

NATIONAL INVENTORY REPORT

**GREENHOUSE GAS EMISSION
INVENTORY IN SLOVAKIA
1990-2003**

BRATISLAVA 2005

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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Annex 1: The key source analysis and uncertainty management in the SR in 2003

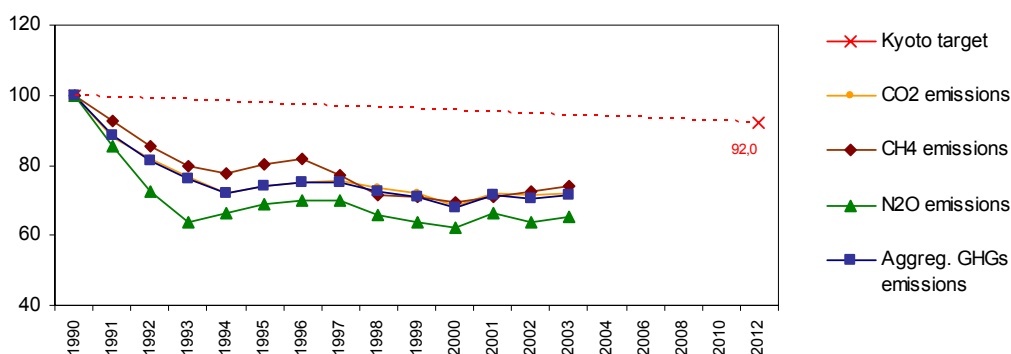
Annex 2: The emission factors from energy sector used in the SR in 2003

EXECUTIVE SUMMARY

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 (CO₂), methane (CH₄), and nitrous oxide (N₂O). Other greenhouse gases included in GHGs inventory are halogenated hydrocarbons (PFCs, HFCs) and SF₆, 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 (SO₂) and aerosol - reduce the greenhouse effect. According to the text of the Final Protocol from Kyoto, the countries of Annex I have agreed to reduce aggregated emissions of all greenhouse gases (CO₂, CH₄, N₂O, HFCs, PFCs and SF₆) on average by 5.2% from the level of the year 1990 during the first commitment period of the years 2008-2012. The Slovak republic (SR), as well as EU, has accepted a target to reduce emissions by 8% in comparison with their level in the base year 1990. The Slovak republic and the EU countries ratified the Kyoto Protocol on May 31, 2002.¹ The emissions of greenhouse gases decreased in EU-15 countries by 2.9%² in 2002 compared to the base year (1990) and in the new EU countries 33%² in 2002 below the base year level. In the SR, by adoption of the reduction commitment of the Kyoto Protocol, pressure is put on a formulation of an efficient strategy to mitigate greenhouse gas emissions.

Figure 1 GHG Emission trends compared with the Kyoto target in %



Note: CO₂ Emissions without LUC&F; emissions are determined as of 15.04.2005

ES.2 National circumstances

This National inventory report (NIR) presents the results of a greenhouse gas emissions inventory in the Slovak republic within the period 1990-2003 as well as summary results of NO_x, CO, NM VOC and SO₂ emissions. The base year in view of the UN Framework Convention and the Kyoto Protocol for the Slovak republic is the year 1990 for all GHGs except halogenated hydrocarbons (PFCs, HFCs) and SF₆, where reference year is the year 1995. The inventory was developed in compliance with the

¹ Kyoto Protocol came into force on February 14, 2005

² European Environmental Agency: GHG Emission Trends and Projections in Europe, 2004

methodology indicated in the IPCC 1996 Revised Guidelines. Detailed inventory results have submitted in CRF format to the DG ENV by January 15, 2005.³

ES.3 Overview of source and sink

In the period 1991-2003, the total greenhouse gas emissions in the Slovak republic did not exceed the level of the year 1990 (Figure 1). The national total emissions determined as of April 15, 2005 are shown in Table 1.

Table 1 The total anthropogenic greenhouse gas emissions

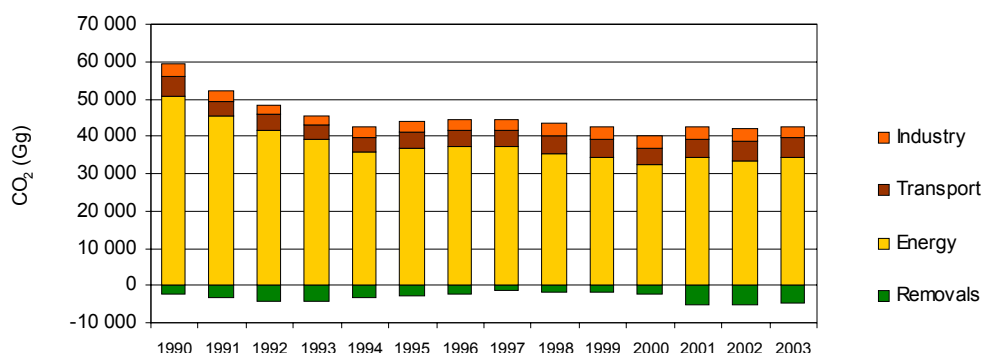
Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Gas	CO ₂ equivalent (Tg)													
CO ₂	59.4	52.1	48.4	45.4	42.4	43.8	44.4	44.7	43.6	42.6	40.1	42.6	42.3	42.8
CH ₄	6.3	5.9	5.5	5.1	5.0	5.2	5.2	4.9	4.7	4.6	4.6	4.6	4.7	4.7
N ₂ O	6.0	5.2	4.4	3.9	4.1	4.2	4.2	4.3	4.0	3.8	3.8	4.0	3.9	3.9
F-Gases	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
GHGs*	72.1	63.5	58.6	54.6	51.7	53.4	54.0	54.0	52.4	51.2	48.6	51.3	50.9	51.6

*Total aggregated GHGs emission without LUC&F

ES.4 CO₂ emissions

A most important anthropogenic source of CO₂ emissions in the atmosphere is combustion and transformation of fossil fuels, which account for about 95% of the total CO₂ emissions in the SR. A calculation of CO₂ emissions is based on energy statistical data when the IPCC reference method (Reference 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 CO₂ emissions arising during aluminium and ammonia production (Figure 2). 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.

Figure 2 A share of individual sector on CO₂ emissions (Gg) in 1990-2003



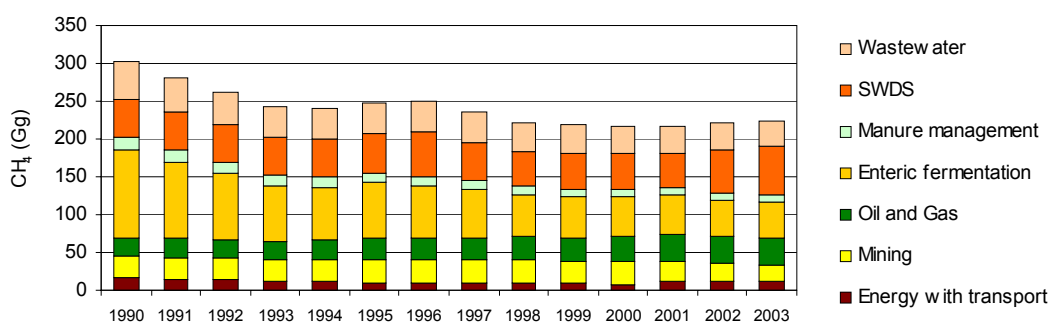
Note: CO₂ Emissions without LUC&F; emissions are determined as of 15.04.2005

³ CRF 2003 Submission 2005, NIR 2005

ES.5 CH₄ emissions

Agriculture, large-scale beef cattle and pig breeding, are major sources of methane on the Slovak territory. The CH₄ 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 republic⁴ and the Green Report⁵ of the Slovak Ministry of Agriculture. 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 (Figure 3).

Figure 3 A share of individual sector on CH₄ emissions (Gg) in 1990-2003

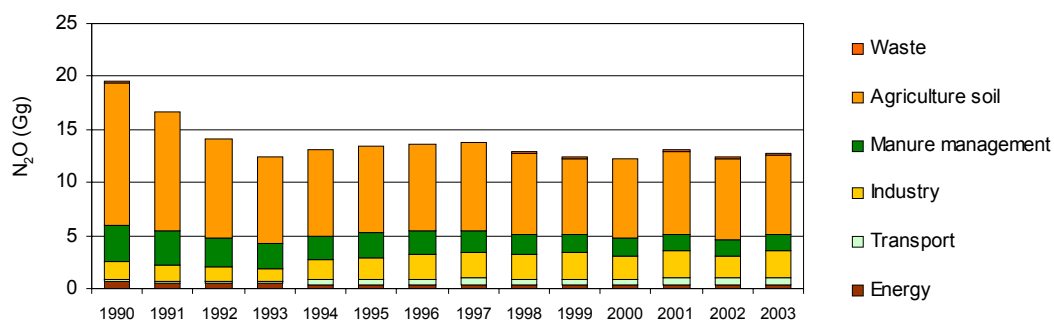


Note: CH₄ Emissions; emissions are determined as of 15.04.2005

ES.6 N₂O emissions

In comparison with other greenhouse gases, the mechanism of N₂O 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 N₂O in the Slovak republic are agriculture, waste treatment and N₂O from combustion of fuels (energy and transport) (Figure 4).

Figure 4 A share of individual sectors in N₂O emissions (Gg) in 1990-2003



Note: N₂O Emissions; emissions are determined as of 15.04.2005

⁴ Statistic Office of the Slovak Republic (updated every year) <http://www.statistics.sk>

⁵ Slovak Ministry of Agriculture (updated every year) <http://www.mpsr.sk>

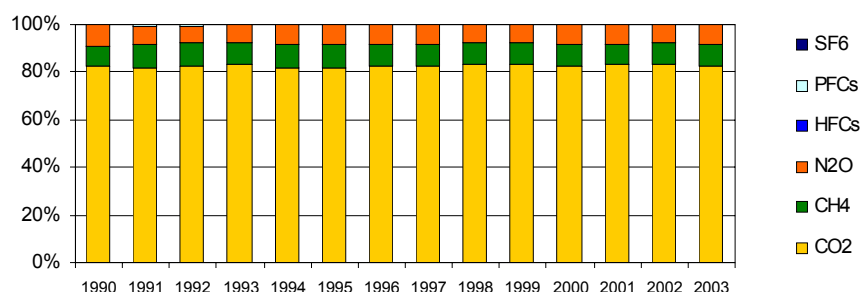
ES.7 HFCs, PFCs and SF₆ emissions

The first inventory of these substances⁶ was executed in 1995. HFCs, PFCs and SF₆ 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 (SF₆).

ES.8 Aggregated emissions

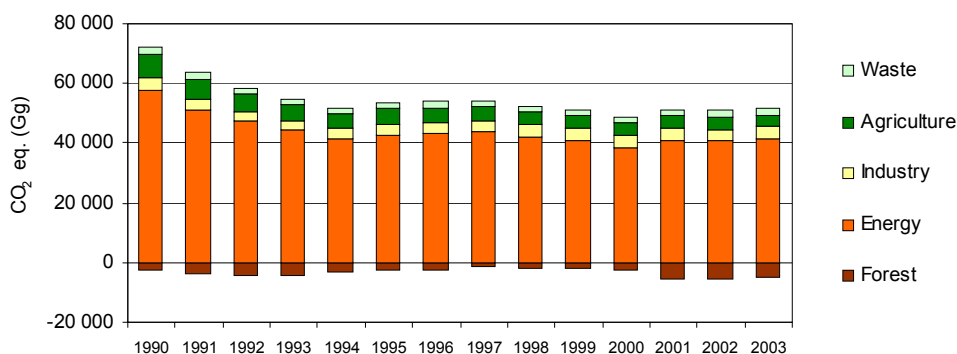
These are the emissions of greenhouse gases recalculated via GWP100 (Global Warming Potential)⁷ on the CO₂ equivalent. Expressed as the CO₂ equivalent, carbon dioxide emissions contributed by more than 80% to the total emissions, CH₄ (GWP = 21) emissions by about 10%, N₂O (GWP = 310) emissions by about 7% and the contribution of "F-gases" is below 1% (Figure 5, 6).

Figure 5 The aggregated emissions of greenhouse gases in 1990-2003 in %



Note: CO₂ Emissions without LUC&F; emissions are determined as of 15.04.2005

Figure 6 The aggregated emissions of greenhouse gases by sectors in 1990-2003



Note: Aggregated emissions are determined as of 15.04.2005

⁶ 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. Freons 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.

⁷ According to the currently valid Convention, the emission reduction expressed in CO₂ equivalent should be reported

ES.9 Indirect greenhouse gases

A major source of SO₂, 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 emission factor for 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, 2005⁸. 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 Act⁹ 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 (Table 2).

Table 2 The anthropogenic emissions of NO_x, CO, NM VOC and SO₂ (Gg) in 1990-2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO	505	482	441	452	427	416	359	359	342	330	307	309	306	302
Stationary	345	335	296	297	268	255	204	201	183	180	179	169	159	178
Transport	154	142	141	151	155	157	151	153	154	145	122	134	141	118
Other*	6	5	4	4	4	4	4	5	5	5	6	6	6	6
NO_x	222	201	188	180	170	178	135	127	133	121	109	108	105	98
Stationary	165	154	144	138	126	133	90	82	87	78	71	67	60	59
Transport	57	47	44	42	44	45	45	45	46	43	38	41	45	39
Other*	0.35	0.28	0.23	0.24	0.2	0.23	0.25	0.27	0.26	0.3	0.33	0.33	0.33	0.36
NM VOC	138	NE	NE	113	NE	107	105	95	92	85	80	83	82	82
Energy	13	NE	NE	12	NE	10	10	8	9	8	8	9	8	8
Industry	11	NE	NE	8	NE	5	5	5	3	3	3	3	3	3
Crude oil	26	NE	NE	20	NE	17	17	17	15	13	13	12	12	12
Sol. Use	48	NE	NE	38	NE	41	40	32	32	29	30	31	31	32
Transport	35	NE	NE	31	NE	33	32	32	32	29	25	27	27	26
Other**	5	NE	NE	2	NE	1	1	1	1	1	1	1	1	1
SO₂	526	445	390	328	245	246	231	205	184	173	127	131	103	106
Stationary	523	442	388	326	243	244	228	202	181	172	126	130	102	105
Transport	3	3	2	2	2	2	3	3	3	1	1	1	1	1

* Biomass burning and forest fires ** waste, agriculture

Note: emissions are determined as of 15.04.2005

1 INTRODUCTION

1.1 Background information on GHG inventories and climate change

Global climate change due to the anthropogenic emission of greenhouse gases is the most important environmental problem in the history of humankind. 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.

