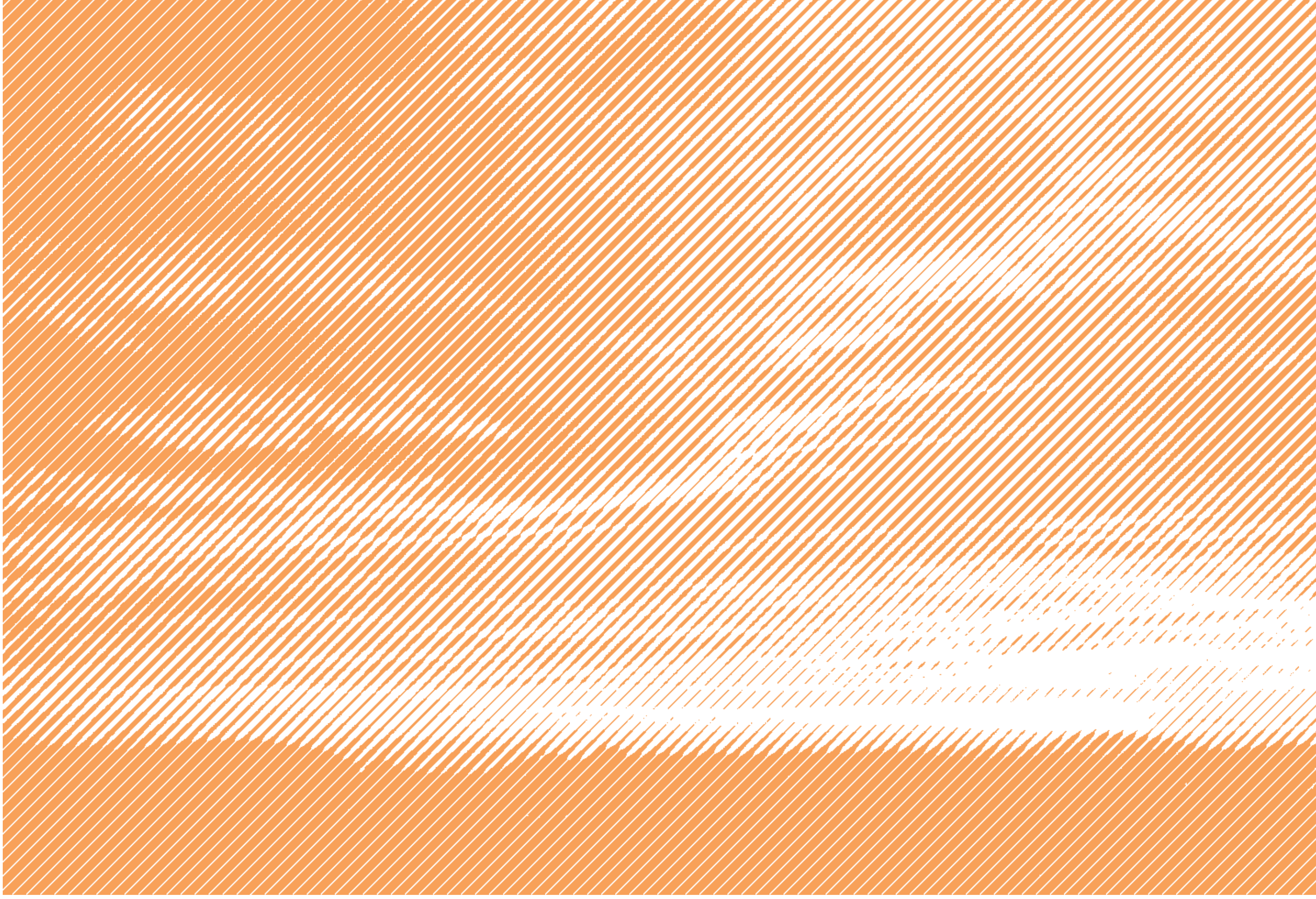

The Third National Communication on Climate Change

Slovak Republic, Bratislava 2001

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Contents

Executive summary

S.1 INTRODUCTION

Climate change, caused by increasing anthropogenic emission of greenhouse gases (CO_2, CH_4, N_2O, PFCs, HFCs a SF_6), represents the most serious environmental issue in the history of mankind. Due to the appearance of dangerous anthropogenic interference with the climate system, the necessity to search for new, more efficient and more effective mechanisms to minimise negative impacts has increased, both at international and national level.

The period following the adoption of the UN Framework Convention on Climate Change at the Conference on Environment and Development in Rio de Janeiro in 1992 can be characterized as a period of intensive efforts to formulate an effective strategy of greenhouse gas emission reduction in a legally binding form, including rules and a control mechanism defined as precisely as possible. Another distinct tendency of this period has been the endeavour to involve developing countries in closer cooperation towards the solution of the problem of global warming, taking into account current prognoses of their future development and related potential negative effects of greenhouse gas emissions on the global balance. Progress in this area is achieved very slowly and it requires much effort on the part of working teams, because it is not easy to break the relationship between economic growth and environmental impacts. The endeavour of expert teams and negotiations of the Conferences of the Parties – COP – ended in the adoption of quantified reduction and/or stabilisation emission targets for the countries specified in Annex I of the Convention at the Third Conference of the Parties in December 1997 in Kyoto, Japan.

According to the text of the Final Protocol from Kyoto, the countries of Annex I have agreed to reduce aggregated emissions of all six greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) on average by 5.2% from the level of the year 1990 during the first commitment period of the years 2008 to 2012. The Slovak Republic, as well as EU, have accepted the target to reduce emissions by 8% in comparison with their level in the base year 1990.

The Kyoto Protocol has generally extended the options of the countries to choose the way and the instruments which are most appropriate for the attainment of reduction targets, having regard to the specific circumstances of the country. The common feature of the new mechanisms is the endeavour to achieve maximum reduction potential in the most effective way.

In Slovakia, by adoption of the reduction commitment of the Kyoto Protocol, which has not been ratified yet, pressure is put on the formulation of an efficient strategy to mitigate greenhouse gas emissions. Flexible mechanisms defined in the Kyoto Protocol, with regard to the actual status of the inventory of greenhouse gas emissions in the Slovak Republic, represent new opportunities for acquisition of investments for emission reduction projects, as well as for more significant implementation of new efficient technologies.

The presented National Communication links conclusions of the Second National Communication on Climate Change, Slovak Republic, updated conceptions of the relevant ministries, as well as programs and projects which have been implemented for this area in Slovakia.

S.2 NATIONAL CIRCUMSTANCES

The Slovak Republic became an independent state on January 1, 1993. According to the Constitution of the Slovak Republic of 1 September 1992, the head of the State is the President elected by the Slovak Parliament for a period of 5 years. The supreme legislative body is the National Council of the Slovak Republic, composed of 150 deputies elected for a period of 4 years. The Government of the Slovak Republic, directed by the Prime Minister has 4 deputy prime ministers and 15 ministers. According to the new administrative zoning, the Slovak Republic is subdivided into 8 regions, 79 districts and 2,904 communities (1999). The legislative process lies within the authority of the ministries, whereby projects of laws, after the evaluation of interdepartmental comments and based on their negotiations in the Legislative Council of the Government, are approved by the Government and subsequently by the Parliament.

The decision-making activity and authorities in the area of air protection are, in compliance with Act No. 595/1990 Coll., conferred to the Ministry of Environment, regional and district authorities and municipalities. Other ministries within the existing structure directly or indirectly involved in the preparation of legislative, regulative and economic instruments for the implementation of the policy of greenhouse gas emission reduction, are: the Ministry of Finance, the Ministry of Economy, the Ministry of Transport, Posts and Telecommunications, the Ministry of Agriculture and the Ministry of Construction and Regional Development.

In April 1993 Slovakia acceded to the General Agreement on Tariffs and Trade (GATT) and subsequently to the World Trade Organization (WTO). In February 1995 the Association Treaty between the European Union (EU) and the Slovak Republic entered into force and in June 1995 Slovakia confirmed its ambitions for integration by the application for membership in EU. In September 2000 Slovakia became a member of OECD.

The Slovak Republic lies in Central Europe, in the territory bordering with the Czech Republic and Austria in the west, with Hungary in the south, with Ukraine in the east and with Poland in the north. The total area of the territory is 49,036 km^2, of which 50% agricultural soil, 41% forest soil, 2% water area and 3% built-up areas. Slovakia is a mountainous country; 60% of its surface is over 300 m. In climate, Slovakia belongs to the moderate climatic zone. The average annual precipitation totals in the whole territory represent 743 mm, of which 65% on average is evaporated and 35% represents runoff. During the last 100 years air temperature has risen by 1 °C and precipitation in the South of Slovakia decreased by 10 to 15%.

After a recession which lasted from 1989 to 1993 and where the gross domestic product decreased by almost one quarter, in 1994 a revival was observed, caused by external demand only. The GDP increase in comparable prices represented 4.9% in 1994, 6.6% in 1995, 6.6% in 1996 and 6.5% in 1997. Since 1996 the rate of GDP growth has slowed, but even in this period it achieved an above-average level within the group of countries with transforming economies.

The complexity of economic base restructuring, including its technical innovation and ownership transformation, is shown by changes in the structure of GDP formation. This change showed especially in the increase of the share of services to the detriment of industry, which also contributed to reduction of energy intensity and production of basic pollutants and greenhouse gases emissions. Transformation of ownership was reflected in the gradual increase of the share of the private sector in GDP formation: growth from 37.3% in 1993 to 82.6% in 1997.

The slowdown of GDP growth in the recent years was accompanied by a slight decrease of consumption of primary energy sources, the decrease of final energy consumption and electricity consumption. The consumption of PES per capita in the Slovak Republic stands at approximately 85% of the average of EU countries. In the future it can be assumed that the structure of PES final consumption will change in favour of higher utilisation of natural gas in industry and in households, as well as in electricity and heat generation. In the area of solid fuel consumption we can expect stagnation or decrease, caused by introduction of more severe emission limits (particularly for brown coal). For liquid fuel consumption there could be a moderate increase in transport.

Currently the transportation sector in Slovakia is represented by road, railway, combined, water and air transports. According to results of deep analysis, the density of road network in Slovakia is adequate, so from the investment planning aspect there is no significant need for construction of new roads – with the exception of the completion of a highway crossing the whole Slovak territory. From the aspect of the number of motor vehicles, the highest dynamics of growth was reached in the category of passenger cars, the number of which increased on average by 36.6% during the period from 1990 to 1998. Similarly, since 1990, the number of automobiles per capita in Slovakia increased by 34%. With the achieved number of 4.7 inhabitants per passenger car (210.8 passenger cars per 1000 inhabitants) Slovakia ranks among European countries with medium-developed motorism.

The area of 0.46 ha of agricultural land per capita is low. On the basis of the document *Analyses of Development and Current State of Agriculture and Foodstuff Industry in the Slovak Republic* [1] we can state that impacts of economic transformation on agriculture were stronger than on other sectors of national economy. The produced real added value (1998), also under influence of differentiated price development, reaches only about 65% of the level of 1990.

In the period 1990 to 1997, gross agricultural production decreased by 29.1% (in constant prices of the year 1995). Gross plant production (decrease of 33.2%) contributed to this decrease more than gross animal production (decrease of 25.9%).

At the present time, forests cover 41% of the territory of the Slovak Republic, timber-growing stock in forests is estimated at more than 396 mil. m^3 (for comparison: in 1950 timber-growing stock in Slovakia represented a volume of 194 mil. m^3).

For energy purposes, it is appropriate to use especially that part of biomass which directly enters the process of decomposition or non-energy combustion, because carbon from this biomass is gradually released to the atmosphere in the form of CO_2.

The new conception of waste economy dates back to 1991, when Act No. 238/1991 Coll. on Waste and its implementation regulations were adopted, by which a separate legal framework for waste disposal was created. By Act No. 494/1991 Coll. on State Administration in Waste, the state administration in waste economy was constituted. The amount of communal waste has almost not changed – a slight increase was observed since 1996. From a total quantity of municipal waste of 1.6 mil. tonnes (the average per capita is about 300 kg), 75% originates directly with inhabitants and 25% represents waste originating in the business sphere.

As in the other Central and East European countries, the existing housing fund is in poor technical condition; it is marked by high losses on energy and its ineffective utilization. The estimated potential for confirmable energy savings in the heating of buildings represents about 40% of total heat consumption. 723 thousand apartments, which were constructed in panel building systems, do not meet the existing more severe requirements for thermal insulation specified in STN 73 0540. Costs of improvement of heat insulation of peripheral and roof jackets were estimated to 1,500 SKK/m^2 – about 100,000 SKK per apartment.

S.3 INVENTORY OF GREENHOUSE GAS EMISSIONS

The most important anthropogenic greenhouse gases are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3). They belong among natural elements of the atmosphere, though their actual concentration in the atmosphere is significantly affected by human activities. Other greenhouse gases are halogenated hydrocarbons (PFCs, HFCs) and SF_6. Photochemical active gases, such as carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane volatile organic hydrocarbons (NMVOCs), are not greenhouse gases, but they contribute indirectly to the greenhouse effect in the atmosphere. These are generally referred to as ozone precursors because they affect the creation and destruction of ozone in the troposphere. Precursors of sulphates – sulphur dioxide (SO_2) and aerosol – reduce the greenhouse effect.

The chapter presents national emissions of CO_2, CH_4, N_2O, CF_4, C_2F_6, NO_x, CO, NMVOC and SO_2 since 1990. According to the existing development we can suppose that in 2000 total greenhouse gas emissions will not exceed the level of the year 1990.

[1] Compiled by VÚEPP Bratislava, 1999.

Table S.1 *Total anthropogenic GHG emissions in Slovakia, 1990–1999*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 * [Gg]	60,000	52,000	49,000	46,000	43,000	44,000	45,000	45,000	44,000	45,000
CH_4 [Gg]	322	294	268	250	244	248	254	241	223	223
N_2O [Gg]	19	16	14	12	12	12	10	10	10	9
PFC, HFC, SF_6 [Gg eqv. CO_2]	272	267	249	156	144	148	91	114	80	92

** CO_2 emissions without LUC&F.*

Note: Emissions determined as of 30 January 2001.

However in the case of ratification of the Kyoto Protocol, the Slovak Republic should reduce total emissions in the target period of the years 2008 to 2012 by 8% against the year 1990.

The greenhouse gas emissions presented in the Second National Communication were updated and converted using the revised methodology of IPCC 1996.

S.3.1 CO_2 emissions

The most important anthropogenic source of CO_2 emissions in the atmosphere is combustion and transformation of fossil fuels, which account for about 95% of the total CO_2 emissions in Slovakia. The total balance of CO_2 is also affected by changes in land use and technological sources of CO_2. The calculation of CO_2 emissions is based on energy statistical data to which the reference IPCC method (Reference Approach) was applied.

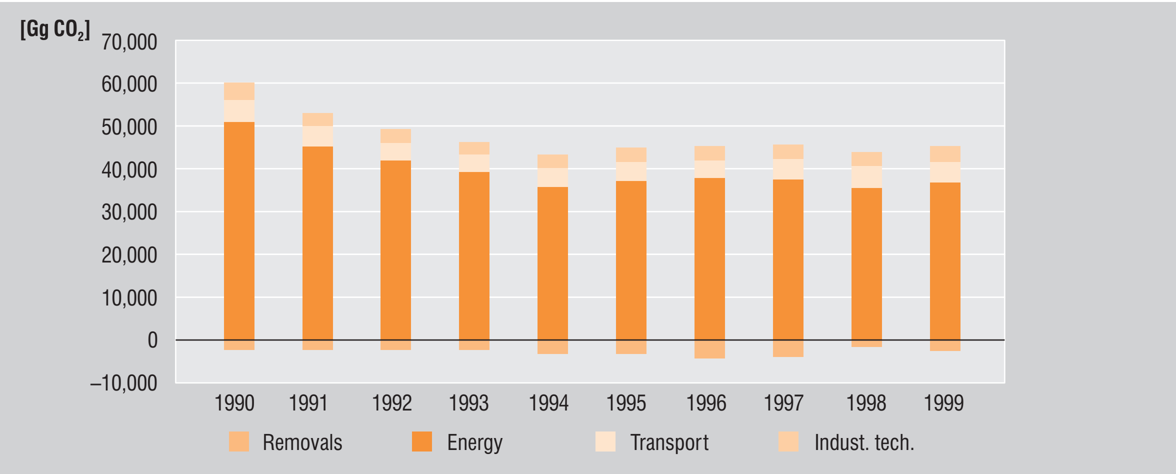
S.3.2 CH_4 emissions

The primary sources of methane in the Slovak Republic are agriculture, fuel exploitation and transport and waste treatment.

S.3.3 N_2O emissions

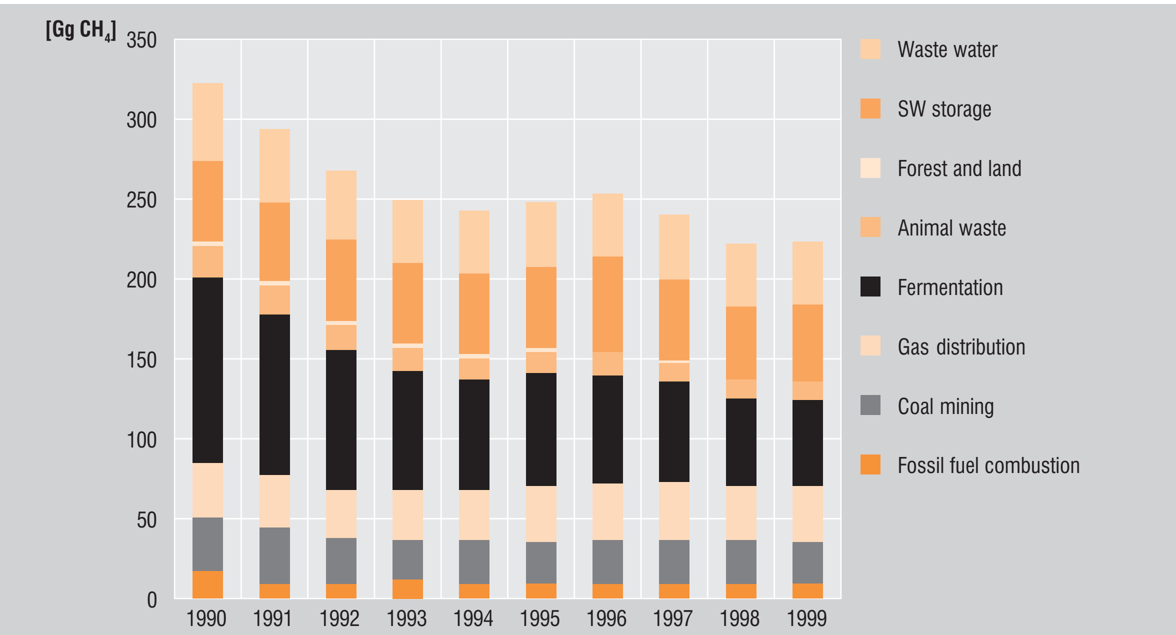
In comparison with other greenhouse gases, the mechanism of N_2O emissions and sinks develops from the nitrogen cycle in the atmosphere and their quantification is rather difficult. The primary

Figure S.1 *Share of individual sectors on CO_2 emissions [Gg] in the period 1990–1999*



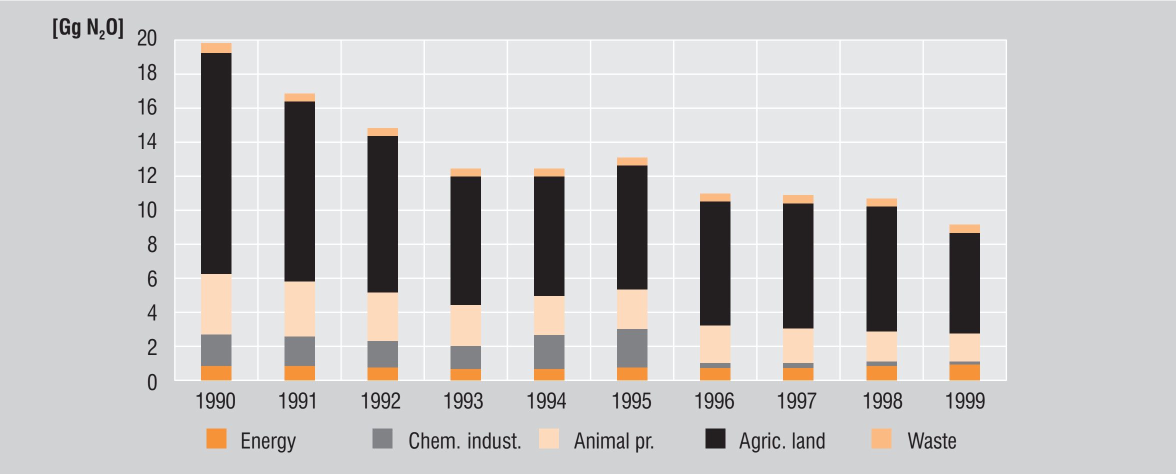
Note: Emissions determined as per 15. 4. 2001.

Figure S.2 *Share of individual sectors on CH_4 emissions [Gg] in the period 1990 to 1999*



Note: Emissions determined as of 30.1. 2001.

Figure S.3 *Share of individual sectors in N_2O emissions [Gg] in the period 1990–1999*



Note: *Emissions determined as of 30 January 2001.*

sources of N_2O are agriculture, waste treatment and N_2O from combustion of fuels (energy and transportation sectors).

S.3.4 Emissions of HFCs, PFCs and SF_6

The first inventory of these substances[2] was executed in 1995. HFCs, PFCs and SF_6 have not been produced in Slovakia, only data on consumption of these substances are available. They are used as coolants, extinguishing agents, blowing agents for PUR, in aerosol products and as insulating gases (SF_6). The Statistical Office has not been monitoring their consumption, it is annually determined by using questionnaires. Since 1995 consumption of HFCs and SF_6 has tripled.

Since 1990 emissions of C_2F_6 and CF_4 occurring through aluminium production have been determined on the basis of frequency of anodic cycles. Following the year 1996, emissions of these substances decreased on average thanks to modernisation of technologies.

S.3.5 Aggregated emissions

Greenhouse gas emissions for the years 1990 to 1999 in aggregate form allow comparison of the contribution of individual greenhouse gases and individual sectors to the global greenhouse effect. Emissions of individual greenhouse gases are expressed using GWP for the span of 100 years.

CO_2 emissions contribute by more than 80% to the total aggregate emission, CH_4 emissions contribute by about 11% (expressed in Gg of the CO_2 equivalent), emissions of N_2O by 6% and emissions of new gases in total account for less than 1%.

S.4 POLICY AND MEASURES TO MITIGATE GREENHOUSE GAS EMISSIONS

Basic conceptual documents, a part of which is the policy to mitigate negative effects of climate change, whether directly by reducing greenhouse gas emissions or indirectly by limiting negative effects of energy sector, agriculture and other economic activities, include:

- Strategy, Principles and Priorities of State Environmental Policy
- National Environmental Action Program SR II
- Strategy of the Slovak Republic in Relation to Global Climate Change
- Energy Policy of the Slovak Republic
- Strategy and Conception of Development of Forestry for the Slovak Republic
- Waste Management Program of the Slovak Republic for the Period 2000–2005
- Conception of Reduction of Greenhouse Gas Emissions in Construction and Public Sector of the Slovak Republic Until 2005
- Proposal for Long-Term Measures Considering Adaptation of the Slovak Republic to Climate Change

Proposals for mitigation and adaptation measures, as well as a comprehensive analysis of the potential of the Slovak Republic in the area of reduction of greenhouse gas emissions are the result of the solution of such research programs and projects:

[2] In Slovakia the utilization of freons (they are not covered by the UN Convention) 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 (The Copenhagen Amendment allows their utilization until 2030).

Figure S.4 *Aggregated emissions of greenhouse gases in 1990–1999 [%]*

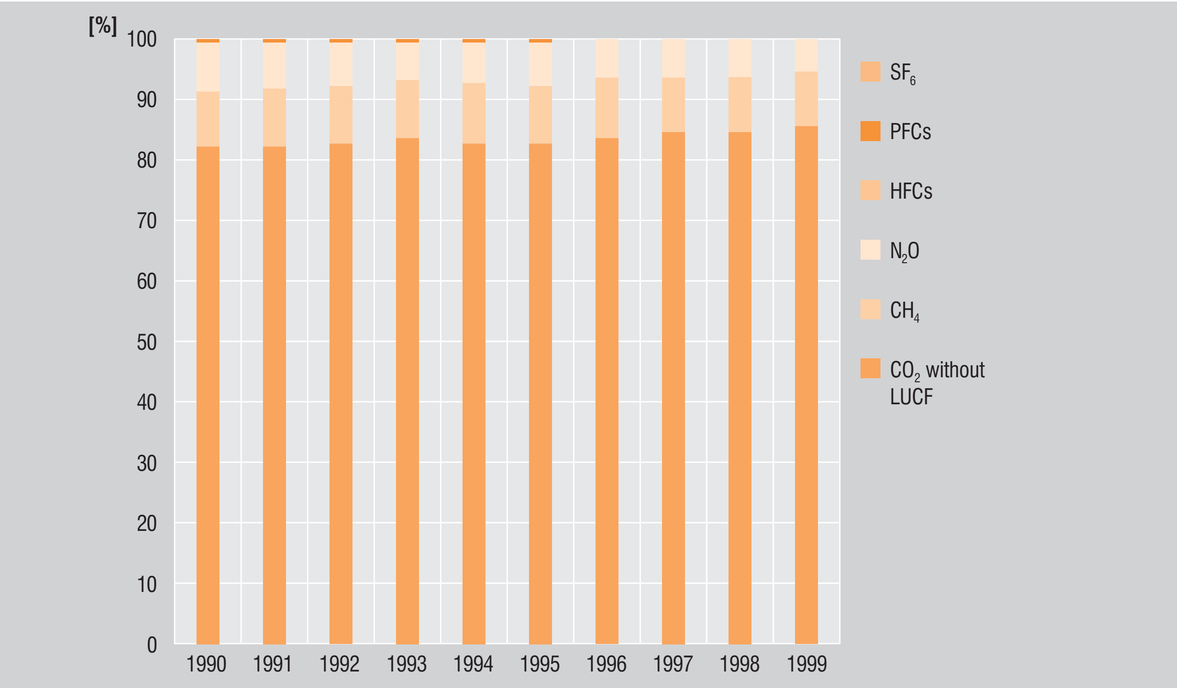
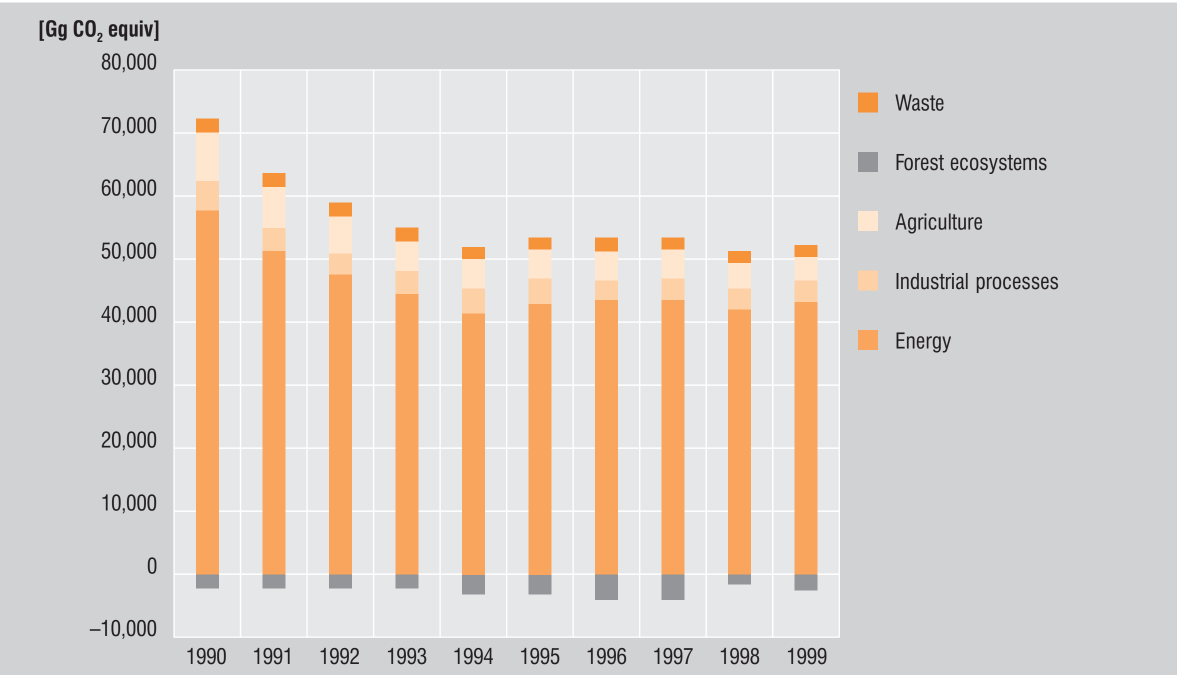


Figure S.5 *Aggregated emissions of greenhouse gases by sectors (without LUCF), 1990–1999*



Values of GWP100 according to Climate Change 1995.

- National Climate Program of the Slovak Republic
- National Program of Inventory of Greenhouse Gases, SHMÚ
- National Program to Stabilise and Reduce CO_2 Emissions in Transportation in the Slovak Republic, November 1994 (VÚD Žilina)
- Country Study of Slovakia, May 1997 (US Country Studies Program)
- Study on Slovak Strategy for GHG Reduction, June 1998 (Project: National Strategy Studies for GHG Reduction, supported by the World Bank, the Swiss Government and the Ministry of Environment of the Slovak Republic: www-esd.worldbank.org/cc/, www.admin.ch/swissaij)

Table S.2 *Characteristics and reduction potential of some mitigating measures in the energy sector* [3]

						Mitigation	impact	ΔGHG	[GgCO$_2$ equiv./year]
Name of policy/measure	**Objective and/or Activity affected**	**GHG affected**	**Type of instrument**	**Status**	**Implementing entity/entities**	**2000**	**2005**	**2010**	**2015**
Act No. 309/1991 Coll. on Protection of the Air	Reduction of emissions of the basic pollutants	CO_2 CH_4 N_2O	Regulatory and economic	I	Slovak Ministry of Environment Environmental authorities	258 4 1	1,365 88 10	1,372 92 13	1,342 72 11
Implementation of of combined cycles	Increase in energy efficiency	CO_2	Regulatory and economic	I	Slovak Ministry of Economy SEA	0	972	814	911
Thermal insulation of buildings	Reduction of final energy consumption in sectors MVV & RR	CO_2	Regulatory and technical	I	MVV & RR SR	0	78	803	634
Utilisation of renewable energy sources	Decrease in fossil fuel consumption	CO_2	Regulatory and technical	I	Slovak Ministry of Economy SEA	159	1,138	1,857	2,334
Shifting of services from individual to public transport	Decrease in hydrocarbon fuel consumption Environmental protection	CO_2 CH_4 N_2O	Regulatory and technical	S	Slovak Ministry of Transport, Posts and Telecommun.	0 0 0	132 1 6	269 2 19	405 3 34

Note – The positive values of ΔGHG correspond to reduction of greenhouse gas generation at the introduction of the respective measure.

Legend to table:

I – *policy and measure have been already implemented (using criteria of updated IPCC Guidelines 1999/7)*

S – *adopted, approved policy or measure*

P – *planned, prepared policy/measure*

[3] Table S.2 shows aggregated emissions of CH_4 and N_2O converted using GWP [Gg equiv. CO_2].

Table S.3 *Characteristics and potential of some measures in agriculture*[4]

						Mitigation	Impact	ΔGHG	[GgCO_2 equiv./year]
Name of policy/measure	**Objective and/or Activity affected**	**GHG affected**	**Type of instrument**	**Status**	**Implementing entity/entities**	**2000**	**2005**	**2010**	**2015**
Reduction of the livestock number	Intensification of agricultural production Harmonisation with EU legislation[5]	CH_4	Regulatory	I	The Ministry of Agriculture SR	0	0	22	2
		N_2O				0	0	–546	–291
		Total				**0**	**0**	**–524**	**–290**
Treatment of animal excrements to biogas	Application of RES Reduction of GHG emissions	CH_4	Technical	I	The Ministry of Agriculture SR	0	0	32	70
		N_2O				0	0	398	849
		Total				**0**	**0**	**430**	**919**

Note – The positive values of ΔGHG correspond to reduction of GHG emissions upon introduction of the respective measure.

Legend to table:

I – *policy and measure have been already implemented (using criteria of updated IPCC Guidelines 1999/7)*

S – *adopted, approved policy or measure*

P – *planned, prepared policy/measure*

[4] Table S.3 shows aggregated emissions of CH_4 and N_2O converted using GWP [Gg equiv. CO_2].

[5] The measures arising under the EU Directive lead to reduction of CH_4 emissions. On the other hand, formation of N_2O emissions increases upon their introduction.

Table S.4 *Characteristics and reduction potential of some mitigating measures in forestry sector*

						Mitigation	impact	ΔGHG	[GgCO₂ equiv./year]
Name of policy/measure	**Objective and/or Activity affected**	**GHG affected**	**Type of instrument**	**Status**	**Implementing entity/entities**	**2000**	**2005**	**2010**	**2015**
Soil stock protection	Increase of soil carbon stock – lower effect*	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	73	51	99
	Increase of soil carbon stock – higher effect	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	88	80	142
Regulation of timber extraction	Reduction of permanently deforested area – lower effect	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	330	660	990
	Reduction of permanently deforested area – higher effect	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	660	990	1,320
Afforestation of non-forest areas	Increase of GHG sinks – lower effect	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	1	10	31
	Increase of GHG sinks – higher effect	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	2	13	42

** The lower effect corresponds to the scenario with measures, the higher effect to the scenario with additional measures (see Chapter 5).*

Note – The positive values of ΔGHG correspond to reduction of GHG emissions upon introduction of the respective measure.

Legend to table:

I – *policy and measure have been already implemented (using criteria of the updated IPCC Guidelines 1999/7)*

S – *adopted, approved policy or measure*

P – *planned, prepared policy/measure*

Table S.5 *Characteristics and potential of some measures in the sector of waste management*[6]

						Mitigation	Impact	ΔGHG	[GgCO$_2$ equiv./year]
Name of policy/measure	**Objective and/or Activity affected**	**GHG affected**	**Type of instrument**	**Status**	**Implementing entity/entities**	**2000**	**2005**	**2010**	**2015**
Support of separated waste collection and utilisation of biologically active waste Biogas combustion	Reduction of emissions and the amount of biologically active waste disposed in landfills		Regulatory	I	Slovak Ministry of Environment				
	– lower effect*	CH_4				0	90	260	428
	– higher effect	CH_4				0	181	428	689
Waste water treatment	Reduction of CH_4 emissions and harmonisation with EU								
– effluents	– lower effect	CH_4	Regulatory	I	Slovak Ministry of Environment	0	11	34	53
	– higher effect	CH_4				0	21	55	84
Waste water treatment	Reduction of CH_4 emissions and harmonisation with EU								
– industrial waters	– lower effect	CH_4	Regulatory	I	Slovak Ministry of Environment	0	11	34	59
	– higher effect	CH_4				0	22	57	95
Waste water treatment	Harmonisation with EU	N_2O	Regulatory	P	Slovak Ministry of Environment	0	–3 **	–6	–8

** The lower effect corresponds to the scenario with measures, the higher effect to the scenario with additional measures (see Chapter 5).*

*** Note – The positive values of ΔGHG correspond to reduction of GHG emissions upon introduction of the respective measure.*

Legend to table:

I – *policy and measure have been already implemented (using criteria of updated IPCC Guidelines 1999/7)*

S – *adopted, approved policy or measure*

P – *planned, prepared policy/measure*

[6] Table S.5 shows aggregated emissions of CH_4 and N_2O converted using GWP [Gg equiv. CO_2].

The most important measures and activities in the area of reduction of greenhouse gas emissions were evaluated from the aspect of the present status of their implementation, classified by sectors and subsequently by individual greenhouse gases. Where relevant information and documents were available, the impact of measures and supporting programs was quantified and in modelling the development of emission trajectories it was included in the scenario with measures.

The chapter also includes brief characteristics of other instruments and mechanisms to mitigate greenhouse gas emissions and quantified results of the analysis of the most important measures from the Energy Policy of the Slovak Republic from the aspect of their CO_2 reduction potential, investment requirements and the time horizon for their implementation.

S.5 PROJECTIONS AND ASSESSMENT OF MEASURE EFFECTS

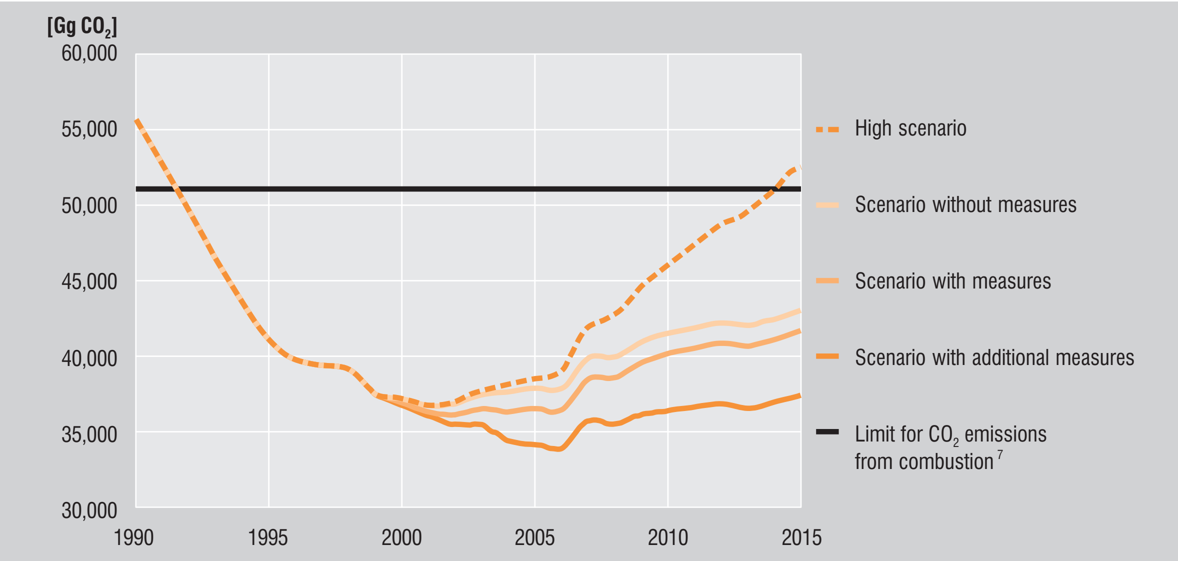
The emission projections in countries with economies in transition, including the Slovak Republic, are influenced by the uncertainties accompanying the transition process, due to which the simple extrapolation of energy consumption historical data cannot be used to model future development. Taking into account the major impacts and key assumptions of the development of decisive parameters, GHG emission scenarios in the area of combustion and transformation of fossil fuels and fugitive emissions in agriculture and in waste treatment were designed and modelled. In addition, unlike the Second National Communication on Climate Change, Slovak Republic, the development of new gas emissions was simulated in the Third Communication.

In the framework of sector projections of GHG emissions were modelled and analysed using the following three scenarios:

1) ***scenario without measures,***
2) ***scenario with measures,***
3) ***scenario with additional new measures.***

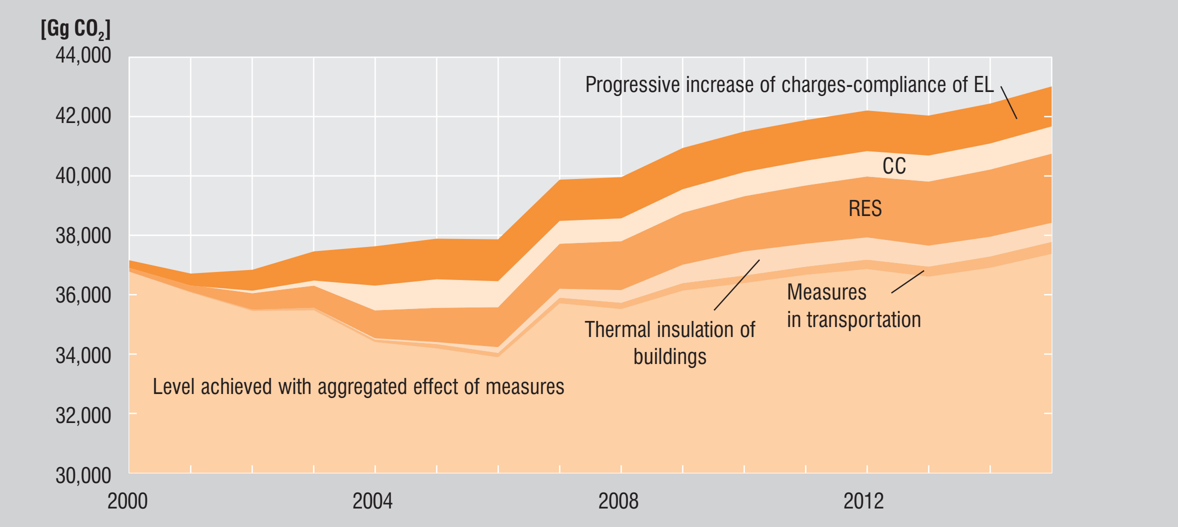
Attention was paid especially to the energy sector, and in the framework of this sector to CO_2 emissions from combustion and transformation of fossil fuels. In addition to scenarios mentioned above, the so-called high scenario was designed and modelled for this area. It is based on the scenario without measures, adapted in view of the expected higher annual increase of energy consumption, which would correspond to higher dynamics of economic growth in the Slovak Republic. The level of CO_2 emissions for individual scenarios is illustrated by courses in Figure S.6. The Figure also shows the so-called *limit level,* which corresponds to the average annual level of CO_2 emissions from combustion and transformation of fossil fuels in an amount of 51,066 Gg CO_2 in the period 2008–2012 (the planned reduction target for this sector is higher). The courses illus-

Figure S.6 *Projections of CO_2 emissions from combustion and transformation of fossil fuels*



[7] The limit corresponds to the average annual volume of CO_2 emissions from fossil fuel combustion and transformation in an amount of 51,066 Gg CO_2 in the period 2008–2012 (Slovak Ministry of Environment) – expected reduction target for this sector is higher.

Figure S.7 *Projections of CO_2 emissions from combustion and transformation of fuels for analysed reducing measures*



trated by Figure S.6 show that even in the case of the development of emissions according to the high scenario, the limit level will not be exceeded during the target period.

In the framework of modelling, the impact of the most important measures on the level of CO_2 emissions from combustion and transformation of fossil fuels in the energy sector (including transportation) was quantified.

The gradual loading of individual measures within modelling can be described by the following steps:

- The basic level is represented by the scenario without measures;
- Step 2 corresponds to the scenario with measures, which illustrates especially the impact of legislation in the area of air protection;
- Step 3 represents reinforcement of the effect of measures in the preceding stage by the utilisation of combined cycles in industrial and public power plants (they are only considered as a replacement of production from coal power plants);
- In step 4, the measures from the preceding step will be supplemented by the utilisation of renewable energy sources (RES) in the framework of energy balance;
- Step 5 – the measures from step 4 will be extended by the effect of thermal insulation of buildings (showing by reduction of heat consumption in apartments and public buildings);
- Step 6 represents the total effect of considered measures, i.e. the preceding measures will be completed by measures implemented in transportation. The achieved level of emissions in this step represents the level of emissions for the scenario with additional measures.

Similarly the impacts of mitigating measures in other sectors were analysed based on data in Tables S.3 to S.5. For individual sectors total aggregated GHG emissions were calculated on the basis of aggregation of scenarios, which are indicated in the tables below.

Table S.6 *Total aggregated GHG emissions [Gg CO_2equivalent] in the energy sector for cross years*

Scenario	1990 *	2000	2005	2010	2015
Without measures	**57,771**	**38,866**	**39,638**	**43,524**	**45,249**
– of which transportation	5,155	4,654	4,862	5,353	5,895
With measures	**57,771**	**38,615**	**38,179**	**41,961**	**43,584**
– of which transportation	5,155	4,654	4,862	5,353	5,895
With additional measures	**57,771**	**38,466**	**35,762**	**38,038**	**39,089**
– of which transportation	5,155	4,654	4,855	5,332	5,858

** Emissions in the reference year of UNFCCC*

Table S.7 *Total aggregated GHG emissions [Gg CO_2equivalent] in industry in cross years*

Aggregated GHG emissions in industry	1990 *	2000	2005	2010	2015
Non-energy related CO_2 emissions in industry	3,882	4,954	5,426	5,426	5,426
N_2O emissions	577	62	62	62	62
Emissions of new gases	272	184	206	230	230
Total	**4,731**	**3,710**	**4,203**	**4,227**	**4,227**

** Emissions in the reference year of UNFCCC*

Table S.8 *Total aggregated GHG emissions [Gg CO_2equivalent] in agriculture in cross years*[8]

Scenario	1990*	2000	2005	2010	2015
Without measures					
CH_4	2,838	1,331	1,526	1,505	1,466
N_2O	5,022	2,449	3,423	3,952	3,926
Total	**7,860**	**3,780**	**4,950**	**5,457**	**5,392**
With measures					
CH_4	2,838	1,331	1,505	1,504	1,434
N_2O	5,022	2,449	3,970	4,244	4,197
Total	**7,860**	**3,780**	**5,474**	**5,747**	**5,631**
With additional measures					
CH_4	2,838	1,331	1,473	1,434	1,267
N_2O	5,022	2,449	3,573	3,395	2,824
Total	**7,860**	**3,780**	**5,046**	**4,829**	**4,091**

** Emissions in the reference year of UNFCCC*

Table S.10 *Total aggregated GHG emissions [Gg CO_2equivalent] in waste management in cross years*[9]

Scenario	1990*	2000	2005	2010	2015
Without measures					
CH_4	2,068	1,543	1,546	1,557	1,566
N_2O	22	13	13	13	13
Total	**2,089**	**1,556**	**1,558**	**1,570**	**1,579**
With measures					
CH_4	2,068	1,543	1,434	1,229	1,026
N_2O	22	13	15	25	27
Total	**2,089**	**1,556**	**1,449**	**1,254**	**1,053**
With additional measures					
CH_4	2,068	1,543	1,322	1,017	699
N_2O	22	13	15	25	27
Total	**2,089**	**1,556**	**1,337**	**1,042**	**726**

** Emissions in the reference year of UNFCCC*

Projections of total aggregated emissions (converted to equivalent amount of CO_2 using GWP) were calculated, as in the case of individual sectors, for three scenarios – scenario without measures, scenario with measures and scenario with additional measures.

Projections of aggregated GHG emissions for the analysed scenarios in the period 2000–2015 are summarised in Figure S.8. In the framework of the emission trajectories, projections of GHG emissions are also represented in the so-called *high scenario*, which represents the aggregation of the high scenario of emissions occurring by combustion and transformation of fuels with the without measures scenarios from the other sectors. The figure also illustrates the level of aggregated emissions corresponding to the national reduction target under the Kyoto Protocol. The courses in the figure show that in the case of balanced economic development of the Slovak Republic, the attainment of the KP reduction target is realistic for all considered scenarios, even without introduction of specific mitigating measures. Moreover, the course of emission trajectory under scenario with additional measures, which simulates the aggregated impact of considered measures, confirms the potential for stabilisation of GHG emissions production.

In addition to a real chance of fulfilment the KP reduction target for Slovakia, the courses of emis-

[8] Table S.8 shows aggregated emissions of CH_4 and N_2O converted using GWP [Gg CO_2 equiv.]
[9] Table S.10 shows the aggregated emissions of CH_4 and N_2O converted using GWP [Gg CO_2 equiv.]

Table S.9 *Total aggregated GHG emissions [Gg CO_2 equivalent] in forestry and land use*

Scenario	1990*	2000	2005	2010	2015
Scenario without measures	– 2,345	–2,625	–1,421	–1,086	–1,170
Scenario with measures	–2,345	–2,625	–1,825	–1,807	–2,290
Scenario with additional measures	– 2,345	–2,625	–2,171	–2,169	–2,673

** Emissions in the reference year of UNFCCC*

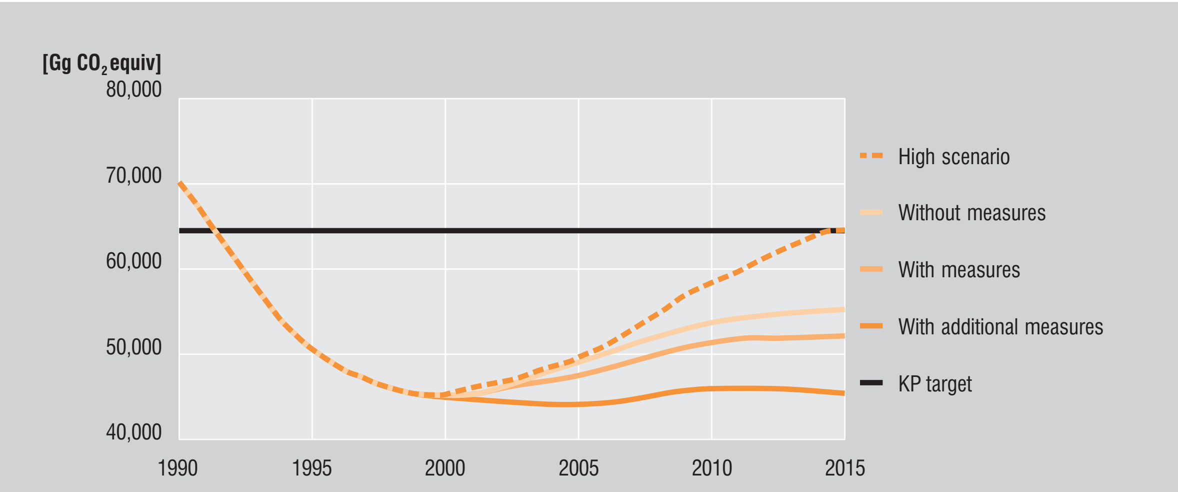
Table S.11 *Projections of aggregated emissions [Gg CO_2 equivalent] in cross years*

Scenario	1990*	2000	2005	2010	2015
Without measures					
Energy sector	57,771	38,866	39,638	43,524	44,994
– of which transportation	5,155	4,654	4,862	5,353	5,894
Industry	4,731	3,710	4,203	4,227	4,227
Agriculture	7,860	3,780	4,950	5,457	5,392
Forestry	–2,345	–2,625	–1,421	–1,086	–1,170
Waste management	2,089	1,556	1,558	1,570	1,579
Total	**70,106**	**45,287**	**48,929**	**53,692**	**55,022**
With measures					
Energy sector	57,771	38,615	38,179	41,961	43,569
– of which transportation	5,155	4,654	4,862	5,353	5,895
Industry	4,731	3,710	4,203	4,227	5,656
Agriculture	7,860	3,780	5,474	5,747	5,631
Forestry	–2,345	–2,625	–1,825	–1,807	–2,290
Waste management	2,089	1,556	1,449	1,247	1,047
Total	**70,106**	**45,036**	**47,480**	**51,375**	**52,184**
With additional measures					
Energy sector	57,771	38,466	35,762	38,038	39,089
– of which transportation	5,155	4,654	4,855	5,332	5,858
Industry	4,731	3,710	4,203	4,227	4,227
Agriculture	7,860	3,780	5,046	4,829	4,091
Forestry	–2,345	–2,625	–2,171	–2,169	–2,673
Waste management	2,089	1,556	1,337	1,042	726
Total	**70,106**	**44,886**	**44,177**	**45,967**	**45,460**

sion trajectories indicate for all scenarios (including the high one) the existence of an emission reduction reserve – so-called offset.

The existence of sufficient "reserve" reduction potential would allow Slovakia not only to meet the more severe commitments in the following target period (post Kyoto period), but also to use possible emission reduction reserve for acquisition of investment funds or innovation of technologies, in the framework of flexible mechanisms under the Kyoto Protocol – Joint Implementation and Emission Trading.

Figure S.8 *Projection of aggregated emissions of greenhouse gases*



S.6 EXPECTED IMPACTS OF CLIMATE CHANGE, VULNERABILITY ASSESSMENT AND ADAPTATION MEASURES

S.6.1 Climate changes and climate change scenarios

Climate changes and variability of climate on the Earth, in Europe and in Slovakia may be described using the observation of meteorological stations and observatories in the period of years 1901–2000. With this objective, courses of monthly air temperature averages from stations in Oravská Lesná, Habura, Košice and Hurbanovo were prepared. The results are shown in Figure S.9.

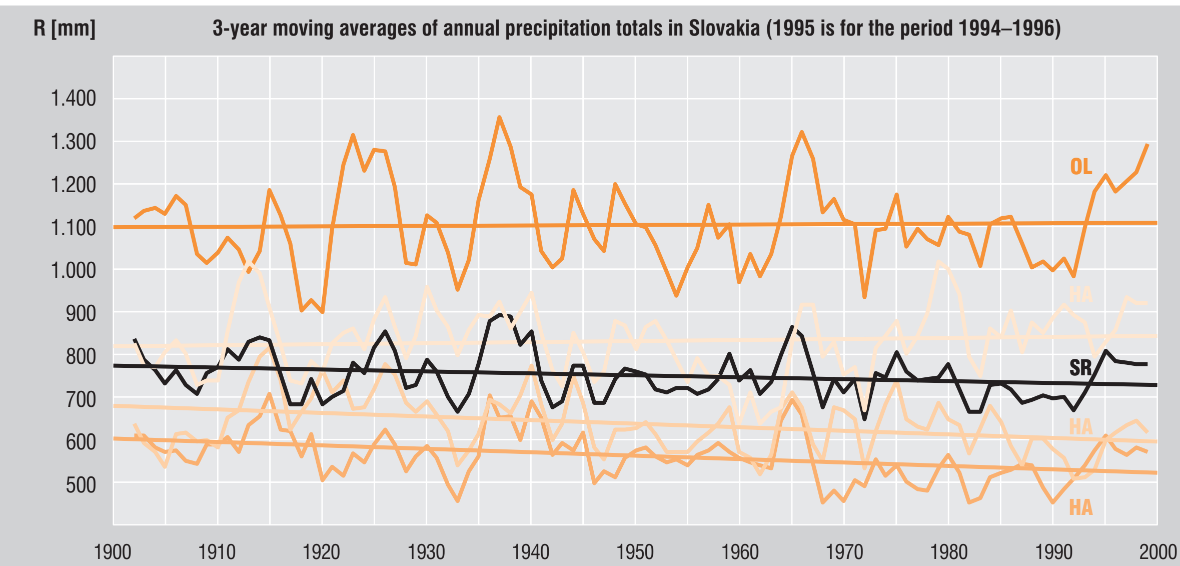
For the last 100 years in Slovakia we recorded a trend of increase of mean annual air temperature (T) of 1.1 °C and a decrease of mean annual precipitation totals (R) of 5.6% (in the South of Slovakia the decrease even exceeded 10%, in the North and the North-East exceptionally an increase up to 3% for the whole century. A significant decrease of relative air humidity (up to 5%) was also recorded, particularly in the South-West of Slovakia, and a decrease of characteristics of snow cover almost in the whole Slovakia. Especially the South of Slovakia has been drying up (potential evapotranspiration increases and soil humidity decreases), but characteristics of solar radiation showed no significant changes, with exception of transitory decrease in the period 1965–1985. After the transitory decrease of occurrence of extreme daily precipitation totals in the period 1977–1993, during the last 7 years there was a considerable increase, due to which the risk of local floods in different areas of Slovakia increased significantly. On the other hand, especially in the period 1989–2000, local or nation-wide drought occurred more frequently than before, which was caused mainly by long periods of warm weather, while precipitation totals did not exceed the interval of standard since 1975.

In 2000, regional modification of outputs from two models of interconnected GCMs (CCM from the Canadian Centre for Climate Modelling and GISS from the Goddard Institute for Space Studies in the United States) was prepared in the framework of the NCP SR. In comparison with the previous scenarios from the years 1995 and 1997, the new scenarios (named CCCMprep a GISSprep) assume slight warming in winter, comparable in summer, while precipitation totals will moderately increase in the cold half-year and remain practically unchanged in the warm half-year.

S.6.2 The hydrological cycle, water resources and water management

On the basis of overall evaluation of the hydrological situation in Slovakia for the last five years we can state that externality of runoff partially in-

Figure S.9 *Time course of 3-year moving averages from annual precipitation totals in Slovakia for the period 1901–2000 and linear trend (OL – Oravská Lesná, 780 m a.s.l., HA – Habura, 372 m a.s.l., KO – Košice, 230 m a.s.l., HU – Hurbanovo 115 m a.s.l. and SR – double weighted averages based on data of 203 precipitation stations in Slovakia)*



creased, while the average values determined for main Slovak river basins for the individual years did not significantly differ from the long-term averages. The years 1996 to 2000 belonged to the period with the most extensive floods, both floods in river systems and torrential floods usually affecting relatively small areas. As the stated floods did not cause any significant increase of average water volume, this means that they were "compensated" by another extreme, i.e. small water volume or long-term decrease of water volume in the other parts of the year. The statistical evaluation of increased externality as well as its persistence assumes monitoring with the same quality in the following years.

This descending trend has been visible since 1980. As far as long-term monthly discharges are concerned, very significant decreases were observed in central and eastern Slovakia during all months, with the exception of May and June, where only minor positive and negative deviations were recorded. Also in some river basins of western Slovakia the values of long-term discharges decreased in all months, save May and June. In West Slovakia the summer and autumn months are drier than in the past, while winter months have runoff exceeding the standard.

The most important decrease in water yield of monitored springs was recorded in the period from 1988 to 1994 (approximately ranging between 1 and 10%), excepting springs in two orographical systems – the Small Carpathians and the White Carpathians. In these regions the increase of water yield (approximately of 0.5 to 5%) was observed. In the monitored probes, which are located in the area of Žitný ostrov and in the river meads of central and lower Hron, no significant changes in levels of ground waters against the long-term values were recorded.

The region of Žitný ostrov is one of the most important regions from the aspect of ground water supplies. As replenishment of its ground waters is in direct contact with the discharge regimen of the Danube, we can further consider this region as inert from the viewpoint of potential impacts of assumed climate changes.

In general, the obtained results from reworked hydrological scenarios for Slovakia can be summarised as follows: in the winter period increased discharges should be expected, particularly in January and February, in northern Slovakia until April and in most territory also in December. The increase of winter runoff in the North can range from 10 to 40%, in central regions of Slovakia from 20 to 50% and in the South from 30 to 80%. Exceptionally winter runoffs may be even higher. The winter runoff increases toward more distant time horizons (toward 2075).

In the warm half-year we can expect a decrease of discharges against the existing level: while in the North it occurs particularly in the middle of summer, in the South this decease can affect the whole warm half-year (April to September). In the North the decrease of monthly discharges should not exceed the limit of 20%. In central regions of Slovakia maximum decrease may reach up to 30% and in the South up to 40%, exceptionally even more. During autumn (from September to November), we can also expect a decrease of discharges on most streams of Slovakia (except those in northern Slovakia). No insignificant changes in one or the other direction can be expected there.

It will probably be necessary to expect general decrease of all three water resources: surface, ground and soil. The proposed adaptation measures are specified in Chapter 6.

S.6.3 Forestry and forest ecosystems

Changed bioclimatic conditions (precipitation and higher evaporation) will endanger the structure of the existing associations and the representation of tree species (especially spruce). At higher vegetation levels the better temperature conditions of the future climate and relatively sufficient water balance may contribute to the creation of bioclimatic conditions suitable for higher representation of broad-leaved tree species (beech, maple, ash) and for higher potential production of tree species. Limiting factors of such estimate of future development of forest vegetation levels are the development of abiotic (wind, frost, meteorological extremes), biotic (insect, pathogens) and anthropogenic (pollutants) noxious agents.

According to the Holdrige model, at altitudes up to 500 m climatic conditions favourable for successful production of spruce cannot be expected even in the future. At higher altitudes, the conditions for broad-leaved species will improve, with increasing above sea elevation favourable conditions for mixed associations will be created.

According to the Forest Gap model, up to 500 m a.s.l., any participation of spruce in forest associations will be excluded, with increasing above sea elevation the representation of spruce will decrease to the detriment of beech, ash and sycamore.

In Slovakia, especially for spruce and fir, there is non-compliance between their bioclimatic requirements and actual occurrence. This is shown significantly in the values of climate change conditions, where 71% of spruce areas, 82% of fir areas and 32% of beech areas are situated at levels 3 to 5 of IT index. The IQ index indicates the most important changes for beech at its lower limit.

Adaptation measures can be summarised as follows:

- To increase carbon sinks in timber-growing stock, biomass and soil by afforestation of unused land, enhanced protection of forest stands and change of tree species composition of forests.
- To enhance adaptability of forests to climate change by the change of tree species composition, substitution of conifers by hard broadleaved species and strengthening the genetic and species diversity of forests.

S.6.4 Agricultural production in Slovakia

During economic transformation, agriculture went through extensive privatisation and saw a total decrease of produced real added value in agriculture. The cooperative form of management was mostly preserved because the majority of new land owners leased this land to cooperatives. Subsidies in agriculture decreased from 1989 by more than 50% and in 1994 they represented 7.1 billion SKK, i.e. 1.8% of GDP and they are much lower than in EU countries. In the period 1986 to 1992, Producer Subsidy Equivalents (PSEs) decreased by 40% and a slight decrease went on until 1994. In the first 5 years of economic transformation production of cereals was preserved. Numbers of cattle decreased by 41% and numbers of pigs by 19%. The application of fertilisers decreased to 20%.

It is expected that climate change will cause changes in time course of vital functions of plants – phenophases, early start and late end, and hence their prolongation to the time horizon of the year 2075, changes of agroclimatic conditions of the large vegetation period in primary indicators such as sums of daily temperatures (by 32 to 55%), increase of the sum of photosynthetic active ration of 10 to 25%, increase of evaporation in the north of Slovakia by of 20%.

Toward 2075, an increase of production potential of biomass in southern Slovakia of 10% and in north of Slovakia of 25% is expected. The transfer of fully profitable corn farming to the above sea elevation of 500 m and profitable corn farming to the above sea elevation of 800 m is supposed.

From the material aspect, the main task will be to solve and implement adaptation projects in ***agriculture*** aimed at:

- the application of protective and economical cultivation technologies, changes in crop growing technologies, changes in agroclimatic division and structure of grown crops and varieties, changes in cultivation programs, changes in the integrated protection of crops, changes in regulation of water regime of soil and changes in plant nutrition;
- reduction of greenhouse gas emissions, excrement and waste treatment in animal production, changes in management of agricultural production, revitalisation of the existing and construction of new irrigation systems.

S.7 REVIEW OF CLIMATE CHANGE RESEARCH

The Chapter provides a brief review of research projects in Slovakia related to climate changes, evaluation of negative impacts and adaptation measures for mitigation. We are referring especially to projects of VEGA grants, which are aimed at analysis of the temporal and spatial variability of water regime components, sensibility of the system of climatic conditions in Slovakia to climate change, impact of global environmental changes on water reserves, monitoring ground ozone etc. These grants were concentrated in the institutions of the Slovak Academy of Sciences and at universities.

S.8 EDUCATION AND ENHANCEMENT OF PUBLIC AWARENESS

In the area of public awareness of environmental issues, many positive changes occurred in the recent period. An important input in this context was adoption of Act No. 211/2000 Coll. on Free Access to Information ("Act on Information Freedom"), which repealed the existing Act on Access to Environmental Information (Act No. 171/1998 Coll.). By this Act, Article 45 of the Constitution of the Slovak Republic is executed, according to which everyone has the right to timely and full information about the condition of environment, as well as reasons for and consequences of this condition. A significant improvement was achieved also in the area of collaboration of governmental and non-governmental organisations and institutions in adoption of new conceptions and important legal norms. However, in connection with enhancement of public awareness, the new communication technology – Internet – has played the decisive role both in Slovakia and in the world.

The most important conceptual and analytical documents for the area of air protection are regularly distributed to members of Slovak Parliament, ministries, state administration, schools, research institutes, libraries and non governmental organisations and they are also available on the following websites:

- www.lifeenv.gov.sk – The most important information about activities of the Slovak Ministry of Environment.

- www.shmu.sk – Report on Air Quality and Share of Individual Sources in Its Pollution in the Slovak Republic, SHMU and the Slovak Ministry of Environment.

- www.sažp.sk – *Enviromagazín,* issued by the Slovak Environmental Agency (SEA) in collaboration with the Slovak Ministry of Environment.

- *Report on the Environment of the Slovak Republic* – prepared and annually issued by the Slovak Ministry of Environment.

- *Sieťovina (Mesh)* – bulletin for open informal association of governmental and non-governmental organisations dealing with environmental education.

- *The Office of the Slovak Ministry of Environment for Public Relations was* established directly in the premises of the Ministry to make available and provide to the general public:
  1. Information on decisions on environmental issues;
  2. Information on condition of environment;
  3. Other environmental information.

1. Introduction

While in the period of the preparation of the First and the Second Slovak National Communications on Climate Change the phenomenon of global warming was rather perceived as the specific problem of a small group of professionals, the development and the consequences of climate changes in the recent period directly in our territory has also caused a significant change of the general public attitude. The frequency and consequences of dangerous anthropogenic interference with the climate system, both in the international context and at the national level, have generated calls for new, more efficient and effective mechanisms to minimize its negative impacts.

The period after the adoption of the UN Framework Convention on Climate Change at the 1992 Conference on Environment and Development in Rio de Janeiro can be characterized as a period of intensive efforts to formulate an efficient strategy for reducing greenhouse gas emissions in a legally binding form, including rules and a control mechanism defined as precisely as possible. Another distinct tendency of this period was the endeavour to involve developing countries in a closer cooperation on the solution of the problem of global warming, in light of actual prognoses of their future development and related potential negative effects on the global balance of greenhouse gas emissions. Progress in this area is being achieved very slowly and it requires much effort on the part of working teams, because it is not easy to break the relationship between economic growth and environmental impacts. The endeavour of expert teams and negotiations of the Conferences of the Parties –COP– ended with the adoption of quantified reduction and/or stabilization emission targets for the Annex I countries of the Convention at the Third Conference of the Parties in December 1997 in Kyoto, Japan.

According to the wording of the Final Protocol from Kyoto, the countries included in Annex I have agreed to reduce aggregate greenhouse gases emission of all six gases (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) on average by 5.2% from the level of the year 1990 during the first commitment period 2008–2012. The Slovak Republic, as similarly the EU, committed itself to an 8% reduction of emissions compared to the base year 1990.

The Kyoto Protocol has generally extended the options of the countries to choose the way and the instruments which are the most appropriate for achievement of reduction targets, having regard to the specific circumstances of the country. The common feature of the new mechanisms is the effort to achieve the maximum reduction potential in the most effective way. In addition to the bubble concept (the European Union), the Protocol defines in the framework of the international collaboration the following flexible mechanisms:

a) Joint Implementation (Art. 6).
b) Clean Development Mechanism (Art. 12).
c) Emission Trading (Art. 17).

The purpose of the Joint Implementation (JI) and of the Clean Development Mechanism (CDM) is to obtain emission reduction credits based on project investments (including transfers of technologies) in the countries with economy in transition (EIT), or in the developing countries, while emission trading allows the buying and selling of emission reduction credits based on national inventory (ERCs) according to the agreed schedule in the Annex I countries.

In spite of the obvious economic and environmental effectiveness, the practical implementation of these mechanisms is connected with a series of institutional and political problems, as well as with the complexity of issues related to the transfer of technologies, monitoring, verification and – last but not least – with the mutual confidence of the involved parties.

In the framework of the strategy under preparation, the Slovak Republic would preferably participate in international emission trading at two levels – the intergovernmental level and the level of individual enterprises – under exactly defined national and international rules. In addition to investments, this participation should bring a more significant transfer of new efficient technologies.

The Third National Communication of the Slovak Republic is developed according to the updated IPCC Guidelines. In addition to an analysis of the conclusions of the Second Slovak National Communication and monitoring the progress made in this area, this document brings forth data on the quantification of the impact of policy and decisive measures. This data allows a more exact formulation of the most efficient strategy in the area of greenhouse gas emissions reduction.

2. National circumstances relevant to GHG emissions and removals

This Chapter contains a brief description of Slovak natural and economic conditions relevant to the development of generation and removal of greenhouse gas emissions. In addition to basic geographical data, a climate profile of the country, population development, economic and environmental frameworks, this Chapter briefly outlines the legislative process in the affected area, together with a definition of functions and responsibilities of the individual institutions involved in this process.

2.1 NATIONAL FRAMEWORK FOR ENVIRONMENTAL POLICY MAKING AND LEGISLATIVE PROCESSES

The Slovak Republic became independent on 1 January 1993. According to the Constitution of the Slovak Republic of 1 September 1992, the head of the State is the President elected directly for a period of 5 years. The supreme legislative body is the Parliament of the Slovak Republic, composed of 150 deputies elected for a period of 4 years. The Government of the Slovak Republic, led by the Prime Minister, has 4 deputy prime ministers and 15 ministers. According to the new administrative zoning, the Slovak Republic is subdivided into 8 regions, 79 districts and 2904 communities (1999). The legislative process lies within the authority of the ministries, whereby projects of laws, after the evaluation of interdepartmental comments and based on their negotiation in the Legislative Council of the Government, are approved by the Government and subsequently by the Parliament.

The decision-making activity and authorities in the area of air protection are, in compliance with Act No. 595/1990 Coll., conferred to the Ministry of Environment, regional and district authorities and municipalities. Other ministries, being, within the existing structure, directly or indirectly involved in the preparation of legislative, regulation and economic instruments for the implementation of the policy to mitigate greenhouse gas emissions are: the Ministry of Finance, the Ministry of Economy, the Ministry of Transport, Posts and Telecommunications, the Ministry of Agriculture and the Ministry of Construction and Regional Development.

National environmental policy observes the principles of sustainable development and under its long-term objectives includes the implementation of the National Program of Greenhouse Gas Emission Reduction.

2.2 GEOGRAPHY

The Slovak Republic lies in the Central Europe, in the territory bordering with the Czech Republic and Austria in the west, with Hungary in the south, with Ukraine in the east and with Poland in the north. Total area of the territory is 49 036 km^2, of which 50% agricultural soil, 41% forest soil, 2% water area and 3% built-up areas. Slovakia is a mountainous country; 60% of its surface is over 300 m, 15% over 800 m and 1% over 1,500 m a.s.l. The difference between the lowest point in Slovakia, which is the discharge of the river Bodrog out of our territory (94 m a.s.l.) and the highest point – the Gerlach peak (2,655 m a.s.l.) – is approximately 2,560 m. Almost the whole territory of the country is drained by the Danube into the Black Sea, only a small part of the territory in the north belongs to the basin of Polish rivers, which flow into the Baltic Sea.

The capital of Slovakia, Bratislava, which is also the biggest Slovak city with 449,547 inhabitants (as per 31 December 1998), is the centre of political, economical and cultural life. Also thanks to its favourable position – it lies on the southwest of the country, in close proximity of the border with Austria and Hungary – in the recent period Bratislava observed a significant economic growth with the lowest rate of unemployment (5.1% as per 31 December 1998) in the framework of the Slovak Republic and the highest percentual share in the formation of GDP.

2.3 CLIMATE

According to the global climatological classification Slovakia is in the mild climate zone category with precipitations uniformly distributed over the whole year. A regular rotation of four seasons and variable weather throughout the year are typical for this country. At the evaluation according to the normal period of the years 1931 to 1960, Slovakia showed the following climate characteristics: Compared to the Czech Republic and Austria, which lie more to the west, the climate in Slovakia showed more distinct continental features. In the east of Slovakia, at the same elevation, winters are colder by about 3 °C and in the south of Slovakia summers are warmer by about 2 °C. This difference increased in winter from the west to the east of the country. The mean January air temperature ranged from -1 °C in the lowlands in the southwest of Slovakia to -12 °C on the top of the Tatra Mountains. Mean air temperature in July exceeded 20 °C in Slovak lowlands, but at the elevations of 1,000 m a.s.l. it reached about 14 °C only. Southern Slovakia received up to 2,000 hours of sunshine each year, while the north-west of the country received only 1,600 hours. Average annual precipitation sum for the whole territory of Slovakia was 754 mm, of which 65% in average was evaporated and 35% represented runoff. The lowest precipitation means (550 mm annually) were observed in the middle of the Danube lowlands, while at the highest elevations of the Carpathians they exceeded 1,500 mm. Snow cover was unstable in the lower altitudes and lowlands in the south were usually without permanent snow cover in winter.

Since 1961 several significant changes of climate conditions were observed in Slovakia. We can document this by the courses of 10-year averages of air temperature and precipitation from end of 19th century to the decade 1990–2000. The values

Figure 2.1 *Deviations of ten-year average annual temperatures from the long-term average*

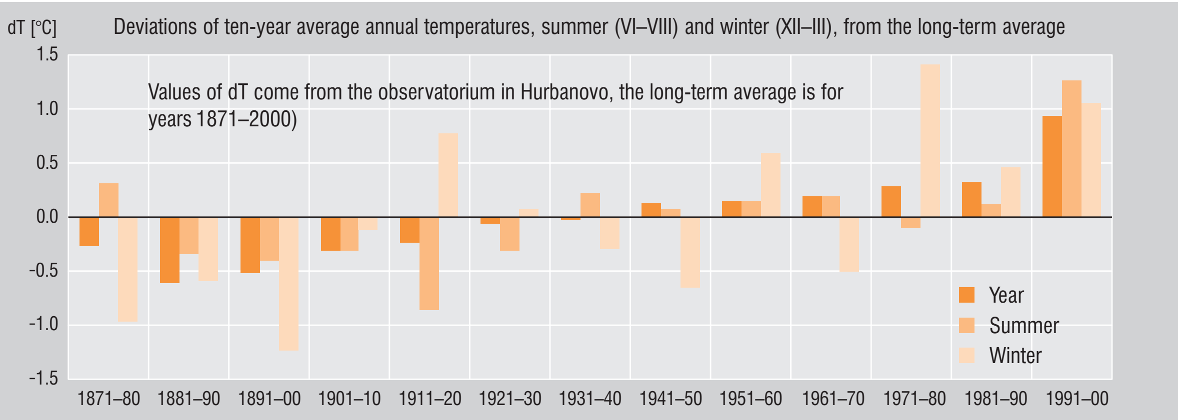
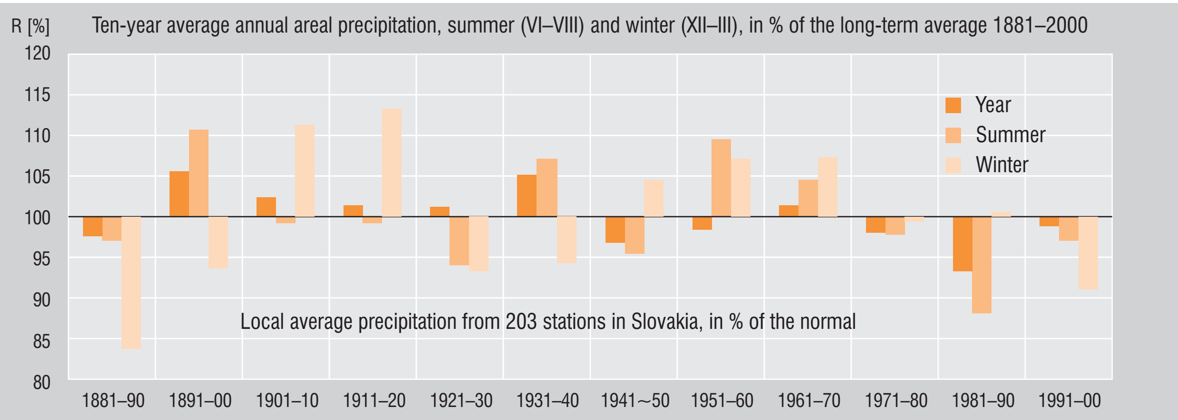


Figure 2.2 *Ten-year average annual areal precipitation sums, in% of the long-term average, 1881 to 2000*



of air temperature deviations from Hurbanovo are representative for the whole Slovakia. The ten-year averages of air temperature successively increased and in the last ten years, for annual values, they reached by almost 1.5 °C more than by the end of the last century. Summer air temperature was extremely high in the last decade only, but winters were very warm during the last three decades. The years 1994 and 2000 were probably the hottest ones since the beginning of meteorological observations in the Central Europe, i.e. since 1775. Since 1988, no year with annual temperature below normal was observed.

For areal averages of precipitation sums, in the last three decades we observed a significant decrease, which, together with increasing air temperature and potential evapotranspiration, showed in the deterioration of the hydrological balance. The discharges in rivers decreased considerably, especially in the south of Central Slovakia, and soil moisture decreased in the whole southern half of the country. The said decrease of precipitation totals was even larger in the south of Slovakia, while in the north and in the northest of the country it was less significant.

Besides the significant changes of the ten-year averages of basic climate elements, other potential indicators of Climate Change were observed in the last decade. In spite of the general decrease of annual and seasonal precipitation totals, several cases of high daily and several day precipitation totals occurred, which caused catastrophic local or large-scale floods in the Central Europe and in Slovakia in the years 1997 to 2000. On the other hand, since 1990 almost every year destructive drought in some part of Slovakia or in some part of the year occurred, mostly in the years 1991, 1992, 1993 and 2000. In connection with the increase of air temperature averages, since 1983 the daily, several day, monthly and seasonal records of air temperature were broken in many cases. Most cases occurred after the year 1988, especially in 1992, 1994 and 2000. The high values of average and extreme air temperatures reflected in an unprecedent shift of phenological phases of wild growing and field plants and wood species towards early spring. An unusual decrease of the occurrence of snow cover not only in lowlands, but also in mountainous areas of Slovakia was also observed. In the last decades relative humidity was generally decreasing, mostly in spring and in summer in the southwest of Slovakia (by about 5%), while sunshine duration and global solar radiation did not reached the high values from the period of years 1931 to 1960.

2.4 POPULATION

The population of Slovakia has grown from 3 million inhabitants in 1920 to 5,390 million as of 31 December 1998[1] . The highest natural increase in population, recorded in 1950, was equal to 1.7%. The natural population increase was in 1993 0.39%, 0.28% in 1994, 0.16% in 1995, 0.17% in 1996, 0.13% in 1997 and only 0.08% in 1998. Since 1950, the natural population increase has been systematically sinking, down to critical values in recent years. The population density has not significantly changed during the last years, and represents 110 inhabitants per km^2 [6]. The highest population density is recorded in the region of Bratislava (310 inhabitants per km^2) the lowest density is in the Banská Bystrica region (70 inhabitants per km^2).

The largest city in Slovakia is Bratislava with 449, 547 inhabitants (in 1998), followed by Košice with 241,941 inhabitants (in 1998) and the cities of Prešov, Žilina, Nitra and Banská Bystrica with more than 80,000 inhabitants.

The average life expectancy is 68.3 years for men and 76.5 years for women. The average age for men is about 8.5 years shorter than the highest average life span in developed European countries (e.g. Sweden),for women the average age is shorter by 5.5 years (France, Sweden) [2].

The annual per capita emissions of CO_2, together with global aggregate emissions per capita calculated using GWP to CO_2 [7], are shown in Table 2.1.

Tab. 2.1 *Average CO_2 emissions and global (GWP[2]) aggregate per capita emissions [tons/inhabitant]*

Indicator	1990*	1991	1992	1993	1994	1995	1996	1997	1998
Average per capita CO_2 emissions	11.2	9.9	9.2	8.6	8.0	8.3	8.3	8.4	8.1
Global aggregate per capita emissions	13.7	12.1	11.1	10.3	9.7	10.0	9.9	9.9	9.6

Source: Statistical Yearbook of the Slovak Republic, 1999,
Greenhouse Gas Emission Inventory, SHMU, 2000

[1] Preliminary information

[2] Global Warming Potential – GWP values according to IPCC Guidelines 1995: CO_2 = 1, N_2O = 310, CH_4 = 21, SF_6 = 23,900.;

2.5 ECONOMIC PROFILE

In April 1993 Slovakia acceded to the General Agreement on Tariffs and Trade (GATT) and subsequently to the World Trade Organization (WTO). In February 1995 the Association Treaty between the European Union (EU) and the Slovak Republic entered into force and in June 1995 Slovakia confirmed its ambitions for integration by an application for membership in EU. In addition to political and historical reasons, the integration efforts are determined by the economic development of the country, since at the present time we export to EU markets approximately 44% of our exports and another 43% go to the Central and East European countries which started the accession negotiations in the first round. The most important business partner of Slovakia is the Czech Republic, even though its share in total exports reports a descending tendency, from a value of 42.3% in 1993 to 26.7% in 1997; Germany represents the second largest export market, with a share of 22.3% in 1997 (18.8% in 1995).

Intensive negotiations on the accession of the Slovak Republic to OECD were successfully completed in September 2000 with Slovakia becoming the 30th member of this organization. In this connection it is of importance that the share of exports to OECD countries presently represents approximately 75% of total exports of the country.

The Slovak Republic has ratified the Convention on Energy Charter and the Protocol of Energy Charter on Energetic Effectiveness and Related Environmental Aspects; these documents entered into force in April 1999.

If we consider the economic development of Slovakia as a whole, we can state that after a many-year recession lasting from 1989 to 1993, when the gross domestic product decreased by almost one quarter, in 1994 a revival was observed, which was caused by external demand only.

The GDP increase in comparable prices represented 4.9% in 1994, 6.6% in 1995, 6.6% in 1996 and 6.5% in 1997. Since 1996 the rate of GDP growth has slowed, but even in this period it

Table 2.2 *Development of GDP in the years 1993 to 1998 (ESA methodology)*

Indicator	1990*	1993	1994	1995	1996	1997	1998
GDP in constant prices of 1995 [bill. SKK]	599.2	460.8	511.6	546.0	579.9	615.9	641.1
GDP in current prices [bill. SKK]	257.7	369.1	466.2	546.0	606.1	686.1	750.8
Rate of exchange SKK/USD	18.0	30.8	32.0	29.7	30.6	33.6	35.2
GDP in constant prices of 1995 [bill.USD]	21.5[a]	14.9	15.9	18.3	18.9	18.3	18.2
GDP in current prices [bill.USD]	14.3	11.9	14.5	18.4	19.8	20.4	21.3
GDP per capita in constant prices of 1995 [USD]	4,060[a]	2,811	2,986	3,423	3,521	3,403	3,374
GDP per capita in current prices, taking into account PPP[a] [USD]	N/A	6,400	7,240	7,783	8,651	9,387	9,834

a – constant prices of 1992

*Source: The Statistical Year-Book of the Slovak Republic 1995 – Data for the year 1990**
The Statistical Yearbook 1999 – Data for the year 1993 (ESA methodology)
The Statistical Yearbook of the Slovak Republic 2000 – Data for the years 1994 to 1998 [18]

Table 2.3 *Gross domestic product by branches [%]*

Indicator	1990*	1993	1994	1995	1996	1997	1998
National economy in total	100	100	100	100	100	100	100
Market products	66.5	42.5	39.9	38.8	41.5	38.4	36.1
Agriculture and forestry	7.4	6.6	6.6	5.6	4.8	4.6	4.2
Industry	49.9	29.2	28.7	28.6	29.5	26.8	25.5
– of which industrial production		22.6	23.2	23.4	24.2	22.5	22.2
Construction	9.2	6.7	4.6	4.6	7.1	6.9	6.4
Market services	18.8	41	43.3	41.1	38.0	40.2	41.0
– of which transport and communications		11.2	8.7	8.4	10.0	9.6	9.9
Non-market services	14.7	13.4	12	12.3	12.2	13.7	13.5
Other		3.1	4.8	7.8	8.3	7.8	9.4

Source: The Statistical Year-Book of the Slovak Republic 1999 – Data for the year 1993 (ESA methodology)
*The Statistical Year-Book of the Slovak Republic 1995 – Data for the year 1990**
The Statistical Yearbook of the Slovak Republic 2000 – Data for the years 1994–1998 [18]

reached an above-average level within the group of EIT countries.

In 1996, the level of the economy of the Slovak Republic measured by GDP per capita (in thousand USD, according to purchasing power parity) represented 40% of the level of this indicator for EU countries. The table 2.2 shows data for the evaluation of the progress of the transformation process in the years 1993 to 1998, together with the values for the base year 1990.

The complexity of economic base restructuring, including its technical innovation and ownership transformation, has resulted in changes of the structure of GDP creation. In 1995 almost 60% of GDP was created in the sector of services, including transport and communication, while in 1991 this sector contributed only 40% to GDP creation. On the contrary, the industry and construction sector saw a significant (agriculture only a moderate) decrease in the compared years. Ownership transformations showed a successive increase of the share of the private sector in GDP creation: growth from 37.3% in 1993 to 82.6% in 1997. In trade and services the share of the private sector reached the level of 95.9%, in agriculture 93.2%, in construction 82.2 and in industry 73%.

The development of internal and external economic relations in the country in the past transformation period is also marked by other parameters such as the rate of inflation, average interest rate of credits and deposits according to the National Bank of Slovakia and the balance of foreign trade. The values of these parameters are indicated in Table 2.4.

Table 2.4 *The trend of internal and external economic parameters in the transformation period*[3]

Indicator	1990*	1993	1994	1995	1996	1997	1998
Rate of inflation [%]	10.4	23.2	13.4	9.9	5.8	6.1	6.7
Average interest rate of							
– Credits [%]	N/A	14.5	14.6	13.3	11.9	12.5	13.5
– Deposits [%]	N/A	8.1	9.3	8.3	6.7	8.0	10.2
Average discount rate [%]	N/A	12.0	12.0	9.8	8.8	8.8	8.8
Balance of foreign trade							
– Import (FCO) [bill. SKK]	61.2	195.0	211.8	260.8	340.9	393.9	460.7
– Export (FCO) [bill. SKK]	52.0	167.7	214.4	255.1	279.6	324.0	377.8
Balance [bill. SKK]	–9.2	–27.3	2.6	–5.7	–70.3	–69.9	–82.9

Source: Energy Policy of the Slovak Republic, the Ministry of Economy of the Slovak Republic, 2000
The Statistical Yearbooks of the Slovak Republic, 1995–1999

As documented by data in Table 2.4, with the exception of 1993 when a higher rate of inflation was observed as a result of the introduction of VAT, with the restoration of economic growth, inflation was continuously decreasing from 1994 until 1997. In 1997 this parameter increased moderately to a value of 6.1% (against the value of 5.8% in the previous year), particularly as a result of high growth in domestic demand and the adjustments of some regulated prices.

The relatively high volume of debit balance in the years 1996 and 1997 was affected especially by import prices growing faster than export prices, the liberalisation of passenger car imports, imports under debt recovery from the Russian Federation and by the increase of fuel prices.

Regarding the territorial structure of foreign trade, during the period 1993–1998 the share of trade with EU countries increased (e.g. for export from 24.1% in 1993 to 45% in 1997, for import in the same period from 20.6% to 39.5%). On the contrary, in the same period mutual trade with CEFTA countries and countries with transforming economies decreased.

In the commodity structure of total exports the share of machinery and transport equipment increased and the share of exported semi-products decreased. Real dynamics of export has declined; import has accelerated and export performance of industry, the main bearer of foreign-trade relations, has decreased. This resulted in a balance of trade deficit which in the first half-year 1998 represented 11% of GDP (with the largest share in fuels, machinery, transport equipment and foodstuffs).

[3] Data for balance of foreign trade for the years 1997 and 1998 were processed in compliance with the Regulation of the Ministry of Finance of the Slovak Republic No.167/1997, i.e. they are not comparable with the values for the previous years (Regulation of MF SR No. 82/1993).

2.6 ENERGY STRUCTURE

The development of the primary energy sources structure, as well as final consumption of fuels and energy in the Slovak Republic, classified by sectors and fuels, are characterized by data in Tables 2.5 to 2.9 [2] – [6].

Total supplies of primary energy sources decreased by about 25% in the period of years 1990 to 1994; since 1994 they have been increasing moderately until 1998. From the aspect of PES structure by fuels it is obvious that the share of solid fuels decreased from a volume of 264 PJ in 1993 to the value of 198.8 PJ in 1998, i.e. by about

Table 2.5 *Primary energy sources and final consumption of fuels and energy [PJ]*

Indicator	1990*	1993	1994	1995	1996	1997	1998
Primary energy sources used in the SR	945.3	754.8	743.6	766.4	779.9	777.2	756.2
Final consumption	654.5	544.9	507.1	512.5	519.1	499.3	498.9
– Industry and construction	367.0	284.7	275.8	285.8	277.7	249.1	220.9
– Agriculture	32.7	26.5	17.2	16.9	15.9	16.6	14.2
– Transport	25.5	15.8	19.7	20.9	13.2	14.1	14.4
– Non productive sphere	101.8	116.9	103.2	84.3	97.3	103.3	129.1
– Population	127.4	100.9	91	104.5	114.9	116.1	120.2
PES per capita	0.18	0.14	0.14	0.14	0.15	0.14	0.14
FC per capita	0.12	0.10	0.09	0.10	0.10	0.09	0.09
Share of FC on PES [%]	69.2	72.2	68.2	66.9	66.6	64.2	66.0

Source: Statistical Yearbooks of the Slovak Republic, 1995 to 2000

Table 2.6 *Primary energy sources and final consumption of solid fuels [PJ]*

Indicator	1990*	1993	1994	1995	1996	1997	1998
Primary energy sources – solid fuels	360.2	263.6	235.4	228.9	227.1	216.4	198.8
Final consumption	150.2	101.3	90.8	80.7	83.7	75.7	67.4
– Industry and construction	58.3	46.9	50.9	54.9	47.3	48.8	45.3
– Agriculture	4.6	2.1	1.6	1.5	1.3	1.2	0.8
– Transport	1.3	1.1	0.7	1.0	1.0	0.4	0.7
– Non productive sphere	33.9	19.8	25.9	10.2	19.7	18.3	14.2
– Population	52	31.3	11.7	13.0	14.3	6.9	6.3
PES per capita	0.07	0.05	0.04	0.04	0.04	0.04	0.04
FC per capita	0.03	0.02	0.02	0.01	0.02	0.01	0.01
Share of FC on PES [%]	41.7	38.4	38.6	35.2	36.9	34.9	33.9

Source: Statistical Yearbooks of the Slovak Republic, 1995 to 2000

Table 2.7 *Primary energy sources and final consumption of liquid fuels [PJ]*

Indicator	1990*	1993	1994	1995	1996	1997	1998
Primary energy sources – liquid fuels	197.6	124.1	134.8	145.8	143.7	151.9	146.3
Final consumption	95.3	65.2	83.7	77.5	57.9	71.9	71.4
– Industry and construction	29.2	22.2	37.6	29.8	17.8	13.1	14.2
– Agriculture	19.5	12.3	9.1	8.9	8.5	8.2	7.4
– Transport	17.9	8.9	12	14.1	7.9	9.0	9.0
– Non productive sphere	12.7	13.9	14.7	10.4	11.1	26.5	25.6
– Population	15.9	7.7	10.2	14.3	12.5	15.0	15.2
PES per capita	0.04	0.02	0.02	0.03	0.03	0.03	0.03
FC per capita	0.02	0.01	0.02	0.01	0.01	0.01	0.01
Share of FC on PES [%]	48.3	52.5	62.1	53.2	40.3	47.3	48.8

Source: Statistical Yearbooks of the Slovak Republic, 1995 to 2000

Table 2.8 *Primary energy sources and final consumption of gas fuels [PJ]*

Indicator	1990*	1993	1994	1995	1996	1997	1998
Primary energy sources – gas fuels	223.0	207.6	198.4	219.1	231.6	235.1	239.8
Final consumption	177.8	159.4	153.4	162	178.4	153.7	181.9
– Industry and construction	103.8	78.9	63.5	80.9	90.7	63.4	55.5
– Agriculture	3.1	5.8	2.4	2.2	2.1	2.2	2.5
– Transport	0.5	0.9	1.3	0.32	0.15	0.38	0.2
– Non productive sphere	40.2	39.7	46.9	34.4	32.5	29.2	61.4
– Population	30.1	34.1	39.3	44.2	52.9	58.6	62.4
PES per capita	0.04	0.04	0.04	0.04	0.04	0.04	0.04
FC per capita	0.03	0.03	0.03	0.03	0.03	0.03	0.04
Share of FC on PES [%]	79.7	76.8	77.3	73.9	77.0	65.4	75.9

Source: Statistical Yearbooks of the Slovak Republic, 1995 to 2000

Table 2.9 *Primary energy sources and final consumption of electricity [PJ]*

Indicator	1990*	1993	1994	1995	1996	1997	1998
Primary energy sources – electricity	25.5	17.7	17.2	22.5	28.9	30.5	21.3
Final consumption	84.3	72.8	73.2	78.2	84.5	82.2	75.7
– Industry and construction	54	29.2	36.4	32.9	37.8	36.2	33.9
– Agriculture	4.1	5.7	3.4	3.2	3.1	4.1	3.0
– Transport	4.2	4.1	5.3	4.9	3.5	3.6	3.6
– Non productive sphere	8.7	18.9	11.8	19.1	20.5	18.5	14.8
– Population	13.2	14.9	16.2	17.9	19.6	19.8	20.2
PES per capita	0.005	0.003	0.003	0.004	0.005	0.006	0.004
FC per capita	0.016	0.014	0.001	0.015	0.016	0.015	0.014
Share of FC on PES [%]	330.9	411.8	425.0	346.9	291.5	269.6	355.5

Source: Statistical Yearbooks of the Slovak Republic, 1995 to 2000

25%, and on the contrary, the share of gas fuels in the same period increased by about 15%.

While the share of primary energy sources and final consumption per capita showed only a moderate decrease, the share of final consumption on primary sources decreased by almost 10% – from a value of 72% in 1993 to 66% in 1998. A limiting factor in the development of the power industry of Slovakia is the high level of dependence on imported PES, determined by natural conditions and the existing technological potential of the country. Net imports of energy to the country in 1996 (save nuclear fuel) covered about 73% of total energy consumption of the state. Together with nuclear fuel, the exclusive supplier of which is the Russian Federation, imports cover about 89% of primary energy supplies.

The share of fossil fuels in primary energy sources is relatively high, reaching the level of 80% and it did not significantly change in the examined period.

Table 2.10 shows data on electricity production, classified by source, for the years 1993 to 1999.

The share of imported electricity between the years 1997 and 1999 decreased by almost 50%, from 4082 GWh to 2251 GWh. Production of electricity in 1999 was secured up to 47% by nuclear sources, 36% in fossil fuel power plants and the remaining 17% in hydro-electric power plants. From the aspect of source diversification, i.e. stability and reliability of supplies, the structure of sources is then relatively advantageous.

Energy intensity, expressed by the ratio of total primary energy and gross domestic product, has shown a decreasing tendency since the establishment of the Slovak Republic. However it is still 7.7-times higher than the average of the EU countries when applying the exchange rate; if we apply purchasing power parity, this parameter is 2.3-times higher than the EU average. This is particularly the result of low labour productivity in comparison with the EU countries, the high share of industry in GDP creation and especially the high share of energy-consuming branches (chemical steel, paper and cement industries) [8]. In addi-

Table 2.10 *Production of electricity [TWh]*

Power plants	1990*	1993	1994	1995	1996	1997	1998	1999
Steam	9.5	6.2	5.7	6.8	6.9	6.7	7.3	7.1
Nuclear	12.0	11.0	12.1	11.4	11.3	10.8	11.4	13.1
Hydro-electric	2.5	3.5	4.3	4.9	4.3	4.1	4.4	4.6
Pumped		0.4	0.3	0.3	0.2	0.2	0.2	0.2
Industrial selfproducers		2.3	2.4	2.5	2.7	2.7	2.6	2.8
Other electricity	0.03							
Total production	**24.1**	**23.4**	**24.7**	**25.9**	**25.3**	**24.5**	**26.0**	**27.8**

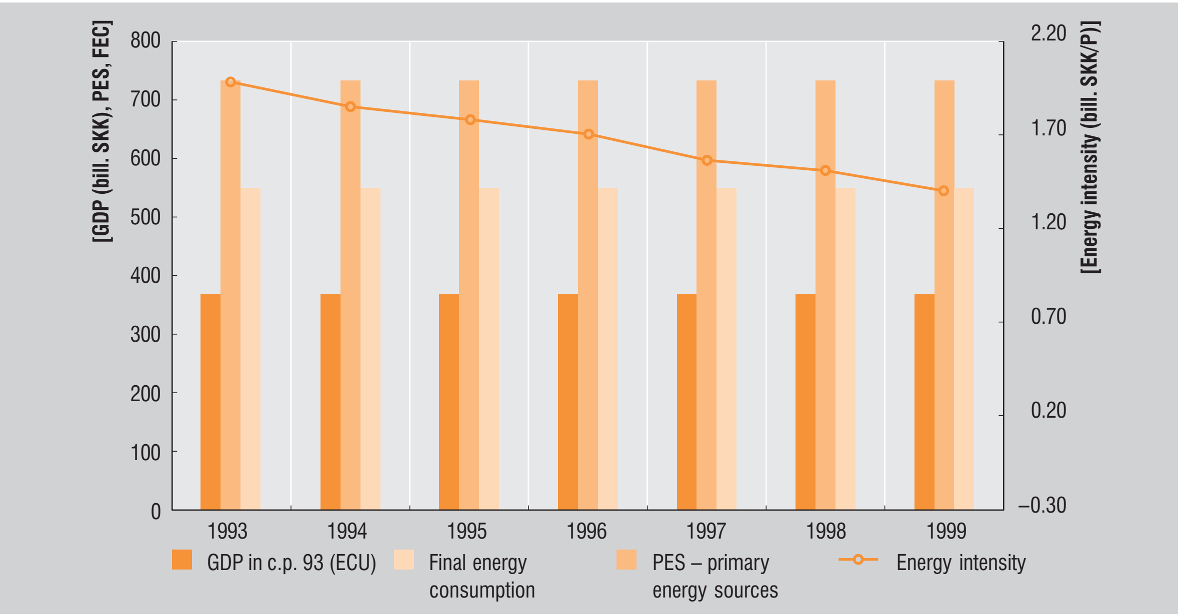
Source: *Energy policy of the Slovak Republic, the Ministry of Economy of the SR, 2000*
Annuals of Electricity Consumption in the SR, 1996 to 1999 [9]

tion, this is the consequence of long-term energy price deformations, the high share of electric heating, low energy efficiency of technological processes and equipment, as well as the utilisation of obsolete technologies.

The slowdown of GDP growth rate in the recent years was accompanied by a moderate decrease in consumption of primary energy sources and a decrease in final energy consumption and electricity consumption. The consumption of PES per capita in the Slovak Republic amounts to approximately 85% of the average of EU countries. In the future it may be supposed that the structure of final PES consumption will change in favour of a larger utilization of natural gas in industry and households, as well as in electricity and heat production. In the area of solid fuel consumption we can expect stagnation or even decrease as a result of the introduction of more stringent emission limits (especially for lignite). As regards liquid fuel consumption, there could be a moderate increase in transport.

The energy industry in its existing structure has clearly the character of a natural monopoly. Therefore it must be subject to state regulation, which also applies to prices of fuels and energy carriers (heat and electricity). The rules for price regulation and pricing are set out in Act No. 18/1996 Coll. on Prices, authorizing the Ministry of Finance of the Slovak Republic to set and regulate prices. In spite of some progress which has been already made during elimination of price deformations, subsidies, including so-called cross subsidies, could still not be eliminated to the full extent.

Figure 2.3 *Development of selected indicators in the period of economic transformation of the Slovak Republic*



Source: *Energy Policy of the Slovak Republic, the Ministry of Economy of the SR, 2000*

The efforts of Slovakia to accede to EU and the struggle for rational functioning of the energy market require the introduction of measures to eliminate price deformations. One of these is the so-called Calendar of Regulated Price Adjustments, which comprises a time schedule of reduction or full removal of subsidies in the energy sector (electricity, natural gas and heat) for the period until 2002.

2.7 INDUSTRY

The development of industrial structure of GDP creation, shown in Table 2.3, confirms the significant changes, which occurred in the structure of the economic base of the EIT countries, including technical innovation and change of property relations. The industrial sector, which was the most affected by the transformation, is actually revitalizing. While the share of the industry and construction sector contribution to GDP creation decreased from almost 60% in 1990 to the level of about 30% in 1998, in the sector of services it increased from 33% in 1990 to almost 50% in 1998. The private sector share in GDP creation also changed significantly; increasing from the level 37.3% in 1993 to 82.6% in 1997 and in industry reaching the level of 82.6% in 1997. As a positive trend of the elapsed period in the branch structure of industry we can consider the gradual, although slow, change to more sophisticated production with a higher level of processing. Data indicated in Table 2.11 outline the changes in the development of decisive branches of industrial activities in the years 1995 to 1997.

Employment in the economy of the Slovak Republic in 1997 increased by 14.8 thousand persons, i.e. by 0.7%, against the year 1992. The average growth rate in employment reached the level of 0.1% between the years 1993 and 1997, whereas in industry it decreased by 1.1%. A significant change in the previous period was also observed in the division of employees between the private and the public sectors, with the share in the private sector increasing from 32.2% in 1993 to 63.4% in 1997.

The share of industry in total investments decreased from 45% in 1993 to 34% in 1997 and the average for the stated period represented 38%. The allocation of investments in the processing industry during this period was uneven: the largest share, more than 35%, fell to the energy industry (especially construction of the nuclear power plant in Mochovce). Investments in the engineering industry decreased considerably, from a volume of 20% in 1993 to 8% in 1997. On the contrary, in the chemical industry they increased from 14% (1993) to 19% (1997).

It is obvious that the development of production in the individual sectors reflects the sources of GDP growth rate only indirectly; in this case the trend of added value in the individual branches is conclusive. In 1997 economic subjects in Slovakia produced added value in current prices in the volume of 583.3 bill. SKK, which means an increase of 25% against the year 1995. Data on the branch structure of the creation of added value in industry, with the index of growth between years 1995 and 1997, are shown in Table 2.12.

According to data in the table, in comparison with the year 1995 the added value in industrial production increased by 11.5%. The largest increase was in production of electrical equipment (43.5%), oil products (22.6%), foodstuffs (21,4%), machinery (16.9%) and non-metal products

Table 2.11 *GDP creation in current prices by economic activity in industry [%]*

Indicator	1995	1996	1997
Industry in total	100	100	100
of which:			
– Mining	3.5	3.9	3.3
– Industrial production	81.6	81.0	83.9
of which: production of foodstuffs. beverages and tobacco products	10.1	10.8	14.3
Chemical, oil and rubber production	15.5	14.2	20.0
Metal and non-metal production	13.0	13.2	12.0
Manufacture of machines and equipment, electrical and optical apparatus, transport devices	17.4	18.8	17.2
– Production and distribution of electricity, gas and water	14.9	15.1	12.8

Source: Internal material of the Ministry of Economy of the SR, 1998

Table 2.12 *Trend of added value in current prices in Slovak industry [mil. SKK]*

Sector	1995	1996	1997	Index 97/95
Industry in total	147,157	152,919	163,811	111.3
of which:				
– Mining	5,120	6,014	6,152	120.2
– Industrial production	120,167	123,863	133,966	111.5
of which:				
Food production	14,920	16,557	18,114	121.4
Textile and clothing production	6,871	7,303	7,380	107.4
Leather processing	2,176	2,344	2,152	98.9
Wood processing	4,608	4,717	4,079	88.5
Paper production, print	11,344	9,291	10,751	94.8
Oil, coke production	6,042	4,608	7,409	122.6
Chemical production	11,290	11,364	11,101	98.3
Rubber and plastics production	5,414	5,781	5,202	96.1
Non-metal production	6,917	7,649	8,039	116.2
Metal production	19,151	20,231	22,223	116.0
High investment machinery production	12,273	12,184	14,352	116.9
Electric equipment	7,613	9,351	10,925	143.5
Transport equipment	5,772	7,238	6,767	17.2
High investment production	5,776	5,245	5,472	94.7
– Production and distribution of electricity, gas and water	21,870	23,042	23,693	108.3

Source: *Internal document of the Ministry of Economy of the SR, 1998, underlying information from the Statistical Office of the SR*

(16.2%). On the contrary, a significant decrease was observed in the wood processing industry (–11.5%).

In the area of final energy consumption, industry is the sector with the highest share – in 1995 about 53%. Currently in the sector of industry, the individual branches participate in fuel and energy consumption in the following volume: metallurgy and energy industry by about 36% each, chemical and pharmaceutical industries by 13% each, wood processing industry by 4%, machine engineering industry by 3%, clothing and textile industries by 2% each, electrotechnical, glass, leather and shoemaking industries by about 1% each. Data on the development of final consumption of fuels and energies in industry during the period 1993 to 1999 are shown in Table 2.13.

In the framework of final consumption in industry, a distinct feature of the examined period is the reduction in consumption of liquid fuels from 12.8% in 1994 to 2.4% in 1998. The share of solid fuel consumption in industry moves about the level of 20% and it is a little lower than the volume of gas fuel consumption.

The potential of energy savings in industry during the following ten years was determined at the level of 25 to 35%. While the energy intensity of iron production or paper industry is comparable with IEA countries, in chemical industry and cement production there is still significant room for energy savings.

Table 2.13 *Final consumption of fuels and energies in the industry sector [%]*

Final consumption	1990*	1993	1994	1995	1996	1997	1998	1999
Industry in total	100	100	100	100	100	100	100	100
Solid fuels	16.0	16.6	18.7	19.5	17.3	20.5	21.5	20.3
Liquid fuels	8.4	7.2	12.8	9.3	5.2	1.9	2.4	4.5
Gas fuels	24.5	27.8	23.2	28.7	32.9	26.1	25.9	27.0
Electricity	15.7	10.2	13.3	11.6	14.1	15.0	16.0	15.3
Heat	35.4	38.2	32.0	30.9	30.5	36.5	34.2	32.8

Source: *Energy Statistics*
Energy industry 1998, The Statistical Office of the SR, 1999

2.8 TRANSPORTATION

Currently, the transportation sector in Slovakia consists of road, railway, combined, water and air transports.

According to results of a detailed analysis, the density of the road network in Slovakia is adequate, even if in some areas the road network is sparse, due to the mountainous surface. From the investment planning aspect there is hence no significant need to build new roads – except for the completion of a highway crossing the whole Slovak territory – but it is necessary to enhance the quality of the existing road system, which actually lags behind the needs of road transport development. The road and highway networks in total represented a length of 36,547 km as per 31 December 1999, of which highways in operation have a length of 366 km.

Data on the number of motor vehicles in the years 1990 to 1999, together with fuel consumption in road transport, are shown in Table 2.14.

Table 2.14. *Number of motor vehicles and fuel consumption in road transport*

Numbers of vehicles	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Passenger cars	875,550	906,129	953,239	994,933	994,046	1,015,794	1,058,425	1,135,914	1,208,239	1,246,959
Vans	22,893	22,989	17,752	17,063	16,765	16,930	15,262	14,061	–	–
Trucks	69,101	72,347	84,459	84,491	85,705	85,704	81,816	89,019	100,672	107,724
Special	53,537	55,120	50,238	46,121	45,484	45,797	45,430	45,976	43,690	41,670
Buses	14,301	13,770	13,338	12,655	12,066	11,812	11,321	11,235	11,293	11,101
Tractors	67,056	67,642	64,713	65,150	64,729	64,536	62,810	63,145	63,448	63,493
Motorcycles	371,593	370,711	330,889	330,235	320,355	317,145	310,537	262,227	272,056	139,215
Total	**1,474,031**	**1,508,708**	**1,514,628**	**1,550,648**	**1,539,150**	**1,557,718**	**1,585,601**	**1,621,577**	**1,699,398**	**1,610,162**
Fuel consumption [in tonnes]										
Gasoline	437,460	434,100	443,870	499,740	534,320	555,512	496,084	610,263	670,102	674,552
Diesel	1,058,600	906,720	680,700	627,240	698,080	724,323	716,025	745,540	780,148	740,049
LPG	–	–	–	–	780	500	588	510	510	5,949

Source: Analytical Documents for the Area of Environment in the Transportation Sector, VÚD Žilina, 2000

Note:

Total numbers of vehicles in the Statistical Year-Book of the SR 1999 and in Table 2.14. are different

The category of vehicles "vans" has not been recorded since 1998 because according to categorization of UN EEC vehicles are either passenger cars or trucks.

In the category "motorcycles" the numbers are indicated inclusive of small motorcycles below 50 ccm (mopeds) without registration number, which are not in records of Policy in the SR. The significant decrease in the number of registered motorcycles in records of Slovak Policy as per 31.12.1999 against the previous year 1998 was caused by the requirement for confirmation of motorcycle registration by each his owner by 31 December 1999. Motorcycles, the registration of which was not confirmed by this date, have been removed from the central records of Sloval Policy.

The development of the number of motor vehicles proves that the highest dynamics of growth was reached by the category of passenger cars, the number of which increased on average by 37% during the period from 1990 to 1998 – in Bratislava it increased by 66%, in Košice by 49%.

Since 1990 the number of automobiles per inhabitant in Slovakia has increased by 34%, with Bratislava and Košice again having the largest share in this increase (64% and 46%, respectively). With the achieved number of 4.7 inhabitants per passenger car (210.8 passenger cars per 1,000 inhabitants) Slovakia ranks among European countries with medium-developed motorism.

After an initial decrease at the beginning of the nineties the index of growth in energy consumption between the years 1993 and 1997 in transport was 124.2. This dynamic was caused especially by the shifting of services to motor transport, whether freight (truck) or individual passenger transport.

Railway transport ranks among those branches which have been greatly affected by the past economic development. The high utilization of capacities and permanent lack of capital sources, reallocated through the state budget, have not allowed railways to ensure even simple reproduction of fixed assets, especially railway lines and nodes. The transformation process and the disintegration of economic and business relations have meant for railway transport significant losses in cargo traffic. In 1999 the volume of transport decreased to 49.1 mil. tonnes, which represents a 61% decrease against 1989. In passenger transport, in 1999 the number of passengers decreased to 69.4 mil. persons, i.e. down 49% in comparison with the year 1989. Transport services are provided within a network with a total length of 3,665 km (this number includes broad-gauge lines with a length of 106 km and narrow-gauge lines with a length of 49.7 km). From the total volume of lines, 2,489 km are single track lines, 1,020 km are double track lines; multi-track lines are not a part of the railway network of the Slovak Republic.

The total number of combined transport shipments during the 1996 to 1999 recorded a moderate increase (index 1.31). However the total values hide some negative tendencies on the market of combined transport in the Slovak Republic. In internal transport the number of transported shipments decreased to 77%, in export to 97% and the most significant decrease in the examined period was observed in import (a value of 56%). On the contrary, in the same period transit increased to 248%.

In 1995 energy consumption in transport accounted for 8.9% of the Slovak Republic final consumption. The estimated potential for reduction of specific consumption of energy until 2010 is approximately 40% for passenger cars and 10% for trucks and buses. In railway transport, with the utilization of the braking energy of locomotives and reduction of wagon weight, 30 to 50% of energy could be saved.

2.9 AGRICULTURE AND FORESTRY

On the basis of the document *Analyses of the Development and Current State of Agriculture and the Foodstuff Industry in the Slovak Republic*[12] we can state that impacts of the economic transformation on agriculture were stronger than on other branches of national economy. The produced real added value (in 1998), also under the influence of the differentiated price trend, stands at only about 65% of the level in 1990. The trend of some economic indicators for agriculture in the elapsed period is described by data shown in the table below.

In the period of years 1990 to 1997, gross agricultural production decreased by 29% (in 1995 constant prices). Gross vegetable production (decrease of 33%) had a larger share in this decrease

Table 2.15 *Trend of economic indicators in Slovak agriculture [in%]*

Indicator	1995	1996	1997	1998
Share of agriculture in GDP	5.62	5.19	4.84	4.40
Share of subsidies to agriculture in GDP	1.40	1.23	1.33	1.19
Share of agriculture in:				
– Intermediate consumption	4.68	4.65	4.23	N/A
– Acquired investments	3.44	2.80	3.31	2.89
– Added value	5.82	5.74	4.65	4.20

Source: Analyses of the Development of Current State in Agriculture and Foodstuff Industry of the SR, VÚEPP, 1999

Table 2.16 *Chosen indicators of the development of agriculture and forestry*

Indicator	Measure	1990*	1995	1996	1997	1998
Animal production						
Cattle	[thous. pieces]	1,563	929	892	803	705
Pigs	[thous. pieces)	2,521	2,076	1,985	1,810	1,593
Sheep	[thous. pieces]	600	428	419	417	536
Poultry	[thous. pieces]	16,478	13,382	14,147	14,222	13,117
Horses	[thous. pieces]	14	10	9.7	9.5	9.5
Vegetable production						
Agricultural soil	[thous. ha]	2,448	2,446	2,444	2,445	2,444
Specific consumption						
of NKP	[kg/ha]	240	45	49	57	56
of which – arable soil	[thous.ha]	1,509	1,479	1,475	1,472	1,491
Share of arable soil	[%]	61.6	60.5	60.4	60.2	61.1
– hop-gardens	[thous. ha]	2	1.3	1.3	1.2	1.0
– vineyards	[thous. ha]	31	29	29	29	28
– gardens	[thous.ha]	78	78	78	78	78
– orchards	[thous. ha]	20	19	19	19	19
– TTP [b]	[thous. ha]	808	839	842	846	848
Forestry						
Logging in total	[thous m^3 i.b.]	5,277	3,965	4,089	4,368	4,146
Total afforestation	[ha]	17,399	9,339	9,009	7,367	8,306

b – Permanent grass cover

Source: Analyses of the Development of Current State in Agriculture and Foodstuff Industry in the SR, VÚEPP, 1999
Statistical Yearbooks 1996–1999

than gross animal production (decline of 26%). The steep decline in the first years of transformation reached the lowest limit in 1993 and it was followed by moderate, but unstable, growth. In vegetable production the structure of produce was changed too. On arable soil the share of cereals, oil-plants and vegetables increased, while areas of annual and multi-year forage, potatoes, corn and leguminous plants were reduced. In the total structure of agricultural soil, the areas of permanent grass cover have increased and the share of hop-gardens, vineyards and orchards has decreased.

Table 2.16 summarizes selected indicators of the development in agriculture and forestry for the period of the years 1995 to 1998.

The decline in gross agricultural production in the previous period was connected with the reduction in specific consumption of fertilizers from 240 kg/ha in 1990 to an average level of about 50 kg/ha in the 1995 to 1998 period. Reduction in consumption of fertilizers by type was varied – while consumption of nitrogen fertilizers per hectare of agricultural soil decreased by 60% from 1990 (91.6 kg/ha) to 1998 (38.3 kg/ha); consumption of phosphorous fertilizers in 1998 only amounted to 13% of the volume in 1990, for nitrogen fertilizers in 1998 it only reached 10% of consumption in 1990. As a result of the substantial reduction in volume of applied fertilizers, the generation of dinitrogen monoxide in agriculture decreased – from 9.5 thousand tonnes of N_2O in 1990 to 5.5 thousand tonnes of N_2O in 1996.

As in the case of N_2O, methane generation in agriculture shows a decrease – from 175 thousand tonnes in 1990 down to the level of 109 thousand tonnes in 1996 – mostly caused by a systematic reduction of the number of farm animals.

The index of fuel and energy consumption in agriculture for the years 1999/1998 was 87.51. In total year-on-year savings in fuels, a decrease was observed, especially in consumption of solid fuels, gasoline, diesel and light heating oil. On the contrary, consumption of natural gas and heavy heating oil increased against the year 1998.

Currently, forests cover 41% of the territory of the Slovak Republic, timber-growing stock in forests is estimated at more than 396 mil. m^3 (for comparison: in 1950 timber-growing stock in Slovakia represented a volume of 194 mil. m^3).

For energy purposes, it is appropriate to use especially that part of the biomass, which directly enters the process of decomposition or non-energy combustion, because carbon from this biomass is gradually released to the atmosphere in the form of CO_2. The energy-related utilization of traditional firewood in Slovakia represents an energetic value of 3,800 TJ/year. Total potential of annual utilizable fuel biomass produced in forestry was estimated at 9,380 TJ/year.

2.10 WASTE MANAGEMENT

The new conception of waste management dates back to 1991, when Act No. 238/1991 Coll. on Waste and its Implementation Regulations, by which a separate legal framework for waste disposal was created, was adopted. By Act No. 494/1991 Coll. on State Administration for Waste, the state administration for waste management was constituted.

According to estimates, annual waste production in Slovakia in this period represented approximately 30 mil. tonnes, and waste was mostly disposed in wild, uncontrolled dumps.

The first complex balancing of waste generation in the Slovak Republic was executed in the framework of the preparation of the first Waste Management Programme in the SR in 1993, whereby data were obtained mainly from data on the quantity of waste ascertained for major producers and individual sectors. Other more complex data on waste generation and disposal were obtained for the years 1994 and 1995 under Regulation of the Slovak Government No. 605/1992 Coll. on Keeping Waste Records using the Regional Waste Information System (RISO). In November 2000 the Slovak Government approved the Waste Act, which modifies in fact the whole legal framework for waste treatment [17]. The amendment is described in more detail in Chapter 4. The occurrence of waste in Slovakia in the years 1992 to 1999 is quantified by data shown in Table 2.17.

Data in the table show a continuous decrease in waste generation during the examined period in all categories. The quantity of municipal waste has hardly changed, and since 1996 a moderate increase has been observed. From the total amount of municipal waste of 1.6 mil. tonnes (the average per capita is about 300 kg), 75% originates directly with inhabitants and 25% represents waste originating in the business sphere. Table 2.18 shows data on waste generation in individual sectors for the year 1995.

Data in Table 2.18 show the dominant share of agriculture, forestry and timber logging on waste generation in the Slovak Republic; other important sources such as foodstuff industry, municipal sphere, fuels and energy, contribute by much lower shares.

In relation to protection of the environment the decisive factor is the way of waste handling (collection, sorting, processing, treatment and disposal), the utilization of waste as secondary raw materials and, of course, the form of treatment or disposal of unused waste. By its Resolution No. 108/1997 the Government has approved the Conception of Separated Waste Collection until 2000. Actually three forms of separated collection are used in Slovakia: so-called calendar collection, container collection and repurchase of potential secondary raw materials. By separated collection the following average quantities of raw materials are regained every year[15]:

- Collection paper 30,000 t
- Glass splinters 5,000 t
- Iron scrap 190,000 t
- Non iron scrap 4,000 t
- Plastic waste 1,300 t
- Textile waste 800 t

According to obtained data, approximately 61% of all waste is reused in Slovakia. Based on the analysis of utilization by type, the level of utilization of other waste is 75.5%, for special waste 15.4% and hazardous waste 16%. The relatively high share of waste utilization is affected by the high level of utilization of various agricultural wastes for breeding purposes or for soil fertilization. The statement of used waste for the year 1995

Table 2.17 *Waste amounts according to RISO*

Waste [mil. tonnes/year]		1992	1993	1994	1995	1996	1997	1998	1999
Other		24.6	25.0	22.3	19.5	10.1	10.1	10.1	10.1
Special		9.0	8.0	7.5	6.2	10.1	9.7	9.7	9.5
of which	– municipal	1.6	1.6	1.6	1.6	1.7	1.8	1.7	1.7
	– hazardous	3.4	3.3	3.3	2.5	1.5	1.5	1.4	1.4
Waste in total		**33.6**	**33.0**	**29.8**	**25.7**	**20.2**	**19.8**	**19.8**	**19.6**

Source: Environment of the Slovak Republic, The Ministry of Environment of the SR, Bratislava, 1999
Environment of the Slovak Republic, The Ministry of Environment of the SR, Bratislava, 2000

Table 2.18 Waste generation by sectors in 1995 [thous.tonnes]

Sphere of economic activity	Total waste	Of which	
		Special (excluding HW[c])	Hazardous
Agriculture, forestry, timber logging	14,358	83	834
Foodstuff industry	1,841	112	444
Wood working industry	785	63	58
Coal mining and mineral working	688	8	29
Fuels and energy	1,404	1,136	76
Metallurgy	866	158	83
Machinery Engineering	609	103	370
Electrical engineering	32	11	16
Chemical industry	596	56	133
Other industrial branches	87	19	10
Construction	168	9	12
Transportation	91	39	3
Trade and services	343	64	114
Health and veterinary care	104	31	57
Water and sewage water treatment	588	215	224
Municipal waste	1,620	1,620	
Other activities	1,488	8	30
Total	**25,668**	**3,735**	**2,493**

c: HW – hazardous waste

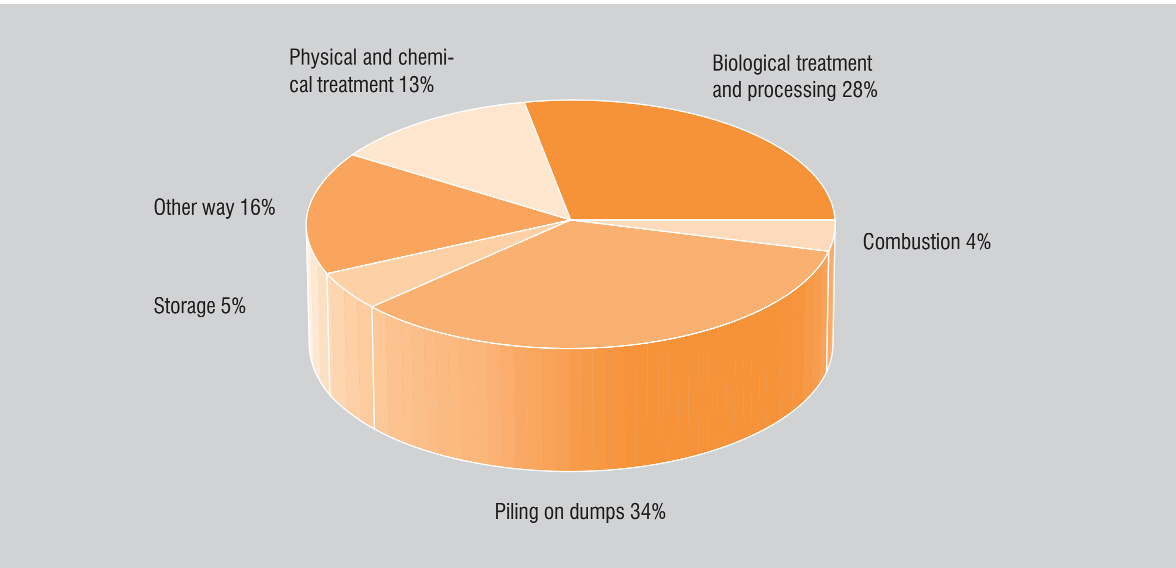
Source: Conception and Legal Regulations of Waste Management, the Ministry of Environment of the SR, 1997

also included manure and straw (in quantity of 7.2 mil. tonnes with utilization of 81%), which are no longer considered as waste according to the new Catalogue of Wastes from 1996. A similar situation occurs in the case of different types of liquid manure and dung. After separation of these types of waste from the total balance, the level of utilization for the year 1995, in individual categories, is as follows: total waste 36.3%, other waste 59.5%, special waste 15.4% and hazardous waste 16%.

Unused waste is treated by using physical and chemical and biological methods and disposed by combustion, piling on dumps, storage or in other ways.

Figure 2.4 illustrates the percentual share of individual forms of waste utilization [15].

Figure 2.4 *Forms of unused waste disposal*



2.11 HOUSING SECTOR – RESIDENTIAL AND COMMERCIAL BUILDINGS

Since 1995 the housing sector has participated in total energy consumption by about 18.5%. One third of this total consumption is covered by coal and heat from central heating systems, approximately one half of the consumption is represented by gas and the rest is electricity consumption – a part for heating and a larger part to supplying electric appliances and for lighting. Heating and hot tap water supplying represent about 80% of the total energy consumption in the housing sector.

Like in other Central and East European countries, the existing housing fund is in poor technical condition; it is marked by high energy losses and its ineffective utilization. The estimated potential for certifiable energy savings in heating of buildings represents about 40% of total heat consumption. From the number of about 1.7 mil. households in Slovakia, one half are family houses and another half are municipal or cooperative apartments. 723 thousand apartments, which were constructed in panel building systems, do not meet present more severe requirements for thermal insulation (specified in STN 73 0540). Costs of improvement of thermal insulation of peripheral and roof jackets were estimated at 1,500 SKK/m^2 (about 100,000 SKK per apartment). The Slovak Government has adopted two decisive programs to reduce energy consumption in blocks of flats, which are specified in Chapter 4.

Table 2.19 *Heat consumption by type of construction*

Area	Built-around space	Heat consumption	Share	Indicator of consumption		
	[mil. m^3]	[PJ]	[%]	[PJ/mil. m^3]	[kWh/ m^3]	[GJ/m^3]
Civil construction and civil construction halls	208	55	23.1	0.264	73.3	0.26
Housing construction – blocks of flats and family houses	318	102	43.7	0.327	90.8	0.33
Industrial halls	333	44	18.5	0.132	36.7	0.13
Industrial buildings	123	35	14.7	0.285	79.2	0.28
CE[d] structures, total	**982**	**236**	**100**	**0.242**	**67.2**	**0.24**

d: CE – civil engineering

Source: from sources of the Ministry of Construction and Regional Development of the SR

2.12 LITERATURE

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3. Greenhouse gas emission inventory

This chapter presents the results of a greenhouse gas emission inventory in the Slovak Republic within the period 1990–1999. The reference year in view of the UN Framework Convention and the Kyoto Protocol for the Slovak Republic is the year 1990. The inventory was developed in compliance with the methodology indicated in the IPCC 1996 Guidelines. Aggregated emissions for all greenhouse gases are converted into the CO_2 *equivalent with the global warming potential (GWP100).*

3.1 INTRODUCTION

The most important anthropogenic greenhouse gases are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3). They belong among natural elements of the atmosphere, though their actual concentration in the atmosphere is significantly affected by human activities. Other greenhouse gases included in inventory are halogenated hydrocarbons (PFCs, HFCs) and SF_6. Photochemical active gases such as carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic hydrocarbons (NMVOCs) are not greenhouse gases, but they contribute indirectly to the greenhouse effect in the atmosphere. These are generally referred to as ozone precursors because they affect the creation and destruction of ozone in the troposphere. Precursors of sulphates – sulphur dioxide (SO_2) and aerosol – reduce the greenhouse effect.

The chapter presents national emissions of CO_2, CH_4, N_2O, CF_4, C_2F_6, NO_x, CO, NMVOC and SO_2 since 1990. According to the existing development it can be supposed that in 2000 total greenhouse gas emissions in Slovakia will not exceed the level of the year 1990. However in the case of ratification of the Kyoto Protocol, the Slovak Republic should reduce total emissions in the target period of the years 2008 to 2012 by 8% against the year 1990.

The greenhouse gas emissions presented in the Second National Communication were updated and converted using the revised methodologies of IPCC 1996 Guidelines. After reconsideration of balance differences reported by the Slovak Gas Enterprise, emission factors in the sector of fugitive emissions were reduced. The Statistical Office has revised data on oil consumption since 1997 and data on the quantity of used limestone. Considering the adjusted emission factors, waste water emissions were revised in accordance with the *Good Practice Guidance*. The updated total emissions are shown in Table 3.1. Appendix P1 includes CRF [1] summary tables of emissions determined as of 15 April 2001.

All emissions are expressed in units of molecular weight (e.g. Gg CO_2, not Gg C). The values of global warming potential (GWP) are used according to IPCC recommendations (Climate Change 1995, The Science of Climate Change: CO_2 = 1, CH_4 = 21, N_2O = 310).

Table 3.1 *Total anthropogenic greenhouse gas emissions in Slovakia (1990 to 1999)*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 * [Gg]	60,000	52,000	49,000	46,000	43,000	45,000	45,000	45,000	44,000	45,000
CH_4 [Gg]	322	294	268	250	244	248	254	241	223	222
N_2O [Gg]	19	16	14	12	12	12	10	10	10	9
PFCs, HFCs, SF_6 [Gg eqv. CO_2]	272	267	249	156	144	148	91	114	80	93

* *CO_2 emissions without LUC&F.*

Note: Emissions determined as of 15. 4. 2001.

3.2 CO_2 EMISSIONS

Fossil fuel combustion is the most important anthropogenic source of CO_2 emissions to the atmosphere. Changes in the utilisation of land use also effect the amount of CO_2 in the atmosphere (e.g. afforestation – removals or deforestation – source of CO_2). CO_2 also occurs during some technological processes (cement, lime, magnesite, ammonium, aluminium, coke, iron and steel production, fermentation processes in the foodstuff industry etc.). Appendix P1 indicates total CO_2 emissions and removals in Slovakia in the period of years 1990 to 1999. These data show that fossil fuel combustion contributes to total CO_2 emissions in Slovakia by about 95%.

Total balance of CO_2 from fossil fuels combustion is based on energy statistics, data the IPCC reference approach was used. The majority of applied emission factors are compliant with the recommendations of IPCC 1996. The energy balance indicated in the Statistical Yearbook (top-down) is compared with data on fuel consumption taken from REZZO[1] [2] (bottom-up). These are two fully independent data sets, whereby differences are smaller than 5%. Since 1990 total fuel consumption decreased significantly and the share of natural gas increased. Emissions from mobile sources (road, railway, air and water transport) were also calculated using the COPERT method. This is based on the fuel balance calculated using a model on the basis of the type of vehicles, average speed and type of driving regime (city, countryside, highway, annual course).

Using the IPCC methodology the quantity of residual carbon from combustion which stayed in products (carbon fixed in tar and tar oils occurring by carbonisation and in petrochemical oil products such as polyethylene, polypropylene, asphalts, lubricants etc., carbon bound in fertilisers) was estimated. The total amount of carbon *stored in products* in 1999 was determined to 853 Gg C, which represents a decrease of 33% against the year 1990. The method of determination is not very exact, but the item is less significant from the viewpoint of total balance.

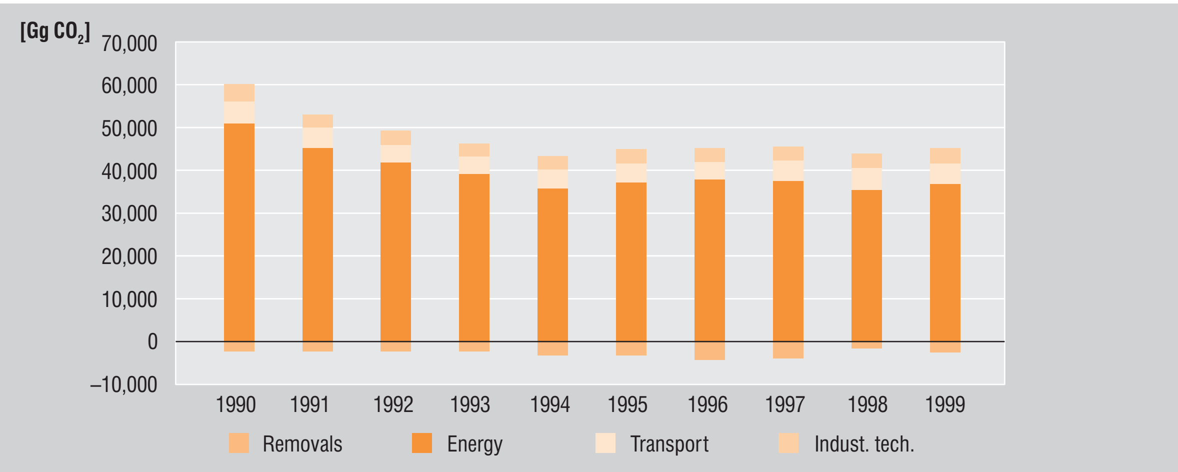
The most important industrial sources of carbon dioxide in Slovakia are cement, lime and magnesite production. The food industry is a less important source. Activity data on production are taken from The Statistical Yearbook of the SR (1990, 1995 and 1999). Carbon dioxide occurring by coke and aluminium production, crude oil processing and metallurgy is included in the balance to CO_2 emissions from fossil fuel combustion (RA). Due to this the share of the industrial sector on greenhouse gas generation seems to be very low.

Forest land covers 41% of the Slovak territory. Since the beginning of this century a part of agricultural land had been converted into forest land. In the period of years 1950 to 1991, the total quantity of carbon stored in Slovak forests increased by approximately 50 Tg. This is the result of extension of afforested/reforestred area and the increase of wood mass stocks per hectare.

The storage of carbon in the forest ecosystems of Slovakia was determined for the years 1990, 1994 and 1996 to 1999 by the balance of carbon in the

[1] REZZO – Register of emissions and air pollution sources. Large sources are updated on a yearly basis, small sources within a 5-year cycle.

Figure 3.1 *Share of individual sectors on CO_2 emissions [Gg] in the period 1990–1999*



Note: Emissions determined as per 15. 4. 2001.

part of forest above ground (trees, plant cover, overlying humus) and below ground (roots, humus in soil), including the estimate of wood cutting and forest fires. The balance of carbon in land use change was also evaluated. Changes in the forests, pastures, arable land, urbanised areas, and others were evaluated. Inputs are based on data of the Green Report [3]. Final annual removals of CO_2 in the territory of Slovakia is relatively variable. In the period of years 1990 to 1999, the calculated values ranged from 1,600 to 4,300 Gg/year, uncertainty of estimation is approximately 30%.

3.3 CH_4 EMISSIONS

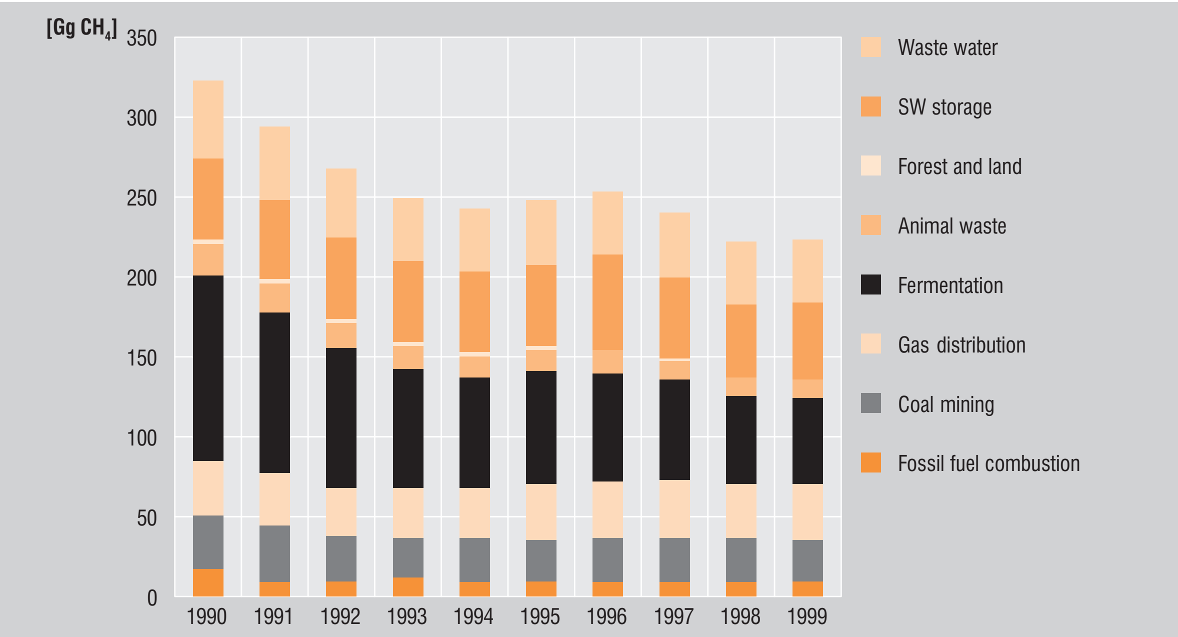
Table 3.2 shows CH_4 emissions classified by sectors. The major sources of methane in the Slovak territory are agriculture, fuel production/transport and waste treatment/disposal. The estimation methods correspond to the IPCC 1996 Guidelines. In addition to these major sources, methane emissions occurring by fossil fuel combustion were determined. Rice is not cultivated in Slovakia.

In the agriculture sector CH_4 occurs as a direct product of the metabolism of herbivorous animals and as a product of organic degradation of animal excrements. The calculations of emissions for the Slovak Republic are based on data of the Green Report of the Slovak Republic for agriculture [3] and The Statistical Yearbooks [4]. The IPCC default emission factors for livestock were modified depending on specific national circumstances. Between the years 1990 and 1993 a significant decrease in livestock farming was observed as a result of the transformation in the economy from a planned system to a market one, and this decrease continued until 1999 (with the exception of the number of poultry, which has been stable). This process was connected with a significant decrease of CH_4 emissions from this source category.

Emissions occurring by *storage of municipal waste* were determined in a special study based on the specific production of municipal solid waste per capita and on the estimated amount of degradable organic carbon in the waste. The IPCC 1996 methodology was applied to controlled and uncontrolled landfills. The amount of waste in landfills has been systematically monitored since 1995 only.

Emissions from *waste water treatment, including sludges,* were determined using the IPCC methodology (based on the estimate of biologically degradable organic matter). More than 40% of the Slovak population is not connected to the public sewage network. Therefore methane emissions occurring in septic tanks and sumps were also calculated.

Figure 3.2 *Share of individual sectors on CH_4 emissions [Gg] in the period 1990 to 1999*



Note: Emissions determined as of 30.1. 2001.

Production and transport of fossil fuels is a relatively important methane source in our territory. The amount of methane released in brown coal and lignite production (underground mines) was estimated based on the extracted coal volume (The Statistical Yearbook 1995, 1999, The Energy Yearbook 1999) and IPCC default emission factors. Emissions are probably a little overvalued.

The distribution networks for natural gas belong among the most important CH_4 sources. Fugitive methane emissions were revised on the basis of data on the length of the high/low pressure network in the Slovak territory and updated information on gas production, transport, transit, consumption and balance differences provided by SPP [5]. The emission factor was reduced and emissions were recalculated since 1990.

Methane emissions occurring by *fossil fuel combustion* are calculated on the basis of fuel consumption records (The Statistical Yearbook 1996, 1999, The Energy Balance 1998) using the IPCC method Tier 1, with the utilization of IPCC default emission factors. A larger amount of methane originates from small sources or from biomass combustion (REZZO 2 and 3). In our circumstances this is however a less significant source.

3.4 N_2O EMISSIONS

Unlike other greenhouse gases, the mechanism of nitrogen oxide emissions and removals develops from the circulation of nitrogen in the atmosphere and their quantification is rather complicated. Therefore the calculated emissions have a high degree of uncertainty.

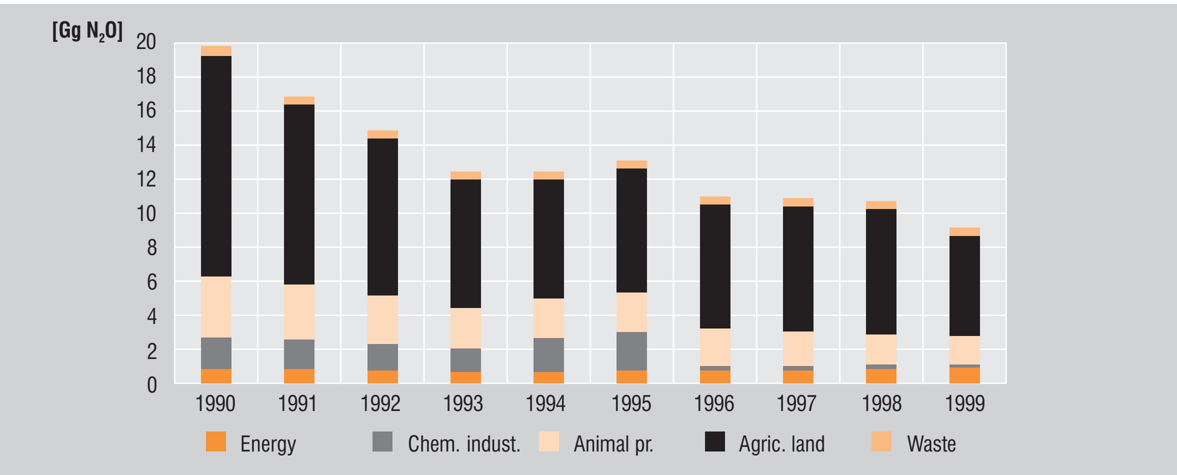
Emissions in the *energy sector* were determined on the basis of total fossil fuel consumption (The Statistical Yearbook 1996–1999, The Energy Yearbook 98, 99) by application of default emission factors according to IPCC 1996 Tier 1. Emissions from *mobile sources* were determined using the COPERT method.

In the sector of *agriculture* the nitrogen balance was elaborated using the revised IPCC 1996 methodology. Direct N_2O emissions from the utilization of agricultural land, emissions occurring by the utilization of animal waste as well as indirect N_2O emissions from agriculture were determined, taking into account different types of soil – vegetation canopy and the application of mineral and organic fertilisers. N_2O emissions are mainly caused by excessive deposits of mineral nitrogen in soil (the result of intensive fertilisation) and unfavourable air regime in soil (the utilization of heavy mechanisms for cultivation). Since the beginning of the nineties the average consumption of fertilisers decreased (90 kg N/ha in 1990, 30 kg N/ha in 1994 and 40 kg N/ha in 1998), as a consequence of the economic recession.

In the sector of *industrial processes* N_2O emissions occurring by nitric acid production were calculated. The significant reduction in emissions since 1996 is the result of modernisation of production. Adipic acid is not produced in the territory of the Slovak Republic.

Dinitrogen monoxide emissions occurring in waste *management* by waste water disposal and industrial sewage treatment were determined using the ICI method on the basis of the amount of waste waters subject to anaerobic purification. This method reflects better national circumstances than the method described in IPCC 1996 Guidelines.

Figure 3.3 *Share of individual sectors in N_2O emissions [Gg] in the period 1990–1999*



Note: Emissions determined as of 30 January 2001.

3.5 EMISSIONS OF HFCs, PFCs AND SF_6 – NEW GASES

The first inventory of these substances[2] was executed in 1995. HFCs, PFCs and SF_6 are not produced in Slovakia, data on consumption of these substances are used for estimation of emissions. These so called new gases are used as coolants, slacks, puffers for PUR, in aerosol products and as insulating gases (SF_6). The Statistical Office has not been monitoring their consumption, it is annually determined using questionnaires. Since 1995 consumption of HFCs and SF_6 have tripled.

Since 1990 emissions of C_2F_6 and CF_4 occurring by aluminium production have been determined on the basis of frequency of anodic cycles. Following the year 1996, emissions of these substances decreased in average as a result of modernisation of technologies.

[2] In Slovakia the utilization of freons (they are not covered by the UN Convention) 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 (The Copenhagen Amendment allows their utilization until 2030).

3.6 OTHER GASES

Table 3.2 shows emissions of NO_x, CO, NMVOC and SO_2 since 1990. Emissions of NO_x, CO and SO_2 were taken from the national inventory of emissions REZZO. The categories of emission sources in REZZO are based on the Air Act and they do not correspond exactly to the structure of sources according to CRF requirements. Therefore it is impossible to provide information on emissions and emission factors according to the classification requested in standard tables. The major source of SO_2, NO_x and CO emissions is power and heat generation. The contribution of transport to NO_x and CO emissions is still growing. Metallurgy is an important source of CO emissions.

Emissions of NMVOC have been regularly estimated in the framework of the National Program of NMVOC Emission Reduction. The year 1990 was used as a starting point and updating was carried out for the years 1990, 1993 and 1996–1999. The major sources of emissions come from the use

Table 3.2 *Anthropogenic emissions of NO_x, CO, NMVOC and SO_2 [Gg] in 1990–1999*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NO_x	**226**	**205**	**191**	**184**	**174**	**182**	**130**	**125**	**130**	**118**
Energy/Industry	146	135	127	122	112	118	77	71	74	65
Medium sources	5	5	5	5	5	5	4	4	4	4
Small sources	7	5	5	4	4	5	6	5	5	5
Transport	67	58	53	52	53	53	43	44	46	43
Forest fires	1	1	1	1	1	1	<1	1	<1	<1
CO	**535**	**485**	**430**	**456**	**446**	**435**	**359**	**352**	**318**	**310**
Energy/Industry	162	161	133	160	169	166	129	142	119	122
Medium sources	27	27	27	27	11	11	12	12	12	12
Small sources	144	103	79	70	47	43	51	38	38	38
Transport	154	146	143	151	185	181	154	144	145	133
Forest fires	48	48	48	48	34	34	13	16	5	5
NMVOC	**148**	**NE**	**NE**	**122**	**NE**	**107**	**104**	**90**	**87**	**79**
Energy	11			11		3	4	3	3	3
Transport	41	NE	37	41	41	40	37	32	33	29
Use of solvents	48			38		41	40	30	32	29
Crude oil, products	26			21		16	16	17	14	13
Others	22			11		7	7	7	5	5
SO_2	**543**	**445**	**380**	**325**	**239**	**239**	**227**	**202**	**179**	**171**
Energy/Industry	422	347	296	246	183	189	197	177	154	147
Medium sources	38	38	38	38	27	27	11	11	11	11
Small sources	79	57	44	39	26	21	16	12	12	12
Transport	4	3	2	2	3	2	2	3	3	1

of solvents, transport, refinery/storage and transport of crude oil and petrol.

3.7 AGGREGATED EMISSIONS

This chapter indicates emissions for the years 1990 to 1999 in aggregated form so as to allow comparison of the contribution of individual greenhouse gases (Figure 3.4) and individual sectors (Figure 3.5) to national total emissions. Emissions of individual greenhouse gases are expressed using GWP for the span of 100 years.

CO_2 emissions contribute by more than 80% to the total aggregated emission (expressed in Gg of the CO_2 equivalent), CH_4 emissions contribute by about 9%, emissions of N_2O 4 by 5% and emissions of new gases in total account for less than 1%.

Even from this viewpoint, the major source of emissions is fuel combustion and transformation, which represents consumption of fuels in industry, as well as power and heat generation in transformation, commercial and residential sectors (71%). Agriculture contributes by about 7%, transport increased to 10%, emissions from technologies in industrial sector forms 7%, waste treatment 3% and fugitive emissions account for approximately 2%. Removals of CO_2 in forests and soil are variable in time and they account for about 5% of the total emissions.

3.8 DISCUSSION AND CONCLUSIONS

3.8.1 Completeness

All sources of emissions which are indicated in the IPCC methodology (1996) and located in the territory of Slovakia are included in the national inventory. For some categories, activity data or emission factors may be estimated with a certain degree of uncertainty, but during the whole examined period (1990 to 1999) the emissions are consistent, i.e. determined using the same methods. Emissions from *international bunkers* were estimated and are included in the transport category. These emissions are assumed to be negligible, however at this stage it was not possible to separate activity data.

3.8.2 Uncertainty of emission estimation

Uncertainty of estimation of CO_2 emissions is mainly caused by uncertainty of statistical data on consumption. Another source of uncertainty is the applied 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 uncertainty according to the IPCC1996 method was not processed due to the lack of input data. We suppose that uncertainty of estimation of CO_2 emissions from fossil fuel combustion is lower than 5%. The accuracy of the CO_2 balance (carbon cycle) in for-

Figure 3.4 *Aggregated emissions of greenhouse gases in 1990–1999 [%]*

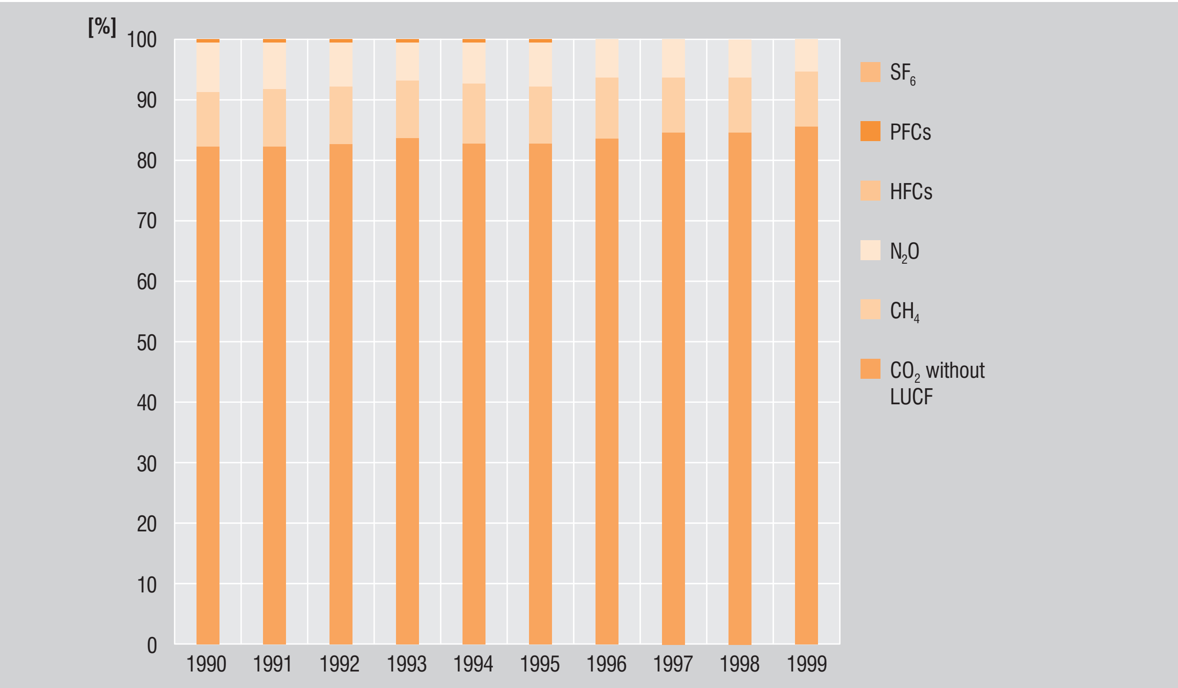
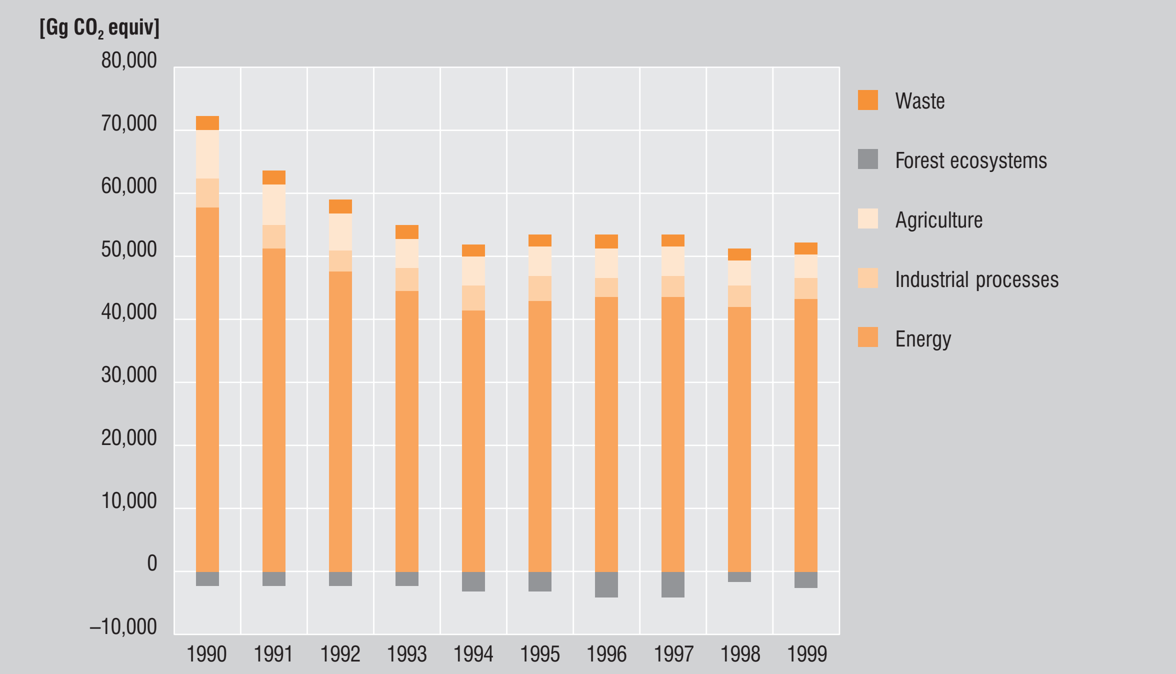


Figure 3.5 *Aggregated emissions of greenhouse gases by sectors (without LUCF), 1990–1999*



Values of GWP100 according to Climate Change 1995.

ests and soil was estimated at 30%. Uncertainty of estimation for methane emissions for individual categories in general moves about 30%. The calculated emissions of dinitrogen monoxide (especially from agricultural soil) show the highest degree of uncertainty, which has not been quantified yet.

3.8.3 Trends

When evaluating trends of greenhouse gas emissions, we have to take into account that during the examined period the statistical system[3] in the Slovak Republic was modernised (harmonized with EU). In Slovakia emissions reached the maximum level at the end of the eighties. Following 1990 a slowing of economic activity started to show and in 1994 emissions decreased below the level of the 1987 values. In 1995 a moderate increase of emissions against the year 1994 was observed for some sources, and since then the total greenhouse gas emissions have been more or less constant (Figure 5). Emissions of CO_2 per capita and year are decreasing but they still amount to around the double of the worldwide average. Commitments arising for Slovakia under the UN Framework Convention (in 2000 not to exceed the level of greenhouse gases of the year 1990) will be met.

3.8.4 Conclusions

In comparison with the Second National Communication information on GHG sources and emissions in Slovakia has been significantly extended. Since 1994 greenhouse gas emissions have been estimated every year and the results in prescribed form are sent to the Secretariat of UN FCCC. In 1999 all emissions were recalculated using the revised IPCC 1996 methodologies. Some emission factors and activity data were also reconsidered. In view of limited financial resources, it is impossible to apply the national emission factors in all sectors and estimate uncertainty according to IPCC Good Practice Guidance. In the future the accuracy of results should be further improved.

[3] Restructuring of energy statistics in 1993, transition to the categories of NACE (OKEČ) in 1997 to 1999, RISO – Register of Wastes since 1995.

3.9 LITERATURE

[1] Common Reporting Format. Document FCCC/CP/1997/7.

[2] REZZO – Register of emissions and sources of air pollution.

[3] Report on Agriculture and Food Industry in the Slovak Republic 1998 (Green Report). MP SR, 1998.

[4] The Statistical Yearbook of the Slovak Republic 1990–1999.

[5] Underlying documents for the Third National Communication on Climate Change, Slovak Republic. SPP, a.s., 2000.

[6] Climate Change 1995, The Science of Climatic Change, contribution of WG1 to the 2nd Assessment Report. Cambridge University Press, 1996.

[7] IPCC-OECD-IEA 1996. Guidelines for national GHG Inventories, Volume 1–3, Paris, 1996.

[8] IPCC-OECD-IEA Good Practice Guidance and Uncertainty management in National Greenhouse Gas Inventories. 2000, http://www.ipcc.ch.

[9] The Kyoto Protocol to the Convention on Climate Change. Printed UNEP France, June 1998, http://www.unep.ch/siuc/.

[10] Marečková, K. et al.: Emissions of GHG in Slovakia, 1990–1994. Final report of the project Country Study. Bratislava: SHMÚ, 1996.

[11] Marečková, K., Spišáková, K., Magulová, K., Sajtáková, E.: Assurance of International Commitments of the Slovak Republic, Evaluation of Air Pollution and Its Global Risks. Final report. Bratislava: SHMÚ, 2000.

[12] Marečková, K., Lapin, M., Závodský, D., Zuzula, I., Minárik, B., Mojík, I. Závadský, I.: A Territorial Study of Slovakia. Final Report of the project Country Studies Program. Bratislava: May 1997.

[13] Report on Air Quality and Share of Individual Sources on Air Pollution in the Slovak Republic 1999. Bratislava: SHMÚ, 2000.

4. Policy and measures to mitigate greenhouse gas emissions

Chapter 4 outlines the existing strategy, legislative framework and decisive measures which were adopted in the Slovak Republic in connection with environmental protection as a whole or with a focus on the mitigation of greenhouse gas emissions. Considering the character of economic development and the structure of industrial production in the Slovak Republic, in this chapter we pay special attention to the possibilities of energy efficiency enhancement under the conditions of sustainable development. In addition to characteristics of recently adopted or prepared measures and activities in the area of mitigation of GHG emissions and sinks, this chapter evaluates the actual situation of policy and decisive measures which were already outlined in the Second National Communication on Climate Change.
The existing strategy in the area of environmental protection can be simply characterised as a move from the removal of consequences of environmental degradation or pollution to elimination of the reasons for this pollution, through the observance of the principle of subsidiarity and the "pollutor pays" principle.

4.1 ENVIRONMENTAL PROTECTION STRATEGY

In this section we provide brief characteristics of decisive conceptual documents, a part of which is the policy of mitigating negative effects of climate change, whether directly by reducing GHG emissions, or indirectly by limiting negative impacts of energy sector, agriculture and other economic activities.

Strategy, Principles and Priorities of Governmental Environmental Policy

The document was approved by decision of the Slovak Government No. 619 of September 7, 1993 and decision of the National Council of the Slovak Republic No. 339 of November 18, 1993. This material determined the priorities of the state environmental policy and formulated the long-term, medium-term and short-term strategies for its implementation. Material and time limits indicated in individual objectives were in reference to international conventions, EU directives and recommendations of UN units. The short-term strategy explicitly comprised the development of a national program to mitigate greenhouse gas emissions and its implementation in the period of years 2000 to 2010. The measures for attainment of objectives of the Strategy in all ten sectors of environmental protection and development were also included in the first National Environmental Action Program (NEAP), adopted by Resolution of the Government No. 350/1996 and specified in 9 regional (KEAP) and 79 district environmental action programs (OEAP).

National Environmental Action Program of SR II

The document approved in December 1999 lays down priorities, principles and objectives of the environmental policy of the Slovak Republic. The priorities of the state environmental policy include the area of air protection from pollutants, particularly greenhouse gases, and global environmental safety, as well as the issues of generation, utilisation and correct disposal of different types of waste.

Strategy of the Slovak Republic in relation to global climate change

The document under preparation should comprise a comprehensive strategy of the Slovak Republic, focused exclusively on climate change issues and reduction of GHG emissions. The global objective of the international community in the framework of the UN Framework Convention is to stabilise concentrations of greenhouse gases in the atmosphere at a level, which has no dangerous effects on the climate system. The Slovak Republic shall participate in these efforts in line with the worldwide division of responsibility, and meet its accepted commitments. For attainment of the global objective from the view of the Slovak Republic, the main goals were defined for short-term, medium-term and long-term periods. In the framework of the medium-term strategy (2003 to 2008) the objective is to achieve such a development of greenhouse gas emissions until 2005 which shall provably allow meeting the commitment of the Kyoto Protocol. This Strategy is directly followed by the *Action Plan of Fulfilment of the Kyoto Protocol Commitments to the UN FCCC* brings an overview of measures, quantification of their impacts on reduction of GHG emissions, together with an estimate of the costs of their implementation, as well as a proposal for competences and a time schedule of their implementation.

Energy Policy of the Slovak Republic

The Government took into consideration the project of a new energy policy of the Slovak Republic by its Resolution No. 5/2000. The decisive objectives defined in this document can be summarily defined as follows: the preparation for integration in the EU internal market, the safety of energy supplies and the sustainable development. Accession to the European Union involves the adoption of several measures, particularly the restructuring of the energy sector, new principle of regulation of the energy sector, adjustment of prices, liberalisation and opening the free electricity market. Environmental protection was one of determining factors of the formulation of energy policy. Based on analyses, basic assumptions for the attainment of the commitment under the Kyoto Protocol in the energy sector were formulated as follows: to maintain the share of power generation from sources producing minimum amounts of CO_2, more significant decrease in energy intensity of production, energy savings and better utilisation of the renewable energy sources (RES) potential. Together with the objectives, potential tools for their achievement were indicated. The document, both in Slovak and English versions, is available on web site: www.economy.gov.sk.

Waste Management Program of the Slovak Republic for the period of years 2000 to 2005

A system conceptual document approved by Resolution of the Slovak Government No. 799/1996, which was elaborated following the evaluation of the first WMP SR started in the year 1993. On the basis of results of the first stage (1993 to 1996), this document modifies objectives until the years 2000 and 2005, taking into account real economic potential and a new territorial and administrative structure. In addition to further development of the whole infrastructure of waste management, main objectives of the Program can be qualified as the limitation of waste generation and enhancement of the recyclable waste utilisation.

Conception to Reduce Greenhouse Gas Emissions in Construction and Public Sector of the Slovak Republic until 2005

According to data of the Second National Communication on Climate Change, Slovak Republic, the share of the construction industry in total CO_2 emissions ranged from 5.9 to 7.9%. After a general decline in building production and limitation of demand for building materials in the period since 1990, recovery of the industry was observed in 1995, which has led to higher generation of CO_2 emissions. This document brings an analysis of potential measures to compensate this negative tendency. Measures representing direct intervention in production technology, measures in the combustion process or changes in the fuel base, as well as measures in the area of heat insulation of buildings, which lead to reduction of CO_2 emissions through energy savings, come into consideration.

Proposal for long-term measures regarding the adaptation of the Slovak Republic to climate changes

This document was negotiated and approved by management of the Ministry of Agriculture of the Slovak Republic in November 2000. It comprises a proposal for a comprehensive set of reduction measures in agriculture and management of water supplies and forestry, which is analysed in more detail in subsection 4.3.

Projects and research programs aimed to the climate change strategy and policy

In connection with acceptance of quantified reduction objectives in line with requirements of the Kyoto Protocol by the Slovak Government, projects and research programs related to issues of climate changes were solved in a larger extent. Proposals for mitigating and adapting measures, as well as a comprehensive analysis of the potential of the Slovak Republic in the area of reduction of GHG emissions are the result of following research programs and projects (we indicate only those of highest importance):

- The National Climate Program of the Slovak Republic
- The National Program of GHGs Inventory, SHMÚ

— The National Program to Stabilise and Reduce CO_2 Emissions in Transportation in the Slovak Republic, November 1994 (VÚD Žilina)
— Country Study of Slovakia, May 1997 (US Country Studies Program)
— Study on Slovak Strategy for GHG Reduction, June 1998 (Project National Strategy Studies for GHG Reduction, supported by the World Bank, the Swiss Government and the Ministry of Environment of the Slovak Republic: www-esd.worldbank.org/cc/, www.admin.ch/swissaij)

4.2 OVERVIEW OF POLICY AND MEASURES TO REDUCE GREENHOUSE GAS EMISSIONS

The following text outlines an evaluation of the actual situation of decisive reduction activities specified in the Second Slovak National Communication, as well as an overview of new measures in the area of GHG emissions reduction. Subject to analysis were measures applied directly with the view of reducing GHG emissions, as well as those for which the mitigating effect is achieved indirectly, through energy savings and by mitigating the negative effects of economic activities on climate change. The measures are evaluated with a view of the current stage of implementation and, where relevant information is available, the impact of measures and supporting programs is quantified. It is clear that the comprehensive framework for the application of the policy to mitigate the negative consequences of climate change in Slovakia consists of a group of measures from the Second National Communication still in force, together with actual measures and activities indicated in the following text.

4.2.1 Cross sectorial measures

These measures represent activities and measures, the effect of which shows in several categories of greenhouse gases or in several sectors at the same time.

4.2.1.1 Policy and mitigating measures from the Second National Communication

- **Act No. 309/1991 Coll. on Protection of the Air against Pollutants**
  Type of measure – **regulatory and economic**
  Status of implementation – **implemented measure, the last amendment – Act No. 459/2000 Coll.**

Initially a strictly regulatory instrument. Though it was aimed at basic pollutants, it represented one of the most efficient instruments for reduction of CO_2 emissions. By amendment it was replaced by a combined regulatory and economic measure. The amendment introduces, for existing sources not meeting the concentration emission limits of the basic pollutants in the initial time limit (before 31 December 1998), the possibility of their further operation until 31 December 2006, after classification to so-called class "B". The classification of a source of pollutants to the class "B" means, in addition to higher basic charges for pollutants, their further current increase through coefficients determined until 2006. Under the stated amendment, a mechanism of declaring so-called "emission quotas", i.e. maximum allowed amounts of pollutants which may be emitted by a group of sources in the country, district, or individual source, was introduced to the environmental protection legislation frame.

- **Act No. 286/1992 Coll. on Income Taxes**
  Type of measure – **economic**
  Status of implementation – **implemented measure, the last amendment – Act No. 366/1999 Coll.**

The Act constitutes an economic instrument which also in the adopted amendment (§ 19, letter c) declares the possibility, in the calendar year when the equipment was put into service, and in the following five years, to obtain income tax allowance for the operation of small hydro-electric power plants with installed output up to 1 MW, equipment with combined power and heat generation with installed output up to 1 MW, heat pumps, solar equipment for the utilisation of geothermal energy, equipment for biogas production, equipment for production of biologically degradable substances etc…

- **Liberalisation of energy and fuel prices**
  Type of measure – **economic**
  Status of implementation – **prices are still regulated (partial liberalisation), gradual elimination of subsidies**

Although the energy sector in its existing structure has the character of a natural monopoly, resulting in the need for state regulation of fuel and energy prices, it has observed positive changes, motivated by the effort towards full price liberalisation, against the situation of the year 1997. In addition to ambitions for integration, the reason for elimination of all types of subsidies to energy prices – including cross sectorial – is the prepared restructuring and privatisation in the electrical and gas industries and the endeavour towards rational function of the market. Regulation of the Ministry of Finance No. 87/1996 Coll., by which Act No. 18/1996 Coll. on prices is executed, remains in force. Several measures were issued – e.g. Measure of the Ministry of Finance of the Slovak Republic No. 94/1999, by which the difference between maximum production price of heat and the price for households was removed. At the same time, a so-called "Schedule of Adjustments of Regulated Prices, Including Energy" for the period until 2002 was elaborated.

- **Program Supporting Economic Activities Resulting in Savings of Energy and Imported Raw Materials**
  Type of measure – **economic**
  Status of implementation – **program completed by 31 December 1999** [1]

The Program was declared by the Ministry of Economy of the Slovak Republic in collaboration with the Ministry of Finance of the Slovak Republic and the Slovak Guarantee and Development Bank. It was aimed at the support of the implementation of projects to decrease energy intensity, better utilisation of renewable energy sources and reduction of imported materials and raw materials in industrial and tertiary areas – the government still covers a part of interest rates and grants advantageous credits. State support for this program was provided only in the years 1992, 1993 and 1995, whereby the provided sum in an amount of 158.1 mil. SKK represented about 11% of total budget costs of the implementation of 64 projects. From the evaluation of the program it results that total heat savings for implemented projects represents 2,331.6 TJ/year, electricity savings 56,571 MWh/year, fuel savings 66.8 TJ/year and total savings in imported raw materials was quantified to 4.087 mil. USD. On the basis of the calculations we can state that 1 GJ of saved energy burdens the state budget in the amount of 120 SKK/GJ. In the years 1996 to 1998 no financial resources from state budget were allocated for this program and it was completed in 1999.

- **Act No. 238/1991 Coll. on Waste**
  Type of measure – **regulatory**
  Status of implementation – **implemented measure, the last amendment – Act No. 255/1993 Z. z., in November 2000 the Slovak Government approved a comprehensive amendment of this Act**

The Waste Act remains the basic legal norm in the area of waste management. Under this Act, an entity generating waste is obliged inter alia to use generated waste as a source of secondary raw materials or energy. Waste storing in landfills is the last stage of waste disposal, which cannot be otherwise used. In June 2000 the Ministry of Environment of the Slovak Republic presented a project of a new act on waste, together with projects of ten implementory regulations. According to this amendment, the whole legal framework for the area of waste management will change and only Act of the National Council of the Slovak Republic No. 327/1996 Coll. on charges for waste disposal will remain in force.

[1] Replaced by the Program supporting energy savings and the utilisation of alternative energy sources (since 1. 1. 2000).

4.2.1.2 Actual policy and measures to reduce GHG emissions

- **Act No. 211/2000 Coll. on Free Access to Information (Act on Information Freedom)**
  Type of measure – **regulatory**
  Status of implementation – **implemented measure, replacing the Act No. 171/1998 Coll. on access to environmental information**

The new legal norm stipulates the conditions, procedure and extent of free access to information. For the area of the environment, a special provision was adopted therein, according to which natural or legal persons were obliged, in compliance with special regulations or decisions, to measure the volume of pollutants released into the atmosphere or water, and under which the obligation to publish results of such measurements arises.

- **Act No. 127/1994 Coll. on Environmental Impact Assessment (EIA)**
  Type of measure – **regulatory**
  Status of implementation – **implemented measure**

The system of comprehensive professional and public assessment of environmental impacts of a prepared building, facility or activity.

- **Act No. 237/2000 Coll. on the State Fund of the Environment**
  Type of measure – **economic**
  Status of implementation – **implemented measure, replacing the Act No. 128/1992 Coll.**

Charges, penalties, sanctions for air pollution, subsidies from state budget and other revenues form the environmental protection and development fund. The amendment extends the existing function of the Fund from purely subsidy-related to a credit function. The Fund should be focused on granting so-called cheap credits (more advantageous conditions than in case of credits granted by commercial banks) and on investments in environmental protection and development.

- **Act No. 401/1998 Coll. on Charges for Air Pollution**
  ***Type of measure* – economic**
  ***Status of implementation* – implemented measure**

According to Act No. 401/1998 Coll., each operator of a pollution source is obliged to pay progressively increasing charges (using coefficients defined for each year), depending on the amount and the type of pollutants emitted into the atmosphere. For example, basic charge for emissions of solid particles is 5,000 SKK/t, for SO_2 emissions 2,000 SKK/t, for NO_x emissions 1,500 SKK/t, for CO emissions 1,000 SKK/t, for total organic carbon emissions 4,000 SKK/t and for other pollutants from 2,000 to 40,000 SKK/t. Although charges for CO_2 emissions were not fixed, their level is indirectly affected by this measure.

- **Regulation of the Ministry of Environment of the Slovak Republic No. 127/2000 Coll. on stipulation of maximum allowed amounts of pollutants emitted into the atmosphere (to the Act No. 309/1991 Coll.)**
  ***Type of measure* – regulatory**
  ***Status of implementation* – implemented measure**

This measure determines emission quotas of sulphur dioxide for individual districts for the period of years 2002 to 2004.

- **The National Program of Environmental Evaluation and Identification of Products**
  ***Type of measure* – regulatory with indirect economic effect**
  ***Status of implementation* – implemented measure**

Since 1996 infrastructure and conditions for the implementation of the Program were created, which allows evaluation and identification of environmentally friendly products (EVV); in the years 1997 and 1998, this marking was granted to 10 products.

4.2.2 Energy sector

4.2.2.1 CO_2 emissions

4.2.2.1.1 Policy and mitigating measures from the Second National Communication

- **Measures resulting from the Energy Strategy and Policy of the Slovak Republic until 2005**

A more specific analysis of some measures from the Energy Conception of the Slovak Republic, from the view of their CO_2 reduction potential, investment intensity and period for the implementation, was executed in the framework of elaboration of the document *Action Plan of the Fulfilment of the Kyoto Protocol Commitments to the UN FCCC, the Ministry of Environment of the Slovak Republic, 2000* [13]. Table 4.8 (section 4.4) provides an overview of measures and quantified parameters, which allow a preliminary evaluation of their reduction potential. Other measures indicated in the Second National Communication, such as the completion of desulphurization equipment for two units 110 MW in ENO B, construction of a new fluid boiler in ENO A and installation of a new complex and continual emission monitoring system (checking emissions of CO_2, CO, SO_2, NO_x and solid particles) have already been executed. In addition to creation of conditions for maintenance of inland brown coal extraction (indirectly declared in the Resolution of the Slovak Government No. 559 of July 12, 2000), the purpose of their introduction was to meet environmental criteria, particularly those of Regulation of the Government No. 92/1996 Coll.

4.2.2.1.2 Present policy and measures for reduction of CO_2 emissions

- **Program Supporting Energy Savings and Utilisation of Alternative Energy Sources**
  ***Type of measure* – economic**
  ***Status of implementation* – implemented measure**

The Program was declared by the Ministry of Economy of the Slovak Republic and the Ministry of Finance of the Slovak Republic, based on the Resolution of the Government No. 1055/1999, with effect as from January 1, 2000. The guarantor and coordinator of the Program is the Slovak Ministry of Economy. Under this Program subsidies or return financial assistance are provided to projects classified in one of the following groups:

Support of energy savings in apartment houses and apartments

- purchase and installation of control equipment to ensure energy-saving operation of apartment houses and apartments,
- reconstruction of heat sources supplying apartment houses,
- optimisation of the extent of centralised district heating (CZT) systems and their extension.

Support of the alternative energy sources utilisation

- stimulates projects of building facilities which use mainly renewable sources of energy (construction of small hydro-electric power plants, energetic utilisation of biomass, utilisation of heat pumps, installation of solar collectors, utilisation of geothermal and wind energy).

Support of activities resulting in energy savings

- introduction of advanced equipment and technologies production,
- rationalisation of fuel and energy consumption (reconstruction of heat sources, heating systems of technological processes),
- replacement of fossil fuels, support of production of facilities for treatment and utilisation of biomass.

The support is provided in two forms – by covering a part of credit interest up to 70% of basic interest, but no more than 4 mil. SKK/project, or by providing return financial assistance at a maximum amount of 3 mil. SKK/project, with term of payment 3 years. Presently the program is subsidised by the lump sum of 30 mil. SKK/year.

- **Regulation of the Ministry of Environment of the Slovak Republic No. 144/2000 Coll. on requirements for fuel quality, keeping operating records.**
  Type of measure – regulatory
  Status of implementation – implemented measure

This measure stipulates requirements for the quality of solid fossil fuels, liquid oil fuels, gasoline and diesel fuel and defines conditions for keeping operating records (type, extent and way of providing data to air protection authorities) for fuel producers, importers and distributors.

- **Act No. 70/1998 on Energy and on a Change of the Act No. 455/1991 Coll. on Trade**
  Type of measure – regulatory
  Status of implementation – implemented measure

The Act stipulates conditions for trade in electrical engineering, gas industry and heat supplies, rights and obligations of electricity, gas and heat consumers, and rules of state regulation in the energy sector. It takes into account the contemporary state of trade legislation in EU countries and comprises recommendations of the EC Commission relating to transparency, licensing, observance of rules of competition and customer protection. It declares the obligation of electricity buyers and heat distributors to buy electricity and heat from renewable resources of energy or from combined electricity and heat production where it is justified by environmental reasons or allowed by technical conditions.

- **Proposal of the Act on Energy Efficiency**
  Type of measure – regulatory
  Status of implementation – measure under preparation

The Act under preparation directly stipulates economic utilisation of energy in all branches of the economy and introduces new institutions for enhancement of energy efficiency and better utilisation of renewable energy sources (RES). The decisive measures under the projected Act can be briefly characterised as follows:

- economic operation of buildings and energy facilities, as well as their need, are assessed during the process of building approbation;
- for licence holders and large consumers of energy the proposed legal norm imposes the obligation to ensure a regular energy audit, appoint an energy manager and elaborate a program of energy efficiency,
- obligatory labelling of chosen energy equipment and appliances, determination of minimum limit of efficiency for operated heat equipment,
- for consumers of liquid fuels the norm imposes the obligation to apply preferentially equipment with combined electricity and heat generation when executing reconstruction or building new heat sources.

An integral part of the projected act is the elaboration of the *National Program of Energy Efficiency*, which should represent a wide range of measures (monitoring trends of energy consumption, data base of projects, demonstration projects, information on potential financial support etc.), to ensure awareness and promote reduction of energy intensity.

- **Protocol of Energy Charter on Energy Efficiency and Related Environmental Aspects**

The Protocol, which was signed on January 17, 1994 in Lisbon and which entered into force in April 1998, was ratified by the Slovak Republic in October 1995 as the first of the member countries of the Energy Charter. In the international context, this is the most important tool to support an energy efficiency policy in the creation of conditions for rational production, distribution and utilisation of energy, and for the support of international collaboration in these areas.

- **Act on Regulation in Network Branches**
  Type of measure – regulatory
  Status of implementation – measure under preparation

The prepared Act should stipulate legal, economic and organisational conditions in those business activities in energy branches which are characterised as a lacking or underdeveloped competition environment due to the existence of a natural monopoly. Several legal norms are amended by this act, such as Act No. 70/98 Coll. on Energy.

4.2.2.2 Fugitive emissions of CH_4

The development and level of fugitive CH_4 emissions will be affected by the level of underground coal extraction, requirements for oil and gas treatment and the level of natural gas transport and distribution through our territory.

4.2.2.2.1 Policy and mitigating measures from the Second National Communication

General gas distribution system

Presently the reported losses in transportation of natural gas, which may be a source of fugitive CH_4 emissions represent about 2% of the total volume of consumed gas. According to actual data for the year 2000, this would correspond to the volume of 150 mil. m^3 or 100 thousand tonnes of CH_4 emissions per year.

However these are only fictive amounts reported on the basis of the actual state of measuring and control equipment, where equipment for temperature and heat compensation are not installed in all cases, due to which uncertainty of measurements amounts to 1.5%. Actual fugitive emissions determined according to the qualified analysis and evaluation of effects of the measures specified in the Second National Communication (whether partially or fully implemented) will probably represent only 10% of the stated volume, i.e. approximately 15 mil. m^3 or 10 thousand tonnes of CH_4 per year.

Transit system

The measures specified in the Second National Communication have been fully implemented. Also thanks to these measures, actual emissions of natural gas in transit range from 10 to 14 mil. m^3, i.e. 6.8 to 9.5 thousand tonnes of CH_4 per year. However the source of these emissions is not uncontrollable leakage from transit transport, but so called technological consumption of natural gas occurring by start-ups of gas turbines and their depressurisation, as well as by depressurisation of line sections of the transit system and different technological units of compressor stations. This depressurisation inevitably precedes repairs on this equipment.

The overview of several executed technical measures for mitigating activities to reduce CH_4 emissions in the area of transit system:

— adaptation of combustion chambers and replacement of regeneration exchangers in operation of turbines GT-750 with total costs of 70 mil. SKK (compressor plant in Jablonov nad Turňou and in Ivánka pri Nitre),
— installation of a Cooper Rolls low-emission turbine unit in Jablonov nad Turňou,
— installation and successful testing of technical solution for reduction of methane leakage into the atmosphere during the start-up of three GT-750 turbines at the compressor plant in Ivánka pri Nitre,
— in Ivánka pri Nitre a continual emission monitoring system was installed on 12 turbine units GT-750 at total costs of 10.5 mil. SKK,
— in 2000 investments in replacement of gas expanders of start-up equipment with electric drive in an amount of 12.5 mil. SKK are planned – this equipment solves the problem of gas leakage during the start-up of gas turbines.

4.2.2.2.2 Actual policy and measures to reduce fugitive CH_4 emissions

General gas distribution system

Type of measure – **technical**

Status of implementation – **implemented measure**

Inspection of networks within the national gas pipeline.

Transit system

Type of measure – **technical**

Status of implementation – **measure under preparation**

- Depending on economic possibilities, continuous replacement of gas expanders at the start-up of gas turbines with electric starters.
- Replacement of installed output of turbine units with more efficient and effective equipment (23 and 28.3 MW, efficiency 37%).
- Permanent monitoring of technological need for natural gas.

It is supposed that total potential of indicated technical measures means annual reduction of fugitive CH_4 emissions from the transit system by 3,000 tonnes. It is also expected that the measure for enhancement of turbine unit output could result in reduction of CO_2 emissions by 10 to 15% (the present level is 2 mil. tonnes).

4.2.2.3 Other gases

The greenhouse effect of the atmosphere is indirectly affected by non methane fugitive organic substances (NVOC), NO_x and CO (ozone precursors) and SO_2 (sulphate precursor). The Slovak Republic is progressively limiting emissions of these gases under legislation in force and accepted international commitments. In the area of energy and fuel transformation the following protocols are in place:

Convention on Long – Range Transboundary Air Pollution

The following executing protocols to the Convention signed in Geneva in 1979 were gradually adopted:

- *Protocol on Reduction of Sulphur Emissions or their Transboundary Fluxes by 30% (Helsinki, 1985)* – The Slovak Republic is the successor of this Protocol. The commitment was met, SO_2 emissions were reduced from the volume of 780 thousand tonnes in 1980 to 380 thousand tonnes in 1992, which represents a decrease of 48% (the protocol requirement is a decrease of 30% by 1993 against the level of the year 1980).
- *Protocol on Further Reduction of Sulphur Emissions (Oslo, 1994)* – The Slovak Republic ratified the Protocol on March 2, 1998. The commitments of the Slovak Republic to reduce SO_2 emissions under this protocol are as follows:

Year	2000	2005	2010
Emissions of SO_2 [thous. t]	337	295	240

The protocol requirement for acceptance of emission limits was executed by Regulation of the Slovak Government No. 92/1996 Coll., by which the Act on Air is executed. In the years 1994 and 1995 the volume of SO_2 emissions decreased to 238 thousand tonnes and 223 thousand tonnes, respectively. To meet the commitment under the Protocol, it is necessary to maintain the reached level and prevent any excess of the stated emission volumes.

- *Protocol on Reduction of Nitrogen Oxide Emissions or their Transboundary Fluxes (Sophia, 1988)* – Slovakia is a successor of the Protocol and it has adhered to its commitments, i.e. to reduce NO_x emissions by 1994 to the level of the year 1987, to introduce emission limits for NO_x and ensure availability of leadless gasoline. Since 1998 exclusive utilisation of leadless gasoline was introduced by legislative means.
- *Protocol on Limitation of Volatile Organic Compounds (VOC) Emissions or their Cross-Border Transfers (Geneva, 1991)* – Slovakia ratified the Protocol in 1999. Upon a resolution of the Government, the National Program of VOC (NP VOC) was prepared, which has defined the way in which the set objective, i.e. to reduce VOC emissions by 30% by 2000, as compared with the year 1990, would be met.
- *Protocol on Reduction of Acidification, Eutrofication and Ground Ozone* – The protocol tightens up commitments for the generation of SO_2 and NO_x emissions for the year 2010, including a gradual increase of charges as a stimulating factor. Commitments for the Slovak Republic under this Protocol represent a volume of SO_2 emissions in 2010 of 110 thousand tonnes; the reduction target for NO_x is 130 thousand tonnes and for volatile organic compounds VOC, 140 thousand tonnes.

The National Program of Reduction of VOC Emissions (NP VOC)

The attainment of objectives of this program was divided into two stages: stage 1 covered the period 1995–1997 and stage 2 the period 1997–2000. The results of evaluation of stage 1 show that in 1996 VOC emissions were reduced by 30% against the level of the year 1990, whereby the following measures contributed to this reduction:

- reduction of total volume of used paints at an increased share of low-solvent/solvent-free paints,
- intensive gasification of combustion units, particularly in municipal power plants (small and medium-sized sources),
- successful application of the reduction plan for VOC emissions in the sector of industrial crude oil treatment,
- replacement of vehicle fleet in favour of vehicles controlled by catalysers,
- application of the waste management program.

Stage 2 of the National Program of Reduction of VOC Emissions was completed in 2000. From evaluation of the course of the stages 1 and 2 of the Program it results that at both stages a total reduction of VOC emissions by 47% was reached, which was expressed as the average value of reduction for all examined sectors, compared with the level of the year 1990. In individual sectors the level of reduction is different; the most significant reduction of VOC emissions against the year 1990 was reached in the sector of waste management (97%) and in the industrial organic chemistry (88%).

Table 4.1 shows brief characteristics of mitigating measures to reduce CO_2 emissions in the energy sector and quantification of their reduction potential for cross sectorial years.

Table 4.1 *Characteristics and reduction potential of some mitigating measures in the energy sector* [2]

						Mitigation	Impact	ΔGHG	[GgCO_2 equiv./year]
Name of policy/measure	**Objective and/or Activity affected**	**GHG affected**	**Type of instrument**	**Status**	**Implementing entity/entities**	**2000**	**2005**	**2010**	**2015**
Act No. 309/1991 Coll. on Protection of the Air	Reduction of emissions of the basic pollutants	CO_2 CH_4 N_2O	Regulatory and economic	I	Slovak Ministry of Environment Environmental authorities	258 4 1	1,365 88 10	1,372 92 13	1,342 72 11
Implementation of of combined cycles	Increase in energy efficiency	CO_2	Regulatory and economic	I	Slovak Ministry of Economy SEA	0	972	814	911
Thermal insulation of buildings	Reduction of final energy consumption in sectors MVV & RR	CO_2	Regulatory and technical	I	MVV & RR SR	0	78	803	634
Utilisation of renewable energy sources	Decrease in fossil fuel consumption	CO_2	Regulatory and technical	I	Slovak Ministry of Economy SEA	159	1,138	1,857	2,334
Shifting of services from individual to public transport	Decrease in hydrocarbon fuel consumption Environmental protection	CO_2 CH_4 N_2O	Regulatory and technical	S	Slovak Ministry of Transport, Posts and Telecommun.	0 0 0	132 1 6	269 2 19	405 3 34

Note – The positive values of ΔGHG correspond to reduction of greenhouse gas generation at the introduction of the respective measure.

Legend to table:

I – *policy and measure have been already implemented (using criteria of updated IPCC Guidelines 1999/7)*

S – *adopted, approved policy or measure*

P – *planned, prepared policy/measure*

[2] Table 4.1 shows aggregated emissions of CH_4 and N_2O converted using GWP [Gg equiv. CO_2].

4.2.3 Transportation

From the GHG emissions point of view, transport management, the full utilisation of the transport system, as well as the use of proper type of transport play an increasingly important role. In general, the amount of emitted pollutants is in direct proportion to the total output (or the amount of consumed fuel) of the examined type of transport. For road vehicles, railway wagons, vessels and aeroplanes, the calculation of emissions is based on the amount of consumed fuel.

4.2.3.1 CO_2 emissions

4.2.3.1.1 Policy and mitigating measures from the Second National Communication

- **Act No. 316/1993 Coll. on Consumption Tax on Hydrocarbon Fuels and Oils**
  ***Type of measure* – economic**
  ***Status of implementation* – implemented measure, latest amendment – Act No. 254/2000 Coll.**

The Act stipulates the rates of consumption tax on fuels used in transportation, giving preferential tax treatment to those using gaseous hydrocarbon fuels and so-called environmental fuels of domestic origin. Rates of consumption tax under the last amendment are as follows:

— the level of 15,400 SKK/t for gasoline (special types of gasoline not used as fuel 2,800 SKK/t),
— the lower value of consumption tax at the level of 14,600 SKK/t is applied for diesel fuel,
— the consumption tax for LPG is 2,370 SKK/t,
— the consumption tax for natural gas is 2 SKK/m^3,
— the consumption tax for environmental fuel produced in the country is 3,000 SKK/t.

- **Act No. 87/1994 Coll. on Road Tax, as amended**
  ***Type of measure* – economic**
  ***Status of implementation* – implemented measure, latest amendment – Act No. 335/1999 Coll.**

The Act determines road tax for the utilisation of roads by motor vehicles and their attached vehicles used for business or in connection with business. For exclusive utilisation of combined transport for shipment of goods under this Act full or partial tax allowance (from 25 to 75% of tax) may be provided, depending on the range of vehicles participating in combined transport.

- **Control of vehicles in operation**
  ***Type of measure* – regulatory**
  ***Status of implementation* – implemented measure**[3]

Regulation of the Ministry of Transport, Posts and Telecommunications of the Slovak Republic (MTPT SR) No. 265/1996 Coll. on emission controls of motor vehicles used in road transport (implementary regulation to Act No. 309/91 Coll. on Air) stipulates the means of determination of the amount of emitted pollutants from motor vehicles used in road transport, conditions of granting a licence for execution of emission controls and conditions of granting a certificate of professional competence for execution of emission controls. Regulation of the MTPT SR No. 307/1999 Coll., by which Regulation of the MTPT SR No. 265/1996 Coll. on emission controls of motor vehicles used in road transport is modified and amended, determines emission limits for a vehicle in traffic and time limits of emission control of a vehicle in traffic. Regulation of the MTPT SR No. 327/1997 on controls of technical condition of vehicles comprises general provisions for controls of technical condition of vehicles, time limits of controls, extent of control, result and evaluation of technical condition of vehicle and other provisions directly relating to the execution of control of technical condition of a vehicle.

- **Formation and development of combined transport system**

In spite of adopted legislative measures which economically motivate this form of transport using allowances or reductions of road tax (Act No. 87/1994 Coll.), the range of combined transport in Slovakia is small in comparison with the European level. For further development of combined transport it is necessary to legislate, based on practical experiences of operators, some other areas, e.g. to define this form of transport in the Commercial and Trade Codes as an independent area of transport and licensed activity, to support economically the import of technology for combined transport, to exempt it from VAT, or to introduce restrictive measures in international truck transport at border crossing (e.g. weighing) etc. Presently in the territory of the Slovak Republic there are combined transport terminals in Čierna nad Tisou, Dobrá in neighbourhood of Čierna nad Tisou, Košice, Ružomberok, Bratislava – ÚNS, Bratislava – Pálenisko (port), Nové Zámky, Dunajská Streda and Štúrovo. Among them only the terminal located in Dobrá in neighbourhood of Čierna nad Tisou represents a modern combined

[3] Measure implemented through amended decrees.

transport terminal (CTT) meeting the European standard.

Utilisation of alternative fuels

Type of measure – **regulatory and economic**
Status of implementation – **implemented measure, changes in tax rates (amendment of the Act No. 316/1993 Coll.)**

The share of utilisation of alternative fuels in transport is stipulated by Act No. 87/1994 Coll. on road tax, which allows tax exemption for vehicles using electric or solar energy for a 5 year period from allocation of registration number, and reduces by 50% road tax for vehicles powered by liquified petroleum gas (LPG) or compressed natural gas for the first two years from the origin of tax liability. Also Act No. 316/1993 Coll. on consumption tax on hydrocarbon fuels and oils determines lower tax rates for gaseous fuels. In 1999 more than 21 thousand passenger cars powered by LPG and several buses for local transport using natural gas were in operation in the Slovak Republic. More than 30 public LPG filing stations are in operation. Currently, 7 metylester colza oil plants (MERO) with a total production capacity of 17,500 tonnes are located in Slovakia. In 1999, they produced approximately 7,500 tonnes of MERO, which was used for production of mixed fuel [14].

Acceleration of the vehicle fleet replacement

The vehicle fleet replacement continues at a rate corresponding to the economic potential of the country, its enterprises and population. In spite of the unfavourable economic situation, in 1999 of a total operated fleet of 1,246,959 passenger cars, 343,615 vehicles were equipped with a three-way controlled catalyser, i.e. 27.5% of the fleet consists of vehicles which are from the technical and technological point of view new and more friendly to the environment. Some space (though limited in time) for the acceleration of vehicle fleet replacement was created by the provisional cancellation of the import surcharge in 1997 and in the following period it was affected by incentive measures adopted for the purchase of new vehicles on the part of sellers, insurance companies, etc.

To solve the unfavourable situation in the area of obsolescence, wear and tear of the vehicle fleet in public bus transport – enterprises associated in the Slovak Bus Transport, in 1998, by Resolution of the Government No. 453/1998, the *Program of Replacement of the Bus Fleet SAD* was adopted, which allocated 47.5 mil. SKK from funds of the MTPT SR for the purchase of new vehicles. By Act No. 372/1999 Coll. on the state budget of the Slovak Republic for the year 2000, an amount of 200 mil. SKK was allocated in the section of the MTPT SR for bus fleet replacement in 2000, by which the Government contributes up to one third to the purchase of 170 new vehicles. Resolution of the Government No. 544/1999 to the *Project of Economic Stabilisation and Transformation of the Slovak Railways* should help to solve the unfavourable situation in the area of modernisation of the rolling stock.

4.2.3.1.2 Actual policy and measures to reduce CO_2 emissions

Program supporting rationalisation of fuel and energy consumption in transport

Type of measure – **regulatory and technical**
Status of implementation – **approved measure**

The Program, which represents a group of measures and technical solutions aimed to reduce specific consumption and enhance efficiency in transport, was elaborated in compliance with Resolution of the Slovak Government No. 5/2000 to the project of Energy Policy of the Slovak Republic. From the presented group of 27 short-term and medium-term measures until 2007 we chose only those, the introduction of which results in mitigation of negative impacts of transport on the environment.

Acceleration of public transport by

- the utilisation of an analysis of drive course and idle time,
- the introduction of integrated transport systems for railway transport, streetcars and trolley coaches,
- the improvement of the condition and equipment of stops and stations,
- drawing up conceptions of the development of public network in relation to direct, fast and fluent connection of the city centre with suburban areas
- own lines for the elevated railroad (L-train),
- the introduction of an active tariff policy in mass city transport,
- wider utilisation of small-capacity buses in city transport.

Reduction of specific consumption in individual transport

- voluntary agreements between the Government and producers or importers of vehicles (agreements on investments in energy efficiency in exchange for reduction of tax load),
- adjustments of emission limits (systematic application of regulations of UN EEC and EU directives),

- extended use of LPG and natural gas as fuel in passenger and public transport,
- application of fuel systems based on alternative sources,
- development of local energy control systems MERS (autonomous regulation of power consumption with remote control and data collection).

Projection of energy saving objectives in acts, standards and administrative regulations

- charges for authorisation of operation depending on consumption (lower tax rate for vehicles equipped with a catalyser),
- customs duty dependent on consumption – import prices linked to regulated consumption,
- provisions of tax law for investments in enhancement of energy efficiency of the fuel base

Technical measures for improvement of infrastructure and vehicle fleet in public transport

- acceleration of railway transport – integrated transport systems for suburban and local transport,
- support of the development of public transport,
- improvement of road transport continuity – construction of capacity roads (highways),
- development of combined transport – the development of infrastructure and the technical base, more intensive utilisation of CT in main transport directions.

Support of cycling and pedestrian traffic

- planning and construction of a cycling network, combined automobile and cycling transport on subsidiary roads, cycling tracks in pedestrian zones etc.,
- the development of attractive infrastructure for pedestrians.

Development of awareness and information activity

- transport education at schools, aimed in addition to safety problems to issues of energy savings and environmental protection, transport education at driving schools – economic style of driving,
- campaign in media (radio, television, conferences, fairs).

4.2.3.2 Other gases

Many of the measures indicated in the *Program Supporting Rationalisation of Fuel and Energy Consumption in Transport* also apply to the category of other gases.

Regulation of the Slovak Ministry of Transport, Posts and Telecommunications No. 116/1997 Coll. on conditions of road traffic of vehicles (to the Act No. 315/1996 Coll.)

Type of measure **– regulatory**

Status of implementation **– implemented measure**

In addition to conditions of technical condition and equipment of vehicles, it also stipulates emission limits and terms for the verification of prescribed emission limits for mobile sources of air pollution.

4.2.4 Industry

After a many-year transformation process, metallurgy, chemical, engineering and foodstuff industries remain bearing branches of Slovak industry, i.e. there still prevail branches with high demands on raw materials, energy and transport and with a low degree of processing. Although the shutdown of some less-effective production units and reduction of the volume of production in the elapsed period were followed by reduction of CO_2 emissions in industry, in case of economic growth other reserves of reduction of fossil fuel consumption should be found for the modernisation and restructuring of industrial production. In reduction of CO_2 emissions in industry, cross sectoral measures play an important role, especially the synergetic effect of the Act on Protection of the Air, measures for energy savings and the prepared liberalisation of raw material and energy prices.

4.2.4.1 CO_2 emissions

4.2.4.1.1 Policy and reduction measures from the Second National Communication on Climate Change, Slovak Republic

Iron and steel production in VSŽ

In VSŽ, a.s., one of the most important industrial enterprises contributing to the creation of CO_2, a decline in production was observed in the recent period due to changes in property relations. To meet adopted environmental legislation, in the internal heating plant, low-sulphur coal with a content of 0.6% of sulphur is now burnt in five boilers and the sixth boiler is gasified and serves only for combustion of waste gases from technology. The analysis of CO_2 creation in technology itself shows that its level will only depend on the volume of production.

Innovation of aluminium technology in ZSNP Žiar nad Hronom

One condition of the entry of foreign capital in the project of modernisation of aluminium production in ZSNP, a.s. (the utilisation of pre-burnt anodes and dry absorption of exhalation) was adaptation of all productions to environmental requirements. From 25 environmental projects under this program 18 projects have by now been implemented.

Cement production

In cement production CO_2 emissions occur by decomposition of limestone in cement clinker and lime calcinators and by combustion of fuels in technological and auxiliary equipment (furnaces, dryers, combustion chambers).

It is clear that these areas also represent potential room for the implementation of measures to reduce CO_2 emissions [8], [9].

In the area of production technology particularly the following measures come into consideration:

- concentration of cement clinker production in larger production units with planned utilisation of most advanced technologies,
- limitation of wet cement clinker production,
- limitation of cement clinker production in shaft furnaces,
- production of mixed cements with a lower content of cement clinker,
- production of special cements with lower saturation by calcium monoxide,
- production of cements with adjusted chemical composition of raw-material mixture, which are calcinated at lower temperature.

In fuel combustion processes the following measures leading to reduction of CO_2 emissions can be considered:

- the utilisation of waste heat from the technological process (particularly heat from rotary kilns),
- optimisation of the combustion process with a view to fuel saving,
- the utilisation of alternative fuels (used tyres, some types of waste) – actually in very limited amount due to high prices.

Clinker production was closed in ZEOCEM, a.s., Bystré (1997), in Cementáreň Lietavská Lúčka, a.s., (1998) and in two rotary kilns in Stredoslovenská cementáreň Banská Bystrica, a.s.

4.2.4.1.2 Present policy and measures to reduce CO_2 emissions

Cement production

Type of measure – **technical**

Status of implementation – **approved measure**

A specific description of potential areas for the introduction of measures to mitigate CO_2 emissions in cement production, both in production technology and in fuel combustion processes, is provided in subsection 4.2.4.1.1. A brief overview of planned measures together with time schedule and supposed volume of reduction is provided below:

Measures in the area of production technology

Reduction of lime production

- The planned decrease of production in the lime works of Nové Mesto nad Váhom, Žirany, Margecany and Tisovec on one hand and the increase of production in the lime works of Gombasek and Rohožník on the other hand should result in total reduction of CO_2 emissions by 92.4 thousand tonnes per year.

Measures in fuel combustion processes

Reduction of fuel consumption in clinker calcination

- Construction of rotary kiln in the joint-stock company CEMMAC Horné Srnie.
  The new rotary kiln will replace 5 shaft furnaces, whereby planned reduction of specific fuel consumption from 4,300 kJ/kg to 3,100 kJ/kg will show in reduction of CO_2 emissions by about 42 thousand tonnes per year.
- Reconstruction of disperse raw material preheater until 2005 in the joint-stock company Cementáreň Turňa nad Bodvou.
  The purpose of this reconstruction is to enhance thermal efficiency of the preheater and reduce fuel consumption; expected reduction of CO_2 emissions is approximately 13.3 thousand tonnes per year.
- Reconstruction of thickening cyclones in the joint-stock company Považská cementáreň Ladce.
  Planned reduction of CO_2 emissions after reconstruction represents 7.2 thousand tonnes per year

Combustion of alternative fuels

- In the joint-stock company HIROCEM, the rotary kiln PC2 was adapted so as to allow regular combustion of adequately conditioned waste, including tyres. The target value for reduction of CO_2 emissions through the utilisation of alternative fuels was determined at 8.1 thousand tonnes.

4.2.4.2 Other gases

The legislative framework, developed activities and description of their effects, which were specified for the category of other gases in the energy sector (subsection 4.2.2.3), also apply to the industrial sector in the cross sectorial areas.

4.2.4.3 Emissions of HFCs, PFCs and SF_6 – New gases

Under the term *New gases* emissions are analysed of substances which may be classified as greenhouse gases from the aspect of their effects, but before COP3 in Kyoto they were not taken into account in the inventory and projection of greenhouse gases. Their first inventory was executed in 1995. HFCs, PFCs and SF_6 are not produced in Slovakia, only data on their consumption are available. A more specific description of individual gases and the way of their utilisation is provided in Appendix P2 (section P2.1). Considering the nature of these substances the choice of mitigating measures is very limited.

4.2.5 Residential, commercial and institutional sectors

4.2.5.1 CO_2 emissions

4.2.5.1.1 Policy and mitigating measures from the Second National Communication

- **Program of Energy Consumption Reduction in Apartment and Family Houses**
  Type of measure **– economic**
  Status of implementation **– direct funding of the Program from state budget ended on January 1, 1998**[4]**.**

The Program was designed for owners of apartment houses, family houses and thermal sources for district heating.

Part A – Additional provision with thermal insulation of apartment houses in collective forms of construction [10]

From 1992 until the end of the year 1997, 271 projects with a total budget expenditure of 960 mil. SKK were implemented, whereby the participation of the Government represented the amount of 540.8 mil. SKK for the total number of 10,937 apartments. The achieved heat savings for the examined period represented a volume of 196,866 GJ/year and expenditures of state budget per GJ of saved energy were in average 2,747 SKK/GJ.

Part B – Installation of measuring and control equipment and modernisation of heating systems in apartment houses and apartments [9]

The total volume of funds provided under the Program from state budget until the end of the year 1998 amounted to 186.1 mil. SKK.

4.2.5.1.2 Present policy and measures to mitigate CO_2 emissions

- **Proposed conception of building reconstruction with special accent upon housing fund**
  Type of measure **– regulatory and technical**
  Status of implementation **– approved measure (Resolution of the Slovak Government No. 1088/1999)**

This measure comprises a group of measures for reconstruction of the housing fund with a view to preserving the existing fund, extending its useful life and creating conditions for energy savings:

- More intensive procedure in providing the existing housing fund with thermal insulation using the state programs of energy savings.
- Systematic introduction of measuring and control equipment in the housing fund and in the respective energy system.
- Additional improvement of physical parameters of windows and doors built in the existing housing fund.
- More severe requirements on thermotechnical properties of building structures and buildings of new construction.
- Support of heat and hot supply water production from refined fuels directly on the site of consumption, i.e. in houses or apartments.

4.2.6 Agriculture

As was said in subsection 4.1, the elaborated document *Proposal for Measures to Adapt Agriculture of the Slovak Republic to Climate Change* [11] includes a specific overview of activities and projects to solve negative impacts of climate change in chosen areas with effect on emissions of CO_2, CH_4 and N_2O [5].

In agriculture:

- *the application of protective and economic cultivation technologies,*
- changes in growing technologies,
- changes in agroclimatic classification and structure of grown crops and varieties,
- changes in cultivation programs,
- changes in the integrated protection of crops,

[4] This Program was replaced by the Program supporting energy savings and utilisation of alternative energy sources and presently it is supported through the State Fund of Housing Development at the Ministry of Construction and Regional Development of the Slovak Republic.

[5] The overview of measures also includes reduction measures – in italics.

- changes in of water management of soil regulation,
- changes in nutrition of plants,
- *reduction of greenhouse gas emissions, treatment of excrements and wastes in animal production,*
- *changes in agricultural production management,*
- revitalisation of the existing and construction of new irrigation systems.

In management of water supplies:
- solution of potential consequences of climate change on water supplies,
- slowdown of runoff by construction of purpose reservoirs,
- *construction of new hydro-energy sources leading to the utilisation of naturally renewable natural sources in order to reduce consumption of fossil energy sources*.

In forestry:
- *changes of tree species composition of forests,*
- *afforestation of non-forest areas,*
- the area of forestry bioclimatology, eco-physiology, forest protection, genetics and cultivation of tree species,
- *measures to improve vegetation condition in forests affected by emissions,*
- adaptation of extraction and production technologies to environmental requirements,
- preservation and reproduction of the genofund of tree species in forests
- changes of hydric influence of forests.

In the area of breeding, cultivation and nutrition of animals:
- modelling of breeding systems with the possibility to reduce the influence of extreme microclimate on utility and health condition of animals,
- the protection of livestock from high temperatures,
- modelling the influence of the amount of annual genetic gain on milk and beef production and on population of cattle in relation to the required milk and meat production in the Slovak Republic,
- the application of livestock breeding systems which will allow the reduction of the influence of extreme climatic parameters on production and health condition of animals and the influence of breeding on air quality and water management systems,
- *the completion of storage capacities of stable manure and liquid manure in compliance with EU legislation in force,*
- *the utilisation of manure application systems with reduced influence on air quality and water management systems.*

4.2.6.1 CO_2 emissions

As regards the share of the sector in total emissions, measures to reduce formation of CO_2 emissions in agriculture only focus on the area of fuel and energy consumption, i.e. cross-sectorial measures. The analysis of data from the years 1998 and 1999 clearly shows that for total year-on-year savings of fuels and energies in agriculture, consumption of "environmental-friendly" types (natural gas and heavy heating oil) increased. The CO_2 sinks are evaluated in Chapter 3.

Regulation of the Ministry of Agriculture of the Slovak Republic No. 928/1992 – 100 on the support of enterprise in agriculture

Type of measure **– regulatory and economic**
Status of implementation **– implemented measure**

State support to rationalisation of the energy system in agriculture and foodstuff industry, utilisation of renewable sources, wastes and waste heat, purchase of new technologies, production and consumption of biofuel.

Conception of Agrarian and Food Policy until 2005

The document aims to create conditions for the implementation of the European model of multifunctional agriculture. It will include measures of sustainable management.

Agro-environmental Program of the Slovak Republic

The basic document of adaptation of agriculture to environmental requirements, which is the result of the effort towards mutual integration of agrarian and environmental policy.

4.2.6.2 CH_4 emissions

Agriculture, solid waste storage and wastewater treatment are the major sources of methane production. While the share of anthropogenic methane emitted in the atmosphere from waste dumps accounts, by estimate, for 5 to 20% of total production, the share of agriculture on total methane production in 1996 was approximately 35% (109 thousand tonnes) [7].

The sources of methane production in agriculture are concentrated in the area of animal production. They are mostly represented by:
— CH_4 emissions from enteric fermentation of livestock,
— CH_4 emissions from animal waste management.

Based on characteristics of the major sources of methane production in agriculture, we can define as real possibilities of reduction of methane emissions the following measures:
— reduction of livestock or change in representation of livestock in individual categories (cattle, pigs, poultry, horses, sheep, goats),
— treatment of waste from animal production to biogas.

As cattle are the largest methane producer among all animal categories (large weight, digestive system, large number of animals), trends of total CH_4 emissions also reflect the number of animals in this category. In the years 1990 to 1998, the number of cattle decreased by almost one half, which corresponds to a total reduction of CH_4 emissions from more than 133 thousand tonnes in 1990 to 65 thousand tonnes in 1998.

Methane production from animal production may be effectively used for biogas production. The estimate of biogas production from organic substance of excrements of individual categories of livestock can be based on the following data [12]:

— dairy cattle	1.26	m^3 of biogas/unit/day
— beef cattle	0.93	m^3 of biogas/unit/day
— pig	0.15	m^3 of biogas/unit/day
— layer	0.020	m^3 of biogas/unit/day

In Slovakia this technology is applied in Bátka near Rimavská Sobota. Theoretically this method can eliminate methane from dry or wet excrement storage of big farms, which means a potential reduction of methane from this source by up to 80%.

4.2.6.2.1 Policy and mitigating measures from the Second National Communication

Code of Good Agricultural Practice in the Slovak Republic – soil protection

The document which was approved and published in 1996 remains in force. In the framework of this amendment Part II was elaborated, which includes rules for correct utilisation of fertilisers.

4.2.6.2.2 Present policy and measures to reduce CH_4 emissions

Act No. 83/2000 Coll., modifying and amending Act No. 307/1992 on Agricultural Soil Protection
Type of measure – **regulatory**
Status of implementation – **implemented measure**

The amendment of Act No. 307/1992 Coll. stipulates inter alia the definition of agricultural soil stock and obligations of the owner or the lessee of land being a part of the agricultural soil stock to execute agrotechnical measures which guarantee protection, preservation and restoration of natural properties of agricultural soil. Subsection 5 of the Act specifies measures to repair damage to natural properties of agricultural soil.

Act No. 136/2000 Coll. on Fertilisers
Type of measure – **regulatory**
Status of implementation – **implemented measure**

The Act, which was adopted in March 2000, lays down conditions for putting into circulation fertilisers, farming substrates and soil additives, conditions of registration of fertilisers, their storage and utilisation, conditions of agrochemical testing of agricultural soil and determination of soil properties of forest land.

Conception of Cattle Breeding for the period 2000–2005
Type of measure – **regulatory**
Status of implementation – **implemented measure**

The strategy of further development of cattle breeding in Slovakia [14] is based on two basic requirements:
1) production of sufficient amount of quality products for domestic market – after revival of the economy, a gradual increase of meat and milk consumption is expected for breeding of such number of cattle which shall allow to improve permanently the cultural character of the country and partially solve the social problem;
2) the viewpoint of world trade globalisation and the accession of Slovakia to EU – since January 1, 2000, Regulation of the EU Council No. 1254/1999 on common organisation of beef and calf market has been in force, according to which subsidies for prices shall be successively reduced with a view to enhancing competitiveness on international markets. More details and an overview of conceptual documents from the affected area are available on the web site: www.mpsr.sk.

4.2.6.3 N_2O emissions

Unlike other greenhouse gases, the mechanism of formation of N_2O emissions and sinks has not been thoroughly examined, and presented data have a high degree of uncertainty. Agriculture has the largest share on total N_2O production (approximately 75%), which represents the only sector in Slovakia where measures to reduce N_2O emissions can be applied. The process of formation of N_2O emissions by combustion or transformation of fossil fuels is similar as with carbon dioxide and methane, i.e. reduction of its formation is positively affected by all measures, which result in a reduction of fossil fuel consumption. On the contrary, in the case of wastewaters, measures to reduce CH_4 emissions result in an increase of N_2O emissions.

The major sources of N_2O emissions are:

— *N_2O emissions from for soil enterprising for agricultural purposes,*

— *N_2O emissions from animal waste enterprising,*

The release of N_2O emissions also occurs during storage of stable manure. The amount of N_2O depends especially on the way and the period of animal waste storage.

— *indirect N_2O emissions.*

They occur by atmospheric deposit of ammonium and NO_x, as well as by transformation from washed-up nitrogen and from nitrogen losses caused by runoff.

The real potential for reduction of N_2O emissions from agricultural production on the basis of provided characteristics of sources is represented by the following measures:

— reduction of areas used for agriculture (particularly those which are unfit for purposes of agricultural production),

— reduction of the application of fertilisers,

— decrease of the number of livestock or change of its representation in individual categories,

— suitable storage and treatment of wastes from vegetable and animal production, transformation of liquid manure to biogas,

— treatment of post-harvest remainders from vegetable production.

- **Act No. 307/1992 Coll. on Agricultural Soil Protection (section 3, § 4, 5 and 6)**
  Type of measure **– regulatory**
  Status of implementation **– implemented measure, latest amendment – Act No. 83/2000 Coll.**

Though amended, the Act remains the basic legal norm which ensures the fulfilment of environmental criteria in the area of agriculture. According to this Act users of agricultural soil are obliged to use it in such a way that will minimise the negative effects of their activity on the environment (water, atmosphere). All changes in the use of agricultural soil may be executed only after approval by the agricultural soil stock protection body. Another amendment of the Act under preparation (2003) should include definitions of soil functions and comprehensive ensurance of their sustainable development.

- **Directive of the Ministry of Agriculture of the SR No. 5000/1982 on the Water Protection against Agricultural Contamination**
  Type of measure **– regulatory**
  Status of implementation **– implemented measure**

The Directive defines principles for the application of mineral nitrogenous and organic fertilisers in water protected areas. A new regulation is being prepared (Implementation of the EU Nitrate Directive in 2002) on the Protection of Water Sources from Contamination by Agricultural Production.

- **Directive of the Ministry of Agriculture of the SR No. 5001/1982 on Manipulation with and Utilisation of Liquid Manure and Liquidation of Ensilage Juices**
  Type of measure **– regulatory**
  Status of implementation **– implemented measure, amended by Regulation of the Ministry of Agriculture No. 33/1999 Coll. on preparations for plant protection**

The regulation stipulates details on keeping records of consumption and application of preparations for plant protection and on conditions of testing and assessment of the preparations.

- **Code of Good Agricultural Practice – soil protection**

The document, which was approved and published in 1996, deals with protection of soil fertility, protection from physical degradation of soil, soil contamination and its consequences, as well as with management of water and air soil regimes. In the framework of its amendment Section II – Principles of correct application of fertilisers – was elaborated. The prepared Section III of the Code of Good Agricultural Practice will deal with water protection.

Table 4.2 shows brief characteristics of major mitigating measures to reduce CH_4 emissions in agriculture and quantification of their reduction potential for the cross-sectorial years.

Table 4.2 *Characteristics and potential of some measures in agriculture*[6]

						Mitigation	Impact	ΔGHG	[GgCO_2 equiv./year]
Name of policy/measure	**Objective and/or Activity affected**	**GHG affected**	**Type of instrument**	**Status**	**Implementing entity/entities**	**2000**	**2005**	**2010**	**2015**
Reduction of the livestock number	Intensification of agricultural production Harmonisation with EU legislation[7]	CH_4	Regulatory	I	The Ministry of Agriculture SR	0	0	22	2
		N_2O				0	0	–546	–291
		Total				**0**	**0**	**–524**	**–290**
Treatment of animal excrements to biogas	Application of RES Reduction of GHG emissions	CH_4	Technical	I	The Ministry of Agriculture SR	0	0	32	70
		N_2O				0	0	398	849
		Total				**0**	**0**	**430**	**919**

Note – The positive values of ΔGHG correspond to reduction of GHG emissions upon introduction of the respective measure.

Legend to table:

I – *policy and measure have been already implemented (using criteria of updated IPCC Guidelines 1999/7)*

S – *adopted, approved policy or measure*

P – *planned, prepared policy/measure*

[6] Table 4.2 shows aggregated emissions of CH_4 and N_2O converted using GWP [Gg equiv. CO_2].

[7] The measures arising under the EU Directive lead to reduction of CH_4 emissions. On the other hand, formation of N_2O emissions increases upon their introduction.

4.2.7 Land usage change and forestry

4.2.7.1 CO_2 emissions

In general, in forestry we can define the following mitigating measures which develop from basic balance categories and individual related processes:
— reduction of permanently deforested areas,
— afforestation of non-forest areas,
— increase of carbon stock in the existing forests,
— increase of utilisation of wood and its better valorization,
— utilisation of wood as biomass – replacement of fossil fuels.

In the Second National Communication, the following potential mitigating measures were identified for the area of forestry:
— tree species composition change,
— afforestation of non-forest areas,
— protection of the existing carbon stock in forests affected by emissions

Tree species composition change

In the framework of the economical planning (Decree of Ministry of Agriculture No. 5/1995 Coll. on economic forests adjustment), the share of leafy forests will be increased in the area with conifer forests (replacement of spruce by beech, which has higher specific content of carbon per 1 ha). Considering the longevity of the reproduction process in forests, the tree species composition change can be reached only very slowly. At this stage we cannot therefore evaluate the actual effect of this measure on the carbon balance.

Afforestation of non-forest areas

Afforestation of non-forest areas represents the most effective way of carbon sequestration because it is accompanied by formation of new stock as well as carbon accumulation in soil humus. The potential of areas suitable for afforestation in Slovakia is quite large. By repeal of Decree of the Slovak Government No. 550/1994, by which the Program of Afforestation of Non-Forest Areas Unfit for Agricultural Use in the period 1994–1996, with outlook until 2000, was implemented, this Program was suspended, including cancellation of its institutional assurance. The result of program implementation is total afforestation of 877 ha of soil during the period 1995–1999 (against the planned afforestation of 50,000 ha of non-forest areas until 2000). The practical implementation of the program was impeded by several factors, the most important of which were unsettled property relations to land (difficult identification of owners) and unclear financial and subsidy policy in relation to land owners.

Protection of carbon stock in forests affected by emissions

The solution of problems related to improvement of vegetation conditions in forests, i.e. slowdown or stoppage of the decrease of increment in forests affected by emissions, with subsequent positive effect on the carbon balance, has a long tradition in Slovakia, but it obtained a legal framework only in 1994, when the Implementation Program for Elimination of Damages Caused by Anthropogenic Activity, especially by emissions in forest ecosystems, was approved by Resolution of the Slovak Government No. 594/1994. Under this Program implementation projects were developed for individual areas (Low Tatra, Stredné Považie, Belianske Tatry, Žiar nad Hronom, Poľana, Orava-Kysuce, Spiš, Horná Nitra, Jelšava-Lubeník) the implementation of which was however impeded by the lack of funds. During the period 1995–1997, measures for improvement of vegetation conditions were executed on a total area of 3,822 ha, with costs of 48 mil. SKK. In spite of enormous effort, the Program was not implemented in the planned extent of preventive and corrective measures because of the lack of funds.

Table 4.3 *Characteristics and reduction potential of some mitigating measures in forestry*

						Mitigation	Impact	ΔGHG	[GgCO$_2$ equiv./year]
Name of policy/measure	**Objective and/or Activity affected**	**GHG affected**	**Type of instrument**	**Status**	**Implementing entity/entities**	**2000**	**2005**	**2010**	**2015**
Soil stock protection	Increase of soil carbon stock – lower effect *	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	73	51	99
	Increase of soil carbon stock – higher effect	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	88	80	142
Regulation of timber Extraction	Reduction of permanently deforested area – lower effect	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	330	660	990
	Reduction of permanently deforested area – higher effect	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	660	990	1,320
Afforestation of non-forest areas	Increase of GHG sinks – lower effect	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	1	10	31
	Increase of GHG sinks – higher effect	CO_2	Regulatory	I	Slovak Ministry of Agriculture	0	2	13	42

** The lower effect corresponds to the scenario with measures, the higher effect to the scenario with additional measures (see Chapter 5).*

Note – The positive values of ΔGHG correspond to reduction of GHG emissions upon introduction of the respective measure.

Legend to table:

I – *policy and measure have been already implemented (using criteria of updated IPCC Guidelines 1999/7)*

S – *adopted, approved policy or measure*

P – *planned, prepared policy/measure*

4.2.8 Waste management

4.2.8.1 CH_4 emissions

The major sources of methane production are: agriculture, solid waste storage and waste water treatment. The share of anthropogenic methane emission in the atmosphere from waste dumps represents, according to estimates, 5 to 20% of total production [7].

- **Act No. 238/1991 Coll. on Waste**
  Type of measure **– regulatory**
  Status of implementation **– implemented measure, the last amendment approved by the Slovak Government in November 2000**

The Act on Waste remains the basic legal norm in the area of waste management. Among others, according to this Act, the waste producer is obliged to use produced waste as a source of secondary raw materials or energy. Disposal of waste in landfills should be the last step of waste treatment which cannot be used otherwise. In June 2000 the Ministry of Environment of the Slovak Republic submitted a proposal of a new Act on Waste, together with proposals for ten implementation regulations. Under this amendment, the whole legal framework for the area of waste management changes and only Act of the National Council of the Slovak Republic No. 327/1996 Coll. on charges for waste disposal remains in force.

- **Decree of Slovak Government No. 606/1992 Coll. on Waste Treatment**
  Type of measure **– regulatory**
  Status of implementation **– implemented measure, latest amendment – Decree of the Slovak Government No. 190/1996 Coll.**

The Decree stipulates general conditions for waste treatment, special conditions for hazardous waste treatment and rules for landfill management. Waste treatment should be executed so that separable and utilisable substances could be used to a maximum extent in the production process. The amount of subsequently produced waste should be as small as possible, with minimum negative impacts on environment. Vegetable waste, animal excrements, sludge from sewage treatment plants and other similar waste should be preferentially treated in a biological way. The building of new landfills where gas generation is anticipated must contain a gas drainage system. In the framework of the amendment of the Act on Waste, a new form of the stated Decree is being prepared.

- **Waste Management Program of the SR until 2000**
  Type of measure **– regulatory and economic**
  Status of implementation **– implemented measure** [8]

The Waste Management Program of the Slovak Republic, approved by Resolution of the Slovak Government No. 500/1993, determined the conception for solution of issues of waste management and the means of waste treatment in the Slovak Republic. For the attainment of the Program objectives, funds in a total amount of 2,918 mil. SKK were used until the year 1995. The total amount of funds allocated to the support of waste management projects from the State Environment Fund in the period 1993–1997 represented a sum of 1,475 mil. SKK. The evaluation of the progress of implementation of some WMP measures from the Second National Communication, in relation to methane emissions, for the period 1993–1996, is provided in Table 4.4.

[8] Based on the evaluation of the Program for the period 1993–1996, objectives and measures for stage 2 of WMP SR we specified for two periods: 1997–2000 and 2000–2005.

Table 4.4 *Evaluation of the fulfilment of WMP SR measures for the period 1993–1996 [4]*

Objective	Status of implementation
To extend collection and utilisation of secondary raw materials by introduction of separated waste collection to reduce the amount of communal waste determined for disposal by 20% against the level of year 1992.	The separated waste collection is introduced in 500 communities and cities of Slovakia. In this way 350,000 tonnes of recyclable materials are obtained every year, which represents 22% of the total communal waste production.
To refine at least 20% of the volume of biological waste to organic fertilisers.	According to available data, 1.9 mil. tonnes of different agricultural wastes are subject to biological treatment. In addition, 5.9 mil. tonnes of stable manure and straw and 5.6 mil. tonnes of liquid manure are used for fertilisation.
To dispose in the prescribed way 50% of all communal wastes in landfills, which meet technical requirements.	In the examined period, new landfills were built and others were subject to special conditions. Currently more than 95% of communal waste is disposed in approved landfills.
To build a new, or adapt existing communal waste incinerators in Bratislava and Košice.	This measure has not been implemented because of lack of funds.
To build 10 waste composting facilities.	Industrial compost production has decreased by about 85% since 1992, especially due to cancellation of state subsidies and the low interest in these products. The existing facilities are now used particularly for biological decontamination of soils.
To build 9 high-capacity regional landfills for communal waste.	Since 1992, 31 new landfills have been built and 27 are under construction. Most of them have a regional character. The system of transfer stations used for waste transport to more distant landfills is very demanding from the technical aspect and has not been introduced yet.

- **Act No. 128/1992 Coll. on the State Environment Fund**
  Type of measure **– economic**
  Status of implementation **– not in force, it was replaced by the Act No. 237/2000 Coll.**

In the years 1993 to 1997, from the State Environment Fund of the SR, funds for the support of waste management projects in a total amount of 1,475 mil. SKK were allocated. The contributions were used mostly for the development of separated waste collection, construction of regional landfills, reconstruction of old landfills, waste recycling and proper treatment of hazardous waste.

- **Waste Information System**

The Regional Waste Information System (RISO) is designed for all levels of state government in waste management. The first version of the information system was developed in the period of validity of the initial waste catalogue (709 types of waste in 1991), while the existing system was adjusted in terms of the Decree of the MOE SR No. 19/1996 Coll., stipulating waste categorisation and issuing an extended Waste Catalogue (749 types of waste in 1996). RISO is designed so that all waste can be traced to the place of its origin, its quantity and the way of its treatment, including transport and place of neutralisation.

- **Decree of the Slovak Government No. 605/1992 Coll. on Keeping Waste Records**
  Type of measure **– regulatory**
  Status of implementation **– implemented measure**

The Decree defines basic conditions for keeping waste records. In the period since the Second National Communication on Climate Change, it has not been amended.

- **Act No. 327/1996 Coll. on Charges for Waste Disposal**
  Type of measure **– economic**
  Status of implementation **– implemented measure**

The Act determines charges for waste disposal in landfills and sludge beds. It imposes higher charges for waste disposal in landfills, which do not meet legislative requirements, making them disadvantageous. In the period since the Second National Communication on Climate Change, it has not been amended. The anticipated term of its amendment is the year 2001.

Table 4.5 shows brief characteristics and reduction potential of measures in the sector of waste management.

Table 4.5 *Characteristics and potential of some measures in the sector of waste management*[9]

						Mitigation	Impact	ΔGHG	[GgCO_2 equiv./year]
Name of policy/measure	**Objective and/or Activity affected**	**GHG affected**	**Type of instrument**	**Status**	**Implementing entity/entities**	**2000**	**2005**	**2010**	**2015**
Support of separated waste collection and utilisation of biologically active waste	Reduction of emissions and the amount of biologically active waste disposed in		Regulatory	I	Slovak Ministry of Environment				
	landfills – lower effect	CH_4				0	90	260	428
Biogas combustion	– higher effect	CH_4				0	181	428	689
Waste water treatment	Reduction of CH_4 emissions and harmonisation with EU								
– effluents	– lower effect	CH_4	Regulatory	I	Slovak Ministry of Environment	0	11	34	53
	– higher effect	CH_4				0	21	55	84
Waste water treatment	Reduction of CH_4 emissions and harmonisation with EU								
– industrial waters	– lower effect	CH_4	Regulatory	I	Slovak Ministry of Environment	0	11	34	59
	– higher effect	CH_4				0	22	57	95
Waste water treatment	Harmonisation with EU	N_2O	Regulatory	P	Slovak Ministry of Environment	0	–3 **	–6	–8

** The lower effect corresponds to the scenario with measures, the higher effect to the scenario with additional measures (see Chapter 5).*

Note – The positive values of DGHG correspond to reduction of GHG emissions upon introduction of the respective measure.

Legend to table:

I – *policy and measure have been already implemented (using criteria of updated IPCC Guidelines 1999/7)*

S – *adopted, approved policy or measure*

P – *planned, prepared policy/measure*

[9] Table 4.5 shows aggregated emissions of CH_4 and N_2O converted using GWP [Gg equiv. CO_2].

4.3 OTHER INSTRUMENTS AND MECHANISMS TO REDUCE GHG EMISSIONS

The Kyoto Protocol has generally extended the possibilities of countries to choose the means and instruments which are the most suitable for the attainment of reduction objectives with regard to specific circumstances of the respective country. The common feature of the new mechanisms is the effort to achieve maximum reduction potential in the most efficient way. In addition to the bubble concept (the European Union) the protocol defines in the framework of international collaboration the following flexible mechanisms:

a) Joint Implementation (Art. 6).
b) Clean Development Mechanism (Art. 12).
c) Emission Trading (Art. 17).

The Joint Implementation (JI) and the Clean Development Mechanism (CDM) consist in acquisition of emission reduction credits on the basis of investments (including transfers of technologies) in countries with a transforming economy or in developing countries, while emission trading allows purchasing and selling emission reduction credits according to the agreed scheme in the framework of countries specified in ANNEX I of UN FCCC.

In spite of the evident economic efficiency, the practical utilisation of these mechanisms is connected with a number of institutional and political problems, as well as difficult practical issues linked to the transfer of technologies, monitoring, verification and – last but not least – mutual confidence of the concerned parties. Recent development shows that the implementation of new mechanisms of reduction is subject to achievement of consensus in the international context.

In the framework of the prepared strategy, the Slovak Republic would preferentially participate in international emission trading at two levels – intergovernmental and individual enterprises – according to exactly defined international and domestic rules. In addition to foreign investments, this activity should result in the more distinct implementation of efficient technologies. Considering the high transaction costs related to preparation and implementation of projects, the amount of administrative work and lower effectiveness, the utilisation of the JI mechanism in the Slovak Republic will be probably lower. Based on the actual inventory of GHG emissions and projections of future emission development, it can be anticipated that the Slovak Republic will meet the Kyoto reduction target through internal activities, so the application of CDM is not supposed. Within the stage of so-called AIJ (Activities Implemented Jointly), four projects aimed at the utilisation of biomass are now being prepared or implemented in Slovakia.

Other possibilities for gaining financial resources for investments in environmental projects, restructuring of industry, enhancement of energy efficiency, transport and agriculture are represented by pre-accession financial instruments of the European Union for assistance to the associated countries – ISPA (Instrument for Structural Policies for pre-Accession), PHARE II, SAPARD, SAVE II, ALTENER II and JOULE-THERMIE.

4.4 SUMMARY OF MEASURES AND RECOMMENDATIONS UNDER THE ACTION PLAN OF FULFILMENT OF KYOTO PROTOCOL COMMITMENTS

As was stated above, the *Action Plan of Fulfilment of the Kyoto Protocol Commitments of the UN FCCC, the Ministry of Environment of the Slovak Republic, 2000* [13] has thoroughly analysed direct and indirect reduction measures from the viewpoint of their GHG reduction potential, investment intensity and the time horizon for their implementation.

The analysis has focused on the energy sector, namely on the fossil fuel combustion and transformation, which significantly contributes to the total CO_2 emissions, but which also represents the largest potential for implementing the CO_2 mitigation measures.

Based on the projections of CO_2 emissions from combustion and transformation of fossil fuels using scenarios in chapter 5, we can state that in the case of relatively balanced economic development Slovakia has a real chance to meet the reduction commitment under the Kyoto Protocol. The purpose of the analysis in the Action Plan was however to find other reduction potential which would allow meeting the more severe commitments in the following target period (Post-Kyoto period), as well as using the potential emission reduction reserve in the framework of flexible mechanisms (described in section 4.3) for acquisition of investments or innovation of technologies.

The following measures were evaluated:

Measures on the energy demand side

- Improvement of thermal characteristics of building in housing communal sector.
- Shifting from individual road transport to public mode.

Measures on the energy supply side

- Utilisation of combined cycles (CC) with electricity and heat cogeneration in public power plants (public PP).
- Utilisation of combined cycles (CC) with electricity and heat cogeneration in industrial power plants (industrial PP).
- Utilisation of biomass in industrial PP.
- Utilisation of biomass in the central district heating system (DHS).
- Utilisation of geothermal energy in the central heating system.
- Utilisation of biomass for individual heating.
- Utilisation of solar energy for heating and conditioning of hot supply water.

Some of the previous measures interact so that the total reduction effect may be reduced. For example, thermal insulation of buildings reduces the effect of measures implemented in heat production in district heating systems. On the other hand, the introduction of combined cycles in industrial PP reduces the potential for the utilisation of biomass, etc.

Quantified parameters of comprehensive evaluation of the reduction potential of individual measures are summarised in Table 4.8.

Table 4.8 *Summary of measures to mitigate CO_2 emissions from combustion and transformation of fossil fuels [13]*

Measure	Invest. costs [1000 $]	Abatement [Sk/tCO$_2$]	costs [US/tCO_2$]	$\Delta CO_{2,KP}$ [kt/year]	[%]	Implementation of measure until 2005	2010	2015
CC in industrial PP	469,045	1,030	23.1	230	0.45	126 MW_e	283 MWe	440 MWe
CC in public PP	242,300	1,200	27.0	585	1.15	year 2004	242 MWe	
CC in public PP with thermal insulation	242,300	1,198	26.9	541	1.06	year 2004		
Biomass in industrial PP	55,337	–1,884	–42.3	328	0.64	9%	18%	24%
with parallel implementation	69,439	–1,837	–41.3	328	0.64	3,028 TJ	4,468 TJ	5,225 TJ
of CC	129,015	–1,639	–36.8	328	0.64	year 2002		
	258,031	–1,211	–27.2	328	0.64			
Biomass in DHS without	98,118	–1,835	–41.2	386	0.76	10%	20%	30%
effect of thermal insulation	123,121	–1,893	–42.5	386	0.76	3,059 TJ	6,162 TJ	9,265 TJ
of apartments	228,755	–1,667	–37.5	386	0.76	year 2000		
	457,510	–1,179	–26.5	386	0.76			
Biomass in DHS with effect	73,627	–2,035	–45.7	307	0.60	9%	14%	21%
of thermal insulation	92,390	–1,851	–41.6	307	0.60			
of apartments	171,657	–1,618	–36.4	307	0.60			
	343,314	–1,114	–25.0	307	0.60			
Biomass in individual heating	13,525	–1,008	–22.7	685	1.34	5,483 TJ	7,313 TJ	7,313 TJ
of houses	77,448	–888	–20.0	685	1.34	year 2000		
Geothermal energy in DHS	159,959	–1,749	–39.3	217	0.43	102 MWt	229 MWt	355 MWt
without effect of thermal	298,591	–1,242	–27.9	217	0.43	1,646 TJ	3,705 TJ	5,759 TJ
insulation of apartments	888,662	913	20.5	217	0.43	year 2002		
Geothermal energy in DHS	112,013	–1,748	–39.3	165	0.32	102 MWt	229 MWt	355 MWt
with effect of thermal	209,091	–1,253	–28.2	165	0.32			
insulation of apartments	622,294	852	19.2	165	0.32			
Solar heating in individual	459,222	381	8.6	174	0.34	163 TJ	326 TJ	490 TJ
heating of houses	535,665	743	16.7	174	0.34			
	702,009	1,529	34.4	174	0.34	year 2001		
Biomass in heat	56,978	–494	–11.1	267	0.52	10%	20%	30%
monoproduction	71,497	–445	–10.0	267	0.52	2,208 TJ	3,866 TJ	5,380 TJ
in industrial PP	132,839	–239	–5.4	267	0.52			
	265,678	209	4.7	267	0.52	year 2000		
Biomass in cogener. in industrial PP	15,657	–1,830	–41.1	77	0.15	1,172 TJ	1,128 TJ	1,086 TJ

4.5 LITERATURE

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5. Projections and assessment of measures effects

Emission projections in countries with economies in transition, including the Slovak Republic, are influenced by the uncertainties accompanying the transition process, due to which the simple extrapolation of historical energy consumption data cannot be used for modelling future development. From this aspect no significant progress has been made since the elaboration of the Second National Communication. In spite of the existing limitations, based on results of modelling probable scenarios of emission development, sensitivity analysis for evaluation of major effects and subsequent simulation of potential trajectories of emission development, we can evaluate the prospects of the Slovak Republic's meeting the Kyoto reduction target and joining international collaboration in the framework of the utilisation of flexible mechanisms. The year 1998 was chosen as the base year for modelling emission scenarios, considering availability and reliability of its data.

5.1 PROJECTIONS OF ENERGY RELATED GHG EMISSIONS

Fossil fuels combustion and transformation is the most decisive source of energy related GHG emissions, while fugitive methane emissions occur by fuel extraction, transport and treatment.

5.1.1 Projections of energy related CO_2 emissions

As mentioned above, in this sector CO_2 emissions occur by fossil fuel combustion and transformation; in the framework of projections, CO_2 emissions occurring by combustion of motor fuels in transportation are also considered in this sector.

5.1.1.1 Basic assumptions for scenario modelling of CO_2 emissions

For modelling the CO_2 emissions from fossil fuel combustion and transformation according the projected scenarios, the updated Windows modules BALANCE and IMPACT of the ENPEP software package [1] were applied, representing an integrated approach of energy system modelling. The key assumptions applied under the development of modelling scenarios of CO_2 emissions from fossil fuel combustion and transformation are as follows:

- Development of final energy consumption in individual sectors [6];
- Structure of sources which participate in transformation of primary energy sources (PES);
- Conversion, transport and distribution of fuels and energies from primary sources to their final consumption;
- Restructuring in industry, transport and services.

On the basis of expected development of GHG emissions in other sectors (agriculture, forestry, non-energy related CO_2 emissions in industry, etc.) indicated in the Slovak Second National Communication on Climate Change, the average annual level of CO_2 emissions from fossil fuel combustion and transformation in the period 2008–2012 was provisionally determined (by the Slovak Ministry of Environment), which would allow to the Slovak Republic to meet the reduction commitment under the Kyoto Protocol, at the amount of 51,066 Gg CO_2 emissions.

The expected development of final energy consumption for individual sectors was determined on the basis of the following input data and documents:

- Prognosis of dynamics of GDP development [5] [6];
- Prognosis of electricity consumption [6] [7];
- Prognosis of heat consumption in industry and for population [4];
- Structure of road vehicle fleet, annual vehicle travel and their specific consumption [19];
- Transport outputs in railway, water and air transport [19];
- Assumption of industrial production development [5];

- Assumed structure of power generation sources, time schedule of shutdown of nuclear sources and introduction of new sources [7];
- Perspectives of crude oil processing in the Slovak Republic [12];

Tables of basic input data are provided in Appendix P3.

5.1.1.2 Scenarios of CO_2 emissions from fossil fuel combustion and transformation

The following text indicates assumptions common for all considered scenarios of modelling the projections of CO_2 emissions from fossil fuel combustion and transformation:

- Assumption of electricity consumption development corresponds to the reference level of annual growth rate specified in Table P3.3. of Appendix P3;
- Units V1 in Jaslovské Bohunice will be shut down, in compliance with Government Decision No. 801/1999, in the years 2006 and 2008 [4]. Their capacity will be replaced especially by outputs from the installed combined cycles [6];
- Dynamics of considered annual growth rate of heat consumption in residential and industrial sectors correspond to data indicated in Table P3.2 of Appendix P3;
- Final fuel consumption in industry was determined on the basis of the expected share of this sector in GDP formation (Table P3.1 in Appendix P3). We also suppose that from 2002 *internal energy efficiency improvement (IEEI)* in industry will increase yearly by 3%;
- We assume that economic activities in iron production will develop constantly, without jump changes;
- Volumes of crude oil processing and oil products output correspond to assumptions indicated in Table P3.4 of Appendix P3;
- Assumptions of motor fuel consumption in road transport, as well as of transport outputs in railway, air and water transport, are in compliance with the conception of Slovak Ministry of Transport, Posts and Telecommunications [19].

In modelling of individual scenarios other specific assumption were taken into account, which can be briefly characterised as follows:

Scenario with measures
In modelling this scenario, in addition to the above assumptions, adopted measures were taken into account, especially the legislation frame in the area of air protection. The effect of considered measures in scenario modelling was quantified as follows:

- Consumption of fuel oils will be, fully in agreement with forecasted decrease in their production [12], limited only to their technological utilisation and to stabilise combustion in large coal power plants;
- Coal consumption in industrial power plants will gradually decrease as a result of increasing charges for emissions of the basic pollutants – Act No. 309/1991 Coll., as amended. We assume that this fuel will be successively replaced with natural gas;

Scenario without measures
It represents extrapolation of the actual situation from the aspect of source structure and fuel consumption. Its modelling was based on the following assumptions:

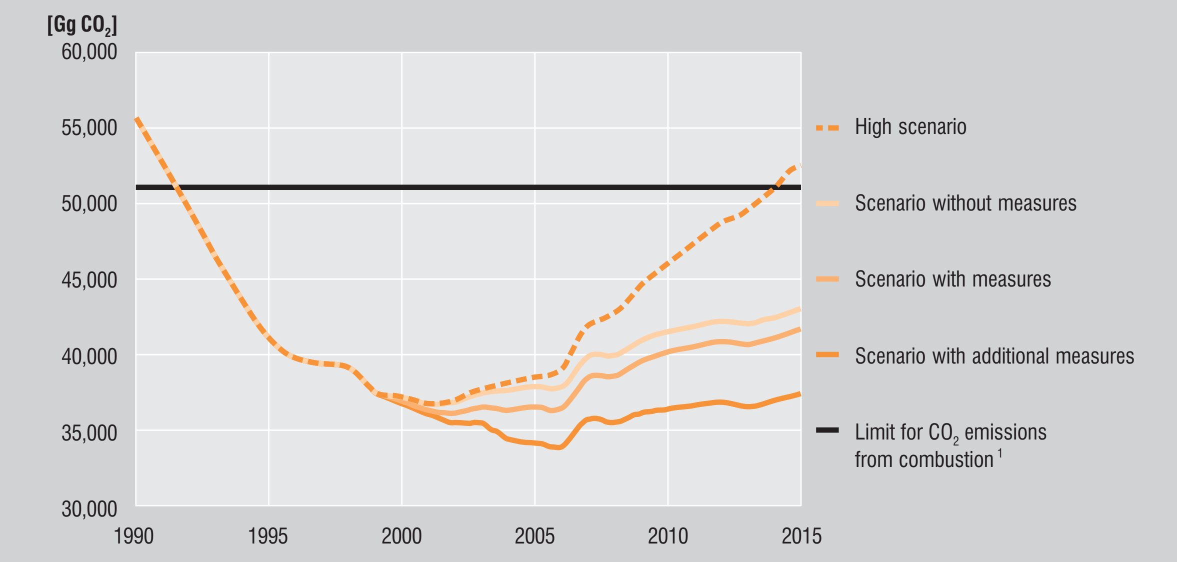
- Annual growth rate of electricity and heat consumption, as well as structure of sources of power generation in the framework of the public energy sector, are the same as for the scenario with measures. No changes in the structure of fuel consumption against that in the base year are considered;
- The scenario allows evaluation of the effect of a decrease of fuel oil and coal consumption, as well as the effect of current increase of charges for production of the base pollutants on the volume of GHG emissions.

High scenario
It corresponds to the scenario without measures, which was further adjusted on the basis of the following assumptions:

- Annual growth rate of electricity consumption in industry, household and service sectors corresponds to the maximum level according to Table P3.3 in Appendix P3;
- Annual growth rate of electricity consumption for chosen branches was defined as follows:
  — for aluminium production from 2002 of 3%;
  — in households of 3% following the year 2005;
  — in area of services gradually from 1.5% in 2001 to 5% following the year 2005;
- After 2005, annual growth rate of 1% for fuel and technological steam consumption in industry was expected;
- The scenario assumes the increase of steel production to the level of the year 1990.

Scenario with additional measures
It was proposed so as to allow evaluation of the aggregated impact of the measures indicated in

Figure 5.1 *Projections of CO_2 emissions from combustion and transformation of fossil fuels*



Chapter 4., using their reduction potential specified in Table P3.5 of Appendix P3. In the framework of modelling, the effect of the following measures was analysed:

- Implementation of combined cycles in industrial energy and centralised district heating systems;
- The utilisation of renewable energy sources within the national energy system of the Slovak Republic;
- Thermal insulation of buildings;
- Shifting of outputs in road transport from individual to public transport.

5.1.1.3 Projections of CO_2 emissions from fossil fuel combustion and transformation

The results of scenario modelling of CO_2 emissions are represented in Figure 5.1. The courses show that during the first commitment period (2008 to 2012), the attainment of national reduction target under the Kyoto Protocol is realistic for all followed scenarios. The scenario with additional measures creates also the opportunity for stabilisation of CO_2 emissions from combustion and transformation of fuels.

Table 5.1 quantifies for considered scenarios so-called offset, i.e. emission reduction reserve of CO_2 emissions from fossil fuel combustion and transformation, related to the national target under the Kyoto Protocol.

[1] The limit corresponds to the average annual volume of CO_2 emissions from fossil fuel combustion and transformation at the amount of 51,066 Gg CO_2 in the period 2008–2012 (Slovak Ministry of Environment) – expected reduction target for this sector is higher.

Table 5.1 *CO_2 emissions from combustion and transformation of fossil fuels [Gg CO_2] in cross years and in the KP target period*

Scenario	1990*	2000	2005	2010	2015	2008–2012	Offset
Without measures	**55,724**	**37,169**	**37,884**	**41,500**	**43,011**	**41,295**	**9,749**
– of which transport	5,070	4,502	4,679	5,129	5,621		
With measures	**55,724**	**36,911**	**36,519**	**40,128**	**41,669**	**39,922**	**11,122**
– of which transport	5,070	4,502	4,679	5,129	5,621		
With additional measures	**55,724**	**36,768**	**34,199**	**36,385**	**37,385**	**36,312**	**14,732**
– of which transport	5,070	4,502	4,547	4,860	5,216		
Maximum	**55,724**	**37,169**	**38,471**	**45,999**	**52,831**	**45,851**	**5,193**
– of which transport	5,070	4,502	4,679	5,129	5,621		

* *Emissions in the reference year of UNFCCC*

5.1.1.4 Analysis of measures' effects on projections of CO_2 emissions from fossil fuel combustion and transformation

To be able to quantify the effect of individual measures (indicated in subsection 5.1.1.2, in the framework of scenario description) on emission trajectories, at their operation, such an approach was chosen for which the measures were progressively introduced and modelled. The gradual implementing of individual measures within modelling can be described by the following steps:

- The basic level is represented by the scenario without measures;
- Step 2 corresponds to the scenario with measures, which illustrates especially the impact of legislation in the area of air protection;
- Step 3 represents reinforcement of the measures' effect in the preceding stage by the utilisation of combined cycles in industrial and public energy supply sectors (heat and electricity CC are only considered as a replacement of production from coal combusting plants);
- In step 4, the measures from the preceding step will be supplemented by the utilisation of renewable energy sources in the framework of the energy balance;
- Step 5 – the measures from step 4 will be extended by the effect of thermal insulation of buildings (which results in reduction of heat consumption in apartments and public buildings);
- Step 6 represents the effect of measures in the transportation sector. The achieved level of

Figure 5.2 *Projections of CO_2 emissions from combustion and transformation of fuels for analysed reducing measures*

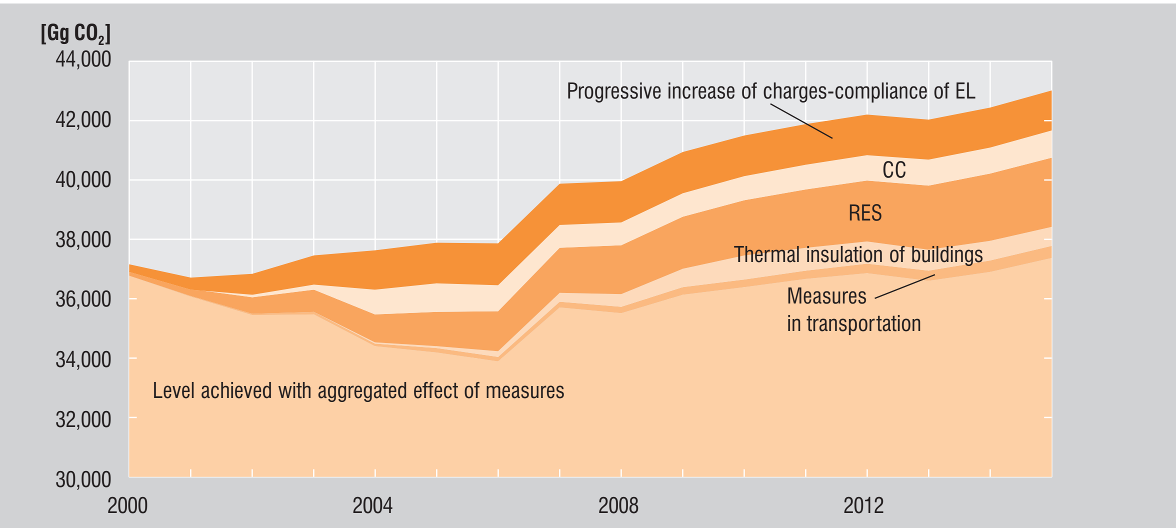


Table 5.2 *Projections of CO_2 emissions [Gg CO_2] in cross years and in KP target period for analysed mitigating measures*

Scenario	2000	2005	2010	2015	2008–2012
Without measures	37,169	37,884	41,500	43,011	41,295
OOV	36,911	36,519	40,128	41,669	39,922
OOV + CC	36,927	35,547	39,314	40,758	39,108
OOV + CC + RES	36,768	34,409	37,457	38,424	37,254
OOV + CC + RES + DSM	36,768	34,331	36,654	37,790	36,579
OOV + CC + RES + DSM + TR	36,768	34,199	36,385	37,385	36,312

Legend:

OOV – Measures in the area of air protection, emission limits of basic pollutants and charges for their non- compliance
CC – combined cycles
RES – renewable energy sources
DSM – demand side option e.g. thermal insulation of buildings
TR – measures in transportation

emissions in this step (low boundary of black area on the figure 5.2) represents the level of emissions in the scenario with additional measures.

A more specific description and the basic assumptions used for modelling the effect of measures are provided in Table P3.5 of Appendix P3. The results of modelling the effect of the measure are presented in Figure 5.2 and Table 5.2.

5.1.2 Projections of energy related CH_4 emissions

The energy related CH_4 emissions occur in fossil fuel combustion and transformation, while fugitive methane emissions occur by fuel extraction, transport and processing.

5.1.2.1 Projections of CH_4 emissions from fossil fuel combustion and transformation

The projections of CH_4 emissions from fossil fuel combustion and transformation were calculated on the basis of fuel consumption for individual scenarios using the IPCC methodology and on the basis of the IPCC default aggregated emission factors. In the case of CH_4 emissions in transport, emission factors from the COPERT program [19] were applied to the individual types of vehicles. For modelling the same scenarios were used as in case of CO_2 emissions from combustion and transformation of fuels (scenarios without measures, with measures and with additional measures, subsection 5.1.1.2), which allowed determination of how the effect of measures aimed at reduction of CO_2 emissions influence the level of CH_4 emissions. The results are shown in Table 5.3, summarising the production of energy related CH_4 emissions.

5.1.2.2 Projections of fugitive emissions of CH_4

In accordance with the methodology for emission inventory of fugitive emissions of $CH_{4,}$ the annual emissions were calculated for the following activities:

- underground coal mining;
- crude oil and oil product processing and storage;
- natural gas storage, transport and distribution;

In the case of underground coal mining, the activity was determined upon a prognosis of brown coal consumption (scenarios in subsection 5.1.1.2). The basis for projections of CH_4 emissions from crude oil processing and storage was the prognosis of production activities quantified in Table P3.4 of Appendix P3. Projections of the development of CH_4 emissions from natural gas transport and distribution are based on assumptions of NG transport declared in the Energy Policy of the Slovak Republic [4], as well as on expected NG consumption in the scenarios of CO_2 emissions from fuel combustion and transport indicated in section 5.1.1.2. The key assumptions for modelling and data on CH_4 emissions by type of activity for the projections of fugitive emissions of CH_4 are indicated in Appendix P3 (Tables P3.6 through P3.8).

5.1.2.3 Total projections of energy related CH_4 emissions

Tab. 5.3 Projections of energy related CH_4 emissions [Gg CH_4] in cross years

Scenario	1990 *	2000	2005	2010	2015
Without measures					
CH_4 from fuel combustion and transformation	**17.33**	**8.12**	**8.10**	**8.54**	**8.53**
– of which transportation	0.94	1.04	1.03	1.06	1.10
Fugitive emissions	**68.06**	**61.85**	**62.96**	**73.23**	**81.16**
– of which coal mining and treatment	33.36	20.02	20.98	21.73	21.25
– of which crude oil processing and production	0.22	0.18	0.19	0.19	0.20
– NG production, transit and distribution	34.48	41.65	41.79	51.31	59.71
Total	**85.39**	**69.97**	**71.06**	**81.77**	**89.69**
Total aggregated (Gg $CO_{2\ equiv}$ GWP = 21)	**1,793**	**1,469**	**1,492**	**1,717**	**1,883**
With measures					
CH_4 from fuel combustion and transformation	**17.33**	**7.96**	**7.43**	**7.88**	**7.88**
– of which transportation	0.94	1.04	1.03	1.06	1.10
Fugitive emissions	**68.06**	**62.43**	**59.65**	**65.34**	**66.95**
– of which coal mining and treatment	33.36	20.00	13.40	13.60	12.50
– of which crude oil processing and production	0.22	0.18	0.19	0.19	0.20
– NG production, transit and distribution	34.48	42.25	46.06	51.55	54.25
Total	**85.39**	**70.39**	**67.08**	**73.22**	**74.83**
Total aggregated (Gg $CO_{2\ equiv}$ GWP = 21**)**	**1,793**	**1,478**	**1,409**	**1,538**	**1,571**
With additional measures					
CH_4 from fuel combustion and transformation	**17.33**	**7.94**	**6.89**	**7.17**	**7.08**
– of which transportation	0.94	1.04	0.98	0.97	0.96
Fugitive emissions	**68.06**	**62.13**	**56.29**	**58.68**	**59.59**
– of which coal mining and treatment	33.36	20.02	11.96	11.60	10.58
– of which crude oil processing and production	0.22	0.18	0.19	0.19	0.20
– NG production, transit and distribution	34.48	41.93	44.14	46.89	48.81
Total	**85.39**	**70.07**	**63.18**	**65.85**	**66.67**
Total aggregated (Gg $CO_{2\ equiv}$ GWP = 21**)**	**1,793**	**1,472**	**1,327**	**1,383**	**1,400**

** Emissions in the reference year of UNFCCC*

5.1.3 Projections of energy related N_2O emissions

The energy related N_2O emissions occur in fossil fuel combustion and transformation. In the framework of this source, production of N_2O emissions in transportation is also subject to balancing. Similarly as with methane, N_2O emissions were calculated applying the IPCC methodology, by using the default values of emission factors, while in transportation emission factors from the program COPERT were applied to individual types of vehicles. Emissions from fuel combustion and transformation were calculated for the same scenarios as in the case of emissions of CO_2 and CH_4, which allowed analysing the effect of measures, aimed at reduction CO_2 emissions, on production of N_2O emissions. Table 5.4 gives data for projections of energy related N_2O emissions.

5.1.4 Total aggregated energy related GHG emissions

Table 5.5 shows data of total aggregated GHG emissions in the energy sector. The value of total aggregated emissions in transportation is indicated separately.

5.2 PROJECTIONS OF GREENHOUSE GAS EMISSSIONS IN INDUSTRY

5.2.1 Projections of non-energy related CO_2 emissions in industry

Projections of CO_2 emissions in industry in Table 5.6 which are not the result of energy utilisation or transformation of fossil fuels were calculated on the basis of the emission inventory (Chapter 3)

Table 5.4 *Projections of energy related N_2O emissions [Gg N_2O] in the cross years*

Scenario	1990 *	2000	2005	2010	2015
Without measures					
N_2O from fuel combustion and transformation	0.82	0.73	0.84	0.99	1.14
– of which transportation	0.21	0.42	0.52	0.65	0.81
Total aggregated (Gg $CO_{2\ equiv}$ GWP = 310)	**254**	**228**	**262**	**307**	**355**
With measures					
N_2O from fuel combustion and transformation	0.82	0.73	0.81	0.95	1.11
– of which transportation	0.21	0.42	0.52	0.65	0.81
Total aggregated (Gg $CO_{2\ equiv}$ GWP = 310)	**254**	**226**	**251**	**295**	**344**
Scenario with additional measures					
N_2O from fuel combustion and transformation	0.82	0.73	0.76	0.87	0.98
– of which transportation	0.21	0.42	0.50	0.59	0.70
Total aggregated (Gg $CO_{2\ equiv}$ GWP = 310)	**254**	**226**	**236**	**270**	**304**

** Emissions in the reference year of UNFCCC*

Table 5.5 *Total aggregated GHG emissions [Gg CO_2 equivalent] in the energy sector for cross years*

Scenario	1990 *	2000	2005	2010	2015
Without measures	**57,771**	**38,866**	**39,638**	**43,524**	**45,249**
– of which transportation	5,155	4,654	4,862	5,353	5,895
With measures	**57,771**	**38,615**	**38,179**	**41,961**	**43,584**
– of which transportation	5,155	4,654	4,862	5,353	5,895
With additional measures	**57,771**	**38,466**	**35,762**	**38,038**	**39,089**
– of which transportation	5,155	4,654	4,855	5,332	5,858

** Emissions in the reference year of UNFCCC*

Table 5.6 *Projections of non-energy related CO_2 emissions [Gg CO_2] in industry in cross years*

Non-energy related CO_2 emissions	1990 *	2000	2005	2010	2015
Cement production	1,554	1,182	1,562	1,562	1,562
Lime production	850	509	600	600	600
Utilisation of cement, lime and magnesite in industry	1,478	1,773	1,773	1,773	1,773
Total	3,882	3,464	3,935	3,935	3,935

** Emissions in the reference year of UNFCCC*

Table 5.7 *Projections of N_2O emissions [Gg N_2O and Gg CO_2 equivalent] in industry in cross years*

N_2O emissions	1990 *	2000	2005	2010	2015
N_2O emissions in nitric acid production	1.86	0.2	0.2	0.2	0.2
Total aggregated (Gg $CO_{2\ equiv}$ GWP = 310)	**577**	**62**	**62**	**62**	**62**

** Emissions in the reference year of UNFCCC*

and the expected activity for mineral processing, such as cement, lime and magnesite production – for production after the year 2000, a constant level was considered.

5.2.2 Projections of N_2O emissions in industry

Projections of N_2O emissions in Table 5.7 were calculated on the basis of the emission inventory for the presumed activities of nitric acid production.

Table 5.8 *Projections of new gas emissions [t/year] for cross years and their GWP equivalent*

Gas	2000	2005	2010	2015	GWP
HFC 41	0.000	0.000	0.000	0.000	150
HFC 23	0.249	0.401	0.334	0.305	11,700
HFC 43-10mee	0.000	0.000	0.000	0.000	1,300
HFC125	1.822	7.554	11.030	11.591	2,800
HFC134	0.000	0.000	0.000	0.000	1,000
HFC134a	65.641	44.579	50.906	49.755	1,300
HFC152a	1.363	0.794	0.301	0.220	140
HFC143	0.000	0.000	0.000	0.000	300
HFC32	0.381	3.201	6.782	7.576	650
HFC143a	2.371	4.662	4.316	4.023	3,800
HFC-227ea	22.223	28.621	29.768	29.886	2,900
SF6	0.560	0.650	0.740	0.770	23,900
PFC14	0.575	0.600	0.600	0.600	6,500
Gg $CO_{2\ equivalent}$	**184**	**206**	**230**	**230**	

For production after the year 2000, a constant level was considered. In comparison with the year 1990, the projected N_2O emissions were considerably decreased, which is connected with technological innovation of production and presumed activities.

5.2.3 Projections of new gas emissions in industry

According to the updated IPCC Guidelines, Chapter 5 indicates among others projections of direct and aggregated emissions of new gases classified by sector of industry. The term *New Gases* includes emissions of the following substances:

- *HFCs – partially fluorinated hydrocarbons*
- *SF_6 – sulphur hexafluoride*
- *PFCs – perfluorocarbons*.

As the inventory and projections of new gas emissions were not included in the previous national communications, in Appendix P2.1 we provide more specific characteristics of emission production and in Appendix P3.2 description of the methodology for projections of new gas emissions.

Comprehensive results of the projection of new gas emissions, together with GWP values and total aggregated emission, are shown in Table 5.8:

In spite of risks, from the aspect of achievement of the expected trend of emission reduction, we do not, particularly after the year 2010, presume any increase, but rather a decrease of the purchase of HFC coolants. The reason is not only the worldwide pressure on reduction of their production, the prepared legislation of regular emission safety controls and the obligation to recycle, but also the demands for more intensive transition to natural, environmentally sound coolants.

5.2.4 Total aggregated emissions of greenhouse gases in industry

Table 5.9 shows total anthropogenic GHG emissions in industry for the cross years as the sum of non-energy related CO_2 emissions (Tab. 5.6), N_2O emissions (Tab. 5.7) and new gas emissions (Tab. 5.8).

Table 5.9 *Total aggregated GHG emissions [Gg CO_2 equivalent] in industry in cross years*

Aggregated GHG emissions in industry	1990 *	2000	2005	2010	2015
Non-energy related CO_2 emissions in industry	3,882	4,954	5,426	5,426	5,426
N_2O emissions	577	62	62	62	62
Emissions of new gases	272	184	206	230	230
Total	**4,731**	**3,710**	**4,203**	**4,227**	**4,227**

** Emissions in the reference year of UNFCCC*

5.3 PROJECTIONS OF GHG EMISSIONS IN AGRICULTURE

5.3.1 Projections of CH_4 emissions in agriculture

Sources of methane production in agriculture were, together with potential measures for reduction, discussed in detail in Chapter 4. As already stated, real potential for reduction of methane emissions is represented by:

- Reduction of the number of livestock, or a change of representation of the number of livestock in individual categories (cattle, pigs, poultry, horses, sheep, goats);
- Treatment of waste from animal production to biogas.

For modelling purposes the following scenarios were proposed [14]:

Scenario without measures
The activity determining production of CH_4 emissions is based on the assumption of lower dynamics of animal production intensification, which can be characterised as follows:

- Following a period of stabilisation of agriculture in the years 2000 to 2002, the annual milk yield will increase to the level of 5,130 kg of milk per dairy cow in 2005, or to 5,800 kg in 2010, which will lead to a reduction in the number of dairy cattle;
- In 2005 the number of pigs will reach the level of the early nineties, in 2010 we presume a further increase in the number of pigs by 10%;
- The number of sheep will be at the level of 400 thousand in 2005, 500 thousand in 2010;
- The number of poultry will increase by 14% until 2005 and there will be no significant change in the following periods;
- The expected number of livestock, according to the directives of the EU Common Agricultural Policy, should be reached in 2010;
- In the following period, until 2015, another intensification of animal production is expected. With regard to the Directive of Common Agricultural Policy, it should result in reduction only of the number of dairy cattle with market milk production.

Scenario with measures
The scenario is based on the conception of high dynamics of animal production intensification, where the expected number of livestock (according to the directives of the EU Common Agricultural Policy) would be reached as early as 2005. From the viewpoint of methane emissions from fermentation, the effect of reduction of the number of cattle due to the increase of its useful properties is shown here. On the other hand, the influence of an increased number of pigs and sheep is apparent, which leads to a moderate increase of methane emissions from excrements [14].

Scenario with additional measures
The treatment of animal excrements to biogas is considered as another measure. It is expected that by 2005 ten per cent, by 2010 twenty per cent and by 2015 up to fifty per cent of excrements will be treated to biogas.

Table 5.10 *Projections of CH_4 emissions [Gg CH_4] for agriculture in cross years*

Scenario	Measure	1990*	2000	2005	2010	2015
Without measures						
	Fermentation	116.30	53.53	59.09	56.64	54.80
	Excrements	18.85	9.67	13.61	15.04	15.00
	Total	**135.15**	**63.20**	**72.70**	**71.68**	**69.80**
With measures						
	Fermentation	116.30	53.53	56.58	55.87	52.69
	Excrements	18.85	9.67	15.07	15.73	15.58
	Totals	**135.15**	**63.20**	**71.65**	**71.60**	**68.27**
With additional measures						
	Fermentation	116.30	53.53	56.57	55.70	52.52
	Excrements	18.85	9.67	13.56	12.59	7.79
	Total	**135.15**	**63.20**	**70.13**	**68.29**	**60.31**

** Emissions in the reference year of UNFCCC*

5.3.2 Projections of N_2O emissions from agriculture

Scenario without measures

- Is based on the conception of lower dynamics of intensification of vegetable and animal production;
- In the program horizon until accession to EU, the following growth of yield per ha. in vegetable production as opposed to the year 1998 was expected:
  - for cereals of 15% – to 4.7 t/ha
  - for oil-plants of 40% – to 2.5 t/ha
  - for potatoes of 43% – to 21 t/ha
  - for sugar beet of 20% – to 45.5 t/ha and 5.9 tones of sugar/ha, purchase sugar content from 15.6 to 16.6%, sugar yield from 11.5 to 12.3%;
- The expected numbers of livestock based on the directives of the EU Common Agricultural Policy correspond to the scenarios described in the framework of methane projections.

Scenario with measures

In this scenario, higher dynamics of vegetable and animal production intensification is assumed, for which we expect an increase of fertiliser consumption in accordance with the development programs of cereal, sugar beet, potato and oil-plant farming. The higher consumption of fertilisers will reflect in increased production of post-harvest remainders, which will lead to higher concentration of mineralisable nitrogen in soil. According to the scenario, it is expected that already in 2005 parameters of intensification of vegetable production will be similar to those in the scenario without measures for the year 2010. In this scenario, for time horizons of years 2010 and 2015 we expect only insignificant changes in inputs of nitrogenous substances to agriculture, which are proportional to inputs from animal production (these will be determined by the Directive of the EU Common Agricultural Policy).

Scenario with additional measures

This scenario is based on the assumption of high dynamics of vegetable and animal production intensification, where adaptation measure can be found especially in better treatment of animal waste and in reduction of direct inputs of nitrogenous substances. We assume that by the year 2005, ten per cent, by the year 2010 twenty per cent and by the year 2015 about fifty per cent of excrements from animal production will be stored in liquid form, without excessive gas leakage, and subsequently treated. Further we expect, that direct inputs of nitrogenous substances will reduce by 10% in 2005, by 15% in 2010 and by approximately 20% in 2015, against the scenario without measures.

Table 5.11 *Projections of N_2O emissions [Gg N_2O] in agriculture for cross years*

Scenario	Emissions	1990 *	2000	2005	2010	2015
Without measures						
	Direct	11.33	5.74	8.31	9.84	9.82
	From animal waste management	3.61	1.67	1.95	1.92	1.87
	Indirect	1.26	0.49	0.79	0.99	0.98
	Total	**16.20**	**7.90**	**11.05**	**12.75**	**12.67**
With measures						
	Direct	11.33	5.74	9.90	10.70	10.65
	From animal waste management	3.61	1.67	1.92	1.93	1.84
	Indirect	1.26	0.49	0.99	1.06	1.05
	Total	**16.20**	**7.90**	**12.81**	**13.69**	**13.54**
With additional measures						
	Direct	11.33	5.74	8.91	8.56	7.46
	From animal waste management	3.61	1.67	1.73	1.54	0.92
	Indirect	1.26	0.49	0.89	0.85	0.73
	Total	**16.20**	**7.90**	**11.53**	**10.95**	**9.11**

** Emissions in the reference year of UNFCCC*

5.3.3 Total aggregated GHG emissions in agriculture

Table 5.12 shows values of total aggregated GHG emissions in cross years for agriculture.

Table 5.12 *Total aggregated GHG emissions [Gg CO_2equivalent] in agriculture in cross years* [2]

Scenario	1990 *	2000	2005	2010	2015
Without measures					
CH_4	2,838	1,331	1,526	1,505	1,466
N_2O	5,022	2,449	3,423	3,952	3,926
Total	7,860	3,780	4,950	5,457	5,392
With measures					
CH_4	2,838	1,331	1,505	1,504	1,434
N_2O	5,022	2,449	3,970	4,244	4,197
Total	7,860	3,780	5,474	5,747	5,631
With additional measures					
CH_4	2,838	1,331	1,473	1,434	1,267
N_2O	5,022	2,449	3,573	3,395	2,824
Total	7,860	3,780	5,046	4,829	4,091

** Emissions in the reference year of UNFCCC*

[2] Table 5.12 shows aggregated emisions of CH_4 and N_2O converted using GWP [Gg $CO_{2\ equiv}$]

5.4 PROJECTIONS OF CO_2 SINKS IN FORESTRY AND LAND USE

Projections of CO_2 sinks in forestry and land use were modelled using measures being introduced in this sector, which are primarily focused on the following areas:

- protection of forest and agricultural soil stock;
- regulation of timber extraction;
- afforestation of non-forest areas.

In the framework of modelling, besides the reference level for projections of CO_2 sinks, effects of individual introduced measures in two alternatives – i.e. as minimum and maximum impact of the respective measure – were monitored. Results of modelling, i.e. balance level of sinks for minimum and maximum impacts of the individual measures, are summarised in Table 5.13. The reference level for sink projections corresponds to the approved policy of the forestry and agriculture development in the years 1999–2000, elaborated in compliance with the Program Declaration of the Slovak Government. Basic assumptions, which were adopted for modelling purposes, are indicated in Appendix P3 – Tables P3.9 through P3.12.

Based on results of the balance, final scenarios for projections of CO_2 sinks in forestry and land use were drawn up, the results of which are shown in Table 5.14.

Table 5.13 *Balance of CO_2 sinks [Gg CO_2] for mitigating measures in forestry*

Measure	2000	2005	2010	2015
Reference level	**–2,640**	**–1,436**	**–1,101**	**–1,185**
Soil stock protection				
– minimum impact	0	–73	–51	–99
– maximum impact	0	–88	–80	–142
Regulation of timber extraction				
– minimum impact	0	–330	–660	–990
– maximum impact	0	–660	–990	–1,320
Afforestation of non-forest areas				
– minimum impact	0	–1.4	–9.7	–31.4
– maximum impact	0	–1.9	–13.0	–41.8
Measures in total				
– minimum impact	**0**	**–404.4**	**–720.7**	**–1,120.4**
– maximum impact	**0**	**–749.9**	**–1,083.0**	**–1,503.8**

Table 5.14 *Projections of CO_2 sinks [Gg CO_2] in cross years*

Scenario	1990 *	2000	2005	2010	2015
Scenario without measures	– 2,426	–2,640	–1,436	–1,101	–1,185
Scenario with measures	– 2,426	–2,640	–1,840	–1,822	–2,305
Scenario with additional measures	–2,426	–2,640	–2,186	–2,184	–2,688

** Emissions in the reference year of UNFCCC*

Table 5.15 *Total aggregated GHG emissions [Gg CO_2equivalent] in forestry and land use*

Scenario	1990 *	2000	2005	2010	2015
Scenario without measures	– 2,345	–2,625	–1,421	–1,086	–1,170
Scenario with measures	–2,345	–2,625	–1,825	–1,807	–2,290
Scenario with additional measures	– 2,345	–2,625	–2,171	–2,169	–2,673

** Emissions in the reference year of UNFCCC*

Scenario without measures – corresponds to the reference level quantified in Table 5.13;

Scenario with measures – corresponds to the minimum impact of measures;

Scenario with additional measures – represents maximum impact of considered measures (see Table 5.13).

In the framework of the evaluation of impacts of measures in forestry and land use on GHG emissions, we have also analysed production of other greenhouse gases. Table 5.15 shows total aggregated emissions for the said sector. For projections of CH_4 and N_2O emissions in the period 2000 to 2015, data from the emission inventory for the year 1999 were used, i.e. 0.61 Gg CH_4 and 0.01 Gg N_2O. Emissions of these gases from biomass combustion at timber exploitation will decrease (increase of the share of undergrowth forest management), but this decrease will be balanced by the increase of emissions from forest fires.

5.5 PROJECTIONS OF GHG EMISSIONS IN WASTE MANAGEMENT

5.5.1 Projections of CH_4 emissions from waste and waste water treatment

Based on identification and brief characteristics of methane production sources in waste management, as well as potential measures for reduction (see Chapter 4), four scenarios were outlined for modelling of CH_4 emissions occurring in waste and waste water treatment: Scenario 1 – without measures, Scenario 2 – low impact of measures, Scenario 3 – medium impact of measures and Scenario 4 – high impact of measures.

Table 5.16 *Projections of CH_4 emissions [Gg CH_4] in waste and waste water treatment*

Scenario	Measure	1990*	2000	2005	2010	2015
1 – without measures						
	Waste dumps	50.27	46.20	46.50	46.70	46.90
	Sewage	15.79	15.60	15.60	15.60	15.40
	Industrial waters	20.32	11.68	11.50	11.84	12.29
	Total	**86.38**	**73.48**	**73.60**	**74.14**	**74.59**
2 – low impact						
	Waste dumps	50.27	46.20	44.10	40.00	35.80
	Sewage	15.79	15.60	15.60	15.10	14.40
	Industrial waters	20.32	11.68	11.50	11.30	11.16
	Total	**86.38**	**73.48**	**71.20**	**66.40**	**61.36**
3 – medium impact						
	Waste dumps	50.27	46.20	42.20	34.30	26.50
	Sewage	15.79	15.60	15.10	14.00	12.90
	Industrial waters	20.32	11.68	10.98	10.21	9.47
	Total	**86.38**	**73.48**	**68.28**	**58.51**	**48.87**
4 – high impact						
	Waste dumps	50.27	46.20	37.90	26.30	14.10
	Sewage	15.79	15.60	14.60	13.00	11.40
	Industrial waters	20.32	11.68	10.45	9.13	7.79
	Total	**86.38**	**73.48**	**62.95**	**48.43**	**33.29**

** Emissions in the reference year of UNFCCC*

The base assumptions considered in developing these scenarios are provided in Appendix P3 – Tables P3.13 through P3.16. In addition to these data, information from the Statistical Yearbook of the Slovak Republic, 1999 was used. The IPCC methodology [21] was applied to calculations.

5.5.2 Projections of N_2O emissions in waste management

Projections of N_2O emissions from waste waters were modelled using two out of four proposed scenarios [15]:

Scenario 1 – without measures

- the amount of communal waste waters from which nitrogen is eliminated will not increase in the examined period;

Scenario 2 – with measures

- the amount of communal waste waters from which nitrogen is eliminated will gradually increase until 2015. As the ISI method applied to the calculation of N_2O emissions is based on data on the number of inhabitants connected to sewage treatment plants with nitrogen elimination, quantitative assumptions are defined on the basis of the number of inhabitants and indicated in Appendix P3;
- For industrial waters we do not consider any changes in nitrogen elimination from waste waters with outlook up to 2015.

Table 5.17 shows values of the projected N_2O emissions from communal and industrial water treatment with outlook up to 2015.

Table 5.17 *Projected N_2O emissions [t N_2O] from waste waters in cross years*

Scenario	1990 *	2000	2005	2010	2015
1 – without measures					
	65.0	41.5	41.5	41.5	41.5
2 – with measures					
	65.0	41. 5	49.8	60.5	66.9

** Emissions in the reference year of UNFCCC*

5.5.3 Total aggregated GHG emissions in waste management

Table 5.18 illustrates the method of scenario aggregation in the calculation of total GHG emissions in waste management.

Table 5.19 shows values of total aggregated GHG emissions in cross years for waste management.

Table 5.19 *Total aggregated GHG emissions [Gg CO_2 equivalent] in waste management in cross years* [3]

Scenario	1990*	2000	2005	2010	2015
Without measures					
CH_4	2,068	1,543	1,546	1,557	1,566
N_2O	22	13	13	13	13
Total	2,089	1,556	1,558	1,570	1,579
With measures					
CH_4	2,068	1,543	1,434	1,229	1,026
N_2O	22	13	15	25	27
Total	2,089	1,556	1,449	1,254	1,053
With additional measures					
CH_4	2,068	1,543	1,322	1,017	699
N_2O	22	13	15	25	27
Total	2,089	1,556	1,337	1,042	726

** Emissions in the reference year of UNFCCC*

5.6 PROJECTIONS OF TOTAL AGGREGATED GHG EMISSIONS

As with individual sectors, projections of total aggregated emissions (converted to equivalent amount of CO_2 using GWP) were calculated for three scenarios – scenario without measures, scenario with measures and scenario with additional measures.

Projections of aggregated GHG emissions for the analysed scenarios in the period 2000–2015 are summarised in Figure 5.3. In the framework of the

[3] Table 5.19 shows the aggregated emissions of CH_4 and N_2O converted using GWP [Gg CO_2 equiv]

Table 5.18 *Aggregation of scenarios for projections of GHG emissions in waste management*

Scenario	Scenario of CH4 emissions	Scenario of N2O emissions
without measures	1 – without measures	1 – without measures
with measures	3 – with medium impact	2 – with measures
with additional measures	4 – with maximum impact	3 – with measures

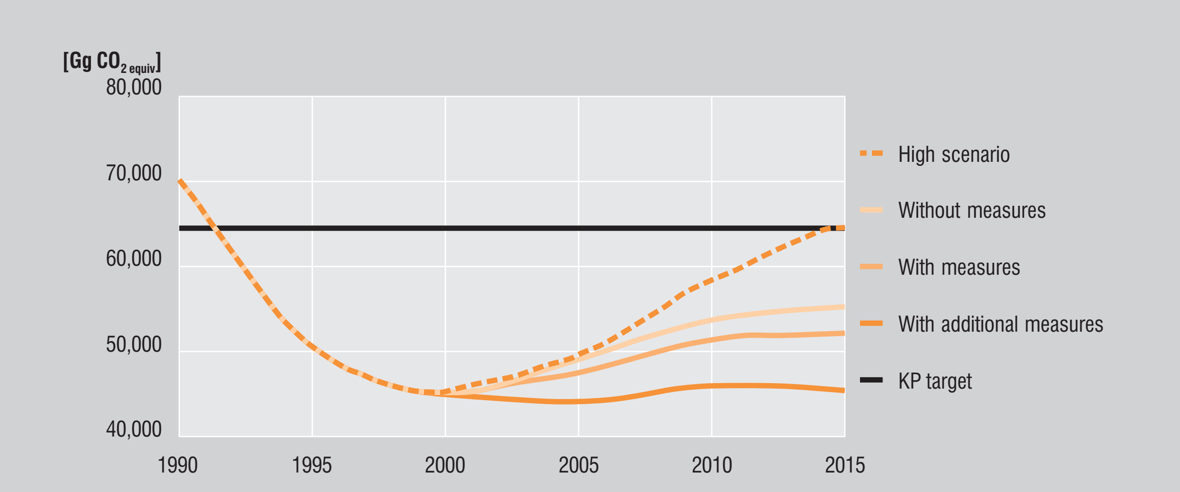
Table 5.20 *Projections of aggregated emissions [Gg CO_2 equivalent] in cross years*

Scenario	1990 *	2000	2005	2010	2015
Without measures					
Energy sector	57,771	38,866	39,638	43,524	44,994
– of which transportation	5,155	4,654	4,862	5,353	5,894
Industry	4,731	3,710	4,203	4,227	4,227
Agriculture	7,860	3,780	4,950	5,457	5,392
Forestry	–2,345	–2,625	–1,421	–1,086	–1,170
Waste management	2,089	1,556	1,558	1,570	1,579
Total	**70,106**	**45,287**	**48,929**	**53,692**	**55,022**
With measures					
Energy sector	57,771	38,615	38,179	41,961	43,569
– of which transportation	5,155	4,654	4,862	5,353	5,895
Industry	4,731	3,710	4,203	4,227	5,656
Agriculture	7,860	3,780	5,474	5,747	5,631
Forestry	–2,345	–2,625	–1,825	–1,807	–2,290
Waste management	2,089	1,556	1,449	1,247	1,047
Total	**70,106**	**45,036**	**47,480**	**51,375**	**52,184**
With additional measures					
Energy sector	57,771	38,466	35,762	38,038	39,089
– of which transportation	5,155	4,654	4,855	5,332	5,858
Industry	4,731	3,710	4,203	4,227	4,227
Agriculture	7,860	3,780	5,046	4,829	4,091
Forestry	–2,345	–2,625	–2,171	–2,169	–2,673
Waste management	2,089	1,556	1,337	1,042	726
Total	**70,106**	**44,886**	**44,177**	**45,967**	**45,460**

** Emissions in the reference year of UNFCCC*

emission trajectories, projections of GHG emissions are also represented in the so-called high scenario, which represents the aggregation of the high scenario of emission occurring by combustion and transformation of fuels (see 5.1.1.2) with the scenarios without measures from the other sectors. The figure also illustrates the level of aggregated emissions corresponding to the national reduction target under the Kyoto Protocol. The courses in the figure show that in the case of balanced economic development of the Slovak Republic, the attainment of KP reduction target is realistic for all considered scenarios, even without implementing any specific mitigating meas-

Figure 5.3 *Projection of aggregated emissions of greenhouse gases*



ures. Moreover, the course of emission trajectory under the scenario with additional measures, which simulates the aggregated impact of mitigating measures, confirms the potential for stabilisation of GHG emissions production.

In addition to a real chance of attainment of the KP Reduction Target, the courses of emission trajectories indicate for all scenarios (including the high one) the existence of an emission reduction reserve – so-called offset.

The existence of sufficient "reserve" reduction potential would allow Slovakia not only to meet more severe commitments in the following target period (post Kyoto period), but also to use the possible emission reduction reserve for acquisition of investment funds or innovation of technologies, in the framework of flexible mechanisms under the Kyoto Protocol – Joint Implementation and Emission Trading – described in detail in section 4.3.

5.7 LITERATURE

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6. Expected impacts of climate change, vulnerability assessment and adaptation measures

This Chapter deals with the evaluation of potential impacts of climate change and the assessment of environmental and selected economic sector vulnerability to climate change. In addition it presents a framework proposal for adaptation measures to mitigate potential negative impacts of climate changes. The published data are the result of the solution of the project of the Slovak National Climate Program and projects in the framework of VEGA grants.

6.1 CHANGES AND VARIABILITY OF CLIMATE AT GLOBAL AND REGIONAL LEVEL

Climate changes and variability of climate on the Earth, in Europe and in Slovakia may be described using the observation of hundreds of meteorological stations and observatories in the period of years 1901–2000. Global air temperature course illustrated by Figure 6.1 was extrapolated for the period since 1861 only. To this end we have prepared courses of monthly air temperature averages from the stations in Hurbanovo (115 m a.s.l.), Košice (230 m a.s.l.) and Liptovský Hrádok (640 m a.s.l.), monthly precipitation totals from 203 stations since 1901 (selected results are shown in Figure 6.2) and areal precipitation totals in the Slovak Republic calculated from monthly data of 203 stations for the period of years 1881–2000. From Hurbanovo we have courses of daily precipitation totals (Figure 6.3) and daily air temperature averages for the period 1871–2000. From a further ten climatic stations we have all observed daily and term data for the period 1951–2000 (all in electronic form). In addition to these data, maximum values of daily precipitation totals were collected for individual months from 607 stations since 1950 (Figure 6.4) and for individual years from 334 stations since 1901. All data and time courses were tested for temporal homogeneity with the application of the method of relative tests using time courses of reliable reference stations from Slovakia and neighbouring countries.

Figure 6.1 *Deviations of annual air temperature averages (dT) on the Earth for the period 1901–1999 from the average for the period 1951–1980 and linear trend*

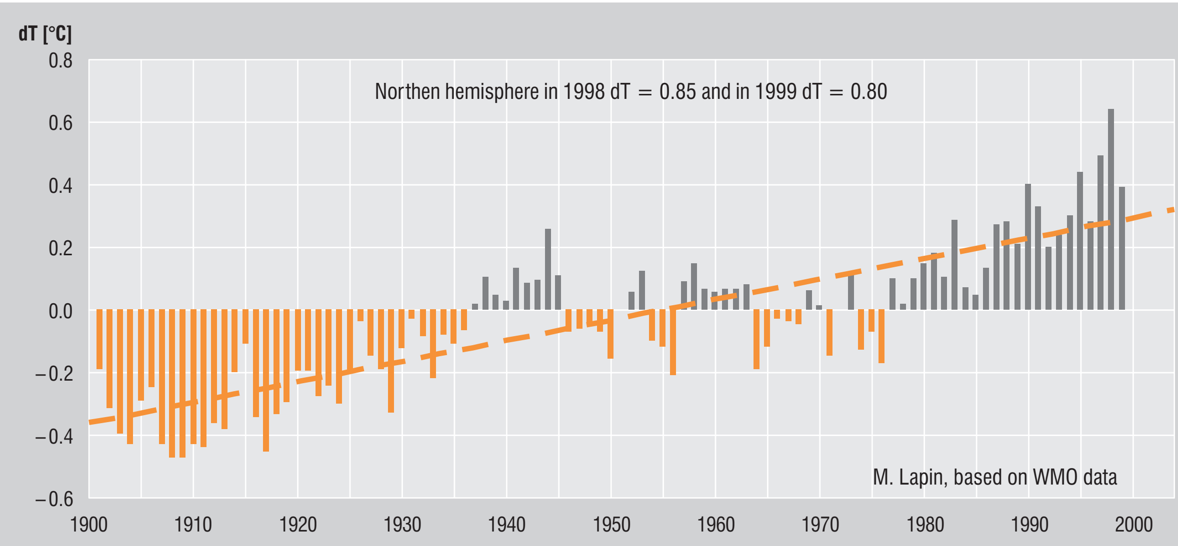


Figure 6.2 *Time course of 3-year moving averages from annual precipitation totals in Slovakia for the period 1901–2000 and linear trend (OL – Oravská Lesná, 780 m a.s.l., HA – Habura, 372 m a.s.l., KO – Košice, 230 m a.s.l., HU – Hurbanovo 115 m a.s.l. and SR – double weighted averages based on data of 203 precipitation stations in Slovakia)*

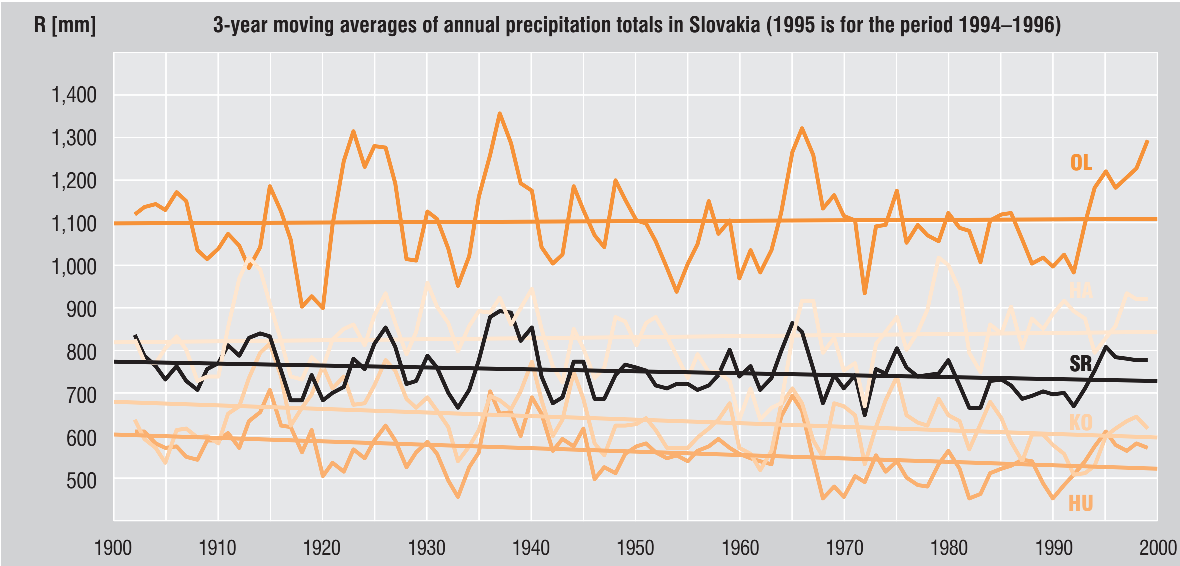
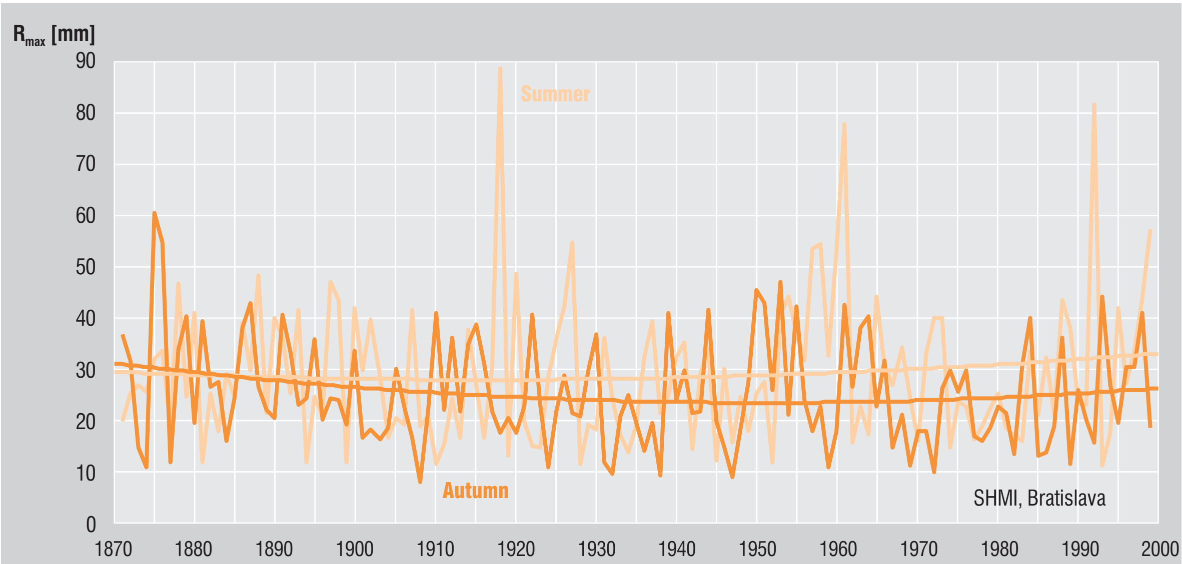


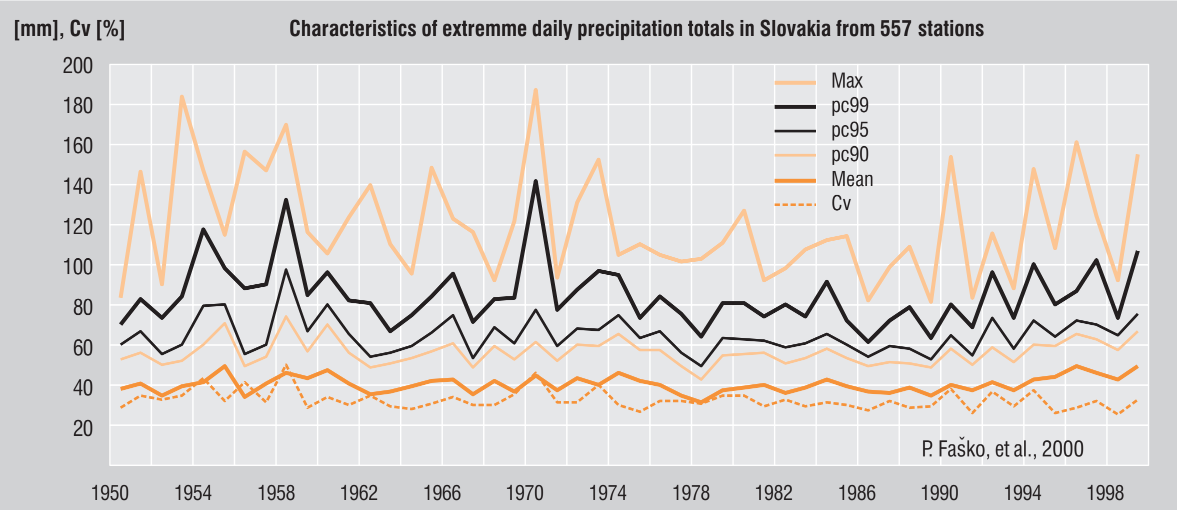
Figure 6.3 *Maximum values of daily precipitation totals and power trend in summer and in autumn in Hurbanovo for the period 1871–1999*



Note: In the last two decades extreme daily precipitation totals show an ascending tendency.

In the twentieth century, an increase of global air temperature on the Earth of 0.7 °C was observed, while on the northern hemisphere the increase was even higher (by about 0.2 °C) (Figure 6.1). The years 1998 and 1999 in the northern hemisphere were by 0.8 °C warmer than the mean for the period 1951–1980, while the year 1998 was declared by the World Meteorological Organisation (WMO) as the warmest year of the previous millennium on the Earth. Central Europe ranks among areas of the Earth with warming exceeding the global mean; since the beginning of the twentieth century, in its south and east parts precipitation moderately decreased, while in its northwest part precipitation moderately increased. For the last 100 years in Slovakia we recorded a trend of increase of mean annual air temperature (T) of 1.1 °C and a decrease of mean annual precipita-

Figure 6.4 *Selected results of the analysis of maximum daily precipitation totals in Slovakia in the period 1950–1999*



Note: Data from 557 stations with complete courses were processed using statistical methods. Max. – maximum total in Slovakia; pc99 – upper percentile of maximum totals (about 6 stations); pc90 – upper decile of maximum totals (57 stations in the considered year); Mean – mean value of maximum totals from all 557 stations in the considered year; Cv – variation coefficient in %.

tion totals (R) of 5.6% (in the south of Slovakia the decrease even exceeded 10%, in the north and the north-east exceptionally an increase up to 3% for the whole century, Figure 6.2). A significant decrease of relative air humidity (up to 5%) was also recorded, particularly in the south-west of Slovakia, and a decrease of snow cover characteristics almost in the whole of Slovakia. In addition to standard climate elements, characteristics of potential and actual evaporation, soil humidity, global radiation and radiation balance for the period 1951–1999 were also elaborated. Also these data confirmed that particularly the south of Slovakia was drying up (potential evapotranspiration increases and soil humidity decreases), but characteristics of solar radiation showed no significant changes, with the exception of a transitory decrease in the period 1965–1985. Special attention is paid to characteristics of climate variability, especially to variability of precipitation totals. Figures 6.3 and 6.4 show results of one of the analyses, which confirms that after a transitory decrease of the occurrence of extreme daily precipitation totals in the period 1977–1993, during the last 7 years there was a considerable increase, due to which the risk of local floods in different areas of Slovakia increased significantly. On the other hand, especially in the period 1989–2000, local or nation-wide drought occurred more frequently than before, which was caused mainly by long periods of warm weather, whereby precipitation totals did not exceed the interval of normal since 1975. The droughts in the years 1990–1994 and 2000 were exceptionally destructive. The decade from 1991 to 2000 with characteristics of air temperature, precipitation totals, evapotranspiration, snow cover and other elements came closer to expected conditions toward the year 2030 (according to climate change scenarios for Slovakia).

6.2 NEW CLIMATE CHANGE SCENARIOS IN SLOVAKIA

Preliminary air temperature change scenarios for CSFR (former Czecho-Slovakia) were prepared in 1991, and preliminary analogue climate change scenarios were issued in December 1993 with respect to expected 1–2 °C mean annual warming toward the year 2025 compared to the period 1951–1980 (The First National Communication on Climate Change, 1995). Regional modification of the General Circulation Models (GCMs, models of general circulation of atmosphere GISS, CCCM and GFD3) outputs was finished in 1995. The complete regional scenarios – based on GCMs, innovated analogue and incremental scenarios for Slovakia were issued in the framework of the Slovak Republic's Country Study (a country study of the Slovak Republic to climate change) and the Slovak National Climate Program until 1996 (The Second National Communication on Climate Change, Slovak Republic, 1997).

Regional climate change scenarios and assessments of related impacts were based on the first estimates and model calculations of the Intergovernmental Panel for Climate Change (IPCC) founded in 1988. In a relatively short time new IPCC estimates were elaborated, which were preliminary presented in 1992 as IS92 scenarios and later officially published in the Second IPCC Report in the years 1994 to 1996. In 2000 the Third IPCC Report (TAR) with more specific analysis of emission and other scenarios was prepared for publication. IS92 emission scenarios were based on very thorough analysis of potential socio-economic development of the human community in a global scope, where the development of world population, energy generation and consumption rightfully played the most important role. This was especially caused by the fact that the development of CO_2 concentration in Earth atmosphere may dominantly affect the development of global warming of the ground layer of atmosphere. In IS92 global warming scenarios and their later specification, for the first time effects connected with a change of concentration of individual types of anthropogenic aerosols in the atmosphere and with feedback processes in the atmosphere-hydrosphere-cryosphere-litosphere-biosphere system were fully taken into account.

Air temperature (T), precipitation totals (R) and global solar radiation flux density (RG) change scenarios, based on GCMs (models GISS, CCCM and GFD3) outputs, were elaborated in the years 1995 and 1996. A selection of GCMs scenarios for Slovakia was done according to the $1 \times CO_2$ GCMs output comparison with 1951–1980 means and annual courses of climatic data. Interpolation of T, R and GR values in GCMs scenarios was done by linear interpolation between the time horizons 1980 (zero change) and 2075 ($2 \times CO_2$ change). The final GCMs climate change scenarios have been calculated for the time horizons 2010, 2030 and 2075. The atmospheric circulation change scenarios could be prepared only on the basis of outputs of the model GFD3. The regional T rise R and GR regimen change scenarios were prepared with the assistance of US experts (US Country Studies, 1994).

The emission scenarios IS92 were followed by the development of more complicated general circulation models (GCMs) with variable solution of outputs. This development was completed after the year 1996 by the most sophisticated existing GCMs with the so-called coupled atmospheric and oceanic circulation model. In 2000, in the framework of the Slovak National Climate Program, the regional modification of outputs from two such interconnected GCMs (CCCM from the Canadian Climate Modelling Centre and GISS from the Goddard Institute for Space Studies in USA) was prepared. In the presented modification, an extensive database from measurements in the network of climate and precipitation stations of SHMI from the period 1901–2000 was used, whereby most of these data were tested for temporal homogeneity of climate courses. The possibility to use the control period of 90 years (1901–1990) has significantly reduced the influence of variability of short-term (30-year) climate normals on the final climate change scenarios. The regional modification of outputs of such most advanced GCMs is still at the incipient stage, only outputs of 5 variables (air temperature, precipitation totals, global radiation, specific air humidity at the level of 850 hPa and at ground surface, all of them as monthly averages) were used. In addition, scenarios of time series of monthly air temperature and precipitation total means were elaborated, which were modified using a special method for individual stations in Slovakia so that the scenarios get closer to the actual temporal and spatial variability of these elements. Illustrations of new regional scenarios for Slovakia are provided in Tables 6.1 to 6.4 and in Figures 6.5 and 6.6. In comparison with the previous scenarios from the years 1995 and 1997, the new scenarios (marked CCCMprep and GISSprep) suppose moderate warming in winter and comparable warming in summer, with precipitation totals moderately increasing in the cold half-year and remaining constant in the warm half-year.

The practical application of the new regional climate change scenarios for Slovakia brings a lot of new possibilities for assessments and calculation of climate change impacts and vulnerability of individual sectors. Outputs of the coupled GCMs have physically plausible variables, which may be preserved even after regional modification. But also for these outputs it applies that they may not be used directly, without regional modification by series of measured values in the respective region. Another important advantage of the new scenarios is the possibility to prepare scenarios as time series year by year and month by month (for a limited number of variable, also day by day) This allows applying more complicated impact models to a more reliable estimate of potential impacts of climate change. In spite of the stated improvements, these scenarios still cannot be considered as a prognosis, but only as a potential alternative of the future climate. For this reason, all combined and incremental scenarios published in Slovakia in the years 1995 and 1997 may be further used as climate change scenarios. The next plans for the preparation of new climate change scenarios will focus on scenarios of occurrence of extremes with different return period, on scenarios of time series of daily values of climatic elements and on scenarios of changes of variability of groups of monthly and daily values. We suppose that in the years 2001 and 2002 real conditions for the fulfilment of these plans will be already created (new GCMs outputs and dynamic-statistical regional models).

Table 6.1 *Monthly air temperature average change scenarios [°C] in 50-year time horizons for the whole Slovakian against the normal 1951–1980*

Time horizon	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
CCCM 1995 (30-year horizons in comparison with 1951–1980)												
2010	1.2	1.4	1.4	1.0	0.9	0.9	1.1	1.0	1.1	1.1	0.9	0.9
2030	2.0	2.4	2.3	1.7	1.5	1.6	1.8	1.7	1.9	1.8	1.4	1.5
2075	3.7	4.5	4.3	3.2	2.9	3.0	3.3	3.2	3.6	3.4	2.7	2.8
CCCMprep (50-year horizons in comparison with 1951–1980, deducted from the modification for the period 1901–1990)												
2010	0.5	0.7	0.9	0.7	0.4	0.6	0.9	1.0	1.0	0.9	0.6	0.4
2030	0.9	1.2	1.4	1.1	0.8	1.1	1.4	1.5	1.6	1.2	0.7	0.7
2075	2.2	2.9	2.8	2.3	2.3	2.9	3.4	3.6	3.6	3.0	2.0	1.8

Note: Legend: for CCCM 1995, see Lapin et al., 1995.

Table 6.2 *Monthly precipitation totals change scenarios (quotients) in 50-year time horizons, the mean for Slovakia (for area precipitation means) in comparison with the normal 1951–1980*

Time horizon	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
CCCM 1995 (30-year horizons in comparison with 1951–1980)												
2010	1.09	1.02	1.03	1.02	0.96	0.97	0.94	0.99	0.97	1.04	1.06	1.08
2030	1.16	1.04	1.06	1.03	0.94	0.94	0.91	0.99	0.94	1.07	1.10	1.14
2075	1.30	1.07	1.10	1.06	0.88	0.88	0.82	0.98	0.90	1.13	1.20	1.26
CCCMprep (50-year horizons in comparison with 1951–1980, deducted from the modification for the period 1901–1990)												
2010	1.02	0.97	1.08	0.98	1.07	0.93	0.92	0.93	1.04	1.08	1.08	1.03
2030	1.05	0.99	1.12	1.04	1.11	0.94	0.92	0.93	1.05	1.10	1.11	1.06
2075	1.24	1.13	1.16	1.02	1.07	0.87	0.87	0.93	1.02	1.09	1.18	1.22

Note: The quotients are dimensionless; CCCM 1995 – scenarios in the Country Study 1995 are prepared using the old version of GCM outputs, the mean for the whole Slovakia is indicated here (Lapin et al., 1995).

Table 6.3 *Scenarios (quotients) of monthly specific air humidity means change (quotients are dimensionless) in 50-year horizons for the whole Slovakia against the normal 1951–1980*

Time horizon	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
CCCMprep (50-year horizons in comparison with 1951–1980, deducted from the modification for the period 1901–1990)												
2010a	1.05	1.04	1.08	1.03	1.04	1.04	1.08	1.07	1.07	1.07	1.04	1.05
2030a	1.08	1.08	1.11	1.06	1.07	1.07	1.12	1.10	1.10	1.10	1.06	1.07
2075a	1.22	1.19	1.18	1.13	1.17	1.19	1.25	1.25	1.25	1.23	1.18	1.20
2010b	1.03	1.02	1.08	1.04	1.05	1.02	1.07	1.07	1.08	1.08	1.03	1.02
2030b	1.06	1.05	1.12	1.07	1.08	1.06	1.11	1.10	1.11	1.10	1.04	1.05
2075b	1.17	1.17	1.22	1.16	1.19	1.18	1.23	1.22	1.24	1.22	1.14	1.13

Note: a – at the level of 850 hPa, b – at ground surface in above sea level of about 500 m; in approximation, it can be also used for partial pressure of water vapour pressure [hPa]; the 50-year horizon 2075 comes from the period 2051–2100 etc.

Table 6.4 *Monthly global radiation means change scenarios (quotients) in 50-year horizons for the centre of Slovakia in comparison with the normal 1951–1980*

Time horizon	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
SR, CCCMprep (50-year horizons in comparison with 1951–1980, from the modification for the period 1901–1990)												
2010	1.001	0.997	0.995	1.006	1.011	1.001	1.005	1.015	1.010	0.999	0.997	1.001
2030	1.002	0.995	0.994	1.004	1.009	0.998	1.001	1.013	1.012	1.004	1.003	1.006
2075	0.978	0.979	0.993	1.007	1.011	1.012	1.008	1.009	1.015	1.005	0.988	0.981

Note: *The quotients are dimensionless, the 50-year horizon 2075 comes from the period 2051–2100 etc.; the version of modification for the period 1901–1990 is used here, without correction.*

For the period 1901–1990, Figure 6.5 shows measured values and for the period 2001–2090 modified values from CCCMprep outputs; for this version of modification the constant difference T for individual months is preserved because only one temperature scenario is used for the whole Slovak Republic; toward the end of the period variability of July temperatures rises in accordance with increasing variability of CCCMprep outputs, modification of variability using standard deviations has only changed the variability of time se-

Figure 6.5 *Illustration of modified outputs of monthly air temperature averages for July from CCCMprep for the stations in Hurbanovo and Liptovský Hrádok*

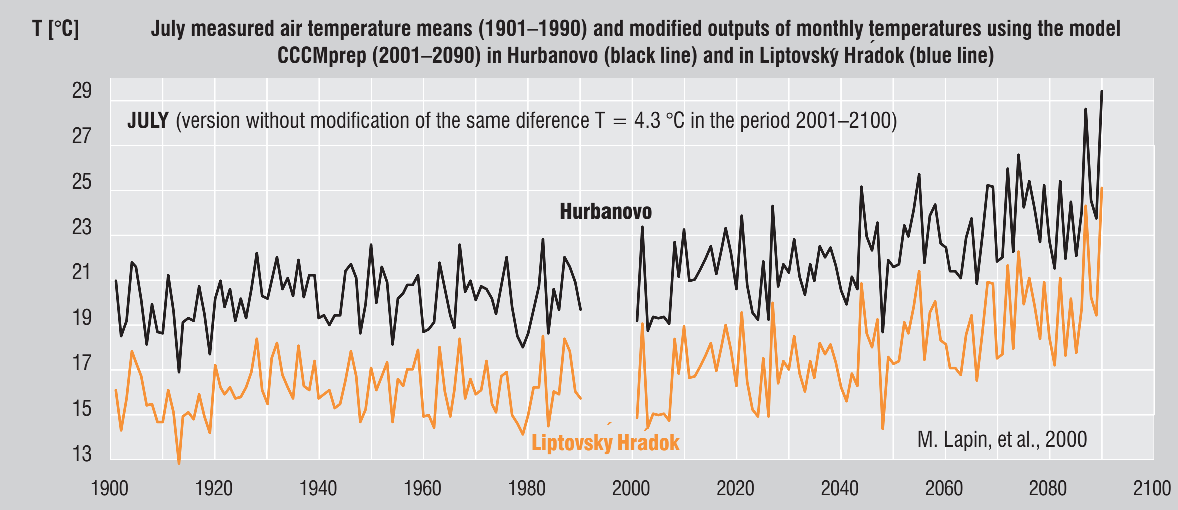
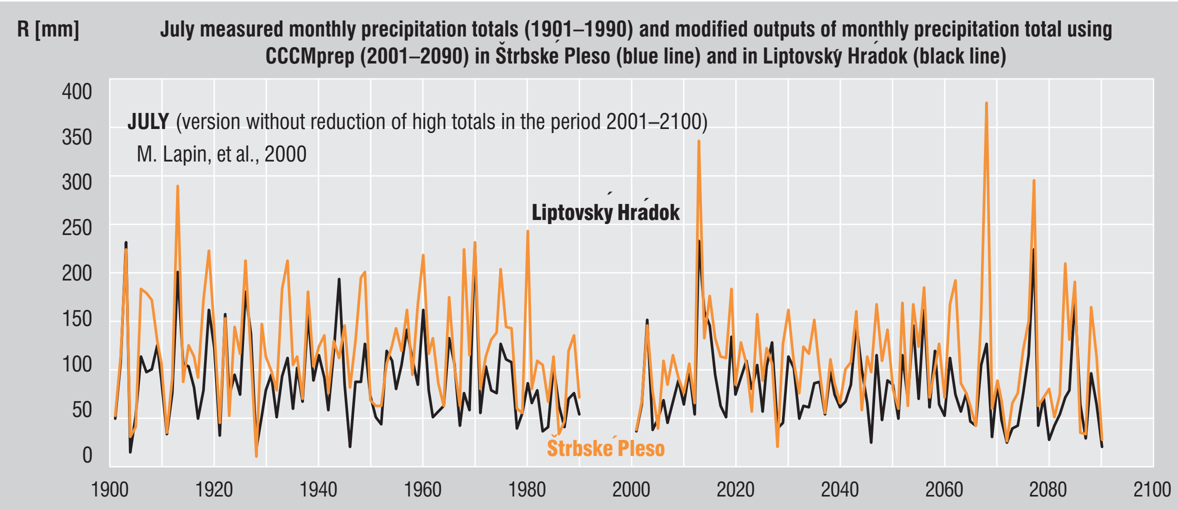


Figure 6.6 *Illustration of modified output of monthly precipitation totals for July from CCCMprep for stations at Štrbské Pleso and Liptovský Hrádok*



ries in the period 2001–2090 with the same quotient as in the control period 1901–1990.

In the period 1901–1990, Figure 6.6 shows measured values and in the period 2001–2090 modified values from CCCMprep outputs; for this version of modification, spatial variability of model data is adjusted in accordance with the value from the control period 1901–1990. Modified time series for the period 2001–2090 have temporal and spatial variability close to the existing variability from the period 1901–1990.

6.3 THE HYDROLOGICAL CYCLE, WATER RESOURCES AND WATER MANAGEMENT

The following bodies have participated in the solution of problems under the National Climate Program in the framework of the subprogram WATER: the Ministry of Environment of the Slovak Republic, the Ministry of Agriculture of the Slovak Republic, the Ministry of Education of the Slovak Republic and the Slovak Academy of Science. Although more than 20 organisations entered the stated subprogram, the following may be considered as the most active ones: The Slovak Hydrometeorological Institute (organisation of the Slovak Ministry of Environment), The Research Institute for Water Management and the Research Institute for Melioration and Landscape Engineering (organisation of the Slovak Ministry of Agriculture), the Department of Land and Water Resources Management of SvF STU (organisation of the Ministry of Education) and the Institute of Hydrology (The Slovak Academy of Sciences).

After completion of stage 1 (in which results of monitoring until 1990, possibly until 1993 were mostly taken into account) the aforesaid institutions in the subprogram WATER focused mainly on further systematic monitoring of hydrological and climatic elements, particularly from the network of monitoring stations classified in the Slovak National Climate Program, on evaluation of measurements, preparation and development of scenarios of potential changes in basic hydrological and meteorological elements and the application of new climate change scenarios for the development of corresponding hydrological element and hydrological balance element change scenarios.

The primary assumption of all solutions of the subprogram WATER are quality, and a reliable and homogenous series of observations. From this aspect attention was paid to continual hydrological and climatic elements monitoring, regular control and evaluation of observed data and protection and maintenance of monitoring networks allocated to the Slovak National Climate Program. Currently the network of the Program consists of 33 stream-gauging stations on surface currents, 29 springs and 6 probes with measuring ground water level. The selection of probes for the Slovak National Climate Program has not been completed yet.

On the basis of overall evaluation of the hydrological situation in Slovakia for the last five years we can state that extremity of runoff partially increased, whereby the average values determined for main Slovak river basins for the individual years did not significantly differ from the long-term means. The years 1996 to 2000 belonged to the period with the most extensive floods, both in river systems and flash floods usually affecting relatively small areas. As the said floods did not cause any significant increase of average water volume, this means that they were "compensated" by another extreme, i.e. small water volume or long-term decrease of water volume in the other parts of the year. The statistical evaluation of increased extremity , as well as its persistence, assumes monitoring with the same quality in the following years.

Evaluation of the hydrological regimen following the year 1990 consisted in calculations of selected hydrological characteristics and their comparison with reference values. In general we can state that in all autochthonous Slovak rivers long-term discharges decreased, only the allochthonous Danube has relatively balanced long-term discharge. This descending trend has been visible since 1980. As far as the long-term monthly discharges are concerned, very significant decreases were observed in central and eastern Slovakia during all months, with the exception of May and June, where only minor positive and negative deviations were recorded. Also in some river basins of western Slovakia the values of long-term discharges decreased in all months, except May and June. In West Slovakia the summer and autumn months are drier than in the past, while winter months have runoff exceeding the normal.

The most important decrease in water yield of monitored springs was recorded in the period from 1988 to 1994 (approximately ranging between 1 and 10%), except springs in two orographical systems – the Little Carpathians and the White Carpathians. In these regions the increase of water yield (approximately of 0.5 to 5%) was observed. In the monitored probes, which are located in the area of Žitný ostrov and in the river alluvium of central and lower Hron, no significant changes in levels of ground waters against the long-term values were recorded.

The region of Žitný ostrov is one of the most important regions from the aspect of ground water supplies. As replenishment of its ground waters is in direct contact with the discharge regimen of the Danube, we can further consider this region as inert from the viewpoint of potential impacts of assumed climate changes.

An example of the development of hydrological course is the line of mean annual discharges from the station in Plášťovce on the stream Krupinica. The stream is located in the region which belong among the most sensitive and most vulnerable regions from the aspect of potential climate changes (increased annual discharges in 1999 was caused mostly by two extraordinary intensive floods, the probability of return period for which was more than 100 years).

The risk trends in the development of hydrological (but also climatic) courses, which are relatively often indicated in different sources of world literature, can be then also demonstrated using observations in Slovakia.

The development of new hydrological scenarios was based on the initial hydrological models, developed or adapted in the framework of stage 1 of the Slovak National Climate Program and the new climate change scenarios. The preservation of initial procedures in the area of hydrology allowed answering the question of how the first hydrological predictions/scenarios affect the new climate change scenarios. On the basis of comparison of initial hydrological scenarios and reworked hydrological scenarios we can state that results are to large extent similar and that the scenarios of change trends differ only in some details. Of course, we will find differences when we compare the particular values of potential changes in hydrological variables.

In general, the obtained results from reworked hydrological scenarios for Slovakia can be summarised as follows: in the winter period increased discharges should be expected, particularly in January and February, in northern Slovakia until April and in most of the territory also in December. The increase of winter runoff in the north can range from 10 to 40%, in central regions of Slovakia from 20 to 50% and in the south from 30 to 80%. Exceptionally, winter runoffs may be even higher. The winter runoff increases toward more distant time horizons (toward 2075).

In the warm half-year we can expect a decrease of discharges against present levels, while in the north it occurs particularly in the middle of summer, in the south this decease can affect the whole warm half-year (April to September). In the north the decrease of monthly discharges should not exceed the limit of 20%. In central regions of Slovakia maximum decrease may reach up to 30% and in the South up to 40%, exceptionally even more. During autumn (from September to November), we can also expect a decrease in discharges on most streams of Slovakia (except those in northern Slovakia). None but insignificant changes in one or the other direction can be expected there.

Figure 6.7 *Line of moving averages of annual discharges in relative values*

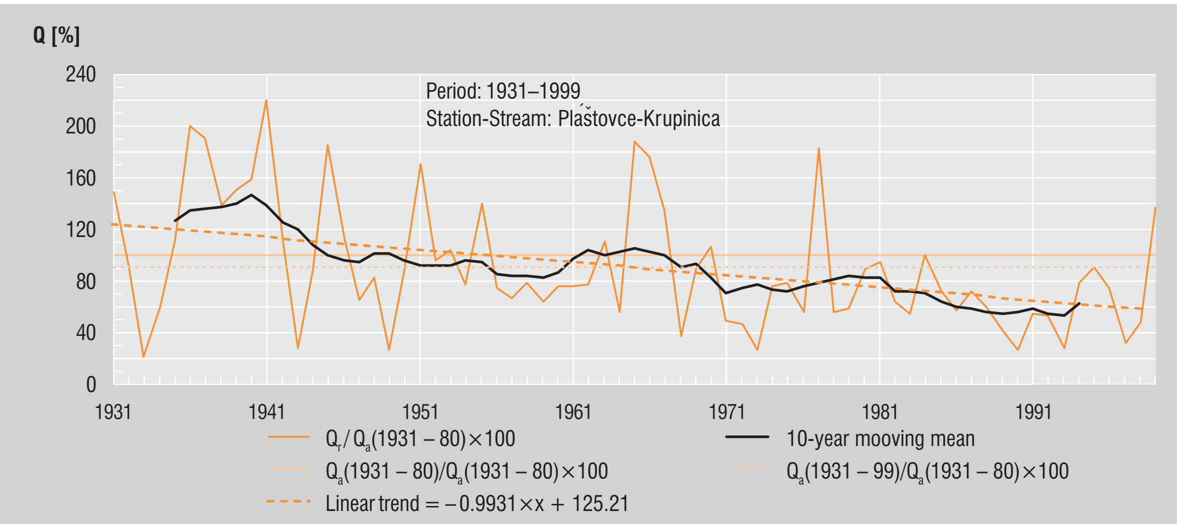
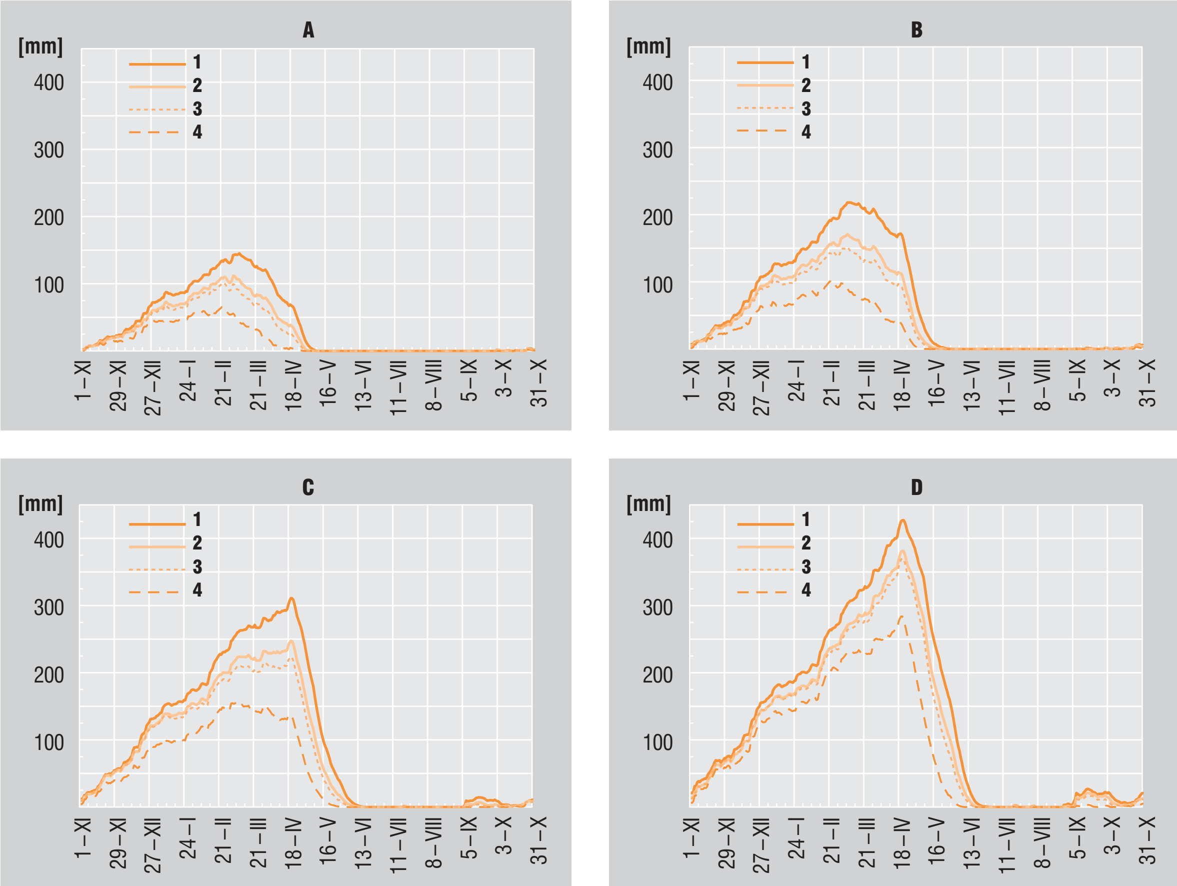


Figure 6.8 *Charts of mean daily values of snow density in individual altitudinal zones*



Legend: A: 800–1,150 m a.s.l., B: 1,150–1,500 m a.s.l., C: 1,500–1,850 m a.s.l., D: 1,850–2,200 m a.s.l. Snow density was simulated using present data (1) and climate scenarios CCCM2010 (2), CCCM2030 (3) and CCCM2075 (4).

As far as another basic element of hydrological balance – evaporation – is concerned, according to model calculations we can expect a rise of potential and actual evapotranspiration and hence higher demands of vegetation on water.

The northern areas of Slovakia were characterised in the Second National Communication as the least vulnerable. But according to results of recent studies (though based on the period of observation since 1989) also in these basins we must expect some changes: increase of winter and decrease of summer runoffs, higher potential and actual evapotranspiration (actual evapotranspiration may increase by 10 to 40% depending on remoteness of the time horizon), decrease of snow cover (in the most far-away time horizon in lower altitudes down to one half) and shortening of the period of snow cover (for the most far-away time horizons up to 10%).

From the results of hydrological course monitoring and from updated hydrological scenarios according to the new climate change scenarios it follows that in the future it will be probably necessary to expect a general decrease of all three water resources: surface, ground and soil. Due to application of "more moderate" climate scenarios (the most probable ones according to the existing knowledge of potential development of the greenhouse effect in the atmosphere) we present more moderate estimates of potential changes in the hydrological regimen and potential changes in basic elements of hydrological balance. As the differences between initial (1997) and the latest (2000) hydrological scenarios are insignificant and the modelled trends of changes differ in small details only, we must always remember that impacts of hydrological changes, especially on water management and agriculture, but also in many other sectors, may be rather negative.

6.3.1 Adaptation measures in water management

Even today, the orientation of adaptation measures for reduction of negative impacts of climate change in water management in the whole Slovakia can still be formulated only generally. At present we recommend as suitable such a procedure which prefers decisions reducing the threat of negative impacts of climate change, taking into account the existing preferences of sustainable development of society, environmental development and protection and integrated water management. The application of such decisions requires that the decision-making sphere is familiarised with the potential consequences of climate change in water management but also with uncertainties in their determination, and coordinates its action accordingly.

6.3.1.1 Proposal for the most important adaptation measures

Primary measures for mitigation of potential negative impacts on water management apply to several areas:

- direct measures for water consumption management,
- indirect instruments affecting behaviour of consumers,
- institutional changes for better water management,
- improvement of operation of existing water management systems.

In the first area, it could be e.g. reduction of specific drinking water consumption per capita using technical means, reduction of losses in production and distribution of drinking water, support of introduction of new technologies in industry, utilisation of precipitation and other waters for utility purposes, construction of split water supply systems in small residential quarters etc.

The second area should support these measures also in the area of subsidies, taxes and charges in water management. At the same time it will be necessary to enhance awareness of the public on impacts of climate changes on the quality of life in general and on the issues of water resources and subsequent measures in particular. The information policy should be connected with education for enhanced environmental awareness of consumers in respect of water resources.

In the third area new legislation in the area of the environment should be fully projected directly in water management legislation. We suggest considering strengthened legislative protection of water resources in the areas about which we can assume that their water resources will be the least affected by climate changes, and explicitly protect all reservoir places planned until today and determine the ways of temporary utilisation of these territories. Further we recommend paying special attention to the protection of the unique ground water resources of Žitný ostrov, whose potential will probably remain at the existing level also in the future. It would be suitable to establish in advance contact with the neighbouring countries who will be affected by the change of hydrological cycle and the need for more strict regulation of runoff from our territory, and to develop organisational measures for common solution of the problem of the potential consequences of climate change.

The fourth area – improvement of operation of the existing water management systems – can be divided to several parts:

- The first part concerns optimisation of the exploitation and management of the existing water management and waterworks construction systems. The provision of water supply meeting the existing standard was seldom determined for water management systems as a whole. Therefore it would be necessary to examine vulnerability of the existing water management systems as a whole in critical situations.
- The second group concerns particularly the discussion around the need for construction of water reservoirs in Slovakia. The estimated tendencies of hydrological regimen changes point out the increased need to reallocate runoff in the space between the north and the south of Slovakia, reallocation of runoff between individual years and reallocation of runoff during one year. Therefore we also must take into account the potential need for compensation of reduction of water resource yield, especially in the lowlands of Central and East Slovakia. For this reason we recommend not excluding the possibility of construction of water reservoirs from the conception of water management development. Particularly required may be reservoirs with long-term runoff regulation and, when planning their location, consideration of spatially differentiated impacts of climate change. It will also be necessary to execute an inventory of so-called small water reservoirs and reconsider their utilisation under new conditions, not only as one element of landscape management, but also as water resources for irrigation of southern regions of the territory.
- The third group involves monitoring of ongoing processes in the hydrosphere. It is necessary to strengthen the existing systematic monitoring of water management balance of water quantity and quality also in smaller basins so as to identify tendencies in potential water disposal over time and to allow to formulation of

strategical decisions of new priorities of water management, particularly during drought.
- The fourth group refers to water management in the country. In cooperation of departments, it would be appropriate to systematically implement measures in river basins with universal effect, aimed to general and permanent improvement of conditions of runoff, as well as to retention of water in the country, reduction of potential negative consequences of extreme runoffs and improvement of water quality.

6.4 AGRICULTURAL PRODUCTION IN SLOVAKIA

As was indicated in Chapter 2, during economic transformation agriculture went through extensive privatisation and saw a total decrease of produced real added value occurring in agriculture. The cooperative form of management was mostly preserved because the majority of new land owners leased this land to cooperatives. Subsidies in agriculture decreased since 1989 by more than 50% and in 1994 they represented 7.1 billion SKK, i.e. 1.8% of GDP, and they are much lower than in EU countries. In the period 1986 to 1992, Producer Subsidy Equivalents (PSEs) decreased by 40% and a slight decrease went on until 1994. In the first 5 years of economic transformation production of cereals was preserved. Numbers of cattle decreased by 41% and numbers of pigs by 19%. The application of fertilisers decreased to 20%.

6.4.1 Change of phenological conditions

The time course of vital functions of plants – phenophases is affected mainly by temperature and water. Changes of temperature, precipitation totals, but also other environmental factors change the starting terms of phenophases and hence lengths of phenophasic intervals and entire vegetation periods of crops.

Vegetation periods limited by physiologically important temperatures are characterised by the early start and late end, and consequently by their extension to the time horizon of the year 2075.

For this reason, extension of large vegetation period (VVO, daily average temperature ≥5 °C) by up to 50 days, i.e. 20%, is expected for southern regions of Slovakia, and by up to 40 days, i.e. 24%, for the northern, highest altitudes serving for agricultural use, until the time horizon of the year 2075. It is also assumed that the main vegetation period (HVO, daily average temperature ≥10 °C) in southern Slovakia will be extended by 43 days, i.e. 23%, and in northern Slovakia by 84 days, i.e. 93%.

6.4.2 Changes of agroclimatic conditions

Toward the time horizon of the year 2075 the following changes are expected:
- In southern – the lowest – Slovak regions, an increase of ∑T (sum of daily air temperature averages) for VVO of 1,138.0 °C, i.e. 32%, and in northern Slovak regions of 913.0 °C, i.e. 55%.
- In southern Slovak regions, an increase of ∑T for HVO of 1,111.0 °C; i.e. 36%, and in the higher altitudes of 802 °C; i.e. 69%.
- In southern, lowest altitudes of Slovakia, an increase of Q_{FAR} (sum of photosynthetic active radiation) for VVO of 49 kWh.m^{-2}, i.e. 10%, and in the highest altitudes used for agricultural purposes of 90 kWh.m^{-2}, i.e. 25% (particularly for extension of VVO).
- In southern, lowest altitudes of Slovakia, an increase of Q_{FAR} for HVO of 72 kWh.m^{-2}, i.e. 17%, and in the highest altitudes of 115 kWh.m^{-2}, i.e. 58%.
- A rise of precipitation totals in HVO in southern Slovakia of 27 mm, i.e. of 8%, and in the north of Slovakia of 202 mm, i.e. 77% (especially for extension of VVO).
- Totals of evapotranspiration (E) in lowlands will probably change only slightly or they will not change at all toward time horizon of the year 2075. Toward the same time horizon, in southern Slovakia, E will probably rise by 27 mm, i.e. 6%, while in northern Slovakia it will rise by up to 68 mm, i.e. 20% (extension of HVO, growth of potential evapotranspiration totals, rise of precipitation totals).

6.4.3 Change of agroclimatic production potential

Biomass production potential will increase by 0.42 kg.m^{-2}, i. e by 10%, in southern Slovakia and by 0.77 kg.m^{-2}, i.e. by 25%, in northern Slovakia, toward the year 2075.

Toward the time horizon of the year 2075, grain corn production potential (U_{uK}) for HVO in southern Slovak regions should increase by 0.58 kg.m^{-2}, i.e. by 16%. The northern limit of profitable grain corn farming is determined by vegetation thermal constant of this crop (3,000–2,400 °C) and it presently corresponds to approximately the same above sea level of 100–400 m.

Toward the time horizon of the year 2075, fully profitable corn farming should move to the above sea level of 500 m and the transfer of profitable corn farming to the above sea level of 800 m.

6.4.4 Adaptation of agriculture in the Slovak Republic to climate change

From a material aspect, the main task will be to solve and implement adaptation projects in ***agriculture*** aimed to:

- the application of protective and saving cultivation technologies,
- changes in crop growing technologies,
- changes in agroclimatic division and structure of grown crops and varieties,
- changes in cultivation programs
- changes in the integrated protection of crops,
- changes in regulation of soil water regime,
- changes in plant nutrition,
- reduction of greenhouse gas emissions, excrement and waste treatment in animal production,
- changes in management of agricultural production,
- revitalisation of the existing, and construction of new irrigation systems.

According to obtained results we can expect the movement of the application of the first irrigation dose to an earlier term. This movement is more significant for cereals sown closer to each other than for the other crops. While e.g. in the area of Hurbanovo, for winter wheat the movement of the application of the first irrigation dose, achieved by modelling, represented more than 3 weeks in the time horizon 2075; for hop clover this term remained more or less stabilised. We can generally state that the movement of the application of the first irrigation dose increased with extending time horizon.

6.4.4.1 Plant production

It is clear that climate changes will have both positive and negative impacts on harvest and plant production under Slovak conditions. According to the results of research in the Slovak Republic, following the year 2025 the mean soil temperature in vegetation period will probably increase by 1 °C and mean values of soil humidity in the vegetation period will decrease by app. 10%. Due to the stated changes, higher intensity of the mineralisation of soil organic substance, and its degradation are supposed, particularly in the area up to 400 m a.s.l., where an evaporation water regime with negative water balance should prevail. Low to medium growth of soil salinization and alcalinization is expected. The higher frequency of torrential rains will increase the danger of soil erosion. The intensity of soil nitrogen mineralisation and the intensity of nitrate production should increase. Higher production of greenhouse gases (N_2O) in soil and their higher emissions to the atmosphere cannot be excluded either.

As positive results we can consider the possibility of extension of areas for thermopile and drought resistant crops with more efficient type of photosynthesis (type C4 – corn, sorghum etc.). Another positive change is the increase of absorption of some nutrients and improvement of microbial life in soil, under favourable humidity conditions.

Potential adaptation to these conditions assumes more effective management of nitrogen minerali-

Table 6.5 *Quantification of mean annual need of irrigation water in Slovakia based on model calculations under the baseline scenario (BLS) and under climate change scenarios for the period of years 2010, 2030 and 2075 (Takáč and Heldi, 1996)*

Climate change scenario	Need of irrigation water 2010		2030		2075	
	total [mil m^3]	[m^3.ha^{-1}]	total [mil m^3]	[m^3.ha^{-1}]	total [mil m^3]	[m^3.ha^{-1}]
BLS	271	874	307	878	358	894
CCCM	302	974	414	1,035	540	1,080
GISS	261	841	283	807	317	791
GFD3	271	874	352	926	446	992
dT1R1	291	939	373	982	464	1,031
dT1R2	316	1,019	434	1,085	565	1,130
dT1R3	362	1,168	730	1,327	1,122	1,603
dT2R1	313	1,009	421	1,053	542	1,083
dT2R2	335	1,081	595	1,189	810	1,351
dT2R3	368	1,188	748	1,360	1,171	1,673

sation and immobilisation processes using adapted cultivation and fertilisation systems, particularly by:

- targeted utilisation of irrigation,
- division of nitrogen doses and increase of the share of liquid fertilisers,
- utilisation of humidity-saving and soil-protecting technologies,
- extension of green fertilisation,
- application of the principle of extension of soil vegetation cover,
- systematic utilisation of biologically fixed nitrogen,
- potential utilisation of synergism of irrigation systems, fertilisers, pesticides and growth regulators.

From the aspect of structure of plant production cereals will represent approximately 55% of arable soil, of which 45% sown close to each other, 12 to 13% oil-plants, 4.6% root-crops and 16.5% forage on arable soil.

Group of problems, which should be solved in the area of agricultural production in view of expected climate change:

1. impact of climate change on the structure of plant production, its productivity and economic effectiveness,
2. possibilities to eliminate negative impact of climate change through a change of representation of crops and their rotation;
3. system for cultivation of soil temporarily excluded from cultivation and cultivation system of alternative crops.

6.4.4.2 Animal production, foodstuff industry

Enhancement of animal yield allows obtaining the same production from a smaller number of animals. As production of greenhouse gases from animal breeding (e.g. methane) is directly proportional to the number of bred animals, by increase of the yield through cultivation it is possible to reduce production of these gases, as well as production of excrements having a negative impact on environment in general. In connection with climate change, we consider as the most important tasks and measures in the area of breeding, cultivation and animal nutrition systems in these days:

- modelling a solution of breeding systems with the potential to reduce the impact of extreme microclimate on yield and health condition of animals,
- protection of livestock from high temperatures,
- modelling the influence of the amount of annual genetic gain on milk and beef production and on the size of cattle population in relation to the required milk and meat production in the Slovak Republic,
- application of livestock breeding systems which will allow reduction of the influence of extreme climatic parameters on production and health condition of animals, and the impact of breeding on air quality and water management systems,
- completion of storage capacities for stable manure and liquid manure in line with EU legislation in force,
- utilisation of systems for application of manure with reduced impact on air quality and water management systems.

6.5 FORESTRY AND FOREST ECOSYSTEMS

In the coming century, global warming of the Earth will also affect natural ecosystems of Central Europe. Scientists estimate that individual vegetation communities are not adapted to long-term deviations of mean temperatures exceeding 1 °C (Míchal 1992, Schneider 1997, Minďáš et *al.* 1996).

Under the conditions of future climate change, the existence of contemporary bioclimatic conditions of forest tree species at lower vegetation zones (vl 1 to 3 and partially 4) will be limited mainly by totals and distribution of precipitation and high evapotranspiration in the vegetation period. These changed bioclimatic conditions will threaten the structure of the existing communities and the occurrence of tree species (especially beech). At higher vegetation zones (vl 5, but particularly 6 and 7) the better temperature conditions of the future climate and relatively sufficient water balance may contribute to the creation of bioclimatic conditions suitable for higher occurrence of broad-leaved tree species (beech, maple, ash) and for higher potential production of tree species. Limiting factors of such estimate of future development of forest vegetation zones are the development of abiotic (wind, frost, meteorological extremes), biotic (insect, pathogens) and anthropogenic (pollutants) noxious agents.

6.5.1 Expected climate change impacts on representation of main tree species

Planar and colline zone

In the time horizon of the year 2075 bioclimatic conditions at this zone will be the most suitable for beech communities, which will prevail there. The bioclimatic area of spruce will not occur at this zone.

Submontane and montane zone
Bioclimatic conditions will be the most suitable for beech communities; in addition the submontane zone will provide favourable conditions for occurrence of oak. The upper limit of the montane zone more or less corresponds to the limit of bioclimatic zone of spruce. Sporadically it could occur here also in the future.

Supramontane zone
This zone covers the existing bioclimatic optimum of occurrence of common spruce (*Picea abies*). For conditions of climate change this optimum will move to the subalpine zone. In the lower part of this zone conditions for occurrence of beech and fir will improve.

6.5.1.1 The Holdrige model

Planar and colline zone
At altitudes up to 500 m, climatic conditions favourable for successful production of spruce cannot be expected even in the future.

Submontane and montane zone
Bioclimatic conditions for broad-leaved species (particularly European beech – *Fagus sylvatica*) will significantly improve, but on the other hand, they will lead to reduction of spruce occurrence.

Supramontane zone
Conditions suitable for mixed spruce communities, but actual environmental conditions of successful growth of spruce will be probably limited by soil and geomorphologic conditions.

6.5.1.2 The Forest Gap Model

Planar and colline zone (for the area of Sitno, 500 m a.s.l.)

- Exclusion of any participation of spruce in forest communities at this zone.

Submontane and montane zone (for the area of Dobročský prales, 850 m a.s.l.)

- Spruce will not be a part of forest communities at this zone, it may sporadically occur at its upper limit only.

Supramontane zone (Piľsko, 1,250 m a.s.l.; closure of the valley Vajskovská dolina 1,300 m a.s.l.)

- Transfer of the upper forest limit to the area of the existing subalpine zone.
- In the supramontane zone the occurrence of spruce will decrease in detriment of occurrence of beech and precious broad-leaved species (sycamore, ash).

6.5.1.3 Analysis of precipitation assurance

Planar and colline zone
Cultivation of spruce in this area seems to be unsuitable in light of the descending trend of precipitation totals in the last years.

Submontane and montane zone
At this zone in the region of Nízke Tatry, Orava and Kysuce, in spite of reduction of precipitation totals, the limit need of precipitation for spruce in the vegetation period is still ensured.

Figure 6.9 *Results of analysis of bioclimatic zones for main tree species depending on biotemperature*

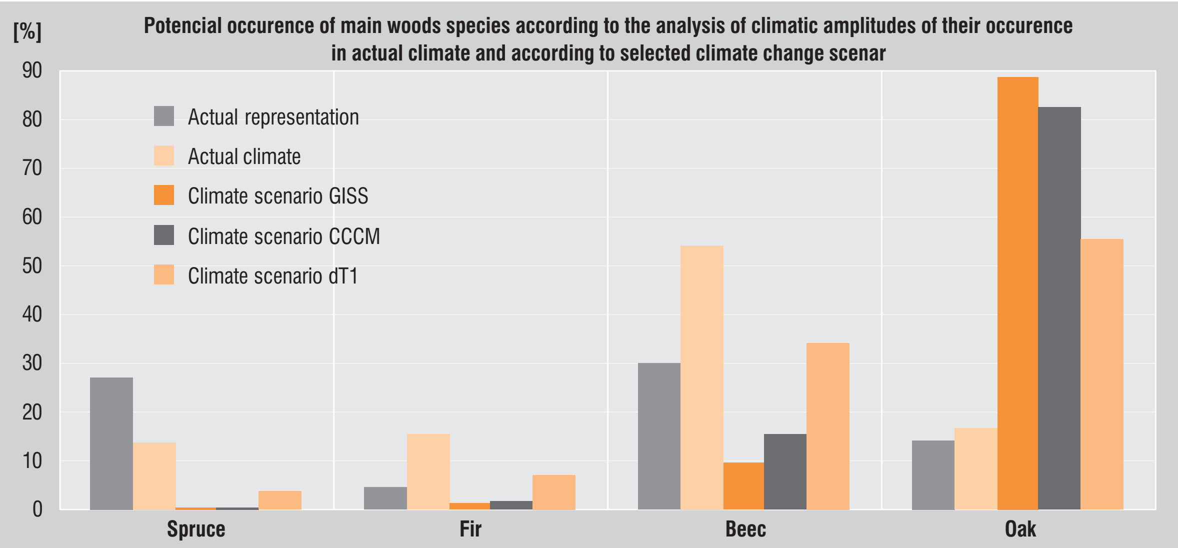


Table 6.6 *Summary results of evaluation of occurrence and further cultivation of spruce in the area of the Western Carpathians, in view of climate change predictions*

Spruce communities (SM)	Holdrige model	Forest Gap Model	Analysis of bioclimatic zones	Analysis of precipitation provision
Planar and colline zone	• absence of conditions of SM occurrence	• extinction of spruce communities	• extinction of conditions for spruce occurrence	• limiting deficit of precipitation for spruce
Submontane and montane zone	• conditions of reduction of SM occurrence	• extinction or marginal SM occurrence	• general decline of conifers (SM)	• sufficient precipitation for SM only in the north of the zone
Supramontane zone	• conditions of development of mixed spruce communities, transfer of the upper limit of forest	• