SLOVAK REPUBLIC

NATIONAL INVENTORY REPORT 2009

GREENHOUSE GAS EMISSION INVENTORY 1990–2007

SUBMISSION UNDER THE UNFCCC AND VOLUNTARY SUBMISSION UNDER THE KYOTO PROTOCOL

Bratislava, April 15, 2009

Slovak Hydrometeorological Institute

Ministry of the Environment of the Slovak Republic

The National Inventory Report was prepared in accordance with UNFCCC related to *FCCC/CP/2002/8* from March 28 2003 – UN FCCC Guidelines on Reporting and Review and in accordance with Decision No 280/2004/EC of the European Parliament and of the Council of 11 February 2004.

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

- National greenhouse gas emission inventory report of the Slovak Republic 1990–2007 (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 (Kyoto Protocol 2005). IPCC and other methods applied in the calculation of the emissions are described, as well as changes to the previous submission. Several summarising tables and graphs of the emission data and emission trends for the years 1990–2007 are included. Annex 1 – The list of cooperating organizations and experts, Annex 2 – The key sources and uncertainty analyses for the most recent inventory year 2007 and the base year 1990 and Annex 3 – The certificate conformity with the ISO standards for SHMÚ.
- CRF (Common Reporting Format) data tables of the Slovak Republic's greenhouse gas emissions for the years 1990–2007. The CFR tables are compiled with the latest UNFCCC CRF Reporter software (version 3.2.3), xml file with the databases, country specific variables and unit's lists.

Slovak Hydrometeorological Institute (Stanislava Nebusova, Michaela Kollarova, Eva Gogova, Andrej Kovarik, Jozef Uhlik, Janka Szemesova), Profing (Jan Judak), Ecosys (Jiri Balajka), Forestry Research Institute Zvolen (Jozef Mindas), the Transportation Research Institute Zilina (Ivan Breziansky, Jozef Pinter), the Slovak Agricultural University Nitra (Bernard Siska), the Slovak Technical University Bratislava (Vladimir Danielik)**,** Faculty of Mathematics, Physics & Informatics Bratislava (Martin Gera)**,** Slovak Energy Agency, Slovak cooling and air conditions association (Peter Tomlein), SPIRIT Information Systems (Jozef Skakala) and veQ s.r.o. (Juraj Farkas) are involved in the process of development and have made the inventory calculations, as well as the description of the methodologies and other information included in the national inventory report. Slovak Hydrometeorological Institute – Department of Emissions is the Single National Entity with the overall responsibility of the compilation and finalisation of inventory reports and their submission to the UNFCCC Secretariat and the European Commission according the official journal: Vestnik, Ministry of Environment, XV, 3, 2007, page 19. Slovak Hydrometeorological Institute – Department of Emission is the coordinator of the National Inventory system.

Since the submission of the Slovak Republic's initial report under the Kyoto Protocol to the UNFCCC secretariat on 4 October 2006, several changes have occurred in the national system or registries. These are presented in chapter 1.2. Information on emissions and removals related to Article 3, paragraphs 3 and 4, as well as on Article 3, paragraph 14 will be included in the inventory submissions from the year 2010 onwards. The main planned methodological improvements and changes, QA/QC procedures, recalculations, uncertainty assessment since the inventory submission in 2009 are listed in every chapter.

All relevant documents have to be approved by National Focal Point to the UNFCCC – Ministry of Environment – Department of Climate-Energy Package and Renewable, Dr. Helena Princova (email: princova.helena@enviro.gov.sk). The Slovak inventory report as well as the CRF tables and other relevant documents can be downloaded from the address: www.ghg-inventory.gov.sk after 15 April 2009. The contact person at Slovak Hydrometeorological Institute is Dr. Janka Szemesova, Head of Department of Emissions (email: janka.szemesova@shmu.sk).

CONTENTS

ES EXECUTIVE SUMMARY

This chapter includes a brief summary of the National Inventory Report of the Slovak Republic 2009 as a part of official GHG inventory submission 2009 to the UNFCCC.

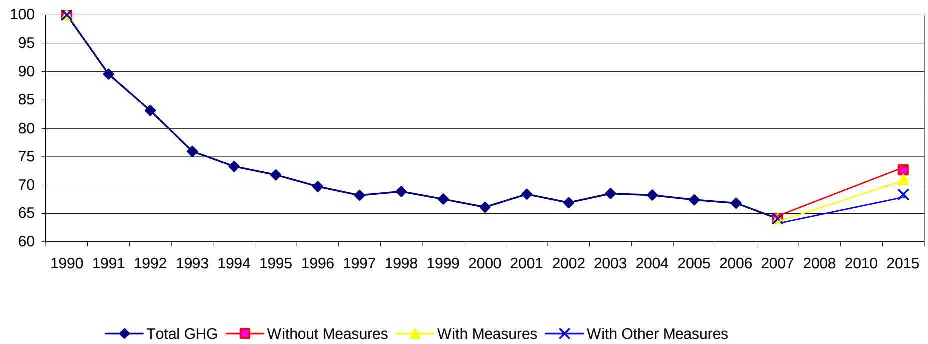
ES.1 Introduction

Climate change, caused by increasing anthropogenic emission of greenhouse gases, represents the most serious environmental issue in the history of humankind. The most important anthropogenic greenhouse gases are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Other greenhouse gases included in GHGs inventory are 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 (NM VOCs) are not greenhouse gases, but they contribute indirectly to the greenhouse effect in the atmosphere. These have 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.

The unfavorable development and balance of GHG emission generation since 1992 have created a demand to adopt an additional and effective instrument that would involve the participation of developing countries. In 1997, the parties of the Convention agreed to endorse the Kyoto Protocol (KP) that defines reduction objectives and instruments to achieve them for countries of the Annex I to the Convention. Developed countries defined in Annex B of the KP should reduce individually or together emissions of six GHG (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) on average by 5.2% from the level of the year 1990 during the first commitment period 2008–2012. The Slovak Republic, as a member states of the EU (the EU commitment was adopted in the form of so-called burden sharing agreement) committed to an 8% reduction of emissions compared to the base year 1990. The Slovak Republic and the EU countries ratified the Kyoto Protocol on May 31, 2002.[1]

Total GHG emissions without LULUCF in the EU-27 were 7.9% below the base year in 2005. By 2010, total EU-27 greenhouse gas emissions are projected to be 7.5% lower than in 1990. The new member states (EU-10) reduced together the GHG emissions in average about 28% in the 1990–2006 period without LULUCF. The main reason for this important emission reducing is above all the strong although temporary decreasing of the economy activities, following restructuring of the economy joined with the implementing of new, more effective technologies, reducing the share of the intensive energy industry and increasing the share of services in the GDP generation. The important exception is transport (mostly road transport), with the increasing of emissions. The continuous pressure is made in the field of the formulating the effective strategy and policy for the further reducing the emissions.

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



CO_2 Emissions without LULUCF; emissions are determined as of 15.04.2009

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

ES.2 National Circumstances

The Slovak Ministry of the Environment (www.enviro.gov.sk) is responsible for national environmental policy including climate change and air protection issues. It has the responsibility to develop acts, and amendments to existing legislation. Legislation proposals are commented by all ministries and other relevant bodies. Following the commenting process, proposed acts are negotiated in the Legislative Council of the Government, approved by the Government, and finally by the Parliament.

Supporting institutions founded by the Ministry of Environment 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 (i.e. the Ecology and Forestry Research Agency Zvolen, the Transportation Research Institute Zilina, the Slovak Agricultural University Nitra, the Slovak Technical University Bratislava**,** Faculty of Mathematics, Physics & Informatics**,** Commenius University Bratislava, and the Slovak Academy of Science), non-governmental organizations, and associations of interested groups (the SEA - the Slovak Energy Agency, PROFING – energy consulting company, SZCHKT – Association for Air Conditioning and Cooling Technique, Detox – solvent use, SPIRIT – information systems, Ecosys – consulting company for projections in energetic) are involved in the process of development and implementation of policy and measures aimed to mitigate climate change impacts.

According to the 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 SR, a continental influence is typical for east part. A regular rotation of four seasons and variable weather throughout the year are typical for this country.

The Slovak Republic has 5.40 mills. inhabitants (as of 31.12.2008). The average population density is 110 inhabitants/km². The population is concentrated in the cities in the lowlands and the main basins. Mountains areas are randomly populated. In the Slovak Republic, there are 47.8% of inhabitants are economically active. The largest city is Bratislava with 428 791 inhabitants (as 31.12.2008). It is the capital of the Slovak Republic.

Since 2000, macroeconomic development of the Slovak Republic has been influenced by implementation of measures with respect to the preparation of the country for EU membership. Among the most important measures were the removal of price distortions, changes in indirect taxes, and reconciliation of public financing mechanisms. In 2001, the growth in GDP reached 3.3%. In 2003, the Slovak economy continued its positive development, when the growth of gross domestic product (GDP) at constant prices reached 6.0%, which is a comparable to the growth of the most developed economies in transition and a double that of the EU27 countries.

ES.3 Overview of Source and Sink

The GHG emissions presented in the National Inventory Report 2009 were updated and converted using the newest available methods, national conditions and data published by the Slovak Statistical Office. Total GHG emissions represented 46 950.67 Gg in 2007 (without LULUCF). This represents a reduction by 35.9% in comparison with the reference year 1990. In comparison with 2006, the emissions decreased by 4.1% Total GHG emissions in the SR are stable or slightly increasing due to recovery of economic activities, increase in transport category and expected increase in actual emissions of F–gases (mainly HFCs and SF_6). Total GHG emissions including LULUCF sector are peaked and exceeded 1998. Significant changes are expected according the revisions of the NEIS database (new fuel's catalogue) and trying to keep consistency with European Trade System (ETS) and changes in balance methodology in sector AFOLU were applied. The Table ES.1 shows the aggregated GHG emissions. In the period 1990–2007, the total greenhouse gas emissions in the Slovak Republic did not exceed the level of the year 1990.

Table ES.1: The total anthropogenic greenhouse gas emissions (Tg of CO_2 eq.).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2	61,96	55,65	52,06	47,82	45,56	44,04	42,50	41,42	42,10	41,35	40,32	41,74	40,05	41,42	41,11	40,74	39,98	38,14
CO_2	59,56	52,14	47,91	43,53	42,25	41,34	40,07	40,01	40,16	39,72	37,92	36,52	34,80	36,59	36,86	39,86	36,93	34,92
CH_4	4,79	4,64	4,38	4,09	4,07	4,25	4,21	4,24	4,50	4,70	4,42	4,47	5,08	4,84	4,82	4,58	4,63	4,53
N_2O	6,23	5,04	4,22	3,58	3,92	4,16	4,29	4,18	3,78	3,32	3,58	3,77	3,73	3,76	3,86	3,85	4,07	4,01
HFCs	0,00	0,00	0,00	0,00	0,00	0,02	0,04	0,06	0,04	0,07	0,08	0,08	0,10	0,13	0,15	0,17	0,20	0,23
PFCs	0,27	0,27	0,25	0,16	0,13	0,11	0,03	0,03	0,03	0,01	0,01	0,02	0,01	0,02	0,02	0,02	0,04	0,02
SF_6	0,00	0,00	0,00	0,00	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02
Total	**73,26**	**65,60**	**60,91**	**55,64**	**53,70**	**52,59**	**51,07**	**49,94**	**50,46**	**49,47**	**48,42**	**50,09**	**48,99**	**50,19**	**49,98**	**49,37**	**48,94**	**46,95**
Total*	**70,87**	**62,10**	**56,77**	**51,37**	**50,39**	**49,91**	**48,66**	**48,55**	**48,53**	**47,85**	**46,04**	**44,88**	**43,76**	**45,38**	**45,75**	**48,53**	**45,91**	**43,75**

*Total aggregated GHGs emission without LULUCF, emissions are determined as of 15.04.2009

ES.4 CO_2 Emissions

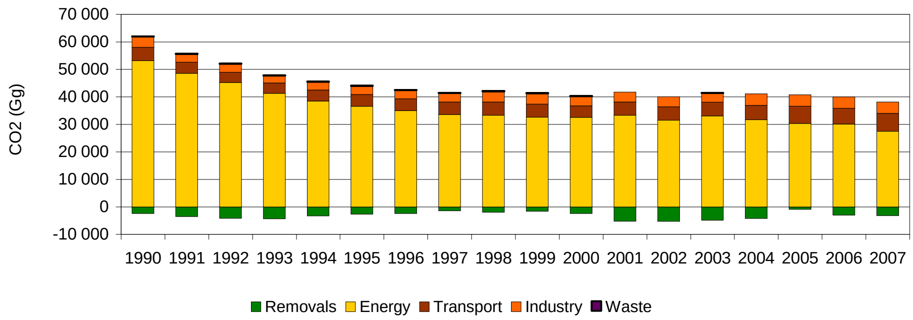
A most important anthropogenic source of CO_2 emissions in the atmosphere is combustion and transformation of fossil fuels, which account for about 95% of the total CO_2 emissions in the SR (Tab. ES.2). A calculation of CO_2 emissions is based on energy statistical data when the IPCC sectoral method (sectoral approach) was applied. In addition, carbon dioxide arises during technological process of cement, lime, magnesite production and using of limestone. The balance includes also the production of coke, iron and steel, as well as CO_2 emissions arising during aluminium and ammonia production. Emission factors, estimated on the carbon content in fuels, were used. Carbon dioxide enters the atmosphere via the conversion of grasslands and forest areas into agricultural land, and forest fires.

Table ES.2: The total CO_2 emissions by sectors (Tg).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Removals	-2,41	-3,51	-4,15	-4,28	-3,32	-2,70	-2,42	-1,40	-1,94	-1,64	-2,40	-5,23	-5,24	-4,83	-4,25	-0,88	-3,05	-3,22
Energy	53,16	48,49	45,19	41,26	38,49	36,56	34,95	33,62	33,32	32,65	32,57	33,33	31,47	33,04	31,65	30,39	30,09	27,49
Transport	4,89	4,12	3,79	3,77	4,01	4,26	4,31	4,48	4,76	4,66	4,18	4,75	4,89	5,00	5,27	6,21	5,74	6,50
Industry	3,84	2,97	3,01	2,72	2,99	3,16	3,17	3,26	3,92	3,98	3,50	3,61	3,65	3,36	4,16	4,12	4,12	4,14
Waste	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,05	0,10	0,07	0,07	0,06	0,04	0,03	0,03	0,01	0,02	0,01
Total	61,96	55,65	52,06	47,82	45,56	44,04	42,5	41,42	42,1	41,35	40,32	41,74	40,05	41,42	41,11	40,74	39,98	38,14

*Total CO_2 with LULUCF, emissions are determined as of 15.04.2009, emissions in Tg.

Figure ES.2: The share of individual sector on CO_2 emissions (Gg) in 1990–2007.



ES.5 CH_4 Emissions

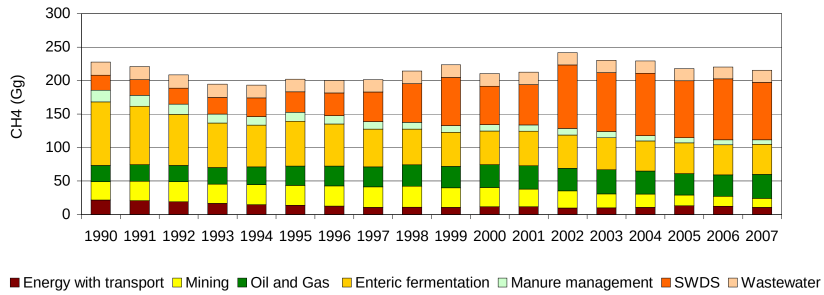
Agriculture, large-scale beef cattle and pig breeding, are major sources of methane on the Slovak territory. The CH_4 does arise as the direct product of the metabolism in herbivores and as the product of organic degradation in animal excrement. Calculations of emissions for the Slovak Republic are based on the data listed in the Statistical yearbook of the Slovak Republic (Statistical yearbook, 2008) and the Green Report of the Slovak Ministry of Agriculture (Green Report, 2008). Leaks of natural gas in the distribution networks are a very important source of methane. Methane is also leaking into the atmosphere from brown coal mining and biomass burning. In addition, municipal waste dumps and sewage (predominantly septic tanks) are also important methane sources. Methane arises without the direct access of oxygen.

Table ES.3: The total CH_4 emissions by sectors (Tg).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Energy with transpor	21,79	20,97	19,22	16,75	14,65	13,63	12,62	10,71	11,22	10,60	11,62	11,72	9,61	9,99	10,79	13,18	12,42	10,78
Mining	27,20	28,83	29,93	28,61	29,91	29,70	30,08	30,61	31,17	29,50	28,82	26,33	25,69	21,11	19,77	16,17	14,67	13,52
Oil and Gas	24,45	24,97	24,24	25,09	26,58	29,13	29,73	29,98	32,01	31,99	34,06	34,86	33,74	35,93	34,32	31,96	32,13	35,45
Enteric fermentation	94,77	86,89	76,41	66,09	62,39	66,90	62,67	56,10	52,91	50,78	50,16	51,44	49,78	47,65	45,02	45,64	44,97	45,07
Manure management	17,56	16,32	14,82	13,62	12,91	13,25	12,60	11,56	10,21	9,87	9,52	9,63	9,74	9,26	7,84	7,66	7,49	6,84
SWDS	22,37	23,45	24,16	24,89	27,75	30,85	33,81	44,10	58,01	72,24	57,47	59,93	94,74	87,97	93,26	85,19	90,66	85,83
Wastewater	19,71	19,62	19,68	19,52	19,33	18,67	18,59	18,50	18,62	18,62	18,77	18,56	18,57	18,52	18,33	18,08	18,04	17,96
Total	**228,0**	**221,2**	**208,6**	**194,7**	**193,6**	**202,3**	**200,3**	**201,8**	**214,3**	**223,8**	**210,6**	**212,7**	**242,1**	**230,6**	**229,5**	**218**	**220,6**	**215,8**

*Total CH_4 emissions without LULUCF are determined as of 15.04.2009, emissions in Tg.

Figure ES.3: The share of individual sector on CH_4 emissions (Gg) in 1990–2007.



ES.6 N_2O Emissions

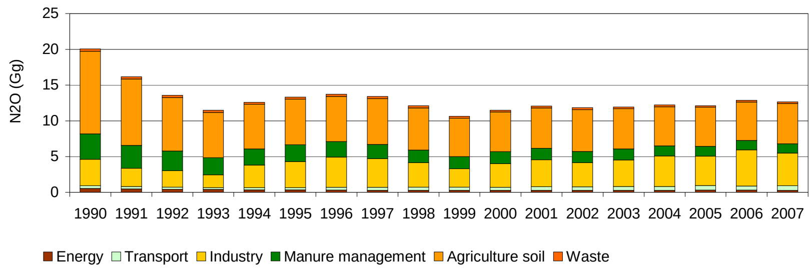
In comparison with other greenhouse gases, the mechanism of N_2O emissions and sinks develops from the nitrogen cycle in the atmosphere and their quantification is rather difficult. Global anthropogenic emission is estimated to be 3–7 billion tons of nitrogen per year. Natural sources are approximately twice as large as anthropogenic ones. The primary sources of N_2O in the Slovak Republic are agriculture, waste treatment and N_2O from combustion of fuels (energy and transport).

Table ES.4: The total N_2O emissions by sectors (Tg).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Energy	0,53	0,49	0,43	0,39	0,36	0,33	0,32	0,30	0,29	0,29	0,28	0,30	0,27	0,29	0,30	0,33	0,31	0,29
Transport	0,39	0,32	0,28	0,27	0,29	0,33	0,35	0,39	0,43	0,44	0,41	0,49	0,49	0,51	0,52	0,61	0,57	0,64
Industry	3,71	2,57	2,29	1,77	3,16	3,63	4,24	4,01	3,41	2,56	3,33	3,77	3,37	3,73	4,26	4,13	5,05	4,56
Manure man	3,53	3,20	2,76	2,40	2,24	2,36	2,18	2,00	1,76	1,68	1,64	1,59	1,58	1,53	1,43	1,38	1,34	1,31
Agricult. soil	11,56	9,28	7,48	6,37	6,26	6,37	6,32	6,40	5,92	5,40	5,56	5,66	5,84	5,62	5,46	5,45	5,36	5,64
Waste	0,34	0,33	0,30	0,29	0,29	0,30	0,30	0,30	0,29	0,28	0,26	0,25	0,29	0,25	0,24	0,24	0,24	0,24
Total	**20,11**	**16,24**	**13,61**	**11,54**	**12,65**	**13,42**	**13,83**	**13,48**	**12,18**	**10,73**	**11,56**	**12,15**	**12,02**	**12,12**	**12,46**	**12,41**	**13,13**	**12,93**

*Total N_2O emissions without LULUCF are determined as of 15.04.2009, emissions in Tg.

Figure ES.4: The share of individual sectors in N_2O emissions (Gg) in 1990–2007.



ES.7 HFCs, PFCs and SF_6 Emissions

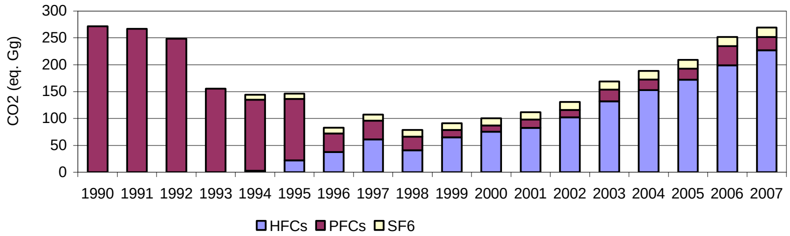
The first inventory of these substances[2] was executed in 1995. HFCs, PFCs and SF_6 are not produced in the SR, only data on consumption of these substances are available. They are used as coolants, extinguishing agents, blowing agents for PUR, in aerosol products and as insulating gases (SF_6).

Table ES.5: The total HFCs, PFCs and SF_6 emissions by sectors (Gg).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HFCs	0,00	0,00	0,00	0,00	2,91	22,15	37,58	61,13	40,96	65,12	75,59	82,43	102,35	131,96	152,88	172,34	198,90	226,99
PFCs	271,37	266,94	248,42	155,42	132,06	114,32	34,51	34,62	25,40	13,60	11,65	15,59	13,75	21,65	19,91	20,25	35,82	24,88
SF_6	0,03	0,03	0,04	0,06	9,27	9,91	10,76	11,34	12,24	12,69	13,25	13,84	14,78	15,39	15,89	16,61	17,15	17,44

*Total HFCs, PFCs and SF_6 emissions are determined as of 15.04.2009, emissions in Gg.

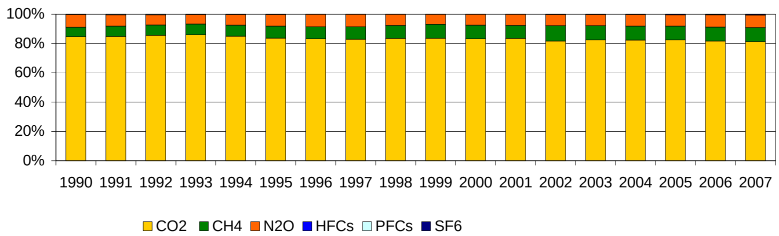
Figure ES.5: The share of individual F-gases emissions (Gg of CO_2 eq.) in 1990–2007.



ES.8 Aggregated Emissions

These are the emissions of greenhouse gases recalculated via GWP100 (Global Warming Potential)[3] on the CO_2 equivalent. Expressed as the CO_2 equivalent, carbon dioxide emissions contributed by almost 81.2% to the total emissions, CH_4 (GWP = 21) emissions by about 9.7%, N_2O (GWP = 310) emissions by about 8.5% and the contribution of F-gases is below 0.5%.

Figure ES.6: The aggregated emissions of greenhouse gases by gases in 1990–2007 in percent.



Emissions without LULUCF in CO_2 equivalents; emissions are determined as of 15.04.2009

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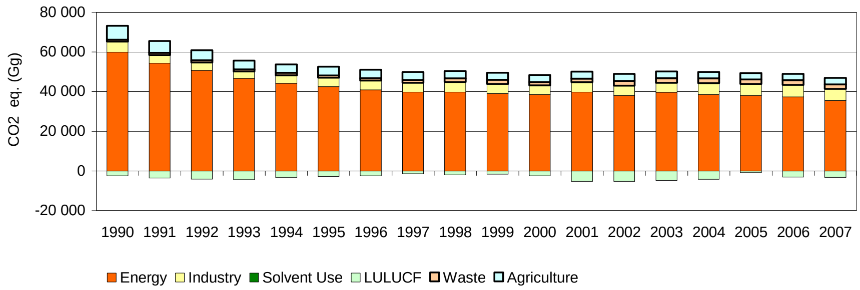
[2] *The utilisation of „F-gases" (they are not covered by the UN Convention) in the SR is regulated in compliance with the Montreal Protocol and its appendices. Since 1986, the total consumption of controlled substances has been decreasing. Freon in cooling systems are successively being replaced by perfluorocarbons, so it can be assumed that consumption of these substances will increase several times following the year 1996.*

[3] *According to the currently valid Convention, the emission reduction expressed in CO_2 equivalent should be reported*

Figure ES.7: The aggregated emissions of greenhouse gases by sectors in 1990–2007.



Emissions without LULUCF in CO_2 equivalents; emissions are determined as of 15.04.2009

ES.9 Indirect Greenhouse Gases

A major source of SO_2, NO_x and CO emissions is power and heat generation. A 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 estimated in the framework of the National Program of NM VOC Emissions Reduction in the SR. In the frame of this Program were revised emission factors for asphalt paving and residential plants combustion (total emission's decrease in 1990 about 45%). The year 1990 was used as a starting point and updating was carried out for the years 1990, 1993, 1996–1999, 2006. A major source of NM VOC emissions come from the use of solvents, transport, refinery/storage and transport of crude oil and petrol. The categories of emission sources in National Emission Inventory System (NEIS) are based on Air Pollution Act (478/2002) and they do not correspond exactly to the structure of sources to CRF requirements. Therefore, it is impossible to provide information on emissions and emission factors according to the classification requested in standard tables.

The NM VOC emissions easily increase in sector solvent and other product use in consequence of increasing of industrial production especially in engineering but also increasing of print's ink consumption and import of solvent paints. New emission factor respect that asphalt mixture contains 5.5% of asphalt and others is create by aggregate

Table ES.6: The anthropogenic emissions of NOx, CO, NM VOC and SO_2 (Gg) in 1990–2007.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO	**511,6**	**487,1**	**444,6**	**455,9**	**431,0**	**419,6**	**363,8**	**363,5**	**346,1**	**335,5**	**312,9**	**315,1**	**292,3**	**308,1**	**309,8**	**299,4**	**289,8**	**276,7**
Stationary	351,3	340,0	300,0	301,0	272,6	258,9	208,2	205,6	187,6	185,4	185,2	175,6	165,2	184,2	189,6	181,4	193,5	183,3
Transport	154,2	142,1	140,6	150,7	154,8	156,7	151,1	153,2	153,9	144,7	121,9	133,6	121,3	117,5	113,1	108,7	88,4	85,4
Other*	6,1	5,0	4,0	4,2	3,6	4,0	4,5	4,7	4,6	5,4	5,8	5,9	5,8	6,4	7,1	9,4	7,9	7,9
NO_x	**221,9**	**201,1**	**188,6**	**180,3**	**170,0**	**177,9**	**134,9**	**127,5**	**133,1**	**121,1**	**109,1**	**108,7**	**101,1**	**98,1**	**98,0**	**98,0**	**86,8**	**83,3**
Stationary	164,8	153,4	144,7	137,7	126,3	132,3	89,7	82,3	86,6	77,6	70,5	67,8	59,9	58,6	56,7	55,7	52,1	46,8
Transport	56,8	47,4	43,7	42,4	43,5	45,4	45,0	44,9	46,2	43,2	38,3	40,6	40,9	39,1	40,9	41,8	33,8	35,7
Other*	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,3	0,3	0,3	0,3	0,3	0,3	0,4	0,4	0,5	1,0	0,7
NM VOC	**141,4**	**NE**	**NE**	**107,9**	**NE**	**101,1**	**97,2**	**91,9**	**88,4**	**82,5**	**76,0**	**79,7**	**77,2**	**81,9**	**82,8**	**79,5**	**75,1**	**74,0**
Energy	14,0	NE	NE	12,6	NE	10,7	11,1	9,5	9,6	9,0	8,7	9,3	7,9	8,4	9,9	12,9	12,2	12,1
Industry	8,8	NE	NE	5,9	NE	2,8	2,7	2,7	1,6	1,5	1,4	1,3	1,4	1,7	1,7	1,6	1,6	1,5
Transport	33,6	NE	NE	30,9	NE	33,0	31,8	32,0	31,9	29,1	25,0	26,6	23,8	26,0	24,7	18,7	15,4	16,0
Cruide Oil	27,1	NE	NE	21,8	NE	16,8	17,2	17,8	14,5	13,8	13,3	13,2	12,4	12,9	13,1	11,9	10,5	10,1
Solvent Use	52,9	NE	NE	35,0	NE	37,1	33,8	29,3	30,2	28,4	27,0	28,7	31,0	32,3	32,8	33,6	34,6	33,6
Agriculture	0,7	NE	NE	0,4	NE	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Waste	4,5	NE	NE	1,3	NE	0,3	0,1	0,2	0,2	0,2	0,2	0,2	0,3	0,2	0,2	0,2	0,2	0,2
SO_2	**526,1**	**445,5**	**389,6**	**328,2**	**245,2**	**246,3**	**230,6**	**204,7**	**184,1**	**173,3**	**127,0**	**131,2**	**103,3**	**106,1**	**96,9**	**89,0**	**87,8**	**70,6**
Stationary	522,7	442,8	387,2	326,0	242,9	243,8	228,1	202,1	181,4	172,2	126,1	130,2	102,5	105,3	96,0	88,8	87,5	70,3
Transport	3,4	2,7	2,4	2,2	2,3	2,5	2,5	2,6	2,7	1,1	0,9	1,0	0,8	0,8	0,9	0,2	0,3	0,3

*Biomass burning and forest fires, emissions are determined as of 15.02.2009

1 INTRODUCTION

1.1 Background Information on GHG Inventories, Climate Change and Supplementary Information under Article 7, paragraph 1 of the KP

Global climate change due to the anthropogenic emission of greenhouse gases is the most important environmental problem in the history of humankind. The instrument to tackle the problem of climate change is the UN Framework Convention on Climate Change adopted in 1992. The aim of the Convention is to stabilize atmospheric concentrations of greenhouse gases to a safe level. Currently, there are 185 countries or international communities, including the Slovak Republic, and the EU that are parties to the Convention. The Convention requires the adoption of measures that aim to reduce the GHG emission to the level of the year 1990.

The framework Convention on Climate Change (UN FCCC) - the basic international legal instrument to protect global climate was adopted at the UN Conference on the environment and sustainable development (Rio de Janeiro, 1992). The final goal of the Convention is to achieve stabilisation of greenhouse gas concentrations in the atmosphere at a level that has not yet developed any dangerous interference in the climate system.

In the Slovak Republic, the Convention came into force on November 23, 1994. The SR accepted all the commitments of the Convention, including reduction of the greenhouse gas emissions by 2000 to the 1990 level. One of the commitments, resulting from the Convention, is to provide a regularly greenhouse gas emission inventory.

The Kyoto Protocol, adopted by consensus at the third session of the Conference of the Parties (COP-3) in Kyoto, December 1997, enforced the international responsibility for the climate change. The all Annex I countries, which ratified the Kyoto Protocol, formally defined their reduction targets in articles of the KP. The Kyoto Protocol came into force on February 16, 2005 after compliance of requirement determined in Article 25, paragraph 1; it means after signing of more than one-half Annex I countries, that representing of minimum 55% of total CO_2 emissions of Annex I countries in 1990 (the signature of the Russian Federation ensured the majority). The Slovak Republic and the most countries of Central and East Europe agreed to reduce base year level of all six GHG emissions by 8% during period 2008–2012. As of June 6th, 2007, 174 countries and one regional integration organisation (the European Community) had ratified, accepted, approved or acceded to the Kyoto Protocol. A meeting of the commitments gains high priority in the EU.

In the context of joining of the Slovak Republic the European Union (May 1st, 2004), raised the new requirements for legislative implementation in the field of air protection. The European Union considers the area of climate change for the one of the four environmental priorities.[4] The Slovak Republic submits the data about GHG emissions in the relevant extend to the January 15, annually, according the 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.[5] The grounds for the implementing of the Decision were the following criteria:

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

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[4] *New environmental action program: Environment 2010 Our Future, Our Choice*
[5] *OJ L 49, 19.2.2004, p. 1.*

The unfavorable development and balance of GHG emissions generation since 1992 have created a need to adopt an additional and effective instrument. In 1997, the parties of the Convention agreed to endorse the Kyoto Protocol (KP) that defines reduction targets for countries of the Annex I to the Convention. Developed countries defined in Annex B of the Kyoto Protocol should individually or together reduce emissions of six GHG on average by 5.2% from the level of the year 1990 during the first commitment period 2008–2012. The reduction target of the Slovak Republic is 8% reduction of emissions compared to the base year 1990. The Kyoto Protocol has generally extended the options of the countries to choose the way and the instruments that are most appropriate for 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 and the EU countries ratified the Kyoto Protocol on May 31, 2002.[6]

The greenhouse effect of the atmosphere is a similar effect to that which 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 a 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 30%, methane (CH_4), nitrous oxide (N_2O) and ozone (O_3), all three together 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 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 4t of CO_2 per capita in the globe). The most important source of "new" carbon dioxide is presented by the fossil fuel combustion and cement production. The 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 yrs.) and is removed from the atmosphere by a complex of

[6] *Kyoto Protocol came into force on February 14., 2005*

natural sink mechanisms. It is expected that 40% of carbon dioxide presently emitted be absorbed by the oceans. Photosynthesis by vegetation and sea plankton is a further 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 are all anthropogenic activities. The natural methane sources are not yet fully investigated 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[7] 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, NOx 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 does seem 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.

According to the emission inventory of March, 2009, the Slovak Republic has achieved a reduction of total anthropogenic emissions of greenhouse gasses expressed as CO_2 equivalent, of approximately 35.91% without LULUCF compared the base year 1990. This achievement is the result of several processes and factors, mainly:

- Higher share of services in the generation of the GDP.
- Higher share of gas fuels in the primary energy resources consumption.
- Restructuring of industries.
- Gradual decrease in energy demands in certain heavy energy demanding sectors (except for metallurgy).
- The impact of air protection legislative measures influencing directly or indirectly the generation of greenhouse gas emissions.

A comparison of the GDP trend with the trend of aggregate emissions of greenhouse gasses shows that the SR is one of few countries where the trend of emissions is decoupled from the GDP increase. However, by international comparison, the generation of greenhouse gasses per capita still remains one of the highest in the Europe.

Without introduction of effective measures SR will contribute to further increase of GHG emissions due to anticipated growth of the GDP and recovery of economic activities. Therefore, the investment strategy to tackle GHG emissions is one of the most important objectives.

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[7] *Intergovernmental panel was established in 1988 commonly by ECE (UNEP) and 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.*

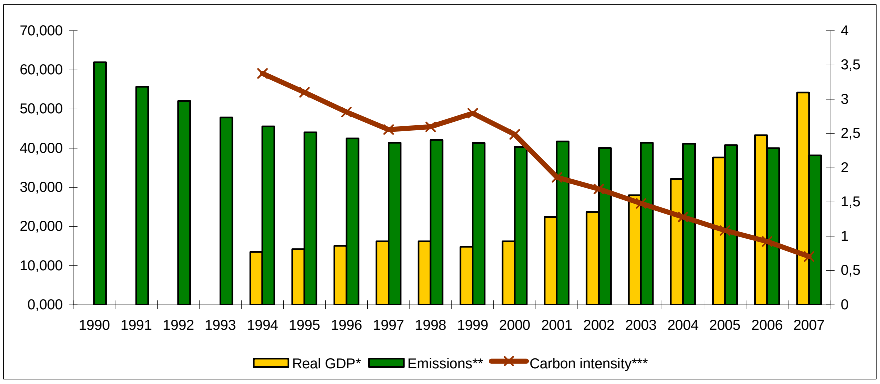
In May 2004, the Slovak Republic joined the European Union. Relevant European legislation is expected to have additional positive direct and indirect effects to reduction of GHG emissions, mainly in the energy sector. The introduction of emission trading scheme will allow for the implementation of further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

Table 1.1: The carbon intensity per GDP in the Slovak Republic.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Real GDP*					13,50	14,20	15,10	16,20	16,20	14,80	16,22	22,44	23,69	28,00	32,10	37,60	43,30	54,24
Emissions**	61,96	55,65	52,06	47,82	45,56	44,04	42,50	41,42	42,10	41,35	40,32	41,74	40,05	41,42	41,11	40,74	39,98	38,14
Carbon intensity***					3,38	3,10	2,81	2,56	2,60	2,79	2,49	1,86	1,69	1,48	1,28	1,08	0,92	0,70

The values are absolute, *in billion Euro in year 2006, **Tg of CO_2 emissions without LULUCF, ***Tg of CO_2/billions Euro 2006

Figure 1.1: The comparison of CO_2 emissions per GDP (carbon intensity).



According to the Initial Report of the Slovak Republic revised version based on FCCC/IRR/2007/SVK from 19 September 2007[8] was quantified emission limitation or reduction commitment of 92% from the base year level has been accepted by the Slovak Republic 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. The assigned amount of the SR 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 tones 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 tones of CO_2 equivalent

The assigned amount of the Slovak Republic averaged over the first commitment period is:

331 433 516/5 = 66 286 703 tones of CO_2 equivalent

Table 1.2: The assigned amount of the Slovak Republic for period 2008–2012.

Item	Unit [tonnes of CO_2 equivalents]
Base year emissions excluding LULUCF (1990)	72 050 764
F-gases emissions in 1990	271 403
Percentage corresponding to the reduction commitment	92%
Estimated assigned amount for the first commitment period	**331 433 516**
Assigned amount averaged over the first commitment period	66 286 703

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 times five, whichever value is the lowest. Due to substantive methodology improvements and fulfilled recalculations the

[8] http://unfccc.int/resource/docs/2007/irr/svk.pdf

Slovak Republic decided to use emission inventory 2007 submitted in 2009 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 234 753 343 tones of CO_2 equivalent. This number is lower than the 90% of the calculated assigned amount, which is 298 290 164 tones of CO_2 equivalent.

Following the decision 11/CMP.1 we would give an estimated commitment period reserve for the Slovak Republic as equal to the 234 753 343 tones of CO_2 equivalent for the submission 2009 emission inventory 2007.

1.2 Institutional Arrangement and National Inventory System

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. In addition, commitments also require estimating of emissions and removals as 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.

Obligation for the Slovak Republic to create and maintain the national inventory system (NIS) which enables continues monitoring of greenhouse gases emissions is given by Article 5, paragraph 1 of the Kyoto Protocol to the United Nations Framework Convention on Climate Change.
Setting up a National Inventory System of emissions in compliance with the Kyoto Protocol and Council Decision 280/2004/EC was the priority of capacity development in the Slovak Republic at all levels identified also as a middle-term objective (2003–2007) of the Strategy of the SR. The basic characteristics of the capacity building the NIS were follows:

- To operate National Inventory System (institutions, competences), which groups the experts from all sectors according to IPCC (NFP, SNE, scientific institutions, universities, research institutes, private sector, non-governmental organisations, Statistic Office...).
- To establish an independent working unit entitled the Single National Entity (SNE – according to a COP recommendation), which coordinate the NIS and have competencies and responsibilities stipulated by law. The SNE controls directly by NFP (MŽP SR), including financial resources.
- To interlink all stakeholders at the horizontal level with regard to expert, financial, legal and information issues. The SNE is responsible for achieving the commitments under the UNFCCC and KP in the field of reporting, assessment and providing information to all stakeholders, administration of national databases (NEIS, IPPC – air, NEC directive, EPER), implementation of QA/QC process, accreditation and certification, organisation of „cross-country“ meetings and communication with international organizations.
- To appoint experts or organisations for each IPCC sector or gas, and explicitly determine their responsibilities; to appoint a team for the work on national communications, modeling and projections of emissions (GAINS, CAFE) in the sense of keeping consistency, reproducibility and transparency.
- To obtain dedicated continuous finances from the State budget for achieving the commitments under the UNFCCC and KP on annual basis and in a sufficient amount (according to actual needs and analysis).
- To determine the competencies of the NIS and the operators of polluting sources with regard to the dissemination of information.

The Slovak Ministry of the Environment (MŽP) (www.enviro.gov.sk) is responsible for national environmental policy including climate change and air protection issues as National Focal Point. It has the responsibility to develop acts, and amendments to existing legislation. All ministries and other relevant bodies comment legislation proposals. Following the commenting process, proposed acts are negotiated in the Legislative Council of the Government, approved by the Government and finally by the Parliament. The Ministry of Environment cooperates with other ministries, such as Ministry of Economy, the Ministry of Agriculture, the Ministry of Finance, the Ministry of Transport, Posts and Telecommunications, and the Ministry of Construction and Regional Development.

District and regional environmental offices are decision-making bodies according to the Act 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 478/2002 Coll. on Air Protection, competencies and decision-making process on large, medium and small pollution sources are given to regional, district levels and municipalities.

The Act 572/2004 Coll. on Trading with Emission Quotas is the first legal instrument directly oriented towards control of GHG emissions. According to this Act, competencies with respect to trading of emission quotas are given to the Ministry of Environment, regional and district environmental offices. Supporting institutions founded by the Ministry of Environment play an important role. These include the Slovak Hydrometeorological Institute (SHMÚ) (www.shmu.sk), the Water Research Institute, and the Slovak Environmental Agency. Academic and research institutions (i.e. the Forestry Research Institute Zvolen, the Transportation Research Institute Zilina, the Slovak Agricultural University Nitra, the Slovak Technical University Bratislava**,** Faculty of Mathematics, Physics & Informatics**,** Bratislava, and the Slovak Academy of Science), non-governmental organizations, and associations of interested groups (the Slovak Energy Agency, PROFING, EFRA Zvolen, SZCHKT, Detox, SPIRIT, Ecosys, veQ s.r.o.) are involved in the process of development and implementation of policy and measures aimed to mitigate climate change impacts.

The National Inventory System (www.ghg-inventory.gov.sk) has been established and officially announced by the Decision of Minister of the Environment of the Slovak Republic on 1st January 2007 in the official bulletin: Vestnik, Ministry of Environment, XV, 3, 2007, page 19 (http://www.enviro.gov.sk/servlets/files/16715).[9] In agreement with the paragraph 30(f) of the Annex to the decision 15/CMP.1 which gives definition of all qualitative parameters for the national inventory systems, description of the quality assurance and quality control plan according to the Article 5, paragraph 1 is also required.

Slovak Hydrometeorological Institute (SHMÚ) www.shmu.sk is the organisation authorised by the Ministry of the Environment to provide yearly and according to the approved status (http://www.shmu.sk/File/statut.pdf) for environmental services, including GHG emissions` inventory. Range of services, competencies, time schedule and financial budget are updated and agreed annually, too. All details of the SHMÚ activities are described in the Plan of Main Projects, which is the subject of comments for involved stakeholders and after approval published on the web page http://www.shmu.sk/File/kontrakt_2007.pdf. Deadline for approval of this plan by the ministry is 31st December each year.

The Slovak Hydrometeorological Institute has built and introduced the quality management system (QMS) according to the requirements of the EN ISO 9001:2000 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 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 air and waters.

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[9] 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

- Study and description of the atmosphere and hydrosphere phenomena.
- Education and training within the activity of institute.

In the frame of introducing the QMS for the SHMÚ as a global standard, the certification itself proceeds according to the partial processes inside the SHMÚ structure. The process of Emission Inventories has been the subject of internal and external audits during the 14–21 April 2008 by the certification body ACERT accredited by Slovak National Accreditation Service. Now, the Department of Emissions (OE) is formally fulfilling the QMS requirements in the area of controlled documents and records in accordance with the QMS of the SHMÚ. The controlled documents and records are available by quality manager at the Department of Emission in Slovak language. The quality manager at the OE has completed several trainings in QMS and control documents issues.

Structural changes occurred after the 1st of January 2008 in the SHMÚ (the new structure of SHMÚ is presented at http://www.shmu.sk/sk/?page=1211) established the Department of Emissions (OE) as Single National Entity and separated from the Air Protection Department. The process of Emission Inventories is the main workload of the OE. There is permanent staff covering positions of the emission experts working at the Department complemented with several external experts working on annual contracts renewed every year. Emission experts cooperate also with the other SHMÚ units (Climatology, Meteorology and Water Management) and other institutions and the state administration. This is mainly represented with the representatives of the Ministry of Environment. Ministry of Environment has established on the 1st October 2008 new Department on Climate-Energy and Renewable Energy Sources. This unit serves as the national focal point to the UNFCCC as well as supervisor for the professional activities of OE connected with this Convention and with the Kyoto Protocol.

The contracts with the external sectoral expert and other institutions are fully in the competence of the SHMÚ, Department of Emissions is using the resources as generated on the projects accounts. The Department of Emissions has usually tree 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 contracts have to be closed after previous assessment both by the SHMÚ and by experts. There is organized also specific workshop on this issue where (usually at the beginning of February) with participation of sectoral experts, SHMÚ and Ministry of Environment. The workshop is official forum for the closing and summing up the previous year according to the SHMÚ's projects, to introduce the tasks and responsibilities for the next year.

The SHMÚ is up to that developing and maintaining a National Emission Inventory System (NEIS) - database of stationary sources to follow development of emissions of SO_2, NO_x, CO at regional level and to fulfill reporting commitments of national and EU Directives (http://www.spirit.sk/ie_home.html). 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 sources like fuel consumption and use for estimation of sectoral approach.

The SHMÚ is annually updating the incoming information and activity data with the corresponding statistical information from the Statistical Office of the SR and other national statistics.

Until the year 2007 the final draft of annual inventory as prepared by the national expert has been the subject of assessment by the interministerial working group. Representatives of the ministry of environment, economy, agriculture, transport, construction and regional development, ministry of finance and ministry of foreign affairs on an expert level were the members of group.

Brand new and high level co-ordination body has been established on June 2008 according to the Resolution of the Slovak Government No 416/2008 from 18 June 2008. Secretary General Commission for Climate and Energy Issues is competent body to define specific tasks and means necessary for further analyses to develop national strategies and particular measures in tackling climate change, adaptation and support of renewable energy sources. Under this Commission is also working wide expert group responsible for preparing of all practical inputs and studies as required for further progress. In next future, this new, two stage structures will be the final responsible body to asses draft of annual inventory and to propose further steps to improve.

1.3 Process of Inventory Preparation

The process of greenhouse gases inventory according the UNFCCC requirements is realized in the Slovak Republic from 1995, from 2000 in the CRF. Next year inventory will be provided in the new CRF Reporter program for the whole time series 1990–2007 according to the COPs Decisions (18/CP.8 about reporting and 13/CP.9 about reporting in the LULUCF sector). Climate Change and Emission Trading Department at the Ministry of the Environment of the Slovak Republic is the national focal point to the UNFCCC. MŽP is granting and supervising development and maintenance of national emission inventories on annual bases. The complete CRF with the emission inventory are reported to the Secretariat of the UN FCCC by 15 of April annually. After review process from the external expert is published Centralized Review on the web page.

Sectoral experts have own responsibility to decide for use of appropriate approach based on national circumstances to collect data from providers and Statistical Office and to develop 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 (waste, energy) which requires detailed review of quality of each input parameter, works out uncertainty analysis. Process of inventory preparation is the major part of the “inventory year” and begins from contract signature (normally middle of February) until 15th October each year. During the preparation of inventory several meetings with the sectoral experts taking place. The meetings are necessary to discuss partial results, possible problems with activity data, timetable or new “ad-hoc” requirements from the legal part of NIS and to exchange information from the process between SNE and external entities. The preparation process of inventory finishes by official assuming the sectoral report from expert by SNE (OE) and the expiring of the contract in 15th October between expert and SHMÚ.

Data are provided in particular by Statistical Office, National Emission Information System – NEIS, operated by SHMÚ and individual questionnaires of national experts through which some data are acquired directly from the legal entities. Relatively large collection and validation of data on air pollution sources via bottom-up approach are carried out in the framework of the National Emission Information System (NEIS). Since 2000, this system has included a large database of data from approximately 10 thousand sources and on 120 pollutants. This system serves primarily to the needs of adopted air protection legislation (Act 478/2002 on air protection, Act 401/1998 on charges for air pollution, Act 245/2003 on integrated pollution prevention and control, Decree of the MŽP SR 61/2004 laying down requirements for keeping operational records on stationary resources and others). NEIS is a source of data on activities serving to estimate greenhouse gas emissions in particular in the energy and industry sectors. However, it will be a difficult task for the future to work out functions of NEIS so that it can provide data for inventory and projections of greenhouse gases and so that the data provided by NEIS and the data provided within the CRF inventory to the UNFCCC or data used in NAP for greenhouse gas trading are consistent.

There are a number of sub-processes and feedbacks in working out an inventory. Inventory in a given sector is divided to partial methodologies (e.g. reference approach and sectoral approach in the energy sector). It is further divided to processing by categories and gases (transport, F-gases).

Energy balance from energy statistics is compared with summary fuel consumption reported by sources. The direct contacts with the important industrial operators are necessary for collection of activity data not included into NEIS database. The direct contact with the industry is useful also for the materials and industrial plans included into projections preparation. The SHMÚ has also direct access into the EU ETS for 2005–2007 and can uses the approved reports for comparison and completing the national energy and industry inventory. Fuel consumption in transport based on fuels sold is compared with the model results and is based on the direct information from Slovnaft a.s. Bratislava, petrochemical refinery, major distributor of the gasoline and diesel oil. The transit, consumption and sale of natural gas are directly known from Slovak Gas Industry a.s. and can be used in national energy balance and fugitive emission estimation. The average EF for natural gas and its composition is published monthly on web page http://www.spp.sk/o-zemnom-plyne/emisie/. Each sector and data source has defined the activity data provider for keeping the consistency in inputs. The data providers are included into the sectoral reports.

National expert for GHG inventory fills in the database all prepared results by sectoral experts and other consultants and after this is running program module CRFReporter. The inventory is submitted to the National Focal Point for approval to the 31st December at the latest. After approval the emission inventory is published and submitted to the UNFCCC and to the European Commission according the decisions.

The relevant documents are archived on tree levels. The general and official documents are archived on web page of NIS (www.ghg-inventory.gov.sk) on two levels (without password for public access and with password for the interest group of experts). The background data and activity data for each sector are archived by sectoral experts. The all relevant documents (also for base year) including official paper, scientific publication, activity data, methodological descriptions, sectoral reports and official submissions of national inventories are archived by SNE (managed by national expert on GHG emissions) on the separated notebook not connect to the internet and not used for any other purposes.

Control procedures are continuously developed and directly transferred into the National Inventory System. Structural changes of the current NIS, in accordance with the new air protection act (transposition of EU air pollution legislation), is ongoing process. Harmonisation of all pollutant inventories and ISO9001 are introducing. In accordance with these requirements the inventory results for the year N are completed to the 31 December (N+1) and the inventory results of the basic pollutants for the year N are completed to the 15 January (N+2) draft and 15 April (N+2) final version. Complete emission inventories of greenhouse gases are subject to critical review by independent experts from the Czech Republic. This approach is unfortunately not regularly and is depended on capacity resources and actual demand. External reviewers are regularly invited to comment the inventory results and methodologies. The meetings with the consultants and experts are documented and are included in the controlled documents of the Department of Emissions as a Single National Entity.

The attention is played on the training of experts and management inside the NIS. The annual plan of training activities including also the participation on the national and international workshops and meetings is evaluated. The training plan includes several courses on QMS and QA/QC for management and quality manager. The philosophy is to ensure continuity in the quality of inventory process and implementation of the further improvements. The training plan is an official document and is included into controlled documentation of the NIS and approves by legal entity.

1.4 General Description of Methodologies and Data Sources

1.4.1 Energy Sector – Category Energy Industry

The main responsibility for the Energy national balance in the energy sector has Jan Judak from the PROFING Ltd. Bratislava. The cooperation with the PROFING Ltd. company and Jan Judak namely with the Single National Entity (SNE) and inventory team is from the year 1998 until present. The legal frame of the cooperation is based on the decree of the Ministry of Environment of the SR and the annually signed agreement with the Slovak Hydrometeorological Institute.

The base for calculation of reference approach is data gathered and processed by the Statistic Office of the SR every year (annual energy statistic balance). These data are therefore official data. Profing Ltd. Bratislava executed the preparation of preliminary energy balance based on published materials from the Statistical Office.

The emission inventory based on the reference approach is periodical include into annual inventory. The data for preparation of the preliminary energy balance are obtained from Statistical Office of the Slovak Republic, which is authority officially organizing and yearly performing statistical findings. Reporting duty to fill the statistical forms is issued by the Act No. 322/1992 Coll., § 27 on the National Statistic, as amended. Statistical Office of the Slovak Republic is yearly performing statistical findings to follow fuel consumption for electricity and heat generation, fuel enrichment processes, 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 following annual statistical forms:

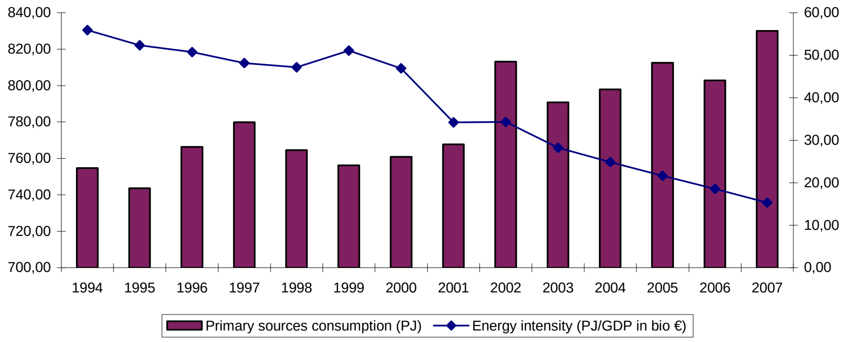
- Energ. P 2-01 Yearly balanced company report on energy process of fuel enrichment.
- Energ. P 3-01 Yearly balanced company report on consumption of fuels, electricity and heat for production of selected commodities.
- Energ. P 4-01 Yearly balanced company report on production of heat and electricity.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

Results of energy statistic that are used for GHG emission inventories are yearly issued in the Statistical Yearbooks and in physical and caloric values in Energetic publications. First preliminary data related to liquid, solid, gaseous and biomass fuels balance for previous year in the SR are available at the beginning of October. This data are verified by Profing Ltd. Bratislava (comparing consumption of fuels and production of heat and electricity, discussion with main producers of heat and electricity and suppliers of fuels, etc.) and used for reference approach.

In the previous inventory submissions, the emission factors of several important fuels were revised according national circumstances and according the direct measurements by sources included in ETS. The CO_2 EF for natural gas, coal, coke and coke oven gas were revised. The further improvements are planned for the revision of CH_4 and N_2O EFs. According to the newly published EUROSTAT information about NCVs for liquid fuels, the expert comparison will be necessary in the next inventory year. The inventory of the category 1A2f - Manufacturing industries and constructions covers all industrial sources not included in other categories. The reallocation will be prepared for the next submission according activity data from NEIS and allocation of sources among the ETS.

In 2007, the energy sector reached a 2.7% share on the total GDP (according statistical information of Ministry of Finance). Energy intensity calculated on purchasing power is gradually decreasing, and was 1.9 times higher than the average recorded in the EU. The reason is a high proportion of heavy-energy-demanded industry contributing to the GDP.

Figure 1.2: Development of primary sources consumption (PJ) per GDP (billions Euro 2000) and energy intensity in the SR.



Two IPCC methods are prescribed for the determination of emissions from fuel combustion of stationary sources. The Statistic Office of SR inserts National energy balance every year, which is base for calculation of reference approach (RA) (top down). The reference approach determines the apparent consumption of individual types of fuels (primary, secondary and biomass) for which inventory is prepared. The sectoral approach (SA) (bottom up) is based on National Emission Inventory System (NEIS), the database of stationary sources, which collects the data of fuels consumption from the major sources of air pollution in the Slovak Republic. Reference and sectoral approach are estimated on fully independent data sets, whereby obtained differences are negligible. The difference between the top down and the bottom up energy balance estimates the uncertainty level. The Slovak Republic is using reference approach as a national total emission estimate of CO_2, while consistent data series since 1990 exist only for this approach. The carbon emission factors (t C/TJ) are estimated for individual fuels type based on international methodology (IPCC, OECD, IAEA) and national measurements (expert judgment). The revision will impact fuels base, NCV and emission factors in accordance with the new inputs from operators of the most important plants and national legislation requirements. The revision was started in previous year and will be developed in co-operation with the Profing Ltd. company.

1.4.2 Energy Sector – Category Transport

The transportation sector is in the last years not negligible source of emissions of all GHGs and indirect pollutants too. The emissions from this sector have increasing tendency every year and are the key source in level and trend assessment for calculation of uncertainty management. The emissions from road transport were calculated by using COPERT III method. The emissions from international bunkers from aviation were improved in the last year and the expert's judgment was used in this estimation.

Emission inventory of pollutants including GHG gases from road traffic is compiled by experts and it is based on relevant input data and other information provided by set of institutions using methodologies recommended and approved by SHMÚ.

Base information used for inventory compilation of GHG gases from road transportation is provided by:

- SLOVNAFT a.s. Bratislava and PETROCHEMA a.s. Dubová – 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 member countries of European union.
- Customs Directorate of the Slovak Republic - provides data concerning import and export of gasoline and diesel fuel from countries that are not members of European union.
- 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 – provide data concerning selling of LPG gas 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 Slovakia.
- 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 Slovak Republic, Department of Documents and Registration of Presidium – provides data concerning numbers of new registrations, changes if the registration and deregistration of road vehicles at the end of the year of the emission inventory.
- Association of car industry of Slovak Republic – in its statistical yearbook can be found detailed data concerning structure of all type of cars sold in Slovak Republic during actual year.