⁸ Preparation for revision

⁹ Act 478/2002 on air protection, www.enviro.gov.sk

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 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 (H₂O), 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 (CO₂) contributes to the greenhouse effect 30%, methane (CH₄), nitrous oxide (N₂O) and ozone (O₃), all three together 3%. The group of synthetic (artificial) substances - chlorofluorocarbons (CFCs), their substitutes, hydrofluorocarbons (HCFCs, HFCs) and others such as fluorocarbons (PFCs) and SF₆, 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 CO₂, CH₄, N₂O 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.

Globally¹⁰ the annual anthropogenic emission of carbon dioxide ranges between 4-8 billion tons of carbon (about 4t of CO₂ per capita in the globe). The most important source of "new" carbon dioxide is presented by the fossil fuel combustion and cement production. The CO₂ 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 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

¹⁰ Climate change 1995, *The Science of Climate Change, Contribution of WG1 to the 2nd Assessment Report*

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 CO₂, 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 (IPCC¹¹ 1995). PFCs, HCFCs, HFCs (perfluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, etc.) and SF₆ 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 (CF₄) of 50 000 years. It means that even minor emissions have a great negative effect. The ground level ozone concentrations are growing as a consequence of CO, NO_x and NM VOC emissions. They have very important source in exhaust gases, fossil fuel combustion and as far as NM VOCs are considered, the use of solvents, as well. N₂O enters the atmosphere from several small sources. The most important source does seem to be the emission from soil (nitrogen surpluses because of intensive fertilising and inconvenient agriculture-technical procedures). Fuel combustion, some industrial technologies, large-scale livestock breeding and sewage are the sources of N₂O 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 N₂O is disintegrated mainly photo chemically in the stratosphere.

1.2 Institutional arrangement

Ministry of Environment (MoE) of the Slovak republic, Department of Air Protection is the national focal point to the UN FCCC. MoE is granting and supervising development and maintenance of national emission inventories on annual bases. Slovak Hydrometeorological Institute (SHMI), Department of Air Quality (DoAQ) is responsible for coordination and compilation of national emission inventories for all pollutants. SHMI also prepares inventories for international reporting to the UN FCCC and UNECE. SHMI is responsible also for filling the new obligations regarding the EU legislation in air protection and climate change. Slovak Environmental Agency has responsibility for official correspondence between EU and the Slovak republic and SEA is a partner organization to the EEA.

National emission inventories are compiled on contractual bases annually, in cooperation with external consultants, NGOs, scientific institutes and universities (Profing – company for energy research, Agricultural University, Research Institute for Transport, Chemical Technical University, Forestry Research Institute, Association for cooling and air condition technique, Central register for waste and wastewater etc.).

The SHMI is up to that developing and maintaining a National Emission Inventory System (NEIS) - database of stationary sources to follow development of emissions of SO₂, NO_x, CO at regional level and to fulfill reporting commitments of national and EU Directives. The NEIS software product is constructed as a multi-module system, corresponding fully to the requirements of current legislation. The NEIS database contains also some technical information about sources like fuel consumption and use for estimation of Sectoral Approach.

¹¹ 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.

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

1.3 Process of inventory preparation

The emissions of GHGs in the Slovak republic were estimated in compliance with the methods provided in IPCC 1996 Revised Guidelines¹² and Good Practice Guidance (GPG)¹³ and the national methodology in important categories. The values listed in Tables are updated annually if information provided in the Statistical Yearbook of the SR is revised and/or if methodology is changed.

1.4 General description of methodologies and data sources

Slovak Inventory Agency (SHMI) is using only official IPCC methodology.^{12,13} The data sources are based on official statistical information.

Energy sector - National energy balance of CO₂ emissions are based on the Statistic Office of SR data source for fuels consumption in all relevant categories. The SR is using reference approach as a national total emission's estimate of CO₂. The data of fuels consumption in sectoral approach are based on database NEIS. For preparation of emission inventory in energy sector was used the IPCC Tier 1 and 2 methodology.

Transport sector - The emission balance from road transport was established by using the COPERT III method (EEA, ETC/ACC 2001) and the consistent dataset was recalculated from the base year (1990). The emissions of GHGs from off-road transport were calculated by using CORINAIR.¹⁴

Fugitive emission sector - The fugitive emissions from mining and gas distribution were calculated based on the IPCC Methodology¹² and Good Practice Guidance¹³ by using Tier 1 and Tier 2, IEA CIAB and national data. The sources of data were the Statistic Office of SR (SO), Ministry of Economy (MoE) and Slovak Gas Industry (SGI).

Industry sector - This sectoral emission inventory summarizes the emissions of greenhouse gases and precursors CO₂, CH₄, N₂O, NO_x, CO, NM VOC, SO₂, CF₄, C₂F₆, and SF₆ produced by industry in the Slovak republic in each inventory year, followed the instructions of the IPCC Methodology¹² and IPCC Good Practice Guidance.¹³ The information used in the sector was obtained from different sources, the Statistic Office of SR and major sources of industrial production information.

"F-Gases" sector - 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.¹²

Solvent and other product use sector - The emissions of NM VOC from this source category are estimated based on CORINAIR methodology¹⁴ since 1990.

Agricultural sector - The sources of N₂O and CH₄ emissions from agriculture are analyzed according to IPCC Methodology,¹² when principles of Good Practice¹³ 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.¹⁵

¹² Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventory, Volume 1-3, IPCC 1996

¹³ Good Practice Guidance and Uncertainty Management in National GHGs Inventories, IPCC 2000

¹⁴ CORINAIR Emission Inventory Guidebook, revised 2003

¹⁵ The Census of sowing areas of field crops in the SR; Annual Census of domestic livestock in the SR; Green Report of the SR, MoA, 1998-2003; The Statistical Yearbook of the SR, SSO, 1990-2003

Land use change and forestry sector - Results of calculations were obtained by using the IPCC Methodology¹² and the national data on wood volume increments for individual forest tree species, and results of a roundwood harvest inventory.

Waste sector - Emissions of methane from SWDS and wastewater management were estimated by using the IPCC Methodology¹² Tier 1 method and Good Practice Guidance.¹³ The emissions of N₂O from wastewater management were estimated by using both IPCC and ISI¹⁶ methodology. For the national emission inventory was used ISI methodology, which brings the more comparable and consistence dataset in time.

Other sectors - Other sectors are not relevant in national emission inventory balance.

1.5 Description of key sources

To reduce uncertainty in emission inventory is important to recognise the key source categories. 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 2005 followed the Good Practice Guidance.¹³ The Slovak republic determined in year 2003 fourteen key source categories by level assessment and sixteen key source categories by trend assessment.¹⁷ The most important key source categories in the SR are fuel combustion, road transport, the emissions of CO₂ from agricultural soil etc.

1.6 QA/QC procedure

The emission estimates elaborated for individual sectors by external consultants are controlled and recalculated at the DoAQ on the SHMI. 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.). Energy balance from energy statistics is compared with summary fuel consumption reported by sources. Fuel consumption in transport sector 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 Emission System. Structural changes of the current national inventory system, 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.

1.7 General uncertainty evaluation

The uncertainty of estimation of CO₂ 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 as a result 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.¹³ The calculation uncertainty by using the more sophisticated Tier 2 - Monte Carlo method was at this time impossible due to the lack of input data and resources. Even though the Tier 1 uncertainty analysis were estimated the uncertainties to be 9.99% by level assessment and 3.15% by trend assessment.¹⁷

¹⁶ *Forschungsbericht 93-104 02 682: Anthropogene N₂O und CH₄ emissionen in der BRD, Fraunhofer – Institut fuer systemtechnik und innovationsforschung, Karlsruhe 6, 1993*

¹⁷ *Key sources & Uncertainty in the SR (Annex I)*

1.8 General assessment of the completeness

The Slovak republic is reported in its CRF 2003 submission 2005 no gases or source/sink categories as not estimated (NE), those categories, whose are reported as included elsewhere (IE) are explained in Table 9s1 CRF. The additional GHG emissions are not reported. In some categories (waste incineration, off-road transport etc.) are not consistent the data from the base year caused by lack of input data and resources, but the SHMI in cooperation with MoE is doing number of steps for improving the actual status in inventory completeness.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Emission trends for aggregated GHG emissions

In accordance with the generally expected results, the aggregated emission of GHGs in year 2003 moderate increased comparable to the year 2002 about more than 700 Gg without LUC&F (app. 1%). There is the significant decreasing of aggregated emission against the base year (1990) about approximately 20 463 Gg it means the decreasing about almost 30%. The total national emission in the current year 2003 was estimated to be 51 641.44 Gg without LUC&F sector and the net GHG emission was 46 758.80 Gg including the LUC&F. The Slovak republic reported the national emission from energy sector based on reference approach data in 2003 to be 41 444.84 Gg including the transport emissions (5 370 Gg), which represent decrease compare the base year by about 28%. The total emissions from industry sector in 2003 were estimated to be 3 938.28 Gg (decrease compare the base year by about 8%), the emissions from agriculture sector were estimated to be 4 016.58 Gg (decrease compare the base year by about 50%), the emissions from waste sector were estimated to be 2 223.23 Gg (no decrease was registered, because of including the waste incineration from year 2000). The emissions from solvent use and other sectors were estimated to be 0 Gg, the total sinks from LUC&F were estimated to be -4 864.12 Gg. A major share of aggregated emission covers the energy sector by about 80%, the industry sector covers about 8%, the agricultural sector about 8% and the waste sector about 4% (Figure 7). The major share of aggregated emission covers CO₂ emissions by about 83%, CH₄ emissions by about 9.1%, N₂O emissions by about 7.6% and "F-gases" emissions by about 0.3% (Figure 8).

Figure 7 The aggregated GHG emissions by sectors in 2003

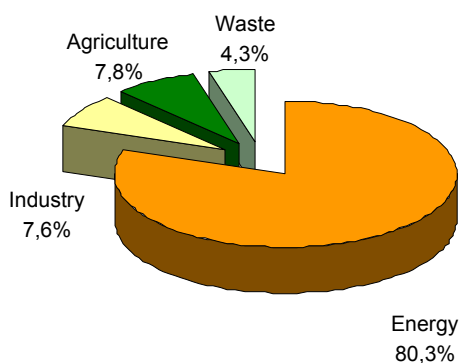
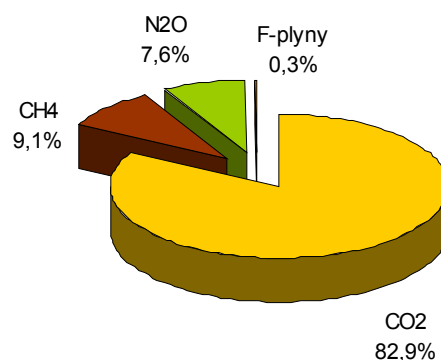


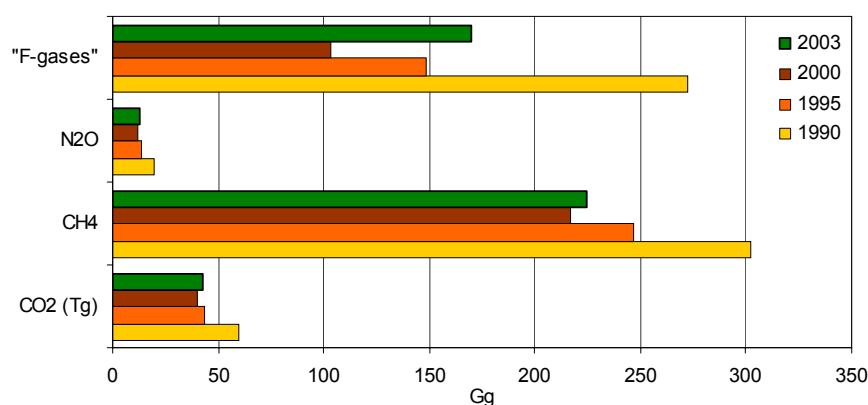
Figure 8 The aggregated GHG emissions by gases in 2003



2.2 Emission trend by gas

The total anthropogenic emissions of carbon dioxide decreased relating to the base year (1990) by about 28% without LUC&F and represented in current year 42 816.85 Gg without LUC&F. The total anthropogenic emissions of methane reached in the 2003 over 224 Gg and increased relating the previous year about 2.4 Gg. The significant increasing of CH₄ emissions from waste management caused this effect. On the other hand, the total anthropogenic emissions remarked the 26% decreasing comparable with the base year (1990). The total emissions of N₂O decreased relating the previous year to 12.73 Gg and increased relating the previous year about 0.3 Gg. The total decreasing comparable with the base year presents 35%. The total emissions of "F-gases" represented 169.73 Gg and are increased comparable with the previous year's inventory by about 40 Gg, but beside the base year (1990) shows a more than 50% decreasing (13% beside 1995), caused by decreasing a consumption of perfluorocarbons (Figure 9).

