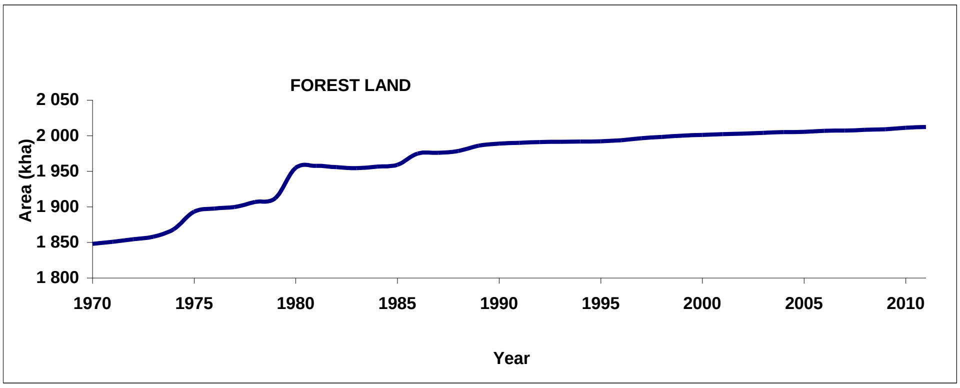
This category represents the last of land use categories in the Slovak Republic. Other land is represented by bare soil, rock and all unmanaged land areas that do not fall into any of the other categories. Each of these categories is divided into lands remaining in the given category during the inventory year, and land converted into the category from different one. The areas of six land use categories remaining in each category are in Table 7.3.

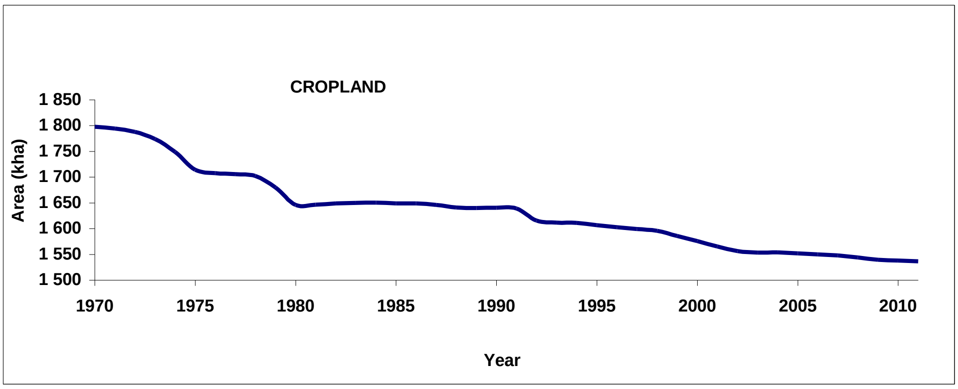
Table 7.3: The areas (kha/year) of land-use categories remaining into category since 1990

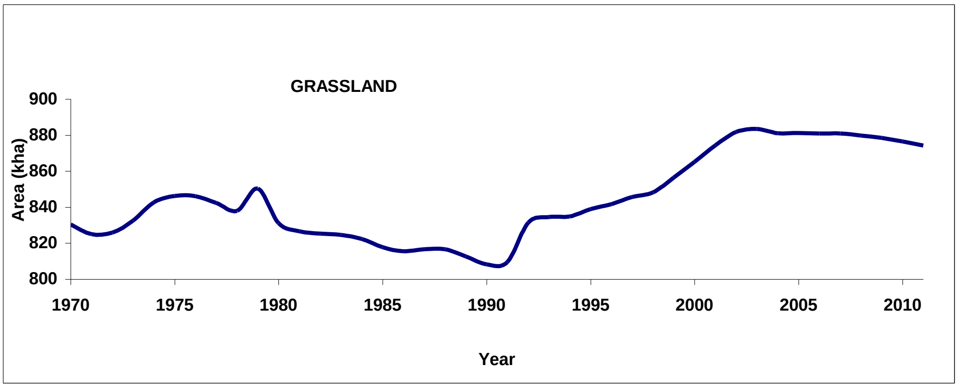
Year	Area (kha)				
	5A1 FL remaining FL	5B1 CL remaining CL	5C1 GL remaining GL	5E1 S remaining S	5F1 OL remaining OL
1990	1 809.15	1 492.51	685.50	97.22	193.00
1991	1 813.81	1 500.65	688.06	96.71	194.42
1992	1 817.65	1 481.64	692.80	98.39	195.15
1993	1 822.29	1 480.78	702.77	99.63	197.60
1994	1 833.68	1 486.74	718.89	101.37	200.08
1995	1 861.77	1 502.51	741.05	103.38	205.46
1996	1 868.44	1 506.22	746.36	104.93	139.05
1997	1 873.39	1 512.60	750.97	105.77	115.93
1998	1 881.17	1 517.93	754.52	106.80	117.16
1999	1 887.29	1 512.52	769.80	108.30	120.82
2000	1 929.76	1 517.74	767.08	110.44	130.45
2001	1 935.71	1 513.56	765.63	112.12	128.92
2002	1 938.38	1 508.66	765.14	113.18	129.28
2003	1 939.25	1 509.67	765.75	114.59	128.86
2004	1 942.12	1 511.55	762.70	115.40	129.28
2005	1 945.27	1 514.54	762.73	118.02	130.84
2006	1 962.09	1 517.88	763.27	119.96	129.92
2007	1 964.04	1 518.45	765.98	121.45	131.40
2008	1 968.41	1 517.92	767.70	123.01	133.26
2009	1 978.59	1 514.12	768.26	124.48	134.33
2010	1 982.03	1 512.31	766.66	123.58	133.58
2011	1 983.91	1 510.99	767.13	124.20	133.40

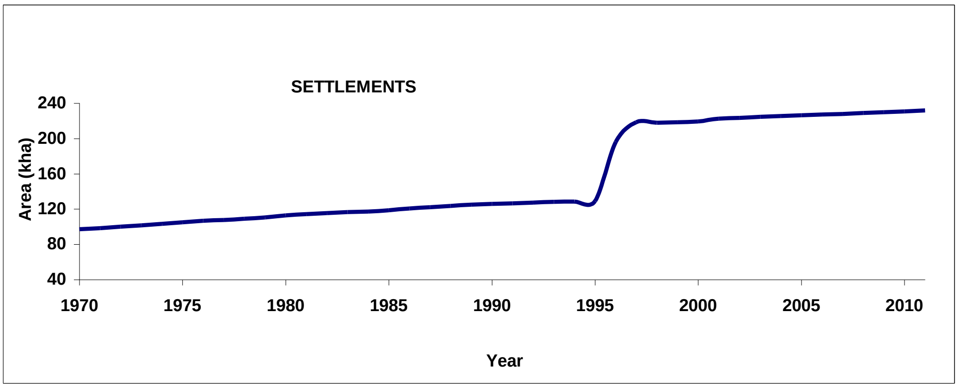
The increasing trend of forest land-use category is evident in the Slovak Republic since 1970. The opposite, decreasing trend of cropland land-use category was recorded at the same time. Grassland areas decreased from 1980 to beginning of 1990 and since this year increasing trend was recorded up to 2005. Since 2005 moderately downward trend has been taking place. Settlements land-use category has continual increasing trend during 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.

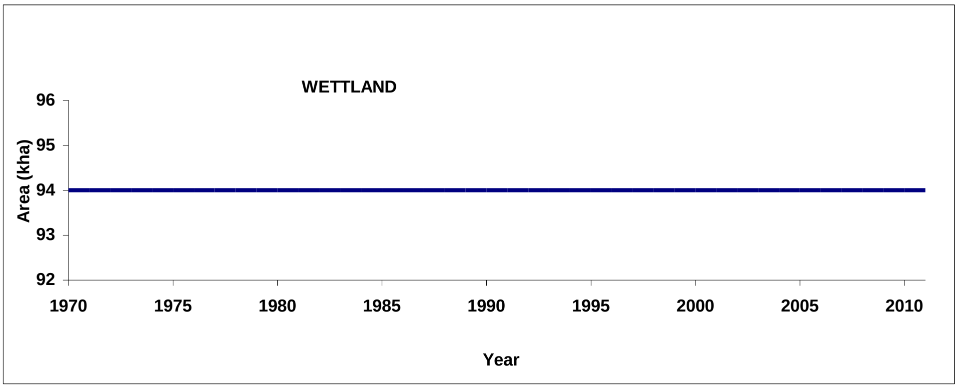
Figure 7.3: *Overall trends in the areas of the land-use categories from 1970 – 2011 (based on information from the GCCA of the Slovak Republic).*

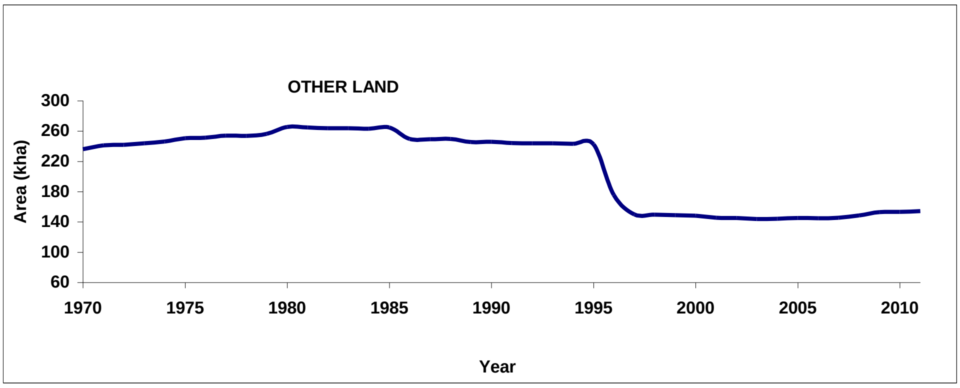



CROPLAND
Area (kha)
1 850
1 800
1 750
1 700
1 650
1 600
1 550
1 500
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


GRASSLAND
Area (kha)
900
880
860
840
820
800
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


SETTLEMENTS
Area (kha)
240
200
160
120
80
40
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


WETTLAND
Area (kha)
96
95
94
93
92
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year



The land-use matrixes shown in Table 7.4 represent the areas of land-use change among the major land use categories from 1990 to 2011 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 GPG for LULUCF 2003 for calculation of soil carbon stocks changes. The areas of biomass carbon pools are not the same as for the soil carbon one.

Table 7.4: *Land-use matrixes identified annual land-use conversions among the categories for the period 1990 – 2011 and describing initial and final areas of particular land-use categories*

Year 1990		**Initial (1989)**						**Area**
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (1990)	Forest Land	**1 985.22**	2.27	0.09	0.00	0.00	1.42	1 988.99
	Grassland	0.35	**807.18**	0.75	0.00	0.00	0.00	808.29
	Cropland	0.01	1.06	**1 639.28**	0.00	0.00	0.00	1 640.34
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.03	0.90	0.00	0.00	**125.11**	0.00	126.03
	Other Land	0.42	1.29	0.00	0.00	0.00	**244.15**	245.86
	Area (kha)	1 986.03	812.70	1 640.12	94.00	125.11	245.57	**4 903.52**
Year 1991		**Initial (1990)**						**Area**
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (1991)	Forest Land	**1 988.00**	0.33	0.01	0.00	0.00	1.63	1 989.96
	Grassland	0.68	**806.58**	2.22	0.00	0.00	0.00	809.48
	Cropland	0.05	0.94	**1 637.98**	0.00	0.00	0.17	1 639.14
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.08	0.36	0.13	0.00	**126.03**	0.00	126.59
	Other Land	0.19	0.09	0.00	0.00	0.00	**244.07**	244.35
	Area (kha)	1 988.99	808.29	1 640.34	94.00	126.03	245.86	**4 903.52**
Year 1992		**Initial (1991)**						**Area**
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (1992)	Forest Land	**1 989.64**	0.20	0.20	0.00	0.00	1.07	1 991.11
	Grassland	0.15	**808.49**	22.78	0.00	0.00	0.00	831.41
	Cropland	0.00	0.79	**1 614.94**	0.00	0.00	0.00	1 615.74
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.06	0.00	0.83	0.00	**126.59**	0.00	127.49
	Other Land	0.11	0.00	0.38	0.00	0.00	**243.28**	243.78
	Area (kha)	1 989.96	809.48	1 639.14	94.00	126.59	244.35	**4 903.52**
Year 1993		**Initial (1992)**						**Area**
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (1993)	Forest Land	**1990.74**	0.14	0.22	0.00	0.00	0.37	1991.46
	Grassland	0.18	**829.86**	4.60	0.00	0.00	0.00	834.63
	Cropland	0.00	0.98	**1610.38**	0.00	0.00	0.00	1611.36
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.07	0.27	0.29	0.00	**127.49**	0.16	128.27
	Other Land	0.12	0.17	0.26	0.00	0.00	**243.25**	243.80
	Area (kha)	1991.11	831.41	1615.74	94.00	127.49	243.78	**4903.52**

Year 1994		**Initial (1993)**						**Area**
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (1994)	Forest Land	**1 991.11**	0.31	0.02	0.00	0.00	0.23	1 991.67
	Grassland	0.19	**833.77**	0.87	0.00	0.00	0.00	834.83
	Cropland	0.01	0.55	**1 610.34**	0.00	0.00	0.29	1 611.20
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.03	0.00	0.13	0.00	**128.27**	0.04	128.46
	Other Land	0.13	0.00	0.00	0.00	0.00	**243.23**	243.36
	Area (kha)	1 991.46	834.63	1 611.36	94.00	128.27	243.80	**4 903.52**
Year 1995		**Initial (1994)**						**Area**
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (1995)	Forest Land	**1 991.54**	0.56	0.03	0.00	0.00	0.14	1 992.26
	Grassland	0.06	**833.33**	5.39	0.00	0.00	0.24	839.03
	Cropland	0.00	0.73	**1 605.79**	0.00	0.00	0.10	1 606.62
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.02	0.21	0.00	0.00	**128.46**	0.29	128.99
	Other Land	0.05	0.00	0.00	0.00	0.00	**242.58**	242.63
	Area (kha)	1 991.67	834.83	1 611.20	94.00	128.46	243.36	**4 903.52**
Year 1996		**Initial (1995)**						**Area**
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (1996)	Forest Land	**1 991.79**	1.11	0.11	0.00	0.00	0.36	1 993.37
	Grassland	0.28	**837.30**	4.02	0.00	0.00	0.12	841.71
	Cropland	0.10	0.61	**1 602.02**	0.00	0.00	0.00	1 602.73
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.03	0.00	0.47	0.00	**128.99**	66.65	196.14
	Other Land	0.06	0.00	0.00	0.00	0.00	**175.51**	175.57
	Area (kha)	1 992.26	839.03	1 606.62	94.00	128.99	242.63	**4 903.52**
Year 1997		**Initial (1996)**						**Area**
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (1997)	Forest Land	**1 992.98**	0.31	0.13	0.00	0.00	2.95	1 996.37
	Grassland	0.20	**840.19**	4.63	0.00	0.00	0.57	845.59
	Cropland	0.03	1.21	**1 597.80**	0.00	0.00	0.00	1 599.04
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.07	0.00	0.16	0.00	**196.14**	22.21	218.58
	Other Land	0.09	0.00	0.00	0.00	0.00	**149.84**	149.93
	Area (kha)	1 993.37	841.71	1 602.73	94.00	196.14	175.57	**4 903.52**
Year 1998		**Initial (1997)**						**Area**
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (1998)	Forest Land	**1 996.00**	0.85	0.07	0.00	0.00	1.38	1 998.28
	Grassland	0.29	**843.17**	4.72	0.00	0.00	0.00	848.19
	Cropland	0.00	1.58	**1 593.84**	0.00	0.00	0.00	1 595.41
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.00	0.00	0.00	0.00	**218.08**	0.00	218.08
	Other Land	0.08	0.00	0.42	0.00	0.50	**148.55**	149.55
	Area (kha)	1 996.37	845.59	1 599.04	94.00	218.58	149.93	**4 903.52**
Year 1999		**Initial (1998)**						**Area**
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (1999)	Forest Land	**1 997.99**	0.83	0.07	0.00	0.00	1.20	2 000.09
	Grassland	0.09	**846.28**	10.06	0.00	0.00	0.00	856.43
	Cropland	0.01	0.87	**1 584.93**	0.00	0.00	0.00	1 585.81
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.03	0.00	0.36	0.00	**218.04**	0.00	218.43
	Other Land	0.17	0.21	0.00	0.00	0.05	**148.35**	148.77
	Area (kha)	1 998.28	848.19	1 595.41	94.00	218.08	149.55	**4 903.52**

Year 2000	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	Area (kha)
		Initial (1999)						
Final (2000)	Forest Land	**1999.96**	0.69	0.10	0.00	0.00	0.50	2001.25
	Grassland	0.02	**852.98**	12.21	0.00	0.00	0.00	865.22
	Cropland	0.01	2.47	**1572.97**	0.00	0.00	0.00	1575.45
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.01	0.28	0.24	0.00	**218.43**	0.38	219.34
	Other Land	0.09	0.00	0.28	0.00	0.00	**147.89**	148.26
	Area (kha)	2000.09	856.43	1585.81	94.00	218.43	148.77	**4903.52**

Year 2001	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	Area (kha)
		Initial (2000)						
Final (2001)	Forest Land	**2 000.95**	0.42	0.01	0.00	0.00	0.74	2 002.13
	Grassland	0.10	**862.20**	12.11	0.00	0.00	0.00	874.42
	Cropland	0.04	2.60	**1 562.35**	0.00	0.00	0.00	1 564.99
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.04	0.00	0.60	0.00	**219.34**	2.50	222.48
	Other Land	0.12	0.00	0.36	0.00	0.00	**145.03**	145.51
	Area (kha)	2 001.25	865.22	1 575.45	94.00	219.34	148.26	**4 903.52**

Year 2002	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	Area (kha)
		Initial (2001)						
Final (2002)	Forest Land	**2 001.98**	0.51	0.01	0.00	0.00	0.28	2 002.77
	Grassland	0.06	**872.81**	8.98	0.00	0.00	0.00	881.86
	Cropland	0.01	1.09	**1 555.39**	0.00	0.00	0.00	1 556.49
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.02	0.00	0.14	0.00	**222.48**	0.72	223.36
	Other Land	0.06	0.00	0.46	0.00	0.00	**144.52**	145.04
	Area (kha)	2 002.13	874.42	1 564.99	94.00	222.48	145.51	**4 903.52**

Year 2003	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	Area (kha)
		Initial (2002)						
Final (2003)	Forest Land	**2 002.45**	1.11	0.05	0.00	0.00	0.49	2 004.10
	Grassland	0.19	**878.76**	4.56	0.00	0.00	0.00	883.51
	Cropland	0.01	1.99	**1 551.37**	0.00	0.00	0.00	1 553.37
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.07	0.00	0.38	0.00	**223.36**	0.87	224.67
	Other Land	0.06	0.00	0.13	0.00	0.00	**143.68**	143.87
	Area (kha)	2 002.77	881.86	1 556.49	94.00	223.36	145.04	**4 903.52**

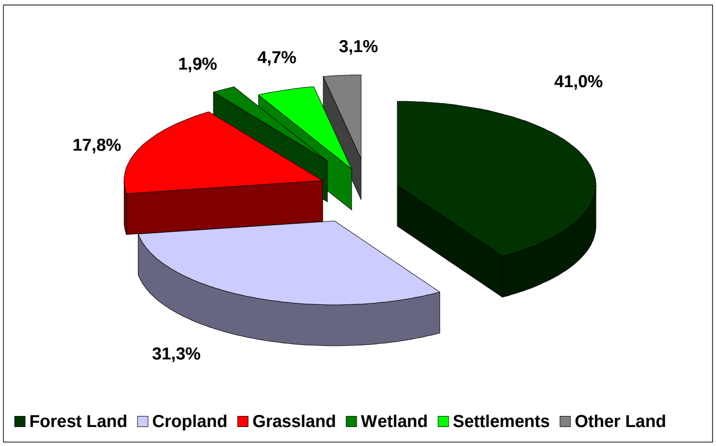
Year 2004	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	Area (kha)
		Initial (2003)						
Final (2004)	Forest Land	**2 004.08**	0.77	0.09	0.00	0.00	0.00	2 004.93
	Grassland	0.02	**878.88**	2.16	0.00	0.00	0.00	881.05
	Cropland	0.01	2.98	**1 550.71**	0.00	0.00	0.00	1 553.70
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.00	0.89	0.00	0.00	**224.67**	0.00	225.56
	Other Land	0.00	0.00	0.42	0.00	0.00	**143.87**	144.29
	Area (kha)	2 004.10	883.51	1 553.37	94.00	224.67	143.87	**4 903.52**

Year 2005	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	Area (kha)
		Initial (2004)						
Final (2005)	Forest Land	**2 004.39**	0.46	0.02	0.00	0.00	0.36	2005.23
	Grassland	0.22	**879.92**	1.15	0.00	0.00	0.00	881.28
	Cropland	0.02	0.68	**1 551.00**	0.00	0.00	0.00	1 551.70
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.04	0.00	0.60	0.00	**225.56**	0.06	226.26
	Other Land	0.26	0.00	0.93	0.00	0.00	**143.86**	145.05
	Area (kha)	2 004.93	881.05	1 553.70	94.00	225.56	144.29	**4 903.52**

Year 2006		Initial (2005)						Area
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (2006)	Forest Land	**2 005.00**	0.50	0.04	0.00	0.00	1.40	2 006.94
	Grassland	0.11	**879.78**	0.98	0.00	0.00	0.00	880.87
	Cropland	0.00	0.45	**1 549.36**	0.00	0.00	0.00	1 549.81
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.02	0.06	0.83	0.00	**226.18**	0.00	227.09
	Other Land	0.11	0.49	0.49	0.00	0.08	**143.65**	144.81
	Area (kha)	2 005.23	881.28	1 551.70	94.00	226.26	145.05	**4 903.52**
Year 2007		**Initial (2006)**						Area
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (2007)	Forest Land	**2 006.49**	0.37	0.07	0.00	0.00	0.23	2 007.14
	Grassland	0.14	**879.69**	1.09	0.00	0.00	0.00	880.92
	Cropland	0.07	0.82	**1 547.09**	0.00	0.00	0.00	1 547.98
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.05	0.00	0.79	0.00	**227.09**	0.00	227.93
	Other Land	0.20	0.00	0.77	0.00	0.00	**144.58**	145.55
	Area (kha)	2 006.94	880.87	1 549.81	94.00	227.09	144.81	**4 903.52**
Year 2008		**Initial (2007)**						Area
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (2008)	Forest Land	**2 006.82**	0.85	0.08	0.00	0.00	0.51	2 008.26
	Grassland	0.12	**878.49**	1.25	0.00	0.00	0.00	879.85
	Cropland	0.01	0.77	**1 542.84**	0.00	0.00	0.00	1 543.63
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.06	0.00	1.07	0.00	**227.93**	0.00	229.06
	Other Land	0.14	0.82	2.73	0.00	0.00	**145.04**	148.73
	Area (kha)	2 007.14	880.92	1 547.98	94.00	227.93	145.55	**4 903.52**
Year 2009		**Initial (2008)**						Area
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (2009)	Forest Land	**2 007.80**	0.47	0.04	0.00	0.00	0.53	2 008.84
	Grassland	0.05	**877.16**	1.26	0.00	0.00	0.00	878.47
	Cropland	0.01	1.24	**1 538.21**	0.00	0.00	0.00	1 539.47
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.26	0.00	0.52	0.00	**229.06**	0.10	229.94
	Other Land	0.14	0.98	3.59	0.00	0.00	**148.10**	152.80
	Area (kha)	2 008.26	879.85	1 543.63	94.00	229.06	148.73	**4 903.52**
Year 2010		**Initial (2009)**						Area
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (2010)	Forest Land	**2 008.52**	1.22	0.04	0.00	0.00	1.48	2 011.25
	Grassland	0.16	**875.77**	0.56	0.00	0.00	0.00	876.48
	Cropland	0.02	0.78	**1 536.59**	0.00	0.00	0.42	1 537.81
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.07	0.52	1.32	0.00	**228.17**	0.50	230.59
	Other Land	0.08	0.18	0.96	0.00	1.77	**150.40**	153.39
	Area (kha)	2 008.84	878.47	1 539.47	94.00	229.94	152.80	**4 903.52**
Year 2011		**Initial (2010)**						Area
	Category	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
Final (2011)	Forest Land	**2 011.16**	0.93	0.12	0.00	0.00	0.13	2 012.34
	Grassland	0.01	**874.05**	0.16	0.00	0.00	0.00	874.22
	Cropland	0.00	1.07	**1 535.34**	0.00	0.00	0.18	1 536.59
	Wetland	0.00	0.00	0.00	**94.00**	0.00	0.00	94.00
	Settlements	0.02	0.42	0.71	0.00	**230.59**	0.22	231.97
	Other Land	0.05	0.00	1.49	0.00	0.00	**152.87**	154.41
	Area (kha)	2 011.25	876.48	1 537.81	94.00	230.59	153.39	**4 903.52**

The distribution of the IPCC land-use categories in Slovakia in 2011 is shown in Figure 7.4. Forest Land represents the dominant land-use category, accounting for 41% of the total area, followed by the Cropland with 31%, Grassland with 18%, Settlements with 5%, Other Land with 3% and Wetlands category with 2% of the total country area.

Figure 7.4: *Distribution of IPCC land-use categories in Slovakia in 2011*



Category	Area (kha)
Forest Land	2 012.336
Cropland	1 536.588
Grassland	874.224
Wetland	94.000
Settlements	231.967
Other Land	154.405

7.3 Methodological issues – methods

The methodology of GHG inventory is built up on the principles of the Revised IPCC 1996 Guidelines 1996, IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories 2000, IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry 2003 and partially on the IPCC Guidelines for National greenhouse gas inventories – Volume IV Agriculture, Forestry and Other Land Use 2006. 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.

7.4 Completeness

The completeness of inventory is determined by several factors, especially by importance of the processes and data availability.

Slovak inventory submission in 2013 reports carbon stock changes, as well as greenhouse gas emissions and removals from Forest Land (CRF 5.A), Cropland (CRF 5.B), Grassland (CRF 5.C), Settlements (CRF 5.E) and Other Land (CRF 5.F). In category 5.A Forest Land carbon stock change in living biomass, dead organic matter and mineral soils is reported. In category 5.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 related to conversion from 5.A category. Direct N_2O emissions from N fertilization of Forest Land and Others (CRF 5(I)) as well as non-CO_2 emissions from drainage of soils and wetlands (CRF 5(II)) are not reported. N_2O emissions from soil disturbance associated with land-use conversion to cropland (CRF 5(III)) are reported for the first time in this submission. In addition, CO_2 emissions from liming are reported in CRF table 5(IV). Emissions of CO_2, CH_4 and N_2O from biomass burning are reported in table 5(V).

The summary of all categories and subcategories in the Slovak national inventory submission for LULUCF sector is described in the Table 7.5.

Table 7.5: *Completeness of LULUCF sector in the Slovak Republic*

5A	**Forest Land**			**Carbon pools**	
5A1	Forest Land Remaining Forest Land	*Y*	Living biomass	DOM	Soil C
5A2	Land Converted to Forest Land	*Y*	Living biomass		Soil C
5A2.1	Cropland Converted to Forest Land	*Y*	Living biomass		Soil C
5A2.2	Grassland Converted to Forest Land	*Y*	Living biomass		Soil C
5A2.3	Wetlands Converted to Forest Land	*NO*			
5A2.4	Settlements Converted to Forest Land	*NO*			
5A2.5	Other Land Converted to Forest Land	*Y*	Living biomass		Soil C
5B	**Cropland**				
5B1	Cropland remaining Cropland	*Y*	Living biomass		
5B2	Land Converted to Cropland	*Y*			Soil C
5B2.1	Forest Land Converted to Cropland	*Y*	Living biomass	DOM	Soil C
5B2.2	Grassland Converted to Cropland	*Y*			Soil C
5B2.3	Wetlands Converted to Cropland	*NO*			
5B2.4	Settlements Converted to Cropland	*NO*			
5B2.5	Other Land Converted to Cropland	*Y*			Soil C
5C	**Grassland**				
5C1	Grassland Remaining Grassland	*NO*			
5C2	Land Converted to Grassland	*Y*			Soil C
5C2.1	Forestland Converted to Grassland	*Y*	Living biomass	DOM	Soil C
5C2.2	Cropland Converted to Grassland	*Y*			Soil C
5C2.3	Wetlands Converted to Grassland	*NO*			
5C2.4	Settlements Converted to Grassland	*NO*			
5C2.5	Other Land Converted to Grassland	*Y*			Soil C
5D	**Wetlands**				
5D1	Wetlands Remaining Wetlands	*NE*			
5D1	CO_2 emissions from peat lands remaining peat lands	*NE*			
5D1	CO_2 emissions from flooded land remaining flooded land	*NE*			
5D2	Land Converted to Wetlands	*NE*			
5D2	CO_2 emissions from land being converted for peat extraction	*NE*			
5D2	CO_2 emissions from land converted to flooded land	*NE*			
5E	**Settlements**				
5E1	Settlements Remaining Settlements	*NO*			
5E2	Land Converted to Settlements	*Y*			Soil C
5E2.1	Forest Land Converted to Settlements	*Y*	Living biomass	DOM	Soil C
5E2.2	Cropland Converted to Settlements	*Y*			Soil C
5E2.3	Grassland Converted to Settlements	*Y*			Soil C
5E2.4	Wetlands Converted to Settlements	*NO*			
5E2.5	Other Land Converted to Settlements	*Y*			Soil C
5F	**Other Land**				
5F1	Other Land Remaining Other Land	*NO*			
5F2	Land Converted to Other Land	*Y*			Soil C
5F2.1	Forest Land Converted to Other Land	*Y*	Living biomass	DOM	Soil C
5F2.2	Cropland Converted to Other Land	*Y*			Soil C
5F2.3	Grassland Converted to Other Land	*Y*			Soil C
5F2.4	Wetlands Converted to Other Land	*NO*			
5F2.5	Settlements Converted to Other Land	*Y*			Soil C
5(I)	N fertilization of Forest land and Other	NO			
5(II)	Drainage of soil and wetland	NO			
5(III)	Disturbance associated with land use conversion to cropland	Y			
5(IV)	Liming of Agricultural soils	Y			
5(V)	GHG emission from biomass burning	Y			
5(V)	Emissions from biomass burning in forest lands	Y			
5(V)	Emissions from biomass burning in croplands	NE			
5(V)	Emissions from biomass burning in grasslands	NE			
5(V)	Emissions from biomass burning in other lands	NE			
5G	**Other (Please specify)**				
5G	*Other (Please specify)*	*NE*			

7.5 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 GPG.

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 (SO 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 (SCCRI). 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 result of laboratories that follow quality management standards in laboratory praxis and successfully participated in 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 at the EU level annually. More information in general part of this report.

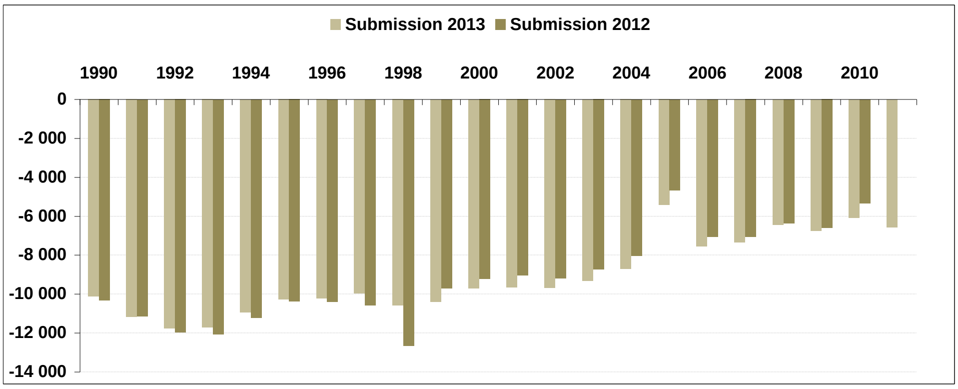
7.6 Source specific recalculations

Forest Land

The Forest Land remaining Forest Land (FL remaining FL) category was recalculated for whole time period since 1990. The main reason was application of new national biomass expansion factor (BEF) in FL remaining FL category. The BEF_1 (used for conversion of merchantable increment to total aboveground increment) and BEF_2 (used for conversion of merchantable volume to total aboveground volume) were derived as recommended by the ERT during the previous review in 2012. The procedure of the BEF derivation is described in the relevant chapter of this report. Furthermore, the factor for the fraction of biomass left to decay in forest (fBL) was included to the calculation of living biomass losses.

The recalculation affected the amount of gains (8-20% decreasing in individual years) and losses (18-25% decreasing in individual years) in living biomass carbon pool. These changes improved comparability of LULUCF inventory by including the disaggregated values of root-shoot ratio, BEFs and wood density instead of the condensed “biomass expansion/conversion factors” in the NIR. Recalculations realized in the category FL remaining FL affected the estimation of emissions and removals of GHGs for the whole 5.A Forest Land category. The comparison of the 2012 and 2013 submission in the category 5.A is presented on the following figure.

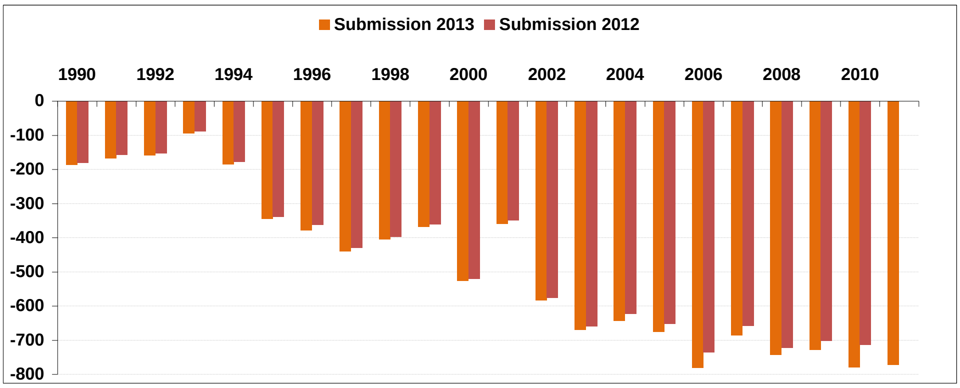
Figure 7.5: *Comparison of the 2012 and 2013 submissions for category 5.A Forest Land*



Cropland

The category Forest Land converted to Cropland (FL converted to CL) was recalculated for the whole time period since 1990 due to the recalculation of living biomass carbon pool using the corrected BEFs value for conifers (0.64) and for broadleaf (0.84). The recalculation reduced carbon losses by 17-26% for living biomass carbon pool in individual years. Recalculation affected the estimation of emissions/removals of GHGs for the subcategory 5.B.2 Land converted to Cropland as well as the whole 5.B Cropland category. The comparison of the 2012 and 2013 submission in the category 5.B is presented on the following figure.

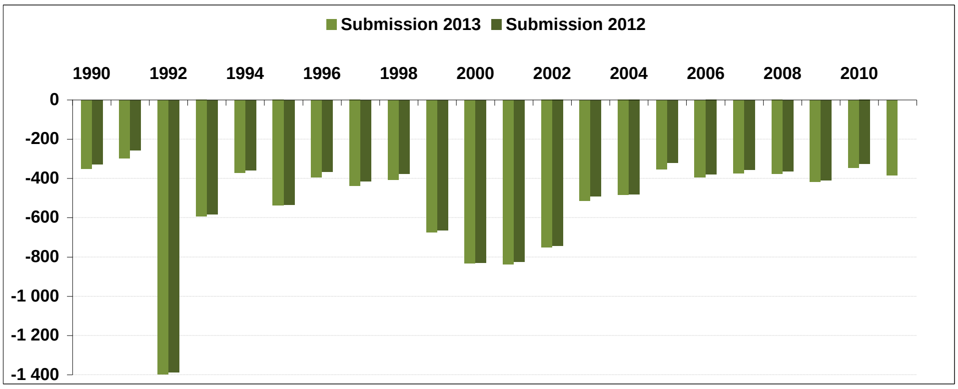
Figure 7.6: *Comparison of the 2012 and 2013 submissions for category 5.B Cropland*



Grassland

The category Forest Land converted to Grassland (FL converted to GL) was recalculated for the whole time period since 1990 due to the recalculation of living biomass carbon pool using the corrected BEFs for conifers (0.64) and for broadleaf (0.84). The recalculation reduced losses by 17-26% for living biomass carbon pool in individual years. Recalculation affected the estimation of emissions/removals of GHGs for the subcategory 5.C.2 Land converted to Grassland as well as the whole 5.C Grassland category. The comparison of the 2012 and 2013 submission in the category 5.C is presented on the following figure.

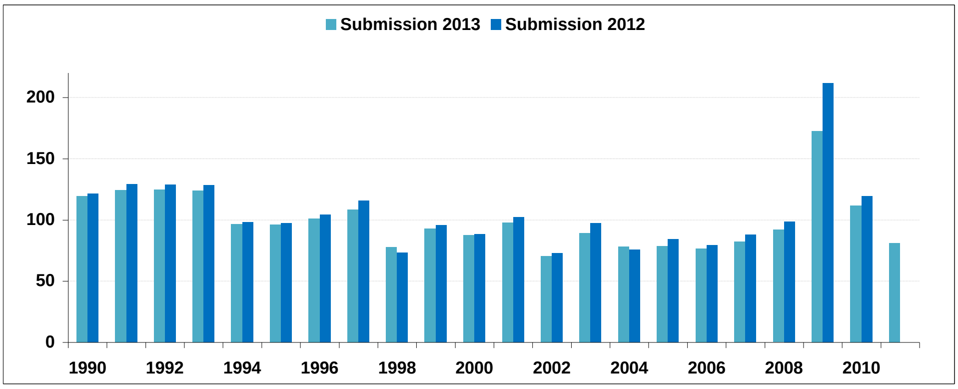
Figure 7.7: *Comparison of the 2012 and 2013 submissions for category 5.C Grassland*



<u>Settlements</u>

The category Forest land converted to Settlements (FL converted to S) was recalculated for the whole time period since 1990. The main reason was recalculation of living biomass carbon pool using the corrected BEFs for conifers (0.64) and for broadleaf (0.84). The recalculation reduced losses by 17-26% for living biomass carbon pool in individual years. Recalculation affected the estimation of emissions/removals of GHGs for the subcategory 5.E.2 Land converted to Settlements as well as the whole 5.E Settlements category. The comparison of the 2012 and 2013 submission in the category 5.E is presented on the following figure.

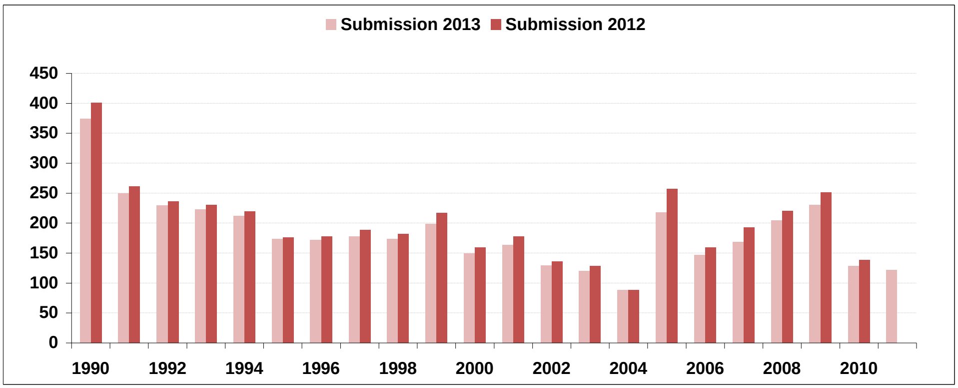
Figure 7.8: *Comparison of the 2012 and 2013 submissions for category 5.E Settlements*



<u>Other Land</u>

The category Forest land converted to Other Land (FL converted to OL) was recalculated for the whole time period since 1990. The main reason was recalculation of living biomass C pool using the corrected BEFs conifers (0.64) and for broadleafs (0.84). The recalculation reduced losses by 17-26% for living biomass carbon pool in individual years. Recalculation affected the estimation of emissions/removals of GHGs for the subcategory 5.F.2 Land converted to Other Land as well as the whole 5.E Other Land category. The comparison of the 2012 and 2013 submission in the category 5.F is presented on the following figure.

Figure 7.9: *Comparison of the 2012 and 2013 submissions for category 5F Other Land*



7.7 Forest Land (CRF 5.A)

7.7.1 Source category description

Forests currently cover 42% 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 cover (32%) followed by Norway spruce (25.1%) and oaks (13.2%) (Green Report, 2012). 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 466 074 705 m^3 (merchantable volume, define as tree stem and branch volume under bark with minimum diameter threshold of 7 cm) in 2011. Average hectare growing stock was 241 m^3.

The total volume of timber felled reached 9 467.4 thousand m^3 in 2011, which represented 392.3 thousand m^3 (3.9%) decrease compared to 2010. The volume of incidental felling formed 52.7% of the total felling volume (similarly as in 2010), the volume of the felling has exceeded 11% of planned felling, mainly due to the high volume of incidental felling in the year 2011. Volume of 2011 harvest timber represents the third largest volume ever recorded in Slovakia.

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, mean breast diameter, 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). Aggregated data refer to various periods and have different time relevance (1-10 years).

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 360/2007 Coll. on Forests and public notice of the Ministry of Agriculture No 453/2006 on Forest Management Planning and Forest Protection. The FMPs are approved by provincial (governmental) forest agencies and are audited by the NFC. The FMPs have been performed for all forests, owners or users within the Slovak territory (Act No 326/2005 Coll.).

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 on 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. But it is usable for estimation of carbon pools for example dead organic matter – dead wood.

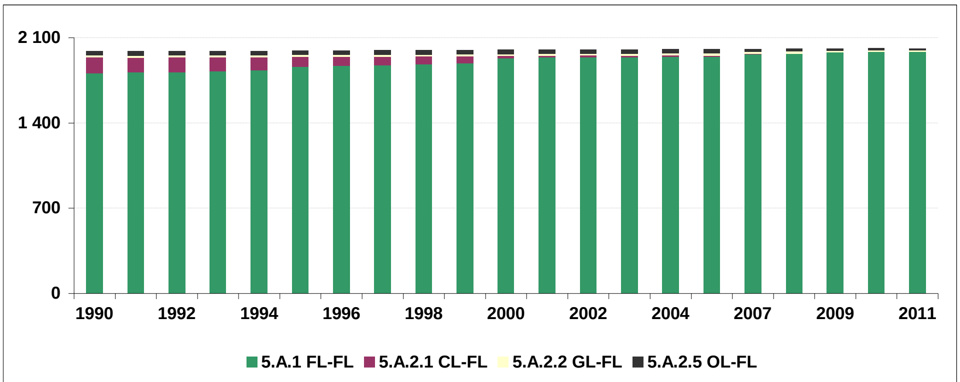
The 5.A category includes emissions and removals of CO_2 (Gg) associated with forests. Category consists of two parts 5.A.1 Forest Land remaining Forest Land (FL remaining FL) and 5.A.2 Land converted to Forest Land (L converted to FL).

7.7.2 Forest Land Remaining Forest Land (CRF 5.A.1)

Calculations are based on the IPCC GPG for LULUCF 2003, IPCC GL for AFOLU 2006 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 for LULUCF 2003 and national data on area of forested land and land converted to the forest during the inventory year 2011. This category includes carbon stock changes in following carbon pools: living biomass (above and below ground), dead organic matter (deadwood 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 1 983.91 kha, the changes in the FL were following: CL converted to FL 1.50 kha, GL converted to FL 12.59 kha, and OL converted to FL 14.34 kha in 2011. Total forest area in 2011 was 2 012.34 kha.

Figure 7.10: *Development of activity data in kha for category 5.A Forest Land in the period 1990 – 2011*



7.7.2.1 Methodological issues – methods, activity data, emission factors and parameters

The carbon stock change in living biomass was estimated using a default method according to the equation 3.2.2 of the IPCC GPG 2003. 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 carried out as follows the equations 3.2.4 - 3.2.6 of the IPCC GPG 2003.

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 input 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 growth, 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 occurrence tree species.

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 basic wood density (D), biomass expansion factor (BEF_1) and root-to-shoot ratio (R) (equation 3.2.5 (A) and (B) of the IPCC GPG 2003) as followed:

- $G_{TOTAL} = G_W * (1 + R)$
- $G_W = I_V * D * BEF_1$

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 7.6: *Annual biomass increment for individual forest tree species in the Slovak Republic*

Tree Species		Current Annual Increment	Basic Wood Density	Biomass Expansion Factor	Annual Biomass Increment	Root Shoot Ratio	Annual Biomass Increment
		m^3/ha	d.m./m^3			%	kt dm/ha
Picea abies	Spruce	8.32	0.40	1.12	3.74	1.2	4.49
Abies alba	Fir	7.15	0.40	1.13	3.23	1.2	3.88
Pinus sp.	Pine	6.23	0.50	1.36	4.23	1.2	5.07
Larix decidua	Larch	5.77	0.60	1.36	4.70	1.2	5.63
Other coniferous			0.40	1.12	1.10	1.2	1.32
Quecus robur, Q. petrea	Oak	4.60	0.65	1.36	4.07	1.2	4.88
Fagus sylvatica	Beech	6.13	0.68	1.16	4.84	1.2	5.81
Carpinus betulus	Hornbeam	5.81	0.80	1.16	5.40	1.2	6.48
Acer sp.	Maple	5.05	0.63	1.16	3.69	1.2	4.43
Fraxinus excelsior	Ash	6.44	0.63	1.16	4.71	1.2	5.65
Ulmus sp.	Elm	5.90	0.65	1.16	4.45	1.2	5.34
Quercus cerris	Turkey oak	4.74	0.70	1.36	4.51	1.2	5.42
Robinia pseudoacacia	Robinia	2.64	0.80	1.16	2.45	1.2	2.94
Betula sp.	Birch	2.72	0.60	1.16	1.89	1.2	2.27
Alnus sp.	Alder	2.73	0.60	1.16	1.90	1.2	2.28
Tilia sp.	Linden	7.08	0.45	1.16	3.70	1.2	4.44
Breeding poplars			0.40	0.95	0.39	1.2	0.47
Populus sp.	Poplar	2.76	0.35	1.16	1.12	1.2	1.35
Salix sp.	Willow	3.20	0.60	0.95	1.81	1.2	2.18
Other broadleaves			0.60	1.16	1.29	1.2	1.55
Total			**0.572**	**1.174**	**3.162**	**1.2**	**3.794**

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 0.47 to 6.48 kt dm/ha for different tree species.

The BEF_1 showed in Table 7.6 were calculated as portion 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. The values of CAI in relevant years and tree species were based on national growth and yield tables (Halaj and Petráš, 1998) using values of average age and “bonita” degree calculated by the NFC-IFRI Zvolen annually. Final BEF values represent the average values in individual years.

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 3.2.4 of the IPCC GPG 2003 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 7.7: *Total carbon uptake increment for individual forest tree species in the Slovak Republic*

Tree Species		Area of Forest/Biomass Stocks	Annual Growth Rate	Annual Biomass Increment	Carbon Fraction of dm	Total Carbon Uptake Increment
		kha	t dm/ha	kt dm		kt C
Picea abies	Spruce	497.96	4.49	2 235.13	0.50	1 117.56
Abies alba	Fir	78.56	3.88	304.67	0.50	152.34
Pinus sp.	Pine	137.68	5.07	698.07	0.50	349.03
Larix decidua	Larch	47.61	5.63	268.30	0.50	134.15
Other coniferous		21,62	1.32	28.47	0.50	14.23
Quecus robur, Q. petrea	Oak	211.48	4.88	1 032.41	0.49	505.88
Fagus sylvatica	Beech	635.64	5.81	3 691.44	0.49	1 808.80
Carpinus betulus	Hornbeam	115.46	6.48	747.69	0.49	366.37
Acer sp.	Maple	43.65	4.43	193.46	0.49	94.79
Fraxinus excelsior	Ash	30.55	5.65	172.70	0.49	84.62
Ulmus sp.	Elm	0.60	5.34	3.18	0.49	1.56
Quercus cerris	Turkey oak	50.19	5.42	271.91	0.49	133.23
Robinia pseudoacacia	Robinia	34.12	2.94	100.41	0.49	49.20
Betula sp.	Birch	28.97	2.27	65.86	0.49	32.27
Alnus sp.	Alder	14.88	2.28	33.96	0.49	16.64
Tilia sp.	Linden	7.94	4.44	35.22	0.49	17.26
Breeding poplars		9,32	0.47	4.40	0.49	2.16
Populus sp.	Poplar	7.74	1.35	10.41	0.49	5.10
Salix sp.	Willow	1.98	2.18	4.32	0.49	2.12
Other broadleaves		7,94	1.55	12.27	0.49	6.01
Total		**1 983.91**	**3.79**	**9 914.26**		**4 893.34**

The annual increase in carbon stocks due to biomass increment in the category 5.A.1 FL remaining FL represents 4 893.34 kt C in 2011.

The annual decrease in carbon stocks due to biomass loss in FL remaining FL follows equations 3.2.6, 3.2.7 and 3.2.8 (IPCC GPG 2003). The annual harvest volume (H) is collected and elaborated by the NFC-IFRI Zvolen, on the basis of about 9 000 respondents (forest owners). It represents 90-95% of annual harvest data and covers thinning and final cut. Relevant forests companies, forest owners or users are obligated annually by the Regulation No 297/2011 of the Ministry of Agriculture to provide data on forest management activities (harvest, silviculture) to the forestry register database. 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 – 2011 in Slovakia are presented on the following figures.

Figure 7.11: *The statistics of forest harvest (coniferous and broadleaved) in Slovakia in 1990 – 2011*

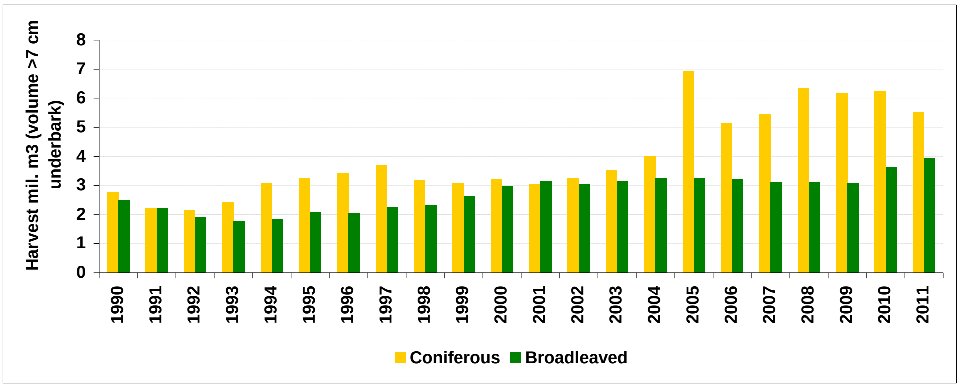
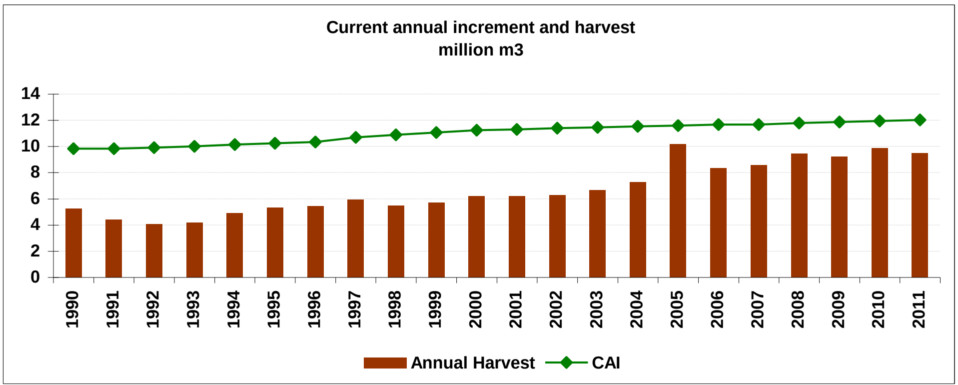


Figure 7.12: *Current annual increment (CAI) and total annual harvest in Slovakia in 1990 – 2011*



The annual carbon loss due to commercial felling was calculated using the equation 3.2.7:

- $L_{fellings}$ = H*BCEF* (1-f_{BL})*CF

Biomass conversion and expansion factors (BCEFs) were developed based on new national NFI data. BCEFs 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 GL 2006. The BCEF is generally defined as:

- $BCEF_i = W_i/V$;

where i indicates a tree biomass component, W_i (Mg) is the dry biomass of component and V (m^3) is the tree merchantable volume.

Tree-level data of the new NFI in Slovakia were used to construct age-related BCEFs. Only inventory plots that contained a dominant share (at least 50% of the basal area) of any of the four key tree species (beech, oak, pine and spruce) were used for the analysis. This selected database contained over 22 thousand trees. Tree volume and tree aboveground biomass were calculated used 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 calculation was published in the report “Different Approaches to Carbon Stock Assessment in Slovakia”, chapter 13, which is available at http://publications.jrc.ec.europa.eu/repository/handle/111111111/14708. Following values of BCEF were used for calculation:

Coniferous species	BCEF	Broadleaved species	BCEF
spruce, pine	0.72, 0.56	beech, oak	0.81, 0.86

The CF factors used in calculation are described in the Table 7.8. The IPCC default value 0.1 for biomass fraction left to decay in forest (f_{BL}) was used. The carbon loss due to fuel wood gathering was estimated using equation 3.2.8 of the IPCC GPG 2003, whereby the factors (BCEF, CF) used in calculation were identical to those used in previous calculation. The total annual carbon release from forest harvest in the Slovak republic was 3 155.50 kt C in 2011.

Table 7.8: *The results of net annual carbon uptake or release in living biomass for individual forest tree species in 2011*

Tree Species		Total Biomass Consumption	Carbon Fraction of dm	Annual Carbon Release	Net Annual Carbon Uptake (+) or Release (-)	Convert to CO_2
		kt dm		kt dm	kt C	Gg CO_2
Picea abies	Spruce	2 295.35	0.50	1 147.68	-30.11	-110.41
Abies alba	Fir	629.63	0.50	314.81	-162.48	-595.74
Pinus sp.	Pine	450.23	0.50	225.11	123.92	454.37
Larix decidua	Larch	64.01	0.50	32.01	102.14	374.52
Other coniferous		0.00	0.50	0.00	14.23	52.19
Quecus robur, Q. petrea	Oak	387.90	0.49	190.07	315.81	1 157.97
Fagus sylvatica	Beech	2 006.62	0.49	983.24	825.56	3 027.06
Carpinus betulus	Hornbeam	97.16	0.49	47.61	318.76	1 168.79
Acer sp.	Maple	58.73	0.49	28.78	66.02	242.07
Fraxinus excelsior	Ash	46.67	0.49	22.87	61.75	226.42
Ulmus sp.	Elm	23.08	0.49	11.31	-9.75	-35.76
Quercus cerris	Turkey oak	102.74	0.49	50.34	82.89	303.94
Robinia pseudoacacia	Robinia	79.31	0.49	38.86	10.34	37.90
Betula sp.	Birch	22.29	0.49	10.92	21.35	78.28
Alnus sp.	Alder	9.53	0.49	4.67	11.97	43.89
Tilia sp.	Linden	0.56	0.49	0.28	16.98	62.28
Breeding poplars		66.31	0.49	32.49	-30.33	-111.22
Populus sp.	Poplar	14.15	0.49	6.93	-1.83	-6.72
Salix sp.	Willow	7.38	0.49	3.62	-1.50	-5.50
Other broadleaves		7.97	0.49	3.91	2.11	7.72
Total		**6 369.61**		**3 155.50**	**1 737.83**	**6 372.05**

The assessment of the net carbon stock change in DOM includes the deadwood and the litter pools. The deadwood carbon pool contains dead trees from standing, stumps, coarse laying deadwood and small-sized laying deadwood not included in litter or soil carbon pools. The information on deadwood stocks were obtained from the first National Forest Inventory realized in 2005 – 2006. Until then, no reliable data on deadwood (except for standing dead trees) were available in Slovakia. Quantification of deadwood before 2005 was performed by methodology when all 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 inventory plot (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).

Estimation followed IPCC tier 1 assumed 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 is Slovak inventory includes all non-living biomass with a size less than the minimum diameter chosen for dead wood (0 cm). 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 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. This definition is similar to the 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.

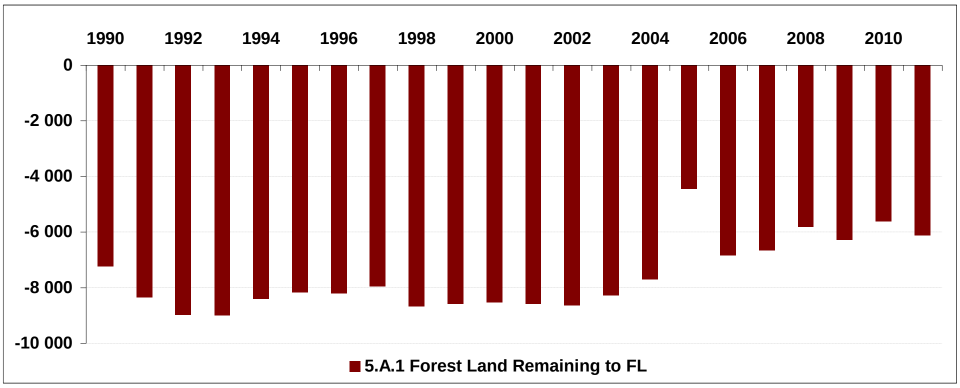
The total carbon stock in litter represents 16.66 Mt (mean value per area is 8.3 t/ha). These values are derived from similar datasets of the Forest Monitoring System (FMS) and the National Forest Inventory (NFI) as a part of soil inventory. The changes of forests management that would dramatically change litter properties and litter carbon changes do not occur, 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 earth, 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 5.A.1 (FL remaining FL) is considered to equal zero, that means it did not change.

Figure 7.13: *Summary results of CO_2 removals (Gg) from 5.A.1 in 1990 – 2011*



The net CO_2 removal in the FL remaining FL represents 6 372.05 Gg of CO_2 in 2011. It is necessary to mention that almost every forest is managed in Slovakia, it means that total annual uptake on woody areas for previous 100 years and the harvest from deforestation are included in this category. Uptake of carbon into the biomass of forest trees has slightly increased since 1990. Despite release of carbon in this category, the high fluctuations can be observed in time series. The main reason is fluctuation of timber harvesting. It is a determining factor of final balance differences.

7.7.3 Biomass Burning (CRF 5(V))

7.7.3.1 Source category description

The biomass burning activity 5(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 is characterized by burning harvesting residues. The harvesting residues are burned on about 50% of the forest clearing area. The differences are only in quantity of burning biomass. For coniferous 10% and for broadleaved trees about 25% of biomass is burned. In addition to harvesting residue burning in this part, CO_2 emissions released from wild forest fires were included. The emissions from burning of biomass residues were estimated according to the equation 3.2.19 (IPCC GPG for LULUCF 2003).

In the Slovak Republic there were reported 303 forest fires in 2011. This number increased in comparison to the previous year 2010. The total burnt area was 402.55 ha. The average burnt forest area per one fire was 1.33 ha. The largest forest area damaged by fire was 64 ha. The forest fires occurred mostly in spring and early summer. The emissions of greenhouse gases from wildfires were estimated on the basis of known areas burnt annually and the average biomass stock in forests according to the equation 3.2.9 (IPCC GPG for LULUCF 2003).

Table 7.9: *Activity data used for estimation of emissions from Wildfires and Controlled Burning of the forest in 2011*

Harvesting residues	**Annual Loss of Biomass**	**Fraction of Biomass Burned on Site**	**Quantity of Biomass Burned on Site**	**Fraction of Biomass Oxidized**	**Quantity of Biomass Oxidized**	**Carbon Fraction of Aboveground Biomass**	**Quantity of Carbon Released**
	kt dm		kt dm		kt dm		kt C
Coniferous	1 761.25	0.03	52.84	0.90	47.55	0.50	23.78
Broadleaves	1 880.26	0.05	94.01	0.90	84.61	0.50	42.31
Forest Fires	2.51	1.00	2.51	0.90	2.26	0.50	1.13

Quantity of C Released	**N/C Ratio**	**Total N Released**		**Trace Gas Emissions Ratio**	**Trace Gas Emissions**	**Conversion Ratio**	**Emissions from Burning**
kt C		kt N			kt C		Gg
			Controlled Burning				
66.083	0.02	1.32166	**CH_4**	0.012	0.793	16/12	1.057
			CO	0.060	3.965	28/12	9.252
					kt N		
			N_2O	0.007	0.009	44/28	0.015
			NOx	0.121	0.160	46/14	0.526
			Wildfires				
1.129	0.02	0.02258	**CH_4**	0.012	0.014	16/12	0.018
			CO	0.060	0.068	28/12	0.158
					kt N		
			N_2O	0.007	0.00016	44/28	0.0003
			NOx	0.121	0.00273	46/14	0.0090

7.10: *Biomass burned in forests, CO_2, CH_4 and N_2O emissions from wildfires and controlled burning of the Slovak forests in 1990 – 2011*

Year	Biomass Burned		CO_2 emissions		CH_4 emissions		N_2O emissions	
	Controlled Burning	Wildfires	Controlled Burning	Wildfires	Controlled Burning	Wildfires	Controlled Burning	Wildfires
	(kg dm)		(Gg)		(t)			
1990	91 778.28	5 320.00	151.43	8.78	661.00	10.00	38.00	1.00
1991	58 294.92	2 150.00	96.19	3.55	420.00	7.00	19.00	0.40
1992	52 180.61	11 733.00	86.10	19.36	376.00	6.00	84.00	0.40
1993	53 130.27	12 860.00	87.66	21.22	380.00	6.00	100.00	0.40
1994	55 527.56	1 570.00	91.62	2.59	400.00	6.00	10.00	0.30
1995	62 261.55	1 542.90	102.73	2.55	448.00	7.00	11.00	0.30
1996	66 932.59	3 886.00	110.44	6.41	480.00	7.00	30.00	0.30
1997	73 143.47	2 090.00	120.69	3.45	530.00	7.00	10.00	0.30
1998	73 096.00	552.00	120.61	0.91	530.00	7.00	3.00	0.30
1999	84 577.70	498.00	139.55	0.82	600.00	9.70	10.00	0.30
2000	76 952.10	15 690.00	126.97	25.89	550.00	9.70	120.00	0.30
2001	92 862.80	540.00	153.22	0.89	670.00	9.70	10.00	0.30
2002	91 587.00	550.00	151.12	0.91	659.00	9.70	4.00	0.30
2003	99 109.00	2 730.00	163.53	4.50	710.00	9.70	20.00	0.30
2004	110 172.00	2 070.00	181.78	3.42	808.00	11.00	14.00	0.20
2005	146 053.00	2 360.00	240.99	3.89	1 051.50	16.99	16.99	0.23
2006	123 469.90	1 920.00	203.73	3.17	890.00	10.00	10.00	0.23
2007	122 296.00	3 620.00	201.79	5.97	880.00	12.17	26.00	0.36
2008	137 348.30	814.85	226.62	1.34	988.90	13.60	5.87	0.08
2009	135 467.42	3 115.05	223.52	5.14	975.40	13.40	22.40	0.30
2010	150 340.39	1 198.95	248.06	1.98	1 082.45	8.63	14.90	0.11
2011	146 850.58	2 508.80	242.30	4.14	1 057.32	18.06	14.54	0.25

7.7.3.2 Controlled Burning

Total methane emissions from controlled burning were 1 057.32 t in 2011 and total emissions of N_2O were 14.54 t in 2011. CO_2 emissions were 242.30 Gg in 2011 and were reallocated from the categories changes in living biomass and reported in this category for whole time series since this submission.

7.7.3.3 Wildfires

Total methane emissions from wildfires were 18.06 t in 2011 and total emissions of N_2O were 0.25 t in 2011. CO_2 emissions were 4.14 Gg in 2011 and were reallocated from the categories changes in living biomass and reported in this category for whole time series since this submission.

7.7.3.4 Uncertainties and time 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.

7.7.3.5 Source specific QA/QC and verification

The source specific QA/QC activities are described in the section 7.5 of this chapter.

The QC checks (eg. check of consistency 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.

7.7.3.6 Source specific recalculations

No recalculations were provided in this category. Emissions of CO_2 from controlled burning and wildfires were reallocated from the categories changes in living biomass (reported in the previous submission) to the category 5.A (5(V)).

7.7.3.7 Source specific planned improvements

There are no short term plans concerning improvements in this land-use category.

7.7.4 Land Converted to Forest Land (CRF 5.A.2)

This category includes all processes connected with conversion of lands into Forest Land. This activity is closely connected with afforestation or reforestation. The Green Report confirmed the decreasing trend in the total volume of artificial reforestation. Improvements in the implementation of shelterwood system increased the rate of natural reforestation up to 39.5 % in 2011.

7.7.4.1 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 GPG 2003) 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 was estimated using equation 3.2.22 (IPCC GPG 2003). 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 for the four main 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 comes 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. 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. Biomass allocation into the tree compartments changed with stand size (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 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 35% for spruce, 15% for pine, 46% for beech and 4% for oak in 2011.

The carbon loss connected with living biomass due to silvicultural cuttings in the category 5.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 deadwood was assumed to be negligible (zero), in accordance with default tier 1 method. Methods to quantify emissions and removals of carbon in deadwood 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 Mg C ha^{-1} for carbon stocks in litter (representing surface organic layer) as well as 0.415 Mg 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 carbon stocks for Land converted to FL = net annual accumulation of litter over length of transition period (Mg 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 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 mean value 166.10 Mg C ha^{-1} for organic carbon stocks in forest soils (including surface organic layer) was used in previous GHG inventory reports. Based on the ERT recommendation this value was reduced to 157.8 Mg C ha^{-1}. The difference represents the amount of carbon accumulated in surface organic layer which is now calculated separately. For respective land use categories following values (calculated as weighted average) were used in calculations of carbon stock changes in mineral soils (0-100 cm, without any surface organic layer):

- Forest Land 157.8 Mg C ha^{-1}
- Grassland 129.7 Mg C ha^{-1}
- Cropland 108.6 Mg C ha^{-1}
- Settlements 97.3 Mg C ha^{-1}
- Other Land 97.3 Mg C ha^{-1}

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 (Mg C ha^{-1} yr^{-1}) x 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 values were calculated for different types of conversion:

- CL converted to FL 2.44 Mg C ha^{-1} yr^{-1}
- GL converted to FL 1.40 Mg C ha^{-1} yr^{-1}
- S converted to FL 3.02 Mg C ha^{-1} yr^{-1}
- OL converted to FL 3.02 Mg C ha^{-1} yr^{-1}

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 5.A.1, the same values as in previous reports were used (validation and final data management from the NFI plots have not been finished yet). The only difference in procedures and values used for calculation is the separation of mean carbon stocks in surface organic layer from stocks in mineral soils for forest land. The land-use matrix from 1991 to 2011 is provided in the Table 7.11.

Table 7.11: *The land-use matrix from 1991 to 2011*

	kha	**Initial (1991)**						**Area**
	Final	Forest Land	Grassland	Cropland	Wetland	Settlements	Other Land	(kha)
2011	Forest Land	1 983.91	12.59	1.50	0.00	0.00	14.34	2 012.34
	Grassland	2.64	767.13	103.53	0.00	0.00	0.93	874.22
	Cropland	0.35	24.26	1 510.99	0.00	0.00	0.99	1 536.59
	Wetland	0.00	0.00	0.00	94.00	0.00	0	94.00
	Settlements	0.96	2.66	9.46	0.00	124.20	94.70	231.97
	Other Land	2.11	2.84	13.66	0.00	2.39	133.40	154.41
	Area (kha)	**1 989.97**	**809.48**	**1 639.14**	**94.00**	**126.59**	**244.35**	**4 903.53**

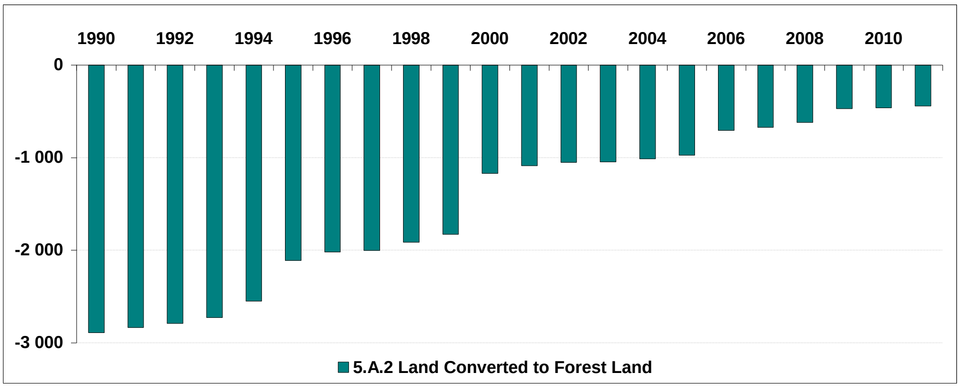
The results from the category 5.A.2 Land converted to Forest Land are summarized in the following Table 7.12.

Table 7.12: *Results for the category 5.A.2 Land converted to Forest Land*

Land Use Category	**Carbon Stock Change in Living Biomass**			**Net Carbon Stock Change in DOM**	**Net Carbon Stock Change in Soil**	**Net CO_2 Emissions/ Removals**
	gains	losses	net change			
	(Gg C)			(Gg C)		(Gg CO_2)
Land - FL	**44.14**	**NO**	**44.14**	**11.80**	**64.71**	**-442.34**
GL - FL	19.54	NO	19.54	5.22	17.67	-155.62
CL - FL	2.33	NO	2.33	0.62	3.68	-24.32
WL - FL	NO	NO	NO	NO	NO	NO
S - FL	NO	NO	NO	NO	NO	NO
OL - FL	22.26	NO	22.26	5.95	43.36	-262.40

The estimated removals were 442 Gg CO_2 in 2011. The net carbon stock change in living biomass, DOM and soil from Land converted to Forest Land represented gains of 44.14, 11.80 and 64.71 Gg C in 2011.

Figure 7.14: *Summary results of CO_2 removals (Gg) in the category 5.A.2 in 1990 – 2011*



7.7.4.2 Uncertainties and time consistency

Information on uncertainties should include information on completeness and accuracy. Concerning completeness, some emissions and removals could not be estimated, because the input data sets are still missing. With respect to accuracy, the estimated values are generally accurate. According to the expert estimation and based on statistical approach for the published estimation of wood stocks in the Slovak forest (Šmelko et al., 2003) the uncertainty 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 annual increment on new afforested areas represented by standard deviation was following: spruce ±1.56 t dm /ha/y, pine ±1.61 t dm/ha/y, beech ±2.04 t dm/ha/y and oak ±1.05 t dm/ha/y. Accuracy of dead wood volume for different parts of DW and tree species: standing dead trees is following: coniferous ±0.03 m^3/ha, broadleaves ±0.02 m^3/ha, stumps – coniferous ±0.01 m^3/ha, broadleaves ±0.01 m^3/ha, coarse laying deadwood – coniferous ±0.07 m^3/ha, broadleaves ±0.04 m^3/ha and small-sized laying deadwood – coniferous ±0.02 m^3/ha, broadleaves ±0.03 m^3/ ha (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.

7.7.4.3 Source specific QA/QC and verification

The source specific QA/QC activities are described in the section 7.5 of this chapter.

The QC checks (eg. check of consistency 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.

7.7.4.4 Source specific recalculations

The recalculations in this land-use category are described in section 7.6 of this chapter.

7.7.4.5 Source specific planned improvements

Following improvements are planned for this category in the next submission:

- Estimation of more accurate soil carbon stocks data for forest soils;
- Planned projects and activities:

Slovakia has applied for the research project: Assessment and modeling of carbon stocks in forest ecosystems for greenhouse gas inventory in landscape of Slovakia. The project application is currently under consideration.

The project proposal C-FORLAND ("Assessment and modeling of carbon stocks in forest ecosystems for GHG inventory in landscape") has been approved 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 will be involved in this project. The project duration is from July 2012 to December 2015. First applicable results can be expected in the second half of 2013. The project will analyze 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 networks and factors affecting carbon stocks changes and to use the knowledge in updating and improvement of methods for carbon balance. Dominant part of the project is improvement of the knowledge base on carbon stocks in soils. Primary, existing databases of monitoring of forests, national forests inventory and information layers on soil including information on agricultural land will be used. However, also new sampling and assessment in model territories will be done. The project will include all components of forest ecosystems (aboveground and belowground biomass, deadwood, litter, soil).

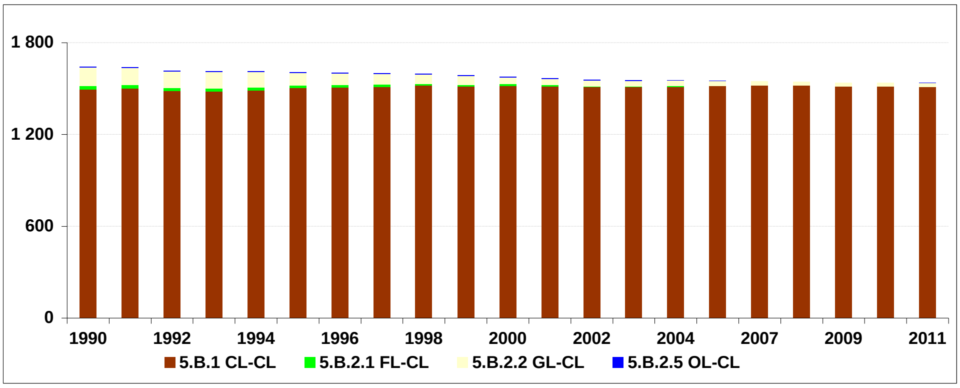
7.8 Cropland (CRF 5.B)

7.8.1 Source category description

The GHGs emissions and removals in this category were estimated by using the IPCC GPG 2003 and national data on area of Cropland and Land converted to Cropland in 2011. The total area of cropland represented 1 536.59 kha in 2011, this is approximately 30% of the total country area. This land use category is constantly decreasing during whole reporting period, even since 1970.

The total area of Cropland remaining Cropland (CL – CL) represents 1 510.99 kha, the changes in the Cropland were following: FL converted to CL 0.35 kha, GL converted to CL 24.25 kha and OL converted to the CL 0.99 kha in 2011.

Figure 7.15: *Development of activity data in kha for category 5.B Cropland in the period 1990 – 2011*



7.8.2 Cropland Remaining Cropland (CRF 5.B.1)

The emission 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 120.418 kha in 2011.

7.8.2.1 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 GPG 2003). The annual change of carbon stocks in biomass was calculated using equation 2.7 from the IPCC GL for AFOLU 2006. 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 GL for AFOLU 2006).

In general, croplands have little or no dead wood, 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 3.3.3 and relative stock change factors for different activities on cropland according to the Table 3.3.4 (IPCC GPG 2003). The default relative stock change factors for land use F_{LU} = 0.82, 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.

7.8.3 CO_2 emissions from agricultural lime application (CRF 5(IV))

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 (ÚKSÚP). For the years 1998 – 2011 the data are based on summarization of recordings that have to be submitted by land owners/users to ÚKSÚP in accordance with the national legislation. For the years 1992 and 1994 – 1997 the data are based on statistics of ÚKSÚP according to the former legislation, for the years 1990, 1991 and 1993 only estimated values are available.

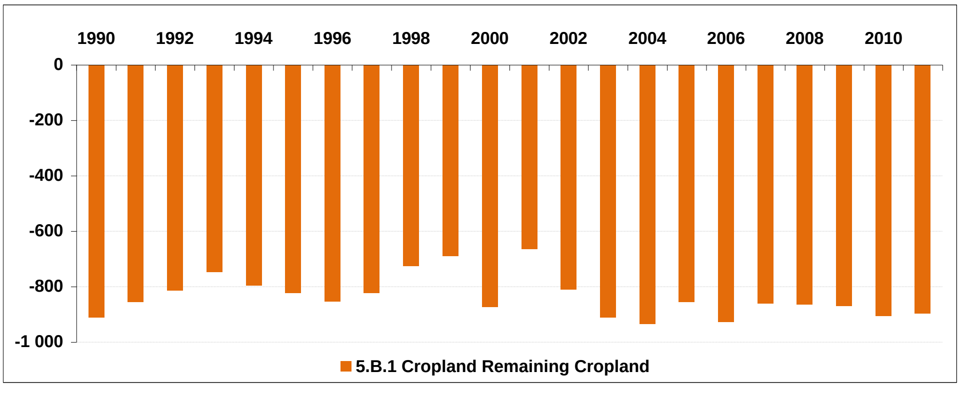
The amount of applied limestone has been registered since 1998. For previous years only information on total application of CaO as component of various materials (besides limestone also burnt lime and other materials) is available. Therefore, the quotient derived from years with detailed information on applied materials (limestone, burnt lime, lime sludge and other calcareous materials) is used for calculation of limestone application in this case. The conversion factor used for limestone ($CaCO_3$) is 0.12 Mg CO_2 -C/Mg.

Table 7.13: *The results for fertilizers in emission inventory of LULUCF (5.B(IV)) in 1990 – 2011*

Year	Total amount of $CaCO_3$	Carbon Conversion Factor	CO_2 Emissions
	(t)		(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	**28.02**
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**

The net CO_2 removals in the category 5.B.1 Cropland remaining Cropland are 897.59 Gg of CO_2 in 2011.

Figure 7.16: *Summary results of CO_2 removals (Gg) in the category 5.B.1 in 1990 – 2011*



7.8.4 Land Converted to Cropland (CRF 5.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.

7.8.4.1 Methodological issues – methods, activity data, emission factors and parameters

Carbon stock changes in biomass were calculated using tier 1 method (IPCC GL for AFOLU 2006). 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, new BCEFs (0.65 for conifers and 0.84 for broadleaf) and default carbon content (0.5) were used. For biomass carbon stock of GL prior the conversion, default values of 6.5 t/ha for above ground and below ground biomass were used (Table 6.4, IPCC GL 2006). 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) realised in 2005 – 2006 was used in estimation of deadwood prior the conversion in FL. The NFI provides data on the mean deadwood biomass stocks (m^3/ha) separately for coniferous and broadleaves trees in the following categories: standing dead trees, stumps, coarse laying deadwood and small-sized laying deadwood. Each of the 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 by 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), 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 deadwood 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) with the default assumption of 20 years period for carbon stock equilibrium in „new land-use“ conditions. The mean value of 8.3 Mg C ha^{-1} for carbon stocks in litter (representing surface organic layer) as well as 0.415 Mg 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. The following equation was used:

- Annual changes in litter C stocks for FL converted to CL = net annual accumulation of litter over length of transition period (Mg 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 carbon stocks for each category of land use associated with FL 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 GPG 2003. The net carbon stock change in mineral soils was estimated by using country specific tier 2 method described in detail in section 7.7.4.1 of this chapter. For estimation of net carbon stock change in mineral soil the average carbon stocks per hectare noted above were used (category 5.A.2 Land Converted to Forest land). 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^{-1} yr^{-1}) 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 values were calculated for different type of conversion:

- FL converted to CL 2.44 Mg C ha^{-1} yr^{-1}
- GL converted to CL 1.40 Mg C ha^{-1} yr^{-1}
- S converted to CL 0.58 Mg C ha^{-1} yr^{-1}
- OL converted to CL 0.58 Mg C ha^{-1} yr^{-1}

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 2011 is provided in the Table 7.11.

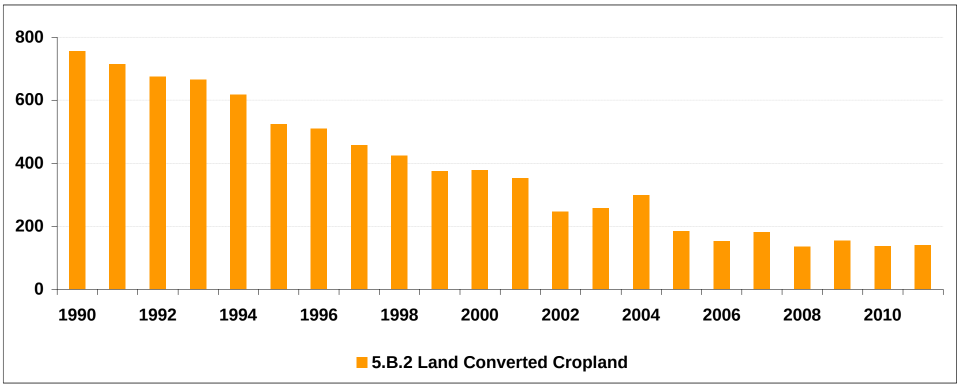
The results from the category 5.B.2 Land converted to Cropland are summarized in the following Table 7.14.

Table 7.14: *Results for the category 5.B.2 Land Converted to Cropland*

Land Use Category	**Carbon Stock Change in Living Biomass**			**Net Carbon Stock Change in DOM**	**Net Carbon Stock Change in Soil**	**Net CO_2 Emissions/ Removals**
	gains	losses	net change			
	(Gg C)			(Gg C)		($Gg CO_2$)
Land - CL	**NO**	**12.34**	**-12.34**	**-0.15**	**-25.54**	**139.44**
FL - CL	NO	NO	NO	-0.15	-0.86	3.67
GL - CL	NO	12.34	-12.34	NA	-25.26	137.87
WL - CL	NA	NA	NA	NA	NA	NA
S - CL	NA	NA	NA	NA	NA	NA
OL - CL	NO	NO	NO	NO	0.57	-2.10

The category 5.B.2 Land converted to Cropland represents 139.44 Gg of CO_2 in 2011. The net carbon stock change in living biomass, DOM and soil from Land converted to Cropland represented losses of -12.34, -0.15 and -25.54 Gg C in 2011.

Figure 7.17: *Summary of CO_2 emissions (in Gg) in the category 5.B.2 in 1990 – 2011*



7.8.5 N_2O emissions from disturbance associated with land use conversion to Cropland (CRF 5(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 3.3.14 and 3.3.15 (IPCC GPG 2003). 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.

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.

7.8.5.1 Uncertainties and time consistency

The default uncertainty for biomass accumulation rate and biomass carbon loss in CL ±75% was used, according to tier 1 (IPCC GL for AFOLU 2006). This error range represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean. No uncertainty analysis has been made for vineyards, orchards and gardens area.

According to the expert estimation and based on statistical approach for the estimation of 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 of this chapter.

No uncertainty analysis has been made for CO_2 emissions from agricultural lime application and for N_2O emissions from disturbance associated with land use conversion to Cropland. Uncertainties in the net amount of carbon added to soils from liming that is emitted as CO_2 are dependent on used tier approach. Using tier 1 method, it is assumed that all carbon in lime is emitted as CO_2 to the atmosphere. This is a conservative approach, and the default emission factors are considered certain given this assumption. In practice, some of carbon in lime is likely to be retained in the soil as inorganic carbon and not emitted as CO_2, at least in the year of application. Consequently, default emission factors can lead to systematic biases in the emission estimates (IPCC GL 2006).

The time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

7.8.5.2 Source specific QA/QC and verification

The source specific QA/QC activities are described in the section 7.5 of this chapter.

The QC checks (eg. check of consistency 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 the next step by independent expert from the Ministry of Agriculture and Rural Development of the Slovak Republic.

7.8.5.3 Source specific recalculations

The recalculations in this land-use category are described in section 7.6 of this chapter.

7.8.5.4 Source specific planned improvements

Following improvement is planned for the next submission in this category:

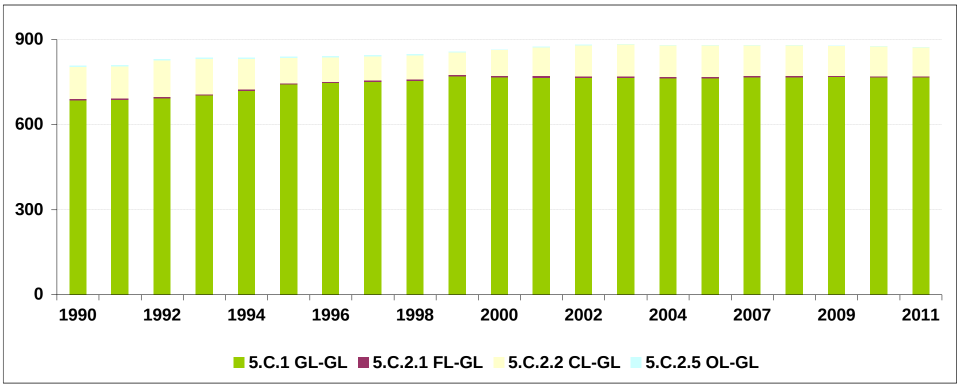
- Estimation of more accurate soil carbon stocks data for soils representing Cropland.

7.9 Grassland (CRF 5.C)

7.9.1 Source category description

The emissions and removals of GHGs in this category were obtained by using the IPCC GPG for LULUCF 2003 and national data on GL and Land converted to GL area in 2011. The total area of GL represented 874.22 kha in 2011; this is approximately 18% 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 7.18: *Development of activity data in kha for category 5.C Grassland in the period 1990 – 2011*



The total area of Grassland remaining Grassland was 767.13 kha in 2011, the changes in the Grassland were following: Forest Land converted to Grassland 2.64 kha, Cropland converted to the Grassland 103.53 kha, Other Land converted to Grassland 0.93 kha in 2011.

7.9.2 Grassland remaining Grassland (CRF 5.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 (deadwood and litter) and soil carbon pools is assumed (tier 1, IPCC GL 2006). 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 5.C.1 notation key "NO" is reported. The limestone application is not 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.

7.9.3 Land converted to Grassland (CRF 5.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 GPG for AFOLU 2006). 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.

7.9.3.1 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, BCEFs (0.7 for conifers and 1.2 for broadleaf) and default carbon content (0.5) were used. For biomass carbon stock on Grassland prior conversion the default values of 5.0 t C/ha for above ground and below ground biomass were used (Table 5.9, IPCC GL 2006). Carbon stock from one-year growth Grassland vegetation following the conversion was 6.5 t C/ha (Table 3.4.9, IPCC GPG LULUCF 2003).

Estimation of DOM emissions includes the emissions from changes in deadwood 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 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 using the country specific tier 2 methodology. 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 20 years period for carbon stock equilibrium in „new land-use“ conditions. The mean value of 8.3 Mg C ha^{-1} for carbon stocks in litter (representing surface organic layer) as well as 0.415 Mg 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:

- Annual changes in litter C stocks for Forest Land converted to GL = net annual accumulation of litter over length of transition period (Mg 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 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 7.7.4.1 of this chapter. Net carbon stock change in mineral soil was used for estimation of the average carbon stock per hectare noted above (5.A.2 Land converted to FL).

The average annual carbon stock change in mineral soil for different conversion of Land to GL category was calculated as:

- Annual changes in mineral soil C stocks for Land converted to GL = average annual change of SOC over length of transition period (Mg C ha^{-1} yr^{-1}) 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 values were calculated for different type of conversion:

- FL converted to GL 1.40 Mg C ha^{-1} yr^{-1}
- CL converted to GL 1.04 Mg C ha^{-1} yr^{-1}
- S converted to GL 1.62 Mg C ha^{-1} yr^{-1}
- OL converted to GL 1.62 Mg C ha^{-1} yr^{-1}

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 2011 is provided in the Table 7.11.

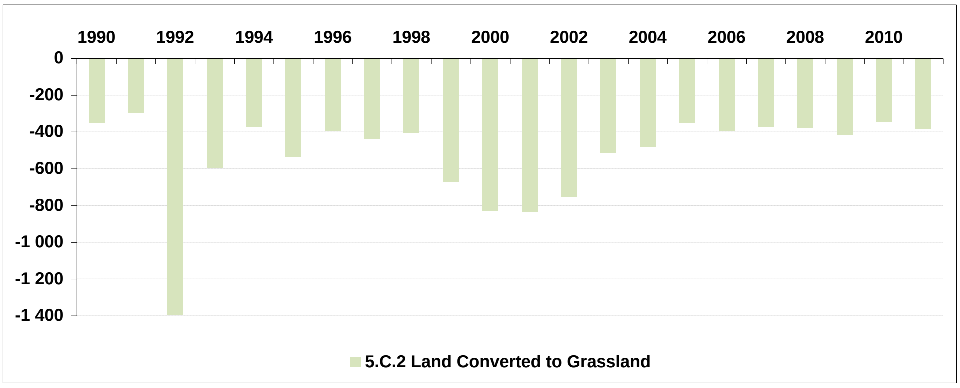
The results from the category 5.C.2 Land converted to Grassland are summarized in the following Table 7.15.

Table 7.15: *Results for the category 5.C.2 Land Converted to Grassland*

Land Use Category	Carbon Stock Change in Living Biomass			Net Carbon Stock Change in DOM	Net Carbon Stock Change in Soil	Net CO_2 Emissions/ Removals
	gains	losses	net change			
	(Gg C)			(Gg C)		(Gg CO_2)
Land - GL	**1.81**	**1.47**	**0.34**	**-1.16**	**105.62**	**-384.27**
FL - GL	NO	1.47	-1.47	-1.16	-3.70	23.19
CL - GL	1.81	NO	1.81	NA	107.82	-401.97
WL - GL	NA	NA	NA	NA	NA	NA
S - GL	NA	NA	NA	NA	NA	NA
OL - GL	NO	NO	NO	NO	1.50	-5.49

Total removals estimated in this category were 384.27 Gg CO_2 in 2011. The net carbon stock change in living biomass and net carbon stock change in soil for this category represented gains of 0.34 and 105.62 Gg C, but the DOM from Land converted to Grassland represented the losses of 1.16 Gg C in the reporting year.

Figure 7.19: *Summary of CO_2 removals (in Gg) in the category 5.C.2 in 1990 – 2011*



7.9.3.2 Uncertainties and time consistency

The default uncertainty for biomass accumulation rate and biomass carbon loss in Grassland ±75% was used, according to tier 1 method (IPCC GPG for AFOLU 2006). 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 wood stocks published by Šmelko et al. (2003), the uncertainty represented the range of 15-20%. The 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 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.

7.9.3.3 Source specific QA/QC and verification

The source specific QA/QC activities are described in the section 7.5 of this chapter.

The QC checks (eg. check of consistency 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.

7.9.3.4 Source specific recalculations

The recalculations in this land-use category are described in section 7.6 of this chapter.

7.9.3.5 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;

7.10 Wetlands (CRF 5.D)

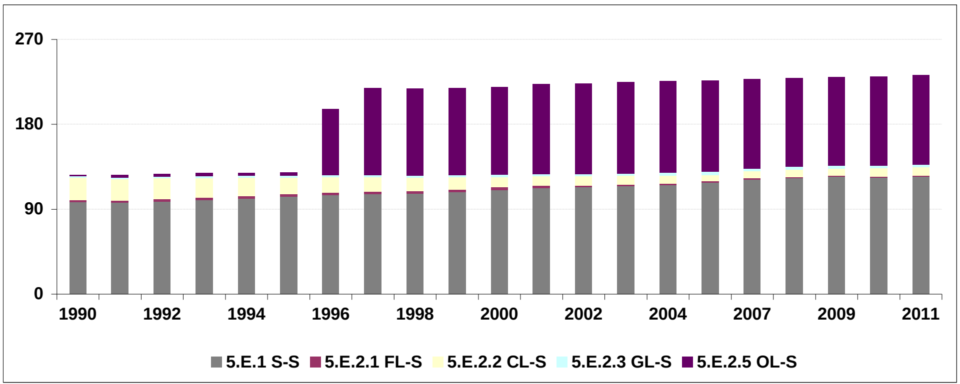
Based on the cadastral data the area of this category is 1.9% (94 kha) of the whole country area. The share of this land use category is unchanged since 1990.

7.11 Settlements (CRF 5.E)

7.11.1 Source category description

The category Settlements was reported as a separate category for the first time in the reporting year 2009. This category represented about 5% of the total country area. Total settlements´ area was 231.97 kha in 2011. The increasing trend of settlements area is visible for the time series, especially during the most recent years. This situation is mostly caused by development of transport infrastructure, industrial areas, municipal development and raising the standards and infrastructure. It is very often connected with decreasing of Cropland and other land use categories.

Figure 7.20: *Development of activity data in kha for category 5.E Settlements in the period 1990 – 2011*



The total area of Settlements remaining Settlements category is 124.20 kha, the changes in the Settlements were following: FL converted to S 0.96 kha, CL converted to S 9.46 kha, GL converted to S 2.66 kha and OL converted to S 94.70 kha in 2011.

7.11.2 Settlements remaining Settlements (CRF 5.E.1)

For this category the emissions of CO_2 can be considered insignificant as no change in living biomass, DOM (deadwood and litter) and soil carbon pools is assumed (tier 1, IPCC GL 2006). 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.

7.11.3 Land converted to Settlements (CRF 5.E.2)

This category includes all processes connected with conversion of Lands into Settlements.

7.11.3.1 Methodological issues – methods, activity data, emission factors and parameters

Tier 1 method from the IPCC GL for AFOLU 2006 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 deadwood in related to conversion of Forest Land. The calculation procedure is identical as is 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) with the default 20 years period for carbon stock equilibrium in „new land-use“ conditions. The mean value is 8.3 Mg C ha^{-1} for C stocks in litter (representing surface organic layer) and 0.415 Mg C ha^{-1} yr^{-1} as a net annual accumulation of litter over length of transition period were used net carbon stock change in litter calculation expressed by following equation:

- Annual changes in litter C stocks for Forest Land converted to S = net annual accumulation of litter over length of transition period (Mg 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 carbon stocks for each category of land use associated with FL converted to S.

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 7.7.4.1 of this chapter. Net carbon stock change in mineral soil was used for estimation of the average carbon stock per hectare noted above (5.A.2 Land converted to FL).

The average annual carbon stock change in mineral soil for different conversion of Lands to S category was calculated as:

- Annual changes in mineral soil C stocks for Land converted to S = average annual change of SOC over length of transition period (Mg C ha^{-1} yr^{-1}) x converted area (kha).
- Average annual change of SOC over length of transition period = (mean SOC stock of S – mean SOC stock of land converted to S)/20.

The following values were calculated for different type of conversion:

- FL converted to S 3.02 Mg C ha^{-1} yr^{-1}
- CL converted to S 0.58 Mg C ha^{-1} yr^{-1}
- GL converted to S 1.62 Mg C ha^{-1} yr^{-1}
- OL converted to S 0.58 Mg C ha^{-1} yr^{-1}

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 1991 to 2011 is provided in the Table 7.11.

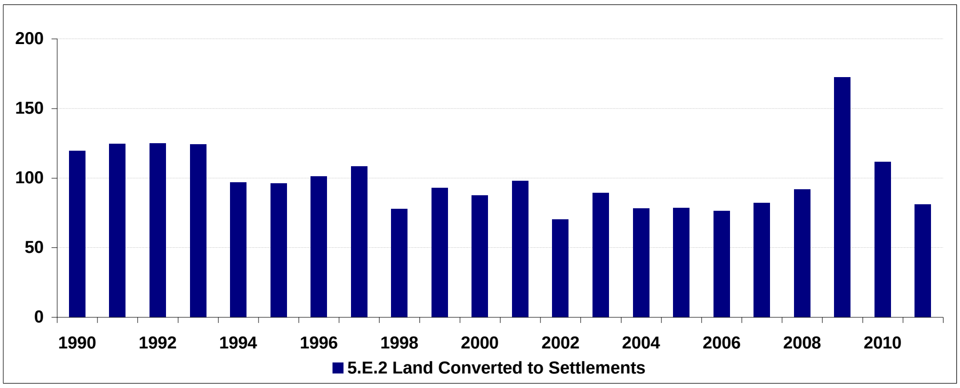
The results from the category 5.E.2 Land converted to Settlements are summarized in the following Table 7.16.

Table 7.16: *Results for the category 5.E.2 Land Converted to Settlements*

Land Use Category	Carbon Stock Change in Living Biomass			Net Carbon Stock Change in DOM	Net Carbon Stock Change in Soil	Net CO_2 Emissions/ Removals
	gains	losses	net change			
	(Gg C)			(Gg C)		(Gg CO_2)
Land - S	**NO**	**8.91**	**-8.91**	**-0.51**	**-12.67**	**81.02**
FL - S	NO	2.59	-2.59	-0.51	-2.90	22.02
CL - S	NO	3.57	-3.57	NA	-5.47	33.13
GL - S	NA	2.76	-2.76	NA	-4.30	25.88
WL - S	NA	NA	NA	NA	NA	NA
OL - S	NO	NO	NO	NO	NO	NO

Total emissions estimated in this category were 81.02 Gg CO_2 in 2011. The net carbon stock change in living biomass and net carbon stock change in soil for this category represented losses of -8.91, -0.51 and -12.67 Gg C in the reporting year.

Figure 7.21: *Summary of CO_2 emissions (in Gg) in the category 5.E.2 in 1990 – 2011*



7.11.3.2 Uncertainties and time consistency

The default uncertainty ±75% for biomass accumulation rate was used, according to tier 1 method published by IPCC GL for AFOLU 2006 for Cropland and Grassland. 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 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.

7.11.3.3 Source specific QA/QC and verification

The source specific QA/QC activities are described in the section 7.5 of this chapter.

The QC checks (eg. check of consistency 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.

7.11.3.4 Source specific recalculations

The recalculations in this land-use category are described in section 7.6 of this chapter.

7.11.3.5 Source specific planned improvements

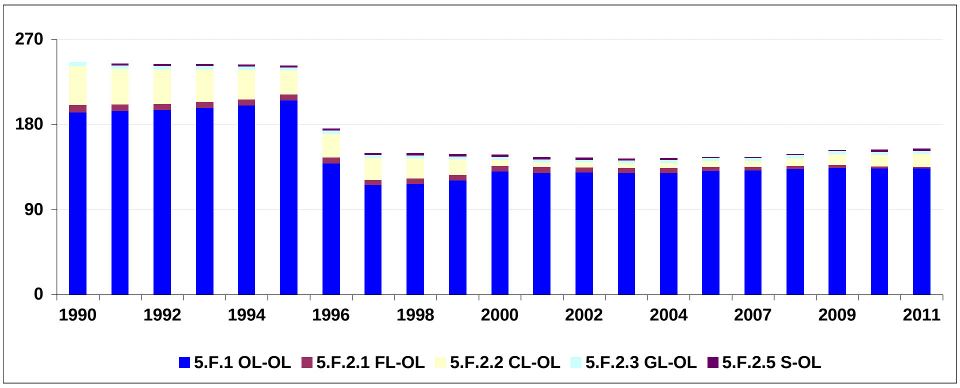
There are no short term plans concerning improvements in this land use category.

7.12 Other Land (CRF 5.F)

7.12.1 Source category description

The emissions and removals of GHGs in this category were estimated by using the IPCC GPG LULUCF 2003 and national data on area of Other Land and Land converted to Other Land during the inventory year 2011. The total area of Other Land represented 154.41 kha in 2011 what is approximately 3% of the total country area. Other Land area decreased sharply between 1995 and 1997. Since this year trend has been balanced.

Figure 7.22: *Development of activity data in kha for category 5.F Other Land in the period 1990 – 2011*



The total area of Other Land remaining Other Land was 133.40 kha, the changes in Other Land were following: FL converted to OL 2.11 kha, CL converted to OL 13.66 kha, GL converted to OL 2.84 kha, S converted to OL 2.39 kha in 2011.

7.12.2 Other Land remaining Other Land (CRF 5.F.1)

The emissions of CO_2 can be considered insignificant as no change in living biomass, DOM (dead wood and litter) and soil carbon pools is assumed (Tier 1, IPCC 2006) 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.

7.12.3 Land converted to Other Land (CRF 5.F.2)

This category includes all processes connected with conversion of Land into Other Lands. Tier 1 method (IPCC GL for AFOLU 2006) 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 for biomass immediately after conversion is 0 t/ha.

7.12.3.1 Methodological issues

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 deadwood in Forest Land. The calculation procedure is identical as described in detail in 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, Pavlenda, 2008) with the default 20 years period for carbon stock equilibrium in „new land-use“ conditions. The mean value 8.3 Mg C ha^{-1} for carbon stocks in litter (representing surface organic layer) and 0.415 Mg 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 with the following equation:

- Annual changes in litter C stocks for Forest Land converted to OL = net annual accumulation of litter over length of transition period (Mg 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 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 7.7.4.1 of this chapter. Net carbon stock change in mineral soil was used for estimation of the average carbon stock per hectare noted above (5.A.2 Land converted to FL).

The average annual C stock change in mineral soil for different conversion of Land to OL category was calculated as:

- Annual changes in mineral soil C stocks for Land converted to OL = average annual change of SOC over length of transition period (Mg C ha^{-1} yr^{-1}) x converted area (kha).
- Average annual change of SOC over length of transition period = (mean SOC stock of OL - mean SOC stock of land converted to OL)/20.

The following values were calculated for different types of conversion:

- FL converted to OL 3.02 Mg C ha^{-1} yr^{-1}
- CL converted to OL 0.58 Mg C ha^{-1} yr^{-1}
- GL converted to OL 1.62 Mg C ha^{-1} yr^{-1}
- S converted to OL 0.58 Mg C ha^{-1} yr^{-1}

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 1991 to 2011 is provided in the Table 7.11.

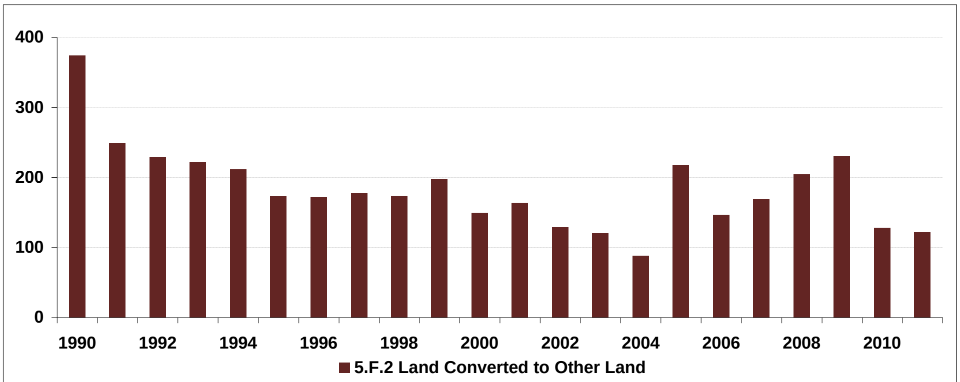
The results from the category 5.F.2 Land converted to Other Land are summarized in the following Table 7.17.

Table 7.17: *Results for the category 5.F.2 Land Converted to Other Land*

Land Use Category	Carbon Stock Change in Living Biomass			Net Carbon Stock Change in DOM	Net Carbon Stock Change in Soil	Net CO_2 Emissions/ Removals
	gains	losses	net change			
	(Gg C)			(Gg C)		(Gg CO_2)
Land - OL	**NO**	**13.17**	**-13.17**	**-1.12**	**-18.89**	**121.68**
FL – OL	NO	5.75	-5.75	-1.12	-6.38	48.59
CL – OL	NO	7.43	-7.43	NA	-7.90	56.19
GL – OL	NA	NA	NA	NA	-4.61	16.89
WL – OL	NA	NA	NA	NA	NA	NA
S - OL	NO	NO	NO	NO	NO	NO

Total emissions estimated in this category were 121.68 Gg CO_2 in 2011. The net carbon stock change in living biomass and net carbon stock change in soil for this category represented losses of -13.17, -1.12 and -18.89 Gg C in the reporting year.

Figure 7.23: *Summary of CO_2 emissions (in Gg) in the category 5.F.2 in 1990 – 2011*



7.12.3.2 Uncertainties and time consistency

The default uncertainty ±75% for biomass accumulation rate was used, according to tier 1 method published by IPCC GL for AFOLU 2006 for Cropland and Grassland. 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 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.

7.12.3.3 Source specific QA/QC and verification

The source specific QA/QC activities are described in the section 7.5 of this chapter.

The QC checks (eg. check of consistency 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.

7.12.3.4 Source specific recalculations

The recalculations in this land-use category are described in section 7.6 of this chapter.

7.12.3.5 Source specific planned improvements

Following improvement is planned for this category for the next submission:

- Re-evaluation of the soil carbon stocks for OL category is planned for the next submission. There is overestimation in this category in this inventory.

7.13 Direct N_2O emissions from N fertilization of forest land and other (CRF 5(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

7.14 Non CO_2 emissions from drainage of soils and wetlands (CRF 5(II))

There are any CO_2 and non-CO_2 emissions related to drainage of wet forest soils reported. Wet forest soils are classified as peat land in Slovakia and therefore this land is included into strictly protected areas without active management. The current area of peat lands is only 2 773 ha (Stanová et al., 2000).

7.15 N_2O emissions from disturbance associated with land use conversion to cropland (CRF 5(III))

Activity data and results of N_2O emissions estimation from disturbance associated with land use conversion to cropland are included in the section Land converted to Cropland of this report.

7.16 CO_2 emissions from agricultural lime application (CRF 5(IV))

Activity data and results of CO_2 emissions estimation from agricultural lime application are included in the section Cropland remaining Cropland of this report.

CHAPTER 8: WASTE (CRF 6)

8.1 Overview of sector (CRF 6)

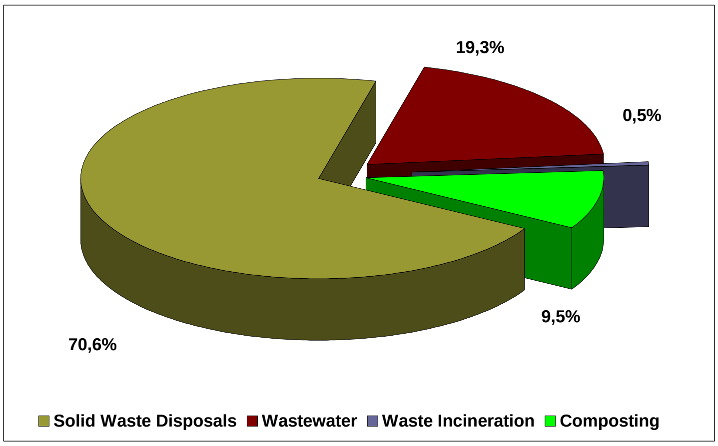
Inventory of emissions from waste management includes direct (CO_2, CH_4, N_2O) and indirect (NMVOCs) greenhouse gas emissions. The production of CH_4 and N_2O emissions are important for waste disposal and wastewater treatment. Disposal of wastes and handling of wastewater results in production of greenhouse gases emissions. An estimation of the following emissions in 2011 is presented:

- 6.A Solid waste disposal sites.
- 6.B Wastewater handling.
- 6.C Waste incineration.
- 6.D Other (Biological treatment of solid waste).

In 2011, total aggregated GHG emissions from waste were 2 227.32 Gg of CO_2 equivalents and they increased compared to the previous year by almost 1% mostly caused by increase in the SWDS category (industrial). Compared to the reference year 1990 the emissions increased two times. To the total emissions from waste sector belongs also the emissions from waste incineration with energy use allocated in energy sector (category 1.A.1a other fuels). Total emissions expressed in CO_2 equivalents in this category were 67.96 Gg in 2011. These emissions are accounting in energy sector.

The most important gas is CH_4, with the 91% share, N_2O emissions with 8.5% and CO_2 emissions with 0.5% (without waste incineration with energy use). The most important source of GHG emissions are solid waste disposal on land (71%), wastewaters (19%), composting (9.5%) and waste incineration without energy use (0.5%).

Figure 8.1: *The share of individual categories in emissions in sector waste in 2011*



Category	GHG (Gg CO_2 eq.)
Solid Waste Disposals	1 572.90
Wastewater	430.09
Waste Incineration	11.84
Composting	2012.49

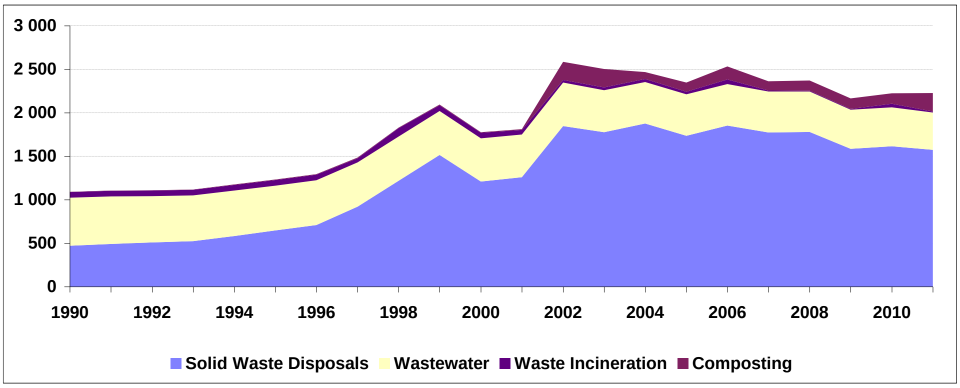
Waste sector contributed by 5.9% to total GHG emissions. Introduction of more exact methodology for the evaluation of methane emissions from solid waste disposal on sites resulted in continual increase of emissions compared to the base year 1990. Similar trend is expected to remain in the future, although only with slight increase in emissions. The amount of emissions from landfills depends, to a large extent, on the methodology adopted to evaluate landfills and on the implementation of energy recovery of landfill gases by landfill operators.

***Table 8.1:** GHG emissions in individual categories in waste sector in 1990 – 2011*

Year	Total CO_2	Total CH_4	Total N_2O	Total GHG	Total 6.A	Total 6.B	Total 6.C	Total 6.D
	Sector Waste (CRF 6)							
	(Gg)			(Gg of CO_2 *eq.*)				
1990	62.70	42.16	0.46	1 091.33	469.77	552.59	65.43	3.54
1991	62.70	43.15	0.44	1 105.90	492.45	544.48	65.43	3.54
1992	62.70	43.92	0.40	1 109.98	507.36	533.65	65.43	3.54
1993	62.70	44.50	0.39	1 119.03	522.69	527.12	65.43	3.79
1994	62.70	47.16	0.39	1 175.03	582.75	523.49	65.43	3.36
1995	62.70	49.66	0.41	1 232.71	647.85	513.16	65.43	6.27
1996	62.70	52.53	0.41	1 293.62	710.01	512.59	65.43	5.59
1997	45.30	62.46	0.41	1 484.45	919.80	509.96	47.84	6.85
1998	91.10	76.77	0.40	1 828.83	1 218.00	509.57	94.54	6.73
1999	63.20	90.96	0.39	2 092.74	1 515.78	504.23	65.77	6.96
2000	62.80	76.42	0.35	1 777.04	1 207.71	497.25	65.65	6.42
2001	52.20	78.68	0.34	1 810.85	1 258.74	489.99	54.40	7.72
2002	24.71	111.16	0.73	2 584.46	1 845.90	501.38	29.58	207.60
2003	26.42	107.90	0.68	2 501.90	1 776.39	483.02	30.57	211.92
2004	28.00	109.46	0.45	2 467.29	1 875.72	478.13	33.33	80.11
2005	21.86	103.15	0.51	2 346.13	1 736.07	476.63	27.28	106.15
2006	48.49	109.71	0.58	2 532.60	1 853.46	474.74	53.54	150.86
2007	7.52	104.83	0.50	2 362.59	1 773.45	470.56	11.67	106.91
2008	5.71	105.30	0.49	2 369.99	1 780.80	462.23	9.56	117.40
2009	5.04	95.54	0.49	2 164.06	1 584.45	451.31	7.70	120.60
2010	37.09	96.74	0.50	2 222.79	1 615.26	447.23	41.84	118.46
2011	9.58	96.40	0.62	2 227.32	1 572.90	430.09	11.84	212.49

Methane emissions from municipal 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.[12] The disaggregation of emissions from waste incineration into two groups, i.e. waste incineration for 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.1a (other fuels). The emissions from waste incineration without energy utilisation are reported under sector waste. Emissions from waste composting are a new category in sector waste, the share of which is supposed to increase due to adopted policies and measures. Less important changes of parameters and methodology have occurred in categories domestic wastewater treatment and industrial wastewater treatment. The temporally decrease in emissions during 1999 – 2002 was caused by the decrease of methane emissions in SWDS category due to the changes in waste catalogue and other legislative changes in waste categorization.

***Figure 8.2:** Emission trends of individual categories in sector waste in 1990 – 2011*



8.2 Solid waste disposal on land (CRF 6.A)

8.2.1 Source category description

The emissions from Solid waste disposal sites (SWDS) are the major emission source in waste sector. The methane emissions are estimated separately for subcategories:

- 6A1 Managed waste disposal on land in 2001 – 2011.
- 6A3 Other:
  - Uncategorized municipal solid waste in 1990 – 2000.
  - Agricultural and industrial solid waste in 1997 – 2011.

Total methane emissions in category 6.A were 74.90 Gg (1 572.90 Gg of CO_2 *eq.*) in 2011 and they decreased by 3% compared to the previous year. This decrease was caused by decreasing of industrial waste disposal. The emissions of NMVOC were estimated to be 4.28 t in 2011. Emissions of CO_2 influencing national total were not occurring in this category. The agricultural and industrial waste before 1997 was not estimated due to the lack of activity data about the waste stream. The emissions from unmanaged waste disposal sites in the subcategory 6.A.2 were not occurring from the base year 1990. The emissions from solid waste disposal on land increased in comparison with the base year by almost 3.4 times due to the improvements of disposal practice, resulting in the increase in MSW emissions together with the cumulative effect of FOD methodology.

Table 8.2: *GHG emissions in individual categories in solid waste disposal on land in 1990 – 2011*

Solid Waste Disposal on Land (CRF 6.A)				
Year	**Total 6.A**	**Managed MSW**	**Uncategorized MSW**	**Agricultural & Industrial SW**
	CH_4 in Gg			
1990	22.370	IE	22.370	NE
1991	23.450	IE	23.450	NE
1992	24.160	IE	24.160	NE
1993	24.890	IE	24.890	NE
1994	27.750	IE	27.750	NE
1995	30.850	IE	30.850	NE
1996	33.810	IE	33.810	NE
1997	43.800	IE	36.700	7.100
1998	58.000	IE	39.400	18.600
1999	72.180	IE	42.180	30.000
2000	57.510	IE	42.510	15.000
2001	59.940	44.940	NO	15.000
2002	87.900	45.540	NO	42.360
2003	84.590	46.270	NO	38.320
2004	89.320	46.630	NO	42.690
2005	82.670	47.040	NO	35.630
2006	88.260	47.650	NO	40.610
2007	84.450	48.220	NO	36.230
2008	84.800	47.960	NO	36.840
2009	75.450	48.890	NO	26.560
2010	76.917	46.860	NO	30.058
2011	74.900	47.512	NO	27.388

8.2.2 Source category description – Managed waste disposal on land (CRF 6.A.1)

A new legislative regulation about SWDS entered into force on 1st July 2001 in accordance with the EU legislative harmonisation. The relevant Act No 223/2001 Coll. and Decree of the Ministry of Environment No 283/2001 Coll. contain new tools for waste disposal restrictions and monitoring of waste sites and waste gases generation. The gases produced by waste disposal, particularly CH_4, can be a local environmental hazard if precautions are not taken to prevent uncontrolled emissions or migration into surrounding land. Landfill gas is known to be produced both in managed "landfill" and "open dump" sites. Landfill gas can migrate from SWDSs laterally or by venting to atmosphere, causing vegetation damage and unpleasant odours at low concentrations, while at concentrations of

5-15% in air, the gas may form explosive mixtures. Development of engineered, controlled landfills, including gas collection systems, started in 1991 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.

8.2.2.1 Methodological issues – methods

The estimation of methane emissions from SWDSs by FOD method were calculated using a spreadsheet model. Results are presented as a cumulative diagram, which shows the contribution of emissions from MSW disposed each year and covers the entire period 1960 – 2011 and as a bar chart showing total emissions for the period 1990 – 2011.

The methane emissions for MSW are included into category Managed waste disposal on land (6A1) since 2001, before this year the waste disposal sites were uncategorized and emissions were included in category Other municipal waste uncategorized (6.A.3). According to the used model for estimation of methane emissions from MSW disposed to SWDSs the total emissions reached 47.51 Gg in 2011, but this number was reduced with the methane recovery value (2.5 Gg of CH_4 according to the information from the Terrasystem company).

When comparing the results obtained by the Tier 1 and Tier 2 method, the basic difference between these methods must be kept in mind:

- Tier 1 method assumes that all methane is emitted “at once” and not only activity data but also parameters reflect the situation in the year of MSW disposal.
- Tier 2 method assumes, that methane is emitted “continuously” and current emissions are influenced by the past emissions.

This difference in approaches can be negligible in countries with a long history in controlled MSW disposal, but in countries which recently significantly changed their waste management practices (like the Slovak Republic) this creates additional uncertainties.

The IPCC 2006 Guidelines presents a decision tree for CH_4 emissions from waste disposal. Tier 2 estimated emissions using the IPCC FOD method with default parameters and good quality country-specific activity data were selected as appropriate method. Comparing the situation abroad with the situation in the Slovak Republic, several differences can be identified:

- Most countries are using the site-specific data. The methane emissions are calculated for each SWDS (or group of SWDS) separately and then the results are summed to obtain national methane emission estimations. This approach is not yet possible, because collected data on MSW do not include the needed characterisation of SWDS.
- Historical data on MSW management and disposal are more detailed than data available in the Slovak Republic.
- Data on MSW fractions are collected in more systematic and regular way than is the practice in the Slovak Republic.

The second version of FOD method, as it is defined in the IPCC 2000 GPG was selected as the most appropriate approach. This decision is supported by following reasons:

- Parameters used are better defined and allow direct comparison with the Tier 1 method.
- Some of the parameters used are defined as time-variables. This allows modelling of the waste sector transformation in the period 1992 – 2000.
- Structure of required input data corresponds better with MSW data available (data for the use of multiphase method are not available).

8.2.2.2 *Methodological issues – emission factors and parameters*

The IPPC methodologies encourage the use of locally based parameters, which reflect local level and conditions of MSW disposal. FOD method parameters (this includes Tier 1 parameters, because they are used in FOD method) were reviewed with the aim to identify parameters specific to MSW management in the Slovak Republic. Parameters currently used for methane emission estimation were critically reviewed and additional data were collected to support proposed changes in these parameters.

<u>MCF:</u>

A small, but important change is done to better reflect the significant improvement of SWDSs practice in the period 1992 – 2000. The MCF does not depend on the year when MSW was disposed, but on the year when the estimation of methane emission was done. The MCF depends on the year when MSW was disposed following the idea that landfill operation practice does not changes with time. This is in contradiction to the situation in the Slovak Republic, where within a relatively short time disposal practices changed toward controlled landfilling. Compacting and covering of waste was introduced and this caused increased generation of methane. However, this period of modernizing of disposal practice requires further investigation.

Recently seven landfills have installed landfill gas recovery systems, in four cases the landfill gas collection and flaring system were installed by company Terrasystems within a carbon trading scheme. The trend is toward utilisation of landfill gas for 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 in accordance 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.

The company wants to include other four landfills, resulting in expected savings of ca. 550 kt of CO_2 in the period 2008 – 2012. The annual saving can be estimated to 110 Gg CO_2 or 5 Gg CH_4 or nearly 10% decrease of methane emissions from MSW landfills in the Slovak Republic. The value of methane recovery was 2.50 Gg in 2011.

The methane correction factor (MCF) describes the way how MSW is managed on site; this factor is individual for each landfill. The currently available data do not allow a site-by-site approach. But, with the adoption of the first Waste Act a period of re-direction of MSW stream from old non-complying SWDSs to controlled EU-standard landfills was enforced by the Ministry of Environment. Thus, the following hypothesis is proposed:

- Before 1992 all MSW were disposed of in SWDSs on which very little or no data exist = IPCC category uncategorized sites (6.A.3).
- Period 1993 – 1999 is a period of transition when managed sites were gradually developed = linear growth of MCF (6.A.3).
- Since 2000 all MSW has been disposed of in managed landfills = IPCC category managed sites (6.A.1).

Of course, there is a risk that managed sites existed before 1992 or uncategorized sites were still in (illegal) operation after 2000, but there is no available evidence to reject the hypothesis above. MCF(x) was 1 fraction from 2001 – 2011 (Table 8.3).

<u>DOC:</u>

An analysis of existing data on MSW fractions in the Slovak Republic was done to verify the value of DOC. The MSW composition data cover different target areas (national, regional, municipal, suburban) and are from various years (in general 1997 – 2011) but the following calculations are aimed more at presenting a DOC calculation method to be used in future when better data are available. The data used can not be fully verified, and the methodology of MSW composition analysis is not known for some data, but they are quoted in official documents of the Ministry of the Environment.

Table 8.3: *Activity data and input parameters for municipal solid waste disposal in 1990 – 2011*

Municipal Solid Waste Disposal on Land (CRF 6.A.1)									
Year	**Annual MSW at the SWD**	**MCF**	**DOC_F**	**EF (CH_4)**	**Waste Generation Rate**	**Fraction of DOC in MSW**	**Fraction of MSW to SWDS**	**Methane Recovery**	**OF**
	(kt)		(%)	(t/t)	(kg/pr/day)			(Gg)	
1990	1 162.000	0.60	60	0.019	219.337	0.12	0.900	0.000	0.00
1991	1 182.000	0.60	60	0.020	223.719	0.12	0.900	0.000	0.00
1992	1 210.000	0.60	60	0.020	228.021	0.12	0.900	0.000	0.00
1993	1 238.000	0.60	60	0.020	232.504	0.12	0.900	0.000	0.00
1994	1 266.000	0.65	60	0.022	236.755	0.12	0.900	0.000	0.00
1995	1 347.000	0.70	60	0.023	251.134	0.12	0.858	0.000	0.00
1996	1 249.000	0.75	60	0.027	232.424	0.12	0.856	0.000	0.00
1997	1 206.000	0.80	60	0.030	224.029	0.12	0.831	0.000	0.00
1998	1 113.000	0.85	60	0.035	206.460	0.12	0.815	0.000	0.00
1999	1 134.000	0.90	60	0.037	210.182	0.12	0.822	0.000	0.00
2000	1 056.000	0.95	60	0.040	195.531	0.12	0.788	0.000	0.00
2001	1 049.000	1.00	60	0.043	194.989	0.12	0.834	0.000	0.00
2002	1 192.000	1.00	60	0.038	221.610	0.12	0.782	0.000	0.00
2003	1 256.000	1.00	60	0.037	233.503	0.12	0.785	0.000	0.00
2004	1 195.000	1.00	60	0.039	222.013	0.12	0.810	0.170	0.00
2005	1 227.000	1.00	60	0.039	227.759	0.12	0.788	0.340	0.05
2006	1 260.000	1.00	60	0.038	233.925	0.12	0.776	0.370	0.05
2007	1 295.000	1.00	60	0.038	240.277	0.12	0.776	0.500	0.05
2008	1 369.000	1.00	60	0.036	253.192	0.12	0.765	1.680	0.05
2009	1 411.000	1.00	60	0.036	260.410	0.12	0.808	1.680	0.05
2010	1 412.000	1.00	60	0.035	259.785	0.12	0.781	2.000	0.10
2011	1 320.073	1.00	60	0.038	244.262	0.12	0.750	2.500	0.10

OF = oxidation factor, (pr = person)

The average DOC value is 0.12 Gg C/Gg MSW. This is very close to the DOC value used in the Slovak Republic for the estimation of methane emissions from SWDSs. Also, MSW composition data by type of dwellings and by type of heating published in Czech Republic in 2003 were processed to verify the DOC values with the following results.

Table 8.4: *Historical DOC data derived from statistical data*

DOC values for FOD model		
Year	**Central heating**	**DOC**
1961	7.40%	0.06
1970	23.60%	0.08
1980	46.20%	0.10
1991	74.70%	0.12
2001	76.30%	0.12

<u>Other parameters:</u>

Well-managed SWDS use value 0.10 for oxidation factor. The current situation of MSW disposal in the Slovak Republic has been improved significantly, according to the waste legislation only well-managed landfills can be operated. This provides the argument that the Slovak Republic should not used the IPCC default zero for this parameter. On the other hand, there are still old SWDS which were not properly built nor operated. The oxidation factor is considered as time-variable, although this is not stated in the IPCC documents. Currently, the fraction with the value of 0.10 is used since 2010.

The methane generation potential is also a time-variable, as its value depends on time-variable parameters (Table 8.3).

The methane generation constant depends mainly on moisture, for areas with rainfall over 500 mm/yr the recommended value is 0.065. The rainfall was over 500 mm/yr in the last 10 years.

Table 8.5: *Parameters proposed as constant for estimation of methane emissions from SWDS*

Parameter	Value	Note
Fraction dissimilated DOC (DOC_F)	0.60	IPCC default value, no national data available
Fraction methane in landfill gas (F)	0.50	IPCC default value, no national data available
Methane recovery (R)	2.50 Gg	Plant specific data
Methane generation rate constant (k)	0.065	Not sufficient data for use of multiphase model

Table 8.6: *Parameters proposed as time-variable for estimation of methane emissions from SWDS*

Parameter	Range	Note
Methane correction factor (MCF)	0.6 - 1.00	Constant in 1960 -1992, linear increase in 1993 – 2000, constant since 2001
Degradable organic carbon (DOC)	0.06 - 0.12	Linear increase in 1960 – 1991, constant since 1992
Oxidation factor (OF)	0.00 - 0.10	Zero until 2000, 0.05 since 2001 and 0.10 since 2010
Methane generation potential (Lo)	0.014 - 0.048	Calculated function of DOC

8.2.2.3 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. There are several possibilities how to estimate the needed length of data timeline:

The latest available estimation on MSW in the Slovak Republic dates back to 1960 and data on housing (needed for estimation of DOC(x)) are available from 1961. Therefore it was decided to generate a MSW data from 1960, i.e. for 52 years. Analysis of MSW generation data shows a huge difference in MSW generation in years 1992 – 1994, compared to data 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 estimation of methane emissions and replaced by interpolated data, as explained in the following. It may be interesting that similar, but smaller “inflation” of data appears also in the period 2002 – 2005, when EU waste classification system was introduced.

Latest indication on MSW generation in the Slovak Republic was found for 1960 and 1970. Since 1992, data from annual monitoring are available. Annual MSW generation was interpolated. It is hard to expect that further research will result in more exact data on MSW generation in the past (before 1989) as the practise of MSW generation estimation in that time was based on number of kilometres driven by a collection vehicle. These data were often considerably exaggerated.

When assessing the amount of MSW disposed to SWDSs, the key factor to the MSW management practice in the Slovak Republic is operation of two MSW incinerators in Bratislava and Kosice.

These two incinerators burned in average 150 Gg MSW per year in the period 1993 – 2011 (BA 100 Gg/yr, KE 50Gg/yr). It is assumed that this amount of MSW was burned since they were put in operation. Thus, the input values for fraction of MSW landfills can be divided into three periods:

- 1960 – 1976: 1 – all waste disposed to SWDS.
- 1977 – 1994: 0.9 – MSW Incinerators in operation.
- 1995 – 2011: Real data on MSW disposed were used.

Activity data used for the estimation of methane emissions from SWDS are the following:

- Length of data timeline.
- Total MSW generated.
- Fraction of MSW landfilled.

8.2.2.4 Uncertainties and time consistency

More complex method for estimating methane emissions from municipal solid waste disposal sites (SWDSs) acknowledges the fact that methane is emitted over a long period of time rather than instantaneously. A kinetic approach therefore needs to take into account the various factors, which influence the rate and extent of methane generation and release from SWDSs. The equations for first order decay (FOD) method are from the IPCC 1996 GL. The IPCC 2000 GPG provides further details on the FOD method, mainly in defining FOD model parameters. This approach can be used to model landfill gas generation rate curves for an individual landfill. It can also be used to model gas generation for a set of SWDSs to develop country emissions estimates or can be applied in a more general way to entire regions.

The IPCC methodology and Good Practice Guidelines were used to estimate methane emissions from landfills. A database of the Centre of Waste Service and Environmental Management in Bratislava has been used as a source of input data. GHG emissions from waste sector are the key source and concerning to the actual emission factors (EF) there are estimated with the high uncertainty level.

The uncertainty of estimation of CH_4 emissions is mainly caused by the uncertainty of statistical data on consumption. Another source of uncertainty is the applied default EFs. An additional error in calculation of the other greenhouse gas emissions may occur as a result of less exact methods and it cannot be estimated. The calculation of emission uncertainty of landfill by using more sophisticated Tier 2 - Monte Carlo method has been evaluated for these reasons. In some cases the pure analytic solution of investigated problem is difficult to find. For events where significant inaccuracy of mentioned data is presented, the statistical approach is accepted and it helps us to include uncertainty to the final assumption. To know the final margin of uncertainty of observed processes, it is necessary to estimate the eventual fluctuation of analyzed variable which entered to the examined processes interdependency. By using a classical statistical approach it can be difficult to obtain in some cases reasonable final information about consequential uncertainty of investigated processes.

A method, which allows implementing all uncertainty to the final analyses, is Monte Carlo method. In many applications of Monte Carlo method, the investigated process is simulated directly. There is no need to describe the behavior of the investigated system. It can be advantageous in some complicated systems. The only important requirement is that this system could be described by probability density functions (PDF). We will assume that the properties of a system can be described by PDF’s. Once the PDF’s are known, the Monte Carlo simulation can proceed by random sampling technique from the PDF’s. This approach works with random number generator of random numbers, which have properties of desirable PDF. Many trials are then performed and the expected result is obtained as an average over the number of values. In this case, it can be predicted the statistical structure such as variance, kurtosis and some other higher statistical moments of this simulated result. From these characteristics the estimation of the number of Monte Carlo trials can be achieved to obtain a result with an expected error. The Monte Carlo method is based on the generation of multiple trials to determine the expected value of a random value. In our case it can be said that this method is uncertainties combination of probability distribution functions for activity data (AD) and EFs. Total emissions are then computed as combination of random numbers for appropriate distribution function for assigned greenhouse gases. The advantage of this method is asymmetry allowance to the statistical distribution (Tier 1 method does not allow asymmetry). This advanced method is useful for data manipulation in the case, when proper input data quality is provided. Usually it can be assumed that higher tier methods should be associated with lower uncertainties of input data.

In practice, uncertainties of processes vary from a few percent to orders of magnitude, and may be correlated. This is not consistent with the simplified assumptions which are applied in the Tier 1 method (the variables are uncorrelated with a standard deviation of less than about 30% of the mean). Tier 1 method supposes the following assumptions: the number of emission and uptake terms is large, no single term dominates the sum and the emissions and uptakes are independent. If this is the case then the sum of the variances of all the terms equals the variance of the total inventory, and the distribution of total emissions is normal. Thus the interval defined by approximately two standard deviations either side of the mean is the 95% confidence interval of the inventory.

In Tier 1, the uncertain quantities are usually combined by addition. In this case, with respect to the limitation it can be supposed that the standard deviation of the sum is the square root of the sum of the squares of the standard deviations of the quantities that are added with the standard deviations all expressed in absolute terms (this rule is exact for uncorrelated variables). On the next, in Tier 1 the uncertain quantities are combined by multiplication, the same rule applies as in previous case; except that the standard deviations must all be expressed as fractions of the appropriate mean values (this rule is approximate for all random variables). In spite of these simplified limitations an approximate results with Tier 1 method could be obtained in the cases, which exceed mentioned circumstances. Unlike previous difficulties the Monte Carlo method can combine uncertainties with any probability distribution (non-Gaussian), range (large variances), and correlation structure. In these cases Monte Carlo method could be preferable method. The practice shows that in some cases Tier 1 method could yield results with lower uncertainty than higher tier methods. In this situation one should know limitation and statistic simplification of Tier 1 method. It is important to know that Tier 1 method offers only rough and approximate results. It gives informative data, which serve the background for more sophisticate analyses. On the other hand, Tier 1 method could be an unique starting point to obtain solid results in the absence of quality input data (high variance of examined processes, etc.). The ideal information of estimated uncertainties includes:

- The arithmetic mean (mean) of the data set.
- The standard deviation of the data set (the square root of the variance).
- The standard deviation of the mean (the standard error of the mean).
- The probability distribution of the data.
- Covariance’s of the input quantity with other input quantities used in the inventory calculations.