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

- Železničná spoločnosť Slovensko, a. s - provides fuel consumption data and selected operation capacity of combustion engine driven locomotives in personnel railway transport.
- Železničná spoločnosť Cargo Slovakia, a. s. – 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 – provides data concerning numbers of driving ships on Slovak extent of Danube.
- Slovak navigation and harbors Inc. Bratislava – provides data about selling of diesel oil from custom storage to navigation companies in Slovak harbors.

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

- Aero servis Košice, ESSO Bratislava and Bratislava airport – provides data about sales of aviation fuels to airlines on important airports in Slovakia.
- Bratislava Airport, Košice Airport, Poprad – Tatry, Sliač Airport, Piešťany Airport and Žilina Airport – provide inventory team with total numbers of LTO cycles on particular airports. These date are partially used as additional data for national GHG inventory compilation. However, such data are fully used to determine local air pollution of the airport.

Most important part of inventory compilation process is to collect and evaluate and process data concerning fuel consumptions used in particular transport categories. Next step is determination of emission factors, according to procedures defined by methodologies required for calculation of emissions.

Several improvements are planned in the transport sector as the most dynamic developing sector. The biofuels balance will be included in the diesel oil fuel consumption. The methodology is based on recent information about national fuel's characterization and other relevant information from major distributors of fuels. Emission factor for the blended diesel oil will be lower than current used EF for CO_2.

In the aviation category, the situation is more complicated with the lack of sufficient information from national and international aviation operators. The first analyses were performed with the relevant institutions and Ministry of Transport. The methodology for aviation emissions estimation will be revised in the concern of aviation ETS decision proposal after 2012. The relevant input date will be also discuss with EUROCONTROL.

The road transport emission estimation is based on model COPERT III at the present. In the next inventory submission the new version COPERT IV will be used. The improvement is in the detailed categorization of heavy duty vehicles.

1.4.3 Energy Sector – Category Fugitive Emissions

The important source of methane emissions in national GHGs inventory are fugitive emissions from coal mining & handling and oil & natural gas distribution as a key sources categories in uncertainty estimation. The Slovak inventory team in co-operation with Profing, Ltd. provided the revision of emissions and emission factors for underground mining and handling during the previous inventory year 2004 due to inconsistent emission factors. These ones used until now were suitable mainly for hard coal underground mines. The important reason for this opinion is an occurrence of brown coal underground mines with mainly non-gaseous system. Emission factors according to the IEA – CIAB – the published values for mining were assigned according to the depth of the mines. The fugitive emissions from transport and distribution of NG were calculated using new emissions factor refined EF (CH_4) for tier 1, based on North America data - IPCC Good Practice Guidelines, Table 2–16. The fugitive emissions of methane were recalculated from transport and distribution of natural gas activities.

1.4.4 Industrial Processes Sector – Category Industry

The industrial sector is a source of CO_2, CH_4, N_2O, NO_x, CO, NM VOC, SO_2, CF_4, C_2F_6, and SF_6 pollution. Even though the emissions of CO_2 and N_2O are reported in this sector only, because of problematic estimation of this emissions and hard separation of industrial sources and fuel combustion sources from each other in industrial processes. The emissions of CO_2 occurring by manufacture of glass, ammonium production and iron & steel production are included in the sectoral approach for energy sector – manufacturing industries and in the reference approach in the balance of fossil fuel combustion. The situation is complicated by the confidentiality aspects of adopted legislation (which is like protecting the large installations against the publicity of activity data). The national EFs are available only for several industrial processes (cement and lime production, limestone and dolomite use and the magnesite production).

The GHG emissions inventory for IP sector is estimated in accordance with the methods provided in IPCC 1996 Revised Guideline and Good Practice Guidance. National methodology is used in some categories. The information required in the sector is obtained from different sources; from the Statistic Office of the SR and from producers.

Major sources are balanced by advanced methods recommended by IPCC 1996 Revised Guideline and Good Practice Guidance (Tier 2 or Tier 3 methods). National methodology is used at balancing of N_2O emissions from nitric acid production on the basis of measurements realized by the plant Duslo, a.s. Šaľa (Research Report, Duslo, a.s. Šaľa, Slovakia, 2006).

Planned improvements in IP sector were decided according priority and analyses of the new 2006 IPCC Guidelines, including new gases and sectors. The methodology of iron and steel industry will be reviewed in the view of the new available specific information from plant and emission trading scheme reports published during 2005–2007. The analyses of urea production in chemical industry is needed. The production of other chemical substances and gases will be considered and included into inventory.

1.4.5 Industrial Processes Sector – Category F-Gases

An evaluation of sent and processed data on the sources and emissions of the substances in the Slovak Republic is realized on the base of recommended emission factors corrected according to the received data by the IPCC Methodology (IPCC, 1996).

In the F-gases, the situation is complicated with the lack of direct information of imported F-gases mixtures. The analysis shows that in the year 2006 was reached faster application of HFCs because the HCFCs applications have been completely abandoned in new installations by the Act n. 76/1998 Z.z. in version n. 408/2000 Z.z. in the year 2004. Given substances are not solo (independently) documented under any of items in custom scale of rates (tariff). On the base of description of the F-gases with GWP in questionnaires, they are sent to potential importers, producers, users and consumers of given substances in SR. It means that we have lot of different data sources on the base of questionnaires. Due to the links, relations in the questionnaire to other potential importers, producers, and that the most of the companies are presented in Catalogue of RAC companies and are the members or are trained by Slovak Association of Cooling and Air Condition Technique which is authorized by Ministry of Environment for training and certification of personnel, or they are on the internet, participate on the exhibitions. Decline of extinguishing media consumption is because they are very expensive and the investment to them is planned for a longer time.

1.4.6 Solvent and Other Product Use Sector

The emissions of NM VOC from this source category are estimated based on CORINAIR methodology since 1990 (CORINAIR, 2003). The N_2O emissions were estimated from 2001, according the internal statistics of distributors for medicinal and food purposes. The solvent use sector was recalculated to the base year in last submission according the recommendations of the ERT in the previous review. The inventory of emissions from solvent and other product use is based on NMVOC emissions and direct N_2O emissions. The methodology for CO_2 emissions according NMVOC emissions is under consideration of the sectoral expert and planned for the next submission.

1.4.7 Agriculture Sector

The sources of N_2O and CH_4 emissions from agriculture are analyzed according to IPCC Methodology (IPCC, 1996), when principles of Good Practice (IPCC, 2000) in GHGs inventory in agriculture (1999) were taking account. The basic sources of data used for evaluations of emissions in this study were published in (Statistical yearbook, 1990–2008, Green Report, 1998–2008).

The several important methodological changes have been occurred during last inventory submission in agricultural sector. The recalculation were based on using Tier 2 methodology in methane emissions from enteric fermentation and manure management. The activity data were compared from two sources – Statistical Office of the SR (regional statistics) and the Green Report of the Ministry of Agriculture of the SR. The data provided by regional statistics are more precise and detailed. The estimation were recalculated to the 1997, until regional data were available. The time series were calculated back to base year using linear regression and expert judgment. Data published in Green Report of the SR, as well as 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%. Subcategories of domestic livestock can be estimated according to Annual census of domestic livestock. in the SR. Data from this publication are issued relatively soon after end of previous year but many times they are different as compare with data from Green Report or Statistical yearbook. Productivity of different categories of domestic livestock varies in conditions of the Slovak Republic significantly in dependence on scale and production level of farm.

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 the animal categories will be updated based on the information known from regional statistics. Table 4B(b) in the CRF will be fulfill according the recommendations of the ERT from the previous review. The direct N_2O emissions from soils will be recalculated according the new research knowledge in agro-climatic regionalisation in the SR. Based on this approach, the first output from the model DNDC are known. The direct measurements of N_2O soil's emissions to adjust model are planned for the international project of the Agricultural University in Nitra (Slovak Republic).

1.4.8 LULUCF Sector

According to the COP Decision 13/CP.9 for reporting in LULUCF sector was adopted new methodology and reporting tables. GHG emissions and sinks were recalculated for the time series 1990–2006 in the consistency with new requirements.

Results of calculations were obtained by using the IPCC Methodology (IPCC, 2003) and the national data on wood volume increments for individual forest tree species, and results of a roundwood harvest inventory.

Compilation of inventory for particular year in the sector LULUCF starts with analysis of previous inventory years (to achieve temporal continuity) and with identification of possible methodological changes issued either by new requirements of the inventory coordinating body or due to new knowledge or relevant databases. After analytical part is closed, following phase of collection and verification of data is started. This phase covers period from April till end of July. Sources of processed data are mainly taken from previous yearly statistics of the Ministry of Agriculture published also on internet pages of the ministry (www.mpsr.sk) and in so called Green reports about status of agriculture, food production and forestry management. During this phase direct contact of experts with officers from ministry or from organizations managed by ministry is also active. This phase finishes normally by end of July, when all base data required for balance calculations are already prepared. During period covering July till September all balance calculations are performed and verified. Results are compared with data from previous inventories. This is also time for recalculation of balance data for more previous years if required. This could be done due to methodology changes or because of acquisition of new actualized data for particular year. Complete inventory data for the sector is normally available on October 15th. This inventory is sent to national coordinator (SHMU). Next period till end of December is used to prepare adequate sectoral part of the National Inventory Report. Along with that problems if there are any are consulted with national coordinator. During December all data should be prepared and be send to „JRC Ispra“(Coordination Center of the EU for GHG inventories for AFOLU sector). Methodological procedure of the GHG inventory for this sector is mainly based on IPCC Revised 1996 Guidelines, 2005 Good Practice Guidance for Land Use, Land-Use Change and Forestry and on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories 2000.

Several improvements can be implemented in the next inventory submission from LULUCF. Due to lack of activity data for dead organic matter (DOM is not a part of forest inventory), this part of stock carbon changes was not estimated in the previous inventory submission. According the recommenddations of ERT from the previous review, the emission balance of DOM shall be completed. Inventory data for soil carbon showed no significant temporal changes in soil carbon stocks on forest land remaining forest land. Therefore the stock carbon changes in mineral soils are not estimated due to less importance in Slovak forests. The statement will be review according the new forest inventory results. The several notation keys in the LULUCF sector were identified as inappropriate use, the revision of using NE notation key will be performed in the next submission.

1.4.9 Waste Sector

Production of CH_4 and N_2O emissions from waste disposal and wastewater treatment activities is balanced. The IPCC methodology and Good Practice Guidelines were used to estimate of methane emissions from waste and wastewater treatment. Emissions of nitrous oxide from wastewater were calculated by using IPCC and recalculated according to country specific parameters. Database of Centre of Waste Service and Environmental Management in Bratislava and database of Wastewater on the SHMÚ have been used as a source of input data GHG emissions from the waste sector are the key source and concerning to the actual EFs there are estimated with the high uncertainty level.

Emissions of methane from SWDS were estimated with the Tier 2 methodology (First Order Decay = FOD) according the advises of the ERT and European Commission. All time series were recalculated from 1960 and the complete methodology approach was changed.

Inventory of waste is based on information published annually by the Statistical Office of the Slovak Republic in the 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 the Slovak Environmental Agency) on industrial solid waste data,
- Terrasystems Banska Bystrica on methane recovered from SWDSs,
- ACE (Association of Experts on Waste Water Treatment) on sewage sludge management,
- Duslo a.s. on ISW incineration

Additionally, web-sites of several companies and institutions were used for inventory: OLO, KOSIT, Slovnaft, Duslo, NsP Prievidza, Fecupral, ecorec.

All information used for preparation of waste inventory is archived by the author.

During last inventory all activity data were critically reviewed and complete recalculation were done in waste sector, especially SWDS, waste incineration and composting. Also, the IPCC 2006 Guidelines were used as the basis for emission estimation for the first time. It is proposed to focus in the next phase on the category 4D: Wastewater Treatment and Discharge in the light of 2006 Guidelines. This would complete the review of the Waste Sector. Further, the IPCC FOD model should be tested for estimation of emissions from SWDS and for emissions prediction, as the 4A category represents 98% of GHG emissions form solid waste.

The major further improvements are planned in the wastewater treatment category. Currently using ISI methodology for N2O emissions will be reviewed and improved based on the new information from the 2006 IPCC Guidelines. Further improving in local parameters is needed including the searching of historical data. Regular data collection is since 1992, the expert judgment will be needed to reconstruct the data series.

Research possibilities for multiphase model to minimize mixed municipal solid waste (MSW) and switch from sectoral approach to waste type approach can be considered. Identification of biodegradable waste in EWC will be needed. Industrial waste is not a function of GDP at the moment; this approach will be included in the next submission.

1.5 Description of Key Sources

To reduce uncertainty in emission inventory is important to recognise the key source categories. It is necessary to know that a key source category is one that is prioritized within the National Inventory System because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both.

The key source categories by level assessment and trend assessment were chosen those, whose cumulative contribution is less than 95% and are enclosed to this National Inventory Report 2007 followed the Good Practice Guidance (IPCC, 2000 and 2003). The Slovak Republic determined in year 2007 17 key source categories by level assessment with LULUCF and 24 key source categories without LULUCF. The SR determined in year 2007 45 key source categories by trend assessment with LULUCF) and 33 key source categories without LULUCF (Annex 2). The most important key source categories in the SR are fuel combustion, road transport and the emissions of N_2O from agricultural soil and methane emissions from SWDS etc. 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.

The presented key source analysis was performed by SHMÚ with data for greenhouse gas emissions of the submission 2009 to the EC (280/2004/EC) and comprises a level assessment for years 1990 and 2000–2007 and a trend assessment for the trend of the years 1990 (1995) to 2007.

The method used to identify key source categories follows the Tier 1 method – quantitative approach described in the IPCC Good Practice Guidance 2000 (Chapter 7 Methodological Choice and Recalculation). The identification of key source categories has following steps:

- Identifying source categories;
- Level Assessment;
- Trend Assessment.

Level of disaggregating and identification of key source categories was chosen according those source categories that have been estimated using the same methodology and the same emission factor. In this way the following categories and sub-sectors were chosen expressed in CO_2 equivalent emissions for the years 1990 (1995) to 2007.

1.5.1 Level Assessment

For the level assessment the contribution of GHG emissions (expressed in CO_2 equivalent emissions) of each relevant source category to national total emissions was calculated. The calculation was performed for the years 1990 or 1995 for to 2007 according to Equation 7.1 of the GPG 2000. Then the sources were ranked in descending order of magnitude according to the results of the level assessment and finally a cumulative total was calculated.

1.5.2 Trend Assessment

The trend assessment identifies source categories that have a different trend from the trend of the overall inventory. As differences in trends are more significant at the overall inventory level for larger source categories, the result of the trend difference is weighted according to the source's level assessment. For the trend assessment, emissions of the years 2007 were compared with base year emissions (1990 or 1995 for F-gases), resulting in eight calculations. The calculation was performed according to Equation 7.2 of the GPG 2000. The results were ranked in descending order of magnitude and a cumulative total was calculated. (Annex 2)

1.5.3 Key Source Analysis for Base Year 1990

The level key source analysis for base year was evaluated by Tier 1 methodology with and without LULUCF. The Slovak Republic determined in year 1990 9 key source categories by level assessment with LULUCF and 14 key sources without LULUCF.

1.6 QA/QC Procedure

SNE still tries to improve quality of greenhouse gas emission inventory according to the IPCC 2000 Good Practice Guidelines and IPCC 2005 GPG in LULUCF in accordance with principles of consistency, transparency, comparability, accuracy and in the framework of QA/QC. A draft to improve quality of process of estimating emissions in particular sector is worked out each year. The first analyses of the 2006 IPCC Guidelines and its implications to the accuracy were done during last inventory preparation. Several improvements were implemented in energy, agriculture and waste sector.

The Slovak Hydrometeorological Institute is a company which has build and introduced the quality management system according the requirements of the EN ISO 9001:2000 standard of conformity 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 air and waters.

- Study and description of the atmosphere and hydrosphere phenomena.
- Education and training within the activity of institute.

Sectoral experts apply the QA/QC methodology to our conditions, 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) which requires detailed review of quality of each input parameter, works out uncertainty analysis. Complete emission inventories of greenhouse gases are subject to critical review by independent experts from the Czech Republic.

There are a number of sub-processes and feedbacks in working out an inventory. Inventory in a given sector is divided to partial methodologies (e.g. „Reference approach“ and „Sectoral approach“ in the energy sector). It is further divided to processing by categories and gases (transport, F-gases).

Data are provided in particular by Statistical Office, National Emission Information System – NEIS, operated by SHMÚ and individual questionnaires of national experts through which some data are acquired directly from legal entities. Relatively large collection and validation of data on air pollution sources via bottom-up approach are carried out in the framework of the National Emission Information System (NEIS). Since 2000, this system has included a large database of data from approximately 10 thousand sources and on 120 pollutants. This system serves primarily to the needs of implementation of air protection legislation (Act 478/2002 on air protection, Act 401/1998 on charges for air pollution, Act 245/2003 on integrated pollution prevention and control, Decree of the MŽP SR 61/2004 laying down requirements for keeping operational records on stationary resources and others). NEIS is a source of data on activities serving to estimate greenhouse gas emissions in particular in the energy and industry sectors. However, it will be a difficult task for the future to work out functions of NEIS so that it can provide data for inventory and projections of greenhouse gases and so that the data provided by NEIS and the data provided within the CRF inventory to the UNFCCC or data used in NAP for greenhouse gas trading are consistent.

National expert responsible for inventory compilation collects partial reports, controls, and comments and publishes in the national report. National expert fills in the database of a used programme module „CRF Reporter“ and provides these data to the UNFCCC and to the European Commission.

After carefully analysing outcomes of the 8th centralised review of 2008 annual submission of the Slovak Republic was initiated meeting with the National Focal Point to the UNFCCC at the Ministry of the Environment – Department of the Climate – Energy Package and Renewable to define and make necessary steps as to avoid problems with compliance. After discussion was agreed that following steps should be taken immediately:

- Screening of companies providing for QMS services in relation with the emission inventories (MŽP- NFP, already done).
- Estimation of financial costs (MŽP – NFP, already done).
- Identification of financial resources (MŽP – already done).
- Terms of reference for tender on QMS provider (MŽP-NFP, SNE – already done).
- Tender for company to realize QMS project (MŽP-NFP).
- QMS project for process and elements of GHG emission inventory, including the QA/QC procedure.
- Necessary further steps based on outcomes of QMS project (MŽP-NFP,SNE).

Extent and requirements for quality management system (QMS) have already been defined, practical application is expected in a short time after completing necessary steps in the area of organisational arrangements and data archiving system. At present a project was completed which was aimed at providing software to archive methodological procedures, database of input and output data in particular IPCC sectors, including the publishing of information in accordance with requirements of 20/CP.7 (obligation to establish and operate postal and electronic address and internet page of a national unit for emission inventories SNE). The emission estimates elaborated for individual sectors by external consultants are controlled and recalculated at the DoAQ on the SHMÚ. Activity data for major sources are compared with national statistics and with previous year's submitted data (e.g. change in fuel base, respectively fuel quality characters, technology, separation technique, etc.) A quality management system (QMS) has been designed to achieve the objectives of good practice guidance, namely to improve transparency, consistency, comparability, completeness and confidence in national inventories of emissions estimates.

Energy balance from energy statistics is compared with summary fuel consumption reported by sources. Fuel consumption in transport based on fuels sold is compared with the model results. External reviewers (from the Czech Republic) are regularly invited to comment the inventory results. Control procedures are continuously developed and built in to the National Inventory System. Structural changes of the current NIS, in accordance with the new air protection act (transposition of EU air pollution legislation), is ongoing process. Harmonisation of all pollutant inventories and ISO9001 are introducing. In accordance with these requirements the inventory results for the year N are completed to the 31 December (N+1) and the inventory results of the basic pollutants for the year N are completed to the 15 January (N+2) draft and 15 April (N+2) final version.

SNE still tries to improve quality of greenhouse gas emission inventory according to the IPCC Good Practice Guidelines 2000 and IPCC GPG in LULUCF 2005 in accordance with principles of consistency, transparency, comparability, accuracy and in the framework of QA/QC. A draft to improve quality of process of estimating emissions in particular sector is worked out each year. The waste sector – solid municipal waste landfills – was reassessed and recalculated in accordance with the methodology FOD, approach Tier 2. Default parameters have also been reassessed or replaced with national data. A plan for revision of emission factors for solid and liquid fuels in the energy sector has been prepared. The solvent sector was assessed since 1997 when information from individual operators became available. Time for the solvent sector is planned to be added in a near future.

Table 1.3: The results of key source analysis in trend and level assessment with and without LULUCF, year 2007.*

Source Category Analysis Summary (2007 GHGs Inventory)			
*Quantitative Method Used: TIER 1 with LULUCF and without LULUCF**			
ENERGY SECTOR	**GHG**	**Key Source**	**Criteria**
1.A.1 Energy Industries	CO_2	yes, yes*	Level, Trend, Level*, Trend*
1.A.1 Energy Industries	CH_4	no	
1.A.1 Energy Industries	N_2O	no	
1.A.2 Manufacturing Industries and Construct	CO_2	yes, yes*	Level, Trend, Level*, Trend*
1.A.2 Manufacturing Industries and Construct	CH_4	no	
1.A.2 Manufacturing Industries and Construct	N_2O	no	
1.A.4 Other sector	CO_2	yes, yes*	Level, Trend, Level*, Trend*
1.A.4 Other sector	CH_4	no	
1.A.4 Other sector	N_2O	no	
1.A.3.a Transport - Civil Aviation	CO_2	no	
1.A.3.a Transport - Civil Aviation	N_2O	no	
1.A.3.b Transport - Road Transportation	CO_2	yes, yes*	Level, Trend, Level*, Trend*
1.A.3.b Transport - Road Transportation	CH_4	no	
1.A.3.b Transport - Road Transportation	N_2O	no	
1.A.3.c Transport - Railways	CO_2	no	
1.A.3.c Transport - Railways	CH_4	no	
1.A.3.c Transport - Railways	N_2O	no	
1.A.3.d Transport - Navigation	CO_2	no	
1.A.3.d Transport - Navigation	CH_4	no	
1.A.3.d Transport - Navigation	N_2O	no	
1.A.5.a Other non-specified	CO_2	yes, yes*	Level, Trend, Level*, Trend*
1.A.5.a Other non-specified	CH_4	no	
1.A.5.a Other non-specified	N_2O	no	
1.B.1.a Coal Mining and Handling	CH_4	no	
1.B.1.b Fugitive Emission from Oil, Natural G	CH_4	yes*	Level*, Trend*
INDUSTRIAL SECTOR	**GHG**	**Key Source**	**Criteria**
2(I).A.1 Cement Production	CO_2	yes, yes*	Level, Trend, Level*, Trend*
2(I).A.2 Lime Production	CO_2	yes, yes*	Level, Trend, Level*, Trend*
2(I).A.3 Limestone and Dolomite Use	CO_2	yes*	Level*, Trend*
2(I).A.7 Magnezite Use	CO_2	no	
2(I).B.2 Nitric Acid Production	N_2O	yes, yes*	Level, Trend, Level*, Trend*
2(I).C.1 Iron and Steel Production	CO_2	yes*	Level*, Trend*
2(I).C.3 Aluminium Production	CO_2	no	
2(I).C.3 Aluminium Production	PFCs	no	
2(I).F HFCs emissions	HFCs	no	
2(I).F SF_6 emissions	SF_6	no	
SOLVENT SECTOR	**GHG**	**Key Source**	**Criteria**
3.D Other Solvent Use	N_2O	no	
AGRICULTURE SECTOR	**GHG**	**Key Source**	**Criteria**
4.A Enteric Fermentation	CH_4	yes, yes*	Level, Trend, Level*, Trend*
4.B Manure Management	CH_4	no	
4.B Manure Management	N_2O	yes*	Level*, Trend*
4.D Agricultural Soils	N_2O	yes, yes*	Level, Trend, Level*, Trend*
LULUCF SECTOR	**GHG**	**Key Source**	**Criteria**
5.A Forest Land	CO_2	no	
5.A Forest Land	CH_4	no	
5.A Forest Land	N_2O	no	
5.B Cropland	CO_2	no	
5.C Grassland	CO_2	no	
5.F Other Land	CO_2	no	
WASTE SECTOR	**GHG**	**Key Source**	**Criteria**
6.A Solid Waste Disposal on Land	CH_4	yes, yes*	Level, Trend, Level*, Trend*
6.B Wastewater Handling	CH_4	yes, yes*	Level, Trend, Level*, Trend*
6.B Wastewater Handling	N_2O	no	

1.7 General Uncertainty Evaluation

The uncertainty of estimation of CO_2 emissions is mainly caused by uncertainty of statistical data on consumption. Another source of uncertainty is the applied default emission factors. An additional error in calculation of the other greenhouse gas emissions may occur because of less exact methods and it cannot be estimated. Quantification of emission's uncertainty by level and trend assessment was calculated by using Tier 1 method published in Good Practice Guidance (IPCC, 2000). Even though the Tier 1 uncertainty analysis were estimated the uncertainties to be 14% by level assessment and 8.0% by trend assessment (Annex 2).

The calculation uncertainty by using the more sophisticated Tier 2 - Monte Carlo method is evaluated second year by cooperation with the external expert from Faculty of Mathematics, Physics & Informatics Mr. Martin Gera.

According to the most resent results, the research article "Emission Estimation of the Solid Waste Disposal Sites According to the Uncertainty Analysis Methodology" was published[10] in the official journal. The main topic of this article was to eliminate uncertainty of methane emissions produced by solid waste disposal sites. From our analyses seems that uncertainty of emissions are strongly dependent to the PDF's setting. These features were identified by simplest linear analyses of uncertainty of total emissions and in the second case with changing PDF's setting. The data accuracy play important role to the total uncertainty. PDFs selection in the case of symmetry uncertainty has no significant influence to the total uncertainty. Increasing of partial uncertainties for input factors multiple total uncertainties in the symmetrical cases. In the case of asymmetry, total uncertainty could be smaller than uncertainties of single input parameters. This approach shows that more important feature which has strongest influence to the total uncertainty is asymmetry allowance. The essential result from our study is fact that total uncertainty was reduced comparable to IPCC default recommended value. This value is 50% for total methane emissions from SWDS. This default uncertainty 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 the 90% of the level or trend uncertainties are also taken for the key sources specification. Specification and identification of the key sources are important for economy and government institutions to obtain overview of emissions unload. During the uncertainty computation the emitting of CH_4 from underlayer and many other factors as meteorological condition, managing of sites are included. These dependences are expressed in FOD model, which was solved by Monte Carlo simulation. Spreading of emission uncertainty during the analyzed period was obtained. From the computed result precision increasing of emissions are observed. In spite of high inaccuracy on the input data in the beginning of the examined period (this uncertainty has influence to the current uncertainty) the relative valuable result are obtained.

The Monte Carlo method is based on the generation of multiple trials to determine the expected value of a random value. In case of the SR this method is uncertainties combination of probability distribution functions for activity data (AD) and emission factors (EFs). Total emissions are computed as combination of random numbers for appropriate distribution function for assigned greenhouses gases. The advantage of this method is asymmetry allowance to the statistical distribution. This is useful for data manipulation, in the case, when proper input data quality is provided. For this reasons the software package, which works with probabilistic distribution and their combination, was developed. With help of AuvTool software, they create useful tools for uncertainties estimation. In developed packages the next statistical distributions are supported.[11]

For specification of probability distribution of AD and EF there are varieties of inputs. For two parameters distributions the mean value and values represented 95% confidence interval are directly expressed. There are few ways how insert these values, one can do it with direct values, or with

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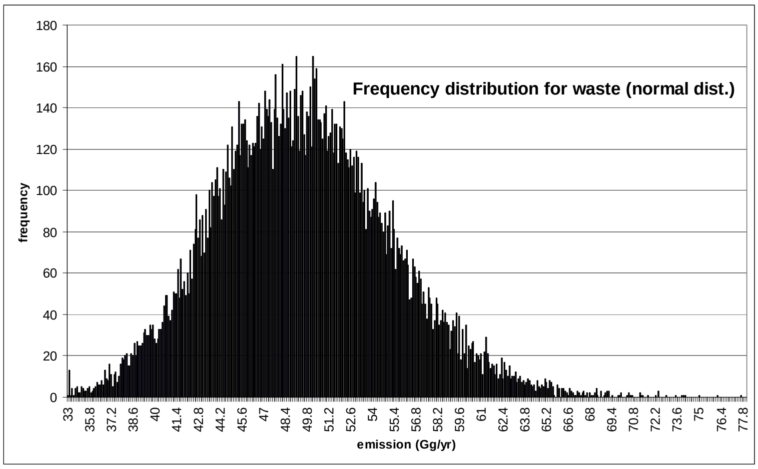
[10] *J. Szemesova, M. Gera: Contributions to Geophysics & Geodesy,37/3, 2007*

[11] *Gumbel, Exponential, Weibull, Lognormal, Uniform, Triangular, Beta, Binomial, Neg_binomial, Chisq, Nc_chisq, F, Nc_F, Gamma, T, Nc_T, Normal and Poisson.*

relative, eventually with percent values. For three parameters distribution there is place for tuning 95% confidence interval (to be close with expert opinion).

From mathematical or better say from statistical point of view, there are no difficulties with formulas computation. After sector expert consultation, how one can expect, the most difficult parts is model initialization (input data for developed software). Chosen of the appropriate distribution function triggers for AD and EF some difficulties, mainly in the case of the absence of the direct measured data. These procedures consume a majority of exerted effort.

Figure 1.3: Total emission of CH_4 for the year 2005 for normal parameters distribution with 10% uncertainties for all parameters.



1.8 General Assessment of the Completeness

Completeness by source and sink categories and gases

The Slovak Republic is reported in its CRF 2007 submission 2009 gases or source/sink categories as not estimated (NE) and categories, whose are reported as included elsewhere (IE) are explained in Tables 9(a) CRF. The additional GHG emissions are not reported. In some categories (waste incineration, off-road transport, wastewater or solvent use sector) are not consistent the data from the base year caused by lack of input data and resources, but the SHMÚ in cooperation with MŽP is doing number of steps for improving the actual status in inventory completeness. In accordance with the IPCC Guidelines, international aviation and marine bunker fuel emissions are not included in national totals. The description of the actual situation in completeness is provided in CRF Table 9. All sources and sinks included in the IPCC Guidelines are covered in the inventory year 2006. No additional sources and sinks have been identified. Both direct GHGs as well as precursor gases are covered by the SR inventory. The geographic coverage is complete; all territory of the Slovak Republic is covered by the inventory. The sources and sinks not considered in the inventory but included in the IPCC Guidelines are clearly indicated, the reasons for such exclusion are explained. In addition, the notation keys presented below 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).

Completeness by geographical coverage

The geographical coverage of the inventory is complete. It includes emissions from the territory of the Slovak Republic.

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 are provided in Annex 5.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Emission Trends for Aggregated GHG Emissions

The major indicator of emissions trend in the last years is the comparison of GDP and per capita emissions. Main reasons for decoupling of GHG emissions from GDP growth in the last period are:

- Higher share of gas fuels in the total primary energy consumption.
- Ongoing privatization and restructuring of industries.
- Slightly increasing share of services on the total GDP.
- Regulation and implementation of energy saving measures in the heavy energy demanding sectors.
- Positive indirect impact of air protection regulatory measures (fuel switching towards less carbon intensive fuels).

While indicator of carbon intensity can be changed much more rapidly in situation of high dynamic of economic growth, GHG per capita is different case where you can get very impressive results even without measures, just by higher population growth rate - and this is not the case of the Slovak Republic just now. It will take much longer time to change numerator by impact of new technologies implementation namely in combination with high dynamic of development in the energy intensive industries.

Table 2.1: The Indicators of per capita trend 1990–2007.

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Populations	5 298	5 283	5 307	5 325	5 347	5 364	5 374	5 383	5 391	5 395	5 401	5 380	5 379	5 379	5 383	5 387	5 394	5 401
Total GHGs	73 255	65 597	60 905	55 640	53 696	52 595	51 071	49 939	50 457	49 470	48 424	50 090	48 986	50 191	49 985	49 375	48 938	46 951
Per capita	**13,83**	**12,42**	**11,48**	**10,45**	**10,04**	**9,81**	**9,50**	**9,28**	**9,36**	**9,17**	**8,97**	**9,31**	**9,11**	**9,33**	**9,29**	**9,17**	**9,07**	**8,69**

In accordance with the generally expected results, the aggregated emission of GHGs in year 2007 decreased significantly comparable to the previous inventory year 2006 by almost 2 000 Gg excluding LULUCF, it means approximately 4%. With the including the sector LULUCF the net aggregated emissions in 2007 inventory year decreased comparable to previous year 2006 by more than 2 100 Gg it means more than 4%. The reason is in increasing the sinks in LULUCF sector, as has been expected in the projections last year. After period of decreasing according the natural catastrophe in the large part of forest in the end of 2004 in High Tatra Mountains, the forest was destroyed, the new reconstruction of forest took place.

There is the significant decreasing of aggregated emission against the base year (1990) about appro-ximately 26 300 Gg it means the decreasing about more then 35.91% without LULUCF and more than 38.26% with LULUCF sector.

The total national emission in the current inventory year 2007 was estimated to be 46 950.67 of CO_2 equivalents without LULUCF sector and the net GHG emission was 43 754.23 Gg including the sinks from LULUCF. The Slovak Republic reported the national emission from energy sector based on sectoral approach data in 2007 to be 35 531.78 CO_2 equivalents including the transport emissions (6 719.36 Gg of CO_2 equivalents), which represent decrease compare the base year by about 40% and also decrease compare to the previous year by 5%. The transport subsector increases against previous year 2006 by 13% and comparable to the base year by 33%.

The total emissions from industrial processes sector in 2007 were estimated to be 5 825.32 Gg of CO_2 equivalents. This is increase compare the base year by about 10%, but also decrease compare to previous year about 2%. The numbers were changed because the recalculation of all time series in the nitric acid production. Intensive growing of the industry production causes the increasing of emissions.

The total emissions from sector of solvent use were estimated to be 79.95 Gg of CO_2 equivalents this is decreasing comparable to previous year about 3%. The time series is now complete, the period

1990–1993 (before the SR formation) is not sufficiency covered by statistical data (lack of the national statistics data) and the constant expert judgment values for this period was used. The comparison with the base year is now possible, the increasing in more than 4 and half time.

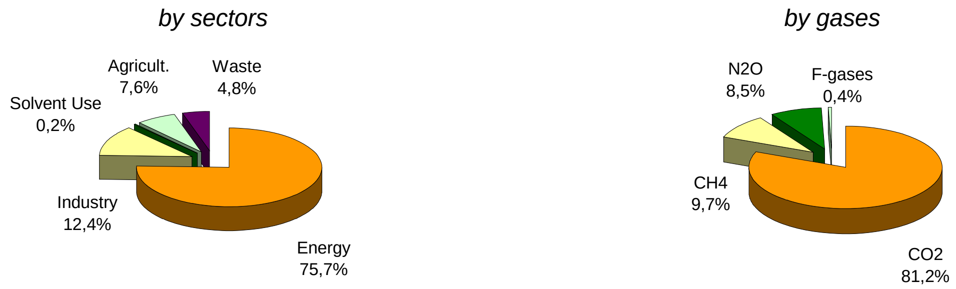
The emissions from agriculture sector were estimated to be 3 224.56 Gg of CO_2 equivalents It is decrease compare the base year by about 54% and minor increase comparable to the previous year. The agriculture sector is the most decreasing sector comparable to the base year 1990.

The total emissions and sinks from LULUCF sector were estimated to be –3 196.44 Gg of CO_2 equivalents, the whole time series 1990–2007 were recalculated according the new methodology[12] and those emissions and sinks were included into the submission. The estimation of emissions and sinks in the LULUCF sector are complicated to explain with the consistent time series.

The emissions from waste sector were estimated to be 2 269.07 Gg of CO_2 equivalents. The decrease comparable to the previous inventory year is 5%, but comparable to the base year the decrease was registered more than 53%, because of including the waste incineration from base year and other waste treatment activities into energy sector (with energy use). The methodology changes for wastewater treatment plants and the complete time series reconstruction was caused the decreasing the waste sector, but this is expected trend. The reallocation of energy used waste incineration and recovery of landfill methane emissions were the driving force for the trend decreasing in the last submission.

A major share of aggregated emission covers the energy sector by about 75.7%, the industrial processes sector covers about 12.4%, the solvent use sector about 0.2%, the agriculture sector about 7.6% and the waste sector about 4.8%. The major share of aggregated emission covers CO_2 emissions by about 81.2%, CH_4 emissions by about 9.7%, N_2O emissions by about 8.5% and F-gases emissions by about 0.4%. The share of gases and sectors didn't change during last period.

Figure 2.1: The aggregated GHG emissions in 2007



2.2 Emission Trend by Gas

The total anthropogenic emissions of carbon dioxide decreased relating to the base year (1990) by more than 38% without LULUCF and represented in current year 38 141.33 Gg of CO_2 without LULUCF sector. Comparable to the previous inventory year, the decreasing is about 1 840 Gg of CO_2.

The total anthropogenic emissions of methane reached in the 2007 almost 4 531.64 Gg of CO_2 equivalent without LULUCF and the trend is relative stable during the last years with decreasing comparable to the base year by more than 5%.

The total emissions of N_2O increased relating the previous year to 4 008.39 Gg of CO_2 equivalent without LULUCF and decreased relating the base year about 36%. The trend is slightly increasing during last years and depends of the nitric acid production.

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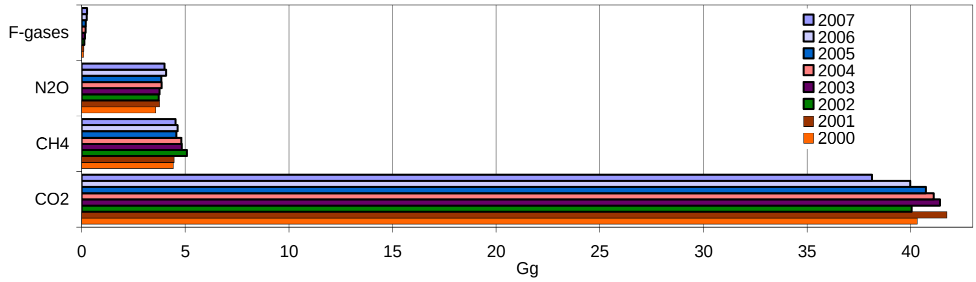
[12] *IPCC 2003 Good Practice Guidelines for LULUCF*

The total emissions of F-gases represented 269.31 Gg and are increased comparable with the previous year's inventory by about 17 Gg, but beside the base year (1990) the emissions reached the same level caused by increasing of hydrofluorocarbons consumption and SF_6 consumption.

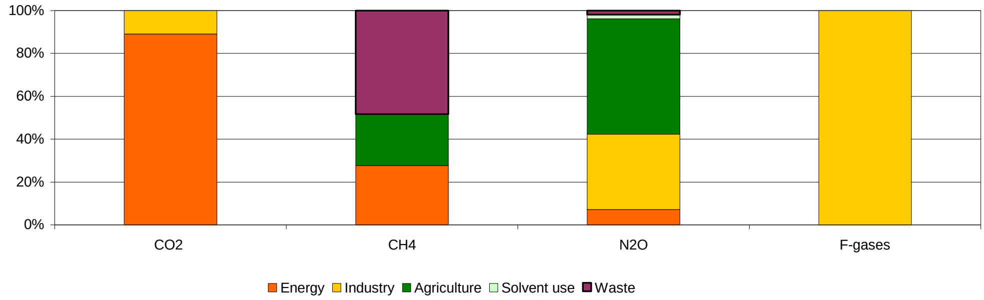
Figure 2.2: The emission trends by gas for the recalculated years 2000–2007.



2.3 Emission Trend by Source

The major share of CO_2 emissions is from energy sector (fuel combustion, transport) with more than 89% from the total carbon dioxide emissions in last 2007 inventory. More than 48% of CH_4 emissions produces waste sector (SWDS), more than 53% of N_2O emissions produces agriculture sector (fermentation) and 100% F-gases emissions come from industrial processes sector as depicted on the following Figure 2.3.

Figure 2.3: The emission trends by source sector in 2007.



2.4 Emission Trends for Indirect GHGs and SO_2

The total anthropogenic emission of NO_x was estimated to 83.26 Gg and the major share was produced by energy sector. The total emission of CO was estimated to 276.67 Gg and the major share of emissions was produced by energy sector. The emission of NM VOC was estimated to 73.99 Gg per year 2007 and the major share was produced by energy sector, industrial processes sector and solvent-use sector. The emissions of SO_2 were estimated to 70.56 Gg per year 2007 and the major share of emissions was produced by energy sector. Emissions of all indirect GHG and SO_2 have decreasing character since 1990 because the air quality management programs.

Although air quality management programs are focused on limitation of basic pollutants, they contribute to decrease GHG emissions in relatively high share. There are actually 18 air quality management areas in 2 agglomerations and 8 specially followed zones due to air quality in the Slovak Republic at present. 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 – capital of the SR. Both areas belong to the air quality management areas. For all these areas have been developed programs on air quality management 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 the Environment (www.enviro.gov.sk). In addition, an action plans containing short time measures.

Programs and plans were developed according to the Act No. 478/2002 on Air Protection as amended and Decree of the Ministry of Environment of the Slovak Republic No. 705/2002 on air quality. EU directives 1999/96/EC 2002/3/EC, 1999/30/EC and 2000/69/EC were transposed by this act and decree.

3 ENERGY (CRF 1)

Fossil fuels combustion in the 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 emission in CO_2 equivalents. It is especially public energy providing for power and heat supplying, industrial energy – energy production for technological processes, road transport and last but not least district heating – heat supply for block of flats and dwelling houses, public equipment and services, objects of non-productive sphere.

A limiting factor for the energy sector and subsequently for the whole economy development is the high level of dependency on import of primary energy sources (PES). Net imports of PES cover almost 90% together with nuclear fuel with the Russian Federation as exclusive supplier. The share of fossil fuels in the PES is relatively high, reaching the level of 80%.

Energy intensity of the Slovak economy is gradually decreasing but is still almost twice time higher than the EU average. To change energy consumption pattern, on January 2004 the transitional period for price subsidies ended and the Regulatory Office for Network Industries removed electricity, gas and heat subsidies for industry and households.

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

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

3.1 Fuel Combustion (CRF 1.A)

Occurred changes when final consumption of brown coal in 2007 was only 21% from this in 1990, light fuel oil consumption in 2007 decreased by 92% and heavy fuel oil by 72% compared to 1990. As an individual example: production of liquid steel in the Slovak Republic increased from 1990 to 2005 by 27.7% whiles the coal consumption to produce energy 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 Slovak Republic is using 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 the robust database system National Emission Information System (NEIS). Sectoral approach is compared with the reference approach based on top-down data from Statistical Office of the SR. The interannual fluctuation is very low and small discrepancies can occur with the fuel characteristics and using average values by the Statistic Office.

3.1.1 Fuel Combustion – Sectoral Approach (CRF 1.AA)

Total emissions from energy sector based on sectoral approach methodology in 2007 represent 34 426 Gg of CO_2 equivalents. This amount degreases comparable to the previous year by almost 5% and comparable to the base year by 41%. The following sub-sectors of the IPCC categories according IPCC 1996 Guidelines are relevant for the Slovak Republic in sectoral approach methodology:

1.A.1	**Energy industry**
1.A.1.a	Public Electricity and Heat Production
1.A.1.b	Petroleum Refining
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries
1.A.2	**Manufacturing Industries and Construction**
1.A.2.a	Iron and Steel
1.A.2.b	Non-Ferrous Metals
1.A.2.c	Chemicals
1.A.2.d	Pulp, Paper and Print
1.A.2.e	Food Processing, Beverages and Tobacco
1.A.2.f	Other
1.A.3	**Transport**
1.A.3.a	Civil Aviation
1.A.3.b	Road Transportation
1.A.3.c	Railways
1.A.3.d	Navigation
1.A.3.e	Other Transportation
1.A.4	**Other Sectors**
1.A.4.a	Commercial/Institutional
1.A.4.b	Residential
1.A.4.c	Agriculture/Forestry/Fisheries
1.A.5	**Other**
1.A.5.a	Stationary

Methodology

The sectoral approach (SA) (bottom up) is based on National Emission Information System (NEIS), the database of stationary sources, which collects the data of fuels consumption from the major sources of air pollution in the Slovak Republic. These data are available in consistent series only from year 2000, when the system NEIS was put in operation and replaced the old system EAPSI (Emission and Air Pollution Source Inventory). These two systems are comparable only on national level. Comparison of the individual parts of EAPSI (EAPSI 1 and EAPSI 2) with the NEIS module (large, medium-size sources), respectively comparison of individual sources in both systems is difficult. According to the Act 134/1992 as amended, the district offices are obliged to elaborate yearly reports about operational characteristics of air pollution sources in their district and provide them electronically (in the NEIS BU format) for the next processing to an SHMÚ. The SHMÚ is an organization accredit by the Ministry of Environment with managing of central database NEIS CU and providing the processes of data on the national level (Bulletin MZP No 6/2000). The first collection and processing of data in module NEIS was realized in 2001 on SHMÚ, Department of Emissions (OE). New system contained 748 large point sources from 79 the NEIS BU district databases in 2007. As the sources of 5 MW and above were included to the evidence of large point sources in the EAPSI system, the comparison of numbers of sources in both systems is difficult. In year 2007 system NEIS registered 10 765 medium sources of the heating output of 0.2–5 MW. The emission balances in 2000–2007 were processed in the NEIS CU module by the same calculation as done up to 1997. 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 Regional Offices in NEIS BU module. The sources below 0.2 MW are qualified as small sources and emissions balance proceed in NEIS CU module is based on the statistical data about sale of solid fuels for households and small consumers according the Directive MŽP SR No. 53/2004. The statistic is completed by the consumption of natural gas for inhabitants (from evidence of the Slovak Gas Industry LtD. www.spp.sk) and correspondent emission factors.

In the context of special revision of the qualitative characterisation of solid fuels (in accordance with the valid legislation and technical standard 2008 of MŽP), the emission of wood were included in the inventory first time and the time series form 1990 was estimated during previous submission. The major changes were occurred in the context of the revision the codebook of fuels in accordance with the actual legislation (706/2002 MŽP SR, 129/2002 MŽP SR about the Catalogue of Waste and Directive 200/76/EC about Waste Incineration). The information about the current legislation in the fuels´ and NEIS can be found on the web side www.spirit.sk, www.air.sk.

Activity data (quantity of fuel burned in physical units) included in each IPCC category of energy sector were collected from the NEIS dbase according to the national methodology Tier 2, the production type of the operators and the complete analysis of the production activities in the included installations. The activity data for the actual year are providing in the mass unit (thousand of m^3 or tones) with the corresponding calorific values (GJ/thous.m^3 or GJ/t). The characterizations of the fuel provide operators through the NEIS. Operators are under the state control and guarantee the quality assurance and control of the data. The calorific values of the fuel's type are announced annually by the Statistical Office. If the operator uses the plant specific calorific values, have obligation to prove the measurements to the NEIS database. A consumption of biomass is not included in the total CO_2 emission balance, but is provided. Information provided by operators was allocated according to the IPCC methodology into the appropriate categories. Several sources were divided into the more than one category due to types of the production or technological equipments.

According to the quantity and calorific values of the fuel the sectoral expert completes the calculation of the quantity the fuel's type in the energy unit (TJ). For each fuel's type the default or national emission factor is used and the correspondent emissions of CO_2, CH_4 and N_2O are calculated. The emission factors for the non-CO_2 are default (IPCC). The emission factors for CO_2 were improved based on plant specific information from the Emission Trading Scheme. The example is described for the natural gas.

The sectoral energy balance "bottom up" is using the IPCC (IPCC, 1996) detail method Tier 2 and national plant specific or default emission factors (mostly for non-CO_2 gases).

The carbon emission factors (t C/TJ) are estimated for individual fuels type based on international methodology (IPCC, OECD, IAEA) and national measurements (expert judgment, Profing Ltd., sectoral expert). Carbon emission factors are estimated from known fuel composition and accessible average low heating values of the most applied fuels. Carbon emission factors may vary considerably both among and within primary fuel types. The national emission factors for CO_2 are in use for this time, for natural gas from year 2000, for coal from 2000, for brown coal according the source (Slovak, Ukraine, Czech Republic) from 2000, for coke from 2000 and for coke gas from 2000. The revised emission factors are depending on net calorific values and slightly vary from year to year and across IPCC categories. The emission factors for natural gas and other most important fuels are based on preciously measurements and calculation published every month by Slovak Gas Industry Ltd, Slovak Energy Industry LtD. and U.S. Steel Company for iron and steel production. These EFs are in use for installations joined in the Emission Trading Scheme and for the requirements of the Ministry of Environment of the SR. Carbon content per unit of energy is usually less for light refined products such as gasoline than for heavier products such as residual fuel oil.

The conversion factors (TJ/Unit) are calculated every year from statistical data and little various annually. The variations depend on fuels characteristics, which are published by Statistical Yearbook annually.

Table 3.1: Overview of national emission factors for CO_2 in 2007.

EF (2007)	Fuel	Value	Unit	Value	Unit	IPCC Category
CO_2	Coal (energy)	97,82	tCO_2/TJ	26,70	tC/TJ	1.A.1.a
CO_2	Coal (for coke)	94,12	tCO_2/TJ	25,69	tC/TJ	1.A.2.a
CO_2	Coal	97,26	tCO_2/TJ	26,54	tC/TJ	other
CO_2	Coke	108,93	tCO_2/TJ	29,73	tC/TJ	all
CO_2	Brown coal (SR)	105,17	tCO_2/TJ	28,70	tC/TJ	all
CO_2	Brown coal (CZ)	97,11-101,14	tCO_2/TJ	26,50-27,60	tC/TJ	vary
CO_2	Natural gas	55,19	tCO_2/TJ	15,06	tC/TJ	all
CO_2	Coke gas	47,36	tCO_2/TJ	12,92	tC/TJ	all
CO_2	Lignite	104,65	tCO_2/TJ	28,56	tC/TJ	all
CO_2	Wood	100,25	tCO_2/TJ	27,36	tC/TJ	all

For natural gas, the carbon emission factor depends on the composition of the gas, which in its delivered state, is primarily methane, but can include small quantities of ethane, propane, butane, and heavier hydrocarbons. Natural gas flared at the production site will usually be "wet", i.e., containing far larger amounts of non-methane hydrocarbons. The carbon emission factor will be correspondingly different. The emission factors for natural gas (Russian) in the Slovak Republic are based on preciously measurements and calculation published every month by the Slovak Gas Industry since 1st January 2000. These EFs are in use for installations covered by the European Trading Scheme (ETS) and for the requirements of the Ministry of Environment of the SR in the present and are published on the website http://www.spp.sk/Archiv/Slovak/zlozenie%20plynu2007SK.pdf.

Table 3.2: Overview of EF CO_2 and NCV for natural gas [15°C; 101,325 kPa].

2007	Natural gas	Density	NCV	Combustion heat		Sulphur content	Wobbe number	EF CO_2
Month	[mol %]	[kg.m-3]	[MJ.m-3]	[MJ.m-3]	[kWh.m-3]	[mg.m-3]	[MJ.m-3]	[tCO_2/TJ]
I.	0,573	0,702	34,327	38,065	10,574	0,20	50,28	55,29
II.	0,571	0,699	34,258	37,993	10,554	0,30	50,30	55,21
III.	0,571	0,700	34,259	37,993	10,554	0,50	50,28	55,22
IV.	0,569	0,697	34,194	37,925	10,535	0,10	50,30	55,14
V.	0,568	0,696	34,199	37,931	10,536	0,00	50,34	55,11
VI.	0,568	0,696	34,223	37,957	10,544	0,00	50,37	55,11
VII.	0,568	0,697	34,254	37,991	10,553	0,00	50,39	55,13
VIII.	0,569	0,697	34,360	38,029	10,564	0,00	50,41	55,02
IX.	0,568	0,696	34,268	37,968	10,547	0,20	50,37	55,16
X.	0,570	0,698	34,319	37,999	10,555	0,20	50,34	55,26
XI.	0,571	0,700	34,327	38,020	10,561	0,20	50,32	55,30
XII.	0,573	0,702	34,307	38,067	10,574	0,10	50,29	55,28
Average			**34,275**					**55,19**

Table 3.3: Parameters of the natural gas published by Slovak Gas Industry on-line in 2007.

Month	Natural gas content in 2007 - mol. %									
	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.	97,10	1,25	0,39	0,06	0,07	0,02	0,01	0,01	0,22	0,87
II.	97,46	1,06	0,34	0,05	0,06	0,01	0,01	0,01	0,15	0,85
III.	97,40	1,08	0,34	0,05	0,06	0,01	0,01	0,01	0,19	0,85
IV.	97,71	0,94	0,29	0,04	0,05	0,01	0,01	0,01	0,12	0,82
V.	97,81	0,91	0,28	0,04	0,04	0,01	0,01	0,01	0,10	0,79
VI.	97,83	0,90	0,29	0,05	0,05	0,01	0,01	0,01	0,09	0,76
VII.	97,75	0,94	0,32	0,05	0,05	0,01	0,01	0,01	0,09	0,77
VIII.	97,68	0,98	0,34	0,06	0,06	0,01	0,01	0,01	0,06	0,79
IX.	97,57	1,02	0,34	0,05	0,06	0,01	0,01	0,01	0,10	0,83
X.	97,12	1,26	0,39	0,06	0,06	0,01	0,01	0,01	0,20	0,88
XI.	96,98	1,33	0,40	0,06	0,06	0,01	0,01	0,01	0,25	0,89
XII.	97,12	1,26	0,38	0,05	0,06	0,01	0,01	0,01	0,23	0,87

Figure 3.1: The distribution of emissions in CO_2 equivalents in 1.AA Fuel Combustion – sectoral approach and according to the type of fuels in 2007.

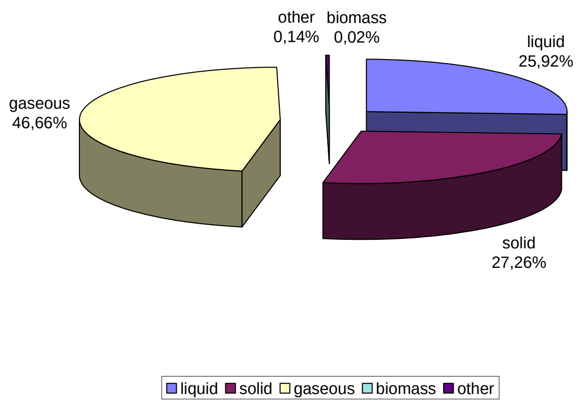
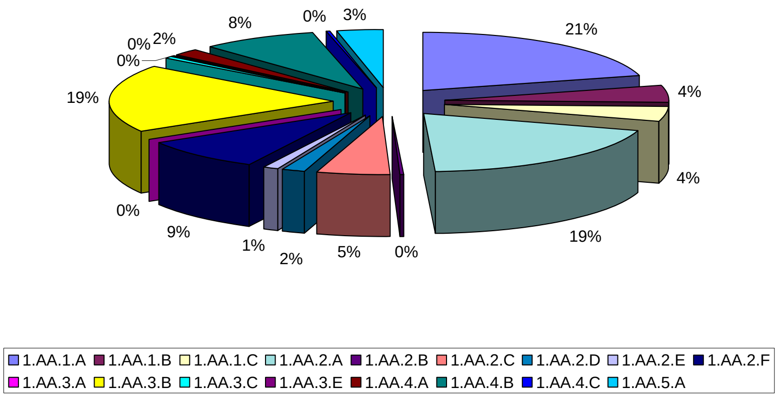


Figure 3.2: The distribution of emissions in CO_2 equivalents in 1.AA Fuel Combustion – sectoral approach and according to the categories in 2007.



The major categories as can be shown on Figure 3.2 are 1.AA.1.A – Public electricity and heat production (21%), 1.AA.3.B – Road transportation (19%), 1.AA.2.A – Iron and steel (19%) and 1.AA.2.F – Other industrial plants. The category other fuel in the 1.AA.1a include three sources of emission. Emissions from combustion of methane from methane cogeneration used in mining industry (see section 1.B.1.A Coal mining and handling), the recalculated emission trend for CO_2 and N_2O from municipal solid waste incineration with energy use (see section 6.C.2 – Municipal waste burning) and the recalculated emission trend for CO_2 and N_2O from industrial solid waste incineration with energy use (see section 6.C.3 – Industrial waste burning).

To avoid double counting of the primary and secondary fuels from iron and steel industry (category 2.AA.2.A), the study was prepared during last year by consultation company in energy tasks (Profing LtD.). The study is not public available, because of sensitive and confidential information included in the calculation about the one of the biggest iron and steel company in the Slovak Republic (U.S. Steel). Total emissions of CO_2 include into the energy sector without double counting can be expressed with the following formula:

$$CO_2\ t= M_{KoP}*Q_{KoP}*EF(CO_2)_{KoP} + M_{VPP}*Q_{VPP}*EF(CO_2)_{VPP} + M_{KonP}*Q_{KonP}*EF(CO_2)_{KonP} + M_{ZP}*Q_{ZP}*EF(CO_2)_{ZP} + M_{ČUenerg}*Q_{ČUenerg}*EF(CO_2)_{ČUenerg} + M_{KOKSagl}*Q_{KOKSagl}*EF(CO_2)_{KOKSagl}$$

M = quantity of fuel in weight units (t, mil m^3)
KoP = Coke oven gas
KonP = Coventry gas
VPP = Blast-Furnace Gas
ZP = Natural gas
ČUenerg = Antracite
KOKSagl – Coke (agglomerated)

From this calculation were excluded the fuels produced as secondary during technology process: heavy heating oil, coal (blast-furnace) and coke (blast-furnace). These amounts of fuels are known and can be extracted from the energy balance of category 2.AA.2.A - coal (blast-furnace) and coke (blast-furnace) and from category 2.AA.2.F - heavy heating oil. The reason behind is in national approved methodology when different parts of iron and steel plant in the SR are included in three categories: 1.AA.1.C (coke production), 2.AA.2.A (iron and steel production and 2.AA.2.F (any other installations inside the plant). This material balance was compared with the direct material balance reported by plat in the ETS. The identification of the fuels included into the balance second time was possible for the 2005, 2006 and 2007. The study was enabling only because of availability of data from ETS direct from operators included in National Allocation Plan I for 2005–2007. For the completeness of calculation, the emissions from limestone used are included into the category 2.A.3 – limestone and dolomite used and technological emissions from steel production included according technology in category 2.C.1 – iron and steel production.

Uncertainties and time consistency

The emissions of CO_2 from categories (liquid, solid and gaseous fuel's combustion) are the most important key sources and they have a decisive effect on the level and trend uncertainty management. The emission balance of other GHGs (CH_4, N_2O) from 1.A.1-5 IPCC categories was estimated by using IPCC methodology (IPCC, 1996) and default emission factors in like manner as previous year. These categories are not key source.

For emission uncertainty assessment AD, caloric value, EF and their uncertainties are available in the energy sector. 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, differences between Tier 1 and Tier 2 method are concentrated to the correlation among inputs parameters in this case, because formulas which are applied in the Tier 2 method use only multiplication and addition operation. In this time, Tier 2 method is computed without correlation dependency, therefore Tier 1 and Tier 2 are well comparable. Tier 2 method offers more reliable statistical results, it shows us 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 our knowledge and experiences, the most difficult part of uncertainty analysis is constructing the PDF (or CDF) for AD and EF. In the some cases the construction of empirical form of PDF are necessary to satisfy the expert statistical criterions (to keep mean value and confidence interval). For this reason special software packages are developed. The work with wide collection of analytical PDF is supported by this software. The next 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 have to be constructed in some situations.

The methodology of empirical function creation has base on four equations with N-4 degree of freedom (N represents the number of values of data sets). These free parameters are applied for construction of PDF (shape, kurtosis …). These equations contain information about requirements to mean value and confidence interval.

Methodology

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

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

where Em_i represents 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 in many cases difficult to compute. For this reason statistical approach is chosen. Method Monte Carlo is utilizes. It induces construction of PDF for all input parameters. We create 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, only in the problem input data empirical PDF is applied.

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

$$\mathbf{E} = \sum_{i=1}^{Z} \mathrm{Emn}_i \,, \qquad (3)$$

where *Z* represents number of source inputs.

Results

The results for every category are generated from 60000 trials, with random number generator of random numbers for adequate PDF.

<u>1.AA.1.A Public Electricity and Heat Production</u>

Table 3.4: The selected statistical characteristics for category 1.AA.1.A, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2.50%	97,50%
8 159 512,29	8 214 708,48	212 494,66	7 918 933,34	8 783 470,46
Min	**Max**		Per_2,5	Per_97,5
7 585 410,77	9 044 047,24		-3,60%	6,92%

Figure 3.3: The probability density function for category 1.AA.1.A in tons of CO_2.

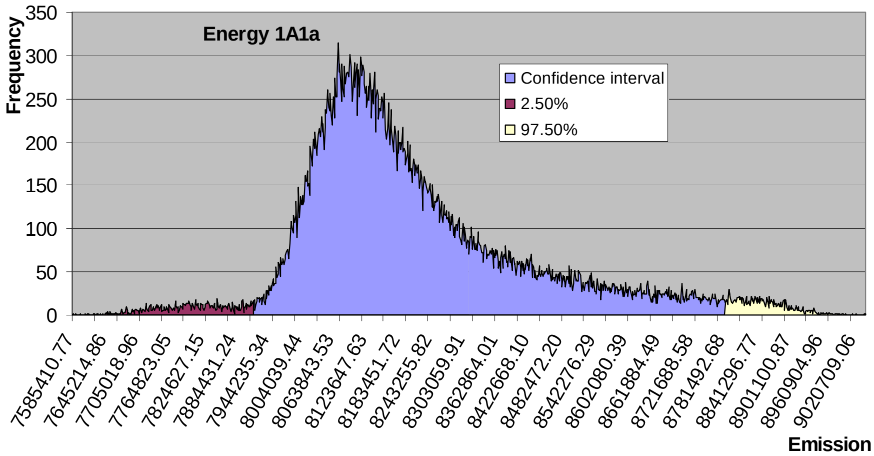
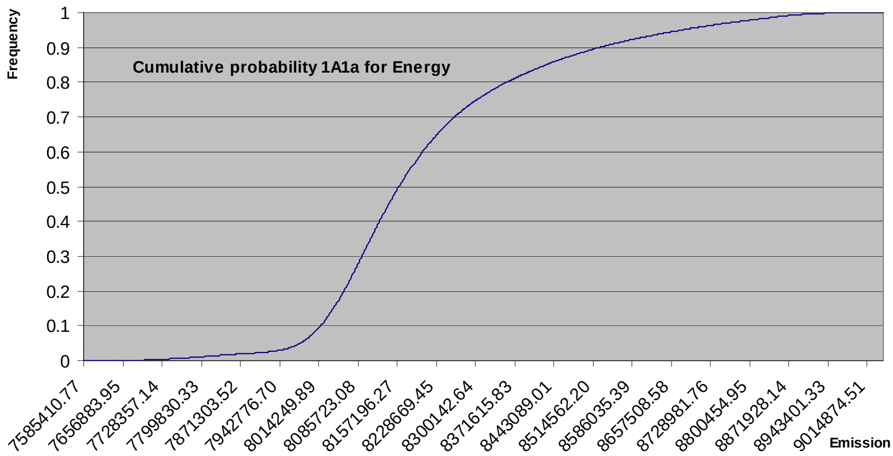


Figure 3.4: The cumulative probability density function for category 1.AA.1.A in tons of CO_2

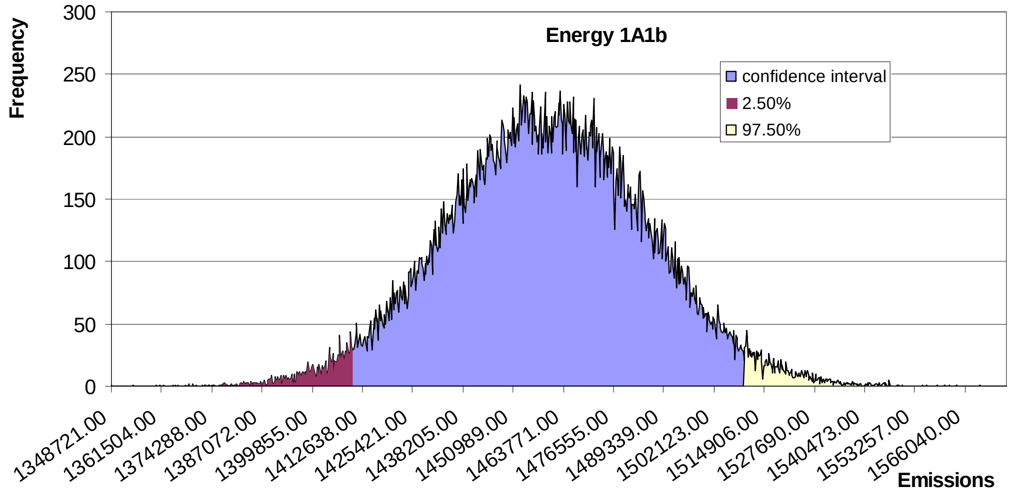


1.AA.1.B Petroleum Refining

Table 3.5: The selected statistical characteristics for category 1.AA.1.B, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2.50%	97.50%
1 459 563,90	1 459 677,35	25 345,95	1 410 317,47	1 509 641,99
Min	**Max**		Per_2,5	Per_97,5
1 348 747,41	1 576 886,64		-3,38%	3,42%

Figure 3.5: The probability density function for category 1.AA.1.B in tons of CO_2.

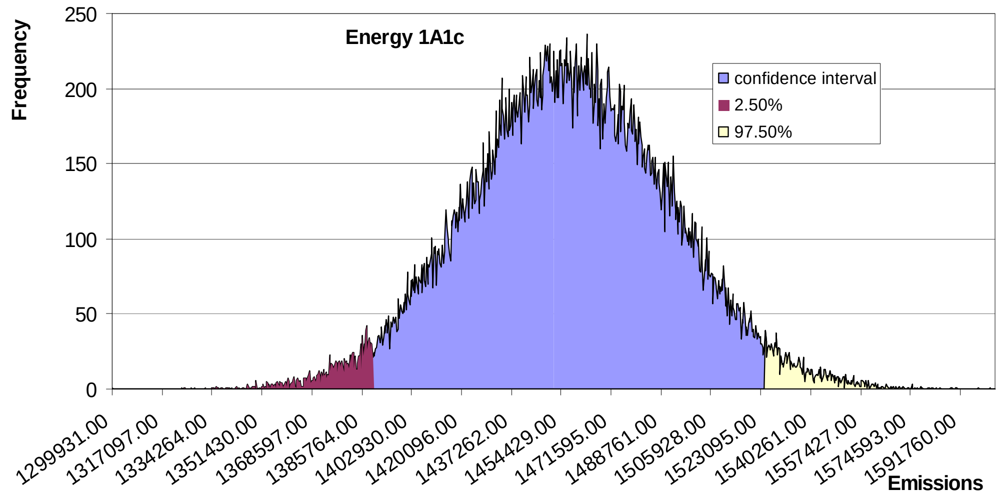


1.AA.1.C Manufacture of Solid Fuels and Other Energy Industries

Table 3.6: The selected statistical characteristics for category 1.AA.1.C, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2,50%	97,50%
1 456 651,29	1 456 936,70	34 442,51	1 389 647,35	1 524 639,37
Min	**Max**		Per_2,5	Per_97,5
1 299 933,15	1 604 007,26		-4,62%	4,65%

Figure 3.6: The probability density function for category 1.AA.1.C in tons of CO_2.

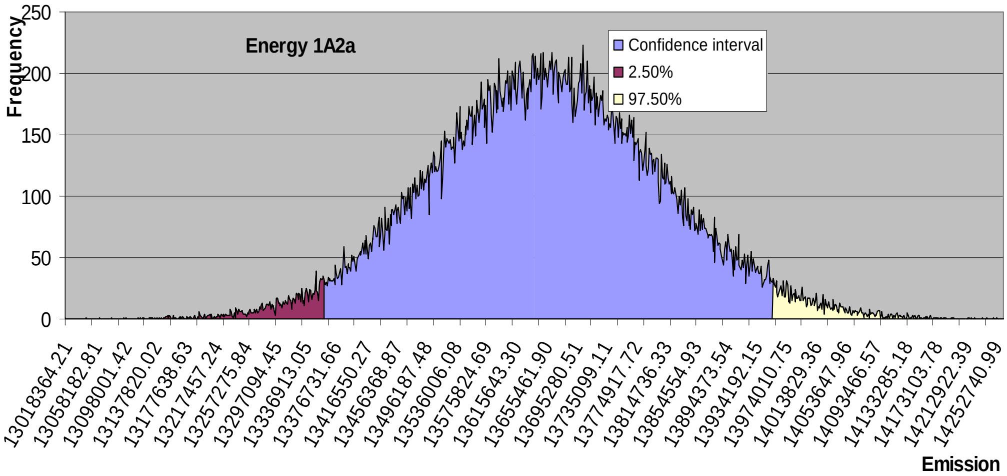


1.AA.2.A Iron and Steel

Table 3.7: The selected statistical characteristics for category 1.AA.2.A, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2,50%	97,50%
13 654 017,05	13 655 367,48	151 747,37	13 362 964,49	13 956 129,47
Min	**Max**		Per_2,5	Per_97,5
13 018 364,21	14 262 695,65		-2,14%	2,20%

Figure 3.7: The probability density function for category 1.AA.2.A in tons of CO_2.

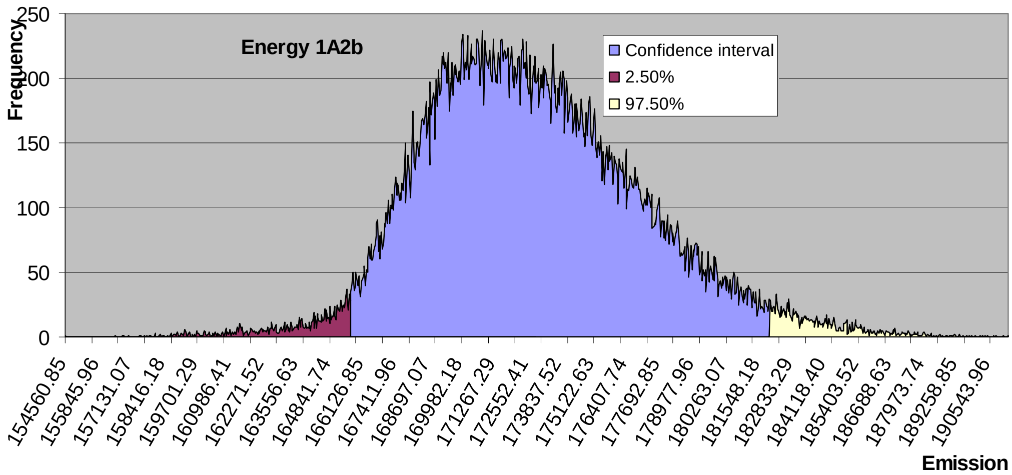


1.AA.2.B Non-Ferrous Metals

Table 3.8: The selected statistical characteristics for category 1.AA.2.B, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2,50%	97,50%
172 321,11	172 713,23	4 216,89	165 685,18	181 985,62
Min	**Max**		Per_2,5	Per_97,5
154 560,85	191 278,31		-4,07%	5,37%

Figure 3.8: The probability density function for category 1.AA.2.B in tons of CO_2.

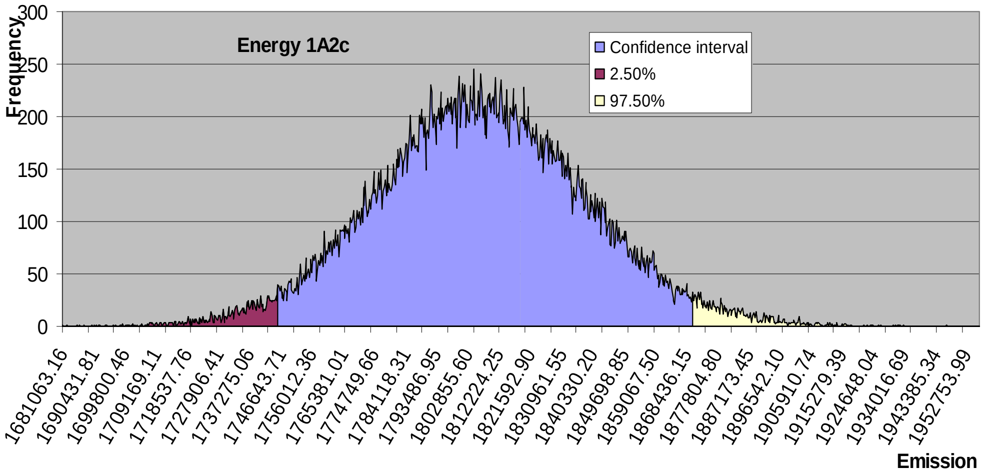


1.AA.2.C Chemicals

Table 3.9: The selected statistical characteristics for category 1.AA.2.C, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2,50%	97,50%
1 806 329,66	1 806 772,47	31 485,16	1 745 881,26	1 870 252,76
Min	**Max**		Per_2,5	Per_97,5
1 681 063,16	1 956 611,67		-3,37%	3,51%

Figure 3.9: The probability density function for category 1.AA.2.C in tons of CO_2.

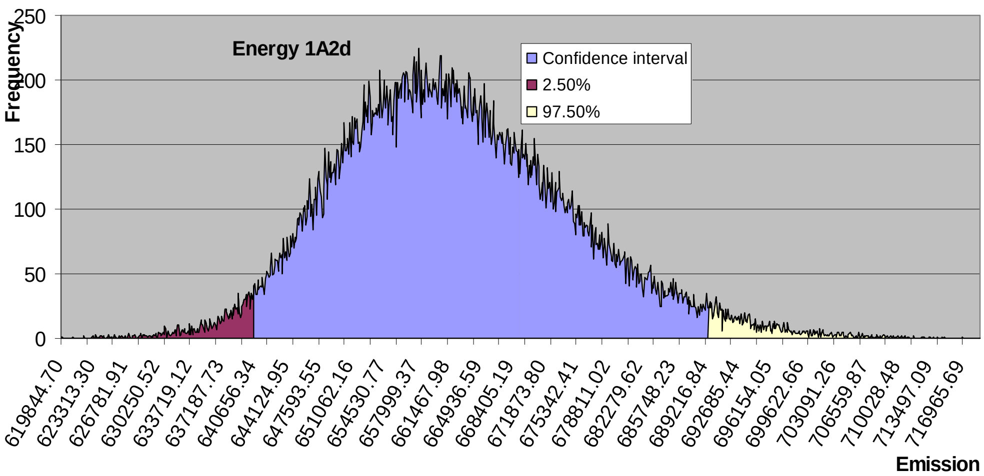


1.AA.2.D Pulp, Paper and Print

Table 3.10: The selected statistical characteristics for category 1.AA.2.D, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2,50%	97,50%
661 172,09	662 219,65	12 488,27	640 746,46	689 600,00
Min	**Max**		Per_2.5	Per_97.5
619 844,70	718 947,75		-3,24%	4,13%

Figure 3.10: The probability density function for category 1.AA.2.D in tons of CO_2.

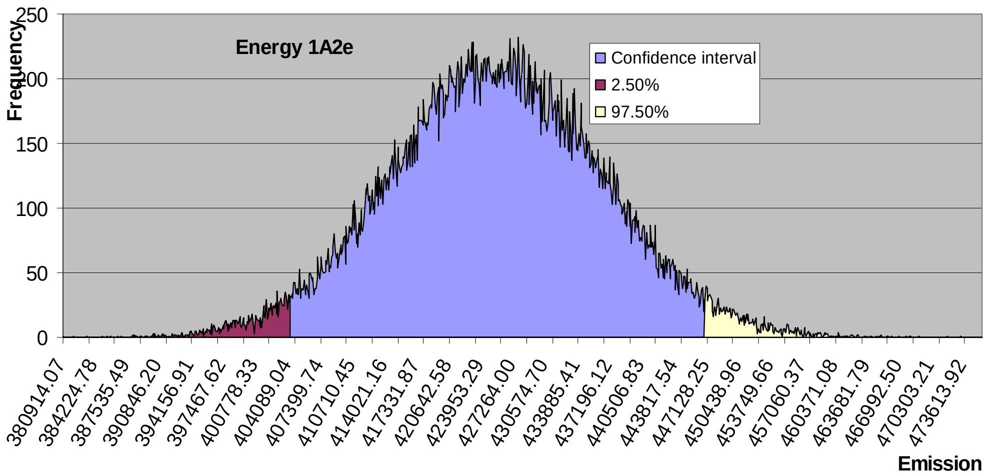


1.AA.2.E Food Processing, Beverages and Tobacco

Table 3.11: The selected statistical characteristics for category 1.AA.2.E, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2,50%	97,50%
425 375,88	425 458,63	10 851,01	404 307,57	446 898,58
Min	**Max**		Per_2,5	Per_97,5
380 914,07	475 505,75		-4,97%	5,04%

Figure 3.11: The probability density function for category 1.AA.2.E in tons of CO_2.

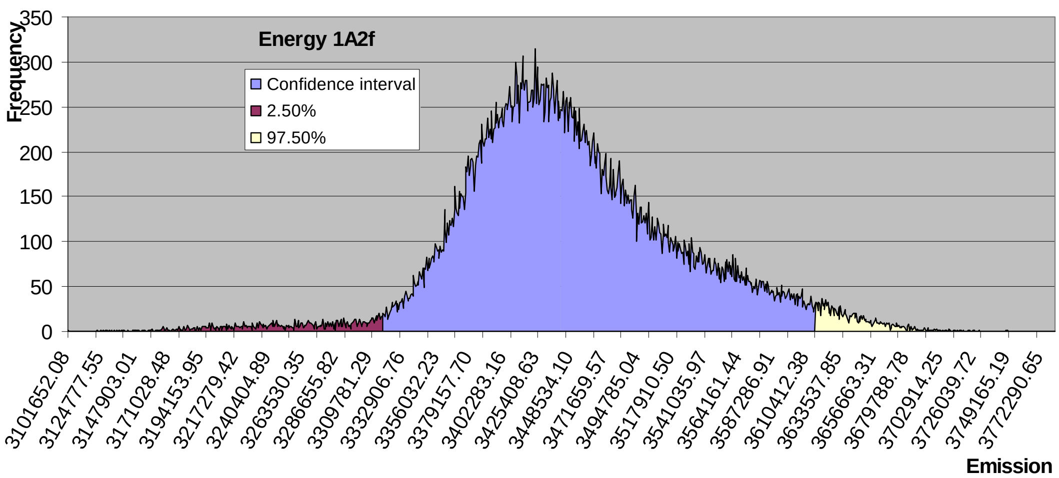


1.AA.2.F Non-Metallic Minerals

Table 3.12: The selected statistical characteristics for category 1.AA.2.F, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2,50%	97,50%
3 438 070,58	3 447 552,04	75 440,86	3 318 402,79	3 616 296,36
Min	**Max**		Per_2,5	Per_97,5
3 101 652,08	3 781 812,91		-3,75%	4,89%

Figure 3.12: The probability density function for category 1.AA.2.F in tons of CO_2.

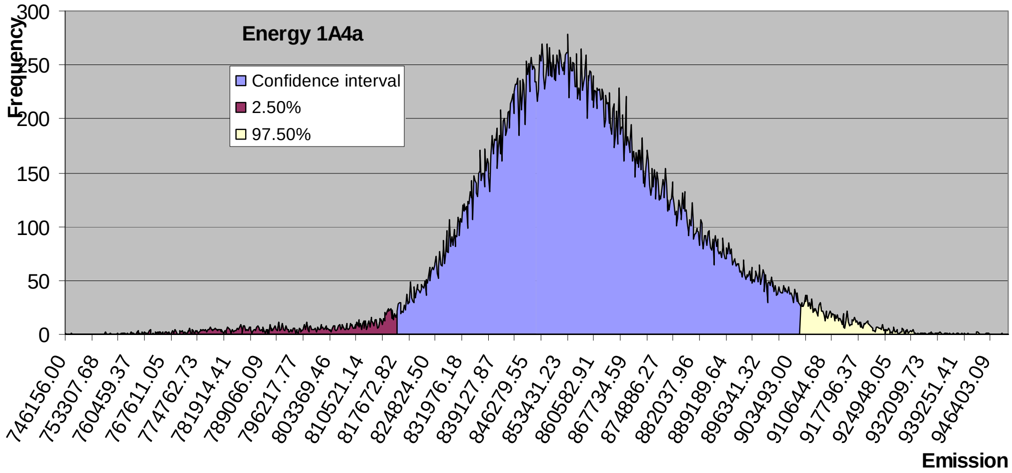


1.AA.4.A Commercial/Institutional

Table 3.13: The selected statistical characteristics for category 1.AA.4.A, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2,50%	97,50%
856 462,53	858 109,32	22 347,99	817 953,53	905 150,76
Min	**Max**		Per_2,5	Per_97,5
746 156,00	950 489,77		-4,68%	5,48%

Figure 3.13: The probability density function for category 1.AA.4.A in tons of CO_2.

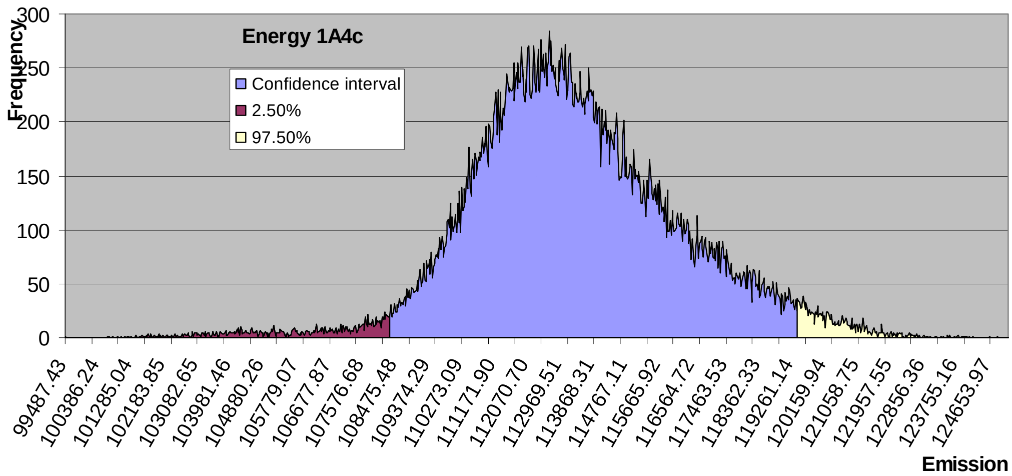


1.AA.4.C Agriculture/Forestry/Fishing/Fish Farms

Table 3.14: The selected statistical characteristics for category 1.AA.4.C, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2,50%	97,50%
113 084,27	113 336,82	2 835,69	108 322,27	119 410,44
Min	**Max**		Per_2,5	Per_97,5
99 487,43	125 167,57		-4,42%	5,36%

Figure 3.14: The probability density function for category 1.AA.4.C in tons of CO_2.

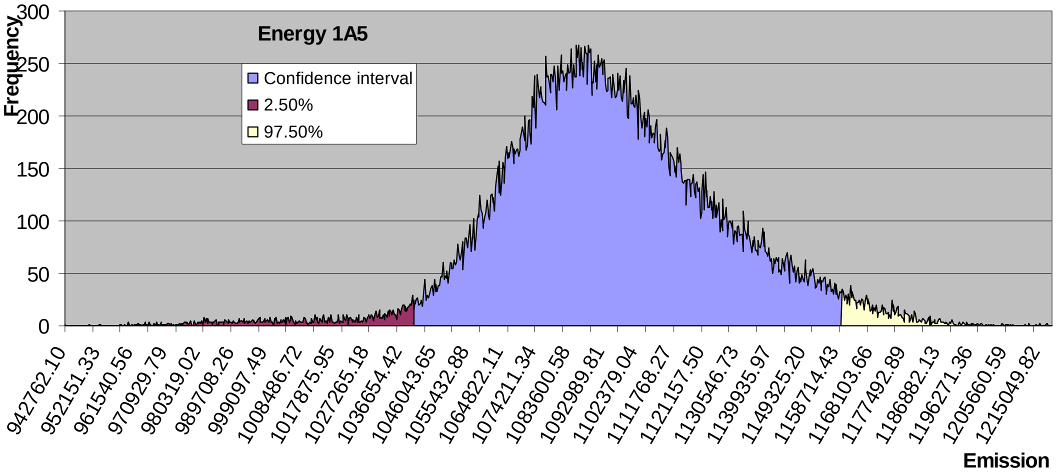


1.AA.5.A Other Stationary

Table 3.15: The selected statistical characteristics for category 1.AA.5.A, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2,50%	97,50%
1 092 882,92	1 095 226,05	30 553,52	1 040 406,87	1 159 730,05
Min	**Max**		Per_2,5	Per_97,5
942 762,10	1 218 915,98		-5,01%	5,89%

Figure 3.15: The probability density function for category 1.AA.5.A in tons of CO_2.

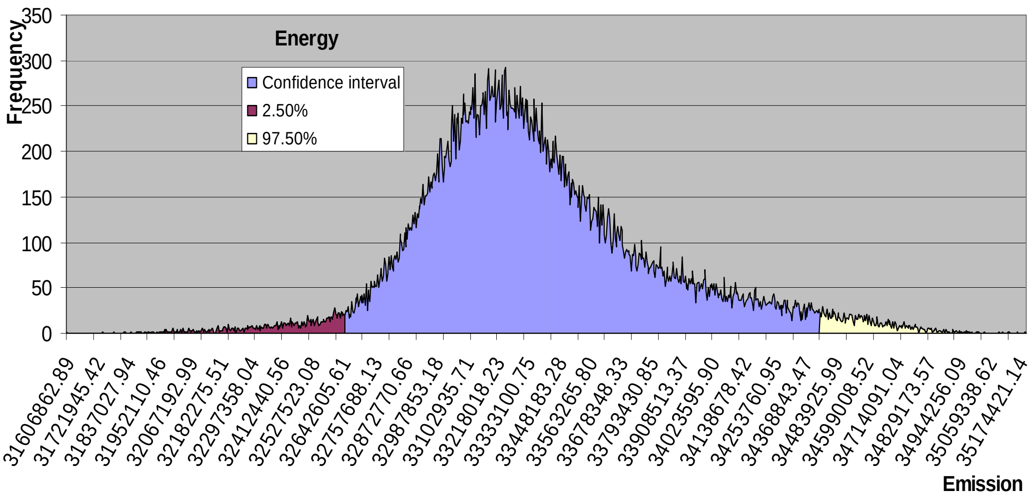


1.AA Fuel Combustion – Sectoral Approach

Table 3.16: The selected statistical characteristics for subsector 1.AA, median, mean value, standard deviation, minimum, maximum of emissions and percentiles.

Median	Average	Standard dev.	2,50%	97,50%
33 298 682,82	33 368 078,21	456 614,39	32 656 080,60	34 429 569,03
Min	**Max**		Per_2,5	Per_97,5
31 606 862,89	35 203 191,77		-2,13%	3,18%

Figure 3.16: The probability density function for subsector 1.AA in tons of CO_2.



From presented results obtained by Monte Carlo simulation it seems that mean value is 33 368 078.21 tons. Confidence interval (95%) has range: <32 656 080.60, 34 429 569.03>, which is represented by the relative values to the mean: –2.13%, 3.18%.

QA/QC and verification

The Slovak inventory team with cooperation of Profing Ltd. (Mr. Jan Judak is sectoral expert for energy and fugitive emissions) were provided the emission estimation according the methodology used from base year and official statistics. The verification process of the NEIS database is running on the two levels. First level according to the national law represents regional offices of the environment and the second level is provided on SHMÚ, Department of Emissions. The verification process of data in NEIS database is ending by the end of July for the data year –1. After closing the verification process the operators of installations received issued decisions according to the valid legislation about the payments for basic pollutants emissions.

The verification process is based on cross-checking the input data from the NEIS database and comparison with the sectoral statistical indicators from ministry of economy and Statistical Office of the SR. The background documents are archived by sectoral experts and in central archiving system of SNE at SHMÚ.

Recalculations

The small recalculations occurred in categories 1.AA.2.F – Other and 1.AA.4.A – Commercial/Institutional in consumption of natural gas. The Slovak Gas Industry, Ltd. executive distributor of gas in the SR has revaluated and corrected information about the natural gas consumption. The changes are below 1%.

Table 3.17: The recalculations for 2005 and 2006 category 1.AA.2.A – Iron and steel production have minor effect on the gaseous fuels and CO_2 emissions from gaseous fuels in this category.

	1.AA.2.A		
	liquid	**solid**	**gaseous**
year 2005		TJ	
Submission 2008	16,36	22 315,19	23 314,89
Submission 2009	16,36	22 315,19	23 381,93
Change in %	**100,00**	**100,00**	**100,29**
CO_2 emissions			100,31
	1.AA.2.A		
	liquid	**solid**	**gaseous**
year 2006		TJ	
Submission 2008	19,12	23 847,30	26 873,69
Submission 2009	19,12	23 847,30	26 947,87
Change in %	**100,00**	**100,00**	**100,28**
CO_2 emissions			100,30

Recalculations in the category 1.AA.2.A – Iron and steel production were continued with the reallocation of the blast furnace gas from gaseous fuels into solid fuels. The total emissions from the category weren't change, only reallocated inside category. The mixed EF for gaseous fuels decreased to 68.32 t/TJ of CO_2 and mixed EF for solid fuels increased to 168.35 t/TJ in 2007 (EF for blast-furnace gas is 261.22 t/TJ of CO_2). The recalculation was provided for years 1990–2006.

Recalculations in the category 1.AA.4.B – Residential were performed for time series 1990–2006. The biomass fuels incineration were estimated based on wood combustion with applying default emission factors for wood (100.25 t/TJ for CO_2, 300 kg/TJ for CH_4 and 4 kg/TJ for N_2O). The amount of wood was incorrect included into the solid fuels in the previous submission, but the emissions were not estimated. The appropriate reallocation was included into the current submission.

Table 3.18: The recalculated category 1.AA.4.B – Residential.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Wood (TJ)	4 787	8 059	6 472	9 295	9 988	10 554	13 660	11 896	11 813	12 141	13 425	15 297	14 900	16 313	20 570	28 657	26 461	24 562
CO_2 (Gg)	480	808	649	932	1 001	1 058	1 369	1 193	1 184	1 217	1 346	1 533	1 494	1 635	2 062	2 873	2 653	2 462
CH_4 (Gg)	1,44	2,42	1,94	2,79	3,00	3,17	4,10	3,57	3,54	3,64	4,03	4,59	4,47	4,89	6,17	8,60	7,94	7,37
N_2O (Gg)	0,02	0,03	0,03	0,04	0,04	0,04	0,05	0,05	0,05	0,05	0,05	0,06	0,06	0,07	0,08	0,11	0,11	0,10

Planned improvements

Several important changes have been successfully implemented for 2008 submission and described in the previous SVK NIR 2008. The planned improvement for the next submissions in sectoral approach will be disaggregation of the category 1.AA.2.F – Other and allocate emissions and energy consumption directly according industry characteristics. The category 1.AA.2.F – Other includes now all other industry not included in other categories.

3.1.2 Fuel Combustion – Reference Approach (CRF 1.AB)

The base for calculation of reference approach is data gathered and processed by the Statistic Office of the SR every year (annual energy statistic balance). These data are therefore official energy balance data. Profing Ltd. Bratislava executed the preparation of preliminary and final energy balance based on published materials from the Statistical Office of the SR.

Methodology

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 for data of fuel consumption by type of fuel, their low heating values, emission factors and share of oxidation). This method is called also the top down or the upstream method and is characterized with minimum requirements on input data. The reference approach provides only aggregate estimates of emissions by fuel type distinguishing between primary and secondary fuels. The aggregate nature of the 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 doesn't involve so called fugitive emissions, i.e. uncontrolled emissions from mining and post-mining treatment, from transport and other use of fuels.

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

- Liquid fuels – primary fuels (Crude Oil, Orimulsion, Natural Gas Liquids); secondary fuels (Gasoline, Jet Kerosene, Other Kerosene, Shale Oil, Gas/Diesel Oil, Residual Fuel Oil, LPG, Ethane, Naphtha, Bitumen, Lubricants, Petroleum Coke, Refinery Feedstock, Other Oil).
- Solid fuels – primary fuels (Anthracite, Coking Coal, Other Bit. Coal, Sub-bit. Coal, Lignite, Oil Shale Peat); secondary fuels (BKB & Patent Fuel, Coke Oven/Gas Coke).
- Gaseous fuels – primary fuels (Natural Gas).
- Fuels used as feed stocks type – Naphtha, Lubricants, Bitumen, Coal Oils and Tars (from Coking Coal), Natural Gas, Gas/Diesel Oil, LPG, Butane, Ethane, Plastics.
- Information Entries - Solid Biomass, Liquid Biomass, Gas Biomass.

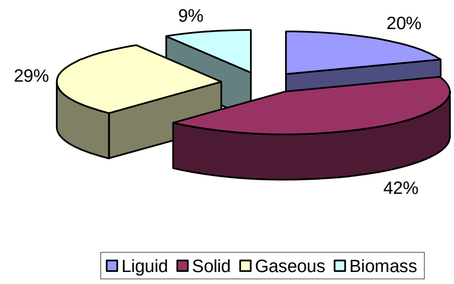
The emission inventory based on the reference approach is periodical include into annual inventory for comparison and verification reasons. The data for preparation of the preliminary energy balance are obtained from the Statistical Office of the Slovak Republic, which is authority officially organizing and yearly performing statistical findings. Reporting duty to fill the statistical forms is issued by the Act No. 322/1992 Coll., § 27 on the National Statistic, as amended. Statistical Office of the Slovak Republic is yearly performing statistical findings to follow fuel consumption for electricity and heat generation, fuel enrichment processes, 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 following annual statistical forms:

- Energ. P 2-01 Yearly balanced company report on energy process of fuel enrichment.
- Energ. P 3-01 Yearly balanced company report on consumption of fuels, electricity and heat for production of selected commodities.
- Energ. P 4-01 Yearly balanced company report on production of heat and electricity.

- Energ. P 5-01 Yearly balanced report of retail trade with solid fuels.
- Energ. P 6-01 Yearly balanced company report on sources and distribution of fuels.
- Energ. P 1-01 Yearly balanced report of manufacture branches.

In the previous inventory submissions, the emission factors of several important fuels were revised according national circumstances and according 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 the section 1.AA – sectoral approach. The consistency is strictly kept between used EFs in sectoral and reference approach.

Figure 3.17: The share of individual fuels categories to the energy balance in reference approach in 2007.



The most significant conclusion comparable with the previous year 2006 is the increasing share of biomass by two times (from 4.8% to 9% in 2007). Other fuels are more or less at the same level.

3.1.3 Difference – Reference and Sectoral Approach (CRF 1.AC)

The complete time series of CO_2, CH_4 and N_2O emissions for reference and sectoral approach from base year were estimated. The higher difference between sectoral and reference approach in the older submissions is caused by the complicated situation in the national database NEIS, changes in the legislation in air protection and different classification of fuels´ type in statistical collection of data and national legislation in large combustion plants and other stationary sources. The previous recalculations of sectoral approach was based on the reallocation of the fuel consumption into the separate CRF categories for the years 1991–1999 according appropriate IPCC methodology. The revised EFs for the natural gas, coal, brown coal, coke and coke gas were used.

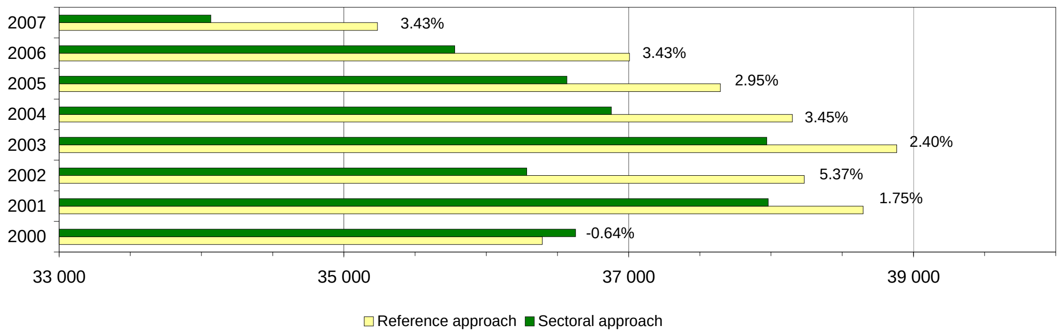
The total anthropogenic emission of carbon dioxide from energy sector, fuel combustion was estimated in the inventory year 2007 to be 35 837 Gg based on sectoral approach methodology as a national total CO_2 emissions.

Reference and sectoral approach are estimated on fully independent data sets, whereby obtained differences are negligible. The difference between the top down and the bottom up energy balance was calculated to be 3.43% in year 2007 (the same as in previous inventory). The differences in fuel consumption between these two approaches can be caused by using average NCVs (net calorific values) in reference approach and fuel specific NCVs in sectoral approach. In the 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, the total fuel combustion decreased significantly and the share of natural gas as an alternatively fuel type increased. After the medium increase of solid fuels in 2001, the decreasing trend in 2002–2007 was appeared in energy balance. The balance of solid fuels consumption is complicated with the calculation of the stock change. The Statistical Office of the SR updates the fuel's categories and methodology for stock fuel annually. The quality of data used for bottom-up approach is higher, because this data are checked more time (by the operators, by providers of NEIS database, by sectoral expert and by SNE).

Table 3.19: The sectoral and reference approach emissions of CO_2, CH_4 and N_2O and differences during time series 1990–2007.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SA (CO_2 Tg)	56,38	49,72	44,94	42,86	39,74	40,88	41,38	41,48	39,68	38,56	36,39	38,65	38,23	38,88	38,15	37,64	37,04	35,23
RA (CO_2 Tg)	57,93	52,49	48,86	44,91	42,38	40,69	39,14	38,01	37,90	37,18	36,63	37,98	36,29	37,97	36,88	36,57	35,78	34,07
Difference in	-2,68	-5,27	-8,02	-4,56	-6,24	0,46	5,73	9,11	4,70	3,71	-0,64	1,75	5,37	2,40	3,45	2,95	3,43	3,43
SA (CH_4 Gg)	22,28	18,98	17,67	14,31	11,98	10,77	8,83	7,44	7,98	7,28	8,01	7,57	5,63	5,65	5,16	5,07	5,05	3,97
SA (N_2O Gg)	0,98	0,82	0,73	0,66	0,64	0,65	0,65	0,67	0,71	0,71	0,69	0,77	0,76	0,80	0,79	0,88	0,84	0,89

Figure 3.18: The comparisons of SA and RA in 1990, 2000–2007.



3.1.4 Feedstocks and Non-energy Use of Fuel (CRF 1.AD)

Using 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. The total amount of carbon stored in products in 2007 was determined to 1 042.46 Gg of carbon. The method of determination is based on plant specific information and expert's judgment (Profing Ltd.) and the balanced items are less significant from the viewpoint of total.

Table 3.20: The overview of carbon stocks in fuels in 2007.

Fuel type	Fuel quantity (TJ)	Fraction of carbon stored	Carbon emission factor (tC/TJ)	Carbon stored in non-energy use (GgC)
Naphtha	24 590,40	0,80	20,00	393,45
Lubricants	2 861,10	0,50	20,00	28,61
Bitumen	4 133,60	1,00	21,83	90,24
Coal Oils and	2 310,88	0,75	25,69	44,52
Natural Gas	20 600,91	0,33	15,06	102,39
Gas/Diesel Oil	591,02	0,80	19,82	9,37
LPG	7 130,00	0,80	17,56	100,16
Butane	0,00	0,80	20,00	0,00
Ethane	568,80	0,80	16,80	7,64
Plastics	16 629,25	0,80	20,00	266,07

Uncertainties and time consistency

Reference approach uncertainties are determined by the methodology of the Statistical Office of the SR. 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 main types of fuels.

QA/QC and verification

Results of energy statistic that are used for GHG emission inventories are yearly issued in the Statistical yearbooks and in physical and caloric values in energetic publications. First preliminary data related to liquid, solid, gaseous and biomass fuels balance for previous year in the SR are available at the beginning of October. These data are verified by Profing Ltd. Bratislava (comparing consumption of fuels and production of heat and electricity, discussion with main producers of heat and electricity and suppliers of fuels, etc.) and used for reference approach.

Profing Ltd. Bratislava (the company for energetic research) executed the preparation of preliminary energy balance based on published materials from the Statistical Office. Profing Ltd. Bratislava namely director Dr. Jan Judak is the sectoral expert for energy and the external consultant for energetic questions in the Slovak National Inventory System. He is responsible for preparation of reference approach balance, the fugitives 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 inventory is prepared. This information is available in energy (TJ) and mass (Gg) units.

Recalculations

No recalculations in reference approach or carbon stock change were provided for the previous inventory year or base year.

Planned improvements

The further improvements are planned for the revision of CH_4 and N_2O EFs. According to the newly published EUROSTAT information about NCVs for liquid fuels, the expert comparison will be necessary in the next inventory year.

3.2 Transport (CRF 1.A.3)

The emissions from subsector Transport include the road transportation, civil aviation, shipping and railways sources of air pollution in the Slovak Republic in year 2007. The emissions from road and non-road transport were calculated by using models and default methods and the consistent data series from 1990–2007.

Aim of the transport category is the emission check of basic pollutants (CO, NOx, SO_2) and solid particles – TSP, PM10, PM2.5, 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) produced by road transport in the Slovak Republic in year 2007. Balance of pollutant and heavy metal emissions is evaluated according EMEP/CORINAIR Emission Inventory Guidebook (EIG) methodology and using COPERT III computer program.

Methodology

The emissions of GHGs from the consumption of the fuels in the civil aviation, shipping and railways transport were estimated by EMEP/CORINAIR EIG methodology (CORINAIR, 2003 and 2008). The emissions from civil aviation transport were estimated according the consumption of fuel and expert judgment in the splitting to the domestic and international flights. The emissions from inland shipping are included into the international bunkers.

Total emissions expressed in CO_2 equivalents from subsector Transport in 2007 were 6 917.36 Gg, comparable to the previous year is increase by 17% and comparable to the base year 1991 by 33%. The major share from emissions represents CO_2 by more than 99% and road transportation with more than 98%. Emissions from inland shipping category are included in category 1.C1 memo items – international bunkers, because of international character of shipping transportation on Danube River. Other inland shipping transportation in the Slovak Republic is negligible and only for tourist purposes. Emissions from military aviation (jet kerosene) were included in other transportation 1.A.3e category.

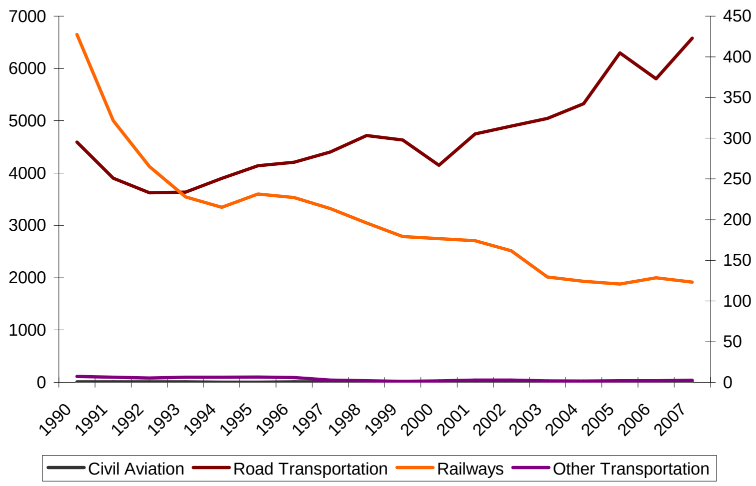
Major increasing was occurred in category civil aviation by 75% comparable to the base year 1990, in category road transportation was significant increasing by 43% taking into account the share of road transportation emission category. The railways and shipping categories have decreasing character in the consistency for the overall trends and projections.

Table 3.21: The overall view on emissions from transport in 2007 in the Slovak Republic.

Sources / Emissions (Gg)	CO_2	CH_4	N_2O
1.A.3 Total Transport	**6 499,400**	**1,074**	**0,637**
1.A.3a Civil Aviation	13,507	0,001	0,001
1.A.3b Road Transportation	6 374,822	1,066	0,588
1.A.3c Railways	108,670	0,006	0,047
1.A.3d Shipping	0,000	0,000	0,000
1.A.3e Military Aviation	2,402	0,0002	0,0003
1.C1 Total Int. Bunkers	**150,012**	**0,004**	**0,018**
1.C1.A Civil Aviation	117,395	0,002	0,004
1.C1.B Shipping	32,617	0,002	0,014

The following Figure 3.19 shows the overall trends in the transport categories during 1900–2007, emissions from railways are related to the second Y axis with the different scale. Other transportation and civil aviation are negligible comparable to the road transportation's emissions.

Figure 3.19: The overall trends in the transport categories during 1900–2007.



3.2.1 Civil Aviation (CRF 1.A.3a)

Inventory evaluation of GHG emissions in category of civil aviation is performed for all GHGs and precursors as well as air pollutants. In the absence of data on the numbers of LTO cycles for the domestic aviation and according recommendations of ERT final findings in 2007 based on IPCC GPG 2000, the calculation is based on fuel sold to both categories of civil aviation (Tier 1 method). In accordance with the IPCC Guidelines 1996 is divided on the fuel consumption in the international and domestic air transport and at the same breakdown is carried out by the calculation of GHG emissions. Recalculation were provided and explained in previous submission 2008.

GHG emissions estimation was performed according the totals of sale fuels on the important Slovak airports (Bratislava, Košice, Poprad, Sliač, Piešťany and Žilina) in the period 1990–2007 and the expert estimated consumption of the fuels to the national and international fuel consumption. In the recent year 2007 emissions from civil aviation were increasing comparable to the previous year by 15% to 13.99 Gg of CO_2 equivalents. The emissions have increasing trend from 2000 and according recent projections the trend will be continuously increasing.

Methodology

The Slovak Republic was used Tier 1 methodology based on fuels sold for emission estimation of aviation transport both for aviation gasoline and jet kerosene. The information of LTO cycles are known (32 939) and used for air pollutants inventory, not divided into national and international flights. Emission estimation is based on fuel consumption and the international rule for domestic and international flights based on expert judgment was evaluated.

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

Table 3.22: The starting points for mixed EFs estimation.

Starting conditions for the estimation of mixed EFs for GHG emissions for Jet Kerosene		
Parameter	**International Flights**	**Domestic Flights**
Fuel	**Jet Kerosene**	
Representative Aircraft	B 737–500, (400,100)	EMB-120, Saab 340B
Average Flight Distance	1 365 km	375 km
Average Flight Duration	1.75 hours	0.75 hours
Average Speed	780 km/hour	500 km/hour

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

Table 3.23: The mixed emission factors for the GHG emission balance in civil aviation according Tier 1 method based on fuel consumption.

Mixed emission factors for the GHG emissions balance in civil aviation according fuel consumption		
Parameter	**Emission factor [g/kg fuel]**	
	International Flights	**Domestic Flights**
GHGs	**Jet Kerosene**	
CO_2	3 150	3 150
N_2O	0,104	0,35
CH_4	0,05	0,25
GHGs	**Aviation Gasoline**	
CO_2	3 150	
N_2O	0,1	
CH_4	1,9	

It is generally know, that in the period 1990–2007 the technological development of aircraft industry took place and emissions were decreasing from air traffic per one LTO cycles. The using of mixed EFs based on recent knowledge about parameters of aircraft can caused underestimating of emissions in the earlier period and base year, too. It is historically proved, that in the earlier 90-ties, the obsolete aircrafts were used. Because no relevant information from earlier period of estimating time series are known, the problem cannot be solved satisfactory.

Based input information used for the emission estimation from civil aviation are the numbers of realized LTO cycles during the year on the monitored airports following the types of aircrafts and the carrying capacity of the airports. The aircrafts are divided into the two weight categories into the 5.7 t and over 5.7 t. The innovated method is using the emission factors for the each aircraft type and weight category. The number of the LTO cycles in inventory year 2007 was 32 939 cycles. The total consumption of jet kerosene was 41 391 t (53 065 113 litre) and the consumption of aviation gasoline was 165 t (223 560 litre).

The overall view of the sale the aviation fuels according type (aviation gasoline and jet kerosene) during 1990–2007 was revaluated. For the period 1994–2007 the data come directly from airport statistical processing information based on annual bases. The data for the period 1990–1993 about the sale of fuel are based on expert estimation according the real LTO cycles in the detached period.

Statistic methodology for the airport traffic is determined only by origin of air operator for domestic and international. It means, that no direct information about numbers of domestic and international operated flights are known for the period 1990–2007. The average splitting of consummated fuel was executed by expert estimation. Based on expert estimation about total fuel sale of jet kerosene was statement, that domestic consumption presents 10% of the total and international 90% from the total. The approximately opposite ration is applied in consumption of aviation gasoline: 90% on domestic flights and 10% on international flights. This assumption is supported with the statistical information from the Slovak airports about LTO and about the fuels sold. The aviation gasoline is consumed mostly by light aircrafts with overall weight categories into the 5.7 t and used for domestic short flights, training curses of Zilina University of Aviation, rescue service or touristic see sighting flights. Zilina airports is the most important airport in the Slovak Republic for domestic flights (over 11 705 LTO cycles). The international flights are mostly operated by medium and large size aircrafts with overall weight over 5.7 t and used jet kerosene. The major of international flights are operated from Bratislava airport.

Table 3.24: The results in domestic and international aviation transport emissions in the 1990–2007.

1.A.3a	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
National airlines	CO_2 (kt)	7,74	7,19	6,65	6,47	5,50	5,48	6,43	5,69	5,23	5,31	5,50	5,23	5,45	6,99	9,07	10,53	11,74	13,51
	CH_4 (t)	1,00	0,93	0,86	0,86	0,71	0,69	0,79	0,70	0,63	0,65	0,73	0,72	0,76	0,87	0,95	1,11	1,20	1,32
	N_2O (t)	0,80	0,75	0,69	0,69	0,57	0,57	0,67	0,60	0,55	0,55	0,57	0,53	0,56	0,73	0,97	1,13	1,20	1,46
International airlines	CO_2 (kt)	63,10	58,68	54,25	53,14	44,78	45,04	53,16	47,08	43,41	43,80	44,51	41,86	43,46	57,46	77,68	90,14	101,09	117,39
	CH_4 (t)	1,05	0,98	0,90	0,90	0,75	0,75	0,88	0,78	0,72	0,72	0,74	0,70	0,73	0,95	1,26	1,47	1,64	1,89
	N_2O (t)	2,08	1,94	1,79	1,79	1,48	1,49	1,75	1,55	1,43	1,45	1,47	1,38	1,43	1,90	2,56	2,98	3,34	3,88

Uncertainties and time consistency

The developing of the civil aviation in the Slovak Republic is influenced by fast entering of low-cost airlines on market (mostly Sky Europe Airlines) from 2002. The most loaded airports are Bratislava and Košice. Other airports have only local character for domestic and sports flights.

The sale of aviation fuels at Slovak airports in the followed period 1990–2007 was influenced mostly by prices and other possibilities on fuel market in the neighbouring airports.

QA/QC and verification

The emission inventory of civil aviation was determined by SHMÚ in cooperation with external experts from the Transport Research Institute in Žilina and Transport University in Žilina. Sectoral experts with several years' experiences Dr. Jan Breziansky and Mr. Jozef Pinter from Research Institute of Transport in Žilina were trained new expert for transport emission inventory and projections Ms. Michaela Kollarova, joining the SNE team at SHMÚ in 2008.

The verification process is based on cross-checking the input data from the Slovak airports by Transport Research Institute and comparison with the sectoral statistical indicators from ministry of transport. The background documents are archived by sectoral experts and in central archiving system of SNE at SHMÚ.

Recalculations

No recalculation in the submission 2009 focused to the base year or 2006 was provided.

Planned improvements

The implementation of Tier 2 methodology was considered in combination with the fuel sold and the number of movements (domestic, international). The discussions are continued with the cooperation of ministry of transport – department of civil aviation and the Bratislava airport for first estimation. The initiative is also increased in the preparing of new methodology for including aviation in emission trading system after 2012.

3.2.2 Road Transportation (CRF 1.A.3b)

Road transportation is the most important category with the highest share of emissions and increasing trend. The total aggregated emissions from road transportation reached in 2007 6 580 Gg of CO_2 equivalents, the increasing comparable to the previous year 2006 is more then 14%, but comparable to the base year is the increase even more significant 43%. The major share belongs to the duty vehicles and passenger cars.

Methodology

The calculation of GHG emissions in annual inventories made EMEP/CORINAIR EIG methodology, which is included in the program product for calculating emissions from road transport COPERT III. Therefore, it is often referred to the name of the methodology consistently with the name of the program COPERT. The procedure for calculating the CO_2 under this methodology is based on Tier 2 or bottom-up. The model COPERT III established vehicle categories for calculation the emissions of CH_4 and N_2O and in subsequent censuses sub-emission. The value of the factors set out for CH_4 and N_2O program COPERT III is different for different types of fuel, various types of vehicles and different technological level. In the case of CH_4 also expresses its dependence on a journey to a particular group of passenger cars and dependence on the average speed. Increasing numbers of the passenger cars with the 3way catalyst lead to significant decrease in methane emissions from road transport. The Slovak Republic has rapidly renewed the car fleet in the 90´ties. The emission factors for CH_4 are different for different categories of passenger car (gasoline, diesel), LDV (gasoline) with catalyst and are functional variable characteristics of average speed mode in urban, rural and highway. This explanation is standard in methodology for using COPERT model and IPCC guidelines and decrease in EF is therefore not unusual.

The emission factors for the group of pollutants such as CO_2, SO_2, N_2O, NH_3, PM and partially also CH_4 is possible to obtain with the simply formula between driving mode and consumed fuel. This value is constant for the different vehicles categories. Emission factors are automatically calculated by COPERT III based on input parameters – average speed, quality of fuel, age of vehicles, weight of vehicles, and volume of cylinders.

The emission inventory of road transport in 2007 included also the emissions from light and heavy-duty vehicles, buses operated by CNG (Compressed Natural Gas) for 2000–2007. This emission is not key source. The input parameters are known only from 2000. It is assumed, that before year 2000 the use of CNG was negligible. The emissions from this sector have increasing tendency every year and are the key source in level and trend assessment for calculation of uncertainty management (Annex 2). The revision of EF for CNG according EMEP/CORINAIR EIG 2008 and new disaggregation of buses to the EURO categories was provided in 2007. Unfortunately the activity data for previous years are not available and the recalculation back to the base year was not provided. The improvements are planned for the next submission. The EF(CH_4) for CNG decreased from 560 kg/TJ to the aggregated EF(CH_4) for CNG 121 kg/TJ. CNG as fuel can neither be used on a diesel engine nor on a gasoline one without modifications because it has a high octane number (120–130) and a lower than 50 octane number which makes it unsuitable for diesel combustion. Most commercial systems therefore utilize a spark plug to initiate natural gas combustion and a higher compression ratio than conventional gasoline engines to take advantage of the high octane rate and to increase efficiency. NGVs may also operate either on stoichiometric mode for low emissions or on lean-mode for higher efficiency. In addition, high pressure storage bottles are required to store compressed NG (CNG) while liquid NG (LNG) stored at low temperature is not that common, mainly due to the higher complexity of storage on the bus. CNG power trains are hence associated with more cost elements and higher maintenance costs than diesel engines. CNG busses may have completely different combustion and after treatment technology, despite using the same fuel. Hence, their emission performance may significantly vary. Therefore, CNG busses also need to fulfil a specific emission standard (Euro II, Euro III, etc.). Due to the low NOx 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 stoichiometric buses are able to fulfil the EEV requirements, while older busses were usually registered as Euro II or Euro III.