Figure 9 The emission trends by gas in 2003

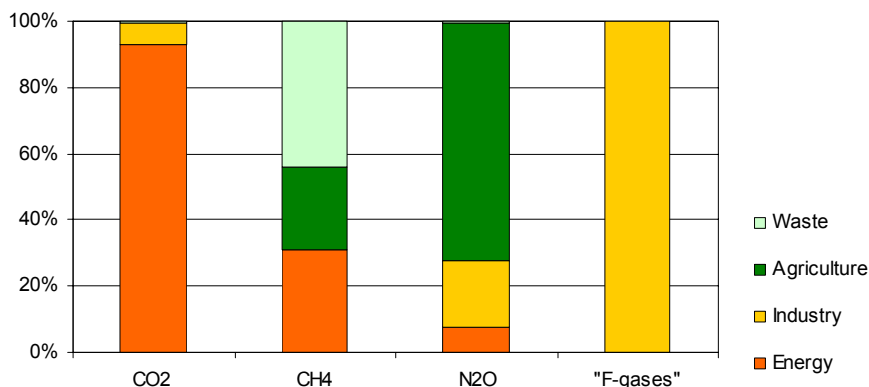


*The total anthropogenic emissions of CO₂ are depicted in Tg (not in scale)

2.3 Emission trend by source

The major share of CO₂ emissions is from energy sector (fuel combustion, transport) with more than 92% from the total carbon dioxide emissions in last 2003 inventory. More than 40% of CH₄ emissions produces waste sector (SWDS), more than 70% of N₂O emissions produces agricultural sector (fermentation) and 100% "F-gases" emissions come from industry sector as depicted on Figure 10.

Figure 10 The emission trends by source in 2003



2.4 Emission trends for indirect GHGs and SO₂

The total anthropogenic emission of NO_x was estimated to 98.06 Gg and the major share was produced by energy sector. The total emission of CO was estimated to 308.18 Gg and the major share of emissions was produced by energy sector. The emission of NM VOC was estimated to 82.24 Gg per year 2003 and the major share was produced by energy, industry and solvent-use sectors. The emissions of SO₂ were estimated to 106.10 Gg per year 2003 and the major share of emissions was produced by energy sector.

3 ENERGY SECTOR

3.1 Combustion of fuels

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). Profing Ltd. Bratislava (the company for energetic research) executed the preparation of preliminary energy balance based on published materials. Profing Ltd. Bratislava namely director Dr. Jan Judak is the external consultant for energetic questions in 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. 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 Statistic Office annually. 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).¹⁸ The national emission factors are not in use for this time, but Slovakia will accentuate the determination of most important national emission factors. The values of fraction of carbon oxidized were changed followed the recommendation of Commission Decision 2004/156/EC (0.995 for liquid and gaseous fuels, 0.99 for solid fuels). Slovakia is using Reference approach as a national total emission estimate of CO₂, while consistent data series since 1990 exist only for this approach. The total anthropogenic emission of carbon dioxide from energy sector – fuel combustion was estimated in national inventory 2003 submission 2005 to be 39 692.28 Gg as a national total CO₂ emissions (Figure 11).

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. 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 SHMI, what 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 MoE No 6/2000). The first collection and processing of data in module NEIS was realized in 2001 on SHMI. New system contained 925 large point sources from 79

¹⁸ Profing Ltd. The list of emission factors for individual fuels type, 2003 (Annex 2)

the NEIS BU district databases in 2003. 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 2003 system NEIS registered 12 697 medium sources of the heating output of 0.2-5 MW. The emission balance in 2000-2003 was 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.

Figure 11 A distribution of CO₂ emissions in type of fuels in RA in 2003

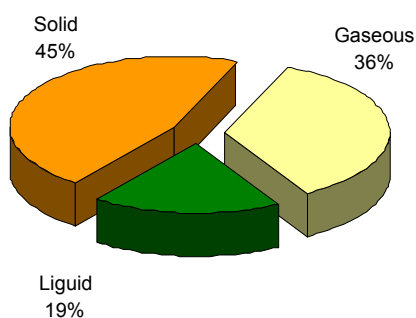
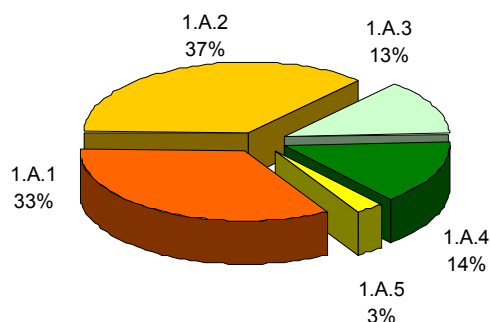
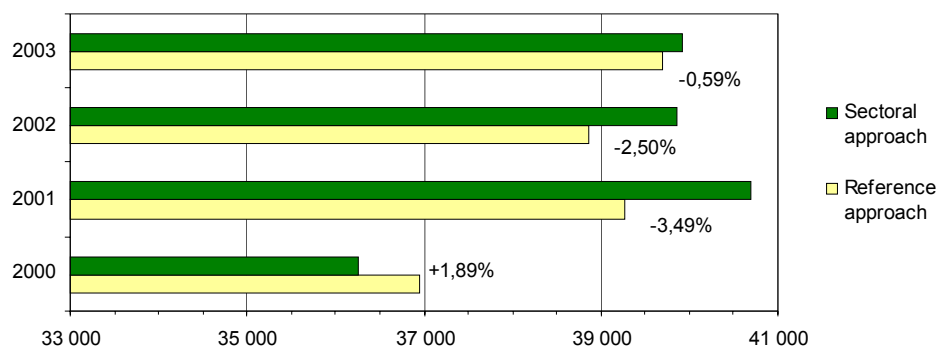


Figure 12 A distribution of CO₂ emissions in the IPCC categories in SA in 2003



The energy balance “bottom up” using the IPCC¹² detail method Tier 2 was used to estimate Sectoral approach in CRF 2003 to be 39 928.93 Gg of CO₂ (Figure 12). The CRF sectoral background tables 1.A(a)s1-4 are estimated and fill in according the parameters published by operators of large, medium and small sources in NEIS system. Each operator is obligate to publish type of production, amount of consumed fuel's types in kt, separation of fuel use for combustion and technology, fuel's type of specific NCVs and other relevant parameters. The emission factors for each IPCC subcategory 1.A.1-5 and each fuel type (coking coal, lignite, natural gas etc.) are used based on recommendation IPCC Guidelines and experts from Profing Ltd. Bratislava.¹⁸

Figure 13 A comparison of SA and RA in 2000, 2001, 2002 and 2003



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 -0.59% (Figure 13). 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 Sectoral approach, the quantities of fuels used in blast furnace (IPCC category 1.A.2a – solid fuels and gaseous fuels) were excluded from energy balance and the quantities of residual carbon from combustion which stayed in products were excluded from energy balance (IPCC categories 1.A.1c – other fuels and 1.A.2c – liquid and gaseous fuels). Since 1990, the total fuel combustion decreased significantly and the share of natural gas as an alternative fuel type increased. After the medium increase of solid fuels in 2001, the slightly decreasing in 2002 and 2003 was appeared in Reference approach balance. The balance of solid fuels consumption is complicated with the calculation of the stock change. The Statistic Office of the SR updates the fuel's categories and methodology for stock fuel annually. Therefore, it is a problematic situation with providing the consistent data series in last year's inventories in Reference approach. A consumption of biomass is not included in the total CO₂ emission balance. The emissions of CO₂ from these 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.¹⁷ The emission balance of other GHGs (CH₄, N₂O) from 1.A.1-5 IPCC categories was estimated by using IPCC methodology¹² and default emission factors in like manner as previous year. These categories are not key source.¹⁷ Using the IPCC methodology,¹² 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 fertilisers) was estimated. The total amount of carbon stored in products in 2003 was determined to 764.22 Gg of carbon, which represents a stable trend against the year 2002. 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 balance.

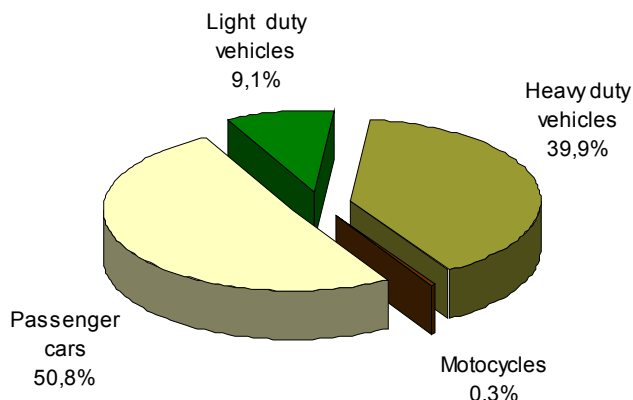
Slovakia is preparing the deep revision of national energetic balance from 1990-2003. The base problem is to change inventory methodology from Reference approach (the national energetic total from 1990) to the Sectoral approach (now only informative character). The revision will be touch the fuels base, NCV and emission factors in base year 1990 accordance the new facts from operators the most important plants. The revision was started this year and will be develop with the Profing Ltd. company. The project is plant to finish by 31.12.2005 and the first results will be known in submission 2006.

3.2 Transport

The transport 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.¹⁷ The total emissions of CO₂ from road and off-road (railway, marine and air) transport reached in 2003 inventory 5 143.03 Gg. The major share 4 868.80 Gg belongs to the road transport. The emissions from road transport were calculated by using COPERT III method and the consistent data series from 1990 were determined in cooperation with external experts Dr. J. Breziansky and Mr. J. Pinter from Research Institute of Transport in Zilina. The more information is depicted on Figure 14. The emissions from aviation transport were represented a total anthropogenic pollution of airport environment. The emission of GHGs (1.A.3.a) from civil aviation was estimated based on LTO cycles. The number of the LTO cycles in inventory year 2003 was 27 598 cycles. The total consumption of jet kerosene was 20 242.7 t (25 952 155 l) and the consumption of aviation gasoline was 215.6 t (291 304 l). The CO₂ emission factors (EFs) from consumption of aviation gasoline and jet kerosene are irrelevant (Table 1.A.3a), the estimation of emissions from aviation was based on Tier 2 method (LTO cycles) using the corresponding default EFs from this methodology and not from consumption of fuels.

Figure 14

A share of individual vehicles in road transport in 2003



The emissions from international bunkers from aviation were improved in the last year and the expert's judgment was used in this estimation. A total consumption of gasoline was divided in domestic consumption (80%) and international consumption (20%). The total consumption of jet kerosene was estimated in opposite ratio (25% of domestic and 75% of international consumption). This is only expert's estimate from fuels sale in the six international airports on the Slovak territory. There is no relationship between international bunkers from aviation and the total emissions of CO₂ from aviation, which are based on LTO cycles. A consumption of gas/diesel oil from railway and navigation transport is used only for domestic purposes.

3.3 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.¹⁷ A total methane emission from underground mining was estimated to be 21.11 Gg. The Slovak inventory team with cooperation of Profing Ltd. was provided the revision of emissions and emission factors for underground mining and handling during the last year 2004 because the emissions factors used until presence 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.

Mining and handling

The fugitive methane emissions from underground coal mining and post - mining in the Slovak republic were estimated as follows:

A. Data of coal production from single underground mines have been obtained from official sources – companies: HBP, a.s., Baňa Dolina, a.s. a Baňa Záhorie, a.s., and Ministry of Economy of SR and Statistic Office of SR. The Table 3 provides the values of coal production from 1990.

B. For the calculation of fugitive methane emissions there were used the emission factors from following sources (Table 4):

1. IPCC Guidance for National Greenhouse Gas Inventories, Fugitive sources, 1.4 Methane Emissions from Coal Mining and Handling Activities
2. IEA - CIAB Global Methane and the Coal Industry¹⁹
3. EF(CH₄) specified of mines operator - HBP, a.s.

¹⁹ <http://spider.iea.org/ciab/>

C. For the calculation used assumptions - fugitive methane emissions don't use to electricity and heat production, and don't flare for reducing methane emissions from coal mining.

Emission factors according to IPCC Guidance - for all mines have been used the identical values 10 m³ CH₄/t for mining and 0.9 m³ CH₄/t for post-mining. Both values are on the lower level of the suggested scale. Emission factors according to IEA – CIAB – the published values for mining were assigned according to the depth of the mines within 6 a 13 m³ CH₄/t and 0.9 m³ CH₄/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 (CH₄) specified of the mines operator - HBP, a.s. on the base of measurement concentration values of the methane and amount of ventilation air data, were assigned to single mines according to suggestion of the operators. EF (CH₄) for post – mining have been used from IPCC 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.

Table 3 The total coal production in the SR during 1992-2008*

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004*	2005*	2006*	2007*	2008*
	Brown coal (kt)																
Mining sum BC	3 804	3 614	3 745	3 759	3 840	3 914	3 951	3 807	3 649	3 424	3 401	3 075	3 105	2 770	2 570	2 460	2 400

* Predicted projection of coal production

Table 4 EF_{CH₄} for coal mining a handling assigned to single mines in SR

Mine	Mine Nováky	Mine Nováky 6.ŤÚ	Mine Cígel'	Mine Cígel' 7.ŤÚ	Mine Handlová	Mine Handlová VŠ	Mine Dolina	Mine Záhorie
Depth of mine [m]	200	200	500	500	500-1500	500-1500	600	400
	EF _{CH4} [m ³ /t]							
1. IPCC Guidance for National Greenhouse Gas Inventories								
IPCC mining tier1	10	10	10	10	10	10	10	10
IPCC post mining	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
2. IEA - CIAB Global Methane and the Coal Industry								
EF(CIAB) mining	6	6	13	13	13	13	13	13
IPCC post mining	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
3. EF _{CH4} specified of the mines operator - HBP, a.s.								
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

The Figure 15 below shows comparison of trends emissions CH₄ in SR in years 1992 - 2008, calculated according to IPCC, IEA-CIAB methodology and EFCH₄ HBP a.s. In the case of emissions calculation with using of IPCC emission factors, the trend of fugitive emissions CH₄ is declining in accordance to reduction of coal mining in SR. Application EF (CH₄) specified of mines operator (HBP, a.s.) - trend of fugitive emissions CH₄ is increasing in contradiction with reduction of coal mining in SR. It is due to the moving of coal mining to parts of mines with coal containing more of gas. The fugitive methane emissions in the period 1990 – 2008 were calculated on the base of coal production from single underground mines, obtained from official sources – companies HBP, a.s., Baňa Dolina, a.s. a Baňa Záhorie, a.s., and Ministry of Economy of SR and Statistic Office of SR. For the balance of the fugitive methane emissions from coal mining and post - mining in SR, we used the value, calculated

according to the methodology IEA -CIAB Global Methane and the Coal Industry according to the depth of the mines (see Table 4 point 2.). Table 5 presents recalculated fugitive emissions from mining and handling and the post – mining activities during 1990-2003.