This information, which have the base in measurement or in empirical source of data or in data which are assessed by expert, are sufficient to define the probability distribution for statistical analysis and for specification of 95% confidence interval. During the inventory the uncertainty source can be identified from next different processes:

- Uncertainties from definitions (e.g. meaning incomplete, unclear, or faulty definition of an emission or uptake).
- Uncertainties from natural variability of the process that produces an emission or uptake.
- Uncertainties resulting from the assessment of the process or quantity, including, depending on the method.

In inventory for simulation of CH_4 emissions from landfill the second variant of FOD method was chosen and additionally Tier 2 approach was used (Tier 1 approach was calculated too). Solid waste disposal site’s emissions of CH_4 are mainly dependent on the factors and other parameters from emission inventory changed from year to year (amount of waste disposed of in landfill, meteorological conditions, population growth, composition of waste...) and from previous years (managing style of sites...), which yield methane contribution from deeper layers to the emissions in the inventory year. It is evident that total emissions depend on many factors, which vary from year to year.

Probability distribution functions and their basic characteristics, mean value and 95% confidence interval expressed with two percentage values relative to the mean value. In Table 8.7 some parameters should be explained. The parameter F is split to the variables with different confidence interval in the years before 1994 and after 1994. Parameters MCF are defined analogically. The difference from the previous case is that the mean value is changed too. For this reason, the data until

1993 and between 1994 and 2001 should be recalculated. In the interval from 1994 to 2001 the mean value is linearly interpolated between the values of data before 1994 and data after 2001. The variability is modified adequately.

Table 8.7: *The uncertainty and mean value estimations, IPCC default values for parameters used in FOD model*

Parameter	IPCC mean value	IPCC confidence interval value	Remark
$Q_t(x,t)$			methane generated in the year t (Gg/yr) from waste layer storage in the year x
Q_T			methane generated in the year t (Gg/yr) from all layers
Fk(x)			normalization factor which corrects the summation, gas leakage from deeper dump layers
k	0.05	-40%,+300%	Methane generation rate constant (1/yr)
MSWT(x)		>±10% For countries with poor quality data: more than a factor of two	Total municipal solid waste (Gg/yr)
MSWF(x)		>±10% For countries with poor quality data: more than a factor of two	Fraction of MSWT disposed in the year x
$L_0(x)$			methane generation potential (Gg CH_4/Gg waste)
MCF(x)	= 1 = 0.4 = 0.6	–10%, +0% –30%, +30% –50%, +60%	Methane correction factor in the year x (fraction)
DOC(x)	0.21 (maximal default value)	–50%, +20%	Degradable organic carbon in the year x (Gg C/Gg waste)
$DOC_F(x)$	0.77	–30%, +0%	dissimilated fraction of DOC
F(x)	0.5	–0%, +20%	Fraction by volume of the methane in the landfill gas
16/12			Conversion factor from C to CH_4
(x)	uncertainty is likely to be relatively small compared to other uncertainties		Recovered methane in the inventory year t (Gg/yr)
OF (x)	if a value other than zero has been used for OF itself		Oxidation factor (fraction)

Special explanation is required in relation to parameter MSWL, which is a product of multiplication of MSWT and MSWF. In this case we exploit the possibility to transform easily the standard distribution to the normal distribution. Parameter MSWL varied during the analyzed period 1960 – 2010 significantly, the mean value and 95% confidence interval varied during this period, but PDF has feature of the normal distribution. The uncertainty of MSWL until 1995 was taken to 50% of the mean value. After 1995 the uncertainty of MSWL was taken to 10% of the mean value. DOC(x) value was changed linearly from value 0.06 in 1960 to value 0.12 in 1990. After 1990 this parameter has constant value. For the parameter OF, the values from Table 8.7 are valid only in the period from 1994 to 2010. Before this period the zero value is assumed. The country specific value for mean values and confidence interval in Table 8.8 were estimated by sector expert for waste.

Table 8.8: *Uncertainty and mean value estimation, which are used in the Slovak Republic*

Category	Mean value	Confidence int.	Distribution function
k	0.065	-45%:230%	empirical
F(x) (until 1994)	0.500	-20%:20%	normal
F(x) (after 1994)	0.500	-2.0%:20%	empirical
MSWL (until 1994)		-50%:50%	normal
MSWL (after 1994)		-10%:10%	normal
DOCF	0.600	-30%:28%	triangular
DOC(x)		-50%:20%	empirical
MCF (until 1994)	0.600	-50%:60%	empirical
MCF (after 2001)	1.000	-30%:4%	triangular
OF	0 – 0.10	-95%:100%	triangular
R(x)		-2.0%:2.0%	triangular

Tier 1 approach is below method limits and its results should be interpreted carefully. The formulas are not simple, they contain time dependence and nonlinear features are important. Standard deviations of some input parameters are higher than 30% of mean value. In this case the rules of uncertainty computation by Tier 1 can serve only informative results.

If obtained data are used for developing distributions, it is important to determine whether it is a random, representative sample. To obtain the 95% confidence limits, some additional information about the data set is needed. The use the properties of PDF or cumulative distribution function (CDF) allows obtaining additional information about percentiles and data properties. Based on this knowledge, the propagation of uncertainties can be analyzed and the values for confidence interval can be determined.

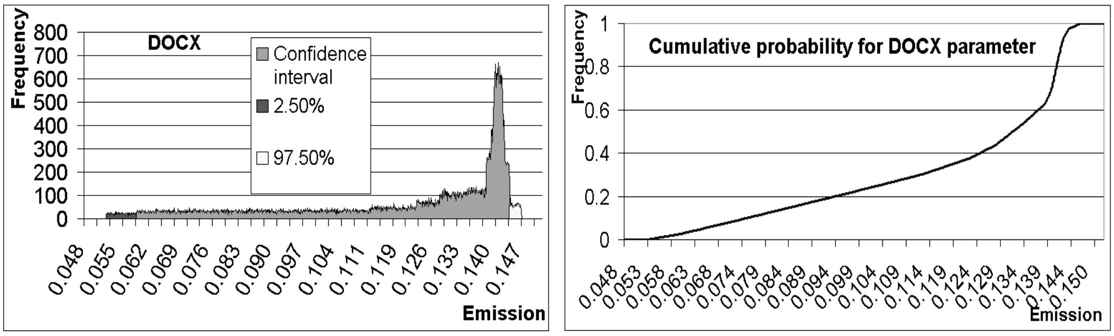
In some cases an empirical distribution is constructed, which supplies analytical properties of PDF or CDF. There are many references, which prefer to use analytical distribution instead of empirical distribution. They say that empirical probability distributions are unwieldy and they offer the replacement of the empirical distribution by an analytical function, either CDF or PDF. In the text below it can be seen that in some cases keeping the empirical distribution has more advantages than forcing to find analytical function. For example in many cases, several functions can fit the empirical data satisfactorily within a given probability criteria. These different functions can have different distributions at the extremes where there are few or no data to constrain them, and the choice of one function over another can systematically change the outcome of an uncertainty analysis.

Several recommendations on the PDF or CDF construction can be found in papers. These recommendations start to be important especially when there are some degrees of freedom for the construction of PDF, usually when expert recommendations are important and no sufficient data are available.

When empirical data are available, the first choice should be to assume a normal distribution of the data (either in complete or truncated form to avoid negative values, if these would be unrealistic), unless the scatter plot of the data suggests a better fit to another distribution. When expert judgment is used, the distribution function adopted should be normal or lognormal as in previous case, supplemented by uniform or triangular distributions. Other distributions are used only where there are compelling reasons, either from empirical observations or from expert judgment backed up by theoretical argument.

The analytical PDF and their statistical properties are well known, except empirical distribution. In some special cases, for example when strong skewness of PDF is desired, empirical distribution has to be constructed. For this reason we develop methodology. To know all the recommendations above, how to construct the PDF, the empirical distribution is constructed in the following way. There are requirements which should be strictly observed. Monotonous property before and after one global maximum on the examined interval is demanded. Probability decomposition is assigned by confidence interval (in our case represents 95%) values, which are known from expert entry. Mean value for data set is assigned too. These requirements create relations which allow us to construct system of equations, which describe these objectives. In the system one can have few free parameters which allow us to modify the shape of probability function. The number of tuned parameters depends on the number of subintervals (relating to points density where function values are computed).

Figures 8.3: *Empirical behavior of DOC(x) parameter*



On the left, probability density function is generated by empirical function, on the right cumulative probability function for DOC(x) parameter is presented. Mean value is 0.120, confidence interval 50%:20% relative to the mean value (0.060:0.144). In this case, with respect to the previous recommendations how to construct the PDF, it should be effective to take this data sample and construct it by some methods, for example by statistical parameters estimation methods, Method of Matching Moment (MoMM) and Maximum Likelihood Estimation (MLE) desired analytical distributions. Our experience suggests keeping empirical form of data in special cases (high skewness), because continuous analytical form which approximate our empirical distribution can change the desired statistical criteria significantly (confidence interval or average differs from initial conditions).

If the expert determines the confidence interval, the PDF procedure creation could force us to play with these input statistical characteristics. Uncertainty changes are not linear and before the value changes for fitting PDF function influence to the total uncertainty should be investigated. To prevent manipulation with input values, which represent confidence interval or mean value, it could be preferable as it was explained above to use empirical PDF. This approach will absolutely satisfy expert requirements.

Figure 8.4: *Frequency distribution function for waste for year 2011*

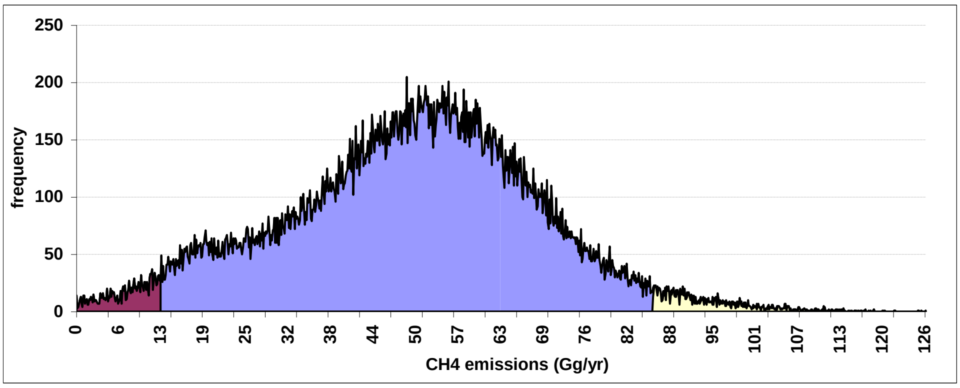


Table 8.9: *Uncertainty and mean value estimation*

Median	Average	Standard dev.	2.50%	97.50%
50.68	49.53	18.68	11.74	85.32
Min	**Max**		**Per_2.5**	**Per_97.5**
0.00	126.0623		-76.30	72.28

Figure 8.5: *Variation of the median, the average, the standard deviation and 95% confidence interval are expressed by the values during the period 1960 – 2011*

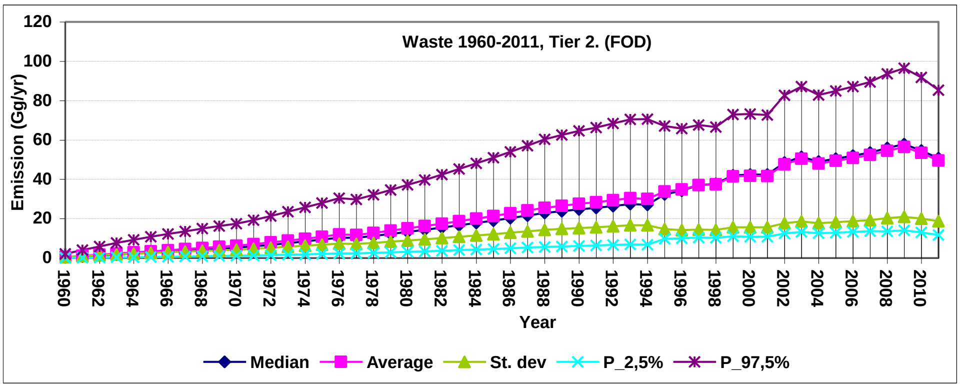
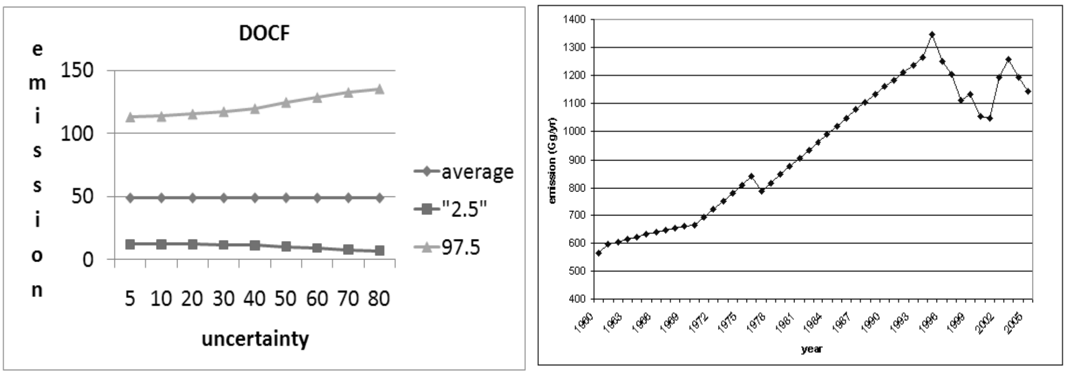


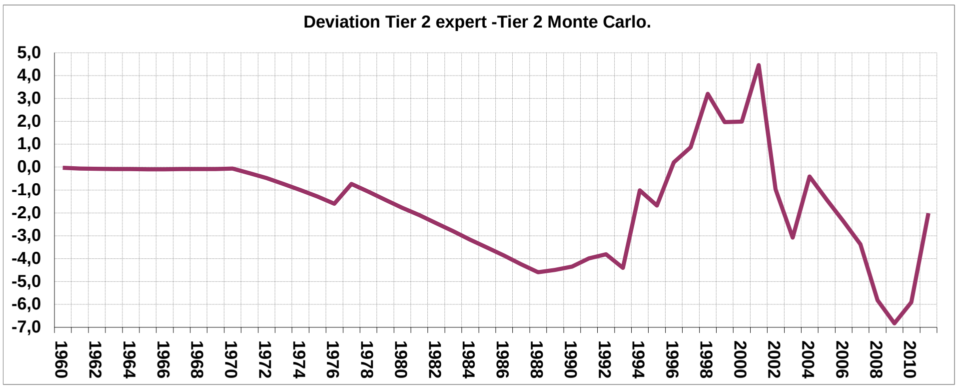
Figure 8.6: *On the left, DOC_F parameter sensitivity to the normal PDF uncertainty variation, on the right, municipal solid waste landfill (MSWL) mean value variation during the period 1960 – 2005*



With this knowledge, the PDF from entered parameters were constructed and consecutively they were applied to the FOD. After application of Monte Carlo method to the FOD model, the final probability distributions are obtained for every inventory year. This approach allows us to see detailed variation and combination of input parameters and their distribution functions. As shown above, the interactions of PDF's are not simple. The final statistics is available for total methane emissions for chosen years (1960 – 2011). The result is from 60 000 trials. A number of trials has the influence on the accuracy of result.

The uncertainty of emissions seems to be strongly dependent on the PDF's setting. These features were identified by FOD model investigation by simple linear analyses of uncertainty of total emissions and in the second case by changing PDF's setting. The data accuracy plays an important role in the computation of total uncertainty. PDFs selection in the case of symmetry uncertainty can only increase the total uncertainty. Increasing of partial uncertainties for input factors, they nonlinearly increase the total uncertainties. In the case of allowing asymmetry, total uncertainty could be smaller than single input parameters uncertainties. It can be seen that variation of parameter K has less significant influence on total emissions than other parameters. This result was obtained with normal PDF setting for all parameters and by changing the uncertainty level from ±50% to ±10% for a given parameter. Other parameters show similar dependence on the uncertainty of total emission. This approach shows that more important feature which has the strongest influence on the total uncertainty is asymmetry allowance. The result is the fact that total uncertainty increased compared to IPCC default recommended value in the interval -76.30 %; +72.28% in 2011. Default value is 50% for total methane emissions from SWDS. This uncertainty increase is not the failure of Tier 2 against Tier 1. Comparison of the both approaches it can be seen in the Figure 8.7. On the text above the applicability of Tier 1 method was discussed. On the contrary, Tier 2 provides deeper analyze and describes reality more precisely. It means that actual uncertainty is close to the Tier 2 result and improvement could be achieved by decreasing of input parameters uncertainty. This default uncertainty value is applicable to the Tier 1 default method. From this value in the Tier 1, the key sources are identified by categories magnitude, which adds up to over 95% of the total emissions or emission trend. In Tier 2 FOD method the 90% of the level or trend uncertainties are also taken for the key sources specification. The results of our analysis show that methane emissions from MSWDs are important key category. Specification and identification of the key sources are important for private companies and governmental institutions to obtain overview of important emissions. During the uncertainty computation, emitting CH_4 from underlayer and many other factors such as meteorological conditions, managing sites and policies and measures are included. These dependences are expressed in FOD model, which has been solved by Monte Carlo simulation. Spreading of emission uncertainty during the analyzed period was obtained. From the computed result precision an increase in emissions is observed. In spite of high inaccuracy on the input data at the beginning of the examined period (this uncertainty has influenced current uncertainty), relatively valuable results have been obtained.

Figure 8.7: *Comparison of Tier 2 expert and Tier 2 Monte-Carlo methodology, deviation has unit (Gg/yr)*



8.2.2.5 Source specific QA/QC and verification

Regarding solid waste, activity data and verification are based on information published annually by the Statistical Office of the Slovak Republic in publication "Odpady" (Waste) since 1993. Also, to verify this information and gain more details, interviews were held with representatives of the following companies:

- Waste service companies: Marius Pedersen Slovakia, Brantner Slovakia, SITA Slovakia, A.S.A. Slovakia, T+T Žilina (landfill gas recovery).

Table 8.10: *Results for uncertainty assessment in the SWDS for period 2001 – 2011*

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Median	40.83	46.69	49.50	47.21	48.58	50.11	51.62	53.72	55.66	52.52	50.68
Average	40.12	45.83	48.54	46.24	47.53	49.00	50.45	52.44	54.30	51.37	49.53
St. dev.	14.97	17.02	17.93	17.06	17.51	17.98	18.47	19.52	20.12	19.26	18.68
0.025	10.42	11.98	12.76	12.09	12.37	12.78	13.13	12.90	13.46	12.51	11.74
0.975	70.01	79.60	83.90	79.73	81.75	83.95	86.19	90.05	92.90	88.37	85.32
Min	0.94	1.10	1.18	0.99	0.88	0.91	0.85	-0.20	0.00	1.00	0.00
Max	100.76	114.50	120.65	114.62	117.53	120.67	123.89	129.84	133.88	130.41	126.06
Per_2.5	**-74.03**	**-73.87**	**-73.72**	**-73.85**	**-73.97**	**-73.91**	**-73.97**	**-75.40**	**-75.21**	**-75.65**	**-76.30**
Per_97.5	**74.50**	**73.69**	**72.87**	**72.45**	**71.99**	**71.34**	**70.85**	**71.70**	**71.08**	**72.03**	**72.28**

8.2.2.6 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided. However, several reporting improvements in the CRF Tables were included. The waste generation rate in kg/person/day was reported since 1990, fractions of MSW disposed to the SWDS since 1990 and fraction of DOC in MSW was corrected to 0.60. Oxidation factors were corrected to

0.05 for the period 2000 – 2004. The harmonisation of number of inhabitant was provided according to exact data published by the Statistical Office of the Slovak Republic.

8.2.2.7 Source specific planned improvements

It is planned, that the activity data on solid waste will be reviewed in details, removing out-lying data and replacing them with interpolations/extrapolations. This was not possible to perform in the past, as the waste data are collected according to European Waste Classification (EWC) since 2002 and only now discrepancies in data become visible.

The national census in 2011 provides new data on the heating distribution structure, which will be used for updating the DOC. Until now results of the census were not published, therefore the planned improvements are still in place.

8.2.3 Source category description – Unmanaged waste disposal on land (CRF 6.A.2)

Emissions do not occur from this category, the unmanaged waste disposal sites do not occur in the Slovak Republic.

8.2.4 Source category description – Other: Agricultural and industrial waste (CRF 6.A.3)

The methane emissions for industrial solid waste are included in this category since 1997, before this year the emissions from industrial waste disposal were not estimated because of lack of activity data. The total emissions of methane from ISW disposed to industrial SWDSs reached 27.39 Gg in 2011. The interpolation method was used for methane emission estimation in the period 1990 – 1996, the estimate is not included in the emission inventory submission 2013, but can be considered in the next submission if no other data will be available.

Table 8.11: *Activity data and methane emissions for industrial solid waste disposal in 1997 – 2011*

Industrial and agricultural waste disposal on land (CRF 6.A.3)			
Year	**Total ISW**	**Biodegradable ISW**	**CH_4 emissions**
	(kt)		(Gg/yr)
1997	3 085.00	115.00	**7.10**
1998	2 861.00	372.00	**18.60**
1999	2 642.00	525.00	**30.00**
2000	2 313.00	222.00	**15.00**
2001	2 470.00	220.00	**15.00**
2002	2 915.00	753.00	**42.36**
2003	3 322.00	612.00	**38.32**
2004	4 262.00	666.00	**42.69**
2005	2 888.00	553.00	**35.63**
2006	5 772.00	659.00	**40.61**
2007	4 269.00	586.00	**36.23**
2008	3 212.00	594.00	**36.84**
2009	2 671.00	368.00	**26.56**
2010	2 397.24	465.51	**30.06**
2011	2 100.00	413.00	**27.39**

8.2.4.1 Methodological issues – methods

The “Tier 0” methodology is still considered as the most appropriate method for the estimation of methane emissions from ISW disposal in SWDSs in the Slovak Republic. The key problem is the unavailability of consistent time series needed for Tier 2. The option of estimating amount of ISW from GDP (Tier 1) is not suitable, as there were/are too many changes (political, technological, ownership) significantly influencing ISW management. The number of companies producing larger amounts of waste is relatively small, thus fluctuations in their production and/or waste generation strongly influence ISW balance in the Slovak Republic.

8.2.4.2 Methodological issues – emission factors and parameters

The default IPCC parameters listed in IPCC 2006 GL were used for the estimation of methane from ISW disposed in solid waste disposal sites. The default DOC values were assigned to individual groups of waste, defined in the old and new classification systems.

This parameter is used in the same manner as for MSW landfills, because co-disposal of MSW and ISW ended with the entry of the Slovak Republic to the EU (2004). The following hypothesis is used:

- Before 1992 all ISW was disposed of in SWDSs on which very little or no data exist = IPCC category uncategorised sites.
- Since 2000 all ISW is disposed of in managed landfills = IPCC category managed anaerobic sites.
- Period 1993 – 1999 is a period of transition when managed sites were gradually developed = linear growth of MCF.

Recommended IPCC default values are used for the remaining parameters DOC (0.03), DOC_F (0.5), F (0.5), R (0) and OF (0.1). Methane recovery is including in the category MSW. Due to lack of detailed information, cannot be report separately.

8.2.4.3 Activity data

The structure of data collected by the Statistical Office of the Slovak Republic allowed identification of waste streams which contain mainly biodegradable carbon.

The extrapolation of emissions from ISW disposal is not supported by sufficient information and should be understood as informational only because of the following reasons:

- The system of waste classification changed in 2002; this is splitting the available data to two non-compatible sets.
- ISW data have been published only since 1997; previous data are not reliable and not compatible with current data.
- The waste management practice has changed significantly in the period 1990 – 2000 towards controlled landfilling this makes extrapolation difficult.
- The political system has changed in 1989 and economic transformation started in 1990, the following decade is full of economic turbulences, e.g. closing of old factories and starting of new enterprises.

8.2.4.4 Uncertainties and time consistency

Industrial waste data are available for the period 1997 – 2001 (according to the Slovak waste classification system) and 2002 – 2011 (according to the European Waste Classification). No data is available for the period 1990 – 1996. Based on the recommendation of the ERT to complete time series estimate, the correlation between amount of IW and energy consumption was done. The ISW quantity can be estimate from the capacity of waste incinerators, the difference between total ISW and the ISW incinerated can be estimated amount of ISW land filled in this period.

8.2.4.5 Source specific QA/QC and verification

Data on ISW are collected annually by the Waste Management Centre of the Slovak Environmental Agency, also according to the EWC. This resource was used when more detailed data were needed, than provided by the Statistical Office of the Slovak Republic. The activity data on methane recovery from landfills was obtained directly from landfill operators.

8.2.4.6 Source specific recalculations

No recalculations were provided in this category in 2013 submission.

8.2.4.7 Source specific planned improvements

The information on methane recovery are not fully complete, more effort will be put on the collection of this data. Therefore, the default value recommended by the IPCC (R=0) was used in this submission.

8.3 Wastewater handling (CRF 6.B)

8.3.1 Source category description

For the estimation of GHG emissions from wastewater treatment and discharge the IPCC 2000 GPG and the IPCC 2006 GL for particular issues were used. Therefore the overall approach to the wastewater sector activity data was reviewed and emission estimates made for following categories:

- Domestic and commercial wastewater treatment and discharge
- Industrial wastewater treatment and discharge (IWW).

Methane and nitrous oxide emissions were estimated for both of these categories. The Statistical Office of the Slovak Republic regularly publishes the information on BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) generated and discharged from many sources. This information was used as activity data, both for domestic and industrial wastewater emission estimation. In 2011, the total methane emissions from wastewater treatment were 16.70 Gg. This is a slight decrease compared to the previous year but the trend is almost stable. In 2011, the total N_2O emissions from wastewater treatment were 0.26 Gg. The trend is almost stable although the slight decrease compared to the previous years has occurred.

For each category in this subsector, the estimation of CH_4 emissions from wastewater handling requires three basic steps:

- Determine the total amount of organic material in the wastewater produced for each wastewater handling system. The principal factor in determining the CH_4 generation potential of wastewater is the amount of degradable organic material in the wastewater. The most common parameters used to measure the degradable organic component (DC) of the wastewater are the BOD (5 days) and COD. Data permitting, COD is the recommended parameter for estimating the DC of wastewater. The DC indicator, usually indicated in units of mass DC per unit volume (e.g., kg COD per m^3 wastewater) is multiplied by the volume of the source of wastewater (e.g., industrial or domestic) to estimate the total amount of organic wastewater produced.
- Estimate emission factors for each wastewater handling system in kg CH_4 per kg DC. The emissions factors depend on the fraction of wastewater managed by each wastewater handling method, maximum CH_4 producing capacity of the wastewater, and the characteristics of the wastewater handling process (principally, the degree to which it is anaerobic).
- Multiply the emission factor for each wastewater handling system by the total amount of organic material in the wastewater produced for each system, and sum across the wastewater system to estimate total CH_4 emissions.

The main source of nitrous oxide emissions from wastewater are the emissions generated from discharge of nitrogen to watercourses. These are sub-divided to emissions from treated discharge and emissions from other discharges. A minor source of nitrous oxide emissions are aerobic processes with nitrification/denitrification stage. The nitrous emissions estimations are based on municipal wastewater and represent full recalculation since 1990.

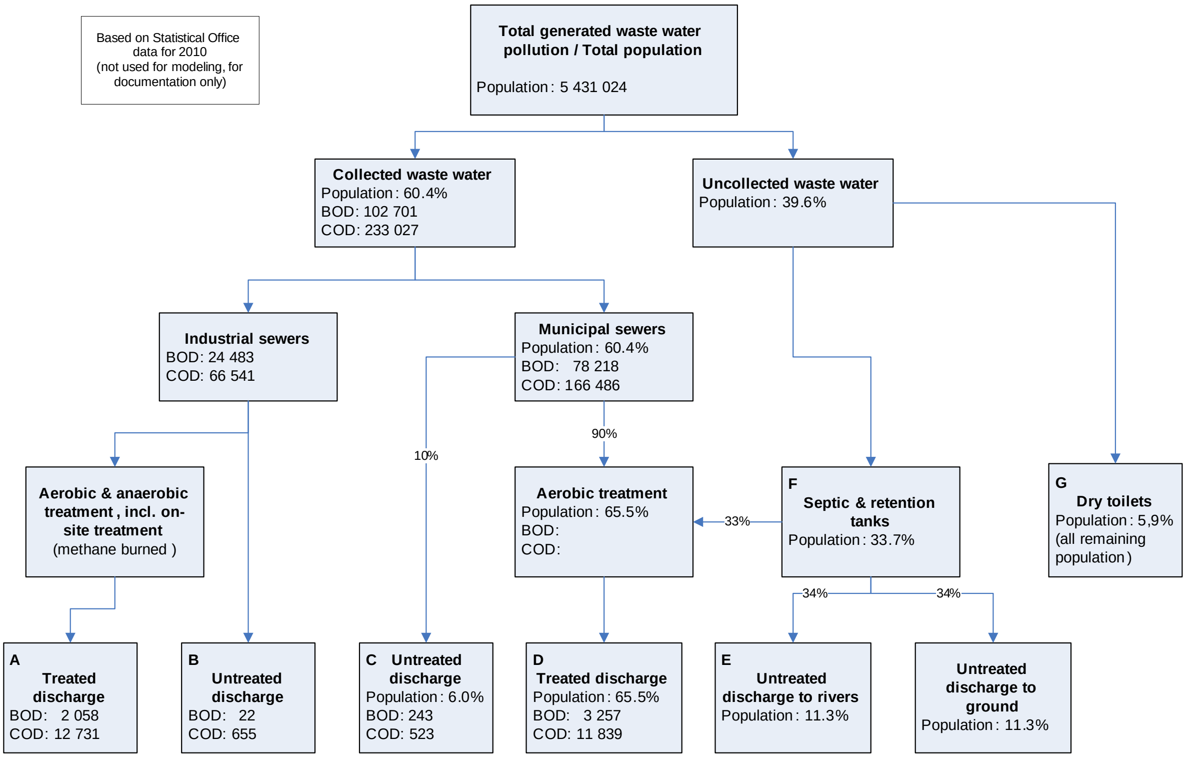
Table 8.12: *GHG emissions in individual categories in wastewater handling in 1990 – 2011*

Wastewater Handling (CRF 6.B)						
Year	**Industrial Wastewater**			**Domestic and Commercial Wastewater**		
	Wastewater Treatment	**CH_4**	**N_2O**	**Population**	**CH_4**	**Human Sewage N_2O**
	(m^3)	(Gg)		1000/number	(Gg)	
1990	72 351.800	1.250	0.065	5 297.770	18.456	0.383
1991	73 589.300	1.250	0.065	5 283.400	18.365	0.362
1992	55 180.700	1.250	0.050	5 306.540	18.434	0.338
1993	42 559.300	1.019	0.040	5 324.630	18.504	0.338
1994	43 256.000	1.211	0.041	5 347.310	18.121	0.338
1995	38 782.100	0.845	0.039	5 363.680	17.825	0.352
1996	43 440.600	0.701	0.042	5 373.790	17.890	0.352
1997	41 474.100	0.662	0.040	5 383.230	17.842	0.352
1998	44 166.600	0.669	0.041	5 390.870	17.952	0.341
1999	36 705.300	0.631	0.036	5 395.320	17.989	0.330
2000	30 295.000	0.726	0.030	5 400.680	18.043	0.302
2001	12 623.000	0.681	0.030	5 379.780	17.880	0.293
2002	34 578.000	0.637	0.072	5 378.810	17.932	0.288
2003	37 763.300	0.664	0.031	5 378.950	17.860	0.273
2004	34 296.750	0.551	0.039	5 382.574	17.783	0.262
2005	31 631.640	0.422	0.043	5 387.285	17.656	0.270
2006	32 865.403	0.324	0.040	5 393.640	17.716	0.269
2007	32 424.285	0.315	0.040	5 400.998	17.651	0.260
2008	28 601.759	0.324	0.033	5 412.254	17.520	0.249
2009	28 111.451	0.342	0.029	5 418.374	17.020	0.251
2010	28 515.780	0.330	0.029	5 435.273	16.820	0.252
2011	24 447.900	0.338	0.028	5 404.322	16.359	0.228

The structure of waste water treatment (WWT) plants in the Slovak Republic was analysed and information regarding WWT sludge generation, share of WWT plants with nitrification/denitrification and efficiency of nitrification/denitrification process was used in estimation of nitrous oxide emissions. The following expectations were considered:

- Data on WWT sludge were identified from 1998. As there are no exact data on generation of WWT sludge prior to 1998, expert estimation was used based on stable/constant generation of WWT sludge. Also, the content of nitrogen in sewage sludge was estimated to 4%. These data allow estimation of the amount of nitrogen removed from waste water with sludge.
- WWT plants started to introduce nitrification/denitrification process in 1998. The database of SHMU indicates that in 2005 – 2011 the amount of waste water treated in WWT plants with nitrification/denitrification represents about 60% of total treated wastewater. The share for the period 1999 – 2004 was interpolated.
- The process generating nitrous oxides is a combination of nitrification (oxidation of ammonia to nitrates) and denitrification (reduction of nitrates to nitrogen). The effectiveness of these processes in national conditions is estimated to 80% for nitrification and 50% for denitrification. The resulting effectiveness of the entire process is then 40%.
- The IPCC 2006 GL provide methodology (Box 6.1 of the IPCC 2006 GL) for estimation of N_2O emissions from advanced centralised WWT plants. Using the default parameters, these emissions were estimated, summarising all three sources of nitrous oxide emission for waste water.

Figure 8.8: *Wastewater pathways in the Slovak Republic (data have only documenting character)*



8.3.2 Source category description – Industrial Wastewater (CRF 6.B.1)

Total methane emissions were 0.34 Gg and total N_2O emissions were 0.03 Gg from industrial wastewater treatment in 2011. The pathways A and B (Figure 8.8) are included in the estimation of methane emissions. The following table shows the activity data and resulting estimation of emissions.

Table 8.13: *Summary of activity data and emissions from IWW by pathways in 1990 – 2011*

Industrial Waste Water (CRF 6.B.1)						
Year	**Generated IWW**	**Treated Discharged IWW**	**CH_4**	**EF (CH_4)**	**N_2O**	**EF (N_2O)**
	(m^3/y)	(%)	(Gg)	(kg/kg DC)	(Gg)	(kg/kg DC)
1990	72 351.800	70.000	1.250	0.025	0.065	0.0013
1991	73 589.300	70.000	1.250	0.025	0.065	0.0013
1992	55 180.700	70.000	1.250	0.025	0.050	0.0010
1993	42 559.300	71.200	1.019	0.025	0.040	0.0010
1994	43 256.000	96.400	1.211	0.025	0.041	0.0008
1995	38 782.100	90.700	0.845	0.025	0.039	0.0011
1996	43 440.600	88.900	0.701	0.025	0.042	0.0015
1997	41 474.100	91.100	0.662	0.025	0.040	0.0015
1998	44 166.600	74.000	0.669	0.025	0.041	0.0015
1999	36 705.300	73.000	0.631	0.025	0.036	0.0014
2000	30 295.000	76.600	0.726	0.025	0.030	0.0010
2001	12 623.000	75.700	0.681	0.025	0.030	0.0011
2002	34 578.000	74.700	0.637	0.025	0.072	0.0028
2003	37 763.300	71.900	0.664	0.025	0.031	0.0012
2004	34 296.750	75.000	0.551	0.025	0.039	0.0018
2005	31 631.640	97.700	0.422	0.025	0.043	0.0026
2006	32 865.403	97.600	0.324	0.025	0.040	0.0031
2007	32 424.285	98.200	0.315	0.025	0.040	0.0032
2008	28 601.759	98.000	0.324	0.025	0.033	0.0026
2009	28 111.451	98.800	0.342	0.025	0.029	0.0021
2010	28 515.780	99.000	0.330	0.025	0.029	0.0022
2011	24 447.900	99.000	0.338	0.025	0.028	0.0021

8.3.2.1 Methodological issues – methods

As recommended by the IPCC 2006 GL, COD values were used for the estimation of methane emissions from industrial waste water (IWW), these direct data are available starting from 1993. Although there may be a similar effect of overestimated pollution at the beginning of nineties and incomplete reporting of pollution after 2003, it is assumed that using the reported COD data will provide better estimates of emissions that estimating pollution according to the methodology provided in chapter 6.2.3.3 of the IPCC 2006 GL. Only methane emissions from IWW discharged into rivers by separate industrial sewers were considered here as a source of methane emissions, IWW discharged to public sewers is included in domestic wastewater. It is expected, if anaerobic treatment of IWW was used, that all methane from this treatment was burned (with or without energy utilisation). The ISI methodology is used for industrial wastewater N_2O emission estimation. The ISI methodology expects that wastewater treatment plant without biological nitrification have no N_2O emission. Only data for treatment plant where biological nitrification and denitrification take place were used for emission balance. For N_2O calculation only data for treatment plant where biological nitrification and denitrification is was used. Numbers of this type of treatment for industrial wastewater have increased, therefore the N_2O emissions in the future will increase. Emission factor for N_2O estimation is dynamic and changing from year to year. It is depending 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 8.13.

8.3.2.2 Methodological issues – emission factors and parameters

The population can be exchanged by the population of equivalents, calculated from COD in the inlet in wastewater treatment and production of BOD for one person (0.05 kg/person/day). Data on treatment plant where the concentration is in the case of k(denit) can be eliminated from the estimation. According to the national data, 99% of industrial wastewaters are treated, of which 95% in anaerobic treatment process and 5% in aerobic treatment process. Methane emission factor is rather constant through time series (0.025 kg per kg of degradable carbon), emission factor for N_2O estimation is dynamic and changes from year to year. It depends on direct measurements of industrial wastewater treatment operators. The list activity data from industrial wastewater treatment is shown in Table 8.14.

Table 8.14: *Summary of wastewater treatment in industry in 1990 – 2011*

Year	Fertilizers		Food and Beverages		Organic Chemicals		Other Streams	
	WW output	**COD**	**WW output**	**COD**	**WW output**	**COD**	**WW output**	**COD**
	(m^3/y)	(kg/m^3)	(m^3/y)	(kg/m^3)	(m^3/y)	(kg/m^3)	(m^3/y)	(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

8.3.2.3 *Activity data*

Information about industrial wastewater is registered in the database of wastewaters at 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 of industrial production and decreasing of volume of treated wastewater.

8.3.2.4 *Uncertainties and time consistency*

Methods used for the estimation of GHG emissions from industrial wastewater are based on equations introduced in the IPCC 2006 GL, with the exception of the ISI methodology for N_2O emission estimation in industrial wastewater. For the uncertainties associated with activity data, the default IPPC values were used. The data available in statistical reports are verified by comparison of the same category in various years. To minimise the uncertainties associated with activity data, the available data sets are reviewed and selected waste streams are used for emissions estimation.

Additional uncertainty is related to the date of published information. The wastewater category is affected by this issue. Wastewater parameters are published with a one year delay. Therefore expert estimate is used for the current year and data from the previous year are recalculated according to the published information. The information on protein consumption is published with two year delay. Similarly, expert estimates are used and emissions are adjusted according to the latest available information. For the uncertainties associated with parameters, the IPCC default parameters were used.

In all cases, the time series consistency is ensured by the consistent methodology and data sources.

8.3.2.5 *Source specific QA/QC and verification*

Data on total organic product (DC) used for methane emissions estimation in industrial wastewater are based on population censuses done in 1991, 2001 and 2011. These data are supported by annually published information by the Statistical Office of the Slovak Republic on population, COD and BOD.

Data on IWW and total nitrogen concentration in water are collected annually via the database of wastewaters collected and operated at the Slovak Hydrometeorological Institute, Department of Water Quality. Expert responsible for operation of this database is a part of the NIS SR and is responsible for the QC activities. The verification of data provided in this database is ensured by the Slovak Environmental Inspection body and the communication with the industrial subjects. These procedural steps are part of the QA. Verified data are further provided to the Statistical Office of the Slovak Republic.

8.3.2.6 *Source specific recalculations*

During the preparation of the 2013 submission, the correction of the 2010 emission estimate was performed. Total organic product was corrected according to the correction in statistics to 13.2 Gg of DC (previously reported 12.0 Gg of DC), this caused the increase of CH_4 emissions by 10% up to 0.33 Gg for the year 2010.

8.3.2.7 *Source specific planned improvements*

The wastewater activity data will be reviewed, after publication of national census results in 2011.

8.3.3 Source category description – Domestic and Commercial Wastewater (CRF 6.B.2)

Total methane emissions were 16.36 Gg and total N_2O emissions were 0.23 Gg (reported in human sewage) from domestic wastewater treatment in 2011. The pathways C – F (Figure 8.8) are included in the estimation of methane emissions. The following table shows the activity data and resulting estimation of methane emissions.

Table 8.15: *Summary of methane emissions from D&C WW by pathways in 1990 – 2011*

Domestic and Commercial Waste Water (CRF 6.B.2)							
Year	**Total Organic Product (Gg)**	**Methane Emissions (Gg)**					
		Pathway C	**Pathway D**	**Pathway E**	**Pathway F**	**Pathway G**	**Total**
1990	145.027	2.396	8.880	1.902	1.956	3.322	18.456
1991	144.633	1.677	9.632	1.923	1.947	3.187	18.365
1992	145.267	1.762	9.549	1.942	1.972	3.209	18.434
1993	145.762	2.108	9.372	1.961	1.998	3.065	18.504
1994	146.383	2.078	9.088	1.932	1.975	3.047	18.121
1995	146.831	1.553	9.731	1.912	1.961	2.668	17.825
1996	147.108	1.184	10.227	1.931	1.986	2.563	17.890
1997	147.366	0.788	10.732	1.937	1.998	2.387	17.842
1998	147.575	0.982	10.677	1.961	2.029	2.304	17.952
1999	147.697	0.937	10.886	1.977	2.051	2.138	17.989
2000	147.844	0.890	10.984	1.994	2.075	2.100	18.043
2001	147.271	0.669	11.187	1.958	2.074	1.992	17.880
2002	147.245	0.626	11.293	1.981	2.086	1.946	17.932
2003	147.249	0.803	11.098	1.990	2.084	1.886	17.860
2004	147.348	0.487	11.533	1.998	2.081	1.684	17.783
2005	147.477	0.905	11.040	2.000	2.072	1.638	17.656
2006	147.451	0.746	11.269	2.024	2.085	1.593	17.716
2007	147.541	0.420	11.880	2.033	2.083	1.236	17.651
2008	148.016	0.386	12.033	2.018	2.067	1.016	17.520
2009	148.328	0.357	11.662	2.325	1.910	0.766	17.020
2010	148.674	0.336	11.688	2.258	1.865	0.673	16.820
2011	147.780	0.327	11.549	2.110	1.799	0.573	16.359

8.3.3.1 Methodological issues – methods

The IPCC 2006 GL (Volume 5, Chapter 6, page 6.11) recommends the following approach by domestic wastewater methane emission estimation:

- Step 1: Estimation of the total organically degradable carbon in wastewater.
- Step 2: Identification of wastewater pathways.
- Step 3: Estimation of methane emissions from wastewater.

This approach was used both for domestic and industrial wastewaters, because information on BOD and COD are known and are used as activity data. The total organically degradable carbon in wastewater (TOW) was estimated using the equation 6.3 (IPCC 2006 GL).

The following parameters were used:

- P - total population of the Slovak Republic (the Statistical Office of the Slovak Republic).
- BOD per capita - BOD in inventory year (60 g/person/day - country specific value).
- I - correction factor for additional industrial BOD discharged into sewers (1.25).

The emissions of methane from domestic wastewater were estimated from pathways C, D, E, F and G using equations 6.1 and 6.2 from the IPCC 2006 GL. The comparison of the data indicates a good correlation for the data in the middle of Table 8.16, initial and final data indicate deficiencies in reporting. The initial data may be influenced by old style of data reporting (similar overestimation of data was experienced also in MSW) and data after 2003 may be influenced by the privatisation of water sector. Therefore TOW estimated according to the IPCC 2006 GL will be used for emission estimations. Public sewers in the Slovak Republic collect wastewater from households, commerce, industry (may be mechanically or chemically pre-treated on-site) and rainwater. The amount of wastewater discharged without treatment is decreasing, due to the development of new wastewater treatment plants. The aerobic process is used for treatment of the majority of domestic wastewater. The overloading of wastewater treatment plants is minimal, due to modernisation of plants and significant decrease in water consumption by households. The parameter Rem was included to take in account treatment efficiency. This parameter was estimated from monitored BOD values.

Table 8.16: *Using the default parameters, these emissions were estimated, summarising sources of nitrous oxide emission for domestic wastewater*

Total N_2O emissions in 6.B.2.2				
Year	**Treated effluent**	**Other effluents**	**Direct from WWT**	**Total N_2O**
	(Gg)			
1990	0.198	0.185	NO	0.383
1991	0.203	0.160	NO	0.362
1992	0.186	0.152	NO	0.338
1993	0.182	0.156	NO	0.338
1994	0.181	0.157	NO	0.338
1995	0.204	0.148	NO	0.352
1996	0.213	0.138	NO	0.352
1997	0.224	0.128	NO	0.352
1998	0.214	0.127	0.000	0.341
1999	0.205	0.123	0.002	0.330
2000	0.173	0.111	0.019	0.302
2001	0.179	0.109	0.005	0.293
2002	0.173	0.108	0.007	0.288
2003	0.155	0.109	0.009	0.273
2004	0.152	0.100	0.011	0.262
2005	0.145	0.113	0.012	0.270
2006	0.145	0.111	0.013	0.269
2007	0.149	0.095	0.016	0.260
2008	0.144	0.091	0.014	0.249
2009	0.143	0.093	0.015	0.251
2010	0.144	0.092	0.015	0.252
2011	0.131	0.084	0.014	0.228

According to the expert opinion, from about one third of septic and retention tanks in the Slovak Republic, the content is delivered and discharged to wastewater treatment plants. It is expected that there are no emissions from the treatment process, but remaining pollution discharged to water courses may be a source of methane emissions. Septic and retention tanks are used in places with no access to sewers. According to the expert estimation, the content from one third of them is delivered to wastewater treatment plants, as required by law. But, although the following practices are not legal, one third of these tanks are discharged on/to ground and one third has a discharge to watercourses. Direct emissions from septic and retention tanks are currently the largest source of methane emissions. The category of dry toilets includes citizens who reported in censuses the use of them (80% of this category) and also population which did not provided any information on their wastewater system (20% of this category).

8.3.3.2 Methodological issues – emission factors and parameters

Wastewater (WW) pathways (see Figure 8.8) were identified using information from two population censuses in 1991 and 2001 and from the Statistical Office of the Slovak Republic (data on generated and discharged pollution). The following pathways were identified as potential sources of methane emissions and activity data were collected to estimate methane emissions. The main source of nitrous oxide emissions from waste water according to the IPCC 2006 GL are emissions generated from discharge of nitrogen to watercourses. These are sub-divided to emissions from treated discharge and emissions from other discharges. A minor source of nitrous oxide emissions are aerobic processes with nitrification/denitrification stage. The nitrous emissions estimations are based on municipal wastewaters and represent full recalculation from 1990.

Table 8.17: *Identification of wastewater pathways in the Slovak Republic*

Pathways	**Emission factors**			**Population using pathway**			
	Bo	**MCF**	**EF**	**1990**	**2000**	**2010**	**2011**
A – Industrial WW treated	0.6	0.1	0.06				
B – Industrial WW untreated	0.6	0.1	0.06				
C – Collected WW untreated	0.6	0.1	0.06	12.98%	4.93%	2.00%	2.00%
D – Collected WW treated	0.6	0.1	0.06	48.12%	60.88%	69.49%	70.60%
E – Untreated discharge from septic tanks	0.6	0.1	0.06	10.60%	11.50%	11.09%	11.00%
F – Emissions from septic & retention tanks	0.6	0.5	0.30	31.20%	33.66%	33.60%	32.90%
G – Dry toilets	0.6	0.1	0.06	18.00%	11.64%	4.00%	3.50%

The sum of "Population using pathway" does not equals 100%

8.3.3.3 Activity data – Human Sewage (CRF 6.B.2.2)

The protein consumption data are published by the Statistical Office of the Slovak Republic, but with one year delay (statistical reports for 2010 include protein consumption data of 2009). The value for actual year was extrapolated from data on the consumption of selected kinds of food.

The nitrous oxide emissions from treated wastewater discharge to watercourses were estimated from:

- Protein consumption per person per day.
- Share of population using WWT plants, this includes share of population directly connected to public sewers and population disposing septic tanks to WWT plants.
- Sludge generation at WWT plants.
- Share of WWT plants with nitrification/denitrification.
- Efficiency of nitrification/denitrification process.

The nitrous oxide emissions from other discharges include all other identified pathways, covering the remaining population. The IPCC 2006 GL provide methodology (Box 6.1) for the estimation of N_2O emissions from advanced centralised wastewater treatment plants. This is the first attempt to estimate direct N_2O emissions from WWT plants with nitrification/denitrification stage; it aimed at the identification how this type of emissions influences the overall balance of nitrous emissions from waste water. The estimated amount of N_2O emissions from WWT plants with nitrification/denitrification stage represents about 10% of total emission of nitrous oxide based on ISI methodology or based on total emissions of nitrogen to water courses. This could lead to conclusion, that this type of emissions does not need to be calculated separately. On the other hand, 47% of WWT plants have nitrification/denitrification stage and their share will grow in the future, thus the separation of these emissions may be reasonable.

Stabilisation of sewage sludge is an integral part of wastewater treatment plants in the Slovak Republic. All sludge leaving a wastewater treatment plant was aerobically or anaerobically stabilised, thus its organic content is reduced. Aerobic stabilisation is done in shallow sludge beds. This practice is used by smaller WWT plants. Anaerobic stabilisation is done in sludge tanks and generated biogas is used for energy generation, mainly for maintaining operational temperature in sludge tanks. The latest trend is to use biogas for co-generation of heat and electricity. Dewatered stabilised sludge is then used in agriculture and for remediation of land and old industrial disposal sites and part of it is disposed in landfills.

A recent study[18] analysed the energy recovery in wastewater treatment plants in the Slovak republic. In total, 45 WWT plant were included in the study, representing about 80% of treated domestic wastewater. All these WWT plant have anaerobic stabilisation of sewage sludge facilities and

[18] Možnosti a perspektívy zvyšovania produkcie bioplynu na komunálnych ČOV s prídavkom externých substrátov, I. Bodík, M. Hutňan, S. Sedláček, M. Lazor,, 2009 (Potential and perspectives for increase of biogas generation in municipal WWTP by addition external substrates), in Slovak language only.

generated about 18 million m^3 of biogas in 2007. Eighteen of these WWT plant have installed a co-generation unit and produced 12.7 GWh of electricity in 2007.

Table 8.18: *Summary activity data and parameters used for N_2O emission estimation for domestic and commercial wastewater*

Year	Total Population	Protein Consumption	Nitrogen Fraction	EF N_2O
	(1 000 persons)	(kg/person/year)	(kg N/kg Protein)	(kg N_2O-N/kg N)
1990	5 297.770	38.325	0.160	0.0075
1991	5 283.400	36.099	0.160	0.0076
1992	5 306.540	33.653	0.160	0.0075
1993	5 324.630	33.617	0.160	0.0075
1994	5 347.310	33.544	0.160	0.0075
1995	5 363.680	34.420	0.160	0.0076
1996	5 373.790	34.128	0.160	0.0076
1997	5 383.230	33.872	0.160	0.0077
1998	5 390.870	32.960	0.160	0.0076
1999	5 395.320	32.777	0.160	0.0074
2000	5 400.680	30.806	0.160	0.0072
2001	5 379.780	30.660	0.160	0.0071
2002	5 378.810	30.879	0.160	0.0069
2003	5 378.950	30.295	0.160	0.0067
2004	5 382.574	29.930	0.160	0.0065
2005	5 387.285	31.755	0.160	0.0063
2006	5 393.640	32.120	0.160	0.0062
2007	5 400.998	31.317	0.160	0.0061
2008	5 412.254	30.478	0.160	0.0060
2009	5 418.374	31.025	0.160	0.0059
2010	5 435.273	31.335	0.160	0.0059
2011	5 404.322	29.565	0.160	0.0057

8.3.3.4 Uncertainties and time consistency

See chapter 8.3.2.4.

8.3.3.5 Source specific QA/QC and verification

Data on wastewater are based on population censuses done in 1991, 2001 and 2011. These data are supported by annually published information on population, COD, BOD also published by the Statistical Office. Additional information was collected from the Ministry of Environment, the Slovak Environmental Agency – the Centre of Waste Management (COHEM), from the Slovak Hydrometeorological Institute and from the Association of Wastewater treatment experts (ACE SR).

8.3.3.6 Source specific recalculations

No recalculations were provided for the category 6.B.2 Domestic and Commercial Wastewater in the 2013 GHG inventory submission.

8.3.3.7 Source specific planned improvements

New source of methane emission was identified: stabilisation of sewage sludge in Emsher tanks. This practice is not in use currently. The model for waste water emissions will be updated to reflect this source.

8.4 Waste Incineration (CRF 6.C)

8.4.1 Source category description

Incineration of waste produces mainly CO_2, N_2O and CH_4 emissions. Emissions of CO_2 from waste incineration are significantly greater than N_2O emissions. Methane emissions are observed during open burning of waste or inefficient (incomplete) incineration of waste and are not occurring in the Slovak Republic. Currently, waste incineration is more common in developed countries, although it is common for both developed and developing countries to incinerate clinical waste. Open burning of waste occurs in developing countries or in countries where this method is traditional.

Incineration of waste is an accepted practice in the Slovak Republic. It is regulated in accordance with EU waste legislation. The number of facilities incinerating waste is decreasing in general. This does not mean that less waste is thermally treated, but small old facilities are replaced by modern, bigger ones. Also, the large facilities are undergoing reconstruction and modernisation, aimed at improvement of environmental standards to comply with EU requirements. These two facts are introducing significant uncertainty into the estimation of GHG emissions from incineration.

The Ministry of Environment published a list of waste incinerators operating in 2011, which includes:

- Two MSW incinerators
- Five ISW incinerators (one of them is co-incinerating waste water sludge)
- Seven clinical waste incinerators
- One industrial waste water sludge incinerator
- One cadaver incinerator
- Four facilities co-incinerating ISW (cement and lime kilns).

The number of incineration plants has significantly decreased due to the expiration of transition period for selected incinerators in 2006, as was defined in the EU accession agreement. Statistical (quantitative) data on incineration are published annually. Data on situation in this sector (qualitative) are updated every four/five years, when a new National Waste Management Plan is published.

In 2011, the total CO_2 emissions reported in category 6.C from waste incineration were 9.58 Gg. This is a decrease compared to the previous year caused by the decreasing volume of industrial waste. In 2011, the total N_2O emissions reported in category 6.C from waste incineration were 0.007 Gg. The trend in N_2O emissions is almost stable with the slight fluctuation in the recent years.

The methodology is partially based on the IPCC 2006 GL and applies to incineration with and without energy recovery and to open burning of waste. Emissions from waste incineration without energy recovery and open burning of waste are reported in the waste sector, while emissions from incineration with energy recovery are reported in the energy sector. For reasons of completeness, first all emissions are estimated and then those without energy recovery are included into results.

Five waste streams are defined, which differ in their content of fossil fuel carbon, thus have different emission potential. These are:

- Municipal solid waste (MSW)
- Industrial waste (ISW)
- Hazardous waste (HW)
- Clinical waste (CW)
- Sewage sludge (SS)

The estimation of CO_2 emissions from waste incineration is summarised based on these conclusions:

- MSW incineration generates CO_2 emissions, but gained heat is used for steam and electricity generation. Thus, MSW incineration does not affect GHG balance of the waste sector, but the results are used in energy sector.
- ISW incineration generates CO_2 emissions, but only about 20% of ISW is incinerated without energy recovery. Thus, ISW incineration does affect GHG balance of the waste sector.
- Sewage sludge is not considered as a CO_2 source as it does not contain fossil carbon.
- Clinical waste incineration is small and there are not sufficiently reliable data. It is assumed, that the emissions from CW incineration are included in ISW incineration data.

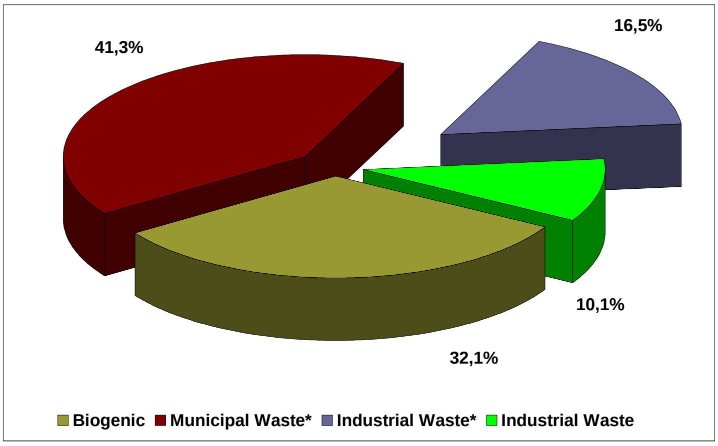
Table 8.19: *Activity data and emissions from waste incineration in 1990 – 2011*

Waste Incineration included in energy sector 1.A.1a – other fuels						
Year	Municipal Waste Incineration			Industrial Waste Incineration		
	Quantity	CO_2	N_2O	Quantity*	CO_2	N_2O
	(TJ)	(Gg)		(TJ)	(Gg)	
1990	1 307.045	43.000	0.005	IE	127.300	0.011
1991	1 307.045	43.000	0.005	IE	127.300	0.011
1992	1 503.093	44.357	0.004	IE	127.300	0.011
1993	1 614.280	47.639	0.005	IE	127.300	0.011
1994	1 409.033	41.582	0.003	IE	127.300	0.011
1995	1 314.201	38.783	0.003	IE	127.300	0.011
1996	1 289.151	38.044	0.003	IE	127.300	0.011
1997	1 404.659	41.453	0.003	IE	91.700	0.010
1998	1 567.065	46.245	0.004	IE	184.900	0.010
1999	1 520.477	44.870	0.004	IE	128.800	0.011
2000	1 816.223	53.598	0.004	IE	127.200	0.010
2001	1 142.095	33.704	0.003	IE	105.800	0.011
2002	1 363.659	40.243	0.003	IE	85.698	0.038
2003	1 416.038	41.788	0.003	IE	70.149	0.057
2004	1 604.256	47.343	0.003	IE	51.568	0.023
2005	1 593.283	47.019	0.002	IE	16.163	0.030
2006	1 655.518	48.856	0.002	IE	15.347	0.027
2007	1 570.341	46.342	0.002	IE	17.887	0.016
2008	1 370.620	40.448	0.002	IE	20.790	0.043
2009	1 548.816	45.707	0.002	IE	22.891	0.017
2010	1 597.021	47.129	0.002	IE	11.556	0.008
2011	1 616.377	47.700	0.002	IE	15.554	0.012

Emissions are reported under energy sector, category 1.A.1a – Public electricity and heat production, other fuels
**IE – quantity of IW in category 1.A.1a is included into category 6.C.2 due to the difficulties with the calculated energy content*

Waste Incineration included in waste sector 6.C					
Year	Industrial Waste Incineration			Biogenic Waste	
	Quantity	CO_2	N_2O	Quantity	CO_2
	(kt)	(Gg)		(kt)	(Gg)
1990	62.700	62.700	0.009	125.000	110.000
1991	62.700	62.700	0.009	125.000	110.000
1992	62.700	62.700	0.009	125.000	110.000
1993	62.700	62.700	0.009	125.000	110.000
1994	62.700	62.700	0.009	125.000	110.000
1995	62.700	62.700	0.009	125.000	110.000
1996	62.700	62.700	0.009	125.000	110.000
1997	187.591	45.300	0.008	107.500	93.000
1998	206.577	91.100	0.011	195.400	166.000
1999	372.263	63.200	0.008	130.300	116.000
2000	662.521	62.800	0.009	129.900	116.000
2001	146.950	52.200	0.007	99.600	93.000
2002	72.959	24.709	0.016	73.000	84.000
2003	70.016	26.418	0.013	70.000	78.000
2004	73.368	28.000	0.017	73.000	81.000
2005	102.937	21.856	0.018	103.000	131.000
2006	98.830	48.488	0.016	99.000	98.000
2007	84.585	7.520	0.013	85.000	118.000
2008	65.878	5.713	0.012	66.000	92.000
2009	28.911	5.039	0.009	29.000	38.000
2010	96.449	37.092	0.015	96.400	106.000
2011	37.719	9.578	0.007	37.719	46.000

Figure 8.9: *The share of individual categories on emissions in waste incineration in 2011*



Category	GHG (Gg CO_2 eq.)
Biogenic	37,72
Municipal Waste*	48,45
Industrial Waste*	19,34
Industrial Waste	11,84

8.4.2 Source category description – Biogenic (CRF 6.C.1)

The estimation of CO_2 emissions from biogenic waste incineration was calculated as a difference between total CO_2 emissions and CO_2 emissions from C-fossil waste fraction. This was separately done for MSW and for ISW and the results are summarised in the following table. The figures for 1990 – 1996 were estimated based on expert judgment (in italics).

Table 8.20: *Activity data and emissions from biogenic waste incineration in 1990 – 2011*

Biogenic waste incineration 6.C.1		
Year	**Total waste incinerated** (kt)	**Biogenic CO_2** (Gg)
	No energy recovery	
1990	*125.00*	*110.00*
1991	*125.00*	*110.00*
1992	*125.00*	*110.00*
1993	*125.00*	*110.00*
1994	*125.00*	*110.00*
1995	*125.00*	*110.00*
1996	*125.00*	*110.00*
1997	107.50	93.00
1998	195.40	166.00
1999	130.30	116.00
2000	129.90	116.00
2001	99.60	93.00
2002	73.00	84.00
2003	70.00	78.00
2004	73.00	81.00
2005	103.00	131.00
2006	99.00	98.00
2007	85.00	118.00
2008	66.00	92.00
2009	29.00	38.00
2010	96.40	106.00
2011	37.72	46.00

In italic – expert judgment for the years 1990 – 1996

8.4.3 Source category description – Municipal Waste Burning (CRF 6.C.2)

The amount of incinerated MSW is published by the Statistical Office of the Slovak Republic since 1993. There are two municipal waste incinerators in the country, in Bratislava and in Košice. The MSW incinerator in Bratislava was put in operation in 1977 and significantly modernised in 2003. Installed capacity is 130 Gg/y, the incinerator can be characterised as continuously operated stoker, and generated heat is used for the production of steam and electric energy. The MSW incinerator in Košice was put in full operation in 1992, and modernised in 2005. Analysis of the 2010 activity data shows that the report from Košice district does not include amount of incinerated waste. Other source[19] confirmed that waste was incinerated and figure from this source was used for emissions estimation. The availability of emission monitoring data (before and after reconstruction of this MSW incinerator) allows documenting the importance on modernisation and the impact on estimation of emissions. Both incineration plants are fully use waste incineration for electricity production. For this reason, the CO_2 and N_2O emissions are included in energy sector, category 1.A.1a Public electricity and heat production.

Table 8.21: *Air emissions from MSW incinerators – comparison before and after reconstructions*

Parameter	Emissions before Reconstruction (2004)	Emissions after Reconstruction (2006)
	(t)	
Amount of Incinerated Waste	43 444.00	72 607.00
Solid Particulates	13.05	0.67
SO_2	45.02	2.45
NOx	48.86	55.93
CO	41.85	8.39
HCl	7.16	3.50
HF	0.70	0.10
Hq+Cd+Tl	0.11	0.01
Pb+Cu+Mn+As+Ni+Cr+Co+Sb+V	8.24	0.04

8.4.3.1 Methodological issues – methods

Consistently with the general IPCC guidelines, only CO_2 emissions resulting from the incineration of carbon in waste of fossil origin (e.g. plastics, certain textiles, rubber, liquid solvents, and waste oil) should be included in emissions estimates. The carbon fraction that is derived from biomass materials (e.g. paper, food waste, and wooden material) is not included. Tier 2a methodology for the estimation of CO_2 emissions from 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 device, 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 is generally available and it was 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 amount by emission factor specific for that waste stream. The equation shown in the IPCC 2000 GPG was used for estimation of N_2O emissions from incineration. It should be noted, that the reconstruction of both incinerators has lead to significant decrease of EF_{NOX} by ca 40%. Also, there is one information on ISW incineration (includes incineration of sewage sludge). Obtaining information on NO_X emissions from ISW is more difficult, as companies publish their emission data as one aggregated number for all emission sources within a company.

8.4.3.2 Methodological issues – emission factors and parameters

For CO_2 emission estimation from MSW incineration, IPPC default parameters and Slovak specific parameters on waste composition were used. The oxidation factor is considered 100%. The emission factor for CO_2 emissions is 29.51 t/TJ in 2011.

Emissions of N_2O were estimated using country specific parameters, taking in account emission levels before modernisation (EF=20 g N_2O/t), after modernisation (EF=12 g N_2O/t) and emissions from small incinerators used in the past (EF=50 g N_2O/t). The default N_2O emission factors (wet weight) were selected from the IPCC 2006 GL, Table 5.6. The selection is based on incinerated waste types and technologies used. Waste amounts are normally given as wet weight in the Slovak Republic. Although

[19] *Správa o prevádzke a kontrole spaľovacieho zariadenia, KOSIT, 2010 (Report on operation and monitoring of incinerator).*

the IPCC 2006 GL recommends using emission factor 50 for MSW, quotations from Europe indicate different values.

Table 8.22: *IPCC input parameters*

MSW Component	Dry Matter Content	Total C Content		Fossil C Fraction	
	(% wet weight)	(% dry weight)		(% C)	
	Default	Default	Range	Default	Range
Paper/Cardboard	90.00	46.00	42-50	1	0-5
Textiles	80.00	50.00	25-50	20	0-50
Food	40.00	38.00	20-50		
Wood	85.00	50.00	46-54		
Garden and Park	40.00	49.00	45-55	0	0
Nappies	40.00	70.00	54-90	10	10
Rubber and Leather	84.00	67.00	67	20	20
Plastics	100.00	75.00	67-85	100	95-100
Metal. Glass and Inert	100 (90)	NA (less than 3)	NA (less than 5)	NA (100)	50-100

Further review of available NO_X emission factors resulted in formulation of two hypotheses:

- Emission factors observed in Germany and Austria may be more suitable for the Slovak Republic, because many Slovak incinerators are of German origin.
- Emission factors for reconstructed plants should be decreased, it is expected that the decrease of EF for NO_X (before and after reconstruction) is the same as for N_2O.

Thus, the calculation was repeated with the EF=20 g N_2O/t MSW and the results are 3 times bigger that the estimate obtained in deposition calculation, which is within the range of the EF (0.002 – 0.05). For estimation for MSW incinerated in smaller units, the EF=1.49 kg N_2O/TJ was used in 2011.

8.4.3.3 Activity data

Although there are available data directly from each incinerator, the requirement to work with one consistent set of data got a priority. Also, although there is identification of “incineration with energy recovery” and “incineration without energy recovery”, these categories do not seem to be correctly used. The information from MSW incinerator operators were used for the indication of proper option. The change of waste classification in 2002 does not seem to have impact on recorded amounts of incinerated MSW.

8.4.3.4 Uncertainties and time consistency

The default IPPC uncertainties for activity data are used. The data available in the statistical reports are verified by comparison of the same category in various years. Example: if incinerated amount of waste in group 54 in three consecutive years is 20 Gg/y and the following year is stated 500 Gg/y, the 500 is the most probably wrong and an explanation must be found.

The consistency of time series is influenced by changes in reporting system:

- 1993 – Implementation of first waste legislation, introduction of the first regular waste monitoring in the Slovak Republic.
- 2002 – Preparation for accession to EU, adoption of EWC.

The impact of these changes is difficult to assess, depending on the level of detail. For example, the total amount of MSW practically has not changed, but the amount of incinerated clinical waste has changed significantly as a result of changes in the waste classification system.

8.4.3.5 Source specific QA/QC and verification

Regarding solid waste, this report is based on information published annually by the SO SR in publication “Odpady” (Waste) since 1993. Also, to verify this information and gain more details, interviews were held with representatives of the following institutions and companies:

- COHEM SAZP (Waste Management Centre of Slovak Environmental Agency) on ISW data.
- Waste service companies: Marius Pedersen Slovakia, Brantner Slovakia, SITA Slovakia, A.S.A. Slovakia, T+T Žilina (landfill gas recovery).
- ACE (Assotiation of Experts on Waste Water Treatment) on sewage sludge management.

Additionally, web-sites of following companies and institutions were used for this report:

- OLO Bratislava, KOSIT Košice (municipal waste incineration).
- Slovnaft, Duslo, Fecupral (industrial waste incineration).
- Enviroportal (info page of the Slovak Environmental Agency).

8.4.3.6 Source specific recalculations

No recalculations were provided in this submission in the category municipal solid waste incineration.

8.4.3.7 Source specific planned improvements

No specific improvements are planned for the next submission.

8.4.4 Source category description – Industrial Waste Incineration (CRF 6.C.2)

From the total of 37 ISW incinerators only a few have installed capacity exceeding 1 t/hour. These are located in the following companies:

- Duslo a.s. Šaľa, operating rotary kiln and fluid bed furnace (5 t/hour).
- Petrochema a.s., Dubová – two rotary kilns (5.5 t/hour).
- Slovnaft a.s., Bratislava – rotary kiln and chamber furnace (3.5 t/hour).
- Helpeco s.r.o, Považská Bystrica – rotary kiln (1 t/hour).

The remaining facilities are smaller units, mostly various versions of HOVAL, rotary kilns or chamber furnaces. Very few of these units comply with EU environmental requirements, thus have to be modernised (equipped with air pollution control) or decommissioned. There is growing interest of cement industries to incinerate waste with high calorific value, but the Statistical Office does not monitor this type of waste treatment. The company Ecorec processes about 25 000 t of waste annually – this is about 6% of all ISW incinerated.

Total emissions of CO_2 from industrial waste incineration were estimated to 25.13 Gg in 2011, but the emissions without energy use were only 9.58 Gg of CO_2 in 2011. The total N_2O emissions from industrial waste incineration were estimated to 0.019 Gg in 2011, but the emissions without energy use were 0.007 Gg of N_2O in 2011.

8.4.4.1 Methodological issues – methods

The CO_2 emissions from industrial solid waste incineration were obtained using activity data and default IPCC parameters. The dry matter content of ISW was estimated to 90% of wet weight. The oxidation factor was estimated to 90%, to compensate for old incinerators.

Although the total amount of incinerated ISW seems to be stable, the share of waste streams rich on fossil carbon is decreasing. The share of incinerated clinical waste is small and there are no reliable data. CO_2 emissions from clinical waste incineration are included in the ISW incineration data.

8.4.4.2 Methodological issues – emission factors and parameters

Consistently with the general IPCC guidelines, 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) were included in emissions estimates. The carbon fraction that is derived from biomass materials (e.g. paper, food waste, and wooden material) is not included. The dry matter content of ISW was estimated to 90% of wet weight. The oxidation factor was estimated to 90%, to compensate for old incinerators. The biogenic CO_2 emissions are estimated as a difference between all carbon incinerated and fossil carbon incinerated.

8.4.4.3 Activity data

The data on incinerated ISW is published in a detailed structure – by Chapters of the European Waste Catalogue. This allowed identifying waste streams of significant share of fossil carbon for estimation of CO_2 emissions. Industrial solid waste has been recorded by the Statistical Office since 1997 and only since 2002 the Statistical Office has been providing information on “incineration with energy recovery” and “incineration without energy recovery”. The analysis of the data allows making a conclusion, that about 20% of total ISW is incinerated without energy recovery and this means that about 35% of “fossil carbon rich” waste is incinerated without energy recovery. Also, further comparison of “fossil carbon rich” waste streams destined for incineration results in conclusion, that industrial solid waste and hazardous waste are nearly identical (or there is very little non-hazardous industrial “fossil carbon rich” waste incinerated), thus in the further the terms “incinerated hazardous waste” and “incinerated ISW” define the same waste.

8.4.4.4 Uncertainties and time consistency

See section 8.4.3.4.

8.4.4.5 Source specific QA/QC and verification

See section 8.4.3.5.

8.4.4.6 Source specific recalculations

The quantity of incinerated waste used for N_2O emission estimation was corrected in reporting of the years 1990 – 2010. This change didn’t influence the N_2O emissions.

8.4.4.7 Source specific planned improvements

No specific improvements are planned for the next submission.

8.4.5 Source category description – Sewage Sludge Incineration (CRF 6.C.2)

Only two incinerators incinerate sewage sludge in the Slovak Republic, in both cases it is the sludge from industrial wastewater treatment. The oil refinery Slovnaft a.s., Bratislava has developed specialised incinerator for burning sewage sludge for company owning wastewater treatment plant in 1986. This facility was significantly improved during reconstruction in 2006. The operational capacity is 24.5 Gg/y of dewatered sludge (20% dry mass). The incinerator is a stacked furnace type, designed to operate continuously. There is no energy recovery. The chemical factory Duslo a.s., Šaľa operates a fluidised bed furnace, incinerating (except of other waste) about 1.7 Gg/y of sewage sludge. This furnace was put in operation in 1985 and was reconstructed in 2006. The heat is used for the generation of steam. Sewage sludge does not contain fossil carbon thus there are no CO_2 emissions to estimate. Sewage sludge is incinerated in two main plants[20]. The amount of incinerated sewage sludge is published annually in reports on incineration plant operation since 2007. These two waste streams represent about 2% of total incinerated industrial waste in the Slovak Republic. Therefore for estimation of CO_2 and N_2O emissions individual calculation of these waste streams is not done and incinerated amounts are included in the sum of industrial waste.

The available data indicate that about 2.5 – 3 Gg of waste from the health sector are incinerated annually. Currently the clinical waste incineration is included in the ISW incineration, but monitoring of this waste stream will continue and can be assessed individually in the future. These emissions are included in industrial waste incineration 6.C.2.

[20] *Správy o prevádzke a kontrole ZZO 1.24 Spaľovňa odpadov Duslo Šaľa 2007-9 (Operation and inspection reports on waste incinerator in Duslo Šaľa 2007-9) and Spaľovňa kalov – Prevádzkovanie spaľovne Slovnaft a.s. Bratislava v r. 2007-9 (Sludge incinerator – operation report 2007-9, Slovnaft a.s. Bratislava).*

8.5 Other – Composting (CRF 6.D)

8.5.1 Source category description

This chapter is aimed at review of preparedness of the Slovak Republic to provide estimates of GHG emissions from the following processes:

- Composting
- Anaerobic digestion of organic waste

Table 8.23: *The overview of municipal and industrial composting in 1990 – 2011*

Year	MSW Composting 6.D			ISW Composting		
	Quantity	CH_4 (Gg)	N_2O (Gg)	Quantity	CH_4 (Gg)	N_2O (Gg)
	(kt)	(Gg)		(kt)	(Gg)	
1990	*20.000*	*0.080*	*0.006*	NO	NO	NO
1991	*20.000*	*0.080*	*0.006*	NO	NO	NO
1992	*20.000*	*0.080*	*0.006*	NO	NO	NO
1993	21.100	0.086	0.006	NO	NO	NO
1994	19.100	0.076	0.006	NO	NO	NO
1995	35.400	0.142	0.011	NO	NO	NO
1996	31.500	0.126	0.010	NO	NO	NO
1997	38.800	0.155	0.012	NO	NO	NO
1998	38.000	0.152	0.011	NO	NO	NO
1999	39.300	0.157	0.012	NO	NO	NO
2000	36.300	0.145	0.011	NO	NO	NO
2001	43.500	0.174	0.013	NO	NO	NO
2002	39.300	0.157	0.012	1 133.500	4.534	0.3401
2003	40.700	0.163	0.012	1 156.600	4.626	0.3470
2004	40.900	0.164	0.012	411.500	1.646	0.1235
2005	20.800	0.083	0.006	579.100	2.316	0.1737
2006	51.600	0.206	0.016	800.800	3.203	0.2402
2007	76.100	0.304	0.023	528.000	2.112	0.1584
2008	80.200	0.321	0.024	583.100	2.332	0.1749
2009	88.900	0.356	0.027	592.400	2.370	0.1777
2010	90.725	0.363	0.027	578.542	2.314	0.1736
2011	99.842	0.399	0.030	1 100.643	4.403	0.3302

In italic – expert judgment for the years 1990 – 1992

The EU requirement to reduce the amount of landfilled biodegradable waste supports the installation of mechanical–biological treatment facilities, which may include also composting or anaerobic treatment. It is expected that the share of waste treated in MF facilities will grow, resulting in higher GHG emissions, which should be included in national balances.

8.5.2 Methodological issues – methods

Because no data on anaerobic treatment were available, only emissions from composting were estimated, separately for MSW and ISW. Default IPCC emission factors for wet weight were used. In case of MSW, emission data were extrapolated back to 1990 using 1993 and 1994 data as a base. Tier 1 is used for emission estimation.

8.5.3 Methodological issues – emission factors and parameters

Table 8.24: *IPCC default parameters for EFs*

Treatment	EF (CH_4)		EF (N_2O)	
	Dry Weight	Wet Weight	Dry Weight	Wet Weight
Composting	10 (0.08-20)	4 (0.03-8)	0.6 (0.2-1.6)	0.3 (0.06-6)
Anaerobic Digestion	2 (0-20)	1 (0-8)	0 (negligible)	0 (negligible)

8.5.4 Activity data

The Slovak Statistical Office has been publishing data on composted MSW since 1993. The reported amount of composted MSW remains stable, about 35 – 40 Gg/y. The data on composted ISW are from the same source and have been published since 2002. The reported data are too few and in too big variation to identify a trend in emissions. There are no centrally collected data on anaerobic treatment or on recovery of methane emissions from composting.

8.5.5 Uncertainties and time consistency

See section 8.4.3.4.

8.5.6 Source specific QA/QC and verification

See section 8.4.3.5.

8.5.7 Source specific recalculations

No recalculations in the submission 2013 focused on the base year 1990 or the other inventory years were provided.

8.5.8 Source specific planned improvements

No specific improvements are planned for the next submission.

CHAPTER 9: OTHER (CRF 7)

According to the information provided in the chapter 4 Industrial Processes under category 2.F.2 – Foam Blowing, Slovak Republic is reported additional GHGs of F-gases HFC245fa (hard foam) and HFC365mfc (soft foam). The utilization of these gases started in 2002. The GWPs from the IPCC Fourth Assessment Report, Chapter 2, WGI were used for the estimation CO_2 equivalents of these gases. The emissions are not included into national total and are summarized in the following table.

Table 9.1: *Emissions from the additional GHGs gases used in industry*

Year	Hard Foam HFC245fa			Soft Foam HFC365mfc		
	Emissions	**GWP**	**Actual emissions from stock**	**Emissions**	**GWP**	**Actual emissions from stock**
	(t)		(Gg of CO_2 eq.)	(t)		(Gg of CO_2 eq.)
2002	0.034	1 030	35.010	0.026	794	20.804
2003	0.068	1 030	70.019	0.052	794	41.609
2004	0.099	1 030	101.846	0.076	794	60.522
2005	0.130	1 030	133.673	0.100	794	79.435
2006	0.156	1 030	160.196	0.120	794	95.196
2007	0.176	1 030	181.414	0.136	794	107.805
2008	0.192	1 030	197.327	0.148	794	117.261
2009	0.203	1 030	208.997	0.156	794	124.196
2010	0.213	1 030	219.606	0.164	794	130.500
2011	0.518	1 030	533.155	0.379	794	300.947

CHAPTER 10: RECALCULATIONS AND IMPROVEMENTS

10.1 Explanations and justifications for recalculations, including for KP-LULUCF inventory

The list of recalculations made in the 2013 submission is summarized in the Table 10.3.

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, 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 sector, F-gases categories) or updated statistical information (e.g. input data in IP sector). The Table 10.3 presents list of performed recalculations with the short summarizing description (detailed information are provided in the sectoral chapters in this report). The recalculations listed in the Tables 10.1 and 10.2 were provided in the CRF Tables version 2013, v1.2 against previous inventory submission from December 2012, version 1.5 with and without LULUCF sectors.

10.3 Recalculations, including in response to the review process, and planned improvements to the inventory

Due to the no delivery of the draft ARR 2012, the Slovak National Inventory System is not in position to include improvements for all recommendations which will be identified in the ARR 2012. The manager of NIS will summarize and evaluate in terms of QA/QC system the list of recommendations made by ERT and implement further steps in line with the IPCC 2000 GPG in the next submission. This report will cover the in-country review of the 2012 annual submission of the Slovak Republic, coordinated by the UNFCCC secretariat, in accordance with the decision 22/CMP.1. The in-country review took place from 1st to 6th October 2012 in Bratislava. The responses to the technical issues identified in the "Saturday Paper" are described in the Table ES.1 of this report.

The latest published Annual Review Report FCCC/ARR/2011/SVK of the individual review of the annual submission of the Slovak Republic was published on May 2012 on http://unfccc.int/resource/docs/2012/arr/svk.pdf. This report covers the in-country review of the 2011 annual submission of the Slovak Republic, coordinated by the UNFCCC secretariat, in accordance with decision 22/CMP.1. The review took place in August 2011 in Bratislava.

Table 10.1: *Comparison of GHG emission trend without LULUCF of the 2012 and 2013 submissions*

Year	National GHG Inventory without LULUCF		
	Submission 2012	Submission 2013	Recalculation Difference
	Gg of CO_2 eq.		%
1990	71 811.55	71 781.85	-0.04
1991	63 793.78	63 746.08	-0.07
1992	58 309.61	58 271.38	-0.07
1993	53 659.14	53 605.29	-0.10
1994	51 481.16	51 423.69	-0.11
1995	53 272.36	53 211.91	-0.11
1996	53 165.07	53 087.19	-0.15
1997	53 255.91	53 188.12	-0.13
1998	52 610.58	52 543.30	-0.13
1999	51 446.96	51 377.81	-0.13
2000	49 375.33	49 298.65	-0.16
2001	52 442.50	52 355.10	-0.17
2002	51 771.71	51 205.27	-1.09
2003	52 410.84	51 544.20	-1.65
2004	51 781.04	51 376.51	-0.78
2005	51 195.93	50 596.32	-1.17
2006	51 033.55	50 502.89	-1.04
2007	48 883.07	48 519.67	-0.74
2008	50 117.16	49 113.78	-2.00
2009	44 296.56	43 956.15	-0.77
2010	46 114.09	45 896.36	-0.47

Figure 10.1: *Comparison of GHG emission trend without LULUCF of the 2012 and 2013 submissions*

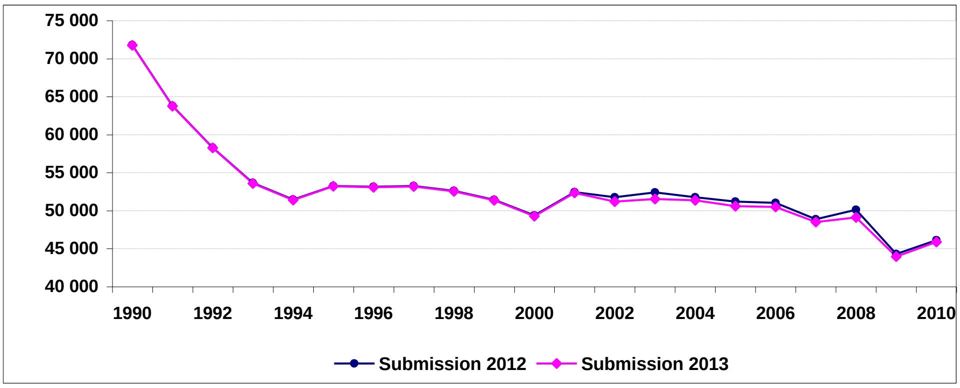


Table 10.2: *Comparison of GHG emission trend with LULUCF of the 2012 and 2013 submissions*

Year	National GHG Inventory with LULUCF		
	Submission 2012	Submission 2013	Recalculation Difference
	Gg of CO_2 eq.		%
1990	61 516.16	61 762.74	0.40
1991	52 641.65	52 603.58	-0.07
1992	45 179.78	45 435.34	0.57
1993	41 314.36	41 672.11	0.87
1994	40 052.28	40 327.18	0.69
1995	42 298.06	42 433.35	0.32
1996	42 331.33	42 472.01	0.33
1997	42 158.40	42 788.57	1.49
1998	39 440.43	41 552.24	5.35
1999	41 043.10	40 328.36	-1.74
2000	39 092.49	38 584.76	-1.30
2001	42 519.08	41 847.42	-1.58
2002	41 486.97	40 440.06	-2.52
2003	42 756.69	41 306.91	-3.39
2004	42 831.94	41 743.17	-2.54
2005	45 914.26	44 493.41	-3.09
2006	43 117.11	42 044.54	-2.49
2007	41 103.04	40 422.25	-1.66
2008	43 018.32	41 895.13	-2.61
2009	37 068.02	36 518.68	-1.48
2010	40 025.67	38 981.23	-2.61

Figure 10.2: *Comparison of GHG emission trend with LULUCF of the 2012 and 2013 submissions*

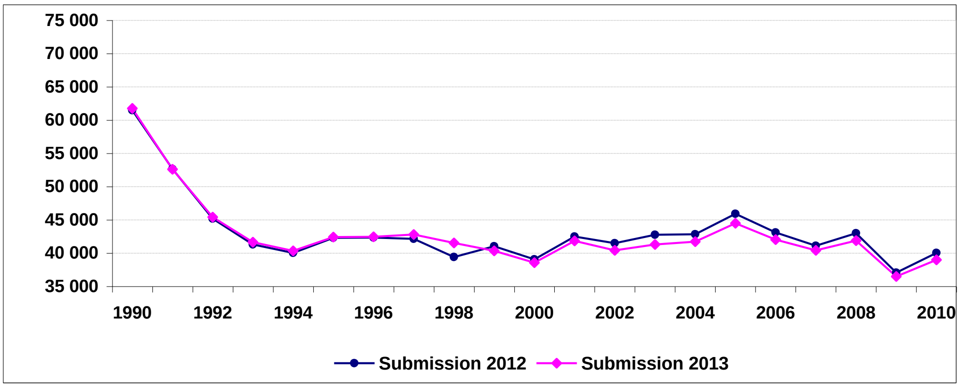


Table 10.3: *List of recalculations in the April 2013 submission (version 1.2) against December 2012 submission (version 1.5) with short explanation*

Recalculated Category (submission 2012v1.5 versus submission 2013v1.2)		Year	GHG Affected	Explanation
1.AA.4.B	Residential/Gaseous Fuel/Natural Gas/CO_2 emission factor in t/TJ	2008	CO_2	The correction of carbon emission factor for natural gas led to the correction of CO_2 emissions in this category. The corrected EF(CO_2) = 54.75 t/TJ (previously incorrect was 56.95 t/TJ). Corrected CO_2 emissions = 2 888.29 Gg. This caused decrease in CO_2 by 4%.
1.AA.3B	Road Transportation/LPG/N2O emission factor in t/TJ	2010	N_2O	Correction in N_2O emission factor for LPG in road transport decreased N_2O emissions by 40%. The corrected EF is 2.46 t/TJ.
1.AA.3B	Road Transportation/CNG/NCV in TJ/t	2000-2010	N_2O	Correction of the NCV for CNG for the previous years, the correct NCV=48TJ/t, the N_2O emissions were recalculated with the EF=0.1 kg/TJ
1.AB	Fuel Combustion/Reference Approach/Coking Coal/Imported quantity in kt	2010	CO_2	The import of coking coal was corrected by the Statistical Office of the Slovak Republic to Eurostat in August 2012. The corrected value is 2 472 kt. The CO_2 emissions in this category increased to 6 580.06 Gg, what is increase by 17%.
1.AB	Fuel Combustion/Reference Approach/BKB&Patent Fuel/Imported quantity in kt	2010	CO_2	The import and stocks of BKB was corrected by the Statistical Office of the Slovak Republic to Eurostat in January 2013. The corrected value is 43 kt and 2kt. The CO_2 emissions in this category increased to 97.92 Gg, what is increase by 4 times.
1.AA.4A	Commercial/Institutional/Biomass/Biomass consumption in TJ, CO_2, CH_4 and N_2O emission factors in kg/TJ	1990-2010	CO_2, N_2O, CH_4	Change in emission factors for biomass, the IPCC 2006 default EF for biomass (solid, liquid, gaseous) were used instead of one average EF and therefore the timeseries were recalculated back to 2000. The corrections occurred also in consumption of biomass mostly caused by the NCVs corrections.
1.AA.4B	Residential/Biomass/CH_4 emission factors in kg/TJ	1990-2010	CH_4	Change in emission factor for biomass, the IPCC 2006 default EF for solid biomass (30 kg/TJ) was used and therefore the timeseries were recalculated back to base year.
1.AA.4C	Agriculture/Forestry/Fishery/Biomass/Biomass consumption in TJ, CO_2, CH_4 and N_2O emission factors in kg/TJ	1996-2010	CO_2, N_2O, CH_4	Change in emission factors for biomass, the IPCC 2006 default EF for biomass (solid, liquid, gaseous) were used instead of one average EF and therefore the timeseries were recalculated back to 2000. The corrections occurred also in consumption of biomass mostly caused by the NCVs corrections.
1.AA.5A	Other Stationary/Biomass consumption in TJ, CO_2, CH_4 and N_2O emission factors in kg/TJ	2000-2010	CO_2, N_2O, CH_4	Change in emission factors for biomass, the IPCC 2006 default EF for biomass (solid, liquid, gaseous) were used instead of one average EF and therefore the timeseries were recalculated back to 2000. The corrections occurred also in consumption of biomass mostly caused by the NCVs corrections.
1.AA.1a	Public Electricity and Heat Production/Other Fuels/ISW incineration with energy use	2002-2010	CO_2	The CO_2 emissions were recalculated based on reconstructed time series for the quantity of waste incinerated with energy use. This was based on the ERT recommendation.
2.B.1	Ammonia Production/CH_4 and N_2O emissions in Gg	2010	N_2O, CH_4	The CH_4 and N_2O emissions were recalculated based on the changes in NG consumption.
2.F.1	Refrigeration and Air Conditioning Equipment/Actual Emissions of CO_2 equivalents	1990-2010	HFCs	Stock was calculated according to the formula in line with the IPCC GPG 2000. Activity data for stock, new fillings (assembly) and disposal have been disaggregated into sub-subcategories (in refrigeration and air conditioning equipment (2.F.1), foam blowing (2.F.2) and fire extinguishers (2.F.3) subcategories). Disposal emissions for subcategories refrigeration and air conditioning equipment (2.F.1), foam blowing (2.F.2) and fire extinguishers (2.F.3) were included. EFs were revised and weighted average was used for disaggregated data.
2.F.2	Foam Blowing/Actual Emissions in Gg of CO_2 equivalents	1990-2010	HFCs	
2.F.3	Fire Extinguisher/Actual Emissions in Gg of CO_2 equivalents	1990-2010	HFCs	
2.F.4	Aerosols	1990-2010	HFCs	
2.F.1	Refrigeration and Air Conditioning Equipment/Potential Emissions in Gg of CO_2 equivalents	1995-2010	HFCs	According to the changes in actual emissions in refrigeration's, potential emissions were recalculated since 1995.
2.F.3	Fire Extinguisher/Potential Emissions in Gg of CO_2 equivalents	1994-2010	HFCs	According to the changes in actual emissions in fire extinguisher, potential emissions were recalculated since 1994.
2.F.4	Aerosols - Actual and Potential Emissions of HFCs	2008-2011	HFC134a, HFC227ea	Based on updating information from the State Institute of Drug Control, the discrepancies in consumption of HFC134a and HFC227ea were corrected for 2008-2011.