The based methodology of GHGs in the road transport is computer program COPERT III, with the desegregation into the 6 base categories and 83 subcategories from the operation of road vehicles in the agglomeration, road and highway traffic mode. This methodology uses for the calculation of emissions the technical parameters about types of vehicles and the country characteristic. For example the composition of car fleet, age of the cars, the parameters of operation and fuels or climate conditions. The estimation is provided in the five main types of the input data:

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

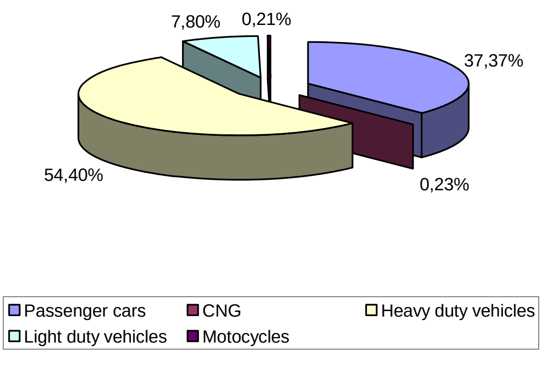
Based on these input parameters and additional information (age of automobiles) is possible to estimate emissions.

The important information about import, production, distribution and sale of the gasoline and diesel oil were received from producer of fuels – Slovnaft Ltd. Bratislava and Petrochema Ltd. Dubová, from the Customs Directory SR, the Statistical Office of the SR. The data about distribution and sale of gaseous fuels – LPG and CNG – were obtained from the exclusive dealers and Slovak Gas Industry Ltd. All materials are in the Slovak language and are official. and in the in the classification of the based group of vehicles fleet, according the structure of COPERT III completed with the information about share of emissions to the operations: city, road and highway traffic. The statistical information about fuels sold in the Slovak Republic are checked with the conclusion of the COPERT III model and the results are with the differences not higher than 2% (in LPG).

Table 3.25: The fuel balance from the COPERT III model results in 2007.

Fuel Balance COPERT III			
Fuel	**Statistical (t)**	**Calculated (t)**	**Deviation (%)**
Gasoline	663 467,00	663 592,20	0,00
Diesel	1 380 255,00	1 378 799,00	-0,10
LPG	21 473,00	21 934,26	2,10

Figure 3.20: The share of emission estimation of GHGs from road transport in 2007 according to the emissions in CO_2 equivalents.



According to the recommendations of the ERT in the previous review process, the blended biomass in liquid fuels was considered and the emission data were recalculated. The information were obtained from Slovnaft Ltd. Bratislava, exclusive distributors of fuels in the Slovak Republic. In terms of implementing directive 2003/30/EC on the replacement of fossil fuels with bio-component:

- In 2005 content bio-component in fuel was value near 0%.
- In 2006 was 1.04%.
- In 2007 was 2.5%.

In 2008 to achieve the target (expected to) figure of 2.6% of all the energy equivalent of gasoline and diesel oil in the condition the Slovak Republic and in 2009 will be expected the value near 3.4%. Requirements for the quality of motor fuels containing bio-component must be at the level of the specifications listed in the STN EN 228:2004 and STN EN 590:2004, respectively. The quality of blending in bio-liquid fuels must meet the requirements specified in the STN EN 14 214, STN EN 15 376.

Table 3.26: The recalculated activity data of gasoline and diesel oil with their emissions and biomass share.

Gasoline blended TJ		Diesel oil blended TJ		CO_2 Gasoline blended Gg		CO_2 Diesel oil blended Gg	
2006	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**
27 281,70	28 927,16	48 478,63	58 660,84	3 578,58	4 327,97	1 991,69	2 110,72
Biomass share %		**Biomass share %**		**Biomass share %**		**Biomass share %**	
1,04	2,5	1,04	2,5	1,04	2,5	1,04	2,5
Biomass TJ		**Biomass TJ**		**Biomass CO_2 Gg**		**Biomass CO_2 Gg**	
283,73	723,18	504,18	1 466,52	36,83	105,56	20,50	51,48
Gasoline fossil TJ		**Diesel oil fossil TJ**		**CO_2 Gasoline fossil Gg**		**CO_2 Diesel oil fossil Gg**	
26 997,97	28 203,98	47 974,46	57 194,32	3 541,75	4 222,41	1 971,19	2 059,24

Table 3.27: The results in GHGs emission balance in 2007 in the road transport according gases and detailed vehicles characteristic.

Category of road vehicles	Emissions GHG in 2007 [t]			Category of road vehicles	Emissions GHG in 2007 [t]		
	CO_2	CH_4	N_2O		CO_2	CH_4	N_2O
Passenger cars	**2 388 745**	**740**	**369**	**Heavy duty vehicles**	**3 606 920**	**246**	**176**
gasoline < 1.4 l	1 077 071	449	176	gasoline > 3.5 t	0	0	0
gasoline 1.4 l–2.0 l	713 493	226	109	diesel 3.5–7.5 t	692 217	71	60
gasoline > 2.0 l	106 395	29	12	diesel 7.5–16 t	662 753	39	35
diesel < 2.0 l	337 200	12	54	diesel 16–32 t	1 384 003	87	52
diesel > 2.0 l	75 548	3	12	diesel > 32 t	415 276	12	12
LPG	78 682	21	6	**City buses**	**189 956**	**18**	**6**
Two stroke engine	356	0	0	**Long-line buses**	**262 715**	**19**	**11**
Light duty vehicles	512 183	28	43	**Vehicles on CNG**	**14 490**	**31**	**0,5**
gasoline < 3.5 t	201 173	22	22	**Motorcycles**	**13 554**	**20**	**0**
diesel < 3.5 t	311 010	6	21	< 50 cm^3	4 688	4	
				Two stroke engine > 50 cm^3	6 173	10	
				Four stroke engine < 250 cm^3	761	2	
				Four stroke engine 250–750	873	2	
				Four stroke engine > 750 cm^3	1 059	2	
				Total blended	**6 535 892**	**1 066**	**588**
				Biomass	161 068	0	0
				Total fossil	**6 374 822**	**1 066**	**588**

Traffic	Emissions GHG [t] in 2007		
	CO_2	CH_4	N_2O
City	2 744 755	829	283
Road	2 685 699	182	204
Highway	1 105 438	54	102
Sum in the SR	**6 535 892**	**1 065**	**589**

Uncertainties and time consistency

The trend in the production of the CO_2 and N_2O emissions from road transportation correspond with the consumption of the fuels. The emission factors are constant during the time series. The development of the Slovak economy is accompanied with the increasing of the road transport and the fuel consumption in total by 21% in 2006/2007 (mostly diesel 21% and gasoline 6%). From these reason the increasing in CO_2 and N_2O emissions is significant.

For the CH_4 emissions are primary important the vehicles alteration for the vehicles with better environmental and energetic parameters (mostly personal cars with catalyzes). The conclusion is slightly decreasing of the CH_4 emission production comparable to the previous year 2006 by 5.6%.

The elimination of the negative influences in the road transport is continuing with the increasing LPG and CNG vehicles (mostly buses and duty vehicles).

The increasing of quality of emission inventory from the transport depends closely on the decreasing and removing of the following uncertainties:

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

The important influence for the quality of calculated results by COPERT III has uncertainty of the following statistics information:

- Statistic information about consumption of the fuels;
- Allocation of the total number of vehicles into the all categories according the methodology;
- The average yearly overrun kilometres;
- The average speed in the traffic mode;
- The average temperatures;
- The beta-factor.

The COPERT III requires the determination of emission factors CH_4 and the calculation of CH_4 emissions accumulate, respectively to determine:

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

QA/QC and verification

The emission inventory of road transportation was determined by SHMÚ in cooperation with external experts from the Transport Research Institute in Žilina and Transport University in Žilina. Sectoral experts with several years' experiences Dr. Jan Breziansky and Mr. Jozef Pinter from Research Institute of Transport in Žilina were trained new expert for transport emission inventory and projections Ms. Michaela Kollarova, joining the SNE team at SHMÚ in 2008.

The verification process is based on cross-checking the input data from the Slovnaft Ltd. Bratislava (exclusive distributor of fuels in the SR) and comparison with the fuel balance from COPERT III model. The background documents are archived by sectoral experts and in central archiving system of SNE at SHMÚ. The list of data providers is included in QA/QC plan:

- Slovnaft Ltd. Bratislava and Petrochema Ltd. Dubová – 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 member countries of European Union.
- Customs Directorate of the Slovak Republic – provides data concerning import and export of gasoline and diesel fuel from countries that are not members of European Union.
- 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 SR.
- 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, Department of Documents and Registration of Presidium – provides data concerning numbers of new registrations, changes if the registration and deregistration of road vehicles at the end of the year of the emission inventory.

- Association of car industry of the Slovak Republic – in its statistical yearbook can be found detailed data concerning structure of all type of cars sold in the SR during actual year.

Recalculations

Only minor recalculations were provided on the correction of NCVs for LPC during 1994–2002, the revised value of NCV for LPG is 45.75 TJ, corresponding with the statistical information and in consistency with time series.

Table 3.28: The recalculated LPG fuel consumption and emissions.

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002
LPG (TJ) 2009	35,7765	22,8750	26,9010	23,3325	23,3325	272,2125	661,8653	996,8000	1 303,9196
LPG (TJ) 2008	9,5000	15,9000	19,3000	23,3000	23,3000	273,2000	661,9000	996,8000	1 303,9196
change %	376,59	143,87	139,38	100,14	100,14	99,64	99,99	100,00	100,00
CO_2 (Gg) 2009	2,8653	1,8320	2,1544	1,8686	1,8686	21,8008	53,0072	79,8312	104,4324
CO_2 (Gg) 2008	0,7609	1,2734	1,5458	1,8661	1,8661	21,8809	53,0123	79,8348	104,4324
change %	376,58	143,86	139,38	100,13	100,13	99,63	99,99	100,00	100,00
CH_4 (Gg) 2009	0,0010	0,0010	0,0010	0,0010	0,0006	0,0070	0,0170	0,0210	0,0327
CH_4 (Gg) 2008	0,0010	0,0010	0,0010	0,0010	0,0010	0,0070	0,0170	0,0210	0,0269
change %	100,00	100,00	100,00	100,00	60,00	100,00	100,00	100,00	121,61
N_2O (Gg) 2009	0,0002	0,0001	0,0002	0,0001	0,0001	0,0016	0,0040	0,0060	0,0078
N_2O (Gg) 2008	0,0000	0,0000	0,0000	0,0000	0,0000	0,0020	0,0040	0,0060	0,0074
change %						81,65	99,28	99,68	105,47

The recalculation of CO_2 emissions based on implementation of the biomass content in the blended fuel was improved for 2006. The bio-component emissions of CO_2 are included in biomass category.

Planned improvements

The improvements are planned for the next submission in disaggregation of buses to the EURO categories for the previous years (2006–1990) and estimating of the new EF(CH_4) for CNG for ensuring the time series consistency after recalculation.

The implementation of COPERT IV model based methodology is expected in the next submission. The data of disaggregation heavy duty vehicles and buses are needed. The first discussions were taken place with the Presidium of the Police Force of the Slovak Republic. The difficulties are expected in the level of detail statistics.

3.2.3 Railways (CRF 1.A.3c)

The second important source of emissions in transport subsector is railways transport, despite to the fact of decreasing character of this transport mode. The decreasing trend is stabilized from 2003 and occurred mostly in the freight transportation. Total emissions from railways transport reach in 2007 123.28 Gg of CO_2 equivalents and have decreasing comparable to previous year 2006 by 4% and comparable to the base year by 70%.

Methodology

Greenhouse gas emission inventory of railways transport represents the operation of diesel traction is performed using the simple methodology Tier 1. The weight of the individual emissions of greenhouse gases is calculated from the weight of fuel consumed by diesel rail traction multiplied by emission factor. The emission factor is the average value for the entire performance spectrum of the driving motor vehicles traction. The methodology is taken and emission factors for CH_4 and N_2O are derived from the EMEP/CORINAIR EIG – Other mobile sources and machinery. IPCC GPG 2000 does not contain recommendation on the choice of methodology and emission factors for GHG emission inventories of railways transport. The mobile sources of pollution in the railways transport included vehicles of the motor traction the Railways Company Ltd. of the SR (RC SR). This motor traction is divided into the two basic groups of vehicles: motor locomotives (Traction 70) and motor wagons (Traction 80). The operation of the motor traction is covered by four depots in the organization structure of the Railways Company Ltd. from 2002 (Bratislava, Zvolen, Žilina and Košice). This structure is respected in the emission inventory. The consumption of diesel oil for the motor traction in the SR 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.

Table 3.29: The statistical information about the railways organisation structure in 2007 for Traction 70+80.

Traction 70+80, CARGO+Public							
Year run	**Košice**	**Žilina**	**Zvolen**	**Bratislava**	**Total public**	**Total CARGO**	**Total SR**
Number of loco	210	113	165	157	238	407	**645**
[km per year]	7 821 470	3 782 622	9 234 527	6 461 186	14 021 796	13 278 009	**27 299 805**
Operations [hrtkm]	536 165 000	229 380 000	2 290 562 000	825 867 000	1 081 476 000	2 800 498 000	**3 881 974 000**
Consumption [l]	9 601 374	3 510 390	16 922 245	10 545 855	15 274 694	25 305 170	**40 579 864**
Consumption [t]	8 065	2 949	14 215	8 859	12 831	21 256	**34 087**

Table 3.30: The consumption/sale of diesel oil in the motor traction section in the railways transportation in the SR during 1990–2007.

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Diesel oil (kt)	118,18	88,90	73,35	62,97	59,44	64,01	62,82	59,03	54,15	49,57	48,86	48,18	44,76	35,80	34,33	33,43	35,52	34,08

Uncertainties and time consistency

The inter-annual decreasing of the diesel oil consumption in motor traction of railways is only minor fluctuation in the trend of permanent decreasing in 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 reduction of number of the realised operations in passenger and freight railways transport causes these decreasing and this trend can be expected in the future. The Railways Company, Ltd. makes new economic and effective policy in the operation of the railway transport. The extensive reconstruction of railways transport infrastructure takes place at the present to fulfil international requirements.

QA/QC and verification

The emission inventory of railways was determined by SHMÚ in cooperation with external experts from the Transport Research Institute in Žilina and Transport University in Žilina. Sectoral experts with several years' experiences Dr. Jan Breziansky and Mr. Jozef Pinter from Research Institute of Transport in Žilina were trained new expert for transport emission inventory and projections Ms. Michaela Kollarova, joining the SNE team at SHMÚ in 2008.

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

In the GHGs emission inventory were made two fundamental changes in the values of emission factor for the motor traction mentioned in the previous submission. Based on the legislative basis (regulation of the Ministry of Environment Nr. 144/2001) about the requirements for the fuels quality the EFs for diesel oil were revised in the years 1994 and 2002. The emissions and the actual EFs are shown in the following Table 3.31. The emissions are divided according the type of the railways operation (passenger, freight and service transport) from 1995.

Table 3.31: The fuel consumption and the emissions in the railways transport in 2007.

Executive Unit	**Diesel oil consumption**		**Emissions [t]**		
	[l]	[t]	CO_2	N_2O	CH_4
EFs for the motor locomotives and wagons kg/t diesel oil			**3 188**	**1,37**	**0,19**
Košice	9 601 374	8 065,15	25 711,71	11,05	1,53
Žilina	3 510 390	2 948,73	9 400,54	4,04	0,56
Zvolen	16 922 245	14 214,69	45 316,42	19,47	2,70
Bratislava	10 545 855	8 858,52	28 240,96	12,14	1,68
Public	15 274 694	12 830,74	40 904,41	17,58	2,44
CARGO	25 305 170	21 256,34	67 765,22	29,12	4,04
Total SR	**40 579 864**	**34 087,09**	**108 669,63**	**46,70**	**6,48**

Recalculations

No recalculation in the submission 2009 focused to the base year or 2006 was provided.

Planned improvements

The information about fuel consumption on the international public transport corridors will be verified in the next inventory year.

3.2.4 Navigation (Inland Shipping) (CRF 1.A.3d)

GHG emission inventory of navigation transport in the Slovak Republic is aimed to calculate the emissions of CO_2, CH_4 and N_2O from shipping activities in the Slovak section of the Danube River. Inventory of GHG emissions from inland shipping transport has no direct methodological support in the IPCC GPG 2000. There are available only minimum information for this type of transport. For this reason and in view of the relationship traction river boats with diesel traction rail transport and was selected the same methodology and the same emission factors to calculate GHG emissions as in the case of rail transport. Consumption of diesel oil is determined indirectly from the available statistical data on shipping activities in the Slovak section of the Danube River in the year and the technical parameters characteristic of the Danube traction vessels.

According to the recommendations of the ERT from 2007 in-country review of the Slovak Republic, all emissions from inland shipping category are included in category 1.C1 memo items – international bunkers, because of international character of shipping transportation on Danube River. Other inland shipping transportation in the Slovak Republic is negligible and only for tourist purposes.

3.2.5 Other Transportation – Military Aviation (CRF 1.A.3e)

Emissions of GHGs from the military aviation, jet kerosene consumption were included into the category 1.A.3e other transportation from 1990. The information are directly from ministry of defence of the Slovak Republic. The methodology is comparable with the methodology for emission estimation of civil aviation, based on fuel consumption in military service multiply with default emission factor for jet kerosene. The emissions are not key source and comparable to the civil aviation represent 17% of the civil aviation category, 2.49 Gg of CO_2 equivalents in 2007.

3.2.6 International Bunkers (CRF 1.C1)

Emission inventory for international bunkers is based on balance for international aviation and inland shipping.

3.2.6.1 Aviation (CRF 1.C1.A)

The information of methodology used for emission estimation of international aviation transport are explained in the category 1.A.3a civil aviation. The expert judgment completed with the activity data from the airports operators were used as base for methodological approach. Emissions are not included in the national total.

3.2.6.2 Marine (CRF 1.C1.B)

The total aggregated emissions from inland shipping reached in 2007 4 419 Gg of CO_2 equivalents, the increasing comparable to the previous year 2006 is more then 7%, but comparable to the base year is the increase even more significant 500%.

The Slovak Republic was used Tier 1 methodology based on transportation model (fuel consumption by transit transport) for emission estimation of inland shipping on Danube River. The national shipping activities are not occurring (except of few tourists sightseeing journey during summer months). According recommendations of ERT final findings and IPCC GPG 2000, the recalculation in category 1.A.3d Navigation was provided, emission estimation based on fuel consumption and the international rule for inland shipping on the Danube River was evaluated.

Methodology

Two relevant ports on Danube River take into consideration for the emission estimation in the Slovak inland international transport – Bratislava and Komárno. The activity data for the period 1994–2007 come from State Shipping Administration in the accordance periodical annual providing of statistical-processing information in the water transport. The activity data for the period 1990–1993 are not statistically documented and that why the expert estimation on the base of the navigation traffic on the Danube River were performed. 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 neighbours' counties (market discrepancies).

The GHG emissions from the diesel oil consumption sold in the Slovak Republic in important ports Bratislava and Komárno were balanced in the period 1990–2007. The following Table 3.32 shows the emission balance using EFs for the different type of ships known in the time of estimation for diesel fuel – more realistic way of emission estimation and recommended to use by sectoral expert (was applied after in-country review in 2007).

Table 3.32: The emission balance of GHGs from diesel oil sold for shipping companies in the SR between 1990–2007 based on historical EFs in that time. In red colour the expert estimation of diesel oil sale based on the developing of diesel fuel consumption on The Slovak part of Danube River.

Year	Sold Diesel oil [t]	Sold Diesel oil [TJ]	Emissions [t] CO_2	N_2O	CH_4
EF in kg/t Diesel oil			**3 188,00**	**0,10**	**0,25**
1990	20 500,00	871,25	65 354,00	2,05	5,13
1991	18 000,00	765,00	57 384,00	1,80	4,50
1992	17 000,00	722,50	54 196,00	1,70	4,25
1993	14 000,00	595,00	44 632,00	1,40	3,50
EF in kg/t Diesel oil			**3 188,00**	**1,37**	**0,20**
1994	13 387,00	568,95	42 677,76	18,34	2,68
1995	18 066,00	767,81	57 594,41	24,75	3,61
1996	15 390,00	654,08	49 063,32	21,08	3,08
1997	9 167,00	389,60	29 224,40	12,56	1,83
1998	12 813,00	544,55	40 847,84	17,55	2,56
1999	2 701,00	114,79	8 610,79	3,70	0,54
2000	0,00	0,00	0,00	0,00	0,00
2001	8 366,00	355,56	26 670,81	11,46	1,67
EF in kg/t Diesel oil			**3 188,00**	**1,37**	**0,19**
2002	9 027,20	383,66	28 778,71	12,37	1,72
2003	6 836,00	290,53	21 793,17	9,37	1,30
2004	2 660,97	113,09	8 483,17	3,65	0,51
2005	214,00	9,10	682,23	0,29	0,04
2006	9 569,00	406,68	30 505,97	13,11	1,82
2007	10 231,24	434,83	32 617,19	14,02	1,94

Uncertainties and time consistency

Table 3.33: Recalculated fuel's sold emissions in the 1990–2007 from inland shipping on Danube River transport.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2 (kt)	65,35	57,38	54,20	44,63	42,68	57,59	49,06	29,22	40,85	8,61	0,00	26,67	28,78	21,79	8,48	0,68	30,51	32,62
CH_4 (t)	5,13	4,50	4,25	3,50	2,68	3,61	3,08	1,83	2,56	0,54	0,00	1,67	1,72	1,30	0,51	0,04	1,82	1,94
N_2O (t)	2,05	1,80	1,70	1,40	18,34	24,75	21,08	12,56	17,55	3,70	0,00	11,46	12,37	9,37	3,65	0,29	13,11	14,02

QA/QC and verification

Verification of the activity data about sold fuel for shipping activities takes place by sectoral experts and comparing with the statistical information.

Recalculations

No recalculation in the submission 2009 focused to the base year or 2006 was provided.

Planned improvements

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

3.3 Fugitive Emissions from Fuels (CRF 1.B)

The important source of methane emissions in national GHGs inventory are fugitive emissions from 1.B.1 Solid fuel (coal mining and handling) and 1.B.2 Oil and natural gas as a key sources categories in uncertainty estimation (Annex 2). No emissions are estimated from other sources in subcategory 1.B Fugitive emissions from fuels. Only emissions of NM VOC from coke production are included in the category 1.B.1.B Solid fuel transformation.

3.3.1 Coal Mining and Handling (CRF 1.B.1.A)

The Slovak Republic are mined 2 064.483 kt of brown coal from domestic production in the 2007 of it 70 kt of assorted coal for the habitants. The coal market is fully liberalized, the domestic production not covers all demand, because of 923 kt of brown coal were imported (mostly from Czech Republic). The production of brown coal (mining) has decreasing trend and decreased comparable to the previous year by more than 6%.

Total methane emission from underground coal mining in 2007 was estimated to be 13.5181 Gg (12.499 Gg of CH_4 from underground coal mining, 1.2449 Gg of CH_4 from post-mining activity and 0.2259 Gg of CH_4 from cogeneration use of methane for electricity and heat production).

Table 3.34: The trend in fugitive emissions from mining and post-mining activities in the period 1990–2007 in the Slovak Republic.

Year	1990	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	Fugitive emissions of CH_4 (Gg)																
Mining	25,11	27,64	26,43	27,65	27,44	27,76	28,25	28,79	27,20	26,62	24,27	23,64	19,26	17,99	14,66	13,30	12,50
Post-mining	2,08	2,29	2,18	2,26	2,27	2,32	2,36	2,38	2,30	2,20	2,07	2,05	1,85	1,78	1,51	1,30	1,24
Total	27,20	29,93	28,61	29,91	29,70	30,08	30,61	31,17	29,50	28,82	26,33	25,69	21,11	19,77	16,17	14,70	13,74
Cogeneration	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	0,00	0,23
Total	27,20	29,93	28,61	29,91	29,70	30,08	30,61	31,17	29,50	28,82	26,33	25,69	21,11	19,77	16,17	14,70	13,52

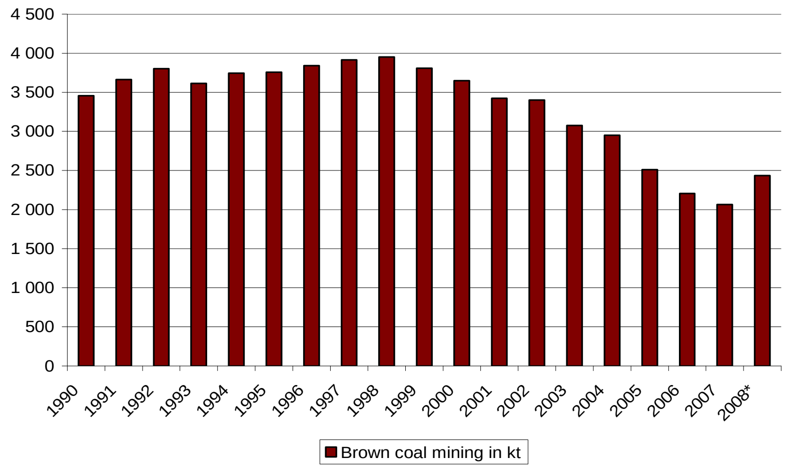
Methodology

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

In the Slovak Republic are five localities of underground mines in operation of tree companies. Data of coal production from single underground mines have been obtained from official sources (official statistical sources: Ministry of Economy of the SR and the Statistical Office of the SR) and directly from three companies: Hornonitrianske bane Prievidza (HBP), Baňa Dolina Veľký Krtíš (BD) and Baňa Čáry (BC). According to the regulation of the Slovak Office of Mines 21/1988 are mines allocated based on gas release as follow:

- HBP 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 3.21: The trend in coal mining productivity in 1990–2008 (*with predictions).*



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

- IPCC 1996 Guidance for National Greenhouse Gas Inventories, Fugitive sources, 1.4 Methane Emissions from Coal Mining and Handling Activities;
- 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.

Table 3.35: The coal production according to the mine, characteristics of mine and availability of EF($CH)_4$ for coal mining a handling assigned to single mines in SR in 2007.

Mine	Mine Nováky	Mine Nováky 6th logging place	Mine Cígeľ	Mine Cígeľ 7th logging place	Mine Handlová	Mine Handlová east shaft	Mine Dolina	Mine Čáry
Coal production [kt]	1 169	0	0	415	0	313,5	146,708	20,275
Depth of mine [m]	200	200	500	500	500–1 500	500–1 500	600	400
	EF(CH_4) [m^3/t]							
1. IPCC Guidance for National Greenhouse Gas Inventories								
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								
EF(CIAB) mining	6	6	13	13	13	13	13	13
IPCC post mining	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9
3. EF($CH)_4$ specified of the mines operator - HBP								
Mining-measure	0,92	4,17	0,00	4,17	0,00	4,17	0,02	0,02
Post mining	0,39	0,46	0,00	0,46	0,00	0,46	0,01	0,01

Emission factors according to IPCC 1996 Guidance used for all mines the identical values 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 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. There were used the values on the lower level of the suggested scale as well as in the previous case. EF(CH_4) specified and measured by the mines operator HBP Prievidza on the base of concentration values of the methane and amount of air ventilation were assigned for single mine according to the suggestion of the operators. EF(CH_4) for post–mining were used from IPCC 2000 Good Practice Guidance for mining without drainage with known of gas amount – in the coal after mining is present 30% of gas and for mines with pre-drainage 10% of gas.

It was decided based on sectoral expert judgment that the fugitive methane emissions in the period 1990–2007 were calculated on the base of coal production from single underground mines obtained from official sources and EF(CH_4) according to the methodology IEA - CIAB Global Methane and the Coal Industry according to the depth of the mines (Table 3.35, point 2) as a best appropriated.

For the calculation are used assumptions that fugitive methane emissions were partly use to electricity and heat production cogeneration first time in 2007 in east shaft of mine Handlova. The amount of methane cogenerated for 2007 is 338 115 m^3 (225.861 kt). The calculation is based on measures of gaseous mixture (air + methane 1 022 730 m^3) and concentration of methane was 33.06%. The emissions of GHGs from cogeneration are included into category 1.AA.1.A – other fuel (methane cogeneration (mining)) and represents 0.64 Gg of CO_2 equivalents in 2007. The increasing of cogeneration activities are expected also in the future.

Flaring activity for reducing methane emissions from coal mining in the Slovak Republic is not occurred in 2007.

The Figure 3.22 shows comparison of trend in CH_4 emissions in the Slovak Republic in years 1990–2007 estimated according to emission factors of IPCC GPG 2000, IEA-CIAB methodology and EF(CH_4) measured by HBP Prievidza. In the case of emissions calculation with using of IPCC emission factors, the trend of fugitive emissions CH_4 is declining in accordance to reduction of coal mining in the SR. Application EF(CH_4) specified of mines operator (HBP) shows increasing trend of fugitive emissions CH_4 in contradiction with decreasing of coal mining in the mines. It is due to the moving of coal mining to parts of mines with coal containing more of gas. Using emission factors from IEA-CIAB according to the depth of mine, the appropriate EF is estimated for each mine and the total emissions from mining are summarizing the emissions from mines. The average EF for methane mining in 2007 is 6.054 kg/t.

Figure 3.22: The comparison of trends emissions CH_4 in SR in years 1990–2008 (*with predictions).*

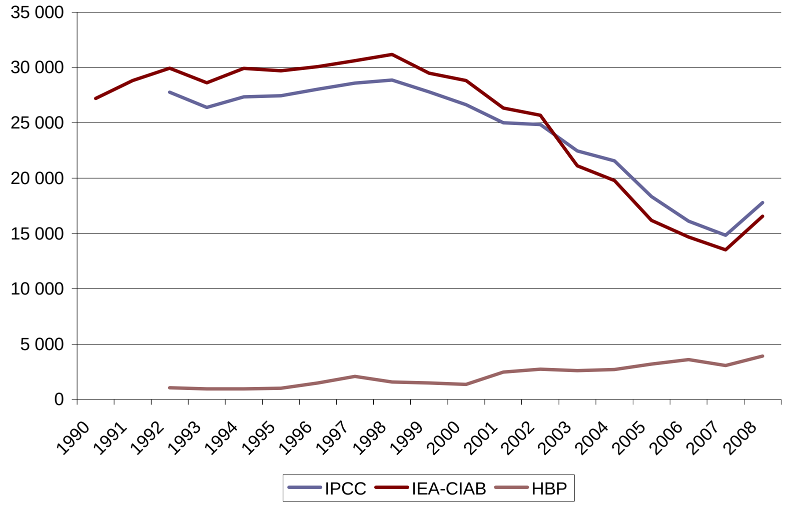
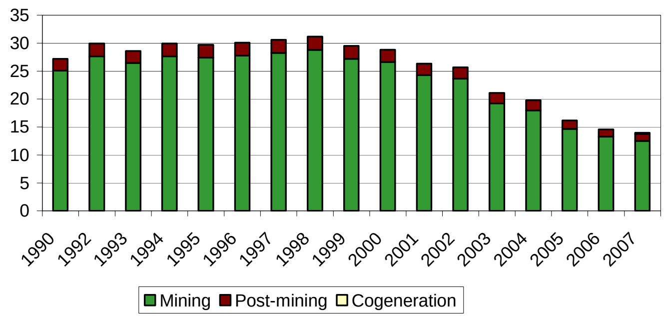


Figure 3.23: The results of emission estimation from mining activities.



Emissions from post-mining activities represent the second part of gaseous methane presents in the mined coal. This source of emission releases the methane into the atmosphere during the manipulation and storage of coal. The measurement of these emissions are not realised and the emission estimation must be done with the default emission factors. It is assumed, that 25–40% of CH_4 is present into the coal. For the without drainage mines is recommended to use 30% and for the pre-drainage mines the emission factor 10%. The average emission factor used for emission estimation from post-mining activities based on IEA-CIAB methodology is 0.9 m^3/t (0.603 kg/t).

Uncertainties and time consistency

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 with the dependence of the measurement's installation. The repeatability of the measurements increases accuracy up to ±5%. For the continual measurement is the uncertainty 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 are corresponding 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.

QA/QC and verification

The Slovak inventory team with cooperation of Profing Ltd. (Mr. Jan Judak is sectoral expert for energy and fugitive emissions) were provided the emission estimation according the methodology used from base year and official statistics.

The verification process is based on cross-checking the input data from the mining companies and comparison with the sectoral statistical indicators from ministry of economy and Statistical Office of the SR. The background documents are archived by sectoral experts and in central archiving system of SNE at SHMÚ.

Recalculations

No recalculation in the submission 2009 focused to the base year or 2006 was provided.

Planned improvements

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

3.3.2 Oil and Natural Gas (CRF 1.B.2)

The production of oil and natural gas from domestic sources are negligible in the SR and the major share of these stocks comes from import. These categories are important key sources in level and trend assessment in uncertainty management (Annex 2). The total methane emissions represent 32.43 Gg in 2007.

The total CO_2 emissions in 2007 were 0.137 Gg and the estimation was based on the composition of natural gas and carbon content. The time series was completed from 1990.

3.3.2.1 Oil (CRF 1.B.2A)

Total emission inventory of category 1.B.2A Oil is provided for CO_2 and CH_4 gases. The emissions of N_2O are negligible and were not measured in the accredited laboratory during flaring. Only minor part of the oil is produced in the Slovak Republic on one oil dwelling place in the west part of the SR (Gbely). Total fugitive emissions from oil in 2007 were estimated for the following categories: 1.B.2.A.2 Production, 1.B.2.A.3 Transport, 1.B.2.A.4 Refining/Storage and from venting and flaring of oil. Total emissions in 2007 were estimated 3.0975 Gg of CO_2 equivalents. The production of oil is at same level as in 2006, the transport is slightly decreases, but refining is increase, the trend is stable. Comparable to the base year, the decreasing is more significant by approximately 25%. The fugitive emissions of CH_4 and CO_2 from oil are only minor part of emission inventory of fugitive emissions (less than 1%).

Methodology

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. Methodology is based on Tier 1 according to the IPCC 2000 GPG and using new emissions factors refined EF (CH_4) for Tier 1, based on North America data – IPCC 2000 Good Practice Guidelines, table 2–16 with applications high level of emission factors (conservative principle). The emissions of CO_2 were estimated based on analyses of natural gas CO_2 content in 2007 (prepared by monthly analyses) with the recalculation value of 4.222 grams CO_2 per kg CH_4.

Table 3.36: The activity data, EFs and fugitive emissions of CH_4 and CO_2 from oil production, transport and refining/storage in 2007.

IPCC 2000 GPG Table 2.16 based on the balance in North America						
2007	**Oil (t)**	**Oil (PJ)**	**EF (CH_4) Gg/t**	**EF (CO_2) g/kg CH_4**	**CH_4 (t)**	**CO_2 (t)**
Oil production	28 000	1,162	1,50E-03	4,222	42,000	0,177
Oil transport	10 637 000	441,436	5,40E-06	4,222	57,440	0,243
Oil refining/storage	6 093 000	252,860	5,40E-06	4,222	32,902	0,139
Oil venting	28 000	1,162	2,70E-04	4,222	7,560	0,032
Oil flaring	28 000	1,162	2,70E-04	4,222	7,560	0,032

Table 3.37: The results from the analytical measurements due in accredited laboratories of Slovak Gas Industry company in the period 2000–2007.

	Composition of Natural Gas [%]									
Year	CH_4	C_2H_6	C_3H_8	i-C_4H_{10}	n-C_4H_{10}	i-C_5H_{12}	n-C_5H_{12}	C_6H_{14}	**CO_2**	N_2
2000	97,14	1,13	0,37	0,05	0,07	0,01	0,01	0,02	**0,27**	0,93
2001	97,37	1,03	0,32	0,04	0,06	0,01	0,01	0,01	**0,23**	0,92
2002	97,42	1,03	0,32	0,04	0,06	0,01	0,01	0,01	**0,21**	0,89
2003	97,57	0,96	0,31	0,05	0,06	0,01	0,01	0,01	**0,15**	0,87
2004	97,69	0,95	0,29	0,05	0,05	0,01	0,01	0,01	**0,12**	0,82
2005	97,50	1,04	0,34	0,05	0,06	0,01	0,01	0,01	**0,14**	0,84
2006	97,22	1,18	0,37	0,05	0,06	0,01	0,01	0,01	**0,19**	0,85
2007	97,46	1,08	0,34	0,05	0,06	0,01	0,01	0,01	**0,15**	0,83

3.3.2.2 Natural Gas (CRF 1.B.2B)

Total emission inventory of category 1.B.2B Natural gas is provided for CO_2 and CH_4 gases. The emissions of N_2O from natural gas are negligible and were not measured in the accredited laboratory during flaring. Only minor part of the natural gas is produced in the Slovak Republic on several dwelling places in the east and west parts of the SR. The major part of fugitive emissions comes from transit and import of natural gas, mostly from Russian Federation (98%). Total fugitive emissions from natural gas in 2007 were estimated for the following categories: 1.B.2.B.2 Production/Processing, 1.B.2.A.3 Transmission, 1.B.2.A.4 Distribution, 1.B.2.A.5 Other leakage (plant, residential – only activity data) and from venting and flaring of natural gas. Total emissions in 2007 were estimated 681.113 Gg of CO_2 equivalents. The production of natural gas decreasing by more than 30% comparable to 2006, the transmission of NG is at the same level (the length of transmission pipelines not change comparable to the previous year), but distribution is increasing in context of increasing length of distribution pipelines by 3%. Comparable to the base year, the increasing is more significant by approximately 50%. The fugitive emissions of CH_4 and CO_2 from natural gas are major part of emission inventory of fugitive emissions (more than 99%).

Methodology

The fugitive emissions CH_4 from transport and distribution of natural gas in the SR have been calculated with IPCC Tier 1 default methodology. Activity data of natural gas have been obtained from official sources – The Slovak Gas Industry, LtD., Ministry of Economy of SR and the Statistical Office of the SR.

Table 3.38: The activity data in year 2007 – production, export and import NG in the SR.

SR	Natural gas [m^3]	Natural gas [PJ]	NCV [m^3/PJ]
Indigenous production	128 000 000	4,5504	35,550
Associated gas	16 000 000	0,5688	35,550
Nonassociated gas	112 000 000	3,9816	35,550
Stock changes	0	0	35,176
Gas vented	5 000 000	0,17775	35,550
Gas flared	11 000 000	0,39105	35,550
Export	180 000 000	6,331284	35,174
Import	6 268 000 000	221,8176252	35,389
Inland consumption	**6 216 000 000**	**218,6515296**	35,176

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.

Emissions from compression stations and pipelines were calculated on the base of gas leakages according to Slovak Gas Industry, LtD. Distribution losses of NG in the SR are 277 286 m^3 (15°C; 101.325 kPa) (184 t of CH_4) according to preliminary balances of gas fuels in year 2007 (Statistical Office of the SR). This value represented approximately 0.0043% of total NG consumption in the SR.

The calculation of fugitive methane emissions from transport and distribution of NG in the SR according to Slovak Gas Industry, LtD. methodology (national approach) is based on the calculation of leakages of NG from the compression stations and from transport pipelines. There are four big compression stations (KS1 – Velke Kapusany, KS2 – Jablonov nad Tunov, KS3 – Velke Zlievce and KS4 – Ivanka pri Nitre) and three transport pipelines (ZLC Roznava, HPS Velky Krtis, ZLC Nitra) in the Slovak Republic. The estimation of the leakages from these facilities is 3 856 t of CH_4 (according the continual measurements). The distribution losses in the distribution pipelines were estimated according to the expert's judgment of the Slovak Gas Industry, LtD. with the following methodology:

Distribution losses [kg CH_4] = 277 286 [m^3 ZP] *0.975* (273.15/(273.15+15)) * 0.7176 = 184 t of CH_4.

Fugitive emission CH_4 from transit and distribution of NG = 3 856 + 184 = 4 040 t of CH_4.

This approach was not applied for the national inventory.

The fugitive emission estimation methodology was used for national inventory with the applications of new refined EF (CH_4) (high) for Tier 1 approach based on North America data (IPCC 2000 GPG, Table 2–16). The results of the calculated fugitive methane emissions show, that disaggregating of gas and oil industry to main- and sub-categories according to principles „good practice“ improved quality of balances. The results received from the calculation of methane emissions with applications 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 SR is increasing. It is due to the expansion of the distributed system and growth of NG consumption. The emissions of CO_2 were estimated based on analyses of natural gas CO_2 content in 2007 (prepared by monthly analyses) with the recalculation value of 4.222 grams CO_2 per kg CH_4 (see Table 3.36 in section 1.B.2A Oil).

Table 3.39: The activity data, EFs and fugitive emissions of CH_4 and CO_2 from NG production/processing, transmission and distribution in 2007.

IPCC 2000 GPG Table 2.16 based on the balance in North America						
2007	**Activity data**	**Unit**	**EF(high) GgCH4/mil.m^{3}NG, GgCH$_4$/km**	**CH_4 (high) t CH_4**	**EF (CO_2) g/kg CH_4**	**CH_4 (high) t CH_4**
NG* production fugitive	128 000 000	m^{3}ZP	2.90E–03	3 453,15	4,222	14,58
NG transmission fugitive	2 270	km	2.90E–03	6 583,00	4,222	27,79
NG distribution fugitive	31 537	km	7.10E–04	22 391,27	4,222	94,54
NG storage fugitive	0	m^{3}ZP	4.20E–03	0,00	4,222	0,00
NG transport venting	2 270	km	1.20E–03	2 724,00	4,222	11,50
NG* Production flaring	128 000 000	m^{3}ZP	1.30E–05	147,58	4,222	0,01
Total				**35 299,00**		**148,42**

Note: NG* production – the values of fugitive and flaring methane emissions were calculated on base reported data of vented NG – 5 mil.m^3 and flared NG – 11 mil.m^3 (Statistical Office of the SR – 2007).

Table 3.40: The fugitive emissions from natural gas processing and distribution in the SR in 2007.

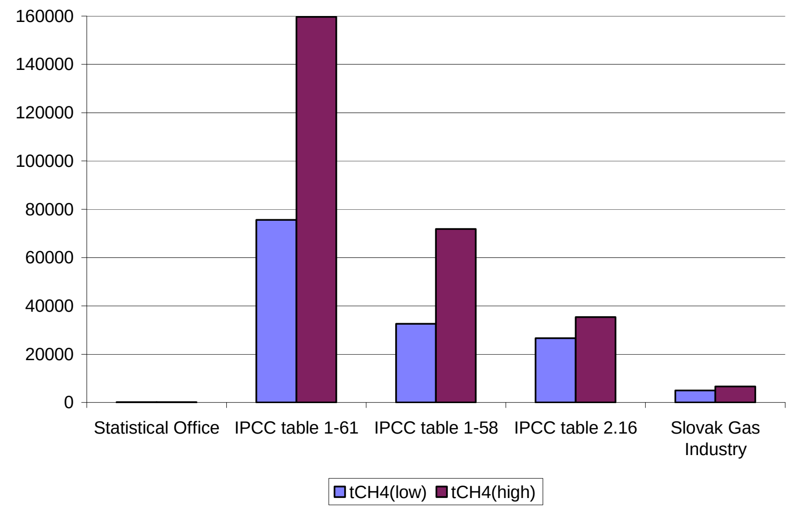
Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
	Fugitive emissions (Gg)																	
CH_4	21,35	21,86	21,18	22,02	23,20	25,34	25,97	26,62	28,38	28,54	28,86	30,03	30,01	32,78	29,76	28,87	29,15	32,43
CO_2	0,13	0,12	0,11	0,12	0,12	0,13	0,14	0,14	0,15	0,15	0,15	0,16	0,16	0,17	0,16	0,15	0,16	0,14
Total CO_2 eq.	**448,6**	**459,1**	**444,8**	**462,5**	**487,4**	**532,3**	**545,5**	**559,1**	**596,1**	**599,6**	**606,3**	**630,9**	**630,3**	**688,6**	**625,0**	**606,4**	**612,4**	**681,1**

Uncertainties and time consistency

The trend of fugitive emissions of CH_4 from transport and distribution of natural gas in the SR is increasing due to the expansion of the distributed system and growth of NG consumption in the SR. 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 in 2006 year was 0.1492% mol.

The application of IPCC default EFs for fugitive emissions from NG for regions of former USSR and Eastern Europe (IPCC Guidelines, Reference Manual Table I-49) give too high results (75 537–159 667 t CH_4) and are approximately 2.9–4.6 times higher as the above-mentioned values. The estimate of the Statistical Office for distributed losses (184 t CH_4) is too low. For the balance of the fugitive methane emissions from transport and distribution of natural gas in the SR we recommend using values calculated using applications new refined EF based on North America data with the conservative approach (using high range of EFs).

Figure 3.24: The comparison between the methodologies used for calculation (national approach according the Slovak Gas Industry, LtD. and IPCC) of the fugitive methane emissions from transport and distribution of natural gas in the SR.



QA/QC and verification

The Slovak inventory team with cooperation of Profing Ltd. (Mr. Jan Judak is sectoral expert for energy and fugitive emissions) were provided the emission estimation according the methodology used from base year and official statistics.

The verification process is based on cross-checking the input data from the Transpetrol company (oil) and Slovak Gas Company (NG) and comparison with the sectoral statistical indicators from ministry of economy and Statistical Office of the SR. The background documents are archived by sectoral experts and in central archiving system of SNE at SHMÚ.
According the activity and input data provided in the results from the analytical measurements due in accredited laboratories of Slovak Gas Industry company, the calculation of so-called recalculation factor for estimation CO_2 emissions from natural gas treatment was evaluated to be 4.222 CO_2 in g per Gg of CH_4.

The N_2O emissions are not estimated (negligible) in the total content of natural gas and oil composition by flaring (measurements in the accredited laboratories).

Recalculations

Recalculation of the activity data of the category 1.B.2A.4 Oil refining/storage for the previous inventory year 2006 was provided. The activity data was corrected according to the revision of the data provider (Transpetrol company). The corrected number of refining/storage oil is 5 749 kilotons of crude oil (the change comparable to the 2008 submission is below 0.5%. The methane and CO_2 emissions were revaluated and the corrected values are (31.04 t CH_4 and 0.169 t CO_2).

Planned improvements

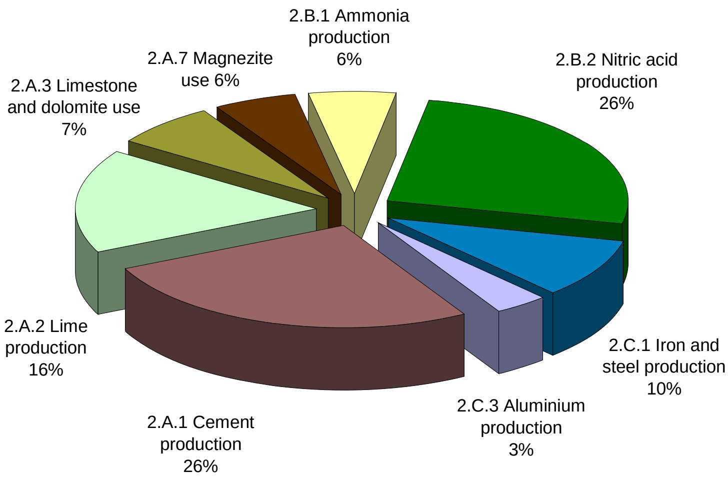
The Slovak Republic is using EFs from the international methodology IEA-CIAB, the improvements can be found in implementation measured EFs directly from the companies. According to the present measurements, the information about the natural gas are not sufficient accurate and measurements are not continual and not at the distribution places. The more effort can be invest into the determination of appropriate national EFs for fugitive emissions from oil and natural gas production, processing and distribution in the SR.

4 INDUSTRIAL PROCESSES (CRF 2)

The Industrial Processes sector in the Slovak Republic is a source of CO_2, CH_4, N_2O, NO_x, CO, NM VOC, SO_2, CF_4, C_2F_6, and SF_6 pollution. Even though the emissions of CO_2 and N_2O are reported in this sector only, because of problematic estimation of this emissions and hardly separation of industrial sources and fuel combustion sources each other in industrial processes. The main attention was paid to the biggest sources of emissions of greenhouse gasses. This approach made it possible to obtain real picture on emissions in the Slovak Republic from Industrial Processes.
The emissions of CO_2 occurring by manufacture of glass, ammonium production and iron & steel production are included in sectoral approach of the energy sector – manufacturing industries and in the reference approach in the balance of fossil fuel combustion. The Faculty of Chemical and Food Technology of Slovak Technical University was took responsibility for preparation of this emission balance and followed the instructions of IPCC methodology and Good Practice Guidance 2000. The information used was obtained from different sources as well (Statistical Office of the SR, Ministry of economy, Union of Slovak Chemical Industry, plant operators, producers etc). The obtained information was checked with the experience of the SHMÚ with monitored industrial technologies in NEIS database.

Whereas the N_2O emissions comes from the nitric acid production only (this category is 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. Total anthropogenic emissions of CO_2 from this sector are 4 108.77 Gg and the major share comes from cement production (26%), nitric acid production (26%) and lime production (16%).

Figure 4.1: The share of individual technologies in the IP sector in 2007 in CO_2 equivalents.



4.1 Mineral Products (CRF 2.A)

The major share of CO_2 pollution comes from mineral products production and transformation. Total emissions in 2007 were 3 088.52 Gg of CO_2, the increasing 2.5% comparable to the previous year is not significant, but the trend of increasing is stable from 2000. The increasing is more visible in cement production category.

4.1.1 Cement Production (CRF 2.A.1)

According to the IPCC Guidelines, it is a good practice that the amount of CO_2 emission is calculated from the mass of produced cement clink. However, in the Slovak Statistical Annual Report only mass of produced cement is published. Therefore, the Slovak cement plants, where the cement clink is produced, are decisive for inventory of greenhouse gases. The CO_2 emissions originate at clink production. Production of cement from clink consists in milling the clink with some solid additives. Therefore it is meaningful to balance just the clink production. Amount of produced cement is not important for greenhouse gases emissions.

Methodology

Cement is produced by a high temperature reaction of calcium oxide (CaO) with silica (SiO_2) and with alumina (Al_2O_3). A source of calcium oxide is limestone ($CaCO_3$). As the cement clink is produced at the temperature of 1 450°C the reaction produces carbon dioxide. The other emissions originate from impurities in the raw material (SO_2).

On the basis of data supplied by plants, Tier 2 methodology according to 2006 IPCC Guidelines can be applied. Content of cement clinker in cement varies in the range 69.9% – 76.6% in Portland cements and 92% in white cement. This value is known for every cement plant. The weighted average value of the clinker content in the cement is 74.22% in 2007.

The content of CaO in the cement clinker varies from 64.2% to 68.8%. The value of the weighted average is 65.74% in 2007. It follows that the emission factor of CO_2 related to the cement clinker is 516.05 kg CO_2/t of cement clinker in 2007. Total CO_2 emission from cement production was 1 458.008 kt in 2007. The total sum of cement clink production was 2 825.32 kt.

Table 4.1: The data necessary for calculation of CO_2 emission from cement plants producing cement clinker.

Cement produced amount [t]	3 749 489
Clinker produced amount [t]	2 825 323
Content of clinker in cement [wt.%]	74,22
Content of CaO in clinker [wt.%]	65,74
Emission factor of CO_2 [t/t of cement clink]	516,05
Emission of CO_2 [Gg]	1 458,01

Uncertainties and time consistency

It should be mentioned that calculation of uncertainties according to Monte-Carlo method couldn't be done because of lack of necessary data. Thus, the uncertainties in mass of clink (2%), composition of limestone (3%), composition of clink (2%) and mass of non-reacted limestone (5%) were estimated according to GPG 2000 for each plant. It follows that uncertainty of EF (per clink) is 0.9% and uncertainty of CO_2 emissions is 2.9%.

QA/QC and verification

Information used for GHG emission inventories of IP sector are directly from questionnaires sent to operators and cement producers in the SR. First preliminary data related to production and quality of products for previous year in the SR is available at the beginning of October. This data are used for emission estimation and verified by Mr. Vladimir Danielik – sectoral expert for IP sector with the cooperation of the Slovak Technical University in Bratislava, Faculty of Chemical and Food Technology comparing with the information from Statistical Office of the SR (cement produced) and available reports from ETS.

Recalculations

No recalculations in cement clinker production were provided for the previous inventory year or base year.

Planned improvements

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

4.1.2 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.

Methodology

Tier 2 according to 2006 IPCC Guidelines was applied with combination of plant specific activity data and emission factors estimated for each plant. According to the data on average purity of lime, the purity of lime varies in the range 85.8 – 97.2%. The weighted average value is 98.68%. The dolomite lime is recalculated into the quicklime on the basis of stoichiometry. This approach was chosen because of time series consistency. The emission factor of CO_2 using the new data on purity of lime is 774.62 kg CO_2/t of lime. In the CaO content the "hypothetical CaO content" from MgO content is included.

Table 4.2: The data necessary for calculation of CO_2 emission from lime production.

Year	2000	2001	2002	2003	2004	2005	2006	2007
	(Gg)							
CaO content	0,9120	0,9120	0,9120	0,9341	0,9421	0,9610	0,9617	0,9868
Lime Production	753,59	815,96	918,99	781,69	908,94	1 041,71	1 131,24	1 158,07
Emissions CO_2	539,57	584,22	657,99	573,17	672,16	785,83	854,02	897,06

Uncertainties and time consistency

It should be mentioned that calculation of uncertainties according to Monte-Carlo method could not be done because of lack of necessary data. Thus, the uncertainties in mass of lime (2%) and content of CaO in lime (2%) were estimated according to the IPCC Good Practice Guidelines for each plant. It follows that uncertainty of EF (per clink) is 0.9% and uncertainty of CO_2 emissions from lime production is 1.4%.

QA/QC and verification

Information used for GHG emission inventories of IP sector are directly from questionnaires sent to operators and lime producers in the SR. First preliminary data related to production and quality of products for previous year in the SR is available at the beginning of October. This data are used for emission estimation and verified by Mr. Vladimir Danielik – sectoral expert for IP sector with the cooperation of the Slovak Technical University in Bratislava, Faculty of Chemical and Food Technology comparing with the information from Statistical Office of the SR (lime produced) and available reports from ETS.

Recalculations

No recalculations in lime production were provided for the previous inventory year or base year.

Planned improvements

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

4.1.3 Limestone and Dolomite Use (CRF 2.A.3)

In this category the mass of consumed limestone in industrial processes except of cement and lime production is presented.

Methodology

The Tier 2 methodology according to the IPCC 2000 GPG was applied to the category 2.A.3 Limestone and dolomite use and the country specific emission factors were used.

At thermal decomposition or chemical reactions of limestone to clink carbon dioxide is produced. The maximum value of emission factor of CO_2 is 440 kg CO_2/t of consumed limestone, which is the recommended value according to the IPCC. However, the average content of $CaCO_3$ in raw material in the Slovak Republic is 97%, therefore the emission factor CO_2 has to be lowered to 427 kg/t of consumed limestone (440 × 0.97). The mass of consumed limestone in industrial processes were estimated except of cement and lime production in the SR. In this category there are also included amounts of other carbonates as limestone used at glass production and used for desulphurization of the lignite used in Slovak power plants EVO and ENO. Those carbonates are recalculated to the "hypothetical limestone" on the basis of stoichiometry.

The amounts of consumed limestone according to the sources and emissions of CO_2 in 2007 are summarized in Table 4.3. It should be mentioned that consumption of iron ore decreased in the comparison with 2006. It follows that consumption of limestone slightly decreased from this source as well. The amount of CO_2 emissions is based on the consumption of limestone and dolomite at production of calcium carbide, desulphurization of the lignite, glass and iron & steel production.

Table 4.3: Total emission of CO_2 at limestone utilization in the period 2000–2007.

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
			(Gg)					
Limestone Use	403,83	386,88	361,73	374,71	615,95	471,19	454,96	429,45

It should be mentioned that consumption of iron ore decreased in the comparison with 2005. It follows that consumption of limestone decreased from this source as well.

Table 4.4: Total emission of CO_2 and the emission factors of CO_2 at limestone utilization in 2007.

Consumption of limestone at:						
desulphuri sation	iron and steel	calcium carbide	glass	**total**	**emissions CO_2**	**EF CO_2**
		[t]			[t]	[kg / t]
80,40	674,12	158,04	93,64	**1 006,20**	**429,45**	**427,00**

Uncertainties and time consistency

It should be mentioned that calculation of uncertainties according to Monte-Carlo method couldn't be done because of lack of necessary data. Thus, the uncertainties in mass of used limestone and dolomite (2%) and their composition (3%) were estimated according to IPCC Good Practice Guidelines for each plant. It follows that uncertainty of EF (per clink) is 0.8% and uncertainty of CO_2 emission is 3.8%.

QA/QC and verification

Information used for GHG emission inventories of IP sector are directly from questionnaires sent to operators and lime producers in the SR. First preliminary data related to production and quality of products for previous year in the SR is available at the beginning of October. This data are used for emission estimation and verified by Mr. Vladimir Danielik – sectoral expert for IP sector with the co-operation of the Slovak Technical University in Bratislava, Faculty of Chemical and Food Technology comparing with the information from Statistical Office of the SR (lime use) and available reports from ETS.

Recalculations

No recalculations in limestone and dolomite use category were provided for the previous inventory year or base year.

Planned improvements

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

4.1.4 Soda Ash Production and Use (CRF 2.A.4)

Soda ash is not produced in the SR. Use of soda ash is included in category 1.A.3 Limestone and Dolomite Use.

4.1.5 Asphalt Roofing (CRF 2.A.5)

A part of asphalt roofing production is asphalt blowing. It is the process of polymerizing and stabilizing asphalt to improve its weathering characteristics.

Methodology

Emissions originating from asphalt roofing production are NMVOC and CO. According to the IPCC 1996 Guidelines the emission factor of CO is 0.0095 kg CO/t of asphalt.

In Icopal, a.s. Štúrovo, asphalt roofing is produced by saturation without spray (by rolling). Default emission factor according to the IPCC recommendation is in the range 0.046 – 0.049 kg/t of asphalt. The higher value was assumed in inventory. In the case of afterburner 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, 29 599 tons of asphalt were used at the production of asphalt roofing in 2007. It follows that the emissions of CO and NMVOC were 0.281 t and 4.410 t, respectively. These emissions are included in energy sector category 1.AA.2.F – Others. Because no national data are known only IPCC default factors are used. Thus, the uncertainties cannot be calculated.

4.1.6 Road Paving with Asphalt (CRF 2.A.6)

Methodology

The emissions of NMVOC from road paving with asphalt were estimated according to the EMEP/ CORINAIR methodology. Total amount of asphalt used for paving the road in 2007 was 115,5 kt. Estimated emission factor for NMVOC was estimated to be 0.00658 kg/t and total emissions of NMVOC included in this category is 0.76 tons. The emissions of NO_x, SO_2 and CO are included in the energy sector, category 1.AA.2.F – Others.

4.1.7 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 at glass production. The most important emissions are NMVOC and CO_2.

Methodology

Emission of CO_2 from glass production is included in the category 2.A.3 Limestone and Dolomite Use. The mass of the other used carbonates than limestone (e.g. Na_2CO_3, K_2CO_3) is recalculated on the basis of stoichiometry to the appropriate mass of limestone. For estimation of emissions the IPCC recommendation was used, 4.5 kg NMVOC/t of glass produced.

In the Slovak Republic was produced following amount of glass: 203 653 tons of white glass, 77 283 tons of green glass, 35 385 tons of crystal glass and 4 739 tons of leaded glass were produced in 2007. Total amount of produced glass was 321 060 t. Because no national data are known only IPCC default factors are used, the uncertainties cannot be calculated.

Table 4.5: Total amounts of NMVOC emissions.

Glass	Emissions of NMVOC [t]
White glass	916,40
Green glass	347,80
Crystal glass	159,20
Leaded glass	21,30
Total	**1 444,70**

4.1.8 Magnezite Production (CRF 2.A.7.2)

At thermal decomposition of magnezite carbon dioxide is produced. The principal chemical reaction scheme of the thermal decomposition is $MgCO_3 = MgO + CO_2$.

Methodology

The Tier 2 methodology according to the IPCC 2000 GPG was applied to the category 2.A.7.2 Magnezite production and the country specific emission factors were used.

Purity of magnezite in the Slovak Republic varies mainly from 86% to 91%. The weighted average was 86.98% and the emission factor of CO_2 is 949.85 kg CO_2/t of magnezite clinker in 2007. It should be noted that CaO content which can be presented in some magnezite clinkers was recalculated to the hypothetical “MgO content” on the basis of stoichiometry.

Total amount of magnezite clinker produced in the Slovak Republic was 320 048.3 t in 2007. It means that 303 997.9 t of CO_2 was released into the air.

Table 4.6: Total CO_2 emissions of magnezite clink production in the period 2000–2007.

Year	2000	2001	2002	2003	2004	2005	2006	2007
					(Gg)			
Magnesite Clink	436,49	459,71	467,06	479,23	524,93	481,88	346,49	320,05
Emissions CO_2	409,82	431,63	438,52	449,95	499,67	476,00	340,62	304,00

Uncertainties and time consistency

It should be mentioned that calculation of uncertainties according to Monte-Carlo method couldn’t be done because of lack of necessary data. Thus, the uncertainties in mass of produced magnezite clink (2%) and it’s content (3%) were estimated according to the IPCC 2000 GPG for each plant. It follows that uncertainty of EF (per clinker) is 2.2% and uncertainty of CO_2 emissions is 2.7%.

The emissions of CO_2 from magnezite clinker production were decreased comparable to the previous year by 11%. This trend was caused by decreasing of production, but also with the innovation of the technology.

QA/QC and verification

Information used for GHG emission inventories of IP sector are directly from questionnaires sent to operators and magnezite producers in the SR. First preliminary data related to production and qualities of products for previous year in the SR are available at the beginning of October. This data are used for emission estimation and verified by Mr. Vladimir Danielik – sectoral expert for IP sector with the cooperation of the Slovak Technical University in Bratislava, Faculty of Chemical and Food Technology comparing with the information from Statistical Office of the SR (magnezite clinker use) and available reports from ETS.

Recalculations

No recalculations in magnezite clinker production were provided for the previous inventory year or base year.

Planned improvements

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

4.2 Chemical Industry (CRF 2.B)

The major share of N_2O pollution comes from chemical industry and product use. Total emissions in 2007 were 4.556 Gg of N_2O, the decreasing almost 10% comparable to the previous year is significant, but was caused by decreasing of production. The decreasing is more visible in nitric acid production category.

4.2.1 Ammonia Production (CRF 2.B.1)

Ammonia is basically made from nitrogen and hydrogen by fine-tuned versions of the process developed by Haber and Bosch $N_2 + 3H_2 = 2NH_3$. In principle the reaction between hydrogen and nitrogen is easy. However, to get a respectable yield of ammonia in a chemical plant use a catalyst and extreme pressures up to 600 atmospheres and temperature of 400°C is needed.

Methodology

The Tier 2 methodology according to the IPCC 2000 GPG was applied to the category 2.B.1 Ammonia production and the plant specific emission factors were used. The direct information about ammonia production from the company was used in 2007 based on information from ETS. For estimation of the CO_2 emissions the measured values of CO_2 production from the plant were used. The produced amount of ammonia was 362 440 tons in 2007. Based on data supplied by the plant 238 779 000 Nm^3 (170 619 tons) of natural gas was consumed for ammonia production and 243 404 000 Nm^3 (477 942 tons) of CO_2 resulted from that. For the urea production was used 76 997 450 Nm^3 (151 193 tons) of CO_2. Consumption of CO_2 for urea production was taken into account in time series and the total emissions of CO_2 are minimized by this amount of CO_2 used for urea production. The carbon dioxide used for urea production is subtracted from the emission balance and will be included in the LULUCF sector in grassland category with the appropriate methodology. The estimation is under preparation. The rest of CO_2 (326 558 tons) was released to the air. The presented data are based on the measurements in the plants, therefore the emission factor of CO_2 changed in comparison with the older inventories (0.901 t/t) and is based on natural gas used for ammonia production, not for ammonia. The emission factor is based on plant specific data and calculated for ammonia produced by chemical reaction. Emissions of CO_2 are estimated from the natural gas consumption. If the amount of CO_2 used for urea production is not subtracted, the EF will be 1.32 t CO_2 / 1 t NH_3, this is in accordance with the default EF (IPCC GPG 2000 = 1.5 and IPCC Guidelines 2006 = 1.6). The minimal EF calculated with theoretical stoichiometry with 10% conversion is 1.23 t CO_2 / 1 t NH_3, this match with the plant specific emission factor used in our study. The calculation of the EF can be expressed by following formula:

EF = [(natural gas used in Nm^3) x 101 325 / 8.314 / 273.15 x (molar weight of CO_2 in g/mol) - (amount of CO_2 used for urea production in grams) / (weight of ammonia produced).

Table 4.7: The amount of CO_2 consumed for urea production in the period 1990–2007.

Year	Consumption of CO_2 [Nm^3]	Consumption of CO_2 [t]
1990	83 132 550	163 240
1991	56 990 250	111 907
1992	63 363 150	124 420
1993	48 879 450	95 980
1994	85 098 600	167 100
1995	73 791 000	144 897
1996	82 824 300	162 634
1997	84 395 700	165 720
1998	67 068 000	131 695
1999	72 091 800	141 560
2000	82 855 800	162 696
2001	88 473 600	173 727
2002	80 707 700	158 478
2003	71 239 950	139 887
2004	78 711 525	154 559
2005	77 671 000	152 515
2006	75 487 050	148 227
2007	76 997 450	151 193

Table 4.8: The emissions and the emission factors at ammonia production in 2007.

	Emissions [t]	Emission factor [kg/t]
CO_2	326 558	901
NMVOC	1,70	4,7
CO	21,75	0,06
SO_2	32 051	0,03
CH_4	40,97	5*
N_2O	0,82	0,1*

* EFs in kg/TJ of natural gas

Table 4.9: Total production of ammonia in the SR in 1990–2007.

Year	NG Consumption [t]	Ammonia Produced [t]	Emissions CO_2 [t]
1990	169,563	360,000	356,040
1991	165,607	351,600	347,732
1992	162,121	344,200	340,414
1993	97,452	206,900	204,624
1994	166,690	353,900	350,007
1995	180,773	383,800	379,578
1996	193,914	411,700	407,171
1997	193,067	409,900	405,391
1998	171,589	364,300	360,293
1999	171,447	364,000	359,996
2000	189,817	403,000	398,567
2001	193,963	411,803	407,273
2002	188,404	400,000	395,600
2003	166,586	353,680	349,790
2004	192,125	407,901	403,414
2005	186,554	426,347	421,657
2006	167,000	354,558	350,658
2007	170,619	362,440	326,558

Recalculations

No recalculations in ammonia production were provided for the previous inventory year or base year.

Planned improvements

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

4.2.2 Nitric Acid Production (CRF 2.B.2)

In a world measure the nitric acid production consumes about 20% of all ammonia produced. Nitric acid production in the Slovak Republic is an important source of N_2O emissions from industrial processes and key source category in level and trend assessment.

Methodology

The Tier 2 methodology according to the IPCC 2000 GPG was applied to the category 2.B.2 Nitric acid production and the plant specific emission factors were used.

The following EFs on the basis of Norsk Hydro since 1990 are implied 13 kg N_2O/t HNO_3 for atom-spheric plant until 2000 was in operation, 7 kg N_2O/t HNO_3 for medium pressure until 2004 and 9 kg N_2O/t HNO_3 for high pressure plant until 2004. It is in agreement with the data presented by Norsk Hydro according to the IPCC 2000 Good Practice Guidance. After 2000 the out-dated atmospheric plant was closed. The medium-pressure plant was renewed in 1980s.

According to the direct measured information of emissions from the nitric acid production, the emission factors were estimated annually, based on certified measurements in the plant. It seems that dis-crepancy between previously and recently used EFs is based on the non-correct information about holding time of gasses at catalyst and temperature in reactor. According to the measured data EFs are updated from 2005 (7.3 kg/t) and from 2006 (10.332 kg N_2O/t of HNO_3) for medium-pressure plant and for high-pressure plant in 2005 9.1 kg/t and from 2006 (9.02 kg N_2O/t of HNO_3).

According to the measured data the actual EFs are: 10.332 kg N_2O/t of HNO_3 for medium-pressure plant and 9.02 kg N_2O/t of HNO_3 for high-pressure plant in 2007. Emission of N_2O at nitric acid production in 2007 was estimated using direct production data and plan specific emission factors. The weighted EF was 9.312 kg N_2O/t of HNO_3 and the N_2O emissions were 4 555 tons.

Table 4.10: The estimated N_2O emissions and lweighted EFs in the 1990–2007 from nitric acid production.

Year	HNO_3 atmospheric [t]	HNO_3 medium pressure [t]	HNO_3 high pressure [t]	HNO_3 medium pressure older technology [t]	Emissions N_2O [t]	Weighted EF [kg/t]
1990	150 290	240 250	0	10 000	3 705,520	9,251
1991	76 105	214 820	0	10 902	2 569,419	8,513
1992	57 489	206 750	0	14 199	2 294,000	8,239
1993	22 980	198 830	0	11 805	1 773,185	7,590
1994	106 280	244 130	0	10 405	3 163,385	8,767
1995	139 900	244 500	0	14 402	3 631,014	9,105
1996	185 590	247 785	0	13 407	4 241,014	9,492
1997	177 260	225 060	0	19 006	4 012,842	9,524
1998	128 380	228 770	0	20 203	3 411,751	9,041
1999	42 660	150 910	80 933	32 007	2 563,396	8,363
2000	0	159 220	239 673	8 324	3 329,865	8,177
2001	0	168 305	258 346	37 698	3 767,135	8,113
2002	0	94 005	271 140	38 699	3 369,188	8,343
2003	0	130 070	273 578	50 987	3 729,601	8,204
2004	0	177 507	294 784	52 531	4 263,322	8,123
2005	0	194 937	281 240	21 500	4 132,824	8,304
2006	0	153 136	292 450	118 417	5 049,019	8,952
2007	0	162 089	292 467	34 666	4 555,418	9,312

Uncertainties and time consistency

It should be mentioned that calculation of uncertainties according to Monte-Carlo method couldn't be done because of lack of necessary data. Thus, the uncertainties in mass of produced nitric acid (2%) and used EF (10%) were estimated according to the IPCC 2000 GPG for each plant. It follows that uncertainty of EF is 5.9% and uncertainty of N_2O emissions is 8.6%.

QA/QC and verification

Information used for GHG emission inventories of IP sector are directly from questionnaires sent to operators and nitric acid producers in the SR. First preliminary data related to production and quality of products for previous year in the SR is available at the beginning of October. This data are used for emission estimation and verified by Mr. Vladimir Danielik – sectoral expert for IP sector with the co-operation of the Slovak Technical University in Bratislava, Faculty of Chemical and Food Technology comparing with the information from Statistical Office of the SR and available reports from ETS.

Recalculations

No recalculations in nitric acid production were provided for the previous inventory year or base year.

Planned improvements

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

4.2.3 Adipic Acid Production (CRF 2.B.3)

Adipid acid is not produced in the Slovak Republic.

4.2.4 Carbide Production (CRF 2.B.4)

4.2.4.1 Silicon Carbide (CRF 2.B.4.1)

Silicon carbide is not produced in the Slovak Republic

4.2.4.2 Calcium Carbide (CRF 2.B.4.1)

Calcium carbide (the correct chemical name of this compound is calcium acetylide) is produced by the reaction of CaO and coke at submerged arc furnace. Recently this plant was modernized in order to decrease the emissions (in 1992).

Methodology

The main component of released emissions is CO_2. Emission factors for CO_2 (0.76 t CO_2/t of CaC_2 at decomposition of limestone; 1.09 t CO_2 /t of carbide at the reduction and 1.1 t CO_2/t of carbide at using of the product) were taken from the IPCC 2000 GPG. However, emissions of CO_2 at the decomposition of limestone are included in the category 2.A.3 Limestone and dolomite use. Because no national data are known only IPCC default factors were used.

Total amount produced in 2007 in the SR was 101 215.3 tons of CaC_2 (calcium carbide). According to data supplied by producer, 64 081 tons of produced calcium carbide was exported from the Slovak Republic. The rest was used for acetylene production. At this production no emission of CO_2 is released.

4.3 Metal Production (CRF 2.C)

Total emissions of category 2.C Metal production were estimated in 2007 to be 724.64 Gg of CO_2, the decreasing comparable to the previous year is almost 5%. The decreasing is caused by decreasing in the emissions from iron and steel production. Total NMVOC emissions from this category are 419.15 tons. The emissions of other basic pollutants are included in the energy sector, category 2.AA.2.A – Iron and steel.

4.3.1 Iron and Steel Production (CRF 2.C.1)

Pig iron is produced by the reduction of iron ore by coke in a blast furnace, the main emission being CO_2. Limestone is added as an agent for slag formation. Pig iron contains about 4% of carbon and in the next step; part of this carbon is oxidized. This process is accompanied by CO emissions most of which is burned to CO_2. Iron ore was processed to pig iron. The emissions of CO_2 from added limestone are included in category limestone and dolomite use 2.A.3. The mass of used coke is included in energy sector category 1.AA.2.A.

Methodology

The Tier 2 methodology based on the plant specific information about activity data and emission factors were applied. The Slovak major producer of iron and steel made 1 740 000 tons of coke, 4 012 080 tons of pig iron and 4 784 806 tons of steel and consumed 3 000 000 of iron ore in 2007. It is assumed that content of carbon in iron ore was 0.216 kg/t (data supplied by the plant), 40 kg/t in pig iron and 2.5 kg/t in steel. From that the emissions of CO_2 can be calculated according to the IPCC 2000 GPG (Tier 2).

In 2007, 4 807 938 tons of CO_2 released into the air from pig iron production and CO_2 emissions from steel production were 535 420 tons. It means that the total CO_2 emissions from iron and steel production were 5 352 516 tons which represent the EF of CO_2 1.119 t/t of steel.

It should be noted that EF is different than in 2006. Differences between each-year emission factors are caused by the different amounts of iron scrap added to the charge at steel making process.

Pig iron is not produced in other plants in the SR. Steel is produced also by other producers in total amount 389 435 tons of steel in 2007. Emissions of CO_2 from these plants originate only from energy production and thus they are not included in this category.

In order to summarize the data based on this new approach the emissions of CO_2 from steel production, which are not included in energy sector are presented in Table 4.11 for the period 1990–2007.

Table 4.11: Emissions of CO_2 from steel production for the period 1990–2007.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	Emissions of CO_2 (Gg)																	
Steel production	420,26	373,28	348,38	378,24	392,99	378,47	344,56	362,53	365,80	403,56	415,36	442,72	484,18	535,15	539,82	506,00	563,65	535,42

Activity data about the cast iron are based on written information supplied by the following companies VSS, a.s. Košice, Zlieváreň SEZ, a.s. Krompachy, Strojchem Chemosvit, SJT Moldava, Prakovská oceliareň, Zlieváreň, s.r.o. Trnava, ZLH, a.s. Hronec, GML Casting, SMZ Kunová Teplica, s.r.o., VSŽ Foundry, Pohronské strojárne Hliník nad Hronom and Nová zlievarenská spoločnosť v Martine. The total production of cast iron in the Slovak Republic was 57 189.2 tons in 2007.

Uncertainties and time consistency

It should be mentioned that calculation of uncertainties according to Monte-Carlo method couldn't be done because of lack of necessary data. Thus, the uncertainties in mass of used coke (2%), mass of used iron ore (2%), mass of produced pig iron (2%), mass of produced steel (2%), contents of carbon in iron ore (25%), in pig iron (25%), in steel (25%) and used default EF from coke (5%) were estimated according to IPCC 2000 GPG for each plant. It follows that uncertainty of EF is 5.1% and uncertainty of CO_2 emissions is 5.1%.

QA/QC and verification

Information used for GHG emission inventories of IP sector are directly from questionnaires sent to operators and iron and steel producers in the SR. First preliminary data related to production and quality of products for previous year in the SR is available at the beginning of October. This data are used for emission estimation and verified by Mr. Vladimir Danielik – sectoral expert for IP sector with the cooperation of the Slovak Technical University in Bratislava, Faculty of Chemical and Food Technology comparing with the information from Statistical Office of the SR and available reports from ETS.

Recalculations

No recalculations in iron and steel production were provided for the previous inventory year or base year.

Planned improvements

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

4.3.2 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.

Methodology

The emission factors for carbon dioxide were taken from the IPCC recommendation (1.6 t/t of ferroalloys based on Mn, 1.3 t/t of ferroalloys based on Cr and 5 t/t of ferroalloys based on Si). These emissions are softly overvalued because content of carbon in iron is neglected. In 2007, the production of ferroalloys in the Slovak Republic was as follows: 145 652 tons of ferroalloys based on Mn and 8 583 tons based on Si. Ferroalloys based on Cr were not produced in 2007. However, without knowledge on composition of used iron ore and ferroalloys mass of emissions cannot be more exact. These emissions are included in energy sector, category iron and steel production 1.AA.2.A – solid fuels.

4.3.3 Aluminium Production (CRF 2.C.3)

As was mentioned earlier, there are very precise data on the emissions from aluminium smelting. Aluminium is produced by the electrolysis of alumina dissolved in cryolite-based melt (t = 950°C). The main additions to cryolite (Na_3AlF_6) are aluminium fluoride (AlF_3) and CaF_2. From the point of emissions view, the content of AlF_3 is of great interest. The Slovak plant uses a modern technology in which most of the HF and other fluorides escaping from the electrolytic cells are absorbed and adsorbed on alumina, which is used subsequently in the electrolytic process. The anodes are made from graphite. Production of the so-called pre-baked anodes is made in a separate plant. As a result of that the emissions are much lower than in the so call Soederberg process. It may happen that at a special technological disturbance (the anode effect) the releasing of CF_4 and C_2F_6 can occur. Because of progress in process control this irregularity occur only 1–2 times in a month.

Methodology

The Tier 2 methodology based on plant specific emissions factors and activity data was applied. It was used 62 007 tons of graphite anodes in 2007 in the Slovak Republic. It follows that emission of CO_2

was 192 220 t in 2007 (EF of CO_2 is 3.1 t/t of coke according to the 2006 IPCC Guidelines). The emission factors of PFCs (CF_4, C_2F_6) were calculated according to the Tabereaux's equation:

$$EF(PFC) = const \cdot \frac{x}{\eta} \cdot AE \cdot AED$$

Where *const* is a constant and it equals to: for emission factor of CF_4 = 1.698,

for emission factor of C_2F_6 = 0.1698.

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.

According to the data from plant operator average current efficiency was 94% in 2007, the number of the anode effects per pot day equals to 0.053 and their average duration was 2.732 min. It follows that the emission factors were 0.0209 kg CF_4/t of aluminium and 0.00209 kg C_2F_6/t of aluminium, respectively. In 2007, the Slovak aluminium company produced 160 464 t of aluminium. In 2007, SF_6 was not used in the Slovak Republic at casting.

Table 4.12: The overview of emissions and EFs in aluminium production in 2007.

	CO_2	CF_4	C_2F_6
Emission [t]	192 221,7	3,3580	0,33600
Emission factor [kg/t of Al]	1 197,9	0,0209	0,00209

Uncertainties and time consistency

It should be mentioned that calculation of uncertainties according to Monte-Carlo method couldn't be done because of lack of necessary data. Thus, the uncertainties in mass of produced aluminium (2%), content of PFC in gas (3%), measuring of CE (5%), AE (5%) and AED (5%) were estimated according to IPCC 2000 GPG for each plant. It follows that uncertainty of EFs of PFCs is 9.2% and uncertainty of PFC emissions is 9.4%.

QA/QC and verification

Information used for GHG emission inventories of IP sector are directly from questionnaires sent to operators and aluminium producers in the SR. First preliminary data related to production and quality of products for previous year in the SR is available at the beginning of October. This data are used for emission estimation and verified by Mr. Vladimir Danielik – sectoral expert for IP sector with the cooperation of the Slovak Technical University in Bratislava, Faculty of Chemical and Food Technology comparing with the information from Statistical Office of the SR and available reports from ETS.

Recalculations

No recalculations in aluminium production were provided for the previous inventory year or base year.

Planned improvements

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

4.3.4 Aluminium and Magnesium Foundries (CRF 2.C.4)

This production is not occurring in the Slovak Republic.

4.4 Other Production (CRF 2.D)

No emissions of GHGs from the technology of paper and pulp and food industry were estimated. The emissions of SO_2 from paper and pulp production were not occurring in 2007 and NMVOC emissions from food industry were 312.1 tons.

4.5 Production of Halocarbons and SF_6 (CRF 2.E)

No halocarbons or SF_6 were produced in the Slovak Republic in 2007.

4.6 Consumption of Halocarbons and SF_6 (CRF 2.F)

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 during the inventory and projection of GHGs. Following gases are considered to be new ones:

- HFCs – hydrofluorocarbons (23, 32, 41, 43, 125, 134, 134a, 152a, 143, 227ea, 236fa, 245ca)
- SF_6 – sulphur hexafluoride
- PFCs – perfluorcarbons (CF_4, C_2F_6, C_3F_8, C_4F_{10}, C_4F_8, C_5F_{12}, C_6F_{14}, CF_3Br)

The aim is to evaluate the sources and emissions of selected substances since 1990. For given years the emissions are set based on list of sources, production or usage of these substances in the Slovak Republic and comments on accuracy of input and calculated data are given. Inventory of F-gases is complicated due to high number of substances HFCs, PFCs a SF_6, totally 12 HFCs substances. They are components of different mixtures used in different more then 15 applications. Each application has its own development of consumption and trend of emission development. To ensure environmental integrity, a post 2012 agreement should include additional fluorinated gases (hydrofluoroethers and perfluoropolyethers) with lower GWPs.

According to the latest inventory data, the actual HFCs emissions in the category 2.F Consumption of halocarbons were 226.99 Gg of CO_2 equivalents and are continually increased comparable to the previous year by 14% and comparable to the base year 1995 ten times. The potential emissions of HFCs represents in 2007 539.59 Gg of CO_2 equivalents and increased comparable to the previous year by 14% and comparable to the base year 1995 4.5 times. Ration of potential/actual HFCs emissions in 2007 is 2.38.

Actual emissions of SF_6 in 2007 reached 0.73 tons and slightly increased comparable to the previous inventory year. The potential emissions of SF_6 reached 3.32 tons and increased by 13% comparable to the previous year. The ration of potential/actual emissions of SF_6 in 2007 is 4.56.

The emissions of PFCs in the category 2.F are not occurring in 2007.

Methodology

Following procedure was engaged to reach the aim:

- Evaluation of the sources and emissions of selected substances since 1990 based on acquired data from importers and users in the last inventory year.
- Evaluation of the data storage in own tables and CRF tables according to IPCC 1996 methodology and IPCC 2000 GPG.

Substances in question alone are not registered under the item of the Custom Tariff in the Slovak Republic. 250 potential supplier, users and consumers of the substances in question are addressed on the base of the description of the substances with GWP (global warming potential). These potential consumers of the substances in question are yearly sent the letter authorized by the Ministry of Environment containing the tables. Data in these tables enable to determine the rate of emissions and new filling using the method of approximation. Received data are in case of doubt verified at sender and they are summarized in the tables according to the way of use.

Tables used since 1990 are used also in the last inventory for data storage in order to retain the continuity of observing the trends of sent data.

Evaluation of sent and processed data on the sources and emissions of the substances in the Slovak Republic is realized on the base of recommended emission factors corrected according to the received data by IPCC methodology.

- in own Excel tables – evaluation according to sent data and IPCC methodology.
- in CRF IPCC tables – evaluation according to sent data and IPCC methodology.

For given years the emissions are set based on list of sources, production or usage of these substances in the Slovak Republic and comments on accuracy of input and calculated data are given. IPCC 2000 Good Practice Guidance documents for groups convened on the following sources:

- SF_6 emissions from electrical equipment and other sources.[13]
- Fluorinated carbon emissions[14] from semiconductor manufacturing.
- HFCs emissions from refrigeration and air conditioning.

4.6.1 Refrigeration and Air Conditioning Equipment (CRF 2.F.1)

The emissions originated from refrigeration and AC equipments represent more than 90% of emissions from 2.F category. Total actual emissions of HFCs were 223.19 Gg of CO_2 equivalents and increased from the previous year by 14%, the potential emissions of HFCs were 517.79 Gg of CO_2 equivalents and increased comparable to the previous inventory year by 14% in 2007. The emissions of PFCs and SF_6 are not occurring in this category. The emissions are included in category 2.IIA.F.1.2 Commercial refrigeration.

Assessment of direct and aggregated emissions of new gases is based on the approximation of the coolant consumption trend considering the up-to-date trend of CFCs and HCFCs decrease and start of HFCs coolants use. Approximation is based on following analyses:

- Trend of decrease of CFCs and HCFCs coolants in appliances fillings, supplies with certain rate of recycling of these coolants and taking into account operational emissions of coolants.
- Approximation of the trend of total consumption and emissions of halogenated coolants.
- Approximation of the trend of total consumption and emissions of particular halogenated co-olants.

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 of CFC, HCFC and HFC coolants. Following areas of the use of these substances are considered in their assessment of the IPCC 2000 GPG practice recommendations on seven sources of emissions of:

- Aerosols and metered dose inhalers
- Solvent uses
- Foams
- Stationary refrigeration

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[13] *SF_6 from other uses like sound-proof windows, medical purposes, military application, equipment used in accelerators, lasers and night vision goggles, car tires, sport shoes, balls, etc. are delayed for some years.*

[14] *Including CF_4, C_2F_6, C_3F_8, C_4F_8, CHF_3, NF_3, SF_6*

- Mobile air conditioning
- Fire protection
- Other applications

Following substances belong to this group:

- HFC 23 (CHF_3 trifluormethane) - it is not used as extinguishing medium for fixed extinguishing devices in the Slovak Republic or there are any requests for its approval. It is used as a coolant for low temperatures cooling devices and as a component of coolant mixtures R503 and R508. Expected slight increase of R23 consumption was not yet confirmed.
- HFC 152a ($C_2H_4F_2$ 1,1–difluormethane) - component of coolant mixtures 401A, B, C. Substitute of coolant R12 in cars AC, aerosols, swell up agent of PUR, polystyrene. Slight decrease of its consumption as a component in coolant mixtures is expected.
- HFC 32 (CH_2F_2 difluormethane) - component of mixtures R407A, B, C, R504, R410A. The increase of its consumption is expected in the near future, especially regarding perspective mixtures as R407C and R410A. Its consumption after 2010-2015 shouldn't increase because of expected start of natural coolant usage.
- HFC 125 (C_2HF_5 pentafluorethane) - component of coolant mixtures R407A, B, C, R504, R410A, R402A, B. The increase of its consumption is expected in the near future as an important component of coolant mixtures. Its consumption after 2015 shouldn't increase because of expected start of natural coolant usage.
- HFC 143a ($C_2H_3F_3$ 1,1,1–trifluorethane) - swell up agent to polystyrene, polyofeline, coolant, component of coolant mixtures R507, R404A. The increase of its consumption as component of coolant mixtures is expected but in the course of time it can be gradually substituted by R410A coolant as well as natural coolants, especially carbon dioxide and ammonia.
- HFC 134a (CH_2FCF3 1,1,1,2-tetrafluorethane) - coolant, extinguishing medium, aerosol, swell up agent into PUR foam, extruded polystyrene, adhesive films, sterilizers, important component of the mixtures R407A, B, C, R404A. The generally expected increase of its consumption, especially as a substitute of R12 coolant and also as coolant in auto air-conditioning till the use of CO_2 coolant has been already reached. Its consumption in the next years shouldn't already increase. Can be expect slow decreasing because of usage R600a in domestic refrigerators, R404A (ammonia in the future) in commercial cooling and CO_2 in auto air-conditioning. As an extinguishing medium it is designed for fixed extinguishing substances. It is not yet used as an extinguishing medium in the Slovak Republic but maybe there will be an effort to approve it in line with the expected consumption increase.
- HFC 227ea (C_3HF_7 1,1,1,2,3,3,3–heptafluorpropane) - coolant, extinguishing medium, aerosol, component of sterile mixtures. As an extinguishing medium it is designed for fixed extinguishing substances. It is approved in the Slovak Republic and nowadays it is the only alternative for H 1301 known under mark FM 100 imported until 1993. Extinguishing medium HFC 227ea is known under mark FM 200. It started to be imported into the Slovak Republic in 1994. It is used as a coolant in AC of cabins in the metal melting plants with high temperature. Slight increase of its consumption is expected in the future.
- HFC 236fa ($C_3H_2F_6$ 1,1,1,2,3,3,3–hexafluorpropane) - extinguishing medium, swell up agent of PUR. As an extinguishing medium it is designed for portable extinguishing substances. It is approved in the Slovak Republic and nowadays it is the only alternative for CFC 1211 and HCFC 123. Extinguishing medium HFC 236fa is known under mark FE 36. It started to be imported into the Slovak Republic in 2000. It is not yet used as coolant in the Slovak Republic. Slight increase of its consumption is expected in the future.

- SF_6 – sulphurhexafluoride - its lifetime is up to 3.200 years and GWP (at lifetime 100 years) is up to 23.9 $kgCO_2/kg$. It is used as an extinguishing medium in electronics, protection against explosion, isolation, sterilization, detection gas, alloying of Al and Mg, tobacco production. Beside that it is substitute for halons, 90% of its use is devoted to the isolation in high and low voltage electric equipment because of higher safety level and dimension reducing, 10% of its use is devoted to the surface treatment of metals and so on in the world. Up to thousands kg of SF_6 can be in one interrupter of high voltage. Highly toxic products originate at temperatures over 400°C. Alternatives at low voltage are vacuum and air. In development is for example Novec™612 (fluorinated ketone) ($C_3F_7C(O)C_2F_5$). In last times it was used in older types of extinguishers and at aluminium production in the Slovak Republic. Today it is used especially as an isolating gas in high voltage switchgears, in high voltage switchers at Slovenské elektrárne - ENEL (electricity distribution plant) with supposed release 1% of filling per year. Filling is dimension for 30 years without refilling. Nitrasklo Ltd. uses the SF_6 since 1993 for anti noise and thermal isolation into windows. It is mixed with argon in rate 30:70 thus its consumption is decreased, production is more cost-effective. It is filled in close cycles practically without releases. 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 480 kg filled into windows yearly.
- PFCs (perfluorcarbons) - they are produced already 30 years. They are used in special heating and cooling. In electronics they are used in gaseous state as a protection against explosion, isolation and detection gases. Further, they are used for cleansing, dissolving, fluorine etching of glass and as extinguishing media.
- PFC14 (perfluormethane) - it originates as a by-product during the aluminium production in Žiar nad Hronom. PFC 14 is used for fluorine etching of glass and printed circuit.
- PFC116 (C_2F_6 perfluorethane) - it originates as a by-product during the aluminium production in Žiar nad Hronom.
- PFC218 (C_2F_6 perfluorethane) - there is an effort to use PFC218 in research as a component in coolant mixture.
- PFC410 (C_4F_{10} perfluorbuthane) - in electronics it is used as protection against explosion, isolation and detection gas. It is not yet used as an extinguishing medium designed for fixed extinguishing devices in the Slovak Republic but probably there will be an effort to approve it.
- PFC318 (c-C_4F_8 perfluorcyclobuthane) - there will be an effort to approve the PFC318 for cleansing and dissolving as a substitute for 1,1,1–trichlorethane.

The Revised 1996 IPCC Guidelines describe two tiers for estimating emissions from the use of OD substitutes:

- The advanced or actual method (Tier 2)
- The basic or potential method (Tier 1)[15]

The actual emission estimation method (Tier 2) accounts for the time lag between consumption and emissions.

4.6.2 Foam Blowing (CRF 2.F.2)

No emissions of F gases were included in this category.

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[15] *Decision 2/CP.3 affirms that actual emissions should be used for the reporting of emissions to the UNFCCC, and that Parties should make every effort to develop the necessary sources of data.*

4.6.3 Fire Extinguishers (CRF 2.F.3)

The emissions originated from fire extinguishers represent less than 10% of emissions from 2.F category. Total actual emissions of HFCs were 3.8 Gg of CO_2 equivalents and increased from the previous year by 39%, the potential emissions of HFCs were 21.8 Gg of CO_2 equivalents and increased comparable to the previous inventory year by 30% in 2007. The emissions of PFCs and SF_6 are not occurring in this category.

4.6.4 Aerosols/Metered Dose Inhalers (CRF 2.F.4)

No emissions of F gases were included in this category.

4.6.5 Solvents (CRF 2.F.5)

No emissions of F gases were included in this category.

4.6.6 Other Applications Using ODS Substitutes (CRF 2.F.6)

No emissions of F gases were included in this category.

4.6.7 Semiconductor Manufacture (CRF 2.F.7)

No emissions of F gases were included in this category.

4.6.8 Electrical Equipment (CRF 2.F.8)

The emissions originated from electrical equipment represent less than 10% of SF_6 emissions from 2.F category. Total actual emissions of SF_6 were 0.73 Gg of CO_2 equivalents and increased from the previous year by 1.5%. The emissions of HFCs and PFCs are not occurring in this category.

4.6.9 Other (CRF 2.F.9)

The emissions originated other use represent only potential emissions from old use. Total potential emissions of SF_6 were 0.00332 Gg of CO_2 equivalents and continually decreased from year to year. The emissions of HFCs and PFCs are not occurring in this category.

4.7 Consumption of Halocarbons and SF_6 Potential Emissions (CRF 2.F.P)

Total potential emissions of F gases from industry sector are from import in bulk. The emissions of HFCs from consumption were 539.59 Gg of CO_2 equivalents. Total potential emissions of SF_6 in 2007 were 3.32 Gg of CO_2 equivalents.

Methodology

The potential emission estimation method assumes that 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 of CFC, HCFC and HFC coolants.

The Revised 1996 IPCC Guidelines describe two tiers for estimating emissions, which occur during the year in which the chemical is produced or sold into a particular end-use sector. The bottom-up approach takes into account the time lag between consumption and emissions explicitly through emission factors. The top-down approach takes the time lag into account implicitly, by tracking the amount of virgin chemical consumed in a year that replaces emissions from the previous year. The basic approach we use is top down, but we follow the cumulative amount of substances and calculate emissions using emissions factors. We follow; compare the amount of substances used to substitute emissions calculated from:

- Top down approach
- Cumulative amount of substances and emissions factors

Because of expected prohibition of coolant R12 import, 700 tones of it was purchased in years 1993 and 1995. This amount is gradually consumed and coolant R12 was still available in 2001. Coolants consumption has decreased in the Slovak Republic comparing to 1990 by 60%.

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 growth tendency since 1999. Coolant R134a shows continuing growth tendency mainly because of rising import of cars with AC. After 2011 we can expect slight decreasing of R134a consumption.

Table 4.13: Import of coolants in equipments and bulks to the Slovak Republic according to the usage.

Type of equipment	**R22 (t)**									
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Industrial coolants, AC	7,00	8,45	7,06	6,32	-2,30	-2,75	-3,36	-3,40	-0,69	-1,80
Commercial coolants	0,49	0,61	0,24	0,17	0,01	0,19	0,00	0,00	0,00	0,00
Domestic coolants	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Car AC	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total in import equipments	7,49	9,06	7,30	6,49	-2,29	-2,56	-3,36	-3,40	-0,69	-1,80
Import in bulks	129,00	28,60	41,38	50,00	70,36	44,60	32,65	33,20	39,76	42,80
Import in mixtures	0,00	0,00	10,84	10,50	10,07	9,95	5,80	4,70	2,20	6,15
Total	**136,50**	**37,66**	**59,52**	**66,99**	**78,14**	**51,99**	**35,09**	**36,60**	**41,26**	**47,20**

Type of equipment	**R134a (t)**									
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Industrial coolants, AC	0,91	0,67	1,15	0,76	2,27	1,58	0,44	2,90	1,06	1,77
Commercial coolants	0,23	1,28	0,80	-1,11	-0,99	-1,60	1,57	1,30	1,50	0,76
Domestic coolants	16,50	17,35	10,10	9,06	3,11	2,85	1,29	1,20	1,27	0,70
Car AC	0,00	0,00	0,00	19,30	19,05	20,80	29,12	32,30	45,60	49,10
Total in import equipments	17,80	19,30	12,05	28,01	23,44	23,63	32,42	37,70	49,44	54,26
Import in bulks	52,10	50,00	82,00	32,49	50,36	51,70	47,81	54,00	83,00	89,50
Import in mixtures	0,00	0,00	0,00	6,67	12,90	15,00	14,24	20,00	26,50	26,40
Total	**69,80**	**66,60**	**94,00**	**67,16**	**86,70**	**90,33**	**94,46**	**111,70**	**158,50**	**170,10**

Type of equipment	**R404A (t)**									
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Industrial coolants, AC	0,23	0,10	0,21	1,71	0,35	0,34	0,16	0,40	0,00	0,00
Commercial coolants	0,17	0,22	0,60	0,80	0,98	-0,60	-0,49	0,49	1,68	2,06
Domestic coolants	0,00	0,00	0,00	0,00	0,44	0,00	0,00	0,00	0,00	0,00
Car AC	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,90	2,10	1,87
Total in import equipments	0,40	0,32	0,81	2,51	1,77	-0,26	-0,33	2,79	3,78	3,94
Import in bulks	2,70	2,60	23,29	28,39	45,82	45,80	42,81	42,40	59,92	61,20
Total	**3,10**	**4,60**	**24,10**	**30,90**	**47,60**	**45,54**	**42,48**	**45,20**	**63,70**	**65,12**

Type of equipment	**R407C (t)**									
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Industrial coolants, AC	0,10	1,91	3,18	1,93	6,88	5,00	-2,84	0,68	1,73	2,66
Commercial coolants	0,00	0,01	0,00	0,00	0,04	0,04	0,15	1,13	0,34	1,36
Domestic coolants	0,00	0,00	0,00	0,14	0,00	0,00	0,00	0,00	0,00	0,00
Car AC	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total in import equipments	0,10	2,05	3,18	2,07	6,92	5,04	-2,99	1,81	2,10	4,96
Import in bulks	0,50	0,40	6,55	11,56	18,80	25,30	27,06	32,89	43,58	40,60
Total	**0,60**	**1,05**	**9,73**	**13,63**	**25,70**	**30,34**	**24,07**	**34,70**	**45,68**	**45,50**
% in bulks									95,00	89,00

Type of equipment	**R410A (t)**									
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Industrial coolants, AC	0,00	0,03	0,40	0,47	1,66	2,20	3,25	7,24	6,69	18,08
Commercial coolants	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,56	0,04	0,93
Domestic coolants	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Car AC	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Mixures	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total in import equipments	0,00	0,03	0,40	0,47	1,66	2,20	3,25	7,80	9,74	18,86
Import in bulks	0,00	0,03	0,03	0,73	1,55	4,63	1,74	4,54	6,14	9,30
Total	**0,00**	**0,06**	**0,43**	**1,20**	**3,02**	**6,83**	**4,99**	**12,33**	**15,88**	**28,14**
% in bulks									38,00	33,00

Type of equipment	HCFC and HFC mix refrigerants total (t)									
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Industrial coolants, AC	8,24	11,20	12,00	11,20	7,70	6,40	-2,35	7,82	11,79	20,70
Commercial coolants	0,89	2,11	2,33	-0,14	-0,01	-0,40	1,23	3,48	7,52	5,11
Domestic coolants	16,50	17,35	10,10	9,06	3,11	2,85	1,29	1,20	1,27	0,70
Car AC	0,00	0,00	0,00	19,30	19,05	20,80	29,12	34,20	45,60	56,10
HCFC Mixures	0,00	0,00	0,00	24,30	19,36	18,30	9,60	10,44	8,24	4,30
Total in import equipments	26,00	30,50	24,20	39,50	31,20	28,00	29,30	50,28	64,37	82,00
Import in bulks	184,50	80,80	152,80	147,50	214,80	190,00	152,10	167,10	232,40	243,40
Total	**210,50**	**111,30**	**177,00**	**187,00**	**246,00**	**218,00**	**191,00**	**224,00**	**305,00**	**330,00**
% in bulks	87,60	72,60	86,00	78,90	87,00	87,00	79,60	73,00	76,00	74,00

Refrigerant/import 2007	AC	CC	DC	CAR AC	Bulks	Total
R22	-1,80	0,00	0,00	0,00	49,00	**47,20**
R134a	1,70	0,76	0,70	49,10	89,50	**143,70**
R404A	0,00	2,60	0,00	1,87	61,20	**65,12**
R407C	2,66	1,36	0,00	0,00	40,60	**45,50**
R410A	18,08	0,93	0,00	0,00	9,30	**28,14**
Total	**20,64**	**5,65**	**0,70**	**50,97**	**249,60**	**330,00**
TOTAL	**330 tons**					

First picture is showing the development of refrigerants consumption in the Slovak Republic. The higher consumption in the years 1998 and 2002 was caused by higher purchase of refrigerant R22 because of expected legislation, fees and limited possibility of purchase. The consumption of refrigerants is still rising in harmony with the growing economy.

Second picture shows the ratio of import of refrigerants in bulks and products. The level of import in products in the year 2007 is stabilized although the increasing export of products is included too. The main influence has the still rising import of cars with air conditioning with refrigerant R134a and split systems with the refrigerant R410A.Because of expected prohibition of coolant R12 import, 700 tones of it was purchased in years 1993 and 1995. This amount is gradually consumed and coolant R12 was still available in 2001. Coolants consumption has decreased in the Slovak Republic comparing to 1990 by 60%.

Figure 4.2: The development of refrigerant consumption in the Slovak Republic.

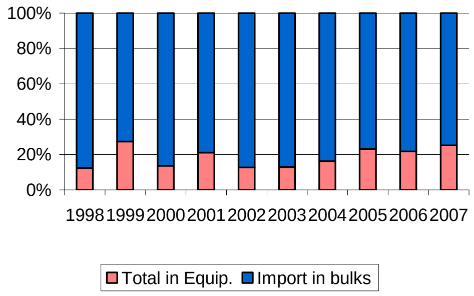
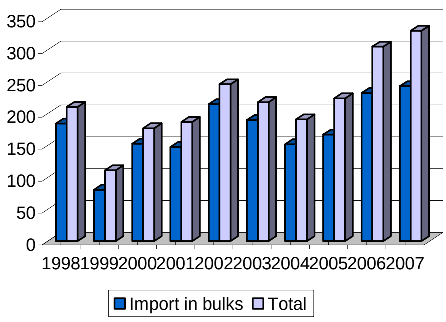
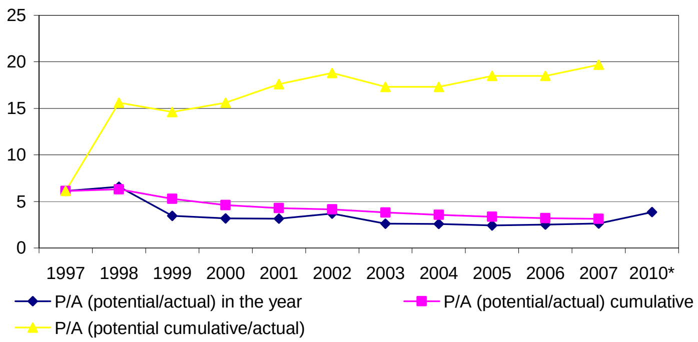


Figure 4.3: The development of refrigerant import in products and bulks in the Slovak Republic.



The potential and real emissions in aluminium production were decreased in 1997, 1998 and mainly in 1999 comparing 1995 due to the new technologies of aluminium production. It can be significantly seen on the decreased P/A ratio in the year 1999 in the next graph. A consumption of coolants and extinguishing media in 1998 has decreased because of decrease of investments in construction works in the Slovak Republic. But in the future mainly potential emissions will increase due to gradual substitution of CFC and HCFC coolants by HFC coolants, especially coolant R134a or coolants R125 and R143a as components in mixtures of coolants R 404A, R407C and R410. On the other hand, there is the decrease from aluminium production and extinguishing media. Increase of extinguishing media started in the year 2000 using not only HFC 227ea, but HFC 236fa as well. There are calculated only 1% emissions from new extinguishing media. Today there are no emissions from foams, solvents and aerosols because these substances are not used for these purposes in the Slovak Republic. A usage of PFC solvents and extinguishing media will probably show its effect on emissions in the future.

Figure 4.4: The development of ratio of potential and actual emissions.



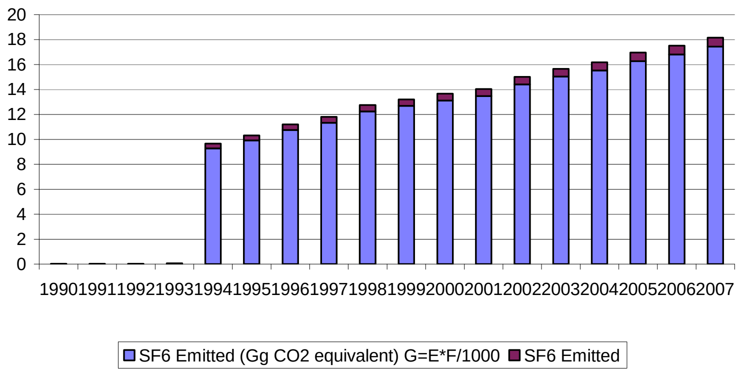
Potential and actual emissions of PFC 14 and PFC116 - C_2F_6 perfluorethane originates as a by-product during the aluminium production in Žiar nad Hronom. Since 2000 PFC14 and PFC116 originated as a by-product during the aluminium production hasn't been included to the emissions of this part of inventory.

There are calculated less then 1% emissions from new extinguishing media (without consumption for extinguishing, no consumption was recorded in the last years).

In relation with the high reliability of the new cooling equipments with the content of HFCs, PFCs and SF_6 and progressive implementation of preventive service, the ratio of cumulative potential and actual emissions is still rising although in the years 2003/2004 and 2006/2007 was nearly on the same level. The ratio of potential and actual emissions and as well of the cumulative potential and cumulative actual emissions is declining. It is because the actual emissions are rising adequately to the cumulative amount of these HFCs substances – substitutes of ODS.

The above analysis shows that in the year 2007 was reached faster application of HFCs because the HCFCs applications have been completely abandoned in new installations by the Act n. 76/1998 Z.z. in version n. 408/2000 Z.z. in the year 2004. Decline of extinguishing media consumption is because they are very expensive and the investment to them is planned for a longer time. Consumption of SF_6 is approximately at the same level. Technical solutions, which could substitute this gas, are still very expensive. Consumption of PFCs during etching is practically without emissions and this technology is still less used.

Figure 4.5: The development of SF_6 emissions.



Uncertainties and time consistency

Inventory of F-gases is complicated due to high number of substances HFCs, PFCs a SF_6, totally 12 HFCs substances. They are components of different mixtures used in different more then 15 applications. Each application has its own development of consumption and trend of emission development. According to the IPCC GPG it is no sense to deal with uncertainties, which do not have fundamental influence to the total emissions. This should be taken into account in all numerous applications of different F-gases. That why in the coincidence with IPCC GPG the first step is the quantifying of uncertainties and it is done by expert judgment due to this large extent of different applications and gases for potential and actual emissions.

Given substances are not solo (independently) documented under any of items in custom scale of rates (tariff). On the base of description of the F-gases with GWP in questionnaires, they are sent to potential importers, producers, users and consumers of given substances in the SR. It means that we have lot of different data sources on the base of questionnaires.

Similarly, uncertainness come out from the assessing of emission factor, which is gradually decreasing during the years 1994–2007 in the range from 17 to 8% according to the application. The lowest emission factors are on the products completed in the factories mainly in domestic refrigerators, chillers and so on. Higher emission factors are in cooling circuits assembled on the place of application for example commercial, agricultural, industrial, transport refrigeration and so on. Given range of emission factors is overcome only in car air conditioning, where emission factor is expected over 20%. From this assessment comes out that emission factor in all applications is in the range from 8 to 25%. Assessment of uncertainties by expert judgment is considered for the development of potential and actual emissions. Potential emissions depended on preciseness and completeness of reported data is evaluated in the range from – 5 to 15% and actual emissions in the range from 8 to 17%. Both distributions are nonsymmetrical. In the case of potential emissions, we suppose that reported data are sooner underestimated and in the case of emission factor, we suppose in more applications trend to the lower emission factor. Potential emissions have correlation to economical development in the SR. Uncertainties in to the relation of potential emissions are dependent on time (years). Trend of development of potential emissions can have fluctuating mainly increasing tendency, which in the future will be decreasing due to implementation of alternative natural refrigerants. Nowadays the development is given mainly by the fact that HFCs substances are substituting CFCs and HCFCs substances excluded from usage by Montreal Protocol. Emission factors depend on time (years) and correlate with the technical and technological development and to the implementation of legal acts, technical standards and so on. Trend of the development of emission factor should have decreasing tendency.

If these assessments should be exactly statistically analyzed, it would be necessary to buy software for statistical analysis by the method of Monte Carlo and analyze probability distribution of inputs it means emission factors and the movement of substances in every application. Such work would be quite extensive and it would require higher financial costs. It is therefore necessary to consider whether such work in comparison with expert judgment, which is acceptable by GPG, will be adequate to the significance and the ratio of emissions in all or only chosen applications.

Method Monte Carlo requires sequence of steps during several years. It is a method, which only on the basement of gradually acquired experiences improves quality of inventory by gradual decreasing of uncertainties.

QA/QC and verification

Due to the links, relations in the questionnaire to other potential importers, producers, and that the most of the companies are presented in Catalogue of RAC companies and are the members or are trained by Slovak Association of Cooling and Air Conditioning Technique (SZ CHKT). The SZ CHKT is authorized by Ministry of Environment for training and certification of personnel, or they are on the internet, participating on the exhibitions and so on, we can assume, that more then 90% of potential companies were addressed. Addressed companies filled the questionnaires on the base of their documentation and so the reported data should correspond to the reality. With the reported data, these companies are confronted during the next two years. It should be enough for checking and correcting the wrong data. The data processed in this way we can consider as representative. During an inventory, we can assume nonsymmetrical error distribution in reported data in the range from –5% to + 15%.

Recalculations

No recalculations in consumption of halocarbons and SF_6 were provided for the previous inventory year or base year.

Planned improvements

The improvements are planed for next submission in the detailed information fill into the sectoral tables.

4.8 Other (CRF 2.G)

No emissions are included in the category 2.G Other in 2007 in the SR.

5 SOLVENT AND OTHER PRODUCT USE (CRF 3)

This category includes the emissions of CO_2, N_2O and NM VOC (photochemical smog) from solvent and other product use according to the IPCC Guidelines. The lack of relevant input sources and emission factors for CO_2 has the significant reason for the omission this source from the inventory. In other way, the CO_2 emissions might be ballast with the high uncertainty.

The primary attention in the 2009 submission in the solvent use sector inventory was put in to the N_2O emissions. The most important problem was to collect all available input data in a consistency manner. The statistical information are poor, so it was decided to request directly the producers, importers, distributors and users.

In the frame of National Program for Emission Reduction of Non-Methane Volatile Organic Compounds were estimated total NM VOC emissions from solvent and other products use with cooperation with Ministry of Environment, team of experts on the base of Directive 1999/13/EC and upon a close cooperation with producers in the Slovak Republic.

5.1 Paint Application (CRF 3.A)

The CO_2 emissions from paint application were not estimated from the reason of lack of methodology and emission factor. The NMVOC emissions from paint application were more than 20 ktons and increased comparable to the previous year. The activity data of used painting and glues was increasing to 36.405 ktons.

5.2 Degreasing and Dry Cleaning (CRF 3.B)

The CO_2 emissions from degreasing and dry cleaning category were not estimated from the reason of lack of methodology and emission factor. The NMVOC emissions from degreasing and dry cleaning use in industry and services were recalculated previous year for the reason exclude double-counting in use of solvents. Some of solvents (like technical gasoline and petroleum) were included in paint application category 3.A. The recalculated values are included in inventory submission 2009 and are consistent with the CLRTAP inventory. Total NMVOC emissions from degreasing and dry cleaning were 5.06 ktons and decreased comparable to the previous year.

5.3 Chemical Products, Manufactured and Processing (CRF 3.C)

The CO_2 emissions from chemical products, manufactured and processing were not estimated from the reason of lack of methodology and emission factor. The NMVOC emissions from chemical products, manufactured and processing were more 8.372 ktons and slightly increased comparable to the previous year. The activity data was number of inhabitants in accordance to the applied methodology (EMEP/CORINAIR).

5.4 Other (CRF 3.D) (3.D.1 Use of N_2O for Anesthesia, 3.D.3 N_2O from Aerosol Cans)

The aim of N_2O emission inventory from solvent and other product use sector is in the medicine (anesthesia) and food use (aerosol cans). There is also the consumption of N_2O for the analytical purposes, but the gas is burned after the use, so this source is not included into the total inventory. The amounts are negligible.

Methodology

The activity data come from the three major distributors of N_2O liquid gas – Messer-Tatragas, Linde and SIAD companies. The methodology is very simple, because the source is not key one. We can suppose that the final emissions from these sources are equal to the consumed gas. The time series was reconstructed based on statistical data about production. The total numbers of used N_2O in the sector is summarized in the following Table 5.1. The emission factors for the consumption of N_2O for the medicine and food purposes are equal to the activity data, with the supposing, that all gas is evaporated into the atmosphere. The total emissions of N_2O in the solvent and other product use sector are 257.9 tons in 2007.

Table 5.1: The consumption of N_2O for the period 1990–2007.

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
	tons																	
Medicine	55,00	55,00	55,00	55,00	54,23	99,98	107,16	86,82	68,33	70,61	64,96	80,99	76,22	73,35	70,61	65,65	59,77	60,90
Food	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	15,68	108,49	117,78	188,37	212,90	206,13	197,00
Total	55,00	55,00	55,00	55,00	54,23	99,98	107,16	86,82	68,33	70,61	64,96	96,67	184,71	191,13	258,98	278,55	265,90	257,90

1990–1993 - estimated on the basis of data supplied by Messer-Tatragas.

The estimation of NM VOC emissions was processed based on IPCC Methodology (IPCC, 1996) uses CORINAIR Methodology (CORINAIR, 2003) and SNAP classification. Inventory was carried out upon the base of data about production, import, export and selling of individual type of solvents. The activity data according to the CORINAIR methodology are in the consistency form from 1990. The emissions of NMVOC from processing of vegetable fat and oil were estimated to be 147.85 tons and decreased comparable to the previous inventory by decreasing of production. The total emissions of NMVOC in the solvent and other product use sector are 33.6 ktons in 2007.

Uncertainties and time consistency

Only default uncertainty analyses were applied on the solvent use sector based on Tier 1 methodology. Time consistency is kept in time series in N_2O emissions estimation and NMVOC estimation based on EMEP/CORINAIR methodology.

QA/QC and verification

Information used for GHG emission inventories of Solvent use sector are directly from questionnaires sent to operators and producers of solvents in the SR. First preliminary data related to production and quality of products for previous year in the SR is available at the beginning of October. This data are used for emission estimation and verified by Mr. Vladimir Danielik – sectoral expert for Solvent use sector with the cooperation of the Slovak Technical University in Bratislava, Faculty of Chemical and Food Technology and the Slovak Union of Paint Producers comparing with the information from Statistical Office of the SR and available information from industrial sources.

Recalculations

No recalculations in Solvent use sector were provided for the previous inventory year or base year.

Planned improvements

The methodology for CO_2 emissions according NMVOC emissions is under consideration of the sectoral expert and planned for the next submission. The first discussion were planned with the experts from Austria to share knowledge of CO_2 emission estimation.

6 AGRICULTURE (CRF 4)

The humankind activities in Agriculture sector significantly contribute to changes of concentration of some gases in atmosphere what consequently increase its greenhouse effect as well as acidity of environment. Despite of fact that water vapour and CO_2 are gases of the highest importance sharing greenhouse effect of the atmosphere, N_2O and CH_4 emitted in Agriculture sector 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 Methodology (IPCC, 1996), when principles of Good Practice in GHGs inventory (IPCC, 2000) in agriculture were taking into account. Some national data from research projects were utilized too. Some of N_2O, CH_4 and NH_3 emissions can be reduced if effective adaptation measures are accepted in agricultural practice. Effective measures were proposed for condition of the Slovak Republic in other studies (NC SR, 2005), shortage of data, especially on storage and application of manures, resulted in fact that emissions are evaluated on the level business as usual in this study. Methodology used in this study utilized also results of research institutions sharing nitrogen fluxes in condition of the Slovak Republic.

Emissions from burning of field residuals were not defined in this study because these forms of soil cultivation are prohibited by low in SR. Area of histosols on the territory of SR is only 4 893 ha and those soils are not cultivated due to landscape protection during last years. This source is not evaluated in the inventory.

As the most important gases emitted from agriculture are considered methane and nitrous oxide. Agriculture produces about 26% of total methane and more than 67% of total nitrous oxide emissions in the Slovak Republic (NC SR, 2005).

The Slovak Agricultural University in Nitra, namely Dr. B. Siska was took responsibility for inventory of emissions from agriculture sector. Methodology used also results of research institutions sharing nitrogen fluxes in condition of the Slovak Republic. Basic sources of data used for evaluations of emissions were published in:

- Census of sowing areas of field crops in the SR;
- Annual census of domestic livestock in the SR;
- Green report of the SR 1998–2008, Ministry of Agriculture of the SR;
- Statistical Yearbook 1990–2008, the Statistical Office of the SR.

Trends of the total CH_4 emissions from agriculture sector reflect trends of direct emissions from enteric fermentation, emissions from manure management. After big decrease of methane emissions in the 90´ties (from 112 Gg in 1990 to 60.5 Gg in 1999) the emissions stabilized on level 50 Gg per year.

Table 6.1: The total methane emissions in the SR for the period 1990–2007 in Gg of CH_4.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Enteric fermentation	94,77	86,89	76,41	66,09	62,39	66,90	62,67	56,10	52,91	50,78	49,93	51,44	49,78	47,65	44,22	44,91	44,21	44,26
Manure management	17,56	16,32	14,82	13,62	12,91	13,25	12,60	11,56	10,21	9,87	9,52	9,63	9,74	9,26	7,84	7,66	7,49	6,84

In future higher part of total methane emission will create emissions from animal excreta that are much more easy to manage, e.g. by proper storage, than emission from enteric fermentation.

Trends of the total N_2O emissions from agriculture sector reflect trends of direct emissions from cultivated soils, emissions from AWMS and indirect emission from leaching and deposition of ammonia and NO_x. After big decrease of N_2O emissions in the 1^{st} half of 90´s (from 15.1 Gg in 1990 to 8.7 Gg in 1995) the emissions stabilized on level 6.95 Gg per year.

The N_2O emissions from agriculture sector create about 49% of total N_2O emissions in the SR. The total N_2O emissions in Agriculture sector are given by direct emissions from cultivated soils and animal husbandry and indirect emissions from leaching and nitrate depositions.

Figure 6.1: The trend of CH_4 emissions in agriculture in 1990–2007.

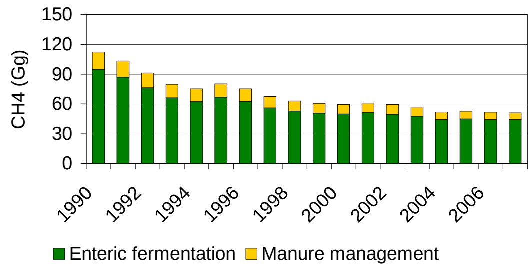
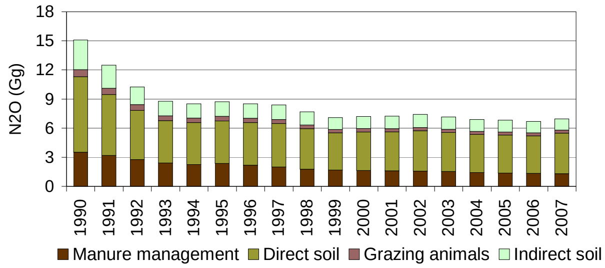


Figure 6.2: The trend of N_2O emissions in agriculture in 1990–2007.



Uncertainties and time consistency

Both for calculation GHG and ammonia emissions there are required data on number of domestic livestock according to categories and amount of applied fertilizers. Basic sources of data used for evaluations of emissions in this study were published in:

- Green Report of SR;
- Statistical yearbook.

Data published in Green Report of the SR (Green Report, 2007), as well as Statistical yearbook (Statistical yearbook, 2007) 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, differences are not of high importance.

Subcategories of domestic livestock can be estimated according to Annual census of domestic livestock in the SR. Data from this publication are issued relatively soon after end of previous year but many times they are different as compare with data from Green Report or Statistical yearbook.

Productivity of different categories of domestic livestock varies in conditions of the Slovak Republic significantly in dependence on scale and production level of farm.

In conditions of the SR, both extensive and intensive farming system in animal husbandry can be found. The range of nitrogen production for dairy cows is in range 60–140 kg per head per year. Nitrogen inputs from animal excreta differ in dependence 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 methodology (IPCC, 1996): cattle (dairy cattle – 90 kg of N per head and others with production of 56 N per head), pigs, sheep, goats, horses and poultry.
- More detailed values for calculation of NH_3 emissions were used, when categories of domestic livestock were separated according to weight to subcategories and production of 100 kg N per year for dairy cattle and 60 kg N for other cattle was supposed.

Nitrogen inputs can differ from calculations in range +10%. Towards future, this mistake should be lower because the level of animal husbandry can be concentrated to relatively smaller number of producers and so it can be much easier to define production level of farms.

According to IPCC methodology (IPCC, 1996), there is next animal waste management systems (AMWS) observed in condition of the Slovak Republic:

- Liquid storage of animal excreta.
- Dry storage.
- Pasture.

Dry storage of animal excreta is the most frequent way of AWMS especially in category cattle. 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 analyses of housing systems on the territory of the Slovak Republic that was made by Research Institute of Animal Production in Nitra (Brestenský, 1998). There was supposed that sheep, goats and horses can stay on pasture 200 days a year, 40% of dairy cattle 150 days during day only. Results of analyses on animal waste management system were used for calculation of nitrogen input from animal husbandry into N-cycle. This analysis was based on questionnaire. 222 agricultural subjects were included (21.3% of total amount of subjects in the SR) in this research. Those subjects cultivated 14.7% of total agricultural land and 15.2% of arable land. It is very probable that answers were received first of all from farmers were elements of good practice in agriculture started to apply. Storage of dry manures is probably more frequent then questionnaire showed and emissions from AWMS will be higher. For sheep, goats and horses is frequent housing on grasslands since April to October. Duration of grazing period can vary significantly in dependence on weather conditions in different part of the SR. There is not enough date for statistical evaluation but in this point can be found significant differences.

Applied amounts of synthetic fertilizers into cultivated soils are very low for last 15 years. Potential for volatilization of ammonia and emissions of N_2O can vary in very large range. The best information on NH_3 emission from cultivated soils in the SR can be reached on the base of applied nitrogen fertilizers. Emissions also depend on 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). Selection of emission coefficients reflect climatic and soil condition of the Slovak Republic, when climate in Central Europe was defined as a cool (ECOTEC, 1994) with prevailing acidic soils. ECOTEC coefficients are lower then those published by (Assman, 1992) or coefficients for non-defined climatic conditions (simple methodology). Emissions of ammonia from cultivated soil can be higher in dependence on used methodology by 6–20%.

N inputs from symbiotic fixation of leguminous crops in condition of SR vary in range 20–30 $kg.ha^{-1}$ (Bielek, 1998). As an average value can be accepted 26 kg $N.ha^{-1}$ (Vostál at all., cit. in Bielek, 1998). This value varies in range $\pm$20% from the mean value. Data on production of nitrogen in excreta of domestic livestock are influenced by facts mentioned above (N production by domestic livestock and numbers of domestic livestock according to categories.

Nitrogen content in crop residuals as well as of their decomposition in soil significantly influences formation of yield in next years. National methodology for calculation of nitrogen inputs from crop residuals was used when nitrogen amount was calculated according to acreage of field crops and nitrogen content in different crops (Jurčová, 1998). The yield of field crops can vary in range $\pm$20% year to year.

Uncertainties are defined by emission coefficients. For direct soil N_2O emissions calculated values from reality can differ in range 20–200%, for N_2O from animal waste management system in range 25 – 150%, for indirect N_2O emissions from NH_3 volatilization in range 20–200% and for indirect N_2O emissions from leaching I range 10–500%.

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 large range. There was found values in range 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 condition than other soils.

According to recommendation in IPCC, 2000 there are necessary also direct measurements gases emissions in agriculture. These data are absent in condition of the SR.

Emissions calculated according IPCC methodology are little bit higher values (by about 3%) than emissions calculated by detailed methodology. This fact is caused by higher nitrogen inputs from animal husbandry calculated by IPCC methodology (IPCC, 1996). According to results reached by two methods we can conclude that calculation methods are relatively similar.

The highest uncertainties are observed on cultivated soils (soils with fertilizers). More exact data on NH_3 and N_2O emissions from cultivated soils is possible to reach by modelling e.g. by DNDC model. Today this kind of model is tested at the Department of Biometeorology and Hydrology at the Slovak Agricultural University in Nitra.

Uncertainties are defined by emission coefficients. For direct soil N_2O emissions calculated values from reality can differ in range 20–200%, for N_2O from animal waste management system in range 25 – 150%, for indirect N_2O emissions from NH_3 volatilization in range 20–200% and for indirect N_2O emissions from leaching I range 10–500%.

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 large range. There was found values in range 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 condition than other soils.

According to recommendation in IPCC, 2000 there are necessary also direct measurements gases emissions in agriculture. These data are absent in condition of the SR.

Emissions calculated according IPCC methodology are little bit higher values (by about 3%) than emissions calculated by detailed methodology. This fact is caused by higher nitrogen inputs from animal husbandry calculated by IPCC methodology (IPCC, 1996). According to results reached by two methods we can conclude that calculation methods are relatively similar.

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QA/QC and verification

Prof. Bernard Siska (Agricultural university Nitra) as sectoral expert for agriculture assigned by the Emissions Department SHMÚ as SNE and Ministry of Environment of the Slovak Republic as NFP by the letter under the National Inventory System, has signed agreement with the Slovak Hydrometeorological Institute on January 2, 2008 on preparing report evaluating GHG emissions from agriculture sector in 2007.

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 (SOSR) and official information from the Ministry of Agriculture of the Slovak Republic (Green Reports).

All information used for preparation of this report is archived by the author and by SNE.

Recalculations

Recalculation of the methane emissions from enteric fermentation for sheep was provided for 2004–2006. The methodology was change for Tier 2 and country specific emission factors were used in emission estimation.

Table 6.2: The changes by recalculation in EFs and methane emissions.

	4.A - Sheep		
	2004	**2005**	**2006**
EFs	kg per head per year		
Submission 2008	8,00	8,00	8,00
Submission 2009	10,50	10,30	10,30
Change in %	**131,29**	**128,75**	**128,76**
	4.A - Sheep		
	2004	**2005**	**2006**
CH_4 emissions	tons		
Submission 2008	2,570	2,564	2,661
Submission 2009	3,374	3,301	3,426
Change in %	**131,29**	**128,75**	**128,76**

Recalculation was provided in the sense to correct fraction of livestock N excreted and deposited onto soil during grazing for the 1990–2005. The error was in formula for fraction calculation.

Table 6.3: The recalculated values for $FRAC_{GRAZ}$.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
$FRAC_{GRAZ}$	0,1328	0,1317	0,1347	0,1278	0,1267	0,1270	0,1273	0,1291	0,1291	0,1315	0,1342	0,1284	0,1263	0,1271	0,1279	0,1290

Recalculation was provided in the sense of correction the N excretion values in swine category based on the direct information from the detailed disaggregation of the swine category to the sow (36 kg/head/year), sow up to 50 kg (15 kg/head/year), young sows over 50 kg (16 kg/head/year) and fattening pigs (14 kg/head/year) for the 1990–2006. The error was in formula for fraction calculation average value, not weighed average. The emissions were not changed.

Table 6.4: The recalculated values for N excretion in swine category.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N swine kg/head/y	16,24	16,35	16,45	16,43	16,46	16,46	16,44	16,45	16,85	16,90	17,03	16,96	16,40	16,27	16,18	16,14	16,09	15,96

Recalculation was provided in the sense to correction of N excretion values in poultry category based on the direct information from the detailed disaggregation of the poultry category to the laying hens (0.8 kg/head/year), broilers up to 50 kg (0.6 kg/head/year) and turkey & ducks (2 kg/head/year) for the 1990–2006. The error was in formula for fraction calculation average value, not weighed average. The emissions were not changed.

Table 6.5: The recalculated values for N excretion in poultry category.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N poultry kg/head/y	0,742	0,767	0,751	0,772	0,750	0,769	0,747	0,750	0,749	0,753	0,752	0,739	0,741	0,737	0,741	0,731	0,751	0,755

Planned improvements

The several important methodological changes have been occurred during last inventory submission in agricultural sector. The recalculation was based on using Tier 2 methodology in methane emissions from enteric fermentation and manure management. The activity data were compared from two sources – Statistical Office of the SR (regional statistics) and the Green Report of the Ministry of Agriculture of the SR. The data provided by regional statistics are more precise and detailed. The estimations were recalculated to the 1997, until regional data were available. The time series were calculated back to base year using linear regression and expert judgment. Data published in Green Report of the SR, as well as 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%. Subcategories of domestic livestock can be estimated according to Annual census of domestic livestock in the SR. Data from this publication are issued relatively soon after end of previous year but many times they are different as compare with data from Green Report or Statistical yearbook. Productivity of different categories of domestic livestock varies in conditions of the Slovak Republic significantly in dependence on scale and production level of farm.

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 the animal categories will be updated based on the information known from regional statistics. Table 4B(b) in the CRF will be fulfill according the recommendations of the ERT from the previous review. The direct N_2O emissions from soils will be recalculated according the new research knowledge in agro-climatic regionalisation in the SR. Based on this approach, the first output from the model DNDC are known. The direct measurements of N_2O soil's emissions to adjust model are planned for the international project of the Agricultural University in Nitra (Slovak Republic).

6.1 Enteric Fermentation (CRF 4.A)

The cattle are among all domestic livestock the most important producer of methane due to its digestive tract, weight and relatively high number as compare with other population of livestock in the SR. Therefore, trends of total CH_4 emissions reflect first numbers of animals in this category. Numbers of animal dairy cows as well as other cattle have decreased by than half during evaluated period. Except for domestic livestock category the amount of emitted methane is influenced by some parameters within the category as age or weight of animal, amount of food and its quality, consumption of energy for basal metabolisms.

Methane emissions from enteric fermentation are dominant emissions from animal husbandry and from agriculture at all. The cattle produce more than 90% of these emissions and dairy cattle give nearly half of emissions in the category. Less then 10% of emissions produce other categories of domestic livestock. An intensification of animal husbandry increased also methane emissions on level 100 kg CH_4 per head per year. On the other hand, higher efficiency leads to decrease of numbers of dairy cattle and consequently decrease of total methane emissions from this category.

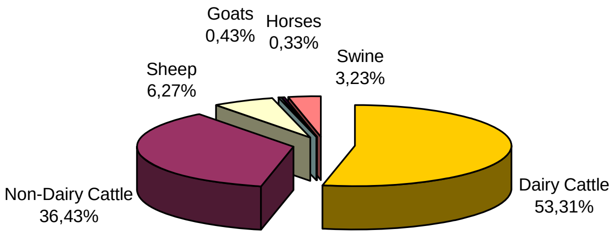
Methane emissions from enteric fermentation of dairy and non-dairy cattle are key source categories according level and trend assessment for the base year and for the 2004. The Slovak Republic used Tier 1 simple methodology based on numbers of animals and milk production for these categories. As the ERT was recalling for the revision of emissions factors for dairy cattle in enteric fermentation category based on milk production, sectoral expert for agriculture was decided to recalculated methodology for Tier 2 based on national data about animal number in detailed categories (for other non-dairy cattle) and more advance characteristic about feed and milk conditions for category dairy cattle. Detail input data are available from 1997 until present published in the Green reports of the SR (www.land.gov.sk) and verified by district offices statistical farm information (bottom-up approach).

Methodology

Methane emissions from enteric fermentation for dairy cattle, non-dairy cattle and sheep are based on Tier 2 approach (sheep from 2004). The bottom-up regional input data about the number of animals, feeding situation, weight, milk production, average gross energy intake and other are available from 1997. The time series 1990–1996 was evaluated based on extrapolation methodology for dairy and non-dairy cattle. The complete time series is consistent with the recommendations of the GPG 2000. The methane emissions from enteric fermentation for other animals (goats, horses, swine) are not significant and were estimated by Tier 1 methodology.

Total emissions of methane from enteric fermentation decreased from 94.77 Gg in year 1990 to 44.26 Gg in year 2007, what is decrease by more than 53%. According to the projections, in 2012 decreasing numbers of dairy cattle (calculated according to milk productivity and limits of milk production for the SR) and numbers of sheep and goats will reduce emissions from this source on level 34.7 Gg per year what is less then one third of emissions of 1990.

Figure 6.3: Methane emissions from enteric fermentation according to livestock categories in 2007.



Emission factors for dairy cattle, non-dairy cattle and sheep were estimated based on milk production, average gross energy intake and are national specific. Methane emissions from enteric fermentation for dairy cattle reflect milk production during evaluated period of year given the following Table 6.6. 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. For the estimation of emission factors for methane emissions of 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 cattle categories analysis. The emission factor for enteric fermentation was estimated according to milk productivity for each year by interpolation when for milk productivity 2 550 l the EF 81 kg CH_4 per head per year was used and for productivity 4 200 l was used the EF 100 kg CH_4 per head per year.

Table 6.6: The milk production in kg per dairy cow in the SR for the period 1990–2007.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Milk production in kg per cow per day	6,34	6,86	7,38	7,91	8,43	8,95	9,48	9,65	10,65	10,94	11,99	12,43	13,07	13,32	13,45	14,24	15,60	16,30

Total emissions of methane from enteric fermentation for dairy cattle decreased from 40.37 Gg in year 1990 to 23.60 Gg in year 2007, what is decrease by more than 42%. According to the projections, in 2012 decreasing numbers of dairy cattle (calculated according to milk productivity and limits of milk production for the SR) will reduce emissions from this source.

Total emissions of methane from enteric fermentation for non-dairy cattle decreased from 45.44 Gg in year 1990 to 16.13 Gg in year 2007, what is decrease by about 64%.

Total methane emissions from enteric fermentation of sheep were estimated from 2004 by Tier 2 methodology based on detailed classification of animal to three categories: ewes, lambs and other sheep. The country specific data are available only from 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 6.7: The overview of country specific values form Tier 2 methodology for dairy, non-dairy cattle and sheep in 2007.

Year 2007	Animal number (1000 heads)	EF (kg CH_4 per head per year)	GE (MJ per head per day)	Ym	Milk productivity (kg per day)
Dairy Cattle	**215,659**	**109,423**	**314,707**	**0,060**	**16,300**
Non-Dairy Cattle	**286,158**	**56,350**	**140,808**	**0,060**	
young male <6m	30,474	25,458	64,691	0,060	
young female <6m	44,736	27,583	70,092	0,060	
young male 6m-1y	25,381	47,834	121,550	0,060	
young female 6m-1y	45,585	51,832	131,710	0,060	
Males 1-2y	28,816	76,065	193,290	0,060	
Females 1-2y	74,360	82,426	209,452	0,060	
Fattering pigs	36,142	51,171	130,030	0,060	
Bulls	0,664	80,929	205,650	0,060	
Sheep	**347,179**	**10,330**			
Ewe	231,097	11,380	24,780	0,070	0,214
Lamb	45,204	11,380	24,780	0,070	0,214
Other	70,878	6,260	13,630	0,070	12,647

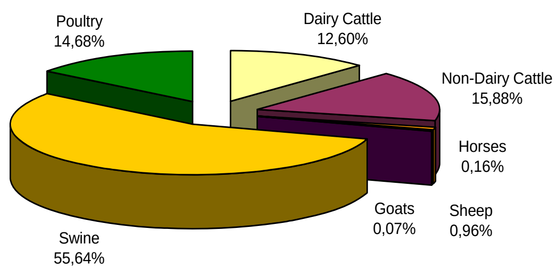
6.2 Manure Management (CRF 4.B)

In anaerobic conditions due to decomposition of manure, some methane is emitted too. These conditions can be found especially in large-scale farms (farms for dairy cattle, fattening pigs, poultry).

Methodology

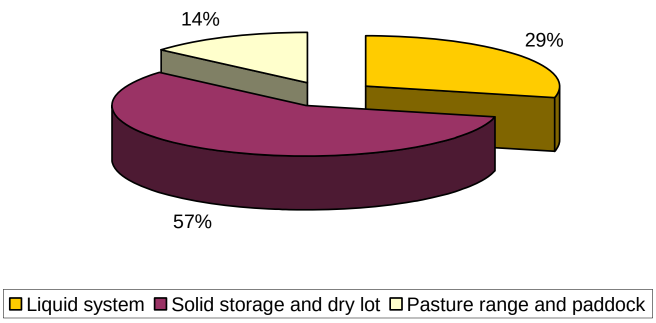
Methane emissions from this source decreased from 17.56 Gg in year 1990 to 6.84 Gg in 2007. Total methane emissions in 2007 from agricultural sector (animal husbandry) were 51.11 Gg. A trend of emissions during evaluated period is depicted on the following Figure 6.4. Total CH_4 emissions from manure management in agriculture decreased due to decrease of livestock numbers of all categories except for poultry. Extreme decrease of animals in category of pigs due to economical reason (low prices of meat on the market) was recorded last year in SR what consequently influenced methane emissions in category manure management. Emissions decreased by about 56% in category manure management. Next decrease is supposed also in year 2008 and during period of years 2008–2012. Methane emissions can drop by about 10% up to year 2012 because of next decrease of populations of cattle. The methodology based on the national data was evaluated for the methane emission estimation in manure management. The national approach is based on the animal numbers per regions, calculation of the volatile solid excretion (VS) and methane conversion factor (MCF) as inputs to the formula for the estimation of national EFs. This approach will be use in the next submission.

Figure 6.4: Methane emissions from manure management according to livestock categories in 2007.



Decreasing numbers of domestic livestock especially in categories pigs (as was mentioned above) and dairy cows also produced lower amount of nitrogen. Numbers of animals in category dairy cows start to be limited by milk quotation. Input of nitrogen from manure management in 2007 from this source was on level 1.307 Gg.

Figure 6.5: The N_2O emissions from manure management according to AWMS in 2007.



Because domestic livestock produce different kind of nitrogen inputs (liquid or dry) into the ecosystem there is important also structure of domestic livestock (ratio of different categories of domestic livestock) from the point of view of direct emissions as well as emissions from AWMS. Except for it production of nitrogen per head per year also plays some role. There is used production of nitrogen in category cattle 90 kg per head per year in this study (according to IPCC, 1996). For dairy cows of productivity higher than 4 500 l there is also published amount 100 kg N per head per year (CORINAIR, 2003).

There are also some differences in category other cattle, where for intensive animal husbandry are presented higher production of nitrogen (instead of 56 kg amount of 60 kg N pre head per year is recommended). Direct measurements of nitrogen produced by domestic livestock in the Czech Republic showed that real amounts could be much more higher than recommended values of produced nitrogen in methodologies what directly influence also N_2O emissions. The applied animal fertilizers lost the definite amount of nitrogen by volatilization and N-NOx conversion, this amount for animal fertilizers is 20%, its means that for the conversion of N to N_2O rest only 80% of total amount applied synthetic fertilizers. For category manure management (especially sows and pigs) is the most often form of management solid and liquid system for storage of excreta in the Slovak Republic. For the sheep, horses and goats is characteristic management system - the pasture range in some period of year (mean is 200 days per year). Input of nitrogen oxide from manure management in 2007 from this source was on level 1.307 Gg and the total decreasing according to the base year is about 62%.

Table 6.8: The N production (kg/head/year) for different categories of domestic livestock (IPCC, 1996).

Livestock categories		N [kg]
	Dairy cows	100
Cattle	Non dairy cows	60
	Mean	20
	Sows*	36
	Piglets up to 50 kg	15
	Young sows over 50 kg	16
Pigs	Fattening pigs	14
Sheep, Goats		16
	Mean	0,6
	Laying hens	0,8
	Broilers	0,6
Poultry	Turkeys and ducks	2
Horses		25

*N production of piglets up to 20 kg is included in category sows

Knowledge on animal housing, pasture and production of manures and slurries was found on the base of questioners in the national paper. Some additional information was based on expert decision. Duration of pasture is limited by climatic conditions. According to methodology IPCC next Animal Waste Management Systems (AWMS) were recognized for evaluation in the Slovak Republic.

- Solid storage and dry lot.
- Pasture range and paddock.

Solid storage of manure was found as the most frequent AMWS in condition of the Slovak Republic. Liquid storage of slurries is also frequently used especially in category pigs. For sheep, goats and horses is frequent housing on grasslands since April to October.

N_2O emissions from AWMS were based on analyses of housing systems on the territory of the Slovak Republic that was made by Research Institute of Animal Production in Nitra. There was supposed that sheep, goats and horses can stay on pasture 200 days a year, 40% of dairy cattle 150 days during day only 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 6.9: The perceptual share of Animal Waste Management Systems (AWMS) in the Slovak Republic.

Categories of domestic livestock		Liquid systems	Solid storage and dry lot	Pasture range and paddock
Cattle	Dairy cattle	5	75	20
	Other cattle	5	85	10
Sheep and goats		0	45	55
Pigs		80	20	0
Poultry	Laying hens	85	15	0
	Broilers	65	35	0
	Other poultry	45	15	40

There is possible to see some trends in use of animal housing and consequently animal waste management system. Ministry of Agriculture of the Slovak Republic is the second source of data on animal housing, pasture and production of manures and slurries. Values are given in table bellow and use as alternative source of data for calculation of emissions. Therefore calculations were done in two variants.

Table 6.10: The trends in use of animal housing and consequently animal waste management system.

		Manure management systems (Fraction of total annual excretion [%])						
	N excretion (kg N/animal/year)	Pasture/ Range/ Paddock	Daily spread	Solid storage	Dry lot	Liquid/ Slurry	Anaerobic lagoon	Open pits below anim.
Cattle total								
Dairy Cows	70,26	20,00		75,00		5,00		
Bulls	67,89			80,00		10,00		10,00
Heifers	54,60	30,00		70,00				
Calves	14,31			100,00				
Cattle total beef								
Dairy Cows	67,53	80,00		20,00				
Sires	78,33	80,00		20,00				
Heifers	52,05	90,00		10,00				
Calves	19,38	90,00		10,00				
Pigs total dairy								
Sows	22,71			25,00		75,00		
Fattening Hogs	8,20			20,00		80,00		
Piglets	0,67			10,00		90,00		
Poultry total								
Hens (Layers)	0,89			10,00	5,00	85,00		
Broilers	0,30			30,00	5,00	65,00		
Turkey	1,10			50,00		50,00		
Ducks	0,88	60,00		40,00				
Gooses	0,94	60,00		40,00				
Horses	72,27	30,00		70,00				
Sheep total								
Milking ewes	1,10	40,00		60,00				
Others	1,60	50,00		50,00				
Goats total				100,00				
Milking She-goats	1,60	40,00		60,00				
Others	1,40	50,00		50,00				
Rabbits	0,91			100,00				
Others								

6.3 Rise Cultivation (CRF 4.C)

No emissions from rise cultivation were estimated in this category.

6.4 Agricultural Soils (CRF 4.D)

The emission factors for calculation of direct N_2O emissions from agriculture sector, emissions from AWMS and indirect emissions from leaching were used.

Table 6.11: The EFs for the calculation of N_2O emissions from agriculture (IPCC, 1996).

EF_1	**Direct emissions - cultivated soils**	0.0125 (0.0025–0.0225) kg N_2O - N/kg
	AWMS - liquid storage	0.001 (0.001) kg N_2O - N/kg
	AWMS - dry storage	0.02 (0.005–0.03) kg N_2O - N/kg
EF_3	**AWMS - pasture**	0.02 (0.005–0.03) kg N_2O - N/kg
EF_4	**Indirect emissions – atmospheric deposition**	0.01(0.002–0.02) kg N_2O-per kg emitted NH_3 and NO_X
EF_5	**Indirect emissions - leaching**	0.025 (0.002–0.12) kg N_2O - per kg of leaching N

6.4.1 Direct N_2O Emissions from Cultivated Soils (CRF 4.D.1)

The N_2O emissions from cultivated soils are of natural origin from microbial processes – nitrification and denitrification. The direct N_2O emissions from cultivated soils in sense of IPCC Methodology (IPCC, 1996) depend on nitrogen inputs: synthetic fertilizers, animal excreta, crop residuals, cultivation of histosols and N-symbiotic fixation of leguminous (Bouwman, 1990).

A consumption of synthetic fertilizers decreased during last decade of 20th century, from 200.0 Gg in 1990 to 80.1 Gg in 2007. The synthetic fertilizers in year 2007 were applied on 60.7% of area of arable soils and only on 62.3% of sowing area of cereals. Especially sugar beet and fodder crops were short of nutrient during last decade of years in condition of the Slovak agriculture. Despite these facts consumption of synthetic fertilizers increased in 2004 and 2005 by about 10–12% during last year as compare with year 2000. Because of decreasing numbers of domestic livestock in some categories (producing still less nitrogen in wastes), this trend in consumption of nitrogen fertilizers should continue if the present level of yields of field crops is accepted (Green Report, 2007).

Table 6.12: Total inputs of N (thousands of t) from mineral fertilizers applied in agriculture during years 1990–2007.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N-inputs (kt)	222,26	146,34	90,19	64,85	68,67	69,59	74,46	88,02	81,84	65,39	72,65	76,03	88,26	81,30	79,91	81,32	78,68	88,94
Fertilisers (kt)	200,03	131,71	81,17	58,37	61,80	62,63	67,02	79,22	73,66	58,85	65,39	73,21	79,43	73,17	71,92	73,19	70,81	80,04
Emissions N_2O (Gg)	3,929	2,587	1,594	1,146	1,214	1,230	1,316	1,556	1,447	1,156	1,284	1,438	1,560	1,437	1,413	1,438	1,391	1,572

6.4.1.1 Synthetic Fertilizers (CRF 4.D.1.1)

The applied synthetic fertilizers lost the definite amount of nitrogen by volatilization and N–NOx conversion, this amount for synthetic fertilizers is 10%, its means that for the conversion of N to N_2O rest only 90% of total amount applied synthetic fertilizers (80.04 kt / year 2007). After using the IPCC default emission factor 0.0125 kg N_2O–N / kg N the total emissions of N_2O from using the synthetic fertilizers in 2007 were 1.57 Gg (1 Gg of N).

The direct inputs of nitrogen slightly vary according to applied methodology. According to IPCC Methodology (IPCC, 1996) (Method A)[16] higher inputs of nitrogen from animal excreta are calculated – in average higher by about 5% as compared with detailed method (Method B).[17] Since 1990 there was recorded decrease of nitrogen inputs from 171.4 Gg to 80.04 Gg in year 2007 – what is representing more than half of original emissions.

6.4.1.2 Animal Manure Applied to Soil (CRF 4.D.1.2)

Methodology

Because domestic livestock produce different kind of nitrogen inputs (liquid or dry) into the ecosystem there is important also structure of domestic livestock (ratio of different categories of domestic livestock) from the point of view of direct emissions as well as emissions from AWMS. Except for it production of nitrogen per head per year also plays some role. There is used production of nitrogen in category cattle 90 kg per head per year in this study (according to IPCC, 1996). For dairy cows of productivity higher than 4 500 l there is also published amount 100 kg N per head per year (CORINAIR, 2003). There are also some differences in category other cattle, where for intensive animal husbandry are presented higher production of nitrogen (instead of 56 kg amount of 60 kg of N pre head per year is recommended). Direct measurements of nitrogen produced by domestic livestock in Czech republic showed that real amounts could be much more higher than recommended values of produced nitrogen in methodologies what directly influence also N_2O emissions.

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[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.

Based on data about management in 222 agriculture farms were performing the total analysis of manure production in the SR.

Table 6.13: Housing of animals and production of liquid and solid manures in percent (Brestensky, 1998).

Category of domestic livestock		Animal Waste Management System Production of slurries [%]	Production of manure [%]	Pasture [%]
	Dairy cows	5,00	75,00	20,00
Cattle	Non dairy cows	5,00	85,00	10,00
	Mean	76,00	24,00	0,00
	Fattening pigs	91,00	9,00	0,00
Pigs	Sows	41,60	58,40	0,00
Sheep and goats		4,00	41,00	55,00
	Mean	55,40	44,60	0,00
	Laying hens	2,20	97,80	0,00
	Broilers	98,20	1,80	0,00
Poultry	Turkeys and ducks	100,00	0,00	0,00
Horses		0,00	45,00	55,00

The calculated amount of nitrogen from animal waste applied on fields was 45.69 kt N (liquid and solid systems; $(1–Frac_{Fuel}+Frac_{Graz}+Frac_{Gasm})$ = 0.703) and the total amount of N_2O emissions from animal excreta in 2007 were 0.832 Gg (0.529 Gg of N).

6.4.1.3 N-Fixing Crops (CRF 4.D.1.3)

Nitrogen inputs from symbiotic fixation are of local importance and depend on acreage of leguminous plants. Total input of nitrogen into cultivated soils drastically decreased in the first half of 90´ (from 760.0 Gg in 1990 to 500.0 Gg in 1995). During last years inputs of nitrogen into soils was stabilized on level 430.0 Gg per year.

Methodology

For the conditions of the SR are the nitrogen inputs from symbiotic fixation in the range 20–30 kg/ha (Bielek 1998), but is enough reasons to accept an experimental value 26 kg N/ha. The details for estimation total input of nitrogen from N-fixing residual were recalculated according the data obtained from direct measurement (Jurcova, 2000) in the conditions of the SR and recalculated to the growing areas of N-fixing crops and average harvest.

The total growing areas of N-fixing crops (peas, lens, beans, mix of fodder beans and cereals, soybeans, alfalfa, clover) in 2006 were 99 136 ha and the direct inputs of nitrogen from N-fixing crops were 22 711 t of N per year 2007. The crops residuals from previous year were base for calculation of N_2O emissions from N-fixing crops (according the used methodology). The used emission factor 0.0125 kg N_2O-N / kg N is according the IPCC methodology and gives the total N_2O emissions from N-fixing crops in 2007 – 0.446 Gg (0.284 Gg of N) including biologic fixation.

Table 6.14: The growing areas and total nitrogen amount of N-fixing crops in the SR.

Crop		1990	2002	2003	2004 [ha]	2005	2006	Average nutrient potential [N kg/ha]	2005	2006 N [t]	2007
	peas	28 446	4 899	5 385	6 134	5 185	9 207	112.0	39 931	8 607	15 284
	lens	2 579	942	1 383	975	676	428,32	163.0	6 822	1 637	1 037
	beans	2 272	720	743	676	678	672,49	192.0	4 735	2 008	1 991
	mix of fodder beans and cereals	9 571	2 527	3 000	2 200	0	20535,81	134.0	24 068	0	0
	soybeans	5 474	10 983	8 510	10 898	12 036	7 910	132.0	37 490	50 432	33 142
N-fixing crops	alfalfa	110 002	61 532	60 967	60 324	53 889	52 786	126.0	422 266	130 413	127 741
	clover	35 068	10 425	8 383	9 371	8 571	7 596	123.5	56 224	16 885	14 965

Biologic fixation from 78 600 ha of N–fixing crops were 3 430 t N per year 2007. The used emission factor 0.0125 kg N_2O–N / kg N is according the IPCC methodology and gives the total N_2O emissions from biologic fixation in 2007 – 0.051 Gg (0.032 Gg of N). The total N_2O emissions from N–fixing crops (residuals + biologic fixation) in 2007 were 0.446 Gg. Except for total nitrogen inputs into soils there are also found changes of importance of nitrogen sources. While the consumption of synthetic fertilizers as well as input of nitrogen from animal husbandry decreased crop residuals created relatively stable input of nitrogen (approximately 180.0 Gg). This fact document abnormal intake of nutrients from soils what can influence their fertility during next years. The 1.25% of nitrogen from inputs defined above in sense of applied methodology creates direct N_2O emissions and so trends reflect their sources.

6.4.1.4 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.

During 1986–1997 the crop and root residuals were observed from 29 crop species on three to seven different soil-climate sites in the Slovak Republic (partly on the small parcels production and partly the large scale production. The sampling was provided according the plant specification (numbers of plants per hectare). The crop residuals were abstracted from the same field as root residuals directly after root take off. Crop residuals as well as symbiotic fixation depend according to applied methodology in this study on acreage of field crops and leguminous. Nitrogen input from crop residuals varies about value 180 000 t per year. Nitrogen in crop residuals according to categories of different crops was established on the base of results of field trial of Research Institute of Plant production (Jurcova, 2000). The details for estimation total input of nitrogen from residual crops are depicted in *Chyba! Nenašiel sa žiaden zdroj odkazov.* and were calculated according the growing areas of crops and vegetable.

The collection of experimental results and samplings were evaluated by statistical method using the polynomial regression.

Methodology

The total growing area of crops (wheat, ray, barley, oat, maize, potato, sugar beet, oil plants, tobacco, vegetable, fodder crops, grassland and other) in 2006 were 1 139 880 ha and the direct inputs of nitrogen from crop residuals were 68 149 t per year 2007. The crops residuals from previous year were base for calculation of N_2O emissions (according the used methodology). The used emission factor 0.0125 kg N_2O-N / kg N is according the IPCC methodology (IPCC, 1996) and gives the total N_2O emissions from crops residuals in 2007 – 1.339 Gg (0.852 Gg of N).

Table 6.15: The growing areas and total nitrogen amount of crops and leguminous in the SR.

Crop		1990	2002	2003	2004	2005	2006	Average nutrient potential	2005	2006	2007
				[ha]				[N kg/ha]		N [t]	
Cereals	Wheat	418 158	405 800	306 900	367 800	349 105	360 786	53	19 493	15 835	16 365
	Ray	46 335	38 000	25 200	32 500	28 717	36 408	45	1 463	793	1 005
	Barley	190 634	194 700	269 300	222 000	184 519	210 697	45	9 990	6 666	7 612
	Oat	13 015	20 500	30 400	24 500	19 530	22 219	55	1 348	762	867
	Maize	150 731	140 400	146 000	147 800	151 006	157 559	39	5 764	7 146	7 456
Potato		55 245	26 100	25 700	24 200	18 384	18 186	59	1 428	1 252	1 238
Sugar beet		51 288	30 900	32 000	35 500	27 719	18 869	20	710	468	318
Oil plants		70 906	201 600	208 900	196 700	250 397	233 620	107	21 047	27 544	25 698
Tobacco		3 019	1 234	1 234	957	920	656	45	43	61	44
Fodder crops		9 718	0	0	2 000	1 664	1 474	20	40	40	25
Maize for silage		179 888	96 787	98 973	95 900	84 495	79 405	55	5 275	5 524	5 191

According the actual results the content of mineral component in the crop residuals fluctuates mostly in dependence of genetic plant attributes and the level of agro technique, primary fertilizing. From the research results assumed, that the content of nitrogen can differ in the residuals by the same crop, content of nitrogen is higher in roots. Nitrogen content is fluctuated and is highest in the N-fixing crops. This is in accordance also with other authors.

The second factor besides nutrient content in plant is the weight of crop residuals and root residuals and this influence the nitrogen in soils, too. This is depending on the crop specification and harvesting practice. Statistically we can specify the potential content of nitrogen in kg per hectare in residuals. Besides the observation this potential we have studied the collection of 29 crops and the most common harvesting practices. Table 6.16 shows the statistical average of potential values of nitrogen inputs for the observed crops. Average nitrogen potential ranges between 19–298 kg per hectare.

Values in yellow fields were used for calculation in excel files directly. Stems and leaves are usually utilized as a fodder for domestic livestock. Missing are data on export of straw abroad. Except for it those values for grasslands, alfalfa, horse been, maize for silage and clover include also a green part of crops (leaves and stems) utilized for animal feeding (in green fields). Therefore crop residuals are defined only as a part of plants – short stems and roots standing on the field – values in yellow area. According to Statistical Yearbook and Green Report of the Slovak Republic it is not possible to split fodder crops and grasslands into year subcategories.

Coefficients for the nutrient estimations and the model for the nutrient input into the soils from crop residuals have a high importance in nutrient balance and agricultural practice by sowing, cultivation and harvesting of effective plant production in agriculture.

The first and second papers (Jurčová, Torma) estimated nitrogen amount applied into soils on the base of higher input of nitrogen fertilizers (both from synthetic and organic fertilizers) into agricultural soils. The analyses were based on results from field trials during years 1986–1997. Those inputs of nitrogen from crop residuals correspondent to common practice in Slovak agriculture.

The third source (Kováčik) used also experimental data from more recent field trials with respect to good practice rules in agriculture.

We decided to calculate nitrogen inputs from crop residual according to acreage of field crops for several reasons:

- We prefer use of national data from direct measurements instead of some default values;
- According to IPCC methodology the basic information on nitrogen input into soil from crop residuals are 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 and so not included into official statistics on crop yields. Anyway they are source of nitrogen in soils. If there is only crop yield taking into account they are not included into calculation of N_2O emissions. Therefore the acreage of field crops and national data about nitrogen content in crop residuals looks as more representative data for calculation procedure. Importance of crops is changing. Still more and more agricultural land is not utilized. Acreage of oil seed rape and sunflower increase, sugar beet, potato and fodder crops (alfalfa, clover, leguminous plants) decrease;
- Regional differences.

Table 6.16: Nutrition potential in crop residuals in kg of nitrogen per hectare.

Crops	kg N per hectare	Notice
Horse been	298	including stems and leaves
Chicken pea	201	including stems and leaves
Beans	192	including stems and leaves
Oil seed rape - spring form	166	including stems and leaves
Lens	163	including stems and leaves
Clover in mix in 2nd year	153	
Grasslands in 4th year	136	
Alfalafa in 4th year	133	
Soybeen	132	including stems and leaves
Corn	127	including stems and leaves
Alfalafa+grass in 3rd year	127	
Clover in 3rd year	127	
Alfalafa in 3rd year	126	
Grasslands in 3rd year	123	
Alfalafa+grass in 2nd year	122	
Alfalafa in 2nd year	120	
Clover in 2nd year	120	
Popper	115	including stems and leaves
Grasslands in 2nd year	113	
Peas	112	including stems and leaves
Sunflower	108	including stems and leaves
Oil seed rape - winter form	107	including stems and leaves
Mustard	91	including stems and leaves
Oat	89	including stems and leaves
Spring wheat	84	including stems and leaves
Triticale	80	including stems and leaves
Winter wheat	79	including stems and leaves
Winter ray	77	including stems and leaves
Linet	67	
Winter barley	66	including stems and leaves
Spring barley	60	including stems and leaves
Potato	59	
Oat	55	
Maize for silage	55	
Triticale	54	
Winter wheat	53	
Spring wheat	52	
Peas	49	
Beans and cereals as fodder crop	46	
Tobacco	45	
Winter ray	45	
Spring barley	43	
Winter barley	45	
Corn	39	
Sugar beet	20	

Nitrogen input from symbiotic fixation of leguminous plants was calculated according to their growing areas, when value 26 kg.ha^{-1} (Vostál, cit. in Bielek, 1998) per year was used for calculation according to equation:

$F_{BN} = 26xSA_{BN}$ [kgN.year^{-1}]

Where: SA_{BN} – acreage of N-fixing crops

Calculation of crop residuals (including N-fixing crops) is based on national data on acreage of field crops and nitrogen content in crop residuals (Table 6.16) according to equation:

$F_{CR} = CR_T \times SA_T$ [kgN.year^{-1}]

Where: CR_T = nitrogen content in crop residuals in category T [kgN.ha^{-1}]

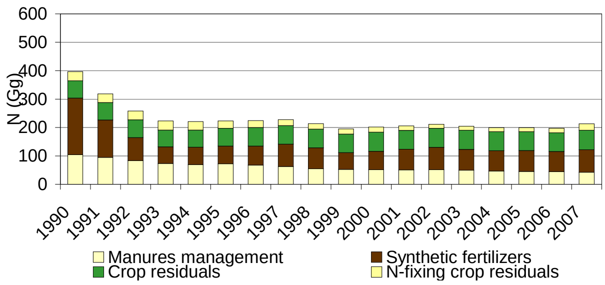
SA_T = acreage of crop in category T [ha]

The activity data on crop residuals start from 1989 because the mineralization rate. It is supposed that crop residuals from one year are mostly source of N_2O emissions in following year. Scientist did this recommendation from department of plant nutrition and agro chemistry.

We use acreage instead of yield for several reasons:

- 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 and so not included into official statistics on crop yields. Anyway they are source of nitrogen in soils. If there is only crop yield taking into account they are not included into calculation of N_2O emissions. Therefore the acreage of field crops and national data about nitrogen content in crop residuals looks as more representative data for calculation procedure,
- The differences between approaches were caused by excluding the permanent grasslands as well as soils not included into statistics. Those soils are not cultivated and fertilized and not sufficient data about nitrogen inputs and acreage are available.

Figure 6.6: The trend of direct N inputs in soils according to sources (SR 1990–2007).



6.4.1.5 Cultivation of Histosols (CRF 4.D.1.5)

No emissions from category 4.D.1.5 Cultivation of histosols were occurred in the Slovak Republic in the 2007. The total area of prevented for landscape protection histosols is 4 893 ha.

6.4.2 Pasture, Range and Paddocks Manure (CRF 4.D.2)

Total emissions of N_2O from pasture of animals in 2007 were 0.299 Gg of N_2O while the total nitrogen from excretion to the pasture was 9 530 t. The trend of pasture, range and paddocks is almost stale from 1998.

6.4.3 Indirect Emissions (CRF 4.D.3)

This part of N_2O emissions resulted from processes of atmospheric deposition of ammonia and NO_x, as well as due to transformation of nitrogen from leaching and runoff losses. The indirect emissions decreased during evaluated period too because of their dependence on direct inputs of nitrogen that decreased too.

Methodology

IPCC default methodology Tier 1 and default emissions factors were used for estimation indirect N_2O emissions from atmospheric deposition and Nitrogen leaching and run-off. The total indirect emissions in 2007 are 1.154 Gg with the reduction of 63% compared to the 1990 year.

6.4.3.1 Atmospheric Deposition (CRF 4.D.3.1)

Mean value for leaching of nitrogen vary in range 7–10 kg per 1 ha per year (7% of N-inputs) in condition of SR. Total indirect emissions of N_2O from atmospheric deposition create 0.331 Gg per year 2007

6.4.3.2 Nitrogen Leaching and Run-off (CRF 4.D.3.2)

Next nitrogen losses 5–10 (7% of N-inputs) kg per ha per year are caused by soil erosion and runoff (Bielek 1998). Totally soils loss about 14% of nitrogen input due to leaching, runoff and erosion in climatic condition of the Slovak Republic. The emissions of N_2O from nitrogen leaching and run-off are 0.823 Gg per year 2007.

6.5 Prescribed Burning of Savannas (CRF 4.E)

No emissions from prescribed burning of savannas were estimated in this category.

6.6 Field Burning of Agricultural Residues (CRF 4.F)

No emissions from prescribed burning of savannas were estimated in this category. Emissions from burning of field residuals were not defined in this study because these forms of soil cultivation are prohibited by low in the SR.

7 LULUCF (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, N_2O a CH_4) 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 Marrakech Accords. The inventory in LULUCF sector is based on the definition of representative types of land use – forest lands, croplands, grasslands, wetlands, settlements and other lands and their temporal changes. The first three land use types have the most importance due to their coverage of the Slovak territory – represent more than 90% of the whole territory. These processes connected with land use and land use change are mostly related to CO_2 balance.

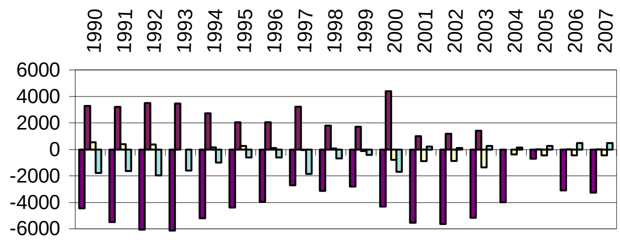
Special category in landscape is biomass burning, which represent managed processes (i. e. burning of harvesting residues) and unmanaged processes (i.e. forest fires). This category covers all three main GHGs and basic pollutants.

The total net emissions/removals of carbon dioxide represent –3 219.35 Gg due to Forest land (–3 266.30 Gg), Cropland (1.998 Gg), Grassland (–439.45 Gg) and Other land (484.40 Gg). Total amount of methane emission from LULUCF sector represents 0.906 Gg of CH_4 and total amount of N_2O was 0.0125 Gg in 2007. The emissions of other pollutant originated from forest fire and controlled burning of forest. The NOx emissions were 0.45 Gg and emissions of CO are 7.93 Gg in 2007. The total removals from the LULUCF sector fluctuated between 1990 and 2007. Emissions from categories Wetlands and Settlements were not occurring in 2007.

Table 7.1: Summary results of the total CO_2 emissions and removals according categories during 1990–2007.

Year	Total Forest land	Total Cropland	Total Grassland	Total Other land	Total LULUCF
1990	-4 453,98	3 286,66	535,88	-1 775,15	-2 406,59
1991	-5 485,31	3 210,98	396,11	-1 629,32	-3 507,55
1992	-6 056,29	3 494,78	372,79	-1 962,42	-4 151,15
1993	-6 135,02	3 456,94	NO	-1 606,08	-4 284,16
1994	-5 205,45	2 724,78	163,09	-998,92	-3 316,51
1995	-4 399,42	2 062,61	256,30	-615,49	-2 695,99
1996	-3 968,47	2 062,61	93,21	-608,98	-2 421,63
1997	-2 717,44	3 226,12	-49,68	-1 860,76	-1 401,76
1998	-3 130,06	1 797,73	69,89	-677,03	-1 939,47
1999	-2 800,33	1 710,69	-126,46	-419,83	-1 635,93
2000	-4 318,38	4 394,23	-797,35	-1 681,86	-2 403,37
2001	-5 550,63	1 002,34	-880,44	203,58	-5 225,15
2002	-5 641,22	1 174,05	-873,73	97,97	-5 242,94
2003	-5 155,57	1 416,27	-1 363,19	269,33	-4 833,16
2004	-3 995,38	-14,17	-373,27	131,93	-4 250,90
2005	-701,25	1,08	-441,65	264,48	-877,34
2006	-3 096,83	1,08	-439,45	484,40	-3 050,80
2007	-3 266,30	2,00	-439,45	484,40	-3 219,35

Figure 7.1: The total CO_2 balance in LULUCF sector in 1990–2007.



Methodology

The methodology of the GHG inventory is built up on the principles from the IPCC Revised 1996 Guidelines, Good Practice Guidance for Land Use, Land-Use Change and Forestry 2003 and Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories 2000.

Based on the previous results there are two main sources/sinks in this sector:

- Changes in living biomass – Forest lands.
- Land use conversion – changes in soil organic carbon.

According to present knowledge, about 55–90% (depending on tree species) of the total tree's biomass can be assumed stored in the stems. The density of wood (at dry weight) varies from 350 to 800 kg/m^3. Using these data and a carbon content of 49.7% for wood (other parts of trees 46.7–52.8%, mean value 50% was used). The total carbon stored in biomass of forest trees of 157.4 Tg C (1990) was estimated based on stemwood biomass data; conversion/expansion factors were estimated according to the experimental data for main forest tree species. The average stock of carbon varies from 47.9 (Poplars) to 108.8 (Beech) tons of carbon per hectare.

Table 7.1: Basic input data of area in kha used for calculations of GHG emissions from LULUCF.

Year	Forest land remaining Forest land (kha)	Cropland remaining Cropland (kha)	Grassland remaining Grassland (kha)	Other land remaining Other land (kha)
1990	1921,71	1509,00	813,00	621,85
1991	1927,89	1509,00	808,00	620,66
1992	1925,78	1486,00	810,00	643,77
1993	1928,32	1482,00	832,00	623,23
1994	1925,85	1482,00	835,00	622,70
1995	1923,51	1483,00	835,00	624,04
1996	1923,72	1475,00	842,00	624,83
1997	1919,91	1482,50	834,63	628,51
1998	1919,27	1480,00	835,00	631,29
1999	1921,95	1460,60	856,43	626,57
2000	1928,33	1450,49	865,22	621,51
2001	1927,39	1449,08	864,79	624,30
2002	1928,71	1441,00	863,50	632,34
2003	1928,83	1430,20	883,51	622,54
2004	1882,00	1417,80	792,80	637,90
2005	1880,00	1423,12	793,00	637,00
2006	1880,00	1409,70	793,00	668,60
2007	1880,00	1409,70	793,00	668,60

7.1 Forest Land (CRF 5.A)

7.1.1 Forest Land remaining Forest Land (CRF 5.A.1)

Results of calculations were obtained by using the new LULUCF methodology (IPCC GPG LULUCF 2003) and national data on area of forested land and land converted to the forest during the inventory year 2007. This category includes the stock carbon changes in all five carbon pools (living biomass – above and below ground, dead organic matter - coarse woody debris and litterfall, soil organic carbon). Activity data in the Slovak Republic are available only for estimation of stock carbon changes in living biomass. Calculations are based on the principles defined in IPCC GPG LULUCF (2003) and data from „Permanent Forest Inventory“ processed in the Slovak Republic continuously each year. Due to lack of activity data for dead organic matter (DOM is not a part of forest inventory) this part of stock carbon changes is not estimated. Inventory data for soil carbon showed no significant temporal changes in soil carbon stocks on forest land remaining forest land. Therefore the stock carbon changes in mineral soils are not estimated due to less importance in Slovak forests.

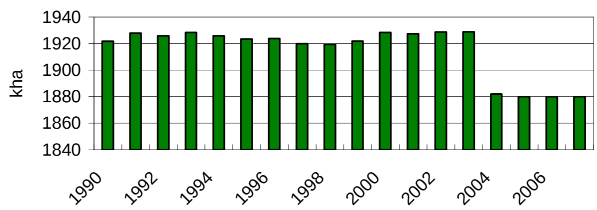
Methodology

Calculations of stock carbon 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 (IPCC GPG LULUCF 2003). The equation for estimating the annual carbon loss due to commercial felling is provided in equation 3.2.7 (IPCC GPG LULUCF 2003). Total biomass associated with the volume of the extracted roundwood is considered as an immediate emission. This is the default assumption and implies that fBL should be set to 0. This assumption should be made unless changes in dead organic matter are being explicitly accounted for, which implies use of higher tiers. The carbon loss due to fuelwood gathering is estimated using equation 3.2.8. The carbon loss due to fuelwood gathering is estimated using equation 3.2.9.

Table 7.2: The biomass conversion/expansion factors and carbon fraction for individual forest tree species in the Slovak Republic.

Tree species		Carbon fraction of dm	Biomass Conversion/Expansion Factor t dm/m^3
Picea abies	Spruce	0,50	0,60
Abies alba	Fir	0,50	0,60
Pinus sp.	Pine	0,50	0,80
Larix decidua	Larch	0,50	0,80
Other coniferous		0,50	0,60
Quecus robur, petr.	Oak	0,49	1,30
Fagus sylvatica	Beech	0,49	1,20
Carpinus betulus	Hornbeam	0,49	1,10
Acer sp.	Maple	0,49	1,10
Fraxinus excelsior	Ash	0,49	1,00
Ulmus sp.	Elm	0,49	1,00
Quercus cerris	Pubescent oak	0,49	1,30
Robinia pseudoac.	Robinia	0,49	1,20
Betulus sp.	Birch	0,49	0,80
Alnus sp.	Alder	0,49	0,90
Tilia sp.	Linden	0,49	0,80
Breeding poplars		0,49	0,60
Populus sp.	Poplar	0,49	0,60
Salix sp.	Willow	0,49	1,00
Other broadleaves		0,49	1,10

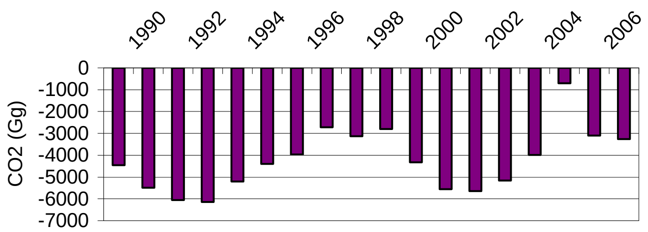
Figure 7.2: The activity data in kha for category 5.A.1 Forest land remaining Forest land per estimated time series 1990–2007.



The total area of Forest land remaining the forest land category in 2007 remains 1 880 kha, the changes in the forest land were following Grassland converted to forest land 23.9 kha and Other land converted to the forest land 29.00 kha per 2007. Total forest area in 2007 was 1 932.9 kha, with the net carbon stock change into the soil per area 74.13 kg C/ha. The annual tree biomass increment per hectare (resulting from application of annual wood volume increment data and biomass conversion/expansion factor) varies from 1.3 to 5.7 t dm/ha. The total annual carbon increment in tree biomass is 4 201.18 kt C. The total annual carbon consumption from forest harvest in the Slovak forests is 747.53 kt C.

The carbon stock change in soil from the forest land per 2007 is –3 266.3 Gg of CO_2. It is necessary to mentioned that almost every forest on the area of the SR are managed, it means that total annually uptake on woody areas for last 100 years and the harvest from deforestation are included in this category. Uptake of carbon into the biomass of forest trees is slightly increased from 1990 despite release of carbon in this category is highly fluctuated and is determining factor of final balance different. The category of fuel wood is connected to the energy sector (fuel combustion) where other gases are balanced. Total decreasing of the removals from the managed forest land in the SR comparable to the 1990 is more than 10%.

Figure 7.3: The summary results of CO_2 removals from 5.A.1 category.



7.1.2 Land converted to Forest Land (CRF 5.A.2)

This category includes all process connecting with conversion of lands into forest land. Due to lack of the activity data only stock carbon 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. The part of stock carbon changes in living biomass is included in category 5.A.1 due to sharing of the new establish forests by permanent forest inventory.

Table 7.3: Calculations of stock carbon changes in mineral soils as a result of land conversion.

Soil type	Soil Carbon (t C/ha) Land use category			
	Forest Land	Grassland	Cropland	Other Land*
Regosol	8	7	6	5
Ranker	27	22	19	16
Rendzina	130	104	91	78
Chernozem	180	144	126	108
Fluvi-gleyic phaozem	180	144	126	108
Orthic Luvisol	200	161	141	121
Luvisol	100	80	70	60
Cambisol	200	160	140	120
Podzol	53	42	37	32
Albo-gleyic Luvisol	57	45	40	34
Fluvisol	41	32	28	24

*includes wetland and settlements categories

Table 7.4: The land use matrix from 1987 to 2007.

	kha	Initial				2007
	Final	Forests	Grasslands	Croplands	Other	Final area
	Forests	1 880,00	23,90	0,00	29,00	1 932,90
	Grasslands	0,00	793,00	73,50	26,70	881,50
	Croplands	0,00	0,00	1 409,70	0,00	1 408,70
	Other	35,00	7,00	46,80	668,60	680,40
1987	Initial area	1 916,00	822,00	1 526,00	639,60	4 903,60
	Net change	16,90	59,50	-117,30	40,80	0,00

Table 7.5: The results from the category 5.A.2 Land converted to forest land.

Forests	FF	GF	CF	OF	Total
kha	1 880,00	23,90	0,00	29,00	1 932,90
GgC	312 203,68	43,55	0,00	99,73	143,30

Uncertainties and time consistency

According to the expert estimation and based on statistical approach for estimation of wood stocks in the Slovak forest is 20% in the category 5.A.

QA/QC and verification

The completeness of inventory is determined by several factors, especially by importance of the processes and data availability. Forest and research institute in Zvolen namely Dr. J. Minďáš (external expert for SHMÚ) took responsibility for the inventory emission balance from LULUCF.

Table 7.6: The source of activity data, methodology, uncertainty, references and planned improvements.

Input activity data	Area of forest land remaining forest land, by forest tree species	Permanent forest inventory (National Forest Centre)
	Average annual increment rate in total biomass by forest tree species	Permanent forest inventory (National Forest Centre)
	Carbon fraction of dry matter	Pozgaj et al. 1993
	Biomassconversion/ expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment	Pozgaj et al. 1993, Sebik, L. 1989
	Annual loss due to commercial fellings, fuelwood, and other losses of biomass	
		Permanent forest inventory (National Forest Centre)
Uncertainty estimates	20%	Based on the statistical approach for estimation wood stocks in Slovak forests
Changes in methods	2003	New GPG LULUCF. All inventory years have been recalculated.
Problems	All five carbon pools are not included due to lack of the data. Current process of the „new national forest inventory" will improve the availability of the input data.	

Recalculations

No recalculations in forest land category 5.A were provided for the previous inventory year or base year.

Planned improvements

Several improvements are planned for this category for the next submission according to the information from the "new national forest inventory" in the availability of activity data and with the context of the including National Forest Centrum institution into the National Inventory System of the Slovak Republic.

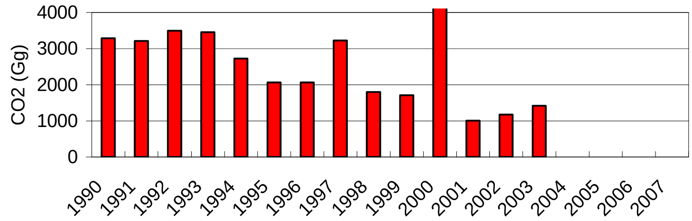
7.2 Cropland (CRF 5.B)

Results of recalculations were obtained by using the new LULUCF methodology (IPCC, 2003) and national data on area of cropland and land converted to the cropland during the inventory year 2007. The total area of cropland remaining cropland in 2007 was 1 409.7 kha.

Figure 7.4: The development of activity data in kha for category 5.B Cropland in 1990–2007.

The carbon stock change in soil from the cropland per 2007 is 4.89 Gg of C. The total quantity of removed CO_2 in this category is 1.998 Gg CO_2. Total decreasing of the removals from the cropland in the SR comparable to the 1990 is more than 100% caused by shifted from the positive emissions to the removals in 2007.

Figure 7.5: The CO_2 balance for category 5.B Cropland during 1990–2007.



7.2.1 Cropland remaining Cropland (CRF 5.B.1)

Due to lack of the data this category is not included into inventory process.

7.2.2 Land converted to Cropland (CRF 5.B.2)

This category includes all process connecting with conversion of lands into croplands. Due to lack of the activity data only stock carbon 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.

Calculations of stock carbon changes in mineral soils as a result of land conversion carried out as follows IPCC GPG LULUCF 2003.

Table 7.7: The results from the category 5.B.2 Land converted to cropland.

Croplands	CC	FC	GC	OC	Total
kha	1 409,70	0,00	0,00	0,00	1 409,70
GgC	153 451,33	0,00	0,00	0,00	0,00

Uncertainties and time consistency

According to the expert estimation and based on statistical approach for estimation of wood stocks in the Slovak forest is 50% in the category 5.B.

QA/QC and verification

The completeness of inventory is determined by several factors, especially by importance of the processes and data availability. Forest and research institute in Zvolen namely Dr. J. Minďáš (external expert for SHMÚ) took responsibility for the inventory emission balance from LULUCF.

Table 7.8: The source of activity data, methodology, uncertainty, references and planned improvements.

Input data	Soil organic carbon stocks for individual land categories	Partial monitoring system – „Soil“ (Soil science and Conservation Research Institute Bratislava)
	Time period for conversion	T=20 years (default value)
	Land area of each soil types per land categories	Soil map of Slovakia, Land Corine map of Slovakia
Uncertainty estimates	50%	Based on the expert judgement.
Changes in methods	2003	New GPG LULUCF. All inventory years have been recalculated.
Problems	All five carbon pools are not included due to lack of the data. Current process of the „new national forest inventory“ will improve the availability of the input data.	

Recalculations

No recalculations in forest land category 5.B were provided for the previous inventory year or base year.

Planned improvements

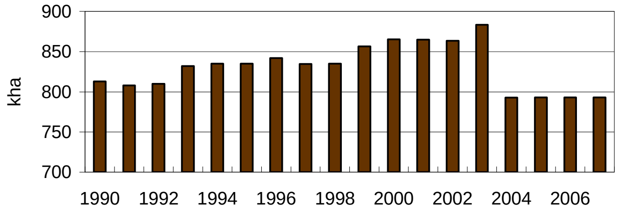
The improvements are planned for this category for the next submission according to the information from the “new national forest inventory” in the availability of activity data and with the context of the including National Forest Centrum institution into the National Inventory System of the Slovak Republic.

7.3 Grassland (CRF 5.C)

Results of recalculations were obtained by using the new LULUCF methodology (IPCC, 2003) and national data on area of grassland and land converted to the grassland during the inventory year 2007.

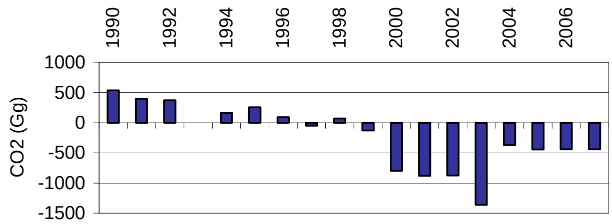
The total area of grassland remaining grassland in 2007 was 793 kha, the changes in the grassland were following cropland converted to the grassland 73.5 kha per 2007 and other land converted to the grassland 26.7 kha per 2007. Total grassland in 2007 was 893.2 kha, with the net carbon stock change into the soil per area 134.18 kg C/ha.

Figure 7.6: The development of activity data in kha for category 5.C Grassland in 1990–2007.



The carbon stock change in soil from the Grassland per 2007 is 119.85 Gg of C. The total quantity of removed CO_2 in this subcategory is –439.45 Gg CO_2. Total decreasing of the removals from the cropland in the SR comparable to the 1990 is more than 100% caused by shifted from the positive emissions to the removals in 2007.

Figure 7.7: The CO_2 balance for category 5.C Grassland during 1990–2007.



7.3.1 Grassland remaining Grassland (CRF 5.C.1)

Due to lack of the data this category is not included into inventory process.

7.3.2 Land converted to Grassland (CRF 5.C.2)

This category includes all process connecting with conversion of lands into grasslands. Due to lack of the activity data only stock carbon 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.

Calculations of stock carbon changes in mineral soils as a result of land conversion carried out as follows IPCC GPG LULUCF 2003.

Table 7.9: The results from the category 5.C.2 Land converted to grassland.

Grasslands	GG	FG	CG	OG	Total
kha	793,00	0,00	73,50	26,70	893,20
GgC	102 839,15	0,00	76,55	43,30	119,80

Uncertainties and time consistency

According to the expert estimation and based on statistical approach for estimation of wood stocks in the Slovak forest is 50% in the category 5.C.

QA/QC and verification

The completeness of inventory is determined by several factors, especially by importance of the processes and data availability. Forest and research institute in Zvolen namely Dr. J. Minďáš (external expert for SHMÚ) took responsibility for the inventory emission balance from LULUCF.

Table 7.10: The source of activity data, methodology, uncertainty, references and planned improvements.

Input data	Soil organic carbon stocks for individual land categories	Partial monitoring system – Soil (Soil science and Conservation Research Institute)
	Time period for conversion	T=20 years (default value)
	Land area of each soil types per land categories	Soil map of Slovakia, Land Corine map of Slovakia
Uncertainty estimates	50%	Based on the expert judgement.
Changes in methods	2003	New GPG LULUCF. All inventory years have been recalculated.
Problems	All five carbon pools are not included due to lack of the data. Current process of the „new national forest inventory“ will improve the availability of the input data.	

Recalculations

No recalculations in forest land category 5.C were provided for the previous inventory year or base year.

Planned improvements

The improvements are planned for this category for the next submission according to the information from the “new national forest inventory” in the availability of activity data and with the context of the including National Forest Centrum institution into the National Inventory System of the Slovak Republic.

7.4 Wetlands (CRF 5.D)

This category is not important in the Slovak Republic.

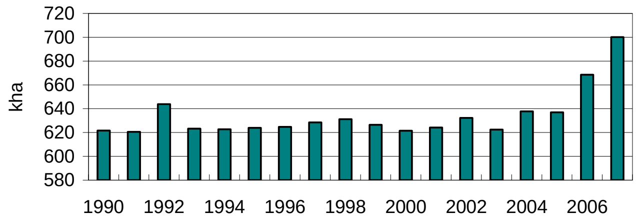
7.5 Settlements (CRF 5.E)

Due to lack of the data this category is not included into inventory process. This category is partly included into category 5.F Other land (carbon in mineral soils).

7.6 Other Land (CRF 5.F)

Results of recalculations were obtained by using the new LULUCF methodology (IPCC, 2003) and national data on area of other land and land converted to the other land during the inventory year 2007.

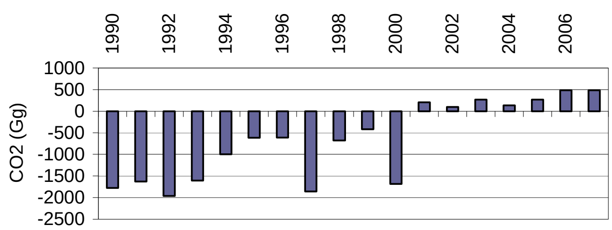
Figure 7.8: The development of activity data in kha of the category 5.F Other land in 1990–2007.



The total area of other land remaining other land in 2007 was 668.6 kha, the changes in the other land were following Forest land converted to the other land 35 kha per 2007, Cropland converted to other land 46.8 kha per 2007 and Grassland converted to other land 7 kha per 2007. Total Other land in 2007 was 757.4 kha, with the net carbon stock change into the soil per area 26.6 kg C/ha.

The carbon stock change in soil from the other land per 2007 is –158.71 Gg of C. The total quantity of removed CO_2 in this subcategory is 484.40 Gg CO_2. Total decreasing of the removals from the Other land in the SR comparable to the 1990 is more than 100% caused by shifted from the removals to the emissions in 2007.

Figure 7.9: The CO_2 balance from total Other land during 1990–2007.



7.6.1 Other Land remaining Other Land (CRF 5.F.1)

Due to lack of the data this category is not included into inventory process.

7.6.2 Land converted to Other Land (CRF 5.F.2)

This category includes all process connecting with conversion of lands into other lands. Due to lack of the activity data only stock carbon 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.

Calculations of stock carbon changes in mineral soils as a result of land conversion carried out as follows IPCC GPG LULUCF 2003.

Table 7.11: The results from the category 5.F.2 Land converted to other land.

Other	OO	FO	GO	CO	Total
kha	668,60	35,00	7,00	46,80	757,40
GgC	65 048,44	-120,37	-11,27	-27,07	-158,70

Uncertainties and time consistency

According to the expert estimation and based on statistical approach for estimation of wood stocks in the Slovak forest is 50% in the category 5.F.

QA/QC and verification

The completeness of inventory is determined by several factors, especially by importance of the processes and data availability. Forest and research institute in Zvolen namely Dr. J. Minďáš (external expert for SHMÚ) took responsibility for the inventory emission balance from LULUCF.

Table 7.12: The source of activity data, methodology, uncertainty, references and planned improvements.

Input data	Soil organic carbon stocks for individual land categories	Partial monitoring system – Soil (Soil science and Conservation Research Institute)
	Time period for conversion	T=20 years (default value)
	Land area of each soil types per land categories	Soil map of Slovakia, Land Corine map of Slovakia
Uncertainty estimates	50%	Based on the expert judgement.
Changes in methods	2003	New GPG LULUCF. All inventory years have been recalculated.
Problems	All five carbon pools are not included due to lack of the data. Current process of the „new national forest inventory" will improve the availability of the input data.	

Recalculations

No recalculations in forest land category 5.F were provided for the previous inventory year or base year.

Planned improvements

The improvements are planned for this category for the next submission according to the information from the "new national forest inventory" in the availability of activity data and with the context of the including National Forest Centrum institution into the National Inventory System of the Slovak Republic.

7.7 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. CO_2 emissions from liming can be calculated according to the equation (IPCC 1996).

Table 7.13: The emission factors used for emission estimation.

Lime	EF
Limestone $CaCO_3$	0,12
Dolomite $CaMg(CO_3)_2$	0,122

Table 7.14: The results in emission inventory for fertilizers in LULUCF in 2007.

Type of Lime	**Total Annual Amount of Lime** Mg	**Carbon Conversion Factor**	**Carbon Emissions from Liming Organic Soils** Mg C	**CO_2 Emissions** Mg
Limestone $CaCO_3$	2000	0,12	240	880
Dolomite $CaMg(CO_3)_2$	2500	0,122	305	1 118
		Total	**545**	**1 998**

Urea application is not important in the SR.

7.8 Biomass Burning (CRF 5(V))

Activity data and emissions from controlled burning and forest fires are summarized by the Statistical Office of the SR.

Table 7.15: Biomass burned in tons dm in forest fires and controlled burning of the forest in 1990–2007.

Year	Control Burning	Forest Fires
1990	82,600	4,788
1991	52,465	1,935
1992	46,963	10,560
1993	47,817	11,574
1994	49,975	1,413
1995	56,035	1,389
1996	60,239	3,497
1997	65,829	1,881
1998	65,786	0,497
1999	76,120	0,448
2000	69,257	1,412
2001	83,577	0,486
2002	82,428	0,495
2003	89,198	2,457
2004	110,172	2,070
2005	131,448	2,124
2006	123,470	1,920
2007	110,066	3,258

7.9 Controlled Burning

Table 7.16: The emission ratios for open biomass burning (GPG LULUCF 2003, Table 3A.1.15).

Compound	Emision ratios
CH_4	0,012
CO	0,060
N_2O	0,007
NOx	0,121

Total methane emissions from controlled burning in 2007 were 0.88 Gg and total emissions of N_2O in 2007 were 0.01217 Gg.

7.10 Forest Fires

Total methane emissions from forest fires in 2007 were 0.026 Gg and total emissions of N_2O in 2007 were 0.000358 Gg.

Table 7.17: The source of activity data, methodology, uncertainty, references and planned improvements.

Input data	area burnt, ha	Forest Protection Service – Forest Fire Statistics (NFC Zvolen)
		Forest Protection Service – Forest Fire Statistics (NFC Zvolen)
	mass of 'available' fuel	IPCC default value
		IPCC default value
	combustion efficiency	
	emission factor	
Uncertainty estimates	100%	Based on the expert judgement.
Changes in methods	No	
Problems	No exact data about „mass of available fuel“.	

8 WASTE (CRF 6)

The production of emission of CH_4 and N_2O are important by disposal waste and wastewater treatment. Disposal of wastes and handling of wastewater results in production of greenhouse gases emissions. An estimation of the following emissions in 2007 is presented:

- 6.A Solid Waste Disposal Sites
- 6.B Wastewater Handling
- 6.C Waste Incineration
- 6.D Other (Biological Treatment of Solid Waste)

Methodology

The IPCC Methodology (IPCC, 1996) and IPCC Good Practice Guidelines (IPCC, 2000) were used by estimation of methane emissions from waste and wastewater. The emissions of nitrous oxide from wastewater were calculated by using IPCC and ISI methodologies. As a source of input data were used the database of Centre of Waste Service and Environmental Management in Bratislava and database of wastewater on the SHMÚ. Other necessary input was obtained from publications (Statistical yearbook, 2008, Green Report, 2008).

Total emissions expressed in CO_2 equivalents from sector Waste in 2007 were 2 269.07 Gg, comparable to the previous year is slightly decrease by 5% and comparable to the base year 1990 is increase by more than 100%, because of implementation of new FOD methodology. The major share from emissions represents CH_4 by more than 96% and solid waste disposal on land with more than 79%.

Table 8.1: The overall view on emissions from waste in 2007 in the Slovak Republic.

Category	MSWD	ISWD	IWW	DWW	MSWI	ISWI	SSI	Composting
Year	Gg of CO_2 equivalents							
1990	469,77		46,27	465,54	30,93	196,60	4,34	3,54
1991	492,45		46,47	459,63	44,43	196,60	4,34	3,54
1992	507,36		41,84	457,48	44,43	196,60	4,34	3,54
1993	522,69		33,87	457,71	49,33	196,60	4,34	3,79
1994	582,75		38,17	448,90	42,78	196,60	4,34	3,36
1995	647,85		29,72	445,19	40,06	196,60	4,34	6,27
1996	710,01		27,90	446,12	39,28	196,60	4,34	5,59
1997	770,70	7,40	26,19	444,80	42,71	142,83	4,34	6,85
1998	827,40	18,61	26,82	445,13	48,85	282,21	4,34	6,73
1999	885,78	30,06	24,27	443,68	46,17	197,16	4,34	6,96
2000	892,71	14,96	24,59	439,42	55,19	196,06	4,34	6,42
2001	943,74	14,99	23,63	434,16	34,76	163,61	4,34	7,72
2002	956,34	49,20	35,59	434,26	41,38	119,75	4,34	6,96
2003	971,67	41,70	23,42	429,93	42,97	102,05	4,34	7,21
2004	981,96	46,50	23,55	426,27	48,63	78,64	4,34	7,26
2005	976,29	38,70	22,22	421,93	48,09	42,34	4,34	3,67
2006	975,66	44,20	19,20	421,85	49,87	68,40	4,34	9,13
2007	975,03	39,40	19,00	420,30	47,37	29,68	4,34	13,45

MSWD – municipal solid waste disposal, ISWD – industrial solid waste disposal, IWW – industrial wastewater, DWW – domestic wastewater, MSWI – municipal solid waste incineration, ISWI – industrial solid waste incineration, SSI – sewage sludge incineration.

This overview shows that the key category of the waste sector categories is disposal of solid waste to the SWDS, emitting in total 85.83 Gg CH_4/y (or 1 802 Gg CO_2eq/year). The total emissions from the Waste sector activities are estimated to 2 269.07 Gg CO_2eq/y.

Uncertainties and time consistency

More complex method for estimating methane emissions from 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 presented in IPCC manuals form the base for first order decay (FOD) method kinetics and are quoted from the Revised 1996 IPCC Guidelines. IPCC Good Practice Guidance and Uncertainty Management in National

Greenhouse Gas Inventories provide further details on the FOD method, mainly in defining FOD model parameters in terms familiar to users of the default method Tier 1.

This approach can be used to model landfill gas generation rate curves for 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 of methane emissions from landfill. Database of Centre of Waste Service and Environmental Management in Bratislava have been used as a source of input data GHG emissions from the waste sector are the key source and concerning to the actual emission factors (EF) there are estimated with the high uncertainty level.

For better estimation of emissions it is considerable to follow the IPCC Guidelines and develop the country specific methodology for the waste sector. From government engagement it is important to test the preparedness of the Slovak Republic to prepare methane emissions estimation according to the method - Tier 2. There are three main challenges in the application of the Tier 2 method in the Slovak Republic:

- Selection of an appropriate FOD method - Tier 2.
- Preparation of activity data needed as input for the FOD method.
- Reflection of waste management practice changes in the period 1960–2007.

Emissions of methane from landfill were estimated with methodology First Order Decay (FOD) method Tier 2 according advises of the expert review team of UNFCCC secretariat and European Commi-ssion. All time series were recalculated until 1960 and the complete methodology approach was changed.

Three recommended versions of FOD method were considered for the use as Tier 2 method for estimation of methane emissions from SWDS in the SR. Comparing the situation abroad with the situation in country, several differences can be identified:

- Most countries are using 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 emissions estimations. This approach is not yet possible in the SR, because collected data on municipal solid waste (MSW) do not include the needed characterization of SWDS.
- Historical data on MSW management and disposal are more detailed that data available in the Slovak Republic.
- Data on MSW fractions are collected in more systematic and regular way that is the practice in the Slovak Republic.

As the most appropriate approach was selected the second version of FOD method, as it is defined in the IPCC 2000 GPG. 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 Slovak Republic in the period 1992–2000. Structure of required input data better corresponds with MSW data available for the Slovak Republic (data for the use of multiphase method are not available). The uncertainty of estimation of CH_4 emissions is mainly caused by 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 emission uncertainty of landfill by using the more sophisticated Tier 2 - Monte Carlo method is for these reasons evaluated. In the 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 accepting and it help us to include uncertainty to the final assumption. To know the final margin of uncertainty of observed processes is necessary to estimate the eventual fluctuation of analyzed variable which entered to the examined processes interdependency. With using a classical statistical approach it can be difficult in some cases obtain reasonable final information about consequential uncertainty of investigated processes.

One method, which allows us to implement 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 behaviour of the investigated system. It can be advantages 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 as are 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 greenhouses gases. The advantage of this method is asymmetry allowance to the statistical distribution (Tier 1 method do 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 suppose next assumptions: the number of emission and uptake terms are 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 the 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 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 limitation an approximate results with Tier 1 method could be obtained in the cases, which are exceed mentioned circumstances. Unlike to 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 then 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 side, Tier 1 method could be unique starting point to obtain solid results in the absence of quality input data (high variance of examined processes, etc.). The ideal information of estimating 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 base in measurement or in empirical source of data or in data which are assed 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 was chosen second variant of FOD method and in addition 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 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 visible that the total emissions are dependent to the many factors, which vary from year to year.

Table 8.2: The uncertainty and means value estimation, IPCC default values for parameters used in FOD model.

Parameter	IPCC mean value	IPCC confidence interval value	
Qt(x,t)			Methane generated in the year t (Gg/yr) from waste layer storage in the year x
QT			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
L0(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)
DOCF(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
R(x)	Uncertainty is likely to be relatively small compared to other Uncertainties		Recovered methane in the inventory year t (Gg/yr)
OX(x)	If a value other than Zero has been used for OX itself		Oxidation factor (fraction)

Probability distribution functions and their basic characteristics, mean value and 95% confidence interval expressed with two percentage values relative to the mean value. In the Table 8.2 some parameters value should be explained. The parameter 'F' is split to the variables with different confidence interval in years before 1994 and after 1994. Analogical are defined parameters 'MCF'. Difference from previous case is that the mean value is changed too. For this reason it should resolve data until 1993 and among the years 1994 to 2001. In the interval 1994 to 2001 the mean value is linearly interpolated among the values from data before 1994 and data after 2001. Variability is adequate modified. Special explanation required parameter ’MSWL’, which is a product of multiplication of ’MSWT’ and ’MSWF’. In this case we exploit possibility to easy transform the standard normal distribution to the normal distribution. Parameter ’MSWL’ is varied during analyzed period 1960–2007 significantly, the mean value and 95% confidence interval is 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. ’DOCx’ value is linearly changed from value 0.06 in 1960 to value 0.12 in 1990. After year 1990 this parameter has constant value. For the parameter ’OX’, the values from Table 8.2 are valid only in the period 1994 to 2005. Behind this time the zero value is assumed. The country specific value for mean values and confidence interval in the Table 8.3 were estimated by sector expert for waste.

Table 8.3: The uncertainty and mean value estimation, which are used in the SR.

Category	Mean value	Confidence int.	Distribution function
k	0,065	-45%:230%	empirical
F(x) (until 1994)	0,5	-20%:20%	normal
F(x) (after 1994)	0,5	-2.0%:20%	empirical
MSWL			stand. normal
DOCF	0,6	-30%:28%	triangular
DOC(x)	0,12	-50%:20%	empirical
MCF (until 1994)	1	-30%:4%	empirical
MCF (after 2001)	0,6	-50%:60%	triangular
OX	0,05	-95%:100%	triangular

Tier 1 approach is under method limits and its result should interpret carefully. The formulas are not simple, contain time dependence and nonlinear feature are important and standard deviation of some input parameters are greater than 30% of mean value. In this case the rules of uncertainty computation with Tier 1 can serve only informative results.

Methodology

In text above the probability function for model parameters were presented. In the case when obtained data are used for developing distributions, it is important to determine if the data are a random, representative sample, in the case of a sample from a population. To obtain the 95% confidence limits some additional information about the data set is needed. Using properties of PDF or cumulative distribution function (CDF) allow us to obtain additional information about percentiles and data properties. With these knowledge it can be analyzed the propagation of uncertainties and it can be determined the values for confidence interval.

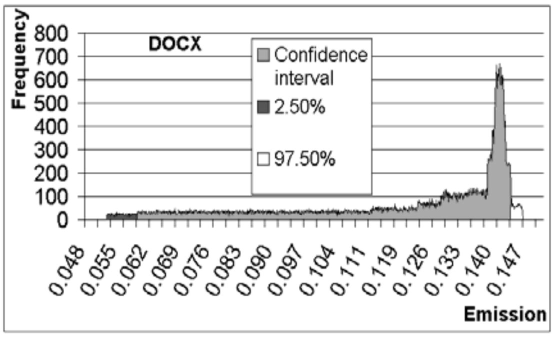
In some cases an empirical distribution are constructed, which supply analytical properties of PDF or CDF. In the literature there are many references, which prefer to use analytical distribution instead empirical distribution. They say that empirical probability distributions are unwieldy and they offer replace the empirical distribution with an analytical function, either with CDF or with PDF. In the text bellow 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.

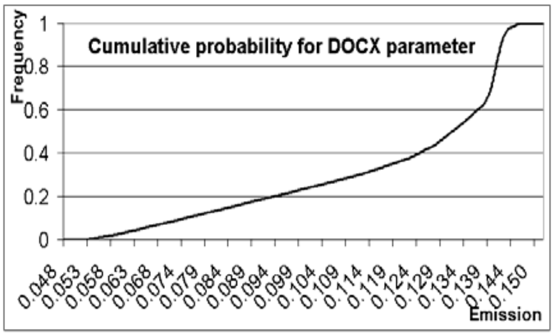
For these reasons it can be seen in the literature some recommendations how to construct PDF or CDF. These recommendations start to be important especially when there are some degrees of freedom for constructing of PDF, usually it became when expert recommendation are important and no sufficient amount of 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 the all recommendations above, how to construct the PDF, the empirical distribution is constructed in the following way. There are requirements which should be strictly observed. On the first, monotonous property before and after one global maximum on the examined interval are 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 modified the shape of probability function. The number of tuned parameter is dependent to the number of subintervals (relate to points density where function values are computed).

Figures 8.1: The empirical behaviour of DOC(x) parameter.





On the left, probability density function is generated by empirical function, on the right cumulative probability function for DOCX parameter is presented. Mean value is 0.120, confidence interval -50%:20% relative to the mean value (0.060:0.144).

In this case to respect the previous recommendations how to construct the PDF it should be effective to take this data sample and construct with some methods, for example with statistical parameters estimation methods, Method of Matching Moment (MoMM) and Maximum Likelihood Estimation (MLE) desired analytical distributions. Our experience suggestion is in the special cases (high skewness) to keep empirical form of data, because continuous analytical form which approximate our empirical distribution can change the desired statistical criteria significantly (confidence interval or average is differ from initial conditions).

In the case where expert determine 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 it should be investigates influence to the total uncertainty. To prevent manipulation with input values, which represent confidence interval or mean value, it could be preferable as was explained above to use empirical PDF. This approach will absolutely satisfy expert requirements.

With these knowledge, the PDF from entered parameters were constructed and consecutive there are 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 was shown, interactions of PDF's are not simple.

The final statistic is available for total methane emission for chosen year's period (1960–2005). The result is for 60 000 trials. A number of trials have influence to the result precision. For all inventory years is added to more specify results.

Figure 8.2: On the left, variation of the median, the average, the standard deviation and 95% confidence interval are expressed by the values during the period 1960–2005, on the right frequency distribution function for waste for year 2005.

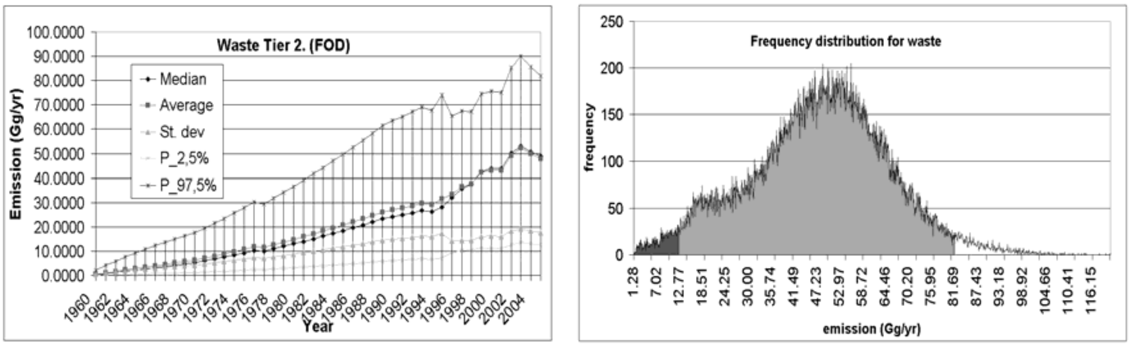
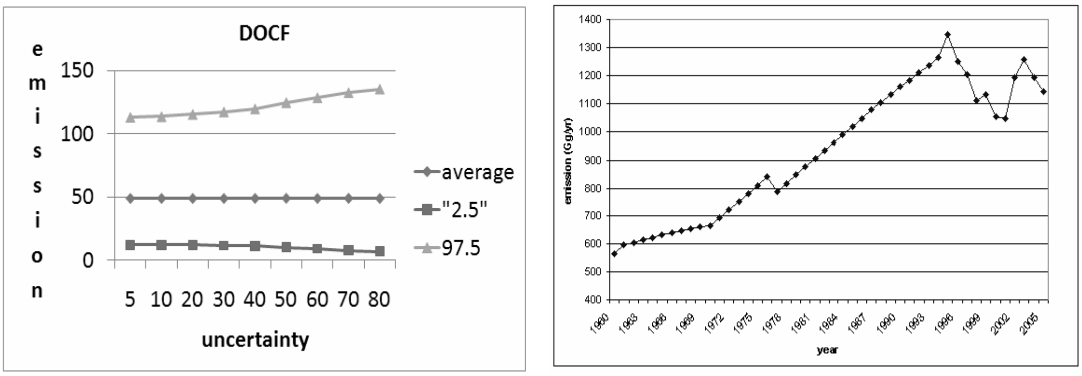


Figure 8.3: On the left, DOCF parameter sensitivity to the normal PDF uncertainty variation, on the right, municipal solid waste landfill (MSWL) mean value variation during the period 1960–2005.



Results

From our analyses seems that uncertainty of emissions are strongly dependent to 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 with changing PDF's setting. The data accuracy play important role to the computation of the total uncertainty. PDFs selection in the case of symmetry uncertainty only can increase the total uncertainty. Increasing of partial uncertainties for input factors, 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 to the total emissions than other parameters. This result was obtained with normal PDF setting for all parameters and with change of uncertainty level from ±50% to ±10% for given parameter. Other parameters show similar dependence to the uncertainty of total emission. This approach shows that more important feature which has strongest influence to the total uncertainty is asymmetry allowance. The result from our study is fact that total uncertainty was increased comparable to IPCC default recommended value to value about ±70% for the year 2005. Default value is 50% for total methane emissions from SWDS. This uncertainty grows is not the failure of Tier 2 against Tier 1. On the text above the applicability of Tier 1 method was discussed. On the contrary Tier 2 provide deeper analyze and describe more precisely reality. 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. From our analyze results methane emissions from MSWDs are important key category. Specification and identification of the key sources are important for economy and government institutions to obtain overview of emissions important categories. During the uncertainty computation, the emitting of CH_4 from underlayer and many other factors as meteorological conditions, managing of sites and policies and measures are included. These dependences are expressed in FOD model, which was solved by Monte Carlo simulation. Spreading of emission uncertainty during the analyzed period was obtained. From the computed result precision increasing of emissions are observed. In spite of high inaccuracy on the input data in the beginning of the examined period (this uncertainty has influence to the current uncertainty) the relative valuable result are obtained.

Table 8.4: The results for uncertainty assessment in the SWDS for period 2000–2005.

	2000	2001	2002	2003	2004	2005
Median	43,7533	43,7509	50,0221	53,0137	50,7267	48,7324
Average	43,1205	43,0749	49,2063	52,1081	49,8123	47,8165
St.dev	16,2150	16,1070	18,3016	19,2825	18,3440	17,5280
2.50%	11,0346	11,0738	1,12,7138	13,5350	13,0018	12,5398
97.50%	75,5031	75,0564	85,3523	90,0037	85,6646	81,8976
Min	1,0628	1,0799	1,2545	1,3506	1,3122	1,2800
Max	111,8264	111,0865	126,2310	133,0095	126,5504	120,9383
Per_2.5	-74,4099	-74,2918	-74,1623	-74,0251	-73,8985	-73,7751
Per_97.5	75,0979	74,2461	73,4580	72,7251	71,9748	71,2749

QA/QC and verification

Juraj Farkas (Integrated Skills Ltd. – UK) as sectoral expert for waste assigned by the Emissions Department SHMÚ as SNE and Ministry of Environment of the Slovak Republic as NFP by the letter dated 17th July 2006 under the National Inventory System, has signed agreement with the Slovak Hydrometeorological Institute on January 2, 2008 on preparing report evaluating GHG emissions from Waste sector in 2007.

The principal source of all waste sector data used for GHG emission estimations is based on official numbers published by the Statistical Office of the Slovak Republic (SOSR). Data on MSW are collected directly by SOSR from municipalities once per year. The data are structured according to the European Waste Classification (EWC).

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 SOSR. Where needed or appropriate, these statistical data are supported by data from individual waste management facilities.

Data on waste water are based on population censuses done in 1991 and 2001. It is expected, that the next census in 2011 may cause some reconsideration and lead to changes in trends currently extrapolated. These data are supported by annually published information on population, COD, BOD also published by the SOSR. Where needed, information from SHMÚ databases were used.

The consistency of time series is influenced by changes in reporting system:

- 1993 – Implementation of first waste legislation, introduction of 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 did not changed, but amount of incinerated clinical waste has changed significantly as a result of changes in the waste classification system.

Regarding solid waste, information are published annually by the SOSR 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
- Terrasystems Banska Bystrica – on methane recovered from SWDSs
- ACE (Association of Experts on Waste Water Treatment) – on sewage sludge management
- Duslo a.s. – on ISW incineration

Additionally, web-sites of following companies and institutions were used for this report:

- OLO
- KOSIT
- Slovnaft
- Duslo
- NsP Prievidza
- Fecupral
- Ecorec

Regarding the waste water, data were using from Annual reports of the SOSR. Additional information on waste water was obtained directly from the SHMÚ.

All information used for preparation of this report is archived by the author and by SNE.

Recalculations

Comparing to previously reported emissions from waste sector, all activity data were critically reviewed and complete recalculation were done. The following major improvements were applied to emission estimations:

- The IPCC 2006 Guidelines were used as the basis for emission estimation for the first time.
- For disposal and incineration of ISW the emission assessment is based on individual waste streams, not on the total amount of ISW.
- Emissions from composting were estimated.
- Recovery of methane from MSW disposal was included into the balance.
- Sewage sludge and clinical waste emissions from incineration were assessed separately.
- Methane emissions from waste water were recalculated according to the IPCC 2006 GL, waste water pathways were identified.

Planned improvements

It is proposed to focus in the next phase on formulation of emission development predictions and improving existing emission estimates as new information becomes available.

Further, the IPCC FOD model should be tested for estimation of emissions from SWDS and for emissions prediction, as the 6.A category represents 98% of GHG emissions form solid waste.

8.1 Solid Waste Disposal on Land (CRF 6.A)

The emissions from category 6.A Solid waste disposal sites (SWDS) are the main emissions of the waste sector. The methane emissions are estimated separately for municipal solid waste (MSW) – category 6.A.1 Managed WDL after 2000 and category 6.A.3 Other, Uncategorised MSW before 2000 and industrial solid waste (ISW) – category 6.A.3 Other, Agricultural and Industrial waste after 1997.

The agricultural and industrial waste before 1997 were not estimated lack of activity data about the waste stream. Category 6.B Unmanaged waste disposal sites was not occurring from base year 1990. Total emissions of methane from SWDS in last inventory year 2007 were 85.83 Gg of CH_4, the decreasing comparable to the previous year is almost 6% and was caused by decreasing of industrial waste disposal. Emissions of CO_2 were not occurring in this category. The emissions of NMVOC were estimated to be 1.771 tons in 2007.

8.1.1 Managed Waste Disposal on Land (CRF 6.A.1)

On July 1, 2001 was taken in force new legislative regulation about SWDS in accordance the harmonisation with EU legislative. The relevant Act No. 223/2001, Decree of Ministry of Environment No. 283/ 2001 contains new regulation of limitation of SWDS, disposal with waste gases and monitoring of waste disposal. The gases produced in solid waste disposal sites, 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. Both are considered here as solid waste disposal sites (SWDSs). Either 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. It will then describe two methodologies for estimating CH_4 emissions from SWDSs. One of these methods is a default base method, which all countries can use to estimate CH_4 emissions from different types of SWDSs. It is recommended that countries, which have adequate data, also estimate their emissions using the second method presented.

The estimation of methane emissions from SWDSs using FOD method were calculated using a spreadsheet model. Results are presented as cumulative diagram, which shows contribution of emissions from MSW disposed each year and covers the entire period 1960–2007 and as a bar chart showing total emissions for the period 1990–2007.

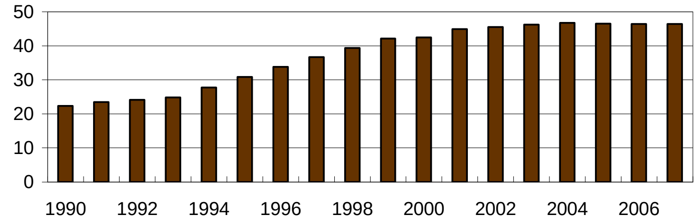
A brief overview of Slovak waste management milestones was prepared as an introduction to the discussion on parameters and activity data. These milestones were selected to provide support to the arguments why and how parameters and activity data were proposed or modified.

Table 8.5: The milestones of waste management in the Slovak Republic.

Year	Milestone
1960	Estimation of MSW generation in Slovakia (565 Gg)
1970	Estimation of MSW generation in Slovakia (665 Gg)
1977	MSW incinerator put in operation in Bratislava
1980	Analysis of MSW fractions in Bratislava and Kosice
1989	MSW incinerator put in operation in Kosice
1991	First waste legislation adopted
1992	Start of regular recording of waste data
1992	A.S.A. started operation in Slovakia (serving ca. 10% of population in 2005)
1995	Marius Pedersen started operation in Slovakia (serving about 20% of population in 2005)
2000	Operation of SWDS non-complying with legislation ended
2000	Reconstruction of MSW incinerator in Bratislava
2001	Waste legislation update, approximation to EU waste law started
2002	EU waste classification system adopted
2003	IPPC Directive implemented in Slovakia
2004	Slovakia joining EU, Transposition of EU waste law to Slovak legal system

The methane emissions for MSW are included into category 6.A.1 Managed waste disposal from 2001, before this year the waste disposal sites were uncategorised and emissions are included before 2001 into the category 6.A.3 Other municipal waste uncategorised. The time series is consistent. According to the used model for estimation of methane emissions from MSW disposed to SWDSs the total emissions reached 47.59 Gg in 2007, but this number was reduced with the methane recovery value (1.16 Gg of CH_4 according to the information from the Terrasystem company). Values and parameters were used for emission estimations according to Tier 2 FOD methodology. The cumulative diagram shows fast increase of methane emissions in the period 1994–2002, this can be explained as a reaction to the improvement of MSW disposal practices in the period 1992–2000. The methane emissions, estimated using the Tier 2 methodology, are lower than those estimated by the Tier 1 methodology. Also, the results of Tier 2 estimation create a smoother line than Tier 1 results as year-to-year changes in amount of disposed MSW are spread in form of emissions to more years.

Figure 8.4: The methane emissions from MSW in the period 1990–2007.



When comparing the results obtained by the Tier 1 and Tier 2 methods, 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 approach to emission estimation can be negligible in countries with long history in controlled MSW disposal, but in countries which recently significantly changed their waste management practices (like the SR) this creates additional uncertainties.

Methodology

A number of methods are used to estimate CH_4 emissions from solid waste disposal sites. These methods vary widely, not only in the assumptions that they make, but also in their complexity, and for data they require. Some very complex models are concerned with movement of CH_4 and other gases through individual disposal sites; however, these models cannot be applied to site populations and therefore will not be considered further here.

Table 8.6: The methane emissions from municipal SWDS during 1990–2007 estimated by FOD methodology

Year	MSWL	MCF	DOC	L0	OX	Rec	CH_4 (Gg)
1990	1 162	0,60	0,12	0,03	0,00	0,00	22,37
1991	1 182	0,60	0,12	0,03	0,00	0,00	23,45
1992	1 210	0,60	0,12	0,03	0,00	0,00	24,16
1993	1 238	0,60	0,12	0,03	0,00	0,00	24,89
1994	1 266	0,65	0,12	0,03	0,00	0,00	27,75
1995	1 347	0,70	0,12	0,03	0,00	0,00	30,85
1996	1 249	0,75	0,12	0,04	0,00	0,00	33,81
1997	1 206	0,80	0,12	0,04	0,00	0,00	36,70
1998	1 113	0,85	0,12	0,04	0,00	0,00	39,40
1999	1 134	0,90	0,12	0,04	0,00	0,00	42,18
2000	1 056	0,95	0,12	0,05	0,05	0,00	42,51
2001	1 049	1,00	0,12	0,05	0,05	0,00	44,94
2002	1 192	1,00	0,12	0,05	0,05	0,00	45,54
2003	1 256	1,00	0,12	0,05	0,05	0,00	46,27
2004	1 195	1,00	0,12	0,05	0,05	0,03	46,79
2005	1 142	1,00	0,12	0,05	0,05	0,45	46,94
2006	1 260	1,00	0,12	0,05	0,05	0,79	47,25
2007	1 378	1,00	0,12	0,05	0,05	1,16	47,59

The IPCC Guidelines 2006 presents a decision tree for CH_4 emissions from waste disposal. Tier 2 estimate 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 SR, several differences can be identified:

- Most countries are using 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 emissions estimations. This approach is not yet possible in the SR, because collected data on MSW do not include the needed characterisation of SWDS.

- Historical data on MSW management and disposal are more detailed that data available in the SR.
- Data on MSW fractions are collected in more systematic and regular way that is the practice in the SR.

As the most appropriate approach was selected the second version of FOD method, as it is defined in the IPCC 2000 GPG. 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 SR in the period 1992–2000.
- Structure of required input data better corresponds with MSW data available for the SR (data for the use of multiphase method are not available).

A small, but important change is done to better reflect the significant improvement of SWDSs practice in the period 1992–2000. The MCF is not depending on the year when MSW was disposed, but on the year when the inventory (estimation of methane emission) was done. The original IPCC equation here MCF is depending on the year when MSW was disposed follows the idea that landfill operation practice does not changes with time. This is in contradiction to the situation in the SR, where within a relatively short time disposal practices changed toward controlled landfilling. Compacting and covering of waste was introduced and this, to our opinion, caused increased generation of methane. However, this period of modernising of disposal practise in the SR requires further investigation.

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 SR. Parameters currently used for methane emission estimation in the Slovak Republic were critically reviewed and additional data were collected to support proposed changes in these parameters.

Currently two landfills have installed flaring systems, in both cases the landfill gas collection and flaring system was installed by company Terrasystems within a carbon trading scheme. The company wants to include another four landfills, resulting in expected savings of ca. 550 000 tons 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 SR. The value of methane recovery in 2007 was 1.16 Gg of CH_4.

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 Slovak Ministry of Environment. Thus, the following hypothesis is proposed:

- Before 1992 all MSW was disposed to SWDSs on which very little or no data exist = IPCC category uncategorised sites.
- Since 2000 all MSW is disposed to managed landfills = IPCC category managed sites.
- Period 1993–1999 is a period of transition when managed sites were gradually developed = linear growth of MCF.

Of course, there is a risk that managed sites existed before 1992 or uncategorised sites were still in (illegal) operation after 2000, but there is no available evidence to reject the hypothesis above. MCF(x) for year 2007 was 1 fraction.

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, sub-urban) and are from various years (in general 1997–2007) but the following calculations are aimed more on 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 Slovak Ministry of Environment.

Table 8.7: The results of MSW composition analysis for various towns and villages in the SR and calculated DOC values. These data should be understood as informative, because the method of analysis is not known in all cases.

Location	Paper, textile	Bio waste	Wood	DOC
D. Streda	18,50%	28,20%	1,30%	0,12
Presov	15,00%	44,50%	2,10%	0,14
Poprad	20,90%	45,40%	1,80%	0,16
Humenne	17,70%	25,20%	2,20%	0,12
Košice	24,00%	45,00%		0,17
Prievidza	10,50%	36,00%		0,10
Brezno	14,00%	31,00%		0,11
Cifare	11,60%	28,30%		0,09
Kálna n/H	17,80%	31,30%		0,12
Levice	23,00%	24,90%		0,13
Nitra	11,10%	31,50%	18,60%	0,15
Trebisov	8,00%	51,00%		0,11

The average DOC value is 0.12 Gg C/Gg MSW. This is very close to the DOC value used in the SR for 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 following results.

Well-managed SWDS use 0.1 for oxidation factor. The current situation of MSW disposal in the SR has 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 build nor operated. The OX value is considered a time-variable, although this is not stated in the IPCC documents. Currently we are using for the 2007 the OX = 0.05 fraction.

The methane generation potential is also a time-variable, as it value depends on time-variable parameters.

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 in the last 10 years over 500 mm/yr.

Table 8.8: The following parameters are proposed as constant for estimation of methane emissions from SWDS.

Parameter	Value	Note
Fraction dissimilated DOC (DOC_F)	0,6	IPCC default value, no national data available
Fraction of methane in landfill gas (F)	0,5	IPCC default value, national data not representative
Methane recovery (R)	1,16	
Methane generation rate constant (k)	0,065	Not sufficient data for use of multiphase model

Table 8.9: The following parameters are proposed as time-variable for estimation of methane emissions from SWDS.

Parameter	Range	Note
Methane correction factor (MCF)	0,6 - 1	Constant in 1960 – 1992 (no data). Linear increase 1993 – 2000. Constant from 2001.
Degradable Organic Carbon (DOC)	0,06 – 0,12	Linear increase in 1960 – 1991. Constant after 1991.
Oxidation factor (OX)	0 – 0,05	Zero till 2000, 0,05 from 2001
Methane generation potential (L_0)	0,014 – 0,048	Calculated as function of DOC

Activity data used for estimation of methane emissions from SWDS are the following:

- Length of data timeline.
- Total MSW generated.
- Fraction of MSW landfilled.
- Length of data timeline.

The Statistical office of the Slovak Republic publishes data on MSW generation and disposal since 1992. Although this creates a timeline of 15 years, this is not sufficient for the use of FOD method. A longer timeline of data is needed. There are several possibilities how to estimate the needed length of data timeline:

- The Waste Act requires monitoring of a landfill at least for 30–50 years (approximately period when all biodegradable components in MSW should decompose).
- The methane generation constant for slower decay rates (k=0.03) means a half life of about 23 years.
- The latest available estimation on MSW in the Slovak Republic dates back to 1960.
- Statistical 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 46 years. Analysis of MSW generation data shows, that there is recorded a huge difference in MSW generation in years 1992–94, comparing to the data 1995–2007. This can be explained by a "learning period" when waste generators getting familiar with the new system of data recording. Therefore it is proposed to exclude these "inflated" data from estimation of methane emissions and replace them 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 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 1993–2004 (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.
- 1995–2005 Real data on MSW disposed were used.

8.1.2 Unmanaged Waste Disposal Sites (CRF 6.A.2)

Emissions are not occurring from this category, the unmanaged waste disposal sites are not occurring in the Slovak Republic.

8.1.3 Other (Agricultural and Industrial Waste) (CRF 6.A.3)

The methane emissions for industrial solid waste are included into category 6.A.3 Other from 1997, before this year the industrial waste emissions were not estimated because of lack of activity data. The total emissions of methane from ISW disposed to industrial SWDSs reached 39.40 Gg in 2007.

The extrapolation of emissions from ISW disposal is not supported by sufficient information and should be understood as informational only from following reasons:

- The system of waste classification has changes in 2002, this is splitting the available data to two non-compatible sets each covering 5 years.
- ISW data are 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.
- The political system has changed in 1989 and economic transformation started in 1990, the following decade is full of economic turbulences, closing of old factories and starting of new enterprises.

Figure 8.5: The methane emissions from MSW in the period 1990–2007.

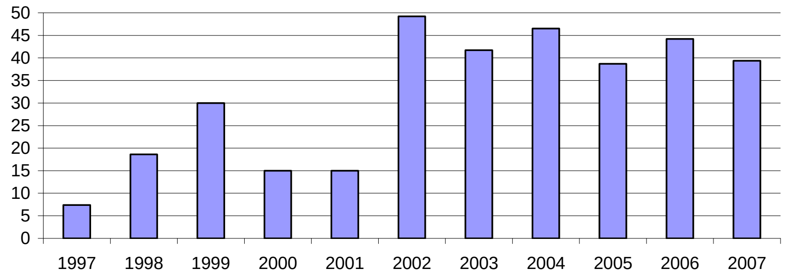


Table 8.10: The resulting methane emissions from ISW disposal to SWDSs.

Year	CH_4 (Gg/y)
1997	7,40
1998	18,60
1999	30,00
2000	15,00
2001	15,00
2002	49,20
2003	41,70
2004	46,50
2005	38,70
2006	44,20
2007	39,40

Dashed line indicates change of waste classification

Methodology

The “Tier 0” methodology is still considered as the most appropriate method for estimation of methane emissions from ISW disposal to SWDSs in the SR. The key problem is the unavailability of a 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.

The default IPCC parameters listed in IPCC Guidelines 2006 were used for estimation of methane from ISW disposed to solid waste disposal sites. The default DOC values were assigned to individual groups of waste, defined in the old and new classification systems.

Table 8.11: The default DOC values for major waste streams.

Default DOC values for major waste streams	
Waste stream	**DOC (fraction by weight)**
Paper and textiles	0,4
Garden and park waste, other (non-food) organic putrescibles	0,17
Food waste	0,15
Wood and straw waste (excluding lignin C)	0,3

Table 8.12: The default SWDS related methane correction factors.

SWDS classification and methane correction factors (MCF)	
Type of Site	**MCF Default Values**
Managed – anaerobic	1
Managed – semi-aerobic	0,5
Unmanaged 3 – deep (>5 m waste) and /or high water table	0,8
Unmanaged 4 – shallow (<5 m waste)	0,4
Uncategorised SWDS	0,6

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 SR to the EU (2004). The following hypothesis is used:

- Before 1992 all ISW was disposed to SWDSs on which very little or no data exist = IPCC category uncategorised sites.
- Since 2000 all ISW is disposed to manage 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_F (0.5) F (0.5), R (0) and OX (0.1).

The structure of data collected by the Statistical Office allowed identification of waste streams which contain mainly biodegradable carbon.

Table 8.13: The default DOC values were assigned to these waste streams and the results in Gg per year.

Year	Total ISW	Biodegradable ISW	Paper, textile	Wood, straw	Garden & park waste	Food waste
DOC			**0,4**	**0,3**	**0,17**	**0,15**
1997	3 085	115	38	25	28	24
1998	2 861	372	31	28	54	260
1999	2 642	525	49	69	88	319
2000	2 313	222	48	17	108	49
2001	2 470	220	43	16	75	86
2002	2 915	813	86		421	
2003	3 322	612	122		420	
2004	4 262	666	155		466	
2005	2 888	553	126		390	
2006	5 772	659	118		427	
2007	4 269	586	104		366	

Recalculations

The activity data in estimation on methane emissions from industrial disposal of waste was recalculated from 2002 according to the new conclusions:

- The change of waste classification in ISW leads to significant change in emission estimation (old system average = 17.2, new system average = 40.3). Thus, there are not sufficient data for extrapolation back to 1990.
- A new approach, based on assessment of DOC content in individual waste streams (categories of EWC) was used to improve the results. This approach shows stable amount of disposed waste with higher DOC, avoiding fluctuations of the total incinerated waste
- DOC parameters of individual waste streams were reviewed and one of them corrected. This increased annual emissions from the ISW disposal by approximately 3%.

The changes are not significant and are below 5% in the amount of industrial waste disposal.

8.2 Wastewater Handling (CRF 6.B)

For each category, the method for estimating 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 of the wastewater. The most common parameters used to measure the degradable organic component (DC) of the wastewater are the BOD (Biochemical Oxygen Demand – 5 days) and COD (Chemical Oxygen Demand). 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., industry or domestic) to estimate the total amount of organic wastewater produced.
- Estimate emissions 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 emissions 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.

For the estimation of GHG emissions from wastewater treatment and discharge the 2006 IPCC GL were used for the first time. Therefore the overall approach to the waste water sector activity data was reviewed and emission estimates were completely recalculated.

The 2006 GL identify two subcategories:

- Domestic Wastewater Treatment and Discharge
- Industrial Wastewater Treatment and Discharge

Methane and nitrous oxide emissions were estimated for both of these categories. The Statistical Office of the Slovak Republic regularly published information on BOD and COD generated and discharged from many sources. This information was used as activity data, both for domestic and industrial waste water emission estimation. Total methane emissions from wastewater treatment were 17.959 Gg of CH_4 in 2007, which is a slight decrease comparable to the previous year, the trend is almost stable. Total N_2O emissions from wastewater treatment were 0.201 Gg of N_2O in 2007, the trend is almost stable.

Figure 8.6: The total methane emissions from wastewater in 1990–2007.

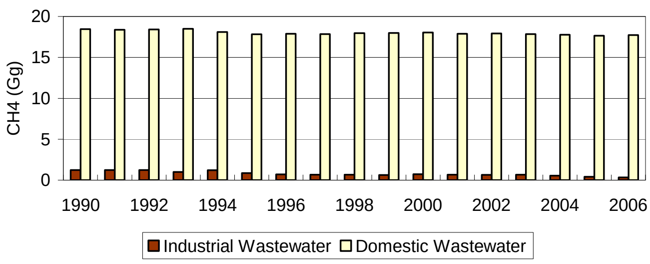
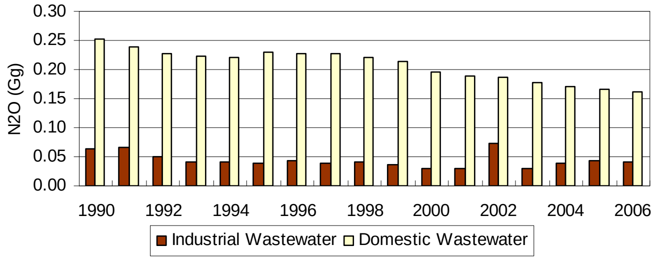


Figure 8.7: The N_2O emissions from wastewater treatment in 1990–2007.



8.2.1 Industrial Wastewater (CRF 6.B.1)

Methodology

The Figure 6.3 in IPCC GL 2006 presents a decision tree for CH_4 emissions from industrial waste water. The following Table presents answers, relevant to situation in industrial waste water in the Slovak Republic.

Question	Answer
Identify major industrial sectors with large potentials for CH4 emission. For these industrial sectors, is a country-specific method from individual facilities or companies available?	NO
For these industrial sectors, are COD and wastewater outflow data available?	YES
Are country-specific emission factors for selected industrial sectors available?	NO
Tier 2: Estimate CH4 emissions using country-specific emission factors. (Estimate emission factors using a review of industry wastewater treatment practices.)	

As recommended by IPCC GL 2006, COD values were used for estimation of methane emissions from industrial waste water (IWW), these data are available starting from 1993. Although there may be a similar effect of overestimated pollution in 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 the chapter 6.2.3.3. of 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 the previous chapter. It is expected, if anaerobic treatment of IWW was used, that all methane from this treatment was burned (with or without energy utilisation). The pathways A and B are included in the estimation of methane emissions.

Table 8.14: The emissions from industrial wastewater by pathways in tons per year.

		Discharged IWW (COD t/y)			
Year	**Generated IWW**	Total	A -Treated	B - Untreated	**Emissions of CH_4**
1990		50 000			1 250
1991		50 000			1 250
1992		50 000			1 250
1993	143 275	40 757	29 018	11 739	1 019
1994	135 011	48 457	46 703	1 754	1 211
1995	138 549	33 814	30 670	3 144	845
1996	133 372	28 054	24 942	3 112	701
1997	133 866	26 489	24 128	2 361	662
1998	133 614	26 751	19 783	6 968	669
1999	129 870	25 220	18 405	6 815	631
2000	110 352	29 035	22 236	6 799	726
2001	121 389	27 254	20 631	6 624	681
2002	124 824	25 473	19 025	6 448	637
2003	93 288	26 555	19 105	7 450	664
2004	83 674	22 049	16 539	5 510	551
2005	81 050	16 880	16 487	393	422
2006	80 629	12 947	12 641	306	324
2007	76 686	12 314	12 023	291	308

For calculation industrial wastewater emissions of N_2O emissions of nitrous oxide are used ISI methodology. ISI method expects that wastewater treatment plant where aren't biological nitrification haven't emission of N_2O. For calculation N_2O, we used only data for treatment plant where biological nitrification and denitrification. Number of this type of treatment for industrial wastewater are increased, therefore this emission of N_2O in the future will increase also. In the calculation are used only data for treatment plant where is c in this case k_{denit} we can eliminate. Population we can exchange with population of equivalents, calculated from COD in the inlet in wastewater treatment and production of BOD for one person (0.05 kg/person/day).

Table 8.15: The parameters for calculation of emissions nitrous oxide for industrial wastewater – ISI.

Parameter	Amount	Unit	Data Source
mn_i		[m^3/day]	Data for individual wastewater plant – database SHMU
(N)i		[mg/l]	Data for individual wastewater plant – database SHMU
k_{N2O}	0,0165	kg N_2O-N/kg N in domestic wastewater	ISI default 0.009-0.024 kg N_2O-N/kg N, medial value are used 0.0165 kg N_2O-N/kg N
K_{diss}	0,65		IPCC default 0.5-0.8, medial value are used 0.65

Table 8.16: the N_2O emissions from industrial and domestic wastewater management estimated by different methodologies.

Method	N_2O emit from domestic wastewater [t/yr]	N_2O emit from industrial wastewater [t/yr]	Emissions of N_2O [t/yr]
IPCC 1996	160,1		160,1
ISI		40,4208	40,4208

8.2.2 Domestic and Commercial Wastewater (CRF 6.B.2)

Methodology

The Figure 6.2 in IPCC GL 2006 presents a decision tree for CH_4 emissions from domestic waste water.

Table 8.17: The answers, relevant to situation in domestic wastewater in the Slovak Republic.

Question	Answer
Are wastewater treatment pathways characterised?	YES
Are measurements or other bottom-up data available from the most important pathways?	YES
Is a country-specific method available?	NO
Are country-specific emission factors available for the key pathways?	NO
Is this a key category?	NO
Tier 1:	
Estimate emissions using default emission factors. (Bo, MCF, etc.)	

The IPCC 2006 GL (Volume 5, Chapter 6, page 6.11) recommend the following approach:

- Step 1: estimation of the total organically degradable carbon in wastewater.
- Step 2: Identification of waste water pathways.
- Step 3: Estimation of methane emissions from waste water.

This approach was used both for domestic and industrial waste waters, 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 SR (Source: Statistical Office of the SR),
- 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).

Table 8.18: The comparison of TOW estimation results using IPCC 2006 GL with BOD – Generated pollution reported by the Statistical Office of the SR.

Year	Population	TOW estimated	BOD reported
1990	5,297,774	145,027	204
1991	5,283,404	144,633	225
1992	5,306,539	145,267	213
1993	5,324,632	145,762	160,385
1994	5,347,307	146,383	152,363
1995	5,363,676	146,831	155,758
1996	5,373,793	147,108	149,683
1997	5,383,233	147,366	152,86
1998	5,390,866	147,575	153,329
1999	5,395,324	147,697	152,303
2000	5,400,679	147,844	137,606
2001	5,379,780	147,271	144,974
2002	5,378,809	147,245	148,697
2003	5,378,950	147,249	130,837
2004	5,382,574	147,348	68,144
2005	5,387,285	147,477	106,436
2006	5,386,353	147,451	102,129
2007	5,400,998	147,541	

The comparison of the data indicates a good correlation for the data in the middle of the Table 8.18, start and end data indicate deficiencies in reporting. The start 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 privatisation of the water sector. Therefore TOW estimated according to the 2006 GL will be used for emission estimations.

Waste water (WW) pathways were identified using information from two population censuses in 1991 and 2001 and from Statistical Office Data on generated and discharged pollution. Data for 2007 are expert estimates based on available statistical data. The following pathways were identified as potential sources of methane emissions and activity data were collected to estimate methane emissions:

	Emission factors			**Population using pathway**		
Pathways	Bo	MCF	EF	1991	2001	2007
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	37.7%	6.7%	5.8%
D – Collected WW treated	0.6	0.1	0.06	39.8%	50.0%	52.4%
E – Untreated discharge from septic tanks	0.6	0.1	0.06	10.6%	11.6%	11.8%
F – Emissions from septic & retention tanks	0.6	0.5	0.30	31.4%	33.7%	34.8%
G – Dry toilets	0.6	0.1	0.06	15.7%	9.8%	7.0%

The sum of “Population using pathway” does not equals 100%

The emissions of methane from domestic waste water were estimated from pathways C, D, E, F and G using equations 6.1 and 6.2 from IPCC 2006 GL.

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 waste water discharged without treatment is decreasing, due to development of new waste water treatment plants.

The aerobic process is used for treatment of the majority of domestic waste water. The overloading of waste water treatment plants is minimal, due to modernisation of plants and significant decrease of water consumption by households. The parameter Rem was included to take in account treatment efficiency. This parameter was estimated from monitored BOD values.

According to the expert opinion, from about one third of septic and retention tanks in the SR the content is delivered and discharged to waste water 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 expert estimate, from one third of them the content is delivered to waste water treatment plants, as required by law. But, although the following practices not legal, one third of these tanks are discharged on/to ground and one third has a discharge to watercourses.

Direct emission 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 of their waste water system (20% of this category).

Table 8.19: The estimates of methane emissions from domestic waste water, by individual pathways.

Year	Pathway C	Pathway D	Pathway E	Pathway F	Pathway G	Total CH_4 emissions
1990	1 140	1 253	922	13 574	1 566	18 456
1991	988	1 307	920	13 644	1 506	18 365
1992	812	1 361	933	13 811	1 517	18 434
1993	739	1 406	945	13 966	1 448	18 504
1994	589	965	957	14 134	1 477	18 121
1995	379	873	969	14 285	1 319	17 825
1996	387	839	980	14 421	1 264	17 890
1997	421	693	990	14 555	1 183	17 842
1998	420	711	1 001	14 684	1 136	17 952
1999	454	666	1 010	14 805	1 053	17 989
2000	426	635	1 020	14 929	1 033	18 043
2001	459	540	1 025	14 871	984	17 880
2002	451	542	1 028	14 953	959	17 932
2003	300	559	1 031	15 037	933	17 860
2004	203	577	1 034	15 131	837	17 783
2005	97	471	1 038	15 228	821	17 656
2006	97	472	1 041	15 31	795	17 716
2007	97	486	1 045	15 403	620	17 651

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. A minor source of nitrous oxide emissions are aerobic processes with nitrification / denitrification stage.

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 following nitrous emissions estimations are based on municipal waste waters and represent full recalculation from 1990. The databases on industrial waste water do not currently include information on nitrogen concentrations and are under review. Thus, these emissions are not included in this report.

The protein consumption data are published by the Statistical Office of the SR, but with one year delay (statistical reports for 2007 include protein consumption data of 2006). The value for actual year was extrapolated from data on consumption of selected kinds of food.

Table 8.20: The estimation of protein consumption in SR used as activity data.

Protein consumption (g/day)	
	Proteins/person
1990	105
1991	100
1992	95
1993	93
1994	92
1995	94
1996	94
1997	93
1998	90
1999	90
2000	84
2001	84
2002	85
2003	83
2004	82
2005	82
2006	81
2007	81

The nitrous oxide emissions from treated waste water 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 structure of 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 emission. The following expectations were considered:

- The 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. 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.
- The WWT plants started to introduce nitrification/denitrification process in 1998. The database of SHMÚ indicates that in 2005 – 2007 the amount of waste water treated in WWT plants with nitrification/denitrification represents about 60% of total treated waste water. 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 conditions of the Slovak Republic is estimated to 80% for nitrification and 50% for denitrification. The resulting effectiveness of the entire process is then 40%.

Based on the above, the following balance of nitrogen was developed and nitrous oxides emissions estimated. Default IPCC GL 2006 parameters were used.

The nitrous oxide emissions from other discharges include all other identified pathways, covering the remaining population. The 2006 IPCC GL provide methodology (Box 6.1 of 2006 GL) for estimation of N_2O emissions from advanced centralised wastewater treatment (WWT) plants.

Table 8.21: Using the default parameters, these emissions were estimated, summarising all three sources of nitrous oxide emission for waste water.

Summary of N_2O emissions from waste water			
Year	From treated waste water	From other discharges	Total N_2O emissions
1990	0,1647	0,0868	0,2515
1991	0,1570	0,0816	0,2386
1992	0,1483	0,0786	0,2269
1993	0,1470	0,0760	0,2230
1994	0,1442	0,0763	0,2205
1995	0,1533	0,0754	0,2287
1996	0,1532	0,0740	0,2272
1997	0,1540	0,0722	0,2262
1998	0,1501	0,0698	0,2199
1999	0,1445	0,0680	0,2125
2000	0,1312	0,0640	0,1952
2001	0,1267	0,0626	0,1893
2002	0,1232	0,0629	0,1861
2003	0,1154	0,0615	0,1769
2004	0,1112	0,0592	0,1704
2005	0,1065	0,0585	0,1650
2006	0,1036	0,0571	0,1607
2007	0,1049	0,0552	0,1601

This is the first attempt to estimate direct N_2O emissions from WWT plants with nitrification/denitrification stage, it aimed on identification how this type of emissions influences the overall balance of nitrous emissions from waste water.

Table 8.22: The information available from SHMÚ for estimation of this type of emissions for 2007.

Parameter	Value	Comment (Source)
P_{TOT}	5 400 998	Total Population of SR (Statistical Office)
T_{POP}	0,69	Share of population using WWT plants (this report, chapter 5.2.2)
P	3 697 279	Population using WWT plants (= P_{TOT} * T_{POP})
WW_{TOTAL}	409 855	Total waste water treated in WWT plants in m^3 (Statistical Office)
WW_{ND}	192 177	Waste water treated in WWT plants with nitrification / denitrification stage in m^3 (SHMU)
T_{PLANTS}	0,47	Share of plants with nitrification / denitrification (= WW_{ND} / WW_{TOTAL})
$F_{IND-COM}$	1,25	Fraction of industrial and commercial co-discharged protein (IPCC default)
EF_{PLANTS}	3,20	emission factor in kg/person/year (IPCC default)
N_2O_{PLANTS}	6,90	total N_2O emissions from plants in 2007, t N_2O/yr
N_{WWT}	4,40	amount of nitrogen associated with these emissions t NO/yr

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 side, 47% of WWT pants have nitrification / denitrification stage and their share will grow in the future, thus separation of these emission may be reasonable.

8.2.3 Other (CRF 6.B.3)

No emissions are reporter into category 6.B.3 Other.

8.3 Waste Incineration (CRF 6.C)

Incineration of waste produces mainly emissions of CO_2, N_2O and CH_4. 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. 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.

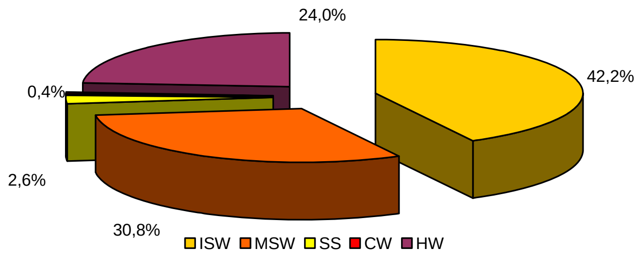
Incineration of waste is an accepted practice in the Slovak Republic. It is regulated in accordance with EU waste legislation. The number of facilities incinerating waste is decreasing in general. This does not mean that less waste is thermally treated, but small old facilities are replaced by modern, bigger ones. Also, the large facilities are undergoing reconstruction and modernisation, aimed on improvement of environmental standards to comply with EU requirements. These two facts are introducing significant uncertainty into estimation of GHG emissions from incineration.

Table 8.23: The number of incinerators during time.

Number of facilities incinerating waste in the SR				
End of year	MSW	ISW	CW	Co-incineration
2006	2	15	18	5
2005	2	15	18	5
2004	2	18	22	3
2003	2	19	23	3
2002	2	21	25	3
2001	2	28	37	-
1996	4	37	39	-

Statistical (quantitative) data on incineration are published annually. Data on situation in this sector (qualitative) data are updated once in four/five years, when a new National Waste Management Plan is published.

Figure 8.8: An estimation of share of individual incinerated waste types was done, based on the total amounts incinerated in 2007 with the following result.



The waste incineration category incinerated 176.8 ktons of waste and emitted in total 8.43 Gg of CO2 emissions, which is a decreasing comparable to the previous year by more than 60%. The decreasing was caused by decreasing of amount the industrial waste incinerated and increasing of energy use incineration. The emissions from energy use incineration of MSW and ISW are included in the energy sector, category 1.AA.1 Energy industry (264.6 ktons of waste incinerated and 62.33 Gg of CO_2). 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.

No new incinerators were put in operation after the base year (1990), thus it can be expected that incinerated amounts of waste are stable – extrapolation was done as average of 1997–2000 data. (The only exception is MSW incinerator in Kosice, this was included in the balance).

Total emissions of N_2O were estimated 0.0176 Gg in 2007, which is decrease comparable to the previous year by 17% caused by decrease in quantity of waste incinerated. The emissions from energy use incineration of MSW and ISW are included in the energy sector, category 1.AA.1 Energy industry (0.0167 Gg of CO_2).

Methodology

The methodology is fully based on IPCC Guidelines 2006 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)

8.3.1 Biogenic (CRF 6.C.1)

No emissions from this category were estimated.

8.3.2 Other (non-biogenic) (CRF 6.C.2)

8.3.2.1 Other (non-biogenic) Municipal Waste Burning (CRF 6.C.2)

The Statistical Office of the Slovak Republic publishes the amount of incinerated MSW since 1993. The data on incineration of MSW for Bratislava region were used as MSW incinerated in Bratislava MSW incinerator, similar approach was used for Kosice. 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 indication of proper option. The change of waste classification in 2002 does not seem to have impact on recorded amounts of incinerated MSW.

Table 8.24: Amount of MSW incinerated in the SR during 1993–2007.

Year	Total	Bratislava incinerator	Kosice incinerator	Other incineration
1993	185	110	45	30
1994	161	109	44	8
1995	151	96	52	3
1996	148	99	46	3
1997	161	114	43	4
1998	184	112	64	7
1999	174	110	61	3
2000	208	117	88	3
2001	131	72	56	3
2002	156	90	64	2
2003	162	95	66	1
2004	184	116	67	1
2005	183	125	56	2
2006	190	128	58	4
2007	180	116	64	0

Dashed line indicates change of waste classification

The MSW incinerator in Bratislava was put in operation in 1977 and significantly reconstructed in the period 2000–2004. Installed capacity is 130 Gg/y, the incinerator can be characterised as continuously operated stoker, and generated heat is used for production of steam and electric energy. The incinerated amounts are shown in the Table 8.24. The operator of the incinerator is OLO – a waste management company servicing Bratislava.

The MSW incinerator in Kosice was put in operation in 1991, after more than 10 years of construction. The emissions exceeded standards and the plant operated in "testing operation" and based "exceptions" from environmental law. The situation has stabilised after entry of foreign investor and creation of company KOSIT, which initiated reconstruction of the plant in 2004. The availability of emission monitoring data (before and after reconstruction of this MSW incinerator) allows documenting the importance on modernisation and impact on estimation of emissions.

Table 8.25: Air emissions from MSW incinerators – comparison before and after reconstruction.

Air emissions from MSW incinerator in Slovakia		
Parameter (all data in t/y)	**Air emissions in 2004 (Before reconstruction)**	**Air emissions in 2006 (After reconstruction)**
Amount of incinerated waste	43 444	72 607
Solid particulates	13,05	0,67
SO_2	45,02	2,45
NO_X	48,86	55,93
CO	41,85	8,39
HCl	7,16	3,50
HF	0,70	0,10
Hg+Cd+Tl	0,11	0,01
Pb+Cu+Mn+As+Ni+Cr+Co+Sb+V	8,24	0,04

Total emissions of CO_2 from municipal waste incineration were estimated to 46.66 Gg in 2007, the decrease comparable to the previous inventory year 2006 was caused by decreasing of municipal waste quantity. The emissions are included into the energy sector, other fuel category because of energy use of incineration MSW.

The total emissions of N_2O from municipal waste incineration were estimated to 0.0023 Gg in 2007. This is a slightly decrease comparable to the previous year 2006 caused by decreasing of the quantity of MSW incinerated. The emissions are included into the energy sector, other fuel category because of energy use of incineration MSW.

Methodology

Consistent 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.

The Tier 2a methodology for estimation of CO_2 emissions from waste incineration and open burning is using the same equation as the Tier 1 approach but is based on country-specific data regarding waste generation, composition and management practices.

The IPCC Guidelines 2006 provides default IPCC values for estimation of CO_2 emissions from incineration. These will be used for estimation of CO_2 EF from incineration, in accordance with the Tier 2a methodology.

Table 8.26: Municipal solid waste parameters used by incineration in the SR.

MSW fractions	SR 2000	Bratislava 1993	Kosice 1995
Food & Garden waste	38.0%	36.7%	44.5%
Paper	13.0%	15.5%	20.0%
Glass	8.0%	5.8%	10.0%
Plastics	7.0%	7.0%	8.0%
Textiles	-	5.1%	4.0%
Metals	3.0%	-	4.5%
Leather, rubber	-	-	3.0%
Hazardous waste	1.0%	0.2%	1.0%
Residues/mineralised	30.0%	29.7%	4.0%

Table 8.27: The IPCC default data for CO_2 EF.

	Dry matter content (% of wet weight)	**Total carbon** (% of dry weight)	**Fossil carbon** (% of total carbon)
Industrial Waste	NA	50	90
Clinical Waste	NA	60	40
Sewage Sludge	NA	40 – 50	0
Fossil liquid waste	NA	80	100

Table 8.28: The IPCC input parameters.

MSW component	**Dry matter content (% wet weight)**	**Total carbon content (% of dry weight)**		**Fossil carbon fraction (% of total carbon)**	
	Default	Default	Range	Default	Range
Paper/cardboard	90	46	42- 50	1	0 – 5
Textiles	80	50	25- 50	20	0 – 50
Food waste	40	38	20 - 50	-	-
Wood	85	50	46- 54	-	-
Garden and park waste	40	49	45- 55	0	0
Nappies	40	70	54 - 90	10	10
Rubber and Leather	84	67	67	20	20
Plastics	100	75	67- 85	100	95 – 100
Metal, glass, inert waste	100 (>90)	NA (<3)	NA (<5)	NA (100)	50 – 100

For estimation of CO_2 emissions from MSW incineration the activity data, IPPC default parameters and the Slovak specific parameters on waste composition were used. The oxidation factor is considered 100%. The results indicate that CO_2 emissions from MSW incineration do not change significantly with time, the main impacts causing variations include:

- Changes in waste data reporting methodology
- Reconstruction of incinerators (period 2001–2003)

This conclusion was used for extrapolation of CO_2 emissions from MSW incineration back to the year 1990 keeping in mind that the Kosice incinerator was put in operation in 1991. These extrapolated data are calculated as average of emission data prior to incinerator reconstruction in 2000.

Table 8.29: The CO_2 emissions from MSW incineration during 1990–2007.

Year	MSW incinerated	CO_2 emissions
1990		30,00
1991		43,00
1992		43,00
1993	185	47,90
1994	161	41,69
1995	151	39,10
1996	148	38,32
1997	161	41,69
1998	184	47,64
1999	174	45,05
2000	208	53,86
2001	131	33,92
2002	156	40,39
2003	162	41,95
2004	184	47,64
2005	183	47,38
2006	190	49,13
2007	180	46,66

Dashed line indicates change of waste classification

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 is used in this chapter as verification tool (emissions of N_2O must not be higher than those of NO_2).

The formula for estimation of emissions is based on multiplying the incinerated waste stream amount by emission factor specific for that waste stream. The equation shown in GPG was used for estimation of N_2O emissions from incineration. The following default N_2O emission factors (wet weight) were selected from the IPCC Guidelines 2006, Table 5.6. The selection is based on incinerated waste types and technologies used. Waste amounts are normally given as wet weight in the Slovak Republic. Although the GL2006 recommend using emission factor 50 for MSW, quotations from Europe indicate different values.

Table 8.30: The IPCC default parameters for emission factors.

Type of waste	Technology	Emission factor ($g\ N_2O/t$ waste)
MSW	Continuous inc.	50
Industrial waste	All types	100
Sewage Sludge	All types	900

It should be noted, that the reconstruction of both incinerators leads 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 bulk number for all emission sources within a company.

- 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, as 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 kg N_2O/t MSW and the new 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 most probably incinerated in smaller units, the EF=50 was used.

Table 8.31: The final estimation of N_2O emissions from MSW incineration.

Year	Bratislava incinerator (20)	Kosice incinerator (20)	Rest (50)	N_2O emissions (Gg/y)
1990	110	0		0.0030
1991	110	45		0.0046
1992	110	45		0.0046
1993	110	45	30	0.0046
1994	109	44	8	0.0035
1995	96	52	3	0.0031
1996	99	46	3	0.0031
1997	114	43	4	0.0033
1998	112	64	7	0.0039
1999	110	61	3	0.0036
2000	117	88	3	0.0043
2001	72	56	3	0.0027
2002	90	64	2	0.0032
2003	95	66	1	0.0033
2004	116	67	1	0.0032
2005	125	56	2	0.0023
2006	128	58	4	0.0024
2007	116	64	0	0.0023

Dashed line indicates change in waste classification. Numbers in italics indicate extrapolated data

8.3.2.2 Other (non-biogenic) Industrial Waste Incineration (CRF 6.C.2)

From the total of 37 ISW incinerators only a few have installed capacity exceeding 1 ton per hour. These are located in following companies:

- Duslo a.s. Sala, operating rotary kiln and fluid bed furnace (5 ton/hour)
- Petrochema a.s. Dubova – two rotary kilns (5.5 ton/hour)
- Slovnaft a.s. Bratislava – rotary kiln and chamber furnace (3.5 ton/hour)
- Helpeco s.r.o Povazska Bystrica – rotary kiln (1 ton/hour)

The remaining 30 facilities are smaller unit, 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 tons of waste annually – this is about 6% of all ISW incinerated. The data on incinerated ISW is published in a detailed structure – by Chapters of the European Waste Catalogue. This allowed identifying waste streams in which is significant share of fossil carbon for estimation of CO_2 emissions. Industrial solid waste is recorded by Statistical Office since 1997 and only since 2002 the Statistical Office provides information on "incineration with energy recovery" and "incineration without energy recovery". The analysis of the data allow to make 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.

Table 8.32: The amount of ISW incinerated in the SR during 1997–2007.

Year	Total ISW	C fossil-rich Waste
1997	220	91
1998	401	87
1999	282	65
2000	278	61
2001	226	67
2002	465	66
2003	638	57
2004	312	42
2005	407	20
2006	364	42
2007	246	16

Dashed line indicates change of waste classification

Total emissions of CO_2 from industrial waste incineration were estimated to 24.1 Gg in 2007, but the emissions without energy use were 8.43 Gg of CO_2 in 2007. The significant decrease comparable to the previous inventory year 2006 was caused by increasing energy use of ISW incineration. The emissions are included into the energy sector, other fuel category.

The total emissions of N_2O from industrial waste incineration were estimated to 0.018 Gg in 2007, but the emissions without energy use were 0.0036 Gg of N_2O in 2007. The significant decrease comparable to the previous inventory year 2006 was caused by increasing energy use of ISW incineration. The emissions are included into the energy sector, other fuel category.

Methodology

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.

Table 8.33: The CO_2 emissions from ISW incineration during 1990–2007.

	ICW incinerated		CO_2 emissions	
Year	Total	C fossil rich	Total	No energy rec.
1990	280,70	128,20	190,40	66,70
1991	280,70	128,20	190,40	66,70
1992	280,70	128,20	190,40	66,70
1993	280,70	128,20	190,40	66,70
1994	280,70	128,20	190,40	66,70
1995	280,70	128,20	190,40	66,70
1996	280,70	128,20	190,40	66,70
1997	219,60	92,50	137,30	48,10
1998	400,90	185,60	275,60	96,50
1999	279,00	128,70	191,10	66,90
2000	278,30	128,10	190,20	66,60
2001	225,50	106,40	158,00	55,30
2002	465,00	75,90	112,60	39,40
2003	637,80	63,30	94,00	32,90
2004	311,70	49,00	72,70	25,40
2005	405,40	24,10	35,80	12,50
2006	364,20	41,90	62,20	22,50
2007	246,30	16,20	24,10	8,43

Dashed line indicates change of waste classification

Although the total amount of incinerated ISW seems to be stable, the share of waste streams rich on fossil carbon is decreasing.

Table 8.34: The estimation of N_2O from ISW during 1990–2007.

Year	ISW incinerated	Total N_2O from ISW	N_2O from ISW, no energy recovery
1990	250	0,0200	0,0052
1991	250	0,0200	0,0052
1992	250	0,0200	0,0052
1993	250	0,0200	0,0052
1994	250	0,0200	0,0052
1995	250	0,0200	0,0052
1996	250	0,0200	0,0052
1997	200	0,0180	0,0041
1998	381	0,0210	0,0077
1999	259	0,0190	0,0053
2000	258	0,0190	0,0053
2001	206	0,0180	0,0042
2002	450	0,0230	0,0090
2003	623	0,0260	0,0125
2004	297	0,0190	0,0059
2005	392	0,0210	0,0078
2006	349	0,0200	0,0070
2007	231	0,0180	0,0036

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.

Recalculation

No real recalculations were provided, but the activity data of industrial solid waste incinerated for 2006 were corrected according to the final statistical information (only draft data were provided in last inventory due to the late date of statistical information availability). The emissions and activity data (only from 2002 it is possible to separate activity data of ISW incinerated) were reallocated according to the energy use in the energy sector.

8.3.2.3 Other (non-biogenic) Sewage Sludge Incineration (CRF 6.C.2)

Activity data on ISW and SS incineration from previous Table 8.34 were used. It is assumed, that the total amount of incinerated sewage sludge (SS) was/is 15 Gg/year and resulting emissions are 0.0135 Gg N_2O/year. The default IPCC parameters were used.

Only two incinerators incinerate sewage sludge in the SR, in both cases it is sludge from industrial waste water treatment. The oil refinery Slovnaft a.s. Bratislava has developed specialised incinerator for burning sewage sludge for company owned waste water treatment plant in 1986. This facility was significantly improved during reconstruction in 2006. The operational capacity is of the incinerator is 24.5 Gg/y of dewatered sludge (20% dry mass). The actually incinerated amount of sludge was 15 Gg/y in 2007. The incinerator is a stacked furnace type, designed to operate continuously. There is no energy recovery. The chemical factory Duslo a.s. Sala operates a fluidised bed furnace, incinerating (except 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 generation of steam. Sewage sludge does not contain fossil carbon thus there are no CO_2 emissions to estimate.

8.4 Other – Composting (CRF 6.D)

This chapter is aimed on review of preparedness of the Slovak Republic to provide estimates of GHG emissions from following processes:

- Composting
- Anaerobic digestion of organic waste

The EU requirement to reduce the amount of landfilled biodegradable waste supports installation of mechanical–biological treatment facilities, which may include also comporting 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.

Methodology

Tier 1 is used for emission estimation. The Slovak Statistical Office publishes data on composted MSW since 1993. The reported amount of composted MSW remain stable, about 35–40 Gg/y. The data on composted ISW are from the same source and are published since 2002. The reported data are too few and in too big variation to identify a trend in emission. There are no centrally collected data on anaerobic treatment or on recovery of methane emissions from composting.

Because there were no data on anaerobic treatment 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.

Table 8.35: The parameters IPCC default EFs.

Treatment	CH_4 Emission Factor		N_2O Emission Factor	
	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)

Table 8.36: Methane and N_2O emissions from MSW composting during 1990–2007.

Year	Composted waste (Gg/y)	CH_4 (Gg/y)	N_2O (Gg/y)	Number of municipalities composting MSW
1990	20,00	0,080	0,006	
1991	20,00	0,080	0,006	
1992	20,00	0,080	0,006	
1993	21,40	0,086	0,006	472
1994	19,10	0,076	0,006	479
1995	35,40	0,142	0,011	577
1996	31,50	0,126	0,010	676
1997	38,80	0,155	0,012	659
1998	38,00	0,152	0,011	748
1999	39,30	0,157	0,012	807
2000	36,30	0,145	0,011	819
2001	43,50	0,174	0,013	780
2002	39,30	0,157	0,012	691
2003	40,70	0,163	0,012	659
2004	40,90	0,164	0,012	635
2005	20,80	0,083	0,006	501
2006	51,60	0,206	0,016	556
2007	76,10	0,304	0,023	1 195

9 OTHER (CRF 7)

Slovak Republic doesn't report any emissions under the sector Other.

10 RECALCULATIONS AND IMPROVEMENTS

Recalculations relevant for the inventory submission 2009 are included in appropriate sector, subsector or category in the each chapter separately. The justification and implication for the trend are included in the section.

Plant improvements relevant for the inventory submission 2009 are included in the appropriate sector, subsector or category in the each chapter separately.

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Chapter 8 – Waste:

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Gera, M., Szemesova, J. *Uncertainty Analysis for Estimation of Landfill Emissions and Data Sensitivity for Input Variation*, 2nd International Workshop on Uncertainty in Greenhouse Gas Inventories, International Institute for Applied Systems Analysis A-2361 Laxenburg, Austria, 27.-28.10. 2007.

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Szemesová J., Gera M. *Uncertainty Analysis for Estimation of Landfill Methane Emissions* Contribution to Geophysics and Geodesy, SAS, Vol 37, No 3, , 251 - 265. 2007.

Szemesová J., 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-

Annex 1: The List of External Experts and Cooperating Organizations.

Name	e-mail	Institution	Position
Janka SZEMESOVÁ	janka.szemesova@shmu.sk	Slovak Hydrometeorological Institute	Coordinator of the SVK NIS
Mária LEXOVÁ	Maria.Lexova@statistics.sk	Statistical Office of the SR	Energy statistics provider
Jozef SKÁKALA	skakala@spirit.sk	Spirit Inc. Informatics System	NEIS dbase provider, web page
Martin GERA	mgera@fmph.uniba.sk	Faculty of Mathematics, Physics & Informatic	Uncertainty´s assessment expert
Eva GOGOVÁ	eva.gogova@shmu.sk	Slovak Hydrometeorological Institute	Manager of quality
Stanislava NEBUSOVÁ	stanislava.nebusova@shmu.sk	Slovak Hydrometeorological Institute	Emission projections´expert
Jiří BALAJKA	ecosys@orangemail.sk	Ecosys Slovakia	Emission projections´expert
Ján JUDÁK	judak@profing.eu	Profing LtD.	Energy sector expert
Michaela KOLLÁROVÁ	michaela.kollarova@shmu.sk	Slovak Hydrometeorological Institute	Transport sector expert
Peter TOMLEIN	zvazchkt@isternet.sk	Slovak Association for Cooling and Air conditioning Technique	F-Gases sector expert
Vladimír DANIELIK	vladimir.danielik@stuba.sk	Faculty of Chemical and Food Technology, Institute of Analytical Chemistry	Industrial processes expert
Bernard ŠIŠKA	bernard.siska@uniag.sk	Slovak Food University	Agricultural expert
Tibor PRIWITZER	priwitzer@nlcsk.org	National Forest Institute	LULUCF expert
Andrej KOVARIK	andrej.kovarik@shmu.sk	Slovak Hydrometeorological Institute	LULUCF expert
Juraj FARKAŠ	jfarkas@integrated-skills.com	Integrated Skills Ltd.	Waste expert
Lea MRAFKOVÁ	lea.mrafkova@shmu.sk	Slovak Hydrometeorological Institute	Wastewater dbase provider
Peter KOVÁR	peter.kovar@shmu.sk	Slovak Hydrometeorological Institute	NEIS dbase administrator

Annex 2: The Key Source Analyses Results in 2007

Key Sources by Level Assessment in 2007 with LULUCF	Direct GHG	Base Year Estimate (1990)	Current Year Estimate (2007)	Level Assesment	Cumulative Total of Column E
1.A.2 Manufacturing Industries and Construction - solid	CO2	14 404,06	7 430,11	15,88	15,88
1.A.3.b Transport - Road Transportation - liquid	CO2	4 892,45	6 484,91	13,86	29,73
1.A.1 Energy Industries - solid	CO2	11 552,58	5 390,56	11,52	41,25
1.A.2 Manufacturing Industries and Construction - gaseous	CO2	5 723,56	3 841,73	8,21	49,46
1.A.1 Energy Industries - gaseous	CO2	2 844,44	3 778,64	8,07	57,53
1.A.4 Other sector - gaseous	CO2	2 841,82	3 301,33	7,05	64,59
1.A.4 Other sector - biomass	CO2	527,45	2 482,72	5,30	69,89
6.A Solid Waste Disposal on Land	CH4	469,77	1 802,43	3,85	73,74
4.D Agricultural Soils	N2O	3 582,15	1 749,14	3,74	77,48
2(I).A.1 Cement Production	CO2	1 438,01	1 458,01	3,12	80,59
2(I).B.2 Nitric Acid Production	N2O	1 148,71	1 412,18	3,02	83,61
1.A.2 Manufacturing Industries and Construction - liquid	CO2	4 163,11	1 193,53	2,55	86,16
1.A.5.a Other non-specified - gaseous	CO2	1 639,63	1 129,63	2,41	88,57
1.A.1 Energy Industries - liquid	CO2	1 540,39	1 006,66	2,15	90,73
4.A Enteric Fermentation	CH4	1 990,16	929,50	1,99	92,71
2(I).A.2 Lime Production	CO2	770,42	897,06	1,92	94,63
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	CH4	513,50	744,38	1,59	96,22

Key Sources by Level Assessment in 2007	Direct GHG	Base Year Estimate (1990)	Current Year Estimate (2007)	Level Assesment	Cumulative Total of Column E
1.A.2 Manufacturing Industries and Construction - solid	CO2	14 404,06	7 430,11	14,86	14,86
1.A.3.b Transport - Road Transportation - liquid	CO2	4 892,45	6 484,91	12,97	27,83
1.A.1 Energy Industries - solid	CO2	11 552,58	5 390,56	10,78	38,61
1.A.2 Manufacturing Industries and Construction - gaseous	CO2	5 723,56	3 841,73	7,68	46,30
1.A.1 Energy Industries - gaseous	CO2	2 844,44	3 778,64	7,56	53,85
1.A.4 Other sector - gaseous	CO2	2 841,82	3 301,33	6,60	60,46
1.A.4 Other sector - biomass	CO2	527,45	2 482,72	4,97	65,42
6.A Solid Waste Disposal on Land	CH4	469,77	1 802,43	3,60	69,03
4.D Agricultural Soils	N2O	3 582,15	1 749,14	3,50	72,53
2(I).A.1 Cement Production	CO2	1 438,01	1 458,01	2,92	75,44
2(I).B.2 Nitric Acid Production	N2O	1 148,71	1 412,18	2,82	78,27
1.A.2 Manufacturing Industries and Construction - liquid	CO2	4 163,11	1 193,53	2,39	80,65
1.A.5.a Other non-specified - gaseous	CO2	1 639,63	1 129,63	2,26	82,91
1.A.1 Energy Industries - liquid	CO2	1 540,39	1 006,66	2,01	84,93
4.A Enteric Fermentation	CH4	1 990,16	929,50	1,86	86,78
2(I).A.2 Lime Production	CO2	770,42	897,06	1,79	88,58
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	CH4	513,50	744,38	1,49	90,07
2(I).C.1 Iron and Steel Production	CO2	420,26	535,42	1,07	91,14
4.B Manure Management	N2O	1 094,56	405,19	0,81	91,95
2(I).A.3 Limestone and Dolomite Use	CO2	302,12	395,32	0,79	92,74
6.B Wastewater Handling	CH4	1 012,05	377,14	0,75	93,49
1.A.4 Other sector - solid	CO2	7 679,65	332,00	0,66	94,16
2(I).B.1 Ammonia Production	CO2	356,04	326,75	0,65	94,81
2(I).A.7 Magnezite Use	CO2	431,94	304,00	0,61	95,42

Key Sources by Trend Assessment in 2007 with LULUCF	Direct GHG	Base Year Estimate	Current Year Estimate	Level Assessment	Cumulative Total	Difference	Trend Assessment	Contribution to Trend	Cumulative Total
		CO2 equivalents (Gg)		%				%	
1.A.2 Manufacturing Industries and Construction - solid	CO2	14 404,06	7 430,11	15,88	15,88	-0,39	6,16	6,27	6,27
1.A.3.b Transport - Road Transportation - liquid	CO2	4 892,45	6 484,91	13,86	29,73	0,80	11,03	11,22	17,49
1.A.1 Energy Industries - solid	CO2	11 552,58	5 390,56	11,52	41,25	-0,59	6,82	6,94	24,43
1.A.2 Manufacturing Industries and Construction - gaseous	CO2	5 723,56	3 841,73	8,21	49,46	0,06	0,50	0,51	24,94
1.A.1 Energy Industries - gaseous	CO2	2 844,44	3 778,64	8,07	57,53	0,80	6,44	6,55	31,49
1.A.4 Other sector - gaseous	CO2	2 841,82	3 301,33	7,05	64,59	0,69	4,87	4,95	36,44
1.A.4 Other sector - biomass	CO2	527,45	2 482,72	5,30	69,89	1,34	7,10	7,22	43,66
6.A Solid Waste Disposal on Land	CH4	469,77	1 802,43	3,85	73,74	1,29	4,97	5,05	48,71
4.D Agricultural Soils	N2O	3 582,15	1 749,14	3,74	77,48	-0,50	1,86	1,89	50,60
2(I).A.1 Cement Production	CO2	1 438,01	1 458,01	3,12	80,59	0,56	1,76	1,79	52,39
2(I).B.2 Nitric Acid Production	N2O	1 148,71	1 412,18	3,02	83,61	0,74	2,22	2,26	54,66
1.A.2 Manufacturing Industries and Construction - liquid	CO2	4 163,11	1 193,53	2,55	86,16	-1,94	4,94	5,03	59,68
1.A.5.a Other non-specified - gaseous	CO2	1 639,63	1 129,63	2,41	88,57	0,10	0,24	0,24	59,92
1.A.1 Energy Industries - liquid	CO2	1 540,39	1 006,66	2,15	90,73	0,02	0,04	0,04	59,97
4.A Enteric Fermentation	CH4	1 990,16	929,50	1,99	92,71	-0,59	1,17	1,19	61,16
2(I).A.2 Lime Production	CO2	770,42	897,06	1,92	94,63	0,69	1,33	1,35	62,51
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	CH4	513,50	744,38	1,59	96,22	0,86	1,37	1,39	63,90
2(I).C.1 Iron and Steel Production	CO2	420,26	535,42	1,14	97,36	0,77	0,88	0,89	64,79
5.F Other Land	CO2	-1 775,15	484,40	1,04	98,40	5,22	5,40	5,49	70,29
4.B Manure Management	N2O	1 094,56	405,19	0,87	99,26	-1,15	1,00	1,01	71,30
2(I).A.3 Limestone and Dolomite Use	CO2	302,12	395,32	0,84	100,11	0,79	0,66	0,68	71,97
6.B Wastewater Handling	CH4	1 012,05	377,14	0,81	100,91	-1,13	0,91	0,93	72,90
1.A.4 Other sector - solid	CO2	7 679,65	332,00	0,71	101,62	-21,58	15,31	15,57	88,48
2(I).B.1 Ammonia Production	CO2	356,04	326,75	0,70	102,32	0,46	0,32	0,33	88,80
2(I).A.7 Magnezite Use	CO2	431,94	304,00	0,65	102,97	0,13	0,08	0,09	88,89
1.B.1.a Coal Mining and Handling	CH4	571,15	283,88	0,61	103,58	-0,46	0,28	0,28	89,17
2(I).F HFCs emissions	HFCs	0,00	226,99	0,48	104,06	1,55	0,75	0,76	89,94
1.A.2 Manufacturing Industries and Construction - biomass	CO2	266,38	204,99	0,44	104,50	0,25	0,11	0,11	90,05
2(I).C.3 Aluminium Production	CO2	121,32	192,22	0,41	104,91	0,92	0,38	0,38	90,43
1.A.3.b Transport - Road Transportation - liquid	N2O	71,61	181,30	0,39	105,30	1,16	0,45	0,46	90,89
1.A.3.b Transport - Road Transportation - biomass	CO2	0,00	161,07	0,34	105,64	1,55	0,53	0,54	91,43
1.A.4 Other sector - biomass	CH4	32,91	155,61	0,33	105,98	1,34	0,45	0,45	91,89
4.B Manure Management	CH4	368,66	143,73	0,31	106,28	-1,01	0,31	0,32	92,20
1.A.3.c Transport - Railways - liquid	CO2	376,77	108,67	0,23	106,51	-1,92	0,44	0,45	92,65
1.A.1 Energy Industries - biomass	CO2	0,00	85,64	0,18	106,70	1,55	0,28	0,29	92,94
3.D Other Solvent Use	N2O	17,05	79,95	0,17	106,87	1,34	0,23	0,23	93,18
1.A.1 Energy Industries - other	CO2	153,70	62,97	0,13	107,00	-0,89	0,12	0,12	93,30
6.B Wastewater Handling	N2O	20,02	62,16	0,13	107,14	1,23	0,16	0,17	93,46
1.A.5.a Other non-specified - biomass	CO2	0,00	42,71	0,09	107,23	1,55	0,14	0,14	93,61
1.A.4 Other sector - biomass	N2O	6,52	30,70	0,07	107,29	1,34	0,09	0,09	93,70
2(I).C.3 Aluminium Production	PFCs	271,37	24,88	0,05	107,35	-9,35	0,50	0,51	94,20
1.A.1 Energy Industries - solid	N2O	52,38	23,07	0,05	107,40	-0,72	0,04	0,04	94,24
1.A.3.b Transport - Road Transportation - liquid	CH4	20,98	21,67	0,05	107,44	0,58	0,03	0,03	94,27
5.A Forest Land	CH4	14,68	19,03	0,04	107,48	0,78	0,03	0,03	94,30
1.A.4 Other sector - solid	CH4	350,07	17,79	0,04	107,52	-18,12	0,69	0,70	95,00

Key Sources by Trend Assessment in 2007	Direct GHG	Base Year Estimate	Current Year Estimate	Level Assessment	Cumulative Total	Difference	Trend Assessment	Contribution to Trend	Cumulative Total
		CO2 equivalents (Gg)		%				%	
1.A.2 Manufacturing Industries and Construction - solid	CO2	14 404,06	7 430,11	14,85	14,85	-0,44	6,53	7,89	7,89
1.A.3.b Transport - Road Transportation - liquid	CO2	4 892,45	6 484,91	12,97	27,82	0,74	9,65	11,66	19,54
1.A.1 Energy Industries - solid	CO2	11 552,58	5 390,56	10,78	38,60	-0,64	6,94	8,38	27,92
1.A.2 Manufacturing Industries and Construction - gaseous	CO2	5 723,56	3 841,73	7,68	46,28	0,01	0,07	0,08	28,01
1.A.1 Energy Industries - gaseous	CO2	2 844,44	3 778,64	7,55	53,83	0,75	5,64	6,81	34,82
1.A.4 Other sector - gaseous	CO2	2 841,82	3 301,33	6,60	60,43	0,64	4,21	5,09	39,90
1.A.4 Other sector - biomass	CO2	527,45	2 482,72	4,96	65,40	1,29	6,39	7,71	47,61
6.A Solid Waste Disposal on Land	CH4	469,77	1 802,43	3,60	69,00	1,24	4,46	5,39	53,00
4.D Agricultural Soils	N2O	3 582,15	1 749,14	3,50	72,50	-0,55	1,92	2,32	55,32
2(I).A.1 Cement Production	CO2	1 438,01	1 458,01	2,91	75,41	0,51	1,49	1,80	57,13
2(I).B.2 Nitric Acid Production	N2O	1 148,71	1 412,18	2,82	78,24	0,69	1,94	2,34	59,46
1.A.2 Manufacturing Industries and Construction - liquid	CO2	4 163,11	1 193,53	2,39	80,62	-1,99	4,75	5,73	65,19
1.A.5.a Other non-specified - gaseous	CO2	1 639,63	1 129,63	2,26	82,88	0,05	0,11	0,13	65,32
1.A.1 Energy Industries - liquid	CO2	1 540,39	1 006,66	2,01	84,89	-0,03	0,06	0,08	65,40
4.A Enteric Fermentation	CH4	1 990,16	929,50	1,86	86,75	-0,64	1,19	1,44	66,84
2(I).A.2 Lime Production	CO2	770,42	897,06	1,79	88,55	0,64	1,15	1,39	68,23
1.B.1.b Fugitive Emission from Oil, Natural Gas and Other	CH4	513,50	744,38	1,49	90,03	0,81	1,20	1,45	69,68
2(I).C.1 Iron and Steel Production	CO2	420,26	535,42	1,07	91,10	0,71	0,76	0,92	70,60
4.B Manure Management	N2O	1 094,56	405,19	0,81	91,91	-1,20	0,97	1,18	71,78
2(I).A.3 Limestone and Dolomite Use	CO2	302,12	395,32	0,79	92,70	0,73	0,58	0,70	72,48
6.B Wastewater Handling	CH4	1 012,05	377,14	0,75	93,46	-1,18	0,89	1,08	73,56
1.A.4 Other sector - solid	CO2	7 679,65	332,00	0,66	94,12	-21,63	14,36	17,34	90,90
2(I).B.1 Ammonia Production	CO2	356,04	326,75	0,65	94,78	0,41	0,27	0,32	91,22
2(I).A.7 Magnezite Use	CO2	431,94	304,00	0,61	95,38	0,08	0,05	0,06	91,28
1.B.1.a Coal Mining and Handling	CH4	571,15	283,88	0,57	95,95	-0,51	0,29	0,35	91,63
2(I).F HFCs emissions	HFCs	0,00	226,99	0,45	96,40	1,50	0,68	0,82	92,45
1.A.2 Manufacturing Industries and Construction - biomass	CO2	266,38	204,99	0,41	96,81	0,20	0,08	0,10	92,55
2(I).C.3 Aluminium Production	CO2	121,32	192,22	0,38	97,20	0,87	0,33	0,40	92,95
1.A.3.b Transport - Road Transportation - liquid	N2O	71,61	181,30	0,36	97,56	1,10	0,40	0,48	93,44
1.A.3.b Transport - Road Transportation - biomass	CO2	0,00	161,07	0,32	97,88	1,50	0,48	0,58	94,02
1.A.4 Other sector - biomass	CH4	32,91	155,61	0,31	98,19	1,29	0,40	0,48	94,50
4.B Manure Management	CH4	368,66	143,73	0,29	98,48	-1,07	0,31	0,37	94,87
1.A.3.c Transport - Railways - liquid	CO2	376,77	108,67	0,22	98,70	-1,97	0,43	0,52	95,39

Annex 3: The certificate of Conformity with the Standard SHMÚ.

ACERT

CERTIFICATION BODY ACCREDITED BY SLOVAK NATIONAL ACCREDITATION SERVICE
FOR CERTIFICATION OF MANAGEMENT SYSTEMS GRANTS

CERTIFICATE

OF CONFORMITY WITH THE STANDARD

EN ISO 9001:2000

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.: **15/2007** LEADER OF CERTIFICATION BODY

DATE OF ISSUE: **19.4.2007**
VALIDITY: **18.4.2010**

IAF – MEMBER OF MULTILATERAL RECOGNITION ARRANGEMENT

SNAS Reg. No. 242/Q-034

ACERT

Annex 4: Details and Updates on the National Emission Registry of the Slovak Republic under the Article 7, paragraph 1

Name	Dexia banka Slovensko, a.s.
Address	Hodzova 11
City	Žilina
Postcode	010 11
Country	Slovak Republic
Telephone number	+421 41 5111 909(914)
Facsimile number	+421 41 5111 910
Web site	http://www.dexia.sk/C12571BE004847DE/en/101
E-mail	co2@dexia.sk

Standard electronic format (SEF)

The standard electronic format tables are included in the submission for the first time (SEF_SK_2009_1_10-59-41 8-4-2009. xls). The tables include all required information on the AAU, ERU, CER, t-CER, l-CER and RMU in the registry 31.12.2008 as well as information on transfers of the units in 2008 to and from other Parties of the Kyoto Protocol. The SEF tables have been filled automatically using SEF reporting module in Seringas software.

National Registry Change

The changes in the national registry software:

The Slovak registry software Seringas has been updated in 2008 (from version 2.95 to version 4.06). The change enabled new registry functions.

The successful testing of the Slovak registry with ITL and CITL was completed and the ITL Administrator authorized the registry of Slovakia to commence live operation with the production environment of the ITL on 29 September 2008. The Slovak registry successfully completed connection to ITL among other EU member states in October 2008 and is operational since.

P1.3.1 15/CMP.1 annex II.E paragraph 32.(a)

Change of name or contact:

No changes to name or contact information of the registry administrator have been made.

P1.3.2 15/CMP.1 annex II.E paragraph 32.(b)

Change of cooperation arrangement:

Slovak Republic does not cooperate with any other Party in maintaining the national registry therefore no changes to the names of the other Parties with which Slovak registry cooperate in maintaining the national registry consolidated have been made.

P1.3.3 15/CMP.1 annex II.E paragraph 32.(c)

Change to the database or the capacity of National Registry:

No changes to the database structure or the capacity of the Slovak Registry have been made.

P1.3.4 15/CMP.1 annex II.E paragraph 32.(d)

Change of conformance to technical standards:

No change to how the Slovak registry conforms to the technical standards for data exchange between registry systems has been made.

P1.3.5 15/CMP.1 annex II.E paragraph 32.(e)

Change of discrepancy procedures:

No changes to the procedures employed in the Slovak Registry to minimize discrepancies have been made.

P1.3.6 15/CMP.1 annex II.E paragraph 32.(f)

Change of Security:

No change to the security measures employed in Slovak Registry to prevent unauthorized manipulations and to prevent operator error has been made.

P1.3.7 15/CMP.1 annex II.E paragraph 32.(g)

Change of list of publicly available information:

No changes to the list of publicly accessible information have been made.

P1.3.8 15/CMP.1 annex II.E paragraph 32.(h)

Change of Internet address:

No change to the Internet address of Slovak Registry has been made.

P1.3.9 15/CMP.1 annex II.E paragraph 32.(i)

Change of data integrity measures:

No changes to the measure ensuring the integrity of data storage and the recovery of registry services in the event of disaster have been made.

P1.3.10 15/CMP.1 annex II.E paragraph 32.(j)

Change of test results:

No changes to the results of any test procedures have been made.

Public Information

P1.4.1 13/CMP Annex II paragraph 45

Account information is public and accessible through registry's website.

P1.4.2 13/CMP Annex II paragraph 46

Article 6 project information:

Slovakia is a host country of the project that has not yet been officially registered as the JI. No ERUs have been issued in 2008 for this potential JI project hosted by the Slovak Republic

P1.4.3 13/CMP Annex II paragraph 47

Holding and transaction information is confidential.

P1.4.4 13/CMP Annex II paragraph 48

Information about legal entities is public and accessible through registry's website.

Accounting of Kyoto Protocol Units

P.1.2.13 15/CMP.1 annex I.E paragraph 17

Actions and changes to address discrepancies:

Slovak registry encountered discrepant transactions with only two error codes (4003 and 4010) on one occasion. This was caused by the fact that the unit blocks transferred in these transactions were obtained previously from other registry. However other registry did not respond to the accept Notification sent by the ITL while SK accepted the transaction. This meant that the ITL still showed the unit blocks as being owned by other registry. Our participant then repeatedly tried to transfer unit blocks locked in this transaction which led to the discrepant transactions. The issue was solved by the Manual Intervention.

Slovak registry is unable to affect the flow of messages sent by ITL or their acceptance by other registries therefore no action or change was made to address the discrepancies that occurred. The participant was contacted and asked not to propose any further transactions with affected unit blocks as soon as the issue was notices as a precaution for further discrepant transactions.

Annex 5: Assessment of Completeness

The following Table shows sources of GHGs that are not estimated in the Slovak national GHG inventory, and the reasons for those sources being omitted. This table is taken from the CRF; "Table9(a)".

GHG	CRF sector	Source/sink category	Reason
CO_2, CH_4, N_2O	1. Energy	1.A.3d Navigation	No inland navigation source is relevant in the Slovak Republic. The navigation has international character and emissions are included in bunkers.
CO_2	1. Energy	1.B.1 Fugitive Emissions from Fuels – Coal Mining	The mining activities not produced CO_2 on measurable level.
N_2O	1. Energy	1.B Fugitive Emissions from Fuels	The mining activities and natural gas are not produced N_2O emissions on measurable level.
CO_2	2. Industrial Processes	2.A.5/6 Asphalt Roofing/Paving	No methodology available but considered negligible.
CO_2	2. Industrial Processes	2.A.7.1 Glass Production	Emissions from glass production are included in 1.A.3 limestone and dolomite use.
CH_4, N_2O	2. Industrial Processes	2.A.7.2 Magnesite Production	Emissions of CH_4 and N_2O from magnesite production are not relevant.
CO_2, CH_4, N_2O	2. Industrial Processes	2.B.3 Adipic Acid Production	Production of adipic acid is not occurred in the SR.
CO_2, CH_4, N_2O	2. Industrial Processes	2.B.4 Carbide Production	Emissions from carbide production are partly included in in 1.A.3 limestone and dolomite use.
CH_4	2. Industrial Processes	2.C.1 Iron and Steel Production	Emissions of methane from iron and steel production are included in sector 1. Energy, 2.A Production of iron and steel and are not technological.
CO_2, CH_4	2. Industrial Processes	2.C.2 Ferroalloy Production	Emissions from ferroalloy production are included in sector 1. Energy, 2.A Production of iron and steel and are not technological.
CO_2, CH_4	2. Industrial Processes	2.C.3 Aluminium Production	Emissions of methane from aluminium production are included in sector 1. Energy, 2.B Production of non ferrous metal and are not technological.
SF_6	2.Industrial Processes	2.C.4. Aluminium Foundries	Data not available, but assumed negligible
CO_2	3. Solvent and Other Product Use	3.A/B/C Paint Application, Degreasing, Chemical Product	Carbon equivalent of solvent use not estimated, methodology is not available.
N_2O	3. Solvent and Other Product Use	3.B Degreasing and Dry Cleaning	Emissions are not estimated, methodology is not available.
CO_2	5. Land-Use Change and Forestry	5.A.2.1 Cropland con. to FL	Emissions are included in 5.A.2.1. No detail data are available.
CO_2	5. Land-Use Change and Forestry	5.A.2.3 WL con. to FL	Emissions are included in 5.A.2.1. No detail data are available.
CO_2	5. Land-Use Change and Forestry	5.A.2.4 Settlements con. to FL	Emissions are included in 5.A.2.1. No detail data are available.
CO_2	5. Land-Use Change and	5.B.2 Land con. to CL	Input data are not available.

GHG	**CRF sector**	**Source/sink category**	**Reason**
	Forestry		
CO_2	5. Land-Use Change and Forestry	5.C.3/4 WL/Settlements con. to GL	Input data are not available.
CO_2	5. Land-Use Change and Forestry	5.D Wetlands	All emissions from wetlands are included in other land, because of not availability of data.
CO_2	5. Land-Use Change and Forestry	5.E Settlements	All emissions from wetlands are included in other land, because of not availability of data.
CO_2	5. Land-Use Change and Forestry	5.F.2.4/5 WL/Settlements con. to Other land	Input data are not available.
N_2O	5. Land-Use Change and Forestry	5 (I) Direct N_2O emissions from N fertilisation	Emissions are not estimated, but included in Agricultural sector.
CH_4, N_2O	5. Land-Use Change and Forestry	5 (II) N_2O emissions from drainage of soils.	Not important source in the SR.
N_2O	5. Land-Use Change and Forestry	5 (III) N_2O emissions from disturbance associated with LU conversion to CL.	Input data are not available.
CO_2	5. Land-Use Change and Forestry	5 (IV) CO_2 emissions from agricultural lime application.	Not important source in the SR.
CO_2	5. Land-Use Change and Forestry	5 (V) Biomass burning	Emissions are including in changes in living biomass category 5.A FL.
CO_2, CH_4	6. Waste	6.A.3 Other	Emissions are included in managed SWDS.
CO_2, N_2O	6. Waste	6.C Waste Incineration	Emissions are included in Energy sector, category Public electricity and heat production, because of energy use of incineration.
CH_4	6. Waste	6.B.1b Industrial Sludge	Emissions are included in category SWDS.
CH_4	6. Waste	6.B.2b Domestic Sludge	Emissions are included in category SWDS.

Annex 6: Reference Approach and Comparison with Sectoral Approach

The basis for reference approach calculation in the Slovak Republic are data gathered and processed annually by the Statistic Office of the SR (annual energy statistic balance) since the year 1990. These data are therefore official energy balance data. Profing Ltd. Bratislava is responsible for preparation of preliminary as well as final energy balance based on documents published officially by the Statistical Office of the SR. In principle, the figures for reference approach are estimated according to the totally different source of information and methodology as these achieved by the sectoral one. Reference approach based on official statistical databases represents top-down data on import, export and stock change balance as published in the Energy Statistics Yearbooks.

Information on the CO_2 reference approach, a comparison of that approach with the sectoral approach and relevant information on the national energy balance are given in Chapters 3.1.2 Fuel Combustion-Reference Approach (CRF 1.AB) and 3.1.3 Difference – Reference Approach and Sectoral Approach (CRF 1.AC).