Figure 15 Comparison of trends emissions CH₄ in SR in years 1992 - 2008

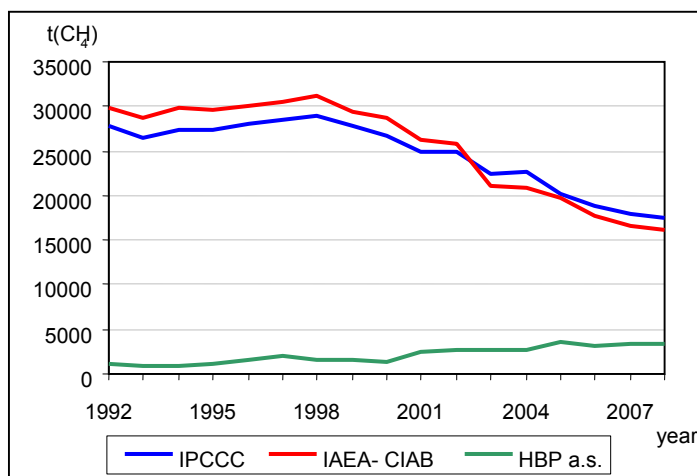


Table 5 The total CH₄ fugitive emissions from mining and post – mining activities in the SR in 1990-2003

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Fugitive emissions of CH ₄ (Gg)														
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

Production of oil and natural gas

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.¹⁷ The total methane emissions represent 35.2 Gg and were recalculated back to the base year because of estimation of emissions from venting and flaring. The fugitive emissions CH₄ from transport and distribution of natural gas in SR have been calculated from following data:

A. Data of NG have been obtained from official sources – Slovak gas industry, Ministry of Economy of SR and Statistic Office of SR (Table 6).

B. For the calculation of fugitive methane emissions, there were used the emission factors from the following sources:

1. IPCC Guidance for National Greenhouse Gas Inventories, Reference manual, Fugitive sources, 1.9 Fugitive Emissions from Oil and Natural Gas Activities;
2. IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories 2.7 Fugitive Emissions from Oil and gas operation; The table 3 in GPG gives of EF used for calculation.

C. Emissions from compression stations and pipelines were calculated on the base of gas leakages according to Slovak gas industry methodology.

Distribution losses of NG in SR are 143 mil.m³ (95 402 t CH₄) according to preliminary balances of gas fuels in year 2003 (Statistic Office of SR). This value represented approximately 2% of total NG consumption in SR.

Table 6 The data in year 2003 - production, export and import NG in SR

SR	Natural gas m³
Indigenous production	234 000 000
Associated gas	18 000 000
Nonassociated gas	216 000 000
Stock changes	1 000 000
Gas vented	7 000 000
Gas flared	9 000 000
Export	4 000 000
Import	6 795 000 000
Inland consumption	7 026 000 000

The fugitive emissions from transport and distribution of NG were calculated according using the new emissions factor refined EF (CH₄) for tier 1, based on North America data - IPCC Good Practice Guidelines, Table 2-16 (max. level of emissions - 35 164 t CH₄). In the Table 7 are presented of fugitive methane emissions for activities related to NG and Oil operations, calculated with applications new refined EF (CH₄) (high) for tier 1, based on North America data.

Table 7 New refined EF (CH₄) for tier 1, based on the balance in North America

Category	emission type	EF(low)	EF(high)	unit
NG production	fugitive	2.60E-03	2.90E-03	GgCH ₄ /mil.m ³ NG
	flaring	1.10E-05	1.10E-05	GgCH ₄ /mil.m ³ NG
NG processing	fugitive	6.90E-04	10.7E-04	GgCH ₄ /mil.m ³ NG
	flaring	1.30E-05	1.30E-05	GgCH ₄ /mil.m ³ NG
NG transmission	fugitive	2.10E-03	2.90E-03	GgCH ₄ /km of pipeline
	venting	0.80E-03	1.20E-03	GgCH ₄ /km of pipeline
NG storage	all	4.30E-04	42.0E-04	GgCH ₄ /mil.m ³ of withdraw. NG
NG distribution	all	5.20E-04	7.10E-04	GgCH ₄ /km of distribut. mains
Oil production	fugitive	1.40E-03	1.50E-03	GgCH ₄ /mil.m ³ Oil
	venting	6.20E-05	27.0E-05	GgCH ₄ /mil.m ³ Oil
	flaring	0.50E-05	27.0E-05	GgCH ₄ /mil.m ³ Oil
Oil transportation	all	5.40E-06	5.40E-06	GgCH ₄ /mil.m ³ Oil- pipeline

The results of the calculated fugitive methane emissions (Table 8) shows, that disaggregating of gas and oil industry to main- and sub- categories according to principles „good practice“ improved balances. The results received from the calculation of methane emissions with applications new refined EF (CH₄) (high) for tier 1, based on North America data are the most real values. The trend of fugitive emissions CH₄ from transport and distribution of natural gas in SR is increasing. It is due to the expansion of the distributed system and growth of NG consumption in SR.

Table 8 Fugitive methane emissions calculated with applications new refined EF (CH₄)

Category	Quantity	Unit	EF(low)	EF(high)	CH ₄ (low)	CH ₄ (high)
			GgCH ₄ /mil.m ³ NG GgCH ₄ /km	GgCH ₄ /mil.m ³ NG GgCH ₄ /km	t CH ₄	t CH ₄
NG* production fugitive	234 000 000	m ³ ZP	2.60E-03	2.90E-03	4 633.1	4 633.1
NG* production flaring	234 000 000	m ³ ZP	1.10E-05	1.10E-05	113.5	113.5
NG processing fugitive	234 000 000	m ³ ZP	6.90E-04	1.07E-03	161.5	250.4
NG processing flaring	234 000 000	m ³ ZP	1.30E-05	1.30E-05	3.04	3.04
NG storage fugitive	32 542 000	m ³ ZP	4.30E-04	4.20E-03	13.99	136.68
NG transport fugitive	2 268	km	2.10E-03	2.90E-03	4 762.8	6 577.2
NG transport venting	2 268	km	8.00E-04	1.20E-03	1 814.4	2 721.6
NG distribution fugitive	29 000	km	5.20E-04	7.10E-04	15 080.0	20 590.0
Oil production fugitive	42 000	t	1.40E-03	1.50E-03	58.8	63.0
Oil production venting	42 000	t	6.20E-05	2.70E-04	2.60	11.34
Oil production flaring	42 000	t	5.00E-06	2.70E-04	0.21	11.34
Oil transport fugitive	9 929 496	t	5.40E-06	5.40E-06	53.62	53.62
Total					26 696.6	35 163.9

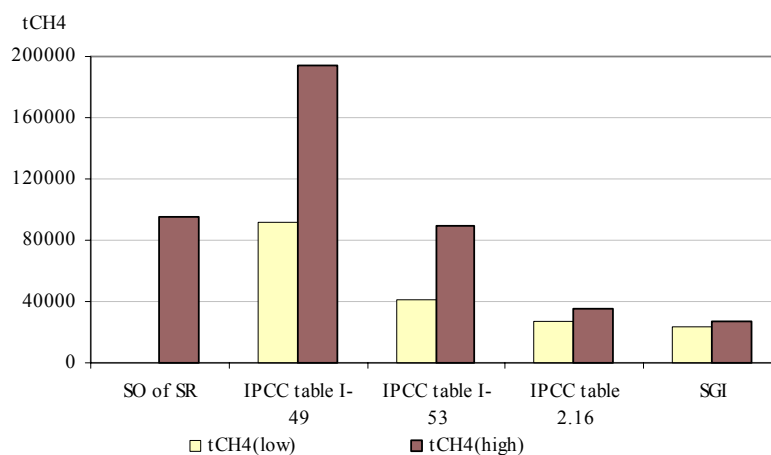
Note: NG* production – the values of fugitive and flaring methane emissions were calculated on base reported data of vented NG - 7 mil.m³ and flared NG - 9 mil.m³ (Statistic Office of SR - preliminary balance of the gas fuels consumptions in year 2003).

Table 9 presents recalculated fugitive emissions of methane from transport and distribution of natural gas activities during 1990-2003 according the IPCC Good Practice Guidelines, Table 2-16 methodology using the EF (high).

Table 9 The total CH₄ fugitive emissions from transport and distribution of NG in the SR in 1990-2003

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	Fugitive emissions of CH ₄ (Gg)													
NG	24.46	24.31	24.24	25.09	26.58	29.13	29.73	29.98	32.01	31.99	34.06	34.86	33.74	35.20

The comparison of the methodologies used for calculation of the fugitive methane emissions from transport and distribution of natural gas in SR is shown on Figure 16.

Figure 16 Comparison of the fugitive methane emissions calculated from IPCC factors and SGI methodology

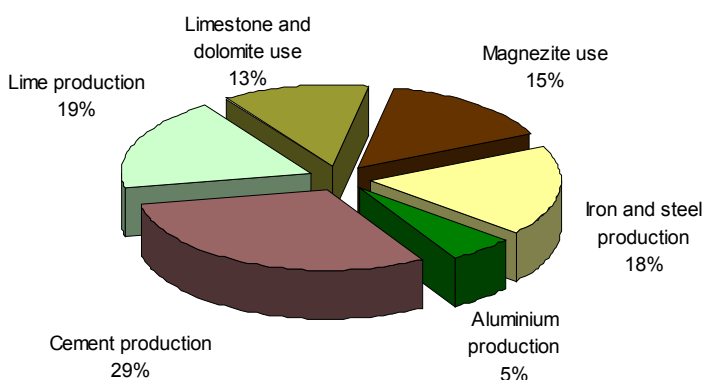
4 INDUSTRIAL PROCESSES

The industrial sector in Slovakia is a source of CO₂, CH₄, N₂O, NO_x, CO, NM VOC, SO₂, CF₄, C₂F₆, and SF₆ pollution. Even though the emissions of CO₂ and N₂O 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 emissions of CO₂ 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 Methodology¹² and Good Practice Guidance.¹³ The information used in the report was obtained from different sources as well (Statistic Office of SR, Ministry of Economy, Union of Slovak Chemical Industry, plant operators, producer etc). The obtained information was checked with the experience of the SHMI with monitored industrial technologies. 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 sector.

Whereas the N₂O emissions comes from the nitric acid production only (2.53 Gg) (this category is key source by level and trend assessment¹⁷), the cement, lime, limestone and dolomite use and iron & steel production are very important key sources¹⁷ of CO₂ emissions. Total anthropogenic emissions of CO₂ from this sector are 2 984.34 Gg and the major share comes from mineral production (2 281.76 Gg) (Figure 17).

Several industrial categories were revised in last 2003 inventory due to more information about the used technologies. Next year is planned more detail separation this sector from energy sector (combustion of fuels) in accordance with upgrade of the NEIS database and recalculation of Sectoral approach of base year 1990.

Figure 17 *A share of individual technologies in industrial sector in 2003*



4.1 Mineral products

Cement is produced by a high temperature reaction of calcium oxide (CaO) with silica (SiO₂) and with alumina (Al₂O₃). A source of calcium oxide is limestone (CaCO₃). 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 (SO₂). Content of cement clink in cement varies in the range 63.6%-94%. This value is known for every cement plant. According to the IPCC Methodology¹² it is a Good Practice¹³ that amount of CO₂ emission is calculated from the mass of produced cement clink.

However, in the Slovak Statistical Yearbook there is only mass of produced cement available. Therefore, emission of CO₂ is calculated from the mass of produced cement. The weighted average value of the clink content in the cement is 74.9% with uncertainty 5.7%. The content of CaO in the cement clink varies from 64% to 70%. The value of the weighted average is 65.7% with uncertainty 1.2%. In 2003 it follows that the emission factor of CO₂ related to the cement clink is 515.5 kg CO₂/1 t of cement clink with uncertainty 1.2% in 2003 (0.785×0.567). The emission factor of CO₂ recalculated to the production of cement is 417.6 kg CO₂/1 t of cement with uncertainty 9.4% (only the plants, where the clink is produced, are included). The total sum of cement production in Slovak republic was 2 930 194 t. The emission factor of CO₂ is 308.7 kg CO₂/1 t of cement based on the total cement production. However, this emission factor has no theoretical background (Table 10).

Table 10 A comparison of EFs and emissions of CO₂ in 2000-2003

	2000	2001	2002	2003
Emission factor of CO₂ [t/t of cement clink]	0.505	0.502	0.506	0.516
Emission of CO₂ [Gg]	1 169	1 187	1 144	905

4.2 Lime Production

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. According to the new data on average purity of lime, the purity of lime varies in the range 84 – 97%. The weighted average value is 91.2% with uncertainty 3.0%. In older inventories the value 97% was used. The emission factor of CO₂ using the new data on purity of lime is 716 kg CO₂ per 1 ton of lime (0.785 × 0.912) with uncertainty 3.0%. Therefore the recalculation of the CO₂ emissions since 1990 has been necessary (Table 11).

Table 11 The recalculated CO₂ emissions from lime production in the SR in 1990-2003

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	Emissions of CO ₂ (Gg)													
Lime production	770.4	586.4	441.1	520.5	547.7	574.9	547.0	490.5	532.6	543.7	539.6	584.2	651.9	552.1

4.3 Limestone and dolomite use

At thermal decomposition or chemical reactions of limestone to clink carbon dioxide is produced. The maximum value of emission factor of CO₂ is 440 kg CO₂/1 t of consumed limestone, which is the recommended value according to the IPCC. However, the average content of CaCO₃ in raw material in Slovakia is 97%, therefore the emission factor CO₂ has to be lowered to 427 kg/1 t of consumed limestone (440 × 0.97). In this category the mass of consumed limestone in industrial processes except of cement and lime production is presented. The recalculated amounts of consumed limestone according to the sources and emissions of CO₂ are summarized in Table 12. This data is different from that reported in previous years. The new data are correct while the previous ones were influenced by wrong methodology which yielded to high consumption of limestone at iron and steel production. (According to the information from the plant, instead of limestone consumption per iron ore the CO₂ emission per tone of pig iron was used in the older inventories. Therefore, the mass of the consumed limestone after our recalculation was more than two times higher.) The amount of CO₂ emissions is based on the consumption of limestone and dolomite at production of calcium carbide, glass and iron & steel.

Table 12 Total emission of CO₂ at limestone utilization in the period 1990 – 2003

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	Emissions of CO ₂ (Gg)													
Limestone use	302.1	271.2	262.5	312.6	340.2	338.9	320.9	337.8	333.8	319.5	403.8	386.9	361.7	374.7

4.4 Magnesite use

At thermal decomposition of magnesite carbon dioxide is produced. Maximum emission factor of CO₂ is 522 kg CO₂/1 t of magnesite or after recalculating 1 092 kg CO₂/1 t of magnesite clink. Purity of magnesite in the SR varies mainly from 84% to 94%. However, in some small plants magnesite of purity 48% is used. Therefore the weighted average is 86.0% with high uncertainty up to 16.5% and the emission factors of CO₂ are 449 kg CO₂/1 t of magnesite and 938.9 kg CO₂/1 t of magnesite clink, respectively. Finally, all the necessary data on magnesite clink production are available. In Table 13, the data on produced magnesite clink together with emission data of CO₂ are summarized.

Table 13 Total emission of CO₂ at magnesite clink production in the period 1990 – 2003

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	Emissions of CO ₂ (Gg)													
Magnesite clink	431.9	257.2	219.5	225.7	204.3	294.0	301.1	310.2	376.5	394.8	409.8	431.6	438.5	449.9

4.5 Ammonia production

Ammonia is made from nitrogen and hydrogen by fine-tuned versions of the process developed by Haber, Nernst and Bosch. In principle, the reaction between hydrogen and nitrogen is easy. However, to get a respectable yield of ammonia in a chemical plant is necessary to use a catalyst and extreme pressure. For estimation of the greenhouse emissions from the production of ammonia was used the emission factors recommended by IPCC (1.5 t/t of ammonia). However, the emissions of CO₂ and CH₄ are included in energy sector in natural gas consumption (1.A.2c).

4.6 Nitric acid production

In a world measure, the nitric acid production consumes about 20% of all ammonia produced. Thorough analysis of technology in Slovak plants was made. The result in the plant with measurement of emissions of N₂O and NO_x was that there was an error in calculating of emissions of N₂O and NO_x. It was necessary to correct emission factors of NO_x and N₂O. The average emission factor of N₂O until 1996 was 5.43 kg/t of produced HNO₃ and emission factor of NO_x was 11 kg/t of produced HNO₃, which were the values recommended by IPCC Methodology.¹² In 1996, a selective catalytic reduction of NO_x based on ammonia became operational. Since 1996, emission factor of N₂O was 5.58 kg/t of produced HNO₃ and emission factor of NO_x was 0.5 kg/t produced HNO₃. In other plant, concentrate nitric acid is also produced without measurement of emissions of N₂O and NO_x. According to the IPCC recommendation the emission factor is 5.43 kg N₂O/1 t HNO₃.

Combined emission factor of N₂O according to these data is 5.56 kg N₂O/1 t of nitric acid with an uncertainty 0.6%. Emission of N₂O at nitric acid production in 2003 was 2 530 tons.

4.7 Production of calcium carbide

Calcium carbide (the correct chemical name of this compound is calcium acetylide) is produced in by the reaction of CaO and coke at submerged arc furnace. Recently this technology was modernized in order to decrease the emissions (in 1992) in the SR. The main component of released emissions is CO₂. Emission factors for CO₂ (0.76 t CO₂/t of CaC₂ at decomposition of limestone; 1.09 t CO₂/t of

carbide at the reduction and 1.1 t CO₂/t of carbide at using of the product) were taken from the IPCC recommendation. Uncertainties in emission factors are ca 5%, which is mainly influenced by composition of limestone and coke. Emissions of CO₂ emitted at decomposition of limestone are included in consumption of limestone in this inventory and emissions of CO₂ at the reduction are included in energy sector - consumption of coke (1.A.2b) and category limestone and dolomite use (2(l)A.3).

100 437 tons of CaC₂ (calcium carbide) was produced in Slovakia in 2003, 95% of produced calcium carbide is exported from Slovakia. Only the rest of 5% is used for acetylene production. At this production no emission of CO₂ is released.

4.8 Production of metal

Iron and steel production

Pig iron is produced by the reduction of iron ore by coke in a blast furnace, the main emission being CO₂. 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 CO₂. Iron ore was processed to pig iron. The emissions of CO₂ from added limestone are included in consumption of limestone in this inventory (2(l)A.3). The mass of used coke is included in energy sector (1.A.2a). In an open-hearth process the steel was produced, the emission factor for CO₂ being 118 kg CO₂/t of steel. This emission factor results from decreasing of carbon from pig iron (40 kg/t) to steel (2.5 kg/t). For estimation of emission, recommended emission factors at steel processing were used. In older inventories, the emissions of CO₂ from coke production were included in iron and steel production as well. In 2001 the method used for calculation of emission was changed. It was based on the mass of the used coke and the amount of used iron ore (Tier 2 in IPCC Guidelines – recommended method).

In order to summarize the data based on this new approach the emissions of CO₂ from steel production, which are not included in energy sector are presented in Table 14 for the period 1900 – 2003.

Table 14 Emissions of CO₂ from steel production for the period 1990 – 2003

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Emissions of CO ₂ (Gg)														
Steel production	420.3	373.3	348.4	378.2	393.0	378.5	344.6	362.5	365.8	403.6	415.4	442.7	484.2	535.2

Production of ferroalloys

Ferro-alloys are produced in arc furnaces and submerged arc furnaces by the reduction of the mixture of iron ore and added metal and/or metalloid (Si) oxides. 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. 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 (1.A.2a).

Aluminium production

Aluminium is produced by the electrolysis of alumina dissolved in cryolite-based melt (t = 950°C). The main additions to cryolite (Na₃AlF₆) are aluminium fluoride (AlF₃) and CaF₂. From the point of emissions view, the content of AlF₃ is of great interest. However, it should be also mentioned that 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 production 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. The emission factor for CO_2 was taken from the IPCC recommendation (1.5 t CO_2 /t of aluminium). The emission factors of PFC (CF_4 , C_2F_6) were calculated according to the Tabereaux's equation. According to the data from plants average current efficiency was 94.04% in 2003, the number of the anode effects per pot day equals to 0.062 and their average duration was 2.81 min. It follows that the emission factors were 0.0252 kg CF_4 /1 t of aluminium and 0.00252 kg C_2F_6 /1 t of aluminium, respectively. In 2003 minor change in composition of the electrolyte was made. The solubility of alumina decreased and the number of anode effects increased. In 2003, the Slovak aluminium company produced 111 617 t of aluminium. The EFs correspond to the most modern technology and they are summarized together with the total amounts of emissions in Table 15.

Table 15 An overview of emissions and EFs in aluminium production in 2003

	CO_2	CF_4	C_2F_6
Emission [t]	167 425	2.809	0.281
Emission factor [kg/t]	1 500	0.0252	0.00252

Consumption of SF_6 at the casting house

The consumption of this greenhouse gas in the SR is low. It is difficult to determine the emission factor. However, there is known a precise value of SF_6 consumption in the SR in 2003, viz. 30 kg of SF_6 . The data on SF_6 emission is not connected with casting production. Therefore, there is no sound reason to calculate the emission factor of SF_6 .

4.9 Consumption of HFCs, PFCs and SF_6

"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 – perfluorocarbons (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 in 2003. 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. Following procedure was engaged to reach the aim:

- An evaluation of the sources and emissions of selected substances in 1990-2002 based on acquired data from importers and users in 2003.
- An evaluation of the data storage in own tables and CRF tables according to IPCC methodology.

Substances in question alone are not registered under the item of the Custom Tariff in the Slovak republic. The 250 Potential supplier, users and consumers of the substances in question are addressed on the base of the description of the substances with GWP. These potential consumers of the substances in question are yearly sent the letter authorised 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 summarised in the tables according to the way of use. Tables used in 1990-2002 are used also in 2003 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 realised on the base of recommended emission factors corrected according to the received data by IPCC Methodology¹² in own tables.

An 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 PFCs and HFCs decrease and start of HFCs coolants use. Approximation is based on following analyses:

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

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 lifetime of SF₆ is up to 3 200 years, GWP is up to 23 900 kg CO₂/kg, and 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 SF₆ 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 last times, it was used in the 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 electricity distribution plant with supposed release 1% of filling per year. A filling is dimension for 30 years without refilling. Since 1993, the SF₆ is used for anti noise and thermal isolation into windows. It is filled in close cycles practically without releases.

The perfluorocarbons 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.

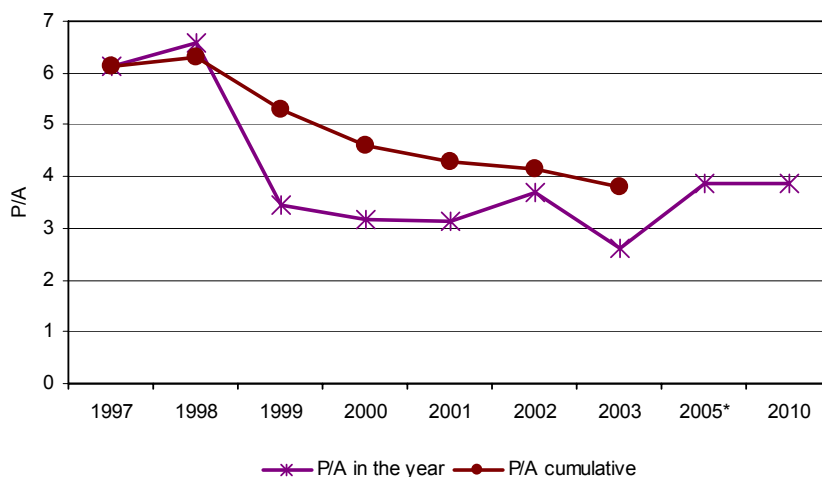
Because of expected prohibition of coolant R12 import, 700 tones of it were purchased in years 1993 and 1995. This amount is gradually consumed and coolant R12 was still available in 2001. Coolants consumption has decreased in the Slovak republic comparing to 1990 by 70%. Up to 1998 the products designed for coolants R22, R134a and R404A were usually imported. Only in 1999, the indications of import of products containing coolants R407C and R410 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. Coolants R407C and R410A shows the growth tendency since 1999. Coolant R134a showed continuing growth tendency until the year 2001. In the near future, we can slight decreasing of R134a consumption.

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. Since the year 2000 these emissions has not been already included to this part of inventory. 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, R410 and so on. 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 18).

Figure 18

The ratio of potential to actual emissions P/A



Notices: The potential and actual emissions of PFC 14 and PFC 116 originated as a by-product during the aluminium production. Since 2000 PFC 14 and PFC 116 originated as a by-product during the aluminium production has not been included to the emissions of this part of inventory. There are calculated only 1% emissions from new extinguishing media (without consumption for extinguishing).

The above analysis shows that in the year 2003 in spite of the forbidden HCFCs applications by the Act n. 76/1998 Z. z. in version n. 408/2000 Z. z. wasn't reached faster application of HFCs. A decline of extinguishing media consumption is because they are very expensive and the investment to them is planned for a longer time. Consumption of SF₆ is not rising. Technical solutions, which could substitute this gas, are still very expensive. Consumption of PFCs during etching is practically without emissions. In relation with the high reliability of the new cooling equipments with the content of HFCs, PFCs and SF₆ and progressive implementation of preventive service, the ratio of potential and actual emissions in the year 2003 and as well the ratio of the cumulative potential and actual emissions is declining. It is because the cumulative amount of these HFCs substances – substitutes of ODS is rising quicker as the actual emissions are declining. The saturation of this ratio we can expect only after the year 2010.

5 SOLVENT AND OTHER PRODUCT USE

This category includes the emissions of NM VOC (photochemical smog) from use of solvents. 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 MoE, team of experts on the base of Directive 1999/13/EC and upon a close cooperation with producers in the Slovak republic. The total emissions of NM VOC from this category were 31.57 Gg per year 2003. The estimation of NM VOC emissions was processed based on IPCC Methodology¹² uses CORINAIR Methodology¹⁴ and SNAP classification. Inventory was carried out upon the base of data about production, import, export and selling of individual type of solvents. The SR does not provide

information about the emissions of CO₂ and N₂O from this sector. No emission factors are available for this emission category.