2.F.8	Electrical Equipment/Potential SF_6 Emissions in t	1990-2010	SF_6	According to the changes in actual emissions in SF_6 in electrical equipment category, potential emissions were recalculated since 1990.
4.A	Enteric Fermentation/Dairy Cattle/AGEI in MJ/head/day	2010	no	Correction in average gross energy intake based on regional statistics.
4.A	Enteric Fermentation/Goats/emission factor in kg/head/year	2009	CH_4	Correction of methane EF (default 5 kg/head/year) led to the small correction of methane emissions (increase by 0.5%) in year 2009.
4.D.1.1	Synthetic Fertilizers/N Applied to Soil in kg N/year	1997-2005	N_2O	Correction of error in formula calculated the nitrogen fraction applied to soil from synthetic fertilizers. The N2O emissions for the entire time series 1997-2005 were increased.
4.D.1.2	Animal Manure Applied to Soil/N Applied to Soil in kg N/year	1990-2010	N_2O	Fraction of nitrogen lost by evaporation was recalculated according to the IPCC default value (20%) instead of previously used 10% of nitrogen. Emissions of N_2O were increased by 10% in the time series.
5.A.1	Forest Land Remaining Forest Land/Carbon Stock Change/Gains and Losses	1990-2010	CO_2	The main reason was recalculation of land areas due to incorrect determination of the length of the transition period. In previous GHG inventory was used the 21 year transition period instead of 20 year period. It affected the estimation of emissions /removals of GHGs for the categories 5.A.1 Forest Land remaining Forest Land, as well as for 5.A.2 Land converted to Forest Land. The current annual biomass increments were recalculated.
5.B.1	5(IV) CO_2 emissions from agricultural lime application, Limestone $CaCO_3$	1990-2011	CO_2	The CO_2 emissions were not reported in correct way, Gg of C were reported in previous submission instead of Gg of CO_2.
5.B.1 and 5.B.2	Cropland Remaining Cropland/Land converted to Cropland	1990-2010	CO_2	The category Cropland was recalculated for whole time period since 1990. The main reason was recalculation of land areas due to incorrect determination of the length of the transition period. In previous GHG inventory was used the 21 year transition period instead of 20 year period. It affected the estimation of emissions/removals for the categories 5.B.1 Cropland remaining Cropland as well as for 5.B.2 Land converted to Cropland.
5.C.1 and 5.C.2	Grassland Remaining Grassland/Land converted to Grassland	1990-2010	CO_2	The category Grassland was recalculated for whole time period since 1990. The main reason was recalculation of land areas due to incorrect determination of the length of the transition period. In previous GHG inventory was used the 21 year transition period instead of 20 year period. It affected the estimation of emissions /removals for the categories 5.C.1 Grassland remaining Grassland as well as for 5.C.2 Land converted to Grassland.
5.D.1 and 5.D.2	Settlements Remaining Settlements/Land converted to Settlement	1990-2010	CO_2	The Settlements category was recalculated for whole time period since 1990. The main reason was recalculation of land areas due to incorrect determination of the length of the transition period. In previous GHG inventory was used the 21 year transition period instead of 20 year period. It affected the estimation of emissions/removals for the categories 5.E.1 Settlements remaining Settlements as well as for 5.E.2 land converted to Settlements.
5.E.1 and 5.E.2	Other Land Remaining Other Land/Land converted to Other Land	1990-2010	CO_2	The category Other land was recalculated for whole time period since 1990. The main reason was recalculation of land areas due to incorrect determination of the length of the transition period. In previous GHG inventory was used the 21 year transition period instead of 20 year period. It affected the estimation of emissions/removals for the categories 5.F.1 Other land remaining Other land as well as for 5.F.2 land converted to Other land.
6.B.1	Industrial Wastewater/Total Organic Product/Quantity of DC in Gg	2010	CH_4	Total organic product was corrected according to the correction in statistics to 13.2 Gg of DC (previously reported 12 Gg of DC), this caused the increasing of CH_4 emissions by 10% up to 0.33 Gg.
6.C.2	Industrial Waste Incineration/Incinerated Waste in Gg	1990-2010	no	The quantity of incinerated waste used for N_2O emission estimation was used in reporting.
KP.A.1	Afforestation and Reforestation/Afforestation/AR area	2008-2010	CO_2	Change in carbon stock due to the changes in AR area - based on recalculation in LULUCF.
KP.A.2	Deforestation/Carbon stock change/DEF area	2008-2010	CO_2	Recalculation in deforestation of CO_2 emissions/removals of carbon stock changes in mineral soils for whole accounting period. The reason was the technical mistake in conversion of soil carbon pool to CO_2 emission/removals.

PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

CHAPTER 11: KP-LULUCF

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 ff).

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 for reporting under the KP in the Slovak Republic*

Parameter	Range	Selected Value
Minimum Land Area	0.05-1 ha	0.3 ha
Minimum Crown Cover	10 - 30%	20%
Minimum Height	2 - 5 m	5 m

The selected threshold values are consistent with those 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 has chosen to account for the activities under Article 3.3 (afforestation, reforestation and deforestation) for the whole commitment period. The Slovak Republic has decided not to use any activities under Article 3.4 (forest management, cropland management, grazing land management and revegetation) for meetings its commitment under the first commitment period of the Kyoto Protocol.

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:

- AR activities represent the conversion of Cropland to Forest land and conversion Grassland to Forest land. D activity represents the conversion of Forest Land to Other Land.

The information about ARD areas is based on the data from the Geodesy, Cartography and Cadastre Authority of the Slovak Republic (GCCA). This institute issues periodically the Statistical Yearbook of the Soil Resources in the Slovak Republic. It provides annually the updated cadastral information not only on land use areas but also the information about the areas which were afforested/reforested and deforested. The Cadastre information is completed by the data from the national program: "Afforestation of the land unavailable 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 will be reported together.

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

Not relevant in the Slovak Republic.

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 afforestation, reforestation and deforestation.

To achieve this, reporting method 1 (see Chapter 4.2.2.2. figure 4.2.3. of the IPCC 2003 LULUCF GPG) could be chosen. 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 districts. The GCCA database includes eight land districts since 1996 and three districts from 1990 to 1995 (see the following figures).

Figure 11.1: *Eight Slovak regional districts established in 1996*

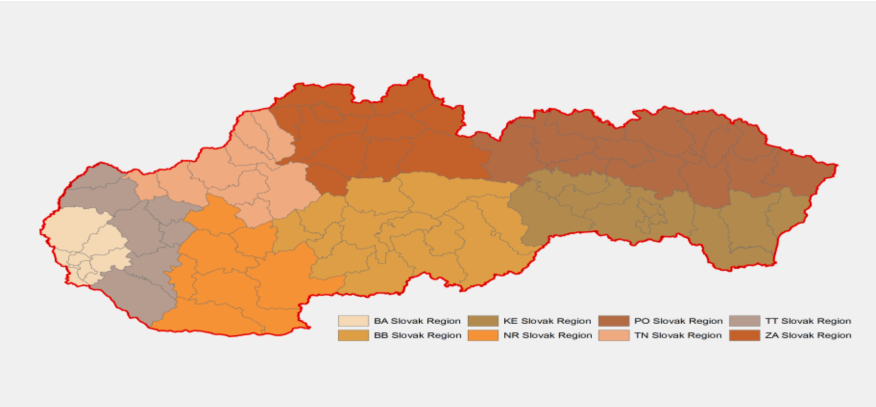
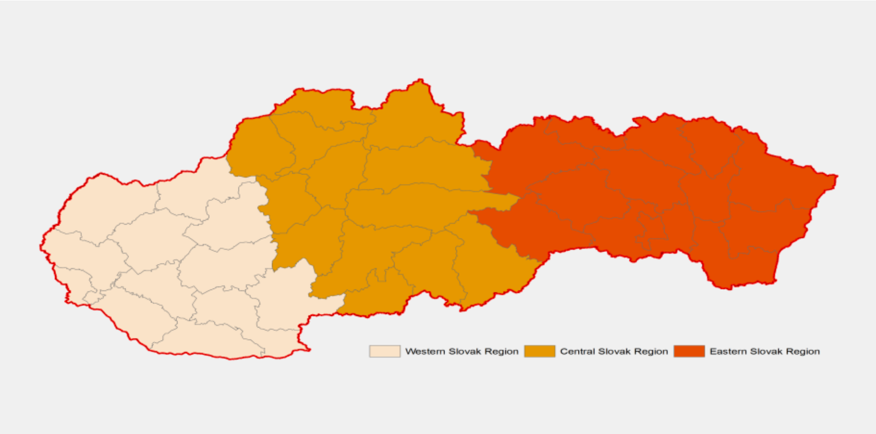


Figure 11.2: *Three Slovak regions used for the assessment of ARD activities since 1990*



Geographical boundaries of these districts are georeferenced by the means of the S – JTSK Krovak system. All maps used in the Slovak Republic are made in coordinated 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, no more than 3 800 ha (AR) or 988 ha (DEF) for the whole country. The following tables are examples of percentage of AR and DEF areas from total area of each district.

Table 11.2: *The areas (in kha/year) of ARD activities during 1990 – 1995 for whole country and different Slovak regions*

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 (in kha/year) of A/R activities during 1996 – 2011 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	0.851	0.000	0.029	0.320	0.017	0.131	0.058	0.222	0.073
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

Table 11.4: *The areas of DEF activities during 1996 – 2011 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	0.025	0.002	0.000	0.002	0.001	0.011	0.002	0.006	0.001
2005	0.534	0.209	0.021	0.187	0.017	0.012	0.037	0.035	0.016
2006	0.239	0.018	0.008	0.026	0.010	0.004	0.035	0.121	0.017
2007	0.454	0.026	0.052	0.047	0.066	0.061	0.023	0.161	0.018
2008	0.323	0.026	0.029	0.033	0.017	0.059	0.091	0.026	0.041
2009	0.462	0.199	0.023	0.053	0.044	0.049	0.010	0.043	0.041
2010	0.326	0.034	0.018	0.027	0.006	0.087	0.025	0.091	0.038
2011	0.087	0.008	0.005	0.008	0.011	0.014	0.020	0.012	0.009

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

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% and it has reached neither 0.5% of total district areas.

Table 11.5: *The percentage of areas of AR activities during 1996 – 2011 from whole country and different Slovak districts*

A/R	SK	BA	TT	TN	NR	ZA	BB	PO	KE
					%				
1996	0.03	0.00	0.00	0.00	0.00	0.03	0.08	0.04	0.03
1997	0.07	0.03	0.05	0.00	0.00	0.22	0.02	0.16	0.00
1998	0.05	0.00	0.02	0.00	0.00	0.12	0.09	0.06	0.00
1999	0.04	0.00	0.03	0.03	0.01	0.07	0.05	0.04	0.07
2000	0.03	0.00	0.00	0.00	0.00	0.10	0.02	0.04	0.01
2001	0.02	0.00	0.00	0.03	0.00	0.09	0.00	0.01	0.04
2002	0.02	0.01	0.00	0.02	0.00	0.07	0.01	0.00	0.02
2003	0.03	0.00	0.00	0.03	0.01	0.11	0.04	0.01	0.05
2004	0.02	0.00	0.01	0.07	0.00	0.02	0.01	0.02	0.01
2005	0.02	0.00	0.02	0.00	0.00	0.09	0.01	0.01	0.00
2006	0.04	0.04	0.01	0.01	0.02	0.11	0.00	0.09	0.01
2007	0.01	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.01
2008	0.03	0.00	0.00	0.10	0.03	0.02	0.03	0.02	0.03
2009	0.02	0.01	0.00	0.02	0.00	0.00	0.02	0.06	0.02
2010	0.06	0.05	0.00	0.10	0.02	0.00	0.12	0.07	0.03
2011	0.02	0.02	0.01	0.05	0.01	0.05	0.02	0.01	0.03

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 Geodesy, Cartography and Cadastre Authority of the Slovak Republic (GCCA). This institute annually updates the cadastral information about the areas which have been afforested/reforested and deforested. The AR area represented 34.161 kha in total and 1.553 kha on average by the year in Slovak conditions from 1990 to 2011. In the same time period the total deforestation areas amounted to 7.853 kha in total resp. 0.357 kha on average. The differences between AR and DEF correspond to the net increment of cadastral forest land between 0.20 and 3.01 kha. The identified land-use change from Cropland, Grassland and Other Land converted to Forest Land, categorized as A/R (kha/year) and land use change from Forest Land to Cropland, Grassland, Settlements and Other Land represent DEF (kha/year) in Slovak conditions for the period 1990 – 2011.

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 of www.geoportal.sk. Beside this since February 1, 2004 a Cadastral Portal (KAPOR) has been established at the web site www.katasterportal.sk. The KAPOR establishment was supported by Decree of the Government of the Slovak Republic No 540/2002, which has enacted the publication of real estate cadastre data at the Internet. KAPOR operation has been supported also by the European Union within the framework of PHARE project. KAPOR enables the access of users to the real estate cadastre data. KAPOR is available only in Slovak language.

Table 11.6: *The differences between AR and DEF activities during 1990 – 2011*

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)					%
1990	0.088	2.266	1.416	**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	0.220	0.135	0.367	**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	0.765	0.000	**0.851**	0.005	0.020	0.000	0.000	**0.025**	**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**

11.2.4 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 of www.geoportal.sk. Beside this since February 1, 2004 a Cadastral Portal (KAPOR) has been established at the web site www.katasterportal.sk. The KAPOR establishment was supported by Decree of the Government of the Slovak Republic No 540/2002, which has enacted the publication of real estate cadastre data at the Internet. KAPOR operation has been supported also by the European Union within the framework of PHARE project. KAPOR enables the access of users to the real estate cadastre data. KAPOR is available only in Slovak language.

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 estimation 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 calculation 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 of IPCC 2003 GPG LULUCF. Changes in carbon stocks in living biomass on land converted to forest through artificial regeneration were estimated with the use of Equation 3.2.22:

Equation 3.2.22: *Annual change in carbon stocks in living biomass in afforested land*

$$\Delta C_{LFLB} = \Delta C_{LFGROWTH} - \Delta C_{LFLOSS}$$

Where:

ΔC_{LFLB} - annual change in carbon stocks in living biomass in afforested land, t C yr^{-1}, $\Delta C_{LFGROWTH}$ - annual increase in carbon stocks in living biomass due to growth in land converted to forest land, t 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, t C yr^{-1}.

Annual Increase in Carbon Stocks in Living Biomass:

The method follows Equation 3.2.4, Section 3.2.1 Forest land remaining Forest land, which refers to Category 5A Changes in Forest and Other Woody Biomass Stocks" of the IPCC 2003 GPG LULUCF. The calculations are made according to Equation 3.2.23:

Equation 3.2.23: *Annual increase in carbon stocks in living biomass in land converted to forest land*

$$\Delta C_{LFGROWTH} = (\sum A \bullet G_{TOTAL}) \bullet CF$$

Where:

$\Delta C_{LFGROWTH}$ - 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 determined 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 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 on stem base as independent variables. The tree biomass at the sites was measured 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. 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 from total artificial regeneration areas for accounting years was selected from database of the Statistical Office of the Slovak Republic (www.statistics.sk) and represented 35% for spruce, 15% for pine, 46% for beech and 4% for oak in 2011.

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 3.2.24 that repeats the good practice approach given in Equation 3.2.6, Section 3.2.1, Forest land remaining Forest land:

Equation 3.2.24: *Annual decrease in carbon stocks in living biomass due to losses in land converted to forest land*

$$\Delta C_{LFLOSS} = L_{fellings} + L_{fuelwood} + L_{other\ losses}$$

Where:

ΔC_{LFLOSS} - 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). Main reason is that the first significant thinning occurs in older age forest stands in the Slovak conditions. Beside this, only total area where the silvicultural cuttings were realized has been registered in the forest database. The data of wood biomass amount removed from forest during the first 40 years are not available in the Slovak conditions.

Change in Carbon Stocks in Living Biomass for Deforestation:

The method requires the estimates of carbon in living biomass stocks prior to deforestation, based on the estimates of the areas of land deforested during the period between land-use surveys. As a result of deforestation, it is assumed that the dominant vegetation is removed entirely, resulting in no carbon remaining in living biomass after deforestation. The difference between initial and final living biomass carbon pools is used to calculate change in carbon stocks due to deforestation using Equation 3.7.2.

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.

Equation 3.7.2: *Annual change in carbon stocks in living biomass in land converted to other land*

$$\Delta C_{LOLB} = A_{Conversion} \bullet (B_{After} - B_{Before}) \bullet CF$$

Where:

ΔC_{LOLB} - annual change in carbon stocks in living biomass in land converted to Other Land, t C yr^{-1}, $A_{Conversion}$ - 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 $(t\ d.m.)^{-1}$.

Tier 1 and tier 2 were used for calculation following the approach in the IPCC 2003 GPG in LULUCF, Section 5.2.3 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.

The annually updated average growing stock volumes, BCEFs (0.65 for conifers and 0.84 for broadleaves) and default carbon content (0.5) were used for calculation of above ground biomass carbon stocks on forest land prior conversion. The average growing stock (m^3/ha) were estimated on the basis of forest taxation data in the Forest Management Plans (FMP), differently for the individual Slovak regions.

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 were used for calculation of below-ground biomass stocks (Table 4.4 of the IPCC GL, 2006).

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 uses 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 laying deadwood and small-sized laying 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 from standing dead trees, stumps, coarse laying deadwood and small-sized laying 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 national 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 the national conditions. 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 this 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 the Forest Monitoring System (FMS) and the National Forest Inventory (NFI) as a part of soil inventory.

The net carbon stock change in litter was estimated using the country specific tier 2. 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 Mg C ha^{-1} for C stocks in litter (representing surface organic layer) as well as 0.415 Mg 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.

For calculation was used following equation:

Annual changes in litter C stocks for ARD = net annual accumulation of litter (Mg 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 carbon stocks for each category of land use associated with ARD.

<u>Change in Carbon Stocks in Soils for ARD:</u>

Carbon stock changes in mineral soils are calculated based on the data from the soil inventory with the default assumption of 20 years period for carbon stock equilibrium in „new land use“ conditions, see chapter Land converted to Forest Land (5.A.2) for AR activity and chapters (5.B.2, 5.C.2, 5.E.2, 5.F.2) concerning Forest Land converted to other land use categories for DEF activity. Calculations of carbon stock changes in mineral soils as a result of ARD activities carried out as follows the IPCC GPG in LULUCF 2003. The net carbon stock change in mineral soils was estimated using the country specific tier 2 described in detail in Chapter 7 – LULUCF of this report. The average carbon stock per hectare noted above (category 5.A.2 Land converted to Forest land.) was used for estimation of net carbon stock change in mineral soil. These values are based on 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.

The mean value of 166.1 Mg C ha^{-1} for organic carbon stocks in forest soils (including surface organic layer) was used in previous KP LULUCF report. As recommended by the review team this value was reduced to 157.8 Mg C ha^{-1}. The difference is the amount of carbon accumulated in surface organic layer which is now calculated separately. For respective land use categories following values (calculated as weighted average) were used for calculations of carbon stock changes in mineral soils (0-100 cm, without any surface organic layer) as a result of land use change:

Forest Land – 157.8 Mg C ha^{-1}, Grassland – 129.7 Mg C ha^{-1}, Cropland – 108.6 Mg C ha^{-1}, Settlements – 97.3 Mg C ha^{-1}, Other Land – 97.3 Mg 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 (Mg 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 were calculated for different types of conversion:

AR of Cropland – 2.446 Mg C ha^{-1} yr^{-1}, AR of Grassland – 1.404 Mg C ha^{-1} yr^{-1}, AR of Other Land – 3.024 Mg C ha^{-1} yr^{-1}. DEF to Cropland – 2.446 Mg C ha^{-1} yr^{-1}, DEF to Grassland – 1.404 Mg C ha^{-1} yr^{-1}, DEF to Settlements and Other Land – 3.024 Mg 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 regions. As mentioned in the Chapter Forest land remaining Forest Land, the same mean values of soil carbon stocks as in previous submissions are used, because the validation and final data evaluation (soil data obtained from NFI plots) has not been finished yet. For this reason, the results of soil survey carried out on the NFI plots are still not used for improvement of carbon stocks and changes estimation.

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 is planned in next submission.

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 (recalculations)

Following recalculations have been performed since the previous submission:

- recalculation of carbon stock changes in above-ground and below-ground biomass in deforestation activity for whole accounting period. The main reason was increasing accuracy of carbon stock changes. New biomass conversion and expansion factors (BCEFs) were developed based on the NFI data (see chapter Forest land remaining Forest land);

- recalculation of CO_2 emissions/removals of carbon stock changes in mineral soils in deforestation activity for whole accounting period. New methodological approach of calculation was applied, which also takes into account the subsequent land use category. Different values for each land use conversion (average annual change of SOC carbon content) were used for calculation in 2013 submission, compared to previous submissions value 3.024 Mg C ha^{-1} yr^{-1} for all forest land use conversions.

11.3.1.5 Uncertainty estimates

The 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 forests 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, 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, 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 2008

Not relevant.

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

The cadastral information is annually updated by the GCCA. This is an official state institution and it is managed in accordance with the Slovak legislative.

The change of land use classification is always initiated by land owners in the Slovak Republic. The owners have interest to make the ARD activity. They need a special plan for afforestation undertake. Deforestation is allowed only by the law.

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 estimated removals from afforestation/reforestation activities represented 527.85 Gg CO_2 in 2011. Deforestation showed emissions 38.53 Gg CO_2 in 2011. The details are noted in the corresponding CRF tables of KP LULUCF

11.5 Article 3.4

The Slovak Republic has not elected reporting under Article 3.4 of the KP.

11.6 Other information

11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

According to the GPG LULUCF (page 5.39) forest management is a key category since Forest land is a key category in the UNFCCC reporting (Section 7.1.3).

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

According to a revised version of the Initial Report of the Slovak Republic based on FCCC/IRR/2007/SVK from 19th September 2007[21] the quantified emission limitation or reduction commitment of 92% from the base year level has been accepted by the Slovak Republic as is stated in Annex B of the Kyoto Protocol. The calculation of assigned amount for the Slovak Republic pursuant to Article 3.7 of the Kyoto Protocol is based on the base year (1990) inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol to the UNFCCC and the base year for F-gases (1995). The assigned amount of the Slovak Republic for the first commitment period (2008 – 2012) pursuant to Article 3.7 and 3.8 of the Kyoto Protocol has been calculated in accordance with Decision 13/CMP.1 as the total GHG emissions in 1990, excluding LULUCF (in t of carbon dioxide equivalents), multiplied by the quantified emission limitation commitment (92%) and multiplied by 5 (years):

72 050 764*0.92*5 = 331 433 516 t of CO_2 equivalent

Average assigned amount of the Slovak Republic over the first commitment period is:

331 433 516/5 = 66 286 703 t of CO_2 equivalent

Table 12.1: *The assigned amount of the Slovak Republic for period 2008 – 2012*

Item	Unit (t of CO_2 eq.)
Base year emissions excluding LULUCF (1990)	72 050 764
F-gases emissions in 1990	271 403
Percentage corresponding to the reduction commitment	1
Estimated assigned amount for the first commitment period	**331 433 516**
Assigned amount averaged over the first commitment period	66 286 703

12.2 Summary of information reported in the SEF tables

The standard electronic format (SEF) tables provide information on AAUs, ERUs, RMUs, CERs, lCERs and tCERs in the Slovak national registry.

SEF tables are included in the submission for the fifth time (SEF_SK_2013_1_13-6-45 10-4-2013.xls). The tables include all required information on Kyoto units in the Slovak national registry for the calendar year 2012 as well as information on transfers of the units in 2012 to and from other Parties of the Kyoto Protocol. SEF tables have been filled automatically respecting all UNFCCC's requirements and guidance and have been checked for completeness and consistency.

The Standard Electronic Format report for year 2012 has been submitted to the UNFCCC Secretariat electronically. According to the information from Slovak national registry the current status of the units and reductions of the end of the year 2012 was summarized in the following Table 12.2.

[21] http://unfccc.int/resource/docs/2007/irr/svk.pdf

Table 12.2: *Statistics of the year 2012 from the Slovak National Registry*

	AAU	CER	ERU	RMU
Issuance	0	0	0	0
Acquisition	7 819 050	535 271	288 689	0
Holding	269 450 658	8 865 197	127 643	0
Transfer	13 132 810	281 857	205 642	0
Retirement	21 250 873	1 018 083	103 578	0
Cancellation	0	0	0	0
Withdrawal	0	0	0	0
Carry-over	0	0	0	0

12.3 Discrepancies and notifications

Reports R-2 to R-5 provide information on discrepant transactions, CDM notifications, non-replacements and invalid units in the registry during reported period.

To minimize discrepancies, internal checks and routines are implemented, as far as possible, 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 reported period no discrepant transactions were identified in the Slovak national registry, no CDM notifications were received, no non-replacements occurred and there were no invalid units identified. Therefore no additional actions or changes of established measures were necessary to be undertaken in order to address discrepancies.

The R-2 to R-5 reports (SIAR_Report_R-2_2012-SK.xls, SIAR_Report_R-3_2012-SK.xls, SIAR_Report_R-4_2012-SK.xls and SIAR_Report_R-5_2012-SK.xls) have been filled automatically respecting all UNFCCC's requirements on format and can be found in this 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 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)

The commitment period reserve of the Slovak Republic is calculated in accordance with Decision 11/CMP.1 (Modalities, rules and guidelines for emission trading under Article 17 of the KP) as 90% of the proposed assigned amount or 100% of its most recently reviewed inventory multiplied by five, whichever value is the lowest. Due to substantive methodology improvements and fulfilled recalculations the Slovak Republic decided to use emission inventory 2011 submitted in 2013 as an alternate to estimate the commitment period reserve. The CPR value will be recalculated every year according to the latest inventory submission data.

Using the 100% of this value multiplied by five gives the number 226 484 821 t of CO_2 equivalent. This number is lower than the 90% of the calculated assigned amount, which is 298 290 164 t of CO_2 equivalent. Following the decision 11/CMP.1 an estimated commitment period reserve for the Slovak Republic is equal to the 226 484 821 t of CO_2 equivalent for the submission 2013 emission inventory 2011.

12.6 KP-LULUCF accounting

In 2011, total CO_2 removals from afforestation/reforestation activities were -527.85 Gg of CO_2 (changes in 34.16 kha to the end of 2011). Total CO_2 emissions from deforestation were 38.53 Gg of CO_2 (changes in 7.85 kha to the end of 2011). In 2011, total removals under the Article 3.3 of the KP -489.33 Gg with the changed area of 42.01 kha. The Slovak Republic has not elected activity under the Article 3.4 of the Kyoto Protocol.

Table 12.3: *Emissions and removals resulting from activities 3.3 of the KP in 2008 – 2011*

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net emissions/removals (Gg)					Accounting Quantity
	2008	2009	2010	2011	Total	
A. Article 3.3 activities						
A.1. Afforestation and Reforestation						-1 963.56
A.1.1. Units of land not harvested since the beginning of the commitment period(2)	-453.55	-469.73	-512.43	-527.85	-1 963.56	-1 963.56
A.1.2. Units of land harvested since the beginning of the commitment period(2)						
A.2. Deforestation	134.80	212.34	141.19	38.53	526.86	526.86

Emissions are determined as of 15.04.2013

CHAPTER 13: INFORMATION ON CHANGES IN NATIONAL SYSTEM

The official report about the Slovak National Inventory System for GHG emissions and projection under the Article 5 of the Kyoto Protocol was published in the Official Journal of the Ministry of Environment of the Slovak Republic http://www.enviro.gov.sk/servlets/files/16715.[22] The revised report of the National Inventory System dated on November 2008 focusing on the changes in the institutional arrangement, quality assurance/quality control plan, planned improvement in the National Inventory System is available in the National Inventory Report of the Slovak Republic 2012, resubmitted August 2012.

Since the in-country review of the 2011 Annual submission, Slovakia in order to enhance the national inventory system in the efficient and consistent manner, so that it will enable continual monitoring of greenhouse gas emissions as required by the Article 5, paragraph 1 of the Kyoto Protocol and later to regain in compliance status, implemented several sets of measures.

Proposed set of measures was in details described in the First Progress Report where the measures were structured according to non-compliance issues as identified in the Final Decision.

The Second Progress Report of Slovakia was delivered to the Compliance Committee – During the last year 2012 several changes concerning the administration and enlargement of the National Inventory System under article 5.1 the Kyoto Protocol has been undertaken. The detailed and comprehensive description of the systematic and institutional changes and improvements implemented since 2011 in-country review (took place in August 2011) are described in the First and the Second Progress Report:

http://unfccc.int/kyoto_protocol/compliance/questions_of_implementation/items/6920.php.

Enforcement Branch in March 2013 and did not fully reflect recommendations from the 2012 ARR (published in May 2013). Despite this delay, major recommendations from the 2012 ARR were already reflected in the 2013 submission to the UNFCCC and to the KP. The

- Enlargement of the capacity of the Single National Entity delegated on the Department on Emissions and Air Quality Monitoring with the permanent staff 3.5 capacity by the director general decree from August 2012.
- Established the Special working group within the Coordination Committee, which comprises the representatives of the relevant institutions at the second meeting of the Inter-ministerial High Level Committee on the Coordination of the Climate Change.
- Increasing number of training and meeting within the NIS SR, experts and stakeholders.
- Signing of the Framework Agreement between the Ministry of the Environment of the Slovak Republic and the Statistical Office of the Slovak Republic on direct access to the relevant statistical information.
- Agreement on cooperation between the MoE and the Ministry of Agriculture and Rural Development of the Slovak Republic to facilitate the task of implementation of reporting obligations under the UNFCCC and the KP LULUCF sectors in 2013. The contract is registered on the web page of the Ministry of Agriculture and Rural Development of the Slovak Republic (http://www.mpsr.sk/index.php?start&navID=10), as *Kontrakt č. 319/2012 – 710/MPRV* (general task number 13 on page 29, the specific task is elaborated in an additional protocol).
- Starting cooperation with the Waste Management Centre Bratislava for enhance capacity in waste sector. Cooperation has been going on since January 2012. In 2013 this obligation is

[22] *Vestnik, 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*

listed as a 53rd task in the Main Tasks of the Slovak Environmental Agency for the year 2013 (http://www.sazp.sk/public/index/open_file.php?file=Admin/2013/phu2013.pdf).

- Agreement between the MoE and the Ministry of Finance of the Slovak Republic on regular provision of data about the consumption of biofuels and bioliquids in the Slovak Republic.
- Enhancement of external inspections of the implementation of the QA/QC procedures and Plan of inventory improvement by the MoE. Improvement of the QA/QC procedures and Plan on Inventory according to the ERT`s recommendations from the most recent and previous reviews.
- Agreement between the Slovak Hydrometeorological Institute (the "SHMU") and Department of Chemical and Environmental Engineering of the Faculty of Chemical Technology of the Slovak Technical University (Energy and IP sectors).
- Agreement on cooperation between the MoE and the Ministry of Transport, Construction and Regional Development of the Slovak Republic, the Transport Research Institute and the SHMU on mutual provision of data and independent inspection of output databases and creation of GHG emissions in transport.
- Inventory planning for 2013: Improvement Plan and Prioritization on the basis of the outcomes and recommendations from the ARR 2012.

CHAPTER 14: INFORMATION ON CHANGES IN NATIONAL REGISTRY

14.1 The changes in the national registry software

Directive No 2009/29/EC adopted in 2009, provides for the centralization of the EU ETS operations into a single European Union registry operated by the European Commission as well as for the inclusion of the aviation sector. At the same time, and with a view to increasing efficiency in the operations of their respective national registries, the EU Member States who are also Parties to the Kyoto Protocol (25) 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 No 13/CMP.1 and Decision No 24/CP.8.

With a view to complying with the new requirements of Commission Regulation No 920/2010 and Commission Regulation No 1193/2011, in addition to implementing the platform shared by the consolidating Parties, EU member states' registries have undergone a major re-development. 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) and was developed together with the new EU registry on the basis the following modalities:

(1) Each Party retains its organization designated as its registry administrator to maintain the national registry of that Party and remains responsible for all the obligations of Parties that are to be fulfilled through registries;

(2) Each Kyoto unit issued by the Parties in such a consolidated system is issued by one of the constituent Parties and continues to carry the Party of origin identifier in its unique serial number;

(3) Each Party retains its own set of national accounts as required by paragraph 21 of the Annex to Decision 15/CMP.1. Each account within a national registry keeps a unique account number comprising the identifier of the Party and a unique number within the Party where the account is maintained;

(4) Kyoto transactions continue to be forwarded to and checked by the UNFCCC Independent Transaction Log (ITL), which remains responsible for verifying the accuracy and validity of those transactions;

(5) The transaction log and registries continue to reconcile their data with each other in order to ensure data consistency and facilitate the automated checks of the ITL;

(6) The requirements of paragraphs 44 to 48 of the Annex to Decision No 13/CMP.1 concerning making non-confidential information accessible to the public would be fulfilled by each Party individually;

(7) All registries reside on a consolidated IT platform sharing the same infrastructure technologies. The chosen architecture implements modalities to ensure that the consolidated national registries are uniquely identifiable, protected and distinguishable from each other, notably:

(a) With regards to the data exchange, each national registry connects to the ITL directly and establishes a distinct and secure communication link through a consolidated communication channel (VPN tunnel);

(b) The ITL remains responsible for authenticating the national registries and takes the full and final record of all transactions involving Kyoto units and other administrative processes such that those actions cannot be disputed or repudiated;

(c) With regards to the data storage, the consolidated platform continues to guarantee that data is kept confidential and protected against unauthorized manipulation;

(d) The data storage architecture also ensures that the data pertaining to a national registry are distinguishable and uniquely identifiable from the data pertaining to other consolidated national registries;

(e) In addition, each consolidated national registry keeps a distinct user access entry point (URL) and a distinct set of authorisation and configuration rules.

Following the successful implementation of the CSEUR platform, the 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on June 20, 2012. During the go-live process, all relevant transaction and holdings data were migrated to the CSEUR platform and the individual connections to and from the ITL were re-established for each Party.

On October 2, 2012 a new software release (called V4) including functionalities enabling the auctioning of phase 3 and aviation allowances, a new EU ETS account type (trading account) and a trusted account list was deployed. The trusted account list adds to the set of security measures available in the CSEUR. This measure prevents any transfer from a holding account to an account that is not trusted.

- P1.3.1 15/CMP.1 annex II.E paragraph 32(a)
  The change of name or contact:

Changes in the contact information of the national registry administrator occurred during reported period: change of business name (from Dexia banka Slovensko a.s. to Prima banka Slovensko, a.s.) as well as telephone and fax numbers changes. These changes were reported to UNFCCC Secretariat through the Focal Point of the Slovak Republic.

There has been further change in the organization designated as registry system administrator, contact persons and contact information including postal address, web site address, email addresses, phone numbers and fax numbers since the end of the reported period which was reported to UNFCCC through the Focal Point of the Slovak Republic. These changes will be reported in the next submission.

- P1.3.2 15/CMP.1 annex II.E paragraph 32.(b)
  The change of cooperation arrangement:

The EU Member States who are also Parties to the Kyoto Protocol (25, including Slovakia) plus Iceland, Liechtenstein and Norway have decided to operate their registries in a consolidated manner. The Consolidated System of EU registries were certified on June 1, 2012 and went to production on June 20, 2012.

A complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. This description includes:

- Application logging
- Change management procedure
- Disaster recovery
- Manual Intervention
- Operational Plan
- Roles and responsibilities
- Security Plan
- Time Validation Plan

- Version change Management

These documents are considered confidential are not to be publicly available. A new central service desk was also set up to support the registry administrators of the consolidated system. The new service desk acts as 2nd level of support to the local support provided by the Parties. It also plays a key communication role with the ITL Service Desk with regards notably to connectivity or reconciliation issues.

- P1.3.3 15/CMP.1 annex II.E paragraph 32.(c)
  The change to the database or the capacity of national Registry:

In 2012, the EU registry has undergone a major redevelopment with a view to comply with the new requirements of Commission Regulation No 920/2010 and Commission Regulation No 1193/2011 in addition to implementing the Consolidated System of EU registries (CSEUR).

The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission, but is considered confidential.

- P1.3.4 15/CMP.1 annex II.E paragraph 32.(d)
  The change of conformance to technical standards:

The overall change to a Consolidated System of EU Registries triggered changes the registry software and required new conformance testing. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission, but is considered confidential.

During certification, the consolidated registry was notably subject to connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the DES. All tests were executed successfully and lead to successful certification on June 1, 2012.

- P1.3.5 15/CMP.1 annex II.E paragraph 32.(e)
  The change of discrepancy procedures:

The overall change to a Consolidated System of the EU Registries also triggered changes to discrepancies procedures, as reflected in the updated manual intervention document and the operational plan. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission, but is considered confidential.

- P1.3.6 15/CMP.1 annex II.E paragraph 32.(f)
  The change of security:

The overall change to a Consolidated System of EU Registries also triggered changes to security, as reflected in the updated security plan. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission, but is considered confidential.

- P1.3.7 15/CMP.1 annex II.E paragraph 32.(g)
  The change of list of publicly available information:

No change to the list of publicly available information occurred during reported period.

- P1.3.8 15/CMP.1 annex II.E paragraph 32.(h)

The change of Internet address:

Internet address of the registry changed in January 2012 from co2.dexia.sk to http://co2.primabanka.sk/.

The Internet address has changed further since the end of the reported period and it was reported to UNFCCC through the Focal Point of the Slovak Republic. This change will be reported in the next submission.

- P1.3.9 15/CMP.1 annex II.E paragraph 32.(i)
  The change of data integrity measures:

The overall change to a Consolidated System of EU Registries also triggered changes to data integrity measures, as reflected in the updated disaster recovery plan. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission, but is considered confidential.

- P1.3.10 15/CMP.1 annex II.E paragraph 32.(j)
  The change of test results:

During certification, the consolidated registry was notably subject to connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the Data Exchange Standard (DES). All tests were executed successfully and lead to successful certification on June 1, 2012.

14.2 The previous annual review recommendations

The recommendations from previous Standard Independent Assessment Report for Slovakia (reference no.: IAR/2011/SVK/2/2) to display complete public information pursuant to part E of the annex to 13/CMP.1, paragraphs 44 to 48 inclusive was not yet fully addressed because of limitations of Union Registry. Partial information is provided on registry administrator's website (http://emisie.icz.sk/). The complete information is foreseen to be provided by the end this year.

14.3 Public Information

Public information is accessible on the national registry administrator's webpage (http://emisie.icz.sk/) and it includes non-confidential information 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.

Detailed information on holdings of accounts and transactions information is considered confidential according to European law. Currently, there is no officially registered JI project (Joint Implementation Project under Article 6 of the Kyoto Protocol) in Slovakia.

14.4 Accounting of Kyoto Protocol Units

- 15/CMP.1 annex I.E paragraph 12

No discrepant transactions occurred in 2012.

- 15/CMP.1 annex I.E paragraph 13 & 14

No CDM notifications occurred in 2012.

- 15/CMP.1 annex I.E paragraph 15

No non-replacements occurred in 2012.

- 15/CMP.1 annex I.E paragraph 16

No invalid units exist as at 31st December 2012.

- P.1.2.13 15/CMP.1 annex I.E paragraph 17

14.5 Actions and changes to address discrepancies

The overall change to a Consolidated System of EU Registries triggered changes to discrepancies procedures. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries.

CHAPTER 15: INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

Economy of the Slovak Republic, being a small open economy does not allow a significant impact of its internal price mechanism development of world prices. From this point of view, any potential impacts of the measures adopted in the Slovak Republic on other countries can be considered as minimal. This situation has changed to some extent following our accession to the EU and integration into the single European market. Historically, a major bulk of the adopted measures within the environmental policy was of command and control type of regulatory measures. By the end of nineties a shift has occurred towards an increasing application of the polluter pays principle penalizing polluters and providing incentives for adoption of more environmentally sound technologies in particular through fiscal policy instruments. Their major benefit expected was an increasing emphasize on cost effective compliance with the adopted environmental target through the function of the price mechanism. The fundamental ideal of the price liberalization was establishment of a competitive environment, where market generates an equilibrium price of commodities. An adequate regulation is acceptable in case of a lasting existence of market imperfections. In charge of supervision on the price development founded by the macroeconomic fundamentals are independent regulatory institutions, which are also responsible to correct the existing market distortions.

15.1 Coal industry

State aid granted to the coal industry consists of three main pillars: coal, steel and electricity markets. The Slovak Republic has fully privatized the former state owned mines and continues in granting the coal industry investment aid. Report prepared by the EC notes that mines in the Slovak Republic are in terms of production costs competitive with respect to the prevailing world prices. Subsidies granted to the coal industry affect only the provision of the coal resources, i.e. the decision whether to buy own or imported coal. However, the other regulation such as compulsory utilization of home extracted coal does also affect the composition of the energy mix, i.e. the share of coal on the electricity production. European Commission has highlighted the potential impact of these decisions on the internal electricity market. Impacts of similar types of measures adopted within the coal industry on the steel markets have not been observed. Within the period of 2003 – 2006 coal prices in the world markets remained more stable in comparison with other fossil fuels such as oil and gas. The Slovak Republic does not export its coal to the other countries. On the base of the mentioned facts we can conclude that the economy of the Slovak Republic has minimal impact on the existing structure of the international trade with coal and pricing.

15.2 Flexible mechanism KP

During the first commitment period of the Kyoto Protocol (2008 – 2012) the emission allowances for the EU ETS sectors are allocated free of charge. No quantitative study has yet examined the potential transmission of the emission allowances prices on the producer prices and the price of electricity within EU ETS sectors. No significant impact of the variation of emission allowance prices on the oil consumption within the Slovak Republic in the near term future is expected. Any influence originating from the actions taken by the regulators on the potential revenues of the oil exporting countries will be insignificant. The Slovak Republic is hosting one JI project and at this stage does not participate in any CDM project in developing countries.

15.3 Utilization of biofuels

Policies supporting the utilisation of the biofuels are closely linked to the EU trade and common agricultural policies. Strategies to phase in the alternative sources of motor fuels have been developed within the National Program of Development of Biofuels, while their practical implementation has been regulated by the Directive No 246/2006 Coll. which entered into force the 1st May 2006. This directive has set the minimum levels of biofuels in motor gasoline and diesel oil. A range of programs with focus on enhancement of biofuels utilisation within the European Union[23] has provided a significant stimulus for the production of biofuels as well as to the stronger growth of the international trade with biofuels, often with negative side impacts on the economies of developing countries. Despite increasing imports of biofuels we perceive the impact of the Slovak Republic on the world prices of biofuels as negligible.

15.4 Carbon leakage

Carbon leakage due to the decreasing share of allocation of emission allowances through grandfathering pro bono of auctions and benchmarks requires detailed and continuous analysis. A potential solution to minimize the risk of carbon leakage and reallocation of the industrial base in the countries with less stringent environmental policies is subsequent rise of the shares of allowances to be allocated through auctioning. This measure is relevant for the sectors, where the risk of the carbon leakage has been identified.

15.5 Foreign aid

According to the preliminary assessment of the bilateral and specific projects of the foreign development policy of the Slovak Republic within 2004 – 2008, more than 21% of these projects focused on the support of the utilization of renewable energy resources and energy efficiency, on the adaptation measures including construction of the early warning systems, adjustments and efficiency improvements of the water management as well as for capacity building and improvement in the infrastructure for the compliance with Convention and Kyoto Protocol (Serbia, Kazakhstan). The Slovak Republic as a country with rich experiences within this area, participates on aid delivered in order to strengthen practical implementation of the Kyoto Protocol and compliance with its commitments and preparation of the legislative framework for implementation of the market mechanisms and emission trading systems (administration and national emission registries, emission audits, monitoring systems and emission balances). The Slovak Republic is able to deliver projections of hydro power plants, complex delivery of the relevant technology as well as inspection of construction. Currently, we have not been carrying out any programs of assistance for oil exporting countries. Recently Slovak oil imports have remained stable with slightly increasing trend, what is not expected to have any negative impacts on oil exporting economies. In addition to the delivered development aid, the Slovak Republic has expanded the provisions of preferential market access for the developing and the least developed countries.

[23] *A strong demand growth for biofuels has contributed also a combination of different supporting policies in the EU and USA.*

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ANNEXES TO THE NATIONAL INVENTORY REPORT

Annex 1: Key categories

Description of methodology used for identifying key categories, including for KP-LULUCF

Those key source categories by level assessment and trend assessment were chosen, of which cumulative contribution is less than 95% and are enclosed in the excel file followed the Good Practice Guidance (IPCC, 2000 and 2003). Using tables 7.1 and 5.4.1 of IPCC (2000) and IPCC (2003) as a basis, the key category analysis consists of 100 category-gas combinations. The identification includes all reported greenhouse gases CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 and all IPCC source categories with or without LULUCF performed with the detailed categorization of the CRF categories.

The Slovak Republic determined using the tier 1 methodology (quantitative) according to the IPCC GPG (2000), section 7.2.1.1, 28 key source categories by the level assessment with LULUCF and 25 key source categories without LULUCF. The trend assessment determined 35 key source categories with LULUCF and 31 key source categories without LULUCF in 2011. The most important key source categories in the Slovak Republic remain fuel combustion, road transport and the emissions of N_2O from agricultural soil and methane emissions from SWDS etc. Key categories are summarized in the CRF Table 7 for every year from 1990. Key categories for KP LULUCF are included in CRF Table NIR-3.

Table NIR.3, as contained in the annex to decision 6/CMP.3

Table A1.1: *Table NIR-3 from CRF*

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS
		Associated category in UNFCCC inventory is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory (including LULUCF)	Other	
Afforestation and Reforestation	CO_2	Forest land remaining forest land, Conversion to cropland, Conversion to grassland, Conversion to other land	Yes	NO	Level assessment
Deforestation	CO_2	Forest land remaining forest land, Conversion to cropland, Conversion to grassland, Conversion to other land	Yes	NO	Level assessment

Tables 7.A1 - 7.A3 of the IPCC good practice guidance

Table A1.2: *Table 7.A1 Tier 1 Analyses – Level Assessment with LULUCF for 2011*

IPCC Source Categories	Direct GHG	Base Year (1990)	Current Year (2011)	Level Assess.	Cumulative
		CO_2 eq. (Gg)		%	
5.A Forest Land	CO_2	10 128.02	6 567.96	12.32	12.32
1.A.3.b Transport - Road Transportation - liquid	CO_2	4 503.02	6 180.77	11.59	23.91
1.A.2 Manufacturing Industries and Construction - solid	CO_2	9 028.51	6 180.48	11.59	35.49
1.A.1 Energy Industries - solid	CO_2	12 879.06	5 489.36	10.29	45.79
1.A.1 Energy Industries - gaseous	CO_2	2 736.47	3 507.37	6.58	52.36
1.A.4 Other sector - gaseous	CO_2	2 884.52	3 467.88	6.50	58.87
2(I).C.1.1 Steel Production	CO_2	4 113.88	3 224.50	6.05	64.91
1.A.2 Manufacturing Industries and Construction - gaseous	CO_2	4 902.48	2 637.03	4.94	69.86
6.A Solid Waste Disposal on Land	CH_4	469.77	1 572.90	2.95	72.81
4.D.1 Agricultural Soils - Direct	N_2O	2 450.40	1 286.13	2.41	75.22
2(I).A.1 Cement Production	CO_2	1 438.01	1 238.93	2.32	77.54
1.A.5.a Other non-specified - gaseous	CO_2	1 968.70	1 025.47	1.92	79.47
1.A.2 Manufacturing Industries and Construction - liquid	CO_2	4 162.04	987.66	1.85	81.32
2(I).B.1 Ammonia Production	CO_2	616.97	779.42	1.46	82.78
5.B Cropland	CO_2	187.15	773.14	1.45	84.23
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	CH_4	513.50	756.70	1.42	85.65
4.A Enteric Fermentation - Cattle	CH_4	1 802.03	747.17	1.40	87.05
2(I).A.2 Lime Production	CO_2	770.42	737.77	1.38	88.43
2(I).F HFCs emissions	HFCs	0.00	437.15	0.82	89.25
2(I).B.2 Nitric Acid Production	N_2O	1 187.50	421.05	0.79	90.04
4.D.3 Agricultural Soils - Indirect	N_2O	995.23	405.57	0.76	90.80
5.C Grassland	CO_2	350.08	384.27	0.72	91.52
4.B Manure Management	N_2O	1 074.32	369.26	0.69	92.21
2(I).A.7.2 Magnesite Production	CO_2	431.94	363.85	0.68	92.90
6.B Wastewater Handling	CH_4	413.83	350.63	0.66	93.55
1.B.1.a Coal Mining and Handling	CH_4	571.15	339.74	0.64	94.19
1.A.1 Energy Industries - liquid	CO_2	1 033.38	334.36	0.63	94.82
2(I).A.3 Limestone and Dolomite Use	CO_2	318.23	328.72	0.62	95.43
2(I).B.4. Calcium Carbide Production	CO_2	0.00	238.09	0.45	95.88
2(I).C.3 Aluminium Production	CO_2	121.32	237.20	0.44	96.33
1.A.4 Other sector - solid	CO_2	7 171.66	222.19	0.42	96.74
6.D Waste Composting	CH_4	1 316.70	201.13	0.38	97.12
2(I).C.2 Ferroalloys Production	CO_2	264.24	187.07	0.35	97.47
5.F Other Land	CO_2	374.05	121.68	0.23	97.70
6.D Waste Composting	N_2O	1.86	111.65	0.21	97.91
4.A Enteric Fermentation - except cattle	CH_4	211.90	110.15	0.21	98.11
4.B Manure Management	CH_4	368.66	107.07	0.20	98.32
4.D.2 Agricultural Soils - PRP	N_2O	221.71	92.17	0.17	98.49
1.A.3.c Transport - Railways - liquid	CO_2	376.77	84.74	0.16	98.65
5.E Settlements	CO_2	119.66	81.02	0.15	98.80
6.B Wastewater Handling	N_2O	138.77	79.45	0.15	98.95
3.D Other Solvent Use	N_2O	17.05	75.85	0.14	99.09
1.A.3.b Transport - Road Transportation - liquid	N_2O	58.64	64.56	0.12	99.21
1.A.1 Energy Industries - other	CO_2	170.30	63.43	0.12	99.33
3.A Paint Application	CO_2	94.44	58.58	0.11	99.44
2(I).C.1.5 EAF Steel Production	CO_2	18.15	26.97	0.05	99.49
5.A Forest Land	CH_4	14.09	22.58	0.04	99.53
2(I).F SF_6 emissions	SF_6	0.03	20.74	0.04	99.57
1.A.1 Energy Industries - solid	N_2O	56.29	19.16	0.04	99.61
3.C Chemical Products, Manufacture and Processing	CO_2	18.11	18.43	0.03	99.64
3.B Degreasing and Dry Cleaning	CO_2	17.55	17.68	0.03	99.68
2(I).C.3 Aluminium Production	PFCs	271.37	17.00	0.03	99.71
1.A.3.b Transport - Road Transportation - gaseous	CO_2	0.00	16.30	0.03	99.74
1.A.2 Manufacturing Industries and Construction - solid	N_2O	29.83	15.25	0.03	99.77
5.B Cropland	N_2O	93.81	13.25	0.02	99.79
1.A.3.b Transport - Road Transportation - liquid	CH_4	24.47	11.96	0.02	99.81
2(I).A.7.1 Glass Production	CO_2	7.88	11.83	0.02	99.84
1.A.3.c Transport - Railways - liquid	N_2O	50.19	11.29	0.02	99.86
6.C Waste Incineration	CO_2	62.70	9.58	0.02	99.88
1.A.4 Other sector - liquid	CO_2	386.64	8.07	0.02	99.89
1.A.4 Other sector - gaseous	CH_4	5.38	6.61	0.01	99.90
1.A.3.a Transport - Civil Aviation - jet kerosene	CO_2	7.00	5.51	0.01	99.91

1.A.2 Manufacturing Industries and Construction - gaseous	CH_4	9.16	5.02	0.01	99.92
5.A Forest Land	N_2O	12.09	4.58	0.01	99.93
1.A.1 Energy Industries - other	N_2O	4.90	4.53	0.01	99.94
1.A.5.a Other non-specified - liquid	CO_2	34.99	4.38	0.01	99.95
1.A.5.a Other non-specified - solid	CO_2	216.08	3.09	0.01	99.95
6.C Waste Incineration	N_2O	2.73	2.26	0.00	99.96
1.A.2 Manufacturing Industries and Construction - liquid	N_2O	10.28	2.16	0.00	99.96
1.A.1 Energy Industries - gaseous	N_2O	1.53	1.97	0.00	99.97
1.A.5.a Other non-specified - gaseous	CH_4	3.63	1.95	0.00	99.97
1.A.4 Other sector - gaseous	N_2O	1.59	1.95	0.00	99.97
1.A.5.b Other Mobile - liquid	CO_2	7.00	1.59	0.00	99.98
1.A.2 Manufacturing Industries and Construction - gaseous	N_2O	2.70	1.48	0.00	99.98
2(I).B.1 Ammonia Production	CH_4	1.14	1.48	0.00	99.98
1.A.1 Energy Industries - gaseous	CH_4	1.04	1.34	0.00	99.98
1.A.2 Manufacturing Industries and Construction - solid	CH_4	1.83	1.15	0.00	99.99
1.A.3.b Transport - Road Transportation - gaseous	CH_4	0.00	1.02	0.00	99.99
1.A.1 Energy Industries - solid	CH_4	2.68	1.02	0.00	99.99
1.A.4 Other sector - solid	N_2O	28.24	0.92	0.00	99.99
1.A.2 Manufacturing Industries and Construction - liquid	CH_4	3.39	0.74	0.00	99.99
2(I).C.2 Ferroalloys Production	CH_4	0.00	0.64	0.00	99.99
1.A.1 Energy Industries - liquid	N_2O	3.84	0.59	0.00	100.00
1.A.5.a Other non-specified - gaseous	N_2O	1.07	0.58	0.00	100.00
2(I).B.1 Ammonia Production	N_2O	0.34	0.44	0.00	100.00
1.A.1 Energy Industries - liquid	CH_4	1.57	0.38	0.00	100.00
1.A.3.a Transport - Civil Aviation - av. Gasoline	CO_2	0.73	0.29	0.00	100.00
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	CO_2	0.15	0.24	0.00	100.00
1.A.3.a Transport - Civil Aviation - jet kerosene	N_2O	0.24	0.19	0.00	100.00
1.A.3.c Transport - Railways - liquid	CH_4	0.62	0.11	0.00	100.00
1.A.5.b Other - Mobile - liquid	N_2O	0.24	0.05	0.00	100.00
1.A.5.a Other non-specified - liquid	N_2O	0.24	0.05	0.00	100.00
1.A.4 Other sector - solid	CH_4	1.51	0.05	0.00	100.00
1.A.4 Other sector - liquid	N_2O	0.72	0.01	0.00	100.00
1.A.5.a Other non-specified - liquid	N_2O	0.09	0.01	0.00	100.00
1.A.3.a Transport - Civil Aviation - jet kerosene	CH_4	0.01	0.01	0.00	100.00
1.A.3.b Transport - Road Transportation - gaseous	N_2O	0.00	0.01	0.00	100.00
1.A.4 Other sector - liquid	CH_4	0.26	0.00	0.00	100.00
1.A.3.a Transport - Civil Aviation - av. gasoline	CH_4	0.01	0.00	0.00	100.00
1.A.5.a Other non-specified - liquid	CH_4	0.03	0.00	0.00	100.00
1.A.3.a Transport - Civil Aviation - av. gasoline	N_2O	0.01	0.00	0.00	100.00
1.A.5.b Other - Mobile - liquid	CH_4	0.01	0.00	0.00	100.00
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	N_2O	0.01	0.00	0.00	100.00
1.A.5.a Other non-specified - solid	CH_4	0.05	0.00	0.00	100.00
1.A.1 Energy Industries - other	CH_4	0.00	0.00	0.00	100.00

Table A1.3: *Table 7.A1 Tier 1 Analyses – Level Assessment without LULUCF for 2011*

IPCC Source Categories	Direct GHG	Base Year (1990)	Current Year (2011)	Level Assess.	Cumulative
		CO_2 eq. (Gg)		%	
1.A.3.b Transport - Road Transportation - liquid	CO_2	4 503.02	6 180.77	13.63	13.63
1.A.2 Manufacturing Industries and Construction - solid	CO_2	9 028.51	6 180.48	13.63	27.25
1.A.1 Energy Industries - solid	CO_2	12 879.06	5 489.36	12.10	39.35
1.A.1 Energy Industries - gaseous	CO_2	2 736.47	3 507.37	7.73	47.08
1.A.4 Other sector - gaseous	CO_2	2 884.52	3 467.88	7.65	54.73
2(I).C.1.1 Steel Production	CO_2	4 113.88	3 224.50	7.11	61.84
1.A.2 Manufacturing Industries and Construction - gaseous	CO_2	4 902.48	2 637.03	5.81	67.65
6.A Solid Waste Disposal on Land	CH_4	469.77	1 572.90	3.47	71.12
4.D.1 Agricultural Soils - Direct	N_2O	2 450.40	1 286.13	2.84	73.95
2(I).A.1 Cement Production	CO_2	1 438.01	1 238.93	2.73	76.69
1.A.5.a Other non-specified - gaseous	CO_2	1 968.70	1 025.47	2.26	78.95
1.A.2 Manufacturing Industries and Construction - liquid	CO_2	4 162.04	987.66	2.18	81.12
2(I).B.1 Ammonia Production	CO_2	616.97	779.42	1.72	82.84
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	CH_4	513.50	756.70	1.67	84.51
4.A Enteric Fermentation - Cattle	CH_4	1 802.03	747.17	1.65	86.16
2(I).A.2 Lime Production	CO_2	770.42	737.77	1.63	87.78
2(I).F HFCs emissions	HFCs	0.00	437.15	0.96	88.75
2(I).B.2 Nitric Acid Production	N_2O	1 187.50	421.05	0.93	89.68
4.D.3 Agricultural Soils - Indirect	N_2O	995.23	405.57	0.89	90.57
4.B Manure Management	N_2O	1 074.32	369.26	0.81	91.38
2(I).A.7.2 Magnesite Production	CO_2	431.94	363.85	0.80	92.19
6.B Wastewater Handling	CH_4	413.83	350.63	0.77	92.96
1.B.1.a Coal Mining and Handling	CH_4	571.15	339.74	0.75	93.71
1.A.1 Energy Industries - liquid	CO_2	1 033.38	334.36	0.74	94.44
2(I).A.3 Limestone and Dolomite Use	CO_2	318.23	328.72	0.72	95.17
2(I).B.4. Calcium Carbide Production	CO_2	0.00	238.09	0.52	95.69
2(I).C.3 Aluminium Production	CO_2	121.32	237.20	0.52	96.22
1.A.4 Other sector - solid	CO_2	7 171.66	222.19	0.49	96.71
6.D Waste Composting	CH_4	1 316.70	201.13	0.44	97.15
2(I).C.2 Ferroalloys Production	CO_2	264.24	187.07	0.41	97.56
6.D Waste Composting	N_2O	1.86	111.65	0.25	97.81
4.A Enteric Fermentation - except cattle	CH_4	211.90	110.15	0.24	98.05
4.B Manure Management	CH_4	368.66	107.07	0.24	98.29
4.D.2 Agricultural Soils - PRP	N_2O	221.71	92.17	0.20	98.49
1.A.3.c Transport - Railways - liquid	CO_2	376.77	84.74	0.19	98.68
6.B Wastewater Handling	N_2O	138.77	79.45	0.18	98.85
3.D Other Solvent Use	N_2O	17.05	75.85	0.17	99.02
1.A.3.b Transport - Road Transportation - liquid	N_2O	58.64	64.56	0.14	99.16
1.A.1 Energy Industries - other	CO_2	170.30	63.43	0.14	99.30
3.A Paint Application	CO_2	94.44	58.58	0.13	99.43
2(I).C.1.5 EAF Steel Production	CO_2	18.15	26.97	0.06	99.49
2(I).F SF_6 emissions	SF_6	0.03	20.74	0.05	99.54
1.A.1 Energy Industries - solid	N_2O	56.29	19.16	0.04	99.58
3.C Chemical Products, Manufacture and Processing	CO_2	18.11	18.43	0.04	99.62
3.B Degreasing and Dry Cleaning	CO_2	17.55	17.68	0.04	99.66
2(I).C.3 Aluminium Production	PFCs	271.37	17.00	0.04	99.70
1.A.3.b Transport - Road Transportation - gaseous	CO_2	0.00	16.30	0.04	99.73
1.A.2 Manufacturing Industries and Construction - solid	N_2O	29.83	15.25	0.03	99.77
1.A.3.b Transport - Road Transportation - liquid	CH_4	24.47	11.96	0.03	99.79
2(I).A.7.1 Glass Production	CO_2	7.88	11.83	0.03	99.82
1.A.3.c Transport - Railways - liquid	N_2O	50.19	11.29	0.02	99.84
6.C Waste Incineration	CO_2	62.70	9.58	0.02	99.86
1.A.4 Other sector - liquid	CO_2	386.64	8.07	0.02	99.88
1.A.4 Other sector - gaseous	CH_4	5.38	6.61	0.01	99.90
1.A.3.a Transport - Civil Aviation - jet kerosene	CO_2	7.00	5.51	0.01	99.91
1.A.2 Manufacturing Industries and Construction - gaseous	CH_4	9.16	5.02	0.01	99.92

1.A.1 Energy Industries - other	N_2O	4.90	4.53	0.01	99.93
1.A.5.a Other non-specified - liquid	CO_2	34.99	4.38	0.01	99.94
1.A.5.a Other non-specified - solid	CO_2	216.08	3.09	0.01	99.95
6.C Waste Incineration	N_2O	2.73	2.26	0.00	99.95
1.A.2 Manufacturing Industries and Construction - liquid	N_2O	10.28	2.16	0.00	99.96
1.A.1 Energy Industries - gaseous	N_2O	1.53	1.97	0.00	99.96
1.A.5.a Other non-specified - gaseous	CH_4	3.63	1.95	0.00	99.96
1.A.4 Other sector - gaseous	N_2O	1.59	1.95	0.00	99.97
1.A.5.b Other Mobile - liquid	CO_2	7.00	1.59	0.00	99.97
1.A.2 Manufacturing Industries and Construction - gaseous	N_2O	2.70	1.48	0.00	99.98
2(I).B.1 Ammonia Production	CH_4	1.14	1.48	0.00	99.98
1.A.1 Energy Industries - gaseous	CH_4	1.04	1.34	0.00	99.98
1.A.2 Manufacturing Industries and Construction - solid	CH_4	1.83	1.15	0.00	99.98
1.A.3.b Transport - Road Transportation - gaseous	CH_4	0.00	1.02	0.00	99.99
1.A.1 Energy Industries - solid	CH_4	2.68	1.02	0.00	99.99
1.A.4 Other sector - solid	N_2O	28.24	0.92	0.00	99.99
1.A.2 Manufacturing Industries and Construction - liquid	CH_4	3.39	0.74	0.00	99.99
2(I).C.2 Ferroalloys Production	CH_4	0.00	0.64	0.00	99.99
1.A.1 Energy Industries - liquid	N_2O	3.84	0.59	0.00	99.99
1.A.5.a Other non-specified - gaseous	N_2O	1.07	0.58	0.00	100.00
2(I).B.1 Ammonia Production	N_2O	0.34	0.44	0.00	100.00
1.A.1 Energy Industries - liquid	CH_4	1.57	0.38	0.00	100.00
1.A.3.a Transport - Civil Aviation - av. Gasoline	CO_2	0.73	0.29	0.00	100.00
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	CO_2	0.15	0.24	0.00	100.00
1.A.3.a Transport - Civil Aviation - jet kerosene	N_2O	0.24	0.19	0.00	100.00
1.A.3.c Transport - Railways - liquid	CH_4	0.62	0.11	0.00	100.00
1.A.5.b Other - Mobile - liquid	N_2O	0.24	0.05	0.00	100.00
1.A.5.a Other non-specified - liquid	N_2O	0.24	0.05	0.00	100.00
1.A.4 Other sector - solid	CH_4	1.51	0.05	0.00	100.00
1.A.4 Other sector - liquid	N_2O	0.72	0.01	0.00	100.00
1.A.5.a Other non-specified - liquid	N_2O	0.09	0.01	0.00	100.00
1.A.3.a Transport - Civil Aviation - jet kerosene	CH_4	0.01	0.01	0.00	100.00
1.A.3.b Transport - Road Transportation - gaseous	N_2O	0.00	0.01	0.00	100.00
1.A.4 Other sector - liquid	CH_4	0.26	0.00	0.00	100.00
1.A.3.a Transport - Civil Aviation - av. gasoline	CH_4	0.01	0.00	0.00	100.00
1.A.5.a Other non-specified - liquid	CH_4	0.03	0.00	0.00	100.00
1.A.3.a Transport - Civil Aviation - av. gasoline	N_2O	0.01	0.00	0.00	100.00
1.A.5.b Other - Mobile - liquid	CH_4	0.01	0.00	0.00	100.00
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	N_2O	0.01	0.00	0.00	100.00
1.A.5.a Other non-specified - solid	CH_4	0.05	0.00	0.00	100.00
1.A.1 Energy Industries - other	CH_4	0.00	0.00	0.00	100.00

Table A1.4: *Table 7.A2 Tier 1 Analyses – Trend Assessment with LULUCF for 2011*

IPCC Source Categories	Direct GHG	Base Year (1990)	Current Year (2011)	Trend Assessment	Contribution to Trend	Cumulative
		CO_2 eq. (Gg)		%		
5.A Forest Land	CO_2	10 128.02	6 567.96	0.49	0.64	0.64
1.A.3.b Road Transportation - liquid	CO_2	4 503.02	6 180.77	9.89	12.84	13.48
1.A.2 Man. Industries and Construction - solid	CO_2	9 028.51	6 180.48	1.41	1.83	15.30
1.A.1 Energy Industries - solid	CO_2	12 879.06	5 489.36	7.86	10.20	25.51
1.A.1 Energy Industries - gaseous	CO_2	2 736.47	3 507.37	5.27	6.84	32.35
1.A.4 Other sector - gaseous	CO_2	2 884.52	3 467.88	4.88	6.33	38.68
2(I).C.1.1 Steel Production	CO_2	4 113.88	3 224.50	1.85	2.40	41.09
1.A.2 Man. Industries and Construction - gaseous	CO_2	4 902.48	2 637.03	1.37	1.78	42.86
6.A Solid Waste Disposal on Land	CH_4	469.77	1 572.90	3.79	4.91	47.77
4.D.1 Agricultural Soils - Direct	N_2O	2 450.40	1 286.13	0.78	1.01	48.78
2(I).A.1 Cement Production	CO_2	1 438.01	1 238.93	0.98	1.27	50.05
1.A.5.a Other non-specified - gaseous	CO_2	1 968.70	1 025.47	0.65	0.84	50.90
1.A.2 Man. Industries and Construction - liquid	CO_2	4 162.04	987.66	4.87	6.32	57.22
2(I).B.1 Ammonia Production	CO_2	616.97	779.42	1.16	1.50	58.72
5.B Cropland	CO_2	187.15	773.14	1.94	2.52	61.24
1.B.1.b Fugitive from Oil, Natural Gas	CH_4	513.50	756.70	1.28	1.66	62.90
4.A Enteric Fermentation - Cattle	CH_4	1 802.03	747.17	1.16	1.51	64.41
2(I).A.2 Lime Production	CO_2	770.42	737.77	0.74	0.97	65.38
2(I).F HFCs emissions	HFCs	0.00	437.15	1.30	1.68	67.06
2(I).B.2 Nitric Acid Production	N_2O	1 187.50	421.05	0.98	1.27	68.33
4.D.3 Agricultural Soils - Indirect	N_2O	995.23	405.57	0.66	0.86	69.19
5.C Grassland	CO_2	350.08	384.27	0.48	0.63	69.82
4.B Manure Management	N_2O	1 074.32	369.26	0.92	1.19	71.01
2(I).A.7.2 Magnesite Production	CO_2	431.94	363.85	0.27	0.35	71.36
6.B Wastewater Handling	CH_4	413.83	350.63	0.26	0.34	71.70
1.B.1.a Coal Mining and Handling	CH_4	571.15	339.74	0.06	0.08	71.78
1.A.1 Energy Industries - liquid	CO_2	1 033.38	334.36	0.95	1.23	73.01
2(I).A.3 Limestone and Dolomite Use	CO_2	318.23	328.72	0.38	0.49	73.50
2(I).B.4. Calcium Carbide Production	CO_2	0.00	238.09	0.71	0.92	74.42
2(I).C.3 Aluminium Production	CO_2	121.32	237.20	0.48	0.62	75.04
1.A.4 Other sector - solid	CO_2	7 171.66	222.19	12.79	16.59	91.63
6.D Waste Composting	CH_4	1 316.70	201.13	1.87	2.43	94.06
2(I).C.2 Ferroalloys Production	CO_2	264.24	187.07	0.06	0.08	94.14
5.F Other Land	CO_2	374.05	121.68	0.34	0.44	94.58
6.D Waste Composting	N_2O	1.86	111.65	0.33	0.43	95.00
4.A Enteric Fermentation - except cattle	CH_4	211.90	110.15	0.07	0.09	95.09
4.B Manure Management	CH_4	368.66	107.07	0.37	0.48	95.58
4.D.2 Agricultural Soils - PRP	N_2O	221.71	92.17	0.14	0.18	95.76
1.A.3.c Transport - Railways - liquid	CO_2	376.77	84.74	0.46	0.59	96.35
5.E Settlements	CO_2	119.66	81.02	0.02	0.02	96.37
6.B Wastewater Handling	N_2O	138.77	79.45	0.02	0.03	96.41
3.D Other Solvent Use	N_2O	17.05	75.85	0.19	0.25	96.66
1.A.3.b Road Transportation - liquid	N_2O	58.64	64.56	0.08	0.11	96.76
1.A.1 Energy Industries - other	CO_2	170.30	63.43	0.13	0.17	96.93
3.A Paint Application	CO_2	94.44	58.58	0.00	0.00	96.94
2(I).C.1.5 EAF Steel Production	CO_2	18.15	26.97	0.05	0.06	97.00
5.A Forest Land	CH_4	14.09	22.58	0.04	0.05	97.05
2(I).F SF_6 emissions	SF_6	0.03	20.74	0.06	0.08	97.13
1.A.1 Energy Industries - solid	N_2O	56.29	19.16	0.05	0.06	97.19
3.C Chemical Products	CO_2	18.11	18.43	0.02	0.03	97.22
3.B Degreasing and Dry Cleaning	CO_2	17.55	17.68	0.02	0.03	97.24
2(I).C.3 Aluminium Production	PFCs	271.37	17.00	0.46	0.59	97.84
1.A.3.b Road Transportation - gaseous	CO_2	0.00	16.30	0.05	0.06	97.90
1.A.2 Manufacturing Industries and	N_2O	29.83	15.25	0.01	0.01	97.92

Construction - solid						
5.B Cropland	N_2O	93.81	13.25	0.14	0.18	98.09
1.A.3.b Road Transportation - liquid	CH_4	24.47	11.96	0.01	0.01	98.11
2(I).A.7.1 Glass Production	CO_2	7.88	11.83	0.02	0.03	98.13
1.A.3.c Transport - Railways - liquid	N_2O	50.19	11.29	0.06	0.08	98.21
6.C Waste Incineration	CO_2	62.70	9.58	0.09	0.12	98.33
1.A.4 Other sector - liquid	CO_2	386.64	8.07	0.70	0.91	99.24
1.A.4 Other sector - gaseous	CH_4	5.38	6.61	0.01	0.01	99.25
1.A.3.a Civil Aviation - jet kerosene	CO_2	7.00	5.51	0.00	0.00	99.25
1.A.2 Man. Industries and Construction - gaseous	CH_4	9.16	5.02	0.00	0.00	99.26
5.A Forest Land	N_2O	12.09	4.58	0.01	0.01	99.27
1.A.1 Energy Industries - other	N_2O	4.90	4.53	0.00	0.01	99.27
1.A.5.a Other non-specified - liquid	CO_2	34.99	4.38	0.05	0.07	99.34
1.A.5.a Other non-specified - solid	CO_2	216.08	3.09	0.40	0.51	99.86
6.C Waste Incineration	N_2O	2.73	2.26	0.00	0.00	99.86
1.A.2 Man. Industries and Construction - liquid	N_2O	10.28	2.16	0.01	0.02	99.87
1.A.1 Energy Industries - gaseous	N_2O	1.53	1.97	0.00	0.00	99.88
1.A.5.a Other non-specified - gaseous	CH_4	3.63	1.95	0.00	0.00	99.88
1.A.4 Other sector - gaseous	N_2O	1.59	1.95	0.00	0.00	99.88
1.A.5.b Other Mobile - liquid	CO_2	7.00	1.59	0.01	0.01	99.89
1.A.2 Man. Industries and Construction - gaseous	N_2O	2.70	1.48	0.00	0.00	99.89
2(I).B.1 Ammonia Production	CH_4	1.14	1.48	0.00	0.00	99.90
1.A.1 Energy Industries - gaseous	CH_4	1.04	1.34	0.00	0.00	99.90
1.A.2 Manufacturing Industries and Construction - solid	CH_4	1.83	1.15	0.00	0.00	99.90
1.A.3.b Road Transportation - gaseous	CH_4	0.00	1.02	0.00	0.00	99.90
1.A.1 Energy Industries - solid	CH_4	2.68	1.02	0.00	0.00	99.91
1.A.4 Other sector - solid	N_2O	28.24	0.92	0.05	0.07	99.97
1.A.2 Man. Industries and Construction - liquid	CH_4	3.39	0.74	0.00	0.01	99.98
2(I).C.2 Ferroalloys Production	CH_4	0.00	0.64	0.00	0.00	99.98
1.A.1 Energy Industries - liquid	N_2O	3.84	0.59	0.01	0.01	99.99
1.A.5.a Other non-specified - gaseous	N_2O	1.07	0.58	0.00	0.00	99.99
2(I).B.1 Ammonia Production	N_2O	0.34	0.44	0.00	0.00	99.99
1.A.1 Energy Industries - liquid	CH_4	1.57	0.38	0.00	0.00	99.99
1.A.3.a Civil Aviation - av. Gasoline	CO_2	0.73	0.29	0.00	0.00	99.99
1.B.1.b Fugitive from Oil, Natural Gas	CO_2	0.15	0.24	0.00	0.00	99.99
1.A.3.a Civil Aviation - jet kerosene	N_2O	0.24	0.19	0.00	0.00	99.99
1.A.3.c Transport - Railways - liquid	CH_4	0.62	0.11	0.00	0.00	99.99
1.A.5.b Other - Mobile - liquid	N_2O	0.24	0.05	0.00	0.00	99.99
1.A.5.a Other non-specified - liquid	N_2O	0.24	0.05	0.00	0.00	99.99
1.A.4 Other sector - solid	CH_4	1.51	0.05	0.00	0.00	100.00
1.A.4 Other sector - liquid	N_2O	0.72	0.01	0.00	0.00	100.00
1.A.5.a Other non-specified - liquid	N_2O	0.09	0.01	0.00	0.00	100.00
1.A.3.a Civil Aviation - jet kerosene	CH_4	0.01	0.01	0.00	0.00	100.00
1.A.3.b Road Transportation - gaseous	N_2O	0.00	0.01	0.00	0.00	100.00
1.A.4 Other sector - liquid	CH_4	0.26	0.00	0.00	0.00	100.00
1.A.3.a Civil Aviation - av. gasoline	CH_4	0.01	0.00	0.00	0.00	100.00
1.A.5.a Other non-specified - liquid	CH_4	0.03	0.00	0.00	0.00	100.00
1.A.3.a Civil Aviation - av. gasoline	N_2O	0.01	0.00	0.00	0.00	100.00
1.A.5.b Other - Mobile - liquid	CH_4	0.01	0.00	0.00	0.00	100.00
1.B.1.b Fugitive from Oil, Natural Gas	N_2O	0.01	0.00	0.00	0.00	100.00
1.A.5.a Other non-specified - solid	CH_4	0.05	0.00	0.00	0.00	100.00
1.A.1 Energy Industries - other	CH_4	0.00	0.00	0.00	0.00	100.00

Table A1.5: *Table 7.A2 Tier 1 Analyses – Trend Assessment without LULUCF for 2011*

IPCC Source Categories	Direct GHG	Base Year (1990)	Current Year (2011)	Trend Assessment	Contribution to Trend	Cumulative
		CO_2 eq. (Gg)		%		
1.A.3.b Road Transportation - liquid	CO_2	4 503.02	6 180.77	12.03	13.75	13.75
1.A.2 Man. Industries and Construction - solid	CO_2	9 028.51	6 180.48	2.05	2.35	16.09
1.A.1 Energy Industries - solid	CO_2	12 879.06	5 489.36	8.89	10.16	26.25
1.A.1 Energy Industries - gaseous	CO_2	2 736.47	3 507.37	6.43	7.35	33.60
1.A.4 Other sector - gaseous	CO_2	2 884.52	3 467.88	5.96	6.81	40.41
2(I).C.1.1 Steel Production	CO_2	4 113.88	3 224.50	2.39	2.73	43.14
1.A.2 Man. Industries and Construction - gaseous	CO_2	4 902.48	2 637.03	1.44	1.64	44.78
6.A Solid Waste Disposal on Land	CH_4	469.77	1 572.90	4.55	5.20	49.98
4.D.1 Agricultural Soils - Direct	N_2O	2 450.40	1 286.13	0.83	0.95	50.94
2(I).A.1 Cement Production	CO_2	1 438.01	1 238.93	1.23	1.41	52.34
1.A.5.a Other non-specified - gaseous	CO_2	1 968.70	1 025.47	0.70	0.80	53.14
1.A.2 Man. Industries and Construction - liquid	CO_2	4 162.04	987.66	5.67	6.48	59.61
2(I).B.1 Ammonia Production	CO_2	616.97	779.42	1.41	1.61	61.22
1.B.1.b Fugitive from Oil, Natural Gas	CH_4	513.50	756.70	1.56	1.78	63.00
4.A Enteric Fermentation - Cattle	CH_4	1 802.03	747.17	1.32	1.51	64.51
2(I).A.2 Lime Production	CO_2	770.42	737.77	0.92	1.05	65.56
2(I).F HFCs emissions	HFCs	0.00	437.15	1.55	1.77	67.34
2(I).B.2 Nitric Acid Production	N_2O	1 187.50	421.05	1.12	1.28	68.62
4.D.3 Agricultural Soils - Indirect	N_2O	995.23	405.57	0.75	0.86	69.48
4.B Manure Management	N_2O	1 074.32	369.26	1.06	1.21	70.69
2(I).A.7.2 Magnesite Production	CO_2	431.94	363.85	0.34	0.39	71.08
6.B Wastewater Handling	CH_4	413.83	350.63	0.33	0.38	71.46
1.B.1.a Coal Mining and Handling	CH_4	571.15	339.74	0.05	0.06	71.52
1.A.1 Energy Industries - liquid	CO_2	1 033.38	334.36	1.09	1.25	72.76
2(I).A.3 Limestone and Dolomite Use	CO_2	318.23	328.72	0.47	0.53	73.30
2(I).B.4. Calcium Carbide Production	CO_2	0.00	238.09	0.85	0.97	74.26
2(I).C.3 Aluminium Production	CO_2	121.32	237.20	0.58	0.66	74.92
1.A.4 Other sector - solid	CO_2	7 171.66	222.19	15.02	17.16	92.09
6.D Waste Composting	CH_4	1 316.70	201.13	2.19	2.50	94.59
2(I).C.2 Ferroalloys Production	CO_2	264.24	187.07	0.08	0.09	94.68
6.D Waste Composting	N_2O	1.86	111.65	0.39	0.45	95.13
4.A Enteric Fermentation -except cattle	CH_4	211.90	110.15	0.08	0.09	95.21
4.B Manure Management	CH_4	368.66	107.07	0.43	0.49	95.71
4.D.2 Agricultural Soils - PRP	N_2O	221.71	92.17	0.16	0.18	95.89
1.A.3.c Transport - Railways - liquid	CO_2	376.77	84.74	0.53	0.61	96.50
6.B Wastewater Handling	N_2O	138.77	79.45	0.02	0.03	96.53
3.D Other Solvent Use	N_2O	17.05	75.85	0.23	0.26	96.79
1.A.3.b Road Transportation - liquid	N_2O	58.64	64.56	0.10	0.11	96.90
1.A.1 Energy Industries - other	CO_2	170.30	63.43	0.15	0.17	97.08
3.A Paint Application	CO_2	94.44	58.58	0.00	0.00	97.08
2(I).C.1.5 EAF Steel Production	CO_2	18.15	26.97	0.06	0.06	97.14
2(I).F SF_6 emissions	SF_6	0.03	20.74	0.07	0.08	97.22
1.A.1 Energy Industries - solid	N_2O	56.29	19.16	0.06	0.06	97.29
3.C Chemical Products	CO_2	18.11	18.43	0.03	0.03	97.32
3.B Degreasing and Dry Cleaning	CO_2	17.55	17.68	0.02	0.03	97.35
2(I).C.3 Aluminium Production	PFCs	271.37	17.00	0.54	0.61	97.96
1.A.3.b Road Transportation - gaseous	CO_2	0.00	16.30	0.06	0.07	98.03
1.A.2 Man. Industries and Construction - solid	N_2O	29.83	15.25	0.01	0.01	98.04
1.A.3.b Road Transportation - liquid	CH_4	24.47	11.96	0.01	0.01	98.05
2(I).A.7.1 Glass Production	CO_2	7.88	11.83	0.02	0.03	98.08
1.A.3.c Transport - Railways - liquid	N_2O	50.19	11.29	0.07	0.08	98.16
6.C Waste Incineration	CO_2	62.70	9.58	0.10	0.12	98.28

1.A.4 Other sector - liquid	CO_2	386.64	8.07	0.82	0.94	99.22
1.A.4 Other sector - gaseous	CH_4	5.38	6.61	0.01	0.01	99.23
1.A.3.a Civil Aviation - jet kerosene	CO_2	7.00	5.51	0.00	0.00	99.24
1.A.2 Man. Industries and Construction - gaseous	CH_4	9.16	5.02	0.00	0.00	99.24
1.A.1 Energy Industries - other	N_2O	4.90	4.53	0.01	0.01	99.25
1.A.5.a Other non-specified - liquid	CO_2	34.99	4.38	0.06	0.07	99.32
1.A.5.a Other non-specified - solid	CO_2	216.08	3.09	0.47	0.53	99.85
6.C Waste Incineration	N_2O	2.73	2.26	0.00	0.00	99.85
1.A.2 Man. Industries and Construction - liquid	N_2O	10.28	2.16	0.01	0.02	99.87
1.A.1 Energy Industries - gaseous	N_2O	1.53	1.97	0.00	0.00	99.87
1.A.5.a Other non-specified - gaseous	CH_4	3.63	1.95	0.00	0.00	99.88
1.A.4 Other sector - gaseous	N_2O	1.59	1.95	0.00	0.00	99.88
1.A.5.b Other Mobile - liquid	CO_2	7.00	1.59	0.01	0.01	99.89
1.A.2 Man. Industries and Construction - gaseous	N_2O	2.70	1.48	0.00	0.00	99.89
2(I).B.1 Ammonia Production	CH_4	1.14	1.48	0.00	0.00	99.89
1.A.1 Energy Industries - gaseous	CH_4	1.04	1.34	0.00	0.00	99.90
1.A.2 Man. Industries and Construction - solid	CH_4	1.83	1.15	0.00	0.00	99.90
1.A.3.b Road Transportation - gaseous	CH_4	0.00	1.02	0.00	0.00	99.90
1.A.1 Energy Industries - solid	CH_4	2.68	1.02	0.00	0.00	99.90
1.A.4 Other sector - solid	N_2O	28.24	0.92	0.06	0.07	99.97
1.A.2 Man. Industries and Construction - liquid	CH_4	3.39	0.74	0.00	0.01	99.98
2(I).C.2 Ferroalloys Production	CH_4	0.00	0.64	0.00	0.00	99.98
1.A.1 Energy Industries - liquid	N_2O	3.84	0.59	0.01	0.01	99.99
1.A.5.a Other non-specified - gaseous	N_2O	1.07	0.58	0.00	0.00	99.99
2(I).B.1 Ammonia Production	N_2O	0.34	0.44	0.00	0.00	99.99
1.A.1 Energy Industries - liquid	CH_4	1.57	0.38	0.00	0.00	99.99
1.A.3.a Civil Aviation - av. Gasoline	CO_2	0.73	0.29	0.00	0.00	99.99
1.B.1.b Fugitive from Oil, Natural Gas	CO_2	0.15	0.24	0.00	0.00	99.99
1.A.3.a Civil Aviation - jet kerosene	N_2O	0.24	0.19	0.00	0.00	99.99
1.A.3.c Transport - Railways - liquid	CH_4	0.62	0.11	0.00	0.00	99.99
1.A.5.b Other - Mobile - liquid	N_2O	0.24	0.05	0.00	0.00	99.99
1.A.5.a Other non-specified - liquid	N_2O	0.24	0.05	0.00	0.00	99.99
1.A.4 Other sector - solid	CH_4	1.51	0.05	0.00	0.00	100.00
1.A.4 Other sector - liquid	N_2O	0.72	0.01	0.00	0.00	100.00
1.A.5.a Other non-specified - liquid	N_2O	0.09	0.01	0.00	0.00	100.00
1.A.3.a Civil Aviation - jet kerosene	CH_4	0.01	0.01	0.00	0.00	100.00
1.A.3.b Road Transportation - gaseous	N_2O	0.00	0.01	0.00	0.00	100.00
1.A.4 Other sector - liquid	CH_4	0.26	0.00	0.00	0.00	100.00
1.A.3.a Civil Aviation - av. gasoline	CH_4	0.01	0.00	0.00	0.00	100.00
1.A.5.a Other non-specified - liquid	CH_4	0.03	0.00	0.00	0.00	100.00
1.A.3.a Civil Aviation - av. gasoline	N_2O	0.01	0.00	0.00	0.00	100.00
1.A.5.b Other - Mobile - liquid	CH_4	0.01	0.00	0.00	0.00	100.00
1.B.1.b Fugitive from Oil, Natural Gas	N_2O	0.01	0.00	0.00	0.00	100.00
1.A.5.a Other non-specified - solid	CH_4	0.05	0.00	0.00	0.00	100.00
1.A.1 Energy Industries - other	CH_4	0.00	0.00	0.00	0.00	100.00

Table A1.6: *Tier 2 Analyses – Level Assessment with uncertainty qualitative approach for 2011*

KEY CATEGORIES WITH UNCERTAINTY CONTRIBUTION									
IPCC Source Category	**Gas**	**Base year emissions (1990)**	**Year t emissions (2011)**	**Combined uncertainty**	**Level Assessment**	**Extreme value**	**Level Assessment**	**Cumulative Total of Column F**	**Cumulative Total of Column H**
		CO_2 eq. (Gg)		%				%	
1.A.2 Man. Industries and Construction - solid	CO_2	9 028.51	6 180.48	5.73	13.55	6 534.66	12.43	13.55	12.43
1.A.3.b Road Transportation - liquid	CO_2	4 503.02	6 180.77	5.10	13.55	6 495.93	12.35	27.11	24.78
1.A.1 Energy Industries - solid	CO_2	12 879.06	5 489.36	4.38	12.04	5 729.95	10.90	39.14	35.68
1.A.1 Energy Industries - gaseous	CO_2	2 736.47	3 507.37	3.72	7.69	3 637.72	6.92	46.83	42.60
1.A.4 Other sector - gaseous	CO_2	2 884.52	3 467.88	3.72	7.60	3 596.77	6.84	54.44	49.44
2(I).C.1 Iron and Steel Production	CO_2	4 113.88	3 224.50	5.39	7.07	3 398.14	6.46	61.51	55.90
6.A Solid Waste Disposal on Land	CH_4	469.77	1 572.90	100.12	3.45	3 147.77	5.99	64.96	61.89
1.A.2 Man. Industries and Construction - gaseous	CO_2	4 902.48	2 637.03	3.72	5.78	2 735.04	5.20	70.74	67.09
4.D.1 Agricultural Soils - Direct	N_2O	2 450.40	1 286.13	103.08	2.82	2 611.84	4.97	73.56	72.06
2(I).A.1 Cement Production	CO_2	1 438.01	1 238.93	2.24	2.72	1 266.63	2.41	76.28	74.47
4.D.3 Agricultural Soils - Indirect	N_2O	995.23	405.57	201.56	0.89	1 223.02	2.33	77.17	76.79
1.A.5.a Other non-specified - gaseous	CO_2	1 968.70	1 025.47	3.72	2.25	1 063.58	2.02	79.42	78.82
1.A.2 Man. Industries and Construction - liquid	CO_2	4 162.04	987.66	6.16	2.17	1 048.51	1.99	81.58	80.81
4.A Enteric Fermentation - Cattle	CH_4	1 802.03	747.17	20.22	1.64	898.27	1.71	83.22	82.52
2(I).B.1 Ammonia Production	CO_2	616.97	779.42	5.39	1.71	821.40	1.56	84.93	84.08
1.B.1.b Fugitive from Oil, Natural Gas	CH_4	513.50	756.70	5.39	1.66	797.45	1.52	86.59	85.60
2(I).A.2 Lime Production	CO_2	770.42	737.77	2.83	1.62	758.64	1.44	88.21	87.04
4.B Manure Management	N_2O	1 074.32	369.26	100.50	0.81	740.37	1.41	89.02	88.45
6.B Wastewater Handling	CH_4	413.83	350.63	50.25	0.77	526.83	1.00	89.78	89.45
2(I).F HFCs emissions	HFC	0.00	437.15	10.01	0.96	480.90	0.91	90.74	90.37
2(I).B.2 Nitric Acid Production	N2O	1 187.50	421.05	10.20	0.92	463.99	0.88	91.67	91.25
2(I).A.7 Magnesite Production	CO_2	431.94	363.85	3.61	0.80	376.97	0.72	92.46	91.96
1.B.1.a Coal Mining and Handling	CH_4	571.15	339.74	8.60	0.74	368.97	0.70	93.21	92.67
1.A.1 Energy Industries - liquid	CO_2	1 033.38	334.36	6.16	0.73	354.96	0.68	93.94	93.34
2(I).A.3 Limestone and Dolomite Use	CO_2	318.23	328.72	3.61	0.72	340.57	0.65	94.66	93.99
6.D Waste Composting	CH_4	1 316.70	201.13	50.25	0.44	302.20	0.57	95.10	94.56
5.F Other Land	CO_2	374.05	121.68	125.00	0.27	273.78	0.52	95.37	95.08

Annex 2.1: Other detailed methodological descriptions for individual source or sink categories, including for KP-LULUCF activities – Comparison of RA and IEA statistics

Comparison for coal	Anthracite	Coking Coal	Other Bit. Coal	Sub-bit. Coal	Lignite/ Brown Coal	Peat	Patent Fuel	Coke Oven Coke	Gas Coke	Coal Tar	BKB/PB	Gas Works Gas	Coke Oven Gas	Blast Furnace Gas	Oxygen Steel Furnace Gas
Unit	***10^3 t***											***TJ (gross)***			
Production	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
From Other Sources	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Imports	0,00	357,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Exports	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Stock Changes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Domestic Supply	0,00	357,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Statistical Differences	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Transformation	0,00	357,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Electricity Plants															
CHP Plants															
Heat Plants															
Other Transformation															
Energy Industry Own use	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Losses															
Final Consumption	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

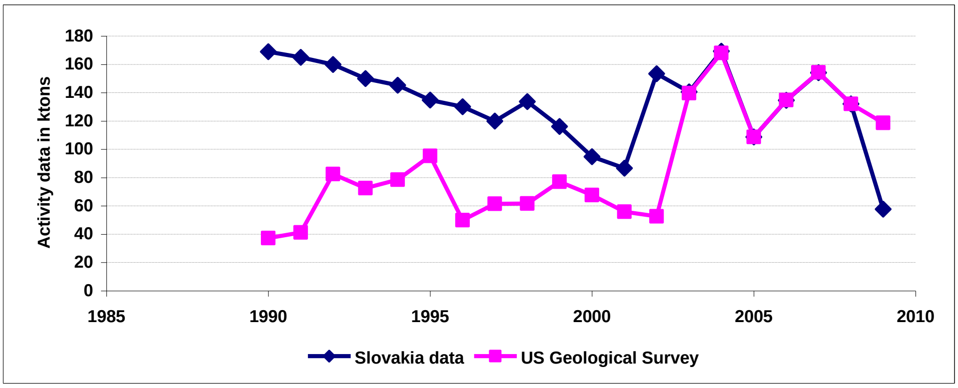
Comparison for oil		Crude Oil	Natural Gas Liquids	Refinery Feedstocks	Additives / Oxygenates	Of which Biofuels	Other Hydrocarbons	TOTAL	Difference IEA-SO SR-RA
Indigenous Production	(+) 1	13,00	3,00		0,00		0,00	16,00	**0,00**
From Other Sources	(+) 2				383,00	197,00	136,00	519,00	**0,00**
Backflows to Refineries	(+) 3			205,00				205,00	**0,00**
Products Transferred	(+) 4			129,00				129,00	**0,00**
Total Imports (Balance)	(+) 5	5 465,00	0,00	0,00	2,00		0,00	5 467,00	**0,00**
Total Exports (Balance)	(-) 6	13,00	0,00	0,00	0,00		0,00	13,00	**0,00**
Direct Use	(-) 7	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**
Stock Changes (National Territory)	(+) 8	-12,00	0,00	0,00	0,00	0,00	4,00	-8,00	**0,00**
Refinery Intake (Calculated)	(=) 9	5 453,00	3,00	334,00	385,00	197,00	140,00	6 315,00	**0,00**
Statistical Differences	(-) 10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**
Refinery Intake (Observed)	(=) 11	5 453,00	3,00	334,00	385,00	197,00	140,00	6 315,00	
MEMO ITEMS:									
Refinery Losses	12	28,00	0,00	0,00	2,00	2,00	1,00	31,00	**0,00**
STOCK LEVELS:									
Opening Stock Level (National Territory)	13	539,00	0,00	0,00	0,00	0,00	4,00	543,00	
Closing Stock Level (National Territory)	14	551,00	0,00	0,00	0,00	0,00	0,00	551,00	**0,00**

Comparison for NG	IEA (TJ)	SO SR (TJ)	NCV (kJ/m^3)	mil.m^3	Difference	FLOW	IEA (TJ)	SO SR (TJ)	NCV (kJ/m^3)	mil.m^3	Difference
Production	3 696,15	4 108,00	35 550,00	103,97	**1,11**	Coal liquefaction plants	0,00	0,00			**0,00**
Imports	209 391,87	232 724,00	34 347,60	6 096,26	**1,11**	Liquefaction (LNG) / regasification plants	0,00	0,00			**0,00**
Exports	0,00	0,00			**0,00**	Gas-to-liquids (GTL) plants	0,00	0,00			**0,00**
International marine bunkers	0,00	0,00			**0,00**	Ow n use in electricity, CHP and heat plants	-34,21	38,00			**-1,11**
International aviation bunkers	0,00	0,00			**0,00**	Pumped storage plants	0,00	0,00			**0,00**
Stock changes	-3 538,68	-3 933,00	34 367,40	-102,97	**1,11**	Nuclear industry	0,00	0,00			**0,00**
Total primary energy supply	209 549,34	232 899,00	34 367,40	6 097,33	**1,11**	Charcoal production plants	0,00	0,00			**0,00**
Transfers	0,00	0,00			**0,00**	Non-specified (energy)	-309,53	344,00			**-1,11**
Statistical differences	0,00	0,00			**0,00**	Losses	0,00	0,00			**0,00**
Transformation processes	-47 722,40	53 040,00			**-1,11**	Total final consumption	154 947,48	172 213,00			**1,11**
Main activity producer electricity plants	-6 047,16	6 721,00			**-1,11**	Industry	37 173,80	41 316,00			**1,11**
Autoproducer electricity plants	0,00	0,00			**0,00**	Iron and steel	6 390,86	7 103,00			**1,11**
Main activity producer CHP plants	-15 941,66	17 718,00			**-1,11**	Chemical and petrochemical	5 119,54	5 690,00			**1,11**
Autoproducer CHP plants	-1 443,19	1 604,00			**-1,11**	Non-ferrous metals	1 339,73	1 489,00			**1,11**
Main activity producer heat plants	-15 975,82	17 756,00			**-1,11**	Non-metallic minerals	6 871,33	7 637,00			**1,11**
Autoproducer heat plants	-1 477,40	1 642,00			**-1,11**	Transport equipment	2 542,69	2 826,00			**1,11**
Heat pumps	0,00	0,00			**0,00**	Machinery	3 126,62	3 475,00			**1,11**
Electric boilers	0,00	0,00			**0,00**	Mining and quarrying	68,37	76,00			**1,11**
Chemical heat for electricity production	0,00	0,00			**0,00**	Food and tobacco	3 229,20	3 589,00			**1,11**
Blast furnaces	0,00	0,00			**0,00**	Paper, pulp and print	3 950,79	4 391,00			**1,11**
Gas w orks	0,00	0,00			**0,00**	Wood and w ood products	240,24	267,00			**1,11**
Coke ovens	0,00	0,00			**0,00**	Construction	1 099,50	1 222,00			**1,11**
Patent fuel plants	0,00	0,00			**0,00**	Textile and leather	1 133,66	1 260,00			**1,11**
BKB plants	0,00	0,00			**0,00**	Non-specified (industry)	2 061,33	2 291,00			**1,11**
Oil refineries	0,00	0,00			**0,00**	Transport	16 594,88	18 444,00			**1,11**
Petrochemical plants	0,00	0,00			**0,00**	Domestic aviation	0,00	0,00			**0,00**
Coal liquefaction plants	0,00	0,00			**0,00**	Road	0,00	0,00			**0,00**
Gas-to-liquids (GTL) plants	0,00	0,00			**0,00**	Rail	0,00	0,00			**0,00**
For blended natural gas	0,00	0,00			**0,00**	Pipeline transport	16 182,78	17 986,00			**1,11**
Charcoal production plants	0,00	0,00			**0,00**	Domestic navigation	0,00	0,00			**0,00**
Non-specified (transformation)	-6 837,17	7 599,00			**-1,11**	Non-specified (transport)	412,06	458,00			**1,11**
Energy industry ow n use	-6 879,46	7 646,00			**-1,11**	Other	92 382,96	102 677,00			**1,11**
Coal mines	-5,40	6,00			**-1,11**	Residential	55 759,80	61 973,00			**1,11**
Oil and gas extraction	-687,39	764,00			**-1,11**	Commercial and public services	35 283,42	39 215,00			**1,11**
Blast furnaces	-446,27	496,00			**-1,11**	Agriculture/forestry	1 339,73	1 489,00			**1,11**
Gas w orks	0,00	0,00			**0,00**	Fishing	0,00	0,00			**0,00**
Gasification plants for biogases	0,00	0,00			**0,00**	Non-specified (other)	0,00	0,00			**0,00**
Coke ovens	-2,68	3,00			**-1,12**	Non-energy use	8 795,88	9 776,00			**1,11**
Patent fuel plants	0,00	0,00			**0,00**	Non-energy use industry/transformation/energy	8 795,88	9 776,00			**1,11**
Oil refineries	-5 393,98	5 995,00			**-1,11**	Memo: Feedstock use in petrochemical industry	8 795,88	9 776,00			**1,11**

Annex 2.2: Other detailed methodological descriptions for individual source or sink categories, including for KP-LULUCF activities: QA/QC performed in ferroalloys production category

The activity data on ferroalloys production were provided by producers. The data were compared with the data from the Statistical Office of the Slovak Republic (ferroalloy production). No discrepancies were found in 2011. Further comparison of the activity data was based on the information from the U.S. Geological Survey (www.usgs.gov). The data for the time period 1990 – 2009 were available at the U.S. Geological Survey and were compared. Result of the comparison is shown in Figure A2.1.

Figure A2.1: *Comparison of activity data for ferroalloys production. (Slovakia data) – data from the Statistical Office of the Slovak Republic*

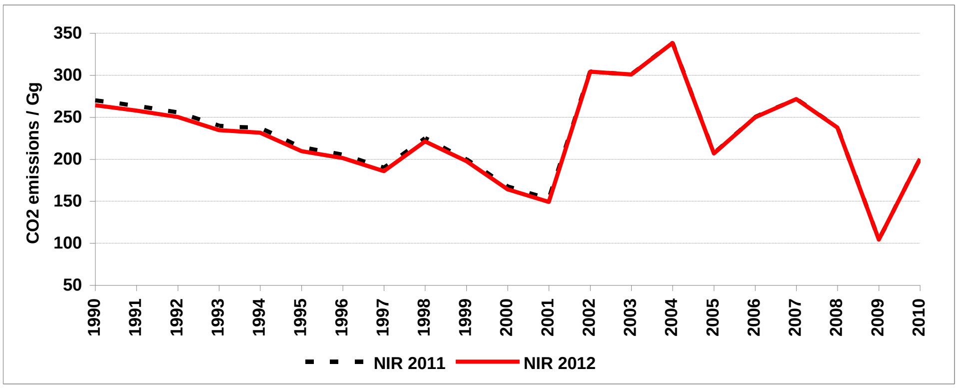


The activity data are equal for the period 2003 – 2008 (Figure A2.1). Data reported in Slovakia are higher for the time period 1990 – 2002. However, in that time period the U.S. Geological Survey did not report the production of FeMn alloy which was a significant portion of production in Slovakia. Since 2009, the U.S. Geological Survey reports only estimation of the FeSi alloys production. On the other hand, the Statistical Office of the Slovak Republic reports the actual FeSi alloys production. The values are not estimated well by the USSG for 1990 – 2002 and for 2009. It is verified that the data reported by the Statistical Office of the Slovak Republic are accurate.

Another QA check in the ferroalloys production was performed. To ensure the time series consistency, the comparison of the CO_2 emission estimate calculated by using previous and new emission factors was made. The comparison of different aggregation of activity data was made, as well. Since 2002, Tier 3 is used for the calculation. Before 2002, the aggregated activity data are available, only. The CO_2 emission factors were: 1.734 t/t of ferroalloys based on Mn, 1.3 t/t of ferroalloys based on Cr and 3.155 t/t of ferroalloys based on Si for the time period 1990 – 2001 (NIR 2011). According to the ERT recommendation (in-country review in 2011), the recalculation as described in the IPCC 2000 GPG was made. The Overlap method described in Chapter 7 of the IPCC 2000 GPG was applied and new EFs were calculated for the period 1990 – 2001 (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) (NIR 2012). Recently, the CO_2 emission estimates were calculated by using these new emission factors for the time period 1990 – 2001. For the time period after 2001, Tier 3 was used for the emission estimation.

Therefore the verification was strengthened and results show, that differences in estimates did not exceed 0.6% as can be seen in Figure A2.2. The comparison of the CO_2 emission estimates presented in NIR 2011 and NIR 2012 is shown. It can be seen that the new presented emission factors for aggregated data are accurate and calculated CO_2 emissions are in great agreement (full and dashed lines). Using of these emission factors resulted in a decrease of CO_2 emissions up to 2.2% as was presented in NIR 2012.

Figure A2.2: *Comparison of the CO_2emission estimates presented in NIR 2011 and NIR 2012*

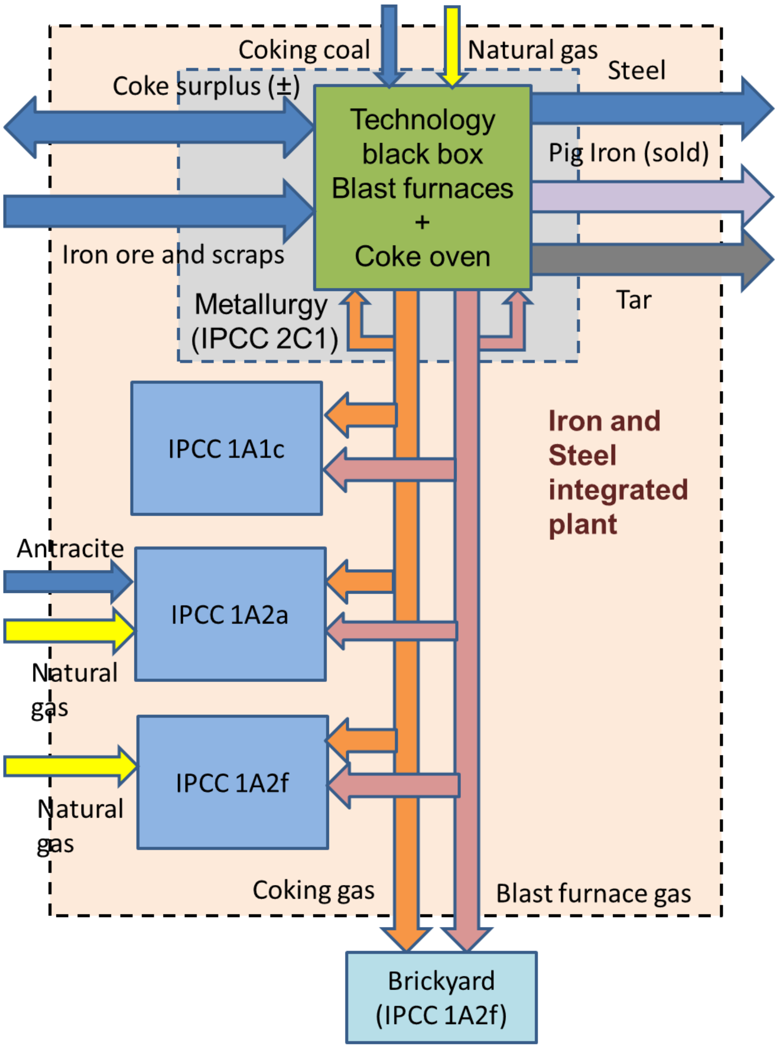


Annex 3: CO_2 reference approach and comparison with sectoral approach, and relevant information on the national energy balance:

Methodology for carbon balance of iron and steel production

The revised country specific methodology was implemented in this submission (see Chapter 4.6 of this report). 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.). 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) NEIS database (detailed data on fuels used and their flows); (iii) 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 differentiation into IPCC categories cannot be made on the basis of data provided in the EU ETS reports. In order to make a carbon balance, the simplified scheme of the plant was drown (Figure A3.1). Consumption of limestone is not included in the scheme because the CO_2 emissions from limestone consumption during iron and steel production are included in category 2.A.3 (see Table 4.10). 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 which was also considered during estimation. Total carbon balance was calculated according to the proposals in the scheme. All the streams were estimated using conversion units and carbon EFs taken from the category 1.A.2a of the energy sector or on the basis of carbon content in material to carbon.

Figure A3.1: *The simplified distribution scheme of the complex plant for pig iron and steel production*



The carbon balance consists of four steps: (1) balance of the category 2.C.1, (2) balance of the category 1.A.1c, (3) balance of the category 1.A.2a and (4) balance of the category 1.A.2f.

Table A3.1: *Balance of the category 2.C.1*

Stream	Activity data	NCV	EF (C)	Carbon (kt)
Coking coal	2 503 kt	29.59 TJ/kt	26.05 t/TJ	1 929.36
Coke surplus	-27 kt	28.05 TJ/kt	29.75 t/TJ	-22.53
Natural gas	28.9 mil. m^3	34.51 TJ/mil. m^3	15.11 t/TJ	15.07
Tar	0 kt	33.49 TJ/kt	19.44 t/TJ	0
Coking gas	- 645.28 kt	17.22 TJ/kt	12.92 t/TJ	-143.56
Blast furnace gas	-4 025.42 kt	3.15 TJ/kt	71.24 t/TJ	-903.33
Iron ore	2 810.39 kt		5.3×10^{-4}	1.49
Steel	-3 961.02 kt		7.47×10^{-4}	-2.96
Pig iron sold	-19.55 kt		0.0436	-0.85
Total				872.69

CO_2 emissions in the category 2.C.1 based on the carbon balance (from that plant) represent the value 3 197.53 Gg (total carbon × 44/12).

Table A3.2: *Balance of the category 1.A.1c*

Stream	Activity data	NCV	EF (C)	Carbon (kt)
Coking gas	110.53 kt	17.22 TJ/kt	12.92 t/TJ	24.59
Blast furnace gas	1 416.87	3.15 TJ/kt	71.24 t/TJ	317.95
Total				342.54

CO_2 emissions in the category 1.A.1c based on the carbon balance (from that plant) represent the value 1 229.98 Gg (total carbon × 44/12). Oxidation factor was 0.98.

Table A3.3: *Balance of the category 1.A.2a*

Stream	Activity data	NCV	EF (C)	Carbon (kt)
Anthracite	395.92 kt	27.43 TJ/kt	26.43 t/TJ	287.03
Natural gas	54.80 mil. m^3	34.51 TJ/mil. m^3	15.11 t/TJ	28.57
Coking gas	265.24 kt	17.22 TJ/kt	12.92 t/TJ	59.01
Blast furnace gas	2291.83 kt	3.15 TJ/kt	71.24 t/TJ	514.30
Total				888.91

CO_2 emissions in the category 1.A.2a based on the carbon balance (from that plant) represent the value 3 195.73 Gg (total carbon × 44/12). Oxidation factor was 0.98 except of the natural gas, where it was 0.995

Table A3.4: *Balance of the category 1.A.2f*

Stream	Activity data	NCV	EF (C)	Carbon [kt]
Natural gas	77.04 mil. m^3	34.51 TJ/mil. m^3	15.11 t/TJ	40.16
Coking gas	269.51 kt	17.22 TJ/kt	12.92 t/TJ	59.96
Blast furnace gas	316.72 kt	3.15 TJ/kt	71.24 t/TJ	71.07
Total				171.20

CO_2 emissions in the category 1.A.2f based on the carbon balance (from that plant) represent the value 617.39 Gg (total carbon × 44/12). Oxidation factor was 0.98 except of the natural gas, where it was 0.995. The output from the plant was 0 kt of coking gas and 0 kt of blast furnace gas in 2011. When there is any output of coking gas or blast furnace gas from the iron and steel plant, the gases are sold to the nearby brickyard and they are balanced on the consumption side (in the category 1.A.2f).

Presented carbon balances are only from the integrated iron and steel plant. The estimations of CO_2 emissions allocated in the categories 1.A.1c, 1.A.2a and 1.A.2f include also other productions or technologies in Slovakia. Therefore total CO_2 emissions calculated via these balances can be lower than those presented in each individual category in CRF tables. In comparison with the CO_2 emissions verified under the EU ETS in this category, the emissions estimated by using this country specific input-output approach differ by 0.2%.

Annex 4: Assessment of completeness

A.4.1 GHG inventory

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 (2013). The improvements were performed in the previous inventory submissions such as estimation of GHG emissions for the agricultural and industrial waste disposal for the years 1990 – 1996.

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. No NE key categories have been reported in 2013 submission for 1990 – 2011.

The included elsewhere categories (IE) are listed in the CRF Table 9(a) and described in this report.

Annex 5: Tables 6.1 and 6.2 of the IPCC good practice guidance

Annex 5 provides the mandatory reporting table for uncertainty analysis. As the Slovak Republic reports the results of tier 1 analysis (UNFCCC 2006, paragraph 14), the reporting is to be carried out using table 6.1 of the Good Practice Guidance. The Slovak Republic did not provide tier 2 uncertainty analyses according to the table 6.2 of the Good Practice Guidance for the complete sectors, but partly provided tier 2 analyses based on Monte Carlo method for energy, IP, solvent use and waste sectors. The methodology and results are described in sectoral chapters

Table A5.1: *Tier 1 uncertainty calculation and reporting in 2011*

IPCC Source Category	Gas	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combine uncertainty as % of emissions 2011	Type A sensitivity	Type B sensitivity	Uncertainty in trend introduced by EF unc.	Uncertainty in trend introduced by a.d.	Uncertainty
1.A.1 Energy Industries - solid	CO_2	2.5	3.6	4.38	0.64	-0.036	0.087	-0.13	0.31	0,33
1.A.1 Energy Industries - liquid	CO_2	5.0	3.6	6.16	0.05	-0.005	0.005	-0.02	0.04	0,04
1.A.1 Energy Industries - gaseous	CO_2	2.5	2.8	3.72	0.34	0.030	0.056	0.08	0.20	0,21
1.A.1 Energy Industries - other	CO_2	5.0	5.0	7.07	0.01	-0.001	0.001	0.00	0.01	0,01
1.A.2 Man. Industries and Construction - solid	CO_2	5.0	2.8	5.73	0.94	0.012	0.098	0.03	0.69	0,69
1.A.2 Man. Industries and Construction - liquid	CO_2	5.0	3.6	6.16	0.16	-0.024	0.016	-0.09	0.11	0,14
1.A.2 Man. Industries and Construction - gaseous	CO_2	2.5	2.8	3.72	0.26	-0.005	0.042	-0.01	0.15	0,15
1.A.3.a Transport - Civil Aviation - jet kerosene	CO_2	1.0	5.0	5.10	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.a Transport - Civil Aviation - av. gasoline	CO_2	1.0	5.0	5.10	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.b Transport - Road Transportation - liquid	CO_2	1.0	5.0	5.10	0.83	0.055	0.098	0.28	0.14	0,31
1.A.3.b Transport - Road Transportation - gaseous	CO_2	1.0	2.5	2.69	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.c Transport - Railways - liquid	CO_2	1.0	5.0	5.10	0.01	-0.002	0.001	-0.01	0.00	0,01
1.A.3.d Transport - Navigation - liquid	CO_2	1.0	5.0	5.10	0.00	0.000	0.000	0.00	0.00	0,00
1.A.4 Other sector - solid	CO_2	5.0	4.0	6.40	0.04	-0.065	0.004	-0.26	0.02	0,26
1.A.4 Other sector - liquid	CO_2	5.0	3.6	6.16	0.00	-0.004	0.000	-0.01	0.00	0,01
1.A.4 Other sector - gaseous	CO_2	2.5	2.8	3.72	0.34	0.028	0.055	0.08	0.19	0,21
1.A.5.a Other non-specified - solid	CO_2	5.0	4.0	6.40	0.00	-0.002	0.000	-0.01	0.00	0,01
1.A.5.a Other non-specified - liquid	CO_2	5.0	3.6	6.16	0.00	0.000	0.000	0.00	0.00	0,00
1.A.5.a Other non-specified - gaseous	CO_2	2.5	2.8	3.72	0.10	-0.002	0.016	-0.01	0.06	0,06
1.A.5.b Other non-specified military aviation - liquid	CO_2	1.0	5.0	5.10	0.00	0.000	0.000	0.00	0.00	0,00
1.B.1.b Fugitive Emission from Oil, Natural Gas	CO_2	2.0	5.0	5.39	0.00	0.000	0.000	0.00	0.00	0,00
2(I).A.1 Cement Production	CO_2	2.0	1.0	2.24	0.07	0.006	0.020	0.01	0.06	0,06
2(I).A.2 Lime Production	CO_2	2.0	2.0	2.83	0.06	0.004	0.012	0.01	0.03	0,03
2(I).A.3 Limestone and Dolomite Use	CO_2	2.0	3.0	3.61	0.03	0.002	0.005	0.01	0.01	0,02
2(I).A.7 Magnesite Production	CO_2	2.0	3.0	3.61	0.03	0.002	0.006	0.00	0.02	0,02
2(I).A.7 Glass Production	CO_2	2.0	3.0	3.61	0.00	0.000	0.000	0.00	0.00	0,00
2(I).B.1 Ammonia Production	CO_2	2.0	5.0	5.39	0.11	0.006	0.012	0.03	0.03	0,05
2(I).B.4 Carbide Production	CO_2	2.0	5.0	5.39	0.03	0.004	0.004	0.02	0.01	0,02
2(I).C.1 Iron and Steel Production	CO_2	2.0	5.0	5.39	0.46	0.012	0.051	0.06	0.14	0,16
2(I).C.1.5 EAF Steel Production	CO_2	2.0	5.0	5.39	0.00	0.000	0.000	0.00	0.00	0,00
2(I).C.3 Aluminium Production	CO_2	2.0	5.0	5.39	0.03	0.003	0.004	0.01	0.01	0,02

2(I).C.2 Ferroalloys Production	CO_2	2.0	5.0	5.39	0.03	0.000	0.003	0.00	0.01	0,01
3.A Paint Application	CO_2	2.0	5.0	5.39	0.01	0.000	0.001	0.00	0.00	0,00
3.B Degreasing and Dry Cleaning	CO_2	2.0	5.0	5.39	0.00	0.000	0.000	0.00	0.00	0,00
3.C Chemical Products	CO_2	2.0	5.0	5.39	0.00	0.000	0.000	0.00	0.00	0,00
5.A Forest Land	CO_2	20.0	60.0	63.25	-10.97	-0.008	-0.104	-0.46	-2.95	2,98
5.B Cropland	CO_2	75.0	100.0	125.00	-2.55	-0.010	-0.012	-1.05	-1.30	1,67
5.C Grassland	CO_2	75.0	100.0	125.00	-1.27	-0.003	-0.006	-0.28	-0.65	0,70
5.E Settlements	CO_2	75.0	100.0	125.00	0.27	0.000	0.001	0.01	0.14	0,14
5.F Other Land	CO_2	75.0	100.0	125.00	0.40	-0.002	0.002	-0.16	0.20	0,26
6.C Waste Incineration	CO_2	5.0	5.0	7.07	0.00	0.000	0.000	0.00	0.00	0,00
1.A.1 Energy Industries - solid	CH_4	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.1 Energy Industries - liquid	CH_4	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.1 Energy Industries - gaseous	CH_4	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.1 Energy Industries - other	CH_4	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.2 Man. Industries and Construction - solid	CH_4	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.2 Man. Industries and Construction - liquid	CH_4	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.2 Man. Industries and Construction - gaseous	CH_4	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.a Transport - Civil Aviation - jet kerosene	CH_4	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.a Transport - Civil Aviation - av. gasoline	CH_4	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.b Transport - Road Transportation - liquid	CH_4	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.b Transport - Road Transportation - gaseous	CH_4	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.c Transport - Railways - liquid	CH_4	1.0	40.0	40.01	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.d Transport - Navigation	CH_4	1.0	40.0	40.01	0.00	0.000	0.000	0.00	0.00	0,00
1.A.4 Other sector - solid	CH_4	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.4 Other sector - liquid	CH_4	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.4 Other sector - gaseous	CH_4	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.5.a Other non-specified - solid	CH_4	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.5.a Other non-specified - liquid	CH_4	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.5.a Other non-specified - gaseous	CH_4	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.5.b Other - Mobile - liquid	CH_4	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.B.1.a Coal Mining and Handling	CH_4	5.0	7.0	8.60	0.08	0.000	0.005	0.00	0.04	0,04
1.B.1.b Fugitive Emission from Oil, Natural Gas	CH_4	2.0	5.0	5.39	0.11	0.007	0.012	0.04	0.03	0,05
2(I).B.1 Ammonia Production	CH_4	2.0	5.0	5.39	0.00	0.000	0.000	0.00	0.00	0,00
2(I).C.2 Ferroalloys Production	CH_4	2.0	5.0	5.39	0.00	0.000	0.000	0.00	0.00	0,00
4.A Enteric Fermentation - Cattle	CH_4	3.0	20.0	20.22	0.40	-0.005	0.012	-0.11	0.05	0,12
4.A Enteric Fermentation - except cattle	CH_4	3.0	20.0	20.22	0.06	0.000	0.002	-0.01	0.01	0,01
4.B Manure Management	CH_4	3.0	45.0	45.10	0.13	-0.002	0.002	-0.08	0.01	0,08
5.A Forest Land	CH_4	5.0	5.0	7.07	0.00	0.000	0.000	0.00	0.00	0,00
6.A Solid Waste Disposal on Land	CH_4	5.0	100.0	100.12	4.16	0.020	0.025	2.05	0.18	2,05
6.B Wastewater Handling	CH_4	5.0	50.0	50.25	0.47	0.002	0.006	0.08	0.04	0,09
6.D Waste Composting	CH_4	5.0	50.0	50.25	0.27	-0.009	0.003	-0.47	0.02	0,47
1.A.1 Energy Industries - solid	N_2O	3.0	50.0	50.09	0.03	0.000	0.000	-0.01	0.00	0,01
1.A.1 Energy Industries - liquid	N_2O	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.1 Energy Industries - gaseous	N_2O	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.1 Energy Industries - other	N_2O	3.0	50.0	50.09	0.01	0.000	0.000	0.00	0.00	0,00

1.A.2 Man. Industries and Construction - solid	N_2O	3.0	50.0	50.09	0.02	0.000	0.000	0.00	0.00	0,00
1.A.2 Man. Industries and Construction - liquid	N_2O	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.2 Man. Industries and Construction - gaseous	N_2O	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.a Transport - Civil Aviation - jet kerosene	N_2O	1.0	50.0	50.01	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.a Transport - Civil Aviation - av. gasoline	N_2O	1.0	50.0	50.01	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.b Transport - Road Transportation - liquid	N_2O	1.0	50.0	50.01	0.09	0.000	0.001	0.02	0.00	0,02
1.A.3.b Transport - Road Transportation - gaseous	N_2O	1.0	50.0	50.01	0.00	0.000	0.000	0.00	0.00	0,00
1.A.3.c Transport - Railways - liquid	N_2O	1.0	50.0	50.01	0.01	0.000	0.000	-0.01	0.00	0,01
1.A.3.d Transport - Navigation	N_2O	1.0	50.0	50.01	0.00	0.000	0.000	0.00	0.00	0,00
1.A.4 Other sector - solid	N_2O	3.0	50.0	50.09	0.00	0.000	0.000	-0.01	0.00	0,01
1.A.4 Other sector - liquid	N_2O	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.4 Other sector - gaseous	N_2O	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.5.a Other non-specified - solid	N_2O	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.5.a Other non-specified - liquid	N_2O	3.0	50.0	50.09	0.00	0.000	0.000	0.00	0.00	0,00
1.A.5.a Other non-specified - gaseous	N_2O	3.0	5.0	5.83	0.00	0.000	0.000	0.00	0.00	0,00
1.A.5.b Other - Mobile - liquid	N_2O	1.0	50.0	50.01	0.00	0.000	0.000	0.00	0.00	0,00
1.B.1.b Fugitive Emission from Oil, Natural	N_2O	6.0	50.0	50.36	0.00	0.000	0.000	0.00	0.00	0,00
2(I).B.2 Nitric Acid Production	N_2O	2.0	10.0	10.20	0.11	-0.005	0.007	-0.05	0.02	0,05
3.D Other Solvent Use	N_2O	5.0	20.0	20.62	0.04	0.001	0.001	0.02	0.01	0,02
4.B Manure Management	N_2O	10.0	100.0	100.50	0.98	-0.004	0.006	-0.44	0.08	0,45
4.D.1 Agricultural Soils - Direct	N_2O	25.0	100.0	103.08	3.50	-0.003	0.020	-0.29	0.72	0,78
4.D.2 Agricultural Soils - PRP	N_2O	25.0	50.0	55.90	0.14	-0.001	0.001	-0.03	0.05	0,06
4.D.3 Agricultural Soils - Indirect	N_2O	25.0	200.0	201.56	2.16	-0.003	0.006	-0.61	0.23	0,65
5.A Forest Land	N_2O	5.0	5.0	7.07	0.00	0.000	0.000	0.00	0.00	0,00
5.B Cropland	N_2O	5.0	5.0	7.07	0.00	-0.001	0.000	0.00	0.00	0,00
6.B Wastewater Handling	N_2O	5.0	50.0	50.25	0.11	0.000	0.001	0.00	0.01	0,01
6.C Waste Incineration	N_2O	1.0	5.0	5.10	0.00	0.000	0.000	0.00	0.00	0,00
6.D Waste Composting	N_2O	5.0	50.0	50.25	0.15	0.002	0.002	0.09	0.01	0,09
2(I).C.3 Aluminium Production	PFCs	5.0	9.4	10.65	0.00	-0.002	0.000	-0.02	0.00	0,02
2(I).F HFCs emissions	HFCs	10.0	0.4	10.01	0.12	0.007	0.007	0.00	0.10	0,10
2(I).F SF_6 emissions	SF_6	10.0	0.4	10.01	0.01	0.000	0.000	0.00	0.00	0,00
	Total			**Total H =**	**12.92**	**Level Uncertainty**			**Total M =**	**4.35**

Annex 6: Additional information to be considered as part of the annual inventory submission

Figure A6.1: *The certificate of conformity with the standard SHMU*

ACERT

ACERT, s.r.o., M.R.Štefánika 24/644, SK 914 51 TRENČIANSKE TEPLICE, SLOVAKIA

CERTIFICATION BODY ACCREDITED BY SLOVAK NATIONAL ACCREDITATION SERVICE FOR CERTIFICATION OF MANAGEMENT SYSTEMS GRANTS

CERTIFICATE

OF CONFORMITY WITH THE STANDARD

EN ISO 9001 : 2008

TO COMPANY

SHMÚ

SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

JESÉNIOVA 17
833 15 BRATISLAVA
SLOVAKIA

ACERT confirms:

COMPANY HAS BUILT AND INTRODUCED THE QUALITY MANAGEMENT SYSTEM ACCORDING THE REQUIREMENTS OF THE ABOVE MENTIONED STANDARD FOR THE FOLLOWING ACTIVITIES:

MONITORING OF THE DETERMINANTS CHARACTERISING THE STATE OF AIR AND WATERS ON THE SLOVAK TERRITORY
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 ATMOSPHERE AND HYDROSPHERE PHENOMENA
EDUCATION AND TRAINING WITHIN THE ACTIVITY OF INSTITUTE

REG. NO. **14/2010** LEADER OF CERTIFICATION BODY

DATE OF ISSUE: **19.4.2010**
VALIDITY: **18.4.2013**

IAF

SNAS Reg. No. 242/Q-034

ACERT

Figure A6.2: *The certificate of conformity with the standard SHMU*

ACERT

ACERT, s.r.o.
M. R. Štefánika 24/644
914 51 Trenčianske Teplice
Accredited Certification Body for certification of management systems

Trenčianske Teplice, 29.3.2010

Based on the results of the recertification audit of the Quality Management System, performed during 15 – 22nd March 2010 at the Slovak Hydrometeorological Institute in Bratislava, we confirm that the Emissions Department has established and maintained quality management system in accordance with the certified quality management system of the Slovak Hydrometeorological Institute.

Ing. Anna Striežovská
Head of ACERT (certification body)

ACERT, s.r.o.
M.R. Štefánika 24/644
914 51 Trenčianske Teplice

ACERT/listy2010/0329

Table A6.1: *The example of the QC checklist for sectoral analyses*

QC Activity	Date, Name	Results (Y/N/NA)	Supporting documents, links
INPUTS			
1. Is the sample of input data without transcription errors?			
CALCULATING EMISSIONS			
2. Does the file contain all the calculations?			
3. Are appropriate parameters, units and conversion factors used?			
4. Are the units properly labeled in calculation sheets?			
5. Are units correctly carried through from beginning to end of calculations?			
6. Are conversion factors correct?			
7. Are Data relationships and the appropriate data processing steps correctly represented in the database?			
8. Are data fields properly labeled?			
9. Are emissions and removals calculated correctly? (Representative sample of calculations)			
10. Is consistency in data between categories?			
11. Are estimates done for all categories?			
12. Are any unusual trends across the time series explained?			
DOCUMENTATION			
13. Are the assumptions and criteria for the selection of activity data, emission factors, and other estimation parameters documented?			
14. Are bibliographical data references and citations correct and complete?			
15. Are changes in data or methodology documented?			
16. Are inventory spreadsheets and documents archived?			
17. Summary of general QC checks and corrective action.			