6 AGRICULTURE

6.1 Cross-cutting

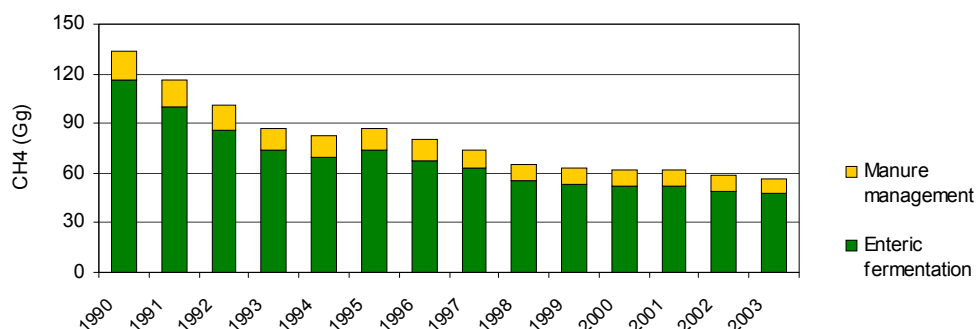
The humankind activities in agricultural sector significantly contribute to changes of concentration of some gases in atmosphere what consequently increase its greenhouse effect as well as acidity of environment. Despite of fact that water vapour and CO₂ are gases of the highest importance sharing greenhouse effect of the atmosphere, N₂O and CH₄ emitted in agricultural 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 N₂O and CH₄ emissions are analyzed according to revised IPCC Methodology,¹² when principles of Good Practice in GHGs inventory¹³ in agriculture were taking account. The Slovak Agricultural University in Nitra, namely Dr. B. Šiška 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. The emissions from burning of field residuals were not defined in this study because these forms of soil cultivation are prohibited by law in the SR. Area of histosols on the territory of the SR is only 4 893 ha and those soils are not cultivated due to landscape protection during last years. This source is not evaluated. Basic sources of data used for evaluations of emissions were published in:

- Census of sowing areas of field crops in the Slovak republic.
- Annual census of domestic livestock in the Slovak republic.
- Green report of the SR 1998-2004, MoA SR.
- Statistical Yearbook 1990-2004, Statistic Office of the SR.

6.2 Methane emissions

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 CH₄ 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. Total methane emissions in 2003 from agricultural sector (animal husbandry) were 47.75 Gg. A trend of emissions during evaluated period is depicted on Figure 19.

Figure 19 *A trend of CH₄ emissions in agriculture in 1990-2003*



The changes of animal populations during evaluated period mentioned above were caused drop of total methane emissions from 133.8 Gg in 1990 to 57.0 Gg in 2003, (decrease by about 57%). In period after enter of the SR in EU methane emissions can drop on level slightly exceeding 50.0 Gg because of next decrease of populations of the cattle. Population of cattle determines total CH₄ emissions. Therefore, the emission from enteric fermentation decreased more drastically (by about 60%) as compare with emission from animal excreta (decrease by about 45%). 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.

Enteric fermentation

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 CH₄ 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. Total emissions of methane from enteric fermentation decreased from 116.3 Gg in year 1990 to 47.8 Gg in year 2003, what is decrease by about 59%. The supposed numbers of dairy cattle calculated according to milk productivity and limits of milk production for the SR as well as numbers of sheep and goats after enter of the SR into EU will reduce emissions on level 42.4 Gg per year what is nearly one third of emissions of 1990. Nearly 45% of total methane emissions are emitted in agricultural sector.²⁰ There are recognized two sources of CH₄ emissions in agricultural sector. 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. According to IPCC Methodology¹² the CH₄ emissions from animal husbandry (enteric fermentation and animal excreta) depends on animal numbers, weight and type of their digestive tract.

Manure management

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). Methane emissions from this source decreased from 17.6 Gg in year 1990 to 9.3 Gg in 2003. Due to changes in animal populations connected with the enter of the SR into EU there will be next decrease observed, approximately on level 9.0 Gg what is half level as compare with 1990. Emissions from animal excreta of domestic livestock decreased in all categories. Numbers of poultry do not decrease so rapidly in comparison with other domestic livestock what resulted in fact that ratio of methane emission raised from 7% in 1990 to 11% in 2003.

6.3 Nitrous oxide emissions

Trends of the total N₂O emissions from agricultural 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 N₂O emissions in the 1st half of 90's (from 17.0 Gg in 1990 to 10.0 Gg in 1995) the emissions stabilized on level 9.5 Gg per year. This level of total N₂O emissions from agricultural sector will be probably reached also after enter of the SR into EU (Figure 20).

The N₂O emissions from agricultural sector create about 76% of total N₂O emissions in the SR. The total N₂O emissions in agricultural sector are given by direct emissions from cultivated soils and animal husbandry and indirect emissions from leaching and nitrate depositions. The emission factors

²⁰ Emissions of Greenhouse Gases in the SR 1990-94

for calculation of direct N₂O emissions from agricultural sector, emissions from AWMS and indirect emissions from leaching were used according to Table 16.

Figure 20 A trend of N₂O emissions in agriculture in 1990-2003

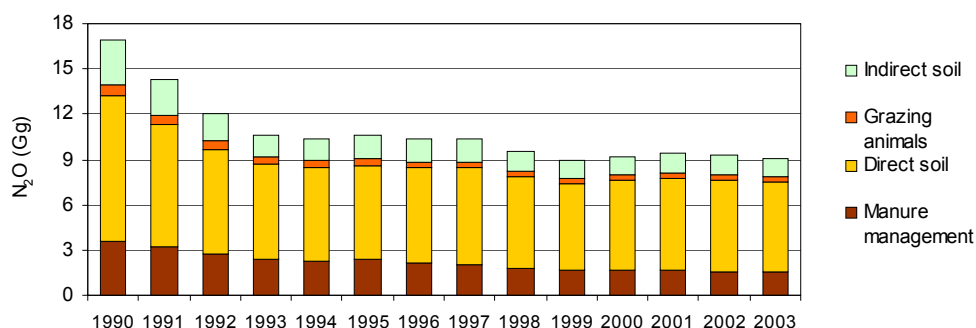


Table 16 The EFs for the calculation of N₂O emissions from agriculture (IPCC, 1996)¹²

EF ₁	Direct emissions - cultivated soils	0.0125 (0.0025-0.0225) kg N ₂ O - N/kg
EF ₃	AWMS - liquid storage	0.001 (0.001) kg N ₂ O - N/kg
	AWMS - dry storage	0.02 (0.005-0.03) kg N ₂ O - N/kg
	AWMS - pasture	0.02 (0.005-0.03) kg N ₂ O - N/kg
EF ₄	Indirect emissions – atmospheric deposition	0.01(0.002-0.02) kg N ₂ O-per kg emitted NH ₃ and NO _x
EF ₅	Indirect emissions - leaching	0.025 (0.002-0.12) kg N ₂ O - per kg of leaching N

Direct N₂O emissions from cultivated soils

The N₂O emissions from cultivated soils are of natural origin from microbial processes – nitrification and denitrification. The direct N₂O emissions from cultivated soils in sense of IPCC Methodology¹² depend on nitrogen inputs: synthetic fertilizers, animal excreta, crop residuals, cultivation of histosols and N-symbiotic fixation of leguminous.²¹

A consumption of synthetic fertilizers decreased during last decade of 20th century, from 222.3 Gg in 1990 to 81.3 Gg in 2003 (with the prognosis of 80 Gg in 2005). The synthetic fertilizers in year 2003 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 2002 and 2003 by about 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.²² The applied synthetic fertilizers lost the definite amount of nitrogen by volatilization and N-NO_x conversion, this amount for synthetic fertilizers is 10%, its means that for the conversion of N to N₂O rest only 90% of total amount applied synthetic fertilizers (73.17 kt / year 2003). After using the IPCC default emission factor 0.0125 kg N₂O-N / kg N the total emissions of N₂O from using the synthetic fertilizers in 2003 were 1.437 Gg (0.915 Gg of N).

²¹ Bouwman, 1990, citation in IPCC, 1996

²² Green Report of the SR, MoA, 2003

The direct inputs of nitrogen slightly vary according to applied methodology. According to IPCC Methodology¹² (Method A)²³ higher inputs of nitrogen from animal excreta are calculated – in average higher by about 5% as compared with detailed method (Method B).²⁴ Since 1990 there was recorded decrease of nitrogen inputs from 171.4 Gg to 79.9 Gg in year 2003 – what represent more than half of original emissions. 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 IPCC¹²). For dairy cows of productivity higher than 4 500 l there is also published amount 100 kg N per head per year (CORINAIR¹⁴). 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 per head per year is recommended – Table 17). 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 N₂O emissions. The applied animal fertilizers lost the definite amount of nitrogen by volatilization and N-NO_x conversion, this amount for animal fertilizers is 20%, its means that for the conversion of N to N₂O 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 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).

Table 17 N production (kg/head/year) for different categories of domestic livestock (IPCC, 1996)^{12,13}

Livestock categories		N [kg]
Cattle	Dairy cows	100
	Non dairy cows	60
Pigs	Mean	20
	Sows*	36
	Piglets up to 50 kg	15
	Young sows over 50 kg	16
	Fattening pigs	14
Sheep, Goats		16
Poultry	Mean	0.6
	Laying hens	0.8
	Broilers	0.6
	Turkeys and ducks	2.0
Horses		25

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

Based on data about management in 222 agriculture farms were performing the total analysis of manure production in the SR (Table 18).

The calculated amount of nitrogen from animal waste applied on fields were 49.04 kt N (liquid and solid systems; $(1 - \text{Frac}_{\text{Fuel}} + \text{Frac}_{\text{Graz}} + \text{Frac}_{\text{GasM}}) = 0.703$) and the total amount of N₂O emissions from animal excreta in 2003 were 0.963 Gg (0.613 Gg of N).

²³ Method A: nitrogen input was calculated for animal categories of domestic livestock according to IPCC Methodology¹² cattle (dairy and others), pigs, sheep, goats, horses, and poultry, 1996

²⁴ Method B: the more detailed values for calculation of N₂O 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 per year for other cattle were supposed.

Table 18 Housing of animals and production of liquid and solid manures in %²⁵

Category of domestic livestock		Animal Waste Management System		
		Production of slurries [%]	Production of manure [%]	Pasture [%]
Cattle	Dairy cows	5	75	20
	Non dairy cows	5	85	10
Pigs	Mean	76	24	0
	Fattening pigs	91	9	0
	Sows	41.6	58.4	0
Sheep and goats		4	41	55
Poultry	Mean	55.4	44.6	0
	Laying hens	2.2	97.8	0
	Broilers	98.2	1.8	0
	Turkeys and ducks	100	0	0
Horses		0	45	55

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 were established on the base of results of field trial of Research Institute of Plant production.²⁶ The details for estimation total input of nitrogen from residual crops are in Table 19 and were calculated according the growing areas of crops and vegetable.

Table 19 Growing areas and total nitrogen amount of crops and leguminous in Slovakia

Crop		1990 [ha]	2001 [ha]	2002 [ha]	2003 [ha]	crop residuals [t/ha]	% N in kg of biomass	N [t/ha]	2002 N [t]
Cereals	Wheat	418 158	448 900	405 800	306 900	5.60	0.81	0.0454	18 407.09
	Ray	46 335	38 200	38 000	25 200	4.06	0.68	0.0276	1 049.10
	Barley	190 634	186 400	194 700	269 300	3.97	0.91	0.0361	7 033.93
	Oat	13 015	17 000	20 500	30 400	3.90	1.00	0.0390	799.50
	Maize	150 731	122 600	140 400	146 000	3.38	1.40	0.0473	6 643.73
	Other	6 323	12 000	15 000	15 000	3.90	1.00	0.0390	585.00
Potato		55 245	26 200	26 100	25 700	2.44	2.79	0.0681	1 776.78
Sugar beet		51 288	31 500	30 900	32 000	1.11	1.52	0.0169	521.34
Oil plants		70 906	180 700	201 600	208 900	10.00	1.10	0.1100	22 176.00
Tobacco		3 019	1 234	1 234	1 234	3.16	2.10	0.0664	81.89
Vegetable		30 075	40 000	33 600	34 500	1.11	0.96	0.0107	358.04
Fodder crops on arable land		48 611	21 960	24 072	24 487	5.49	1.62	0.0169	2 140.92
Maize for silage		179 888	100 030	96 787	98 973	4.67	1.40	0.0889	6 327.93
Grassland and other crops		870 778	1 037 428	1 016 027	1 036 851	5.49	1.62	0.0654	90 363.41

The total growing area of crops (wheat, ray, barley, oat, maize, potato, sugar beet, oil plants, tobacco, vegetable, fodder crops, grassland and other) in 2002 were 2 244 720 ha and the direct inputs of nitrogen from crop residuals were 158 264.66 t per year 2002. The crops residuals from previous year were base for calculation of N₂O emissions (according the used methodology). The used emission factor 0.0125 kg N₂O-N / kg N is according the IPCC methodology and gives the total N₂O emissions from crops residuals in 2003 – 3.1088 Gg (1.978 Gg of N).

²⁵ Brestenský et al., national study, 1998

²⁶ Jurcova, O.; Toma, S. Methodology for quantification of nutriment potential of residual crops, Bratislava 1998

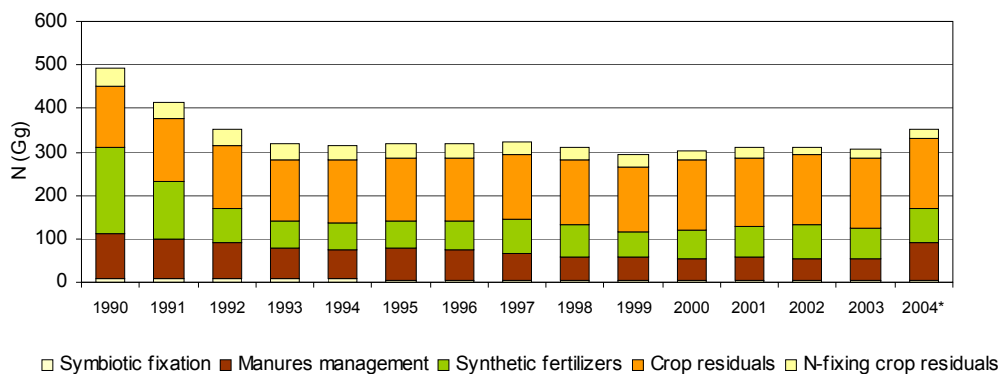
Nitrogen inputs from symbiotic fixation are of local importance and depend on acreage of leguminous plants. Total input of nitrogen into cultivated soils drastically decreased in the first half of 90' (from 760.0 Gg in 1990 to 500.0 Gg in 1995). During last years inputs of nitrogen into soils was stabilized on level 430.0 Gg per year. For the conditions of the SR are the nitrogen inputs from symbiotic fixation in the range 20-30 kg/ha,²⁷ but is enough reasons to accept a experimental value 26 kg N/ha. The details for estimation total input of nitrogen from N-fixing residual are in Table 20 and were calculated according the data obtained from direct measurement²⁶ in the conditions of the SR and recalculated to the growing areas of N-fixing crops and average harvest.

Table 20 Growing areas and total nitrogen amount of N-fixing crops in Slovakia

Crop		1990 [ha]	2001 [ha]	2002 [ha]	2003 [ha]	crop residuals [t/ha]	% N in kg of biomass	N [t/ha]	2002 N [t]
N-fixing crops	Pea	28 446	11 629	8 776	9 000	6.51	1.66	0.1081	948.69
	Lens	2 579	500	546	1 000	7.00	2.42	0.1694	92.49
	Bean	2 272	1 745	781	1 000	7.00	2.96	0.2072	161.82
	Other leguminous plants	11 707	2 400	2 527	3 000	10.94	2.96	0.3238	818.30
	Soybean	5 474	6 430	9 326	11 600	3.44	4.19	0.1441	1 344.21
	Alfalfa	118 125	61 435	62 481	61 532	7.00	2.42	0.1694	10 584.28
	Clover	35 068	12 000	8 761	6 494	6.00	1.97	0.1182	1 035.55
	Other fodder crops	51 605	40 478	57 643	64 293	6.00	1.97	0.1182	6 813.40

The total growing areas of N-fixing crops (pea, lens, bean, other leguminous plants, soybean, alfalfa, clover and other fodder crops) in 2002 were 150 841 ha and the direct inputs of nitrogen from N-fixing crops were 21 798 t N per year 2002. The crops residuals from previous year were base for calculation of N₂O emissions from N-fixing crops (according the used methodology). The used emission factor 0.0125 kg N₂O-N / kg N is according the IPCC methodology and gives the total N₂O emissions from N-fixing crops in 2003 - 0.428 Gg (0.2725 Gg of N). Biologic fixation from 150 841 ha of N-fixing crops were 3 921.87 t N per year 2002. The used emission factor 0.0125 kg N₂O-N / kg N is according the IPCC methodology and gives the total N₂O emissions from biologic fixation in 2003 – 0.077 Gg (0.05 Gg of N). The total N₂O emissions from N-fixing crops (residuals + biologic fixation) in 2003 were 0.505 Gg. A trend of direct N input in agricultural soils according to the sources during 1990-2004 is depicted on the Figure 21.

Figure 21 A trend of direct N inputs in soils according to sources (SR 1990-2004*)



*Prognosis in the Third National Communication on Climate Change

²⁷ Bielek, P. Nitrogen in agricultural soils of the SR, Bratislava 1998

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 documents 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 N₂O emissions and so trends reflect their sources.

N₂O emissions from animal waste management system

The emissions of nitrous oxide from animal waste management system depend first of all on numbers of domestic livestock. Good housing of animals as well as good storage of animal excreta (manure, slurries) can help to reduce emissions from this source. There was also recorded of N₂O emissions from AWMS from 3.5 Gg in 1990 to 1.5 Gg in 2003. The emissions from this source slightly vary during last years and after enter of the SR into EU they can decrease below 1.4 Gg. The detailed methodology (Method B²⁴) gives lower emissions by about 3% as compared with IPCC Methodology.¹² The highest part of these emissions is from dry storage of manure – more than 90%.

Indirect N₂O emissions

The indirect emissions decreased during evaluated period too because of their dependence on direct inputs of nitrogen that decreased too. During last years those emissions are stabilized with slight tendency of growth. After enter of the SR in EU the indirect emissions will be higher than 1.4 Gg and exceed emissions from AWMS decrease from 3.1 Gg in 1990 to 1.3 Gg in 2003. Emissions calculated according IPCC Methodology¹² are little bit higher values (by about 3%) than emissions calculated by detailed methodology (Method B).²⁴ This fact is caused by higher nitrogen inputs from animal husbandry calculated by IPCC Methodology.¹²

Critical notes on input data, methods in condition of the Slovak republic

Presented data on N₂O and CH₄ emissions are little bit different because of difference of the most recent data published in the Green Report 2004²² as compare with data from last year. Especially value for nitrogen fertilizers is rather different. Important appendix of IPCC Methodology (1996) in sense of Good Practice¹³ in GHGs inventory in agriculture are direct measurements of GHGs emissions. Those kinds of measurements absented up to date in condition of the SR. The results of Research Institute of Plant Production were used for more detailed calculation of nitrogen inputs from crop residuals in condition of the SR.²⁵ A national value for calculation of symbiotic fixation of leguminous crops was used too.²⁶ The more precise methodology for evaluation of N-cycle was used when categories of domestic livestock were taken account. The uncertainties are caused first of all by use of default emission factors. Calculated direct N₂O emissions from cultivated soils can differ from reality in range 20-200%, direct N₂O emissions from AMWS in range 25-150%, indirect N₂O emissions from deposition of NH₃ and NO_x in range 20-200%, indirect N₂O emissions from leaching and runoff in range 10-500%. All emissions are evaluated on level business as usual because shortage of information on some agricultural practices. According to recommendation in Good Practice in Greenhouse Gases Inventory there are necessary also direct measurements gases emissions in agriculture. These data are absent in condition of SR. Some factors and calculations generally defined in methodologies mentioned above were eliminated by national data from field trials of research institutions.^{26,27} National value for calculation of symbiotic fixation of leguminous crops was used too. More precise methodology for evaluation of N-cycle was used when categories of domestic livestock were taken account.

7 LAND USE & FORESTRY

7.1 Input data

Forest and research institute in Zvolen namely Dr. J. Mindáš (external expert for SHMI) took responsibility for the inventory emission balance from LULUCF. Basic input data used for calculations of GHG emissions from forestry sector and land use change are showed in Table 21. 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/m³.³⁰ Using these data and a carbon content of 49.7% for wood³⁰ (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.³¹ The average stock of carbon varies from 47.9 (Poplars) to 108.8 (Beech) tons of carbon per hectare.

Table 21 An overview of forest input data

2003	Coniferous	Broadleaved	Total	Source
Total area of forests - kha	-	-	1 929	28
Annual forest harvesting (roundwood) m³	3 209·10 ³	3 039·10 ³	6 248·10 ³	28
Average (10 year) annual area - ha cleared	-	-	900	29
Annual harvesting residues - kt dm *	25.4	66.2	91.6	28
Annual area of forest fires - ha	20	14	34	30

*Annual loss of biomass by burning = annual forest harvesting 0.1 (0.25) (10% is portion of the harvesting residues for coniferous species, 25% for broadleaved species 0.50 (harvesting residues are burned on 50% of the forest harvesting area, obtained from experimental plots and generalised on the whole forest area) (Table 22)

Table 22 An overview of land use input data

	Forest lands	Pastures	Arable lands	Other	Source
Area - 1982, ha	1 894 000	825 000	1505 000	676 000	30
Area - 2003, ha	1 929 310	883 506	1 430 197	660 591	29
Unit carbon stock (t C/ha)	8-200	6-141	7-161	5-121	31,32

7.2 Changes in forest and other woody biomass stocks

Results of calculations were obtained by using the IPCC Methodology¹² and national data on wood volume increments for individual forest tree species, and results of a roundwood harvest inventory (Figure 22).

³¹ Sebik, L. The theory about production, Zvolen 1989

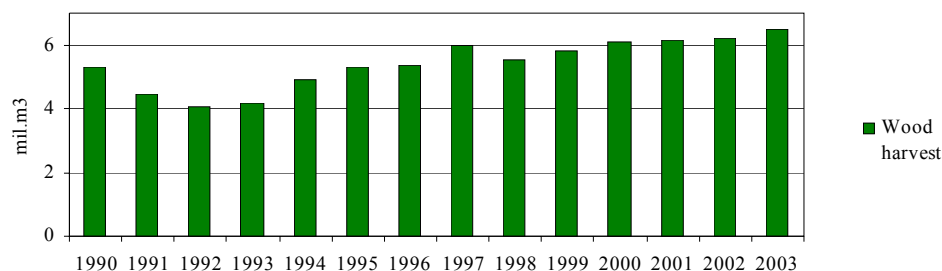
²⁸ Green Report about land use of the SR 2002, MoA www.mpsr.sk Bratislava 2003

²⁹ Permanent inventory of forest 1990-2002, Zvolen 2003

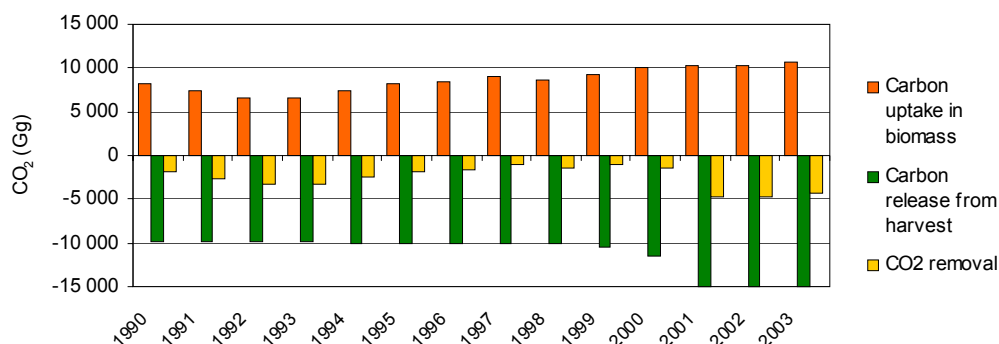
³⁰ Statistical Yearbook of the SR 2003

³² Saly, R. Pedology and microbiology, Zvolen 1998

³³ Monitoring of soils of the SR 1992-1996, Bratislava 1997

Figure 22 *A development of total wood harvest in the SR (1990-2003)*

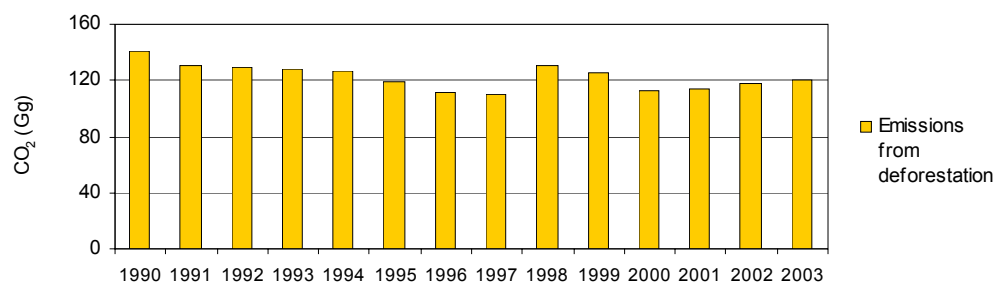
The annual tree biomass increment per hectare (resulting from application of annual wood volume increment data and biomass conversion/expansion factor) varies from 1.3 to 5.7 t dm/ha. The total annual carbon increment in tree biomass is 4 101 kt C. The total annual carbon consumption from forest harvest in the Slovak forests is 2 938 kt C. The difference between annual release and annual increment of carbon is 1 163 kt C (carbon sequestration) or 4 262 Gg of CO₂. 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. The summary results from this category are depicted on Figure 23. 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.

Figure 23 *CO₂ balance from managed forests in 1990-2003*

7.3 Deforestation, biomass burning and forest fires

The total quantity of released CO₂ in this subcategory is 285.2 Gg CO₂. Total CO₂ emissions concerning the deforestation processes were estimated as a result of decay of harvesting residues and the calculated amount is 119.8 Gg CO₂. The total amount of release carbon as CO₂ is relatively stable in the range of 110-140 Gg of CO₂ (Figure 24).

This is caused by quantity of deforestation area, which fluctuated about 1 000 ha per year. Biomass burning processes due to closed carbon cycle are considered to emit only trace gas emissions. Trace gas emissions from biomass burning and forest fires are 0.73 Gg CH₄, 6.42 Gg CO, 0.01 Gg N₂O, and 0.36 Gg NO_x. For calculating trace gas emissions of N₂O and NO_x from the quantity of carbon released, the N/C ratio (0.02)³² was used.

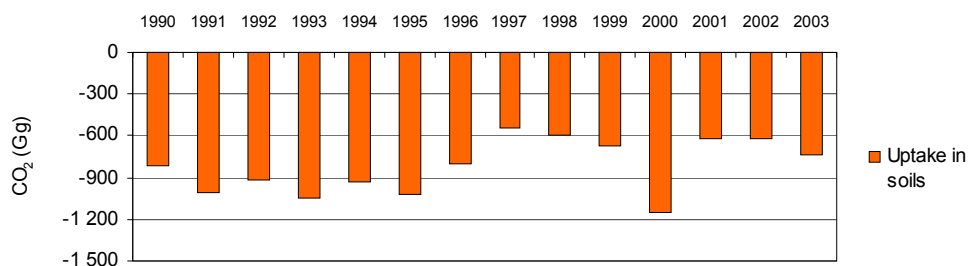
Figure 24 *A deforestation (decay) emissions in 1990-2003*

7.4 Abandonment of managed lands

The changes of carbon in biomass in relation to afforestation activities are included in category changes in forest and other woody biomass stocks and changes of soil carbon within the afforested lands are included in category carbon in soils. As was mentioned above, the total area of forest in the condition of the SR is managed and from this reason, it cannot be balanced independent.

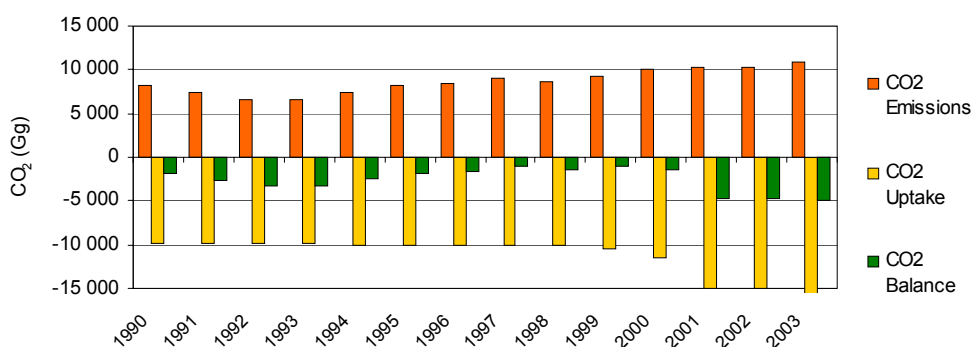
7.5 Carbon in soils

The most important process for changes in soil carbon stocks is change among individual land use categories. The most important categories in the condition of the SR are forest, meadow and grassland, arable land and other (urban land, industrial, water etc.). Due to increase of forest land area during the last 20 years, the total carbon stocks in soils are increased. Annual carbon storage of soil carbon in land use system represents 739.7 Gg CO₂ and annual CO₂ emission from liming of intensive managed agriculture lands represents 1.1 Gg. The average annually carbon storage of soil is fluctuated in the range of 600-1 200 Gg of CO₂, beyond the period 1970-2003 (Figure 25).

Figure 25 *The CO₂ sequestration in soils of the SR in 1990-2003*

7.6 Total emissions and removals

The total carbon dioxide emissions represent 10 894.7 Gg due to biomass consumption from stocks (10 773.9 Gg), forest clearing (119.8 Gg) and liming of intensive managed agriculture lands (1.1 Gg). Total amount of sequestered carbon dioxide represent 15 776.2 Gg due to total carbon uptake by biomass (15 035.5 Gg), and carbon storage in soils (740.8 Gg). A net annual CO₂ balance is -4 881.6 Gg CO₂, what means that carbon stocks in forests and soils increase. Summary results are presented on Figure 26.

Figure 26 The total CO₂ balance in forestry & land use change

8 WASTE

8.1 Input data

The production of emission of CH₄ and N₂O are important by disposal waste and wastewater treatment. The IPCC Methodology¹² and Good Practice Guidelines¹³ 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 SHMI. Other necessary input were obtained from publications.^{30,22}

8.2 Emissions of CH₄ from SWDS

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 MoE No. 283/2001 contains new regulation of limitation of SWDS, disposal with waste gases and monitoring of waste disposal. The emissions of CH₄ were estimated following IPCC Methodology¹² based on quantity of waste disposal on sites, the share of biological degradable waste and decomposed waste in real and the share of methane in disposal gas. In estimation were included besides municipal waste as well the industrial (paper, textile, food and wood industry) and agricultural waste included. The total quantity of municipal waste was 1 599.4 kt in year 2003, but on the sites was stocked 1 255.8 kt from it with the biological degradable share of 12% (expert judgment of SEA based on national data). The emissions of CH₄ from municipal waste were estimated to be 46.42 Gg. The total quantity of industrial waste and the biological degradable share were estimated according the categories of industry production (Table 23).³⁴ The emissions of CH₄ from industrial and agricultural waste were 19.34 Gg of CH₄. Using the values in the Table 23, the DOC content of a waste from agriculture and industry is 30%.

Table 23 Data used for calculation percent DOC in agriculture and industrial waste in 2003

Waste stream	Amount of waste [t]	Percent DOC by weight
Agricultural waste	46 072	17
Paper and pulp	119 000	40
Textiles waste	1 664	40
Food waste	41 992	15
Wood and straw waste	7 826	30

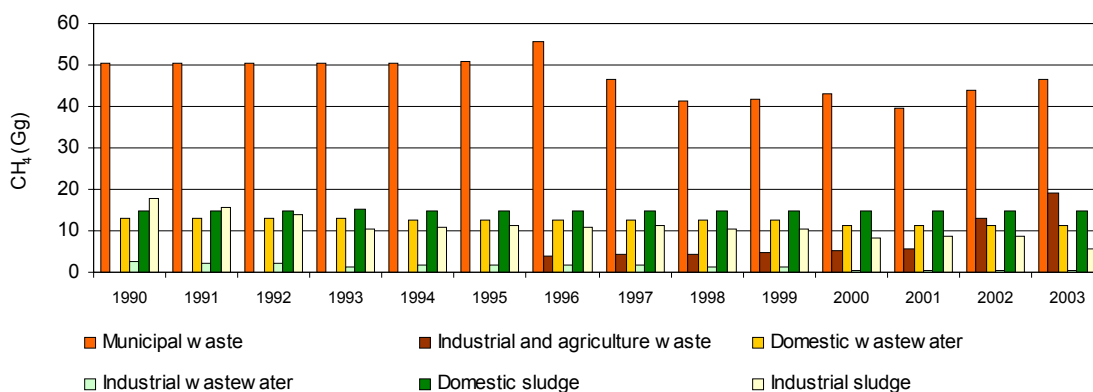
³⁴ Slovak Environmental Agency, database of Waste Management Centre, MoE Department of waste management, 2003

In comparison with previous submission 2002, there is a significant increase of solid waste disposal on site caused by 10% increasing of municipal waste disposal on sites and 55% increasing of industrial (food and wood industry) waste disposal on sites in actually submission year. The recalculation of previous year 2002 was made according the improved data of amount industry waste, the real value in year 2002 is 170.25 kt instead of 167.20 kt of waste (57.18 Gg of CH₄ instead 56.95 Gg of CH₄). The share of industrial waste increased annually from 1996 and it could be supposed to continue with this trend in the SR (Figure 27).

8.3 Emissions of CH₄ from wastewater

The recommended IPCC Methodology¹² for estimation of total quantity of organic compounds in wastewater in industrial sectors was modified for the requirement of the SR. In the SHMI database are concentrated the data about quantity and composition of industrial wastewater from each industrial source in the SR. The concentration of DC/year was estimated on the base of this information and it was not necessary use the data about activity of production. This estimation is much more exact than recommended which represent higher uncertainty. The total emissions of methane from wastewater are 32.1 Gg. The industrial wastewater represents 0.37 Gg of CH₄, the domestic and commercial 11.2 Gg of CH₄. The industrial sludge produces 5.8 Gg of CH₄ emissions and 14.7 Gg of CH₄ are from domestic and commercial sludge (Figure 27).

Figure 27 The total methane emissions from waste sector in 1990-2003



8.4 Emissions of N₂O from wastewater

The emissions of nitrous oxide from wastewater management were estimated by two methods: IPCC¹² and ISI¹⁶ and the results are showed in Table 23.

Table 23 The used EFs in estimation of N₂O emissions

Method	Emissions of N ₂ O (Gg)
IPCC 1996	0.450
ISI	0.081

The IPCC Methodology¹² calculates with population size and the average consumption of proteins without take into account the manner of wastewater treatment. It is known that estimation of N₂O emissions are depend on the wastewater treatment. The ISI Methodology¹⁶ is target on the wastewater treatment station with denitrification process. The emissions from this source are significantly higher than last year because of higher production of DC/year in Bratislava in domestic and com-

mercial wastewater treatment. We suppose the further increasing of N_2O emissions from this source in time because of introduction of denitrification process to the wastewater treatment from the reason of protection of surface water against eutrophication. In comparison between year 2003 and 2002 emission from domestic and industrial waste is increased. The amount of domestic waste is increased about 4% and amount of industrial waste is increased about 22%. Emission from domestic wastewater, industrial wastewater and from industrial waste is decreased. For calculation of nitrous oxide emissions IPCC and ISI method was used. On the basis of IPCC method is calculation of nitrous oxide emissions from consumptions of proteins. ISI method used calculation from treatment domestic wastewater and industrial wastewater. Future predicts that number of wastewater treatment plants where is biological nitrification and denitrification will be rise. IPCC method gives the same results because, the consumptions of protein is stable. This method is taken in account wastewater handling.

9 RECALCULATION AND IMPROVEMENTS

The several recalculations in CRF 2003 submission 2005 are mentioned against the previous CRF 2002 submissions 2004. The most important are following.

9.1 Energy sector

The Statistic Office of SR has opportunity to correct the statistical information about consumption, import and export of fuel and recalculation in Net Calorific Values (NCVs) of fuel base. Therefore, there were correction in emission of CO_2 , CH_4 and N_2O in Sectoral and Reference approach in energy sector (1.A.1, 1.A.2 and 1.A.4) for 2002 submission. The Statistic Office of SR is revising and harmonising methodology for total energy balance of the SR following the EU legislation in last years.

In the transport sector (1.A.3) were recalculated emissions of CO_2 , CH_4 and N_2O due to changes in methodology from COPERT II to COPERT III and the time series from 1990 were recalculated. The information about emissions of methane from venting and flaring processes in oil & natural gas fugitive emission (1.B.2) were recalculated and the complete time series from 1990 was filled in.

9.2 Industry sector

The Statistic Office updated the activity data from production of mineral products (category 2.A). The emissions of CO_2 from cement & lime production were recalculated based on this information. As was mentioned above, the emission factors of N_2O for nitric acid production (category 2.B) were changed from 5.43 kg/t to 5.58 kg/t. The consistent data from 1990 are available in CRF 2003. The recalculation was made in consumption of limestone and magnesite production categories due to revised methodology. The reported emissions in metal production (category 2.C) were revaluated and recalculated. After analysis of production strategy in iron and steel industry only the emissions of CO_2 from production of steel from pig iron were not included in energy sector and the time series from 1990 was recalculated from this category. The IPCC default emission factor 0.118 t/t of CO_2 was used. The emissions of CO_2 from primary production of aluminium, which are not included in energy sector, were estimated (category 2.C). The IPCC default emission factor 1.5 t/t of CO_2 was used. The emissions of carbon dioxide from aluminium production were not included in energy sector balance and come from prebaked anode process. The consistent data series from 1990 are available.

9.3 Agricultural sector

The emissions of methane from manure management were recalculated due to the changes in emission factor for dairy and non-dairy cattle. For this recalculation, the IPCC default emission factors were used and the consistent time series from 1990 are available.

9.4 Waste sector

The emissions of CO₂ and N₂O from waste incineration (category 6.C) were recalculated due to the using the IPCC default emission factors. The emissions of CH₄ (6.A) according the detailed information about industrial waste disposal on site in previous year.

9.5 International bunkers

The emissions of CO₂, CH₄ and N₂O from aviation international bunkers were estimated based on expert's judgment. The estimation assumes the separation of fuel's consumption between international and domestic usage. The consistent time series was calculated from base year.

9.6 Improvements

The Slovak Inventory Agency (SHMI) is evolving the permanent activity to improve annually GHG emission inventory for the UN FCCC secretariat in Common Reporting Format following the IPCC methodology.^{12,13} The major accent is put on consistency of time series data and transparency of choosing methodology and activity data. The Slovak republic is improving annually the database of sources of pollution (NEIS) in energy sector and fuel combustion.

10 CONCLUSION

The National Inventory Report 2005 of the Slovak republic is inseparable part of 2003 CRF submission of national inventory of GHGs. This report is trying to explain and compare the informational about emissions inventory in all six sectors of IPCC categories in the Slovak republic for all GHG basic pollutants. The 2003 emission inventory is based on IPCC Methodology and is related to the previous inventory for 2002. The methodological progress for calculation of national total emissions is consistent from base year (1990). The IPCC default and national determined emission factors were used. The following Table 25 gives the summary about total emission of GHGs in the Slovak republic in the period 1990-2003.

Table 25 An overview of GHG emissions (in Gg of CO₂ equivalents) in 1990-2003

GHG	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO ₂ *	57 019	48 637	44 269	41 158	39 154	41 158	41 961	43 250	41 712	40 978	37 703	37 337	36 975	37 934
CH ₄	6 343	5 901	5 527	5 113	5 047	5 192	5 250	4 959	4 681	4 623	4 555	4 548	4 677	4 709
N ₂ O	6 047	5 173	4 401	3 872	4 051	4 180	4 243	4 285	3 986	3 831	3 819	4 040	3 861	3 946
HFCs	0.00	0.00	0.00	0.00	2.91	24.52	44.86	69.83	43.58	66.01	78.30	83.23	103.74	133.83
PFCs	271.37	267.12	249.03	155.82	132.26	113.90	35.15	33.19	23.81	13.93	11.65	11.43	11.41	20.87
SF ₆	0.03	0.03	0.04	0.06	9.27	9.91	10.76	11.34	12.24	12.68	13.11	13.48	14.42	15.03
Total	69 680	59 978	54 446	50 299	48 396	50 678	51 545	52 609	50 459	49 525	46 181	46 033	45 643	46 759

* The CO₂ emissions with LUC&F

Note: emissions are determined as of 15.04.2005

The over view Table 25 shows trend in reduction of GHG emissions compare to the base year 1990. The total decrease in anthropogenic GHG emissions represents 32.9 % from the base year and the

Kyoto conditions for the Slovak republic are already realised at the present. The next Table 26 indicates the percent dependence of each gas compared to the base year (100%).

Table 26 The overview of the relative contribution of GHGs to the total emissions

GHG (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO ₂ *	100	88	82	77	72	74	75	75	74	72	68	72	71	72
CH ₄	100	93	85	77	78	80	82	77	72	71	69	71	73	74
N ₂ O	100	86	73	64	66	69	70	70	66	64	62	66	64	65

* The CO₂ emissions with LUC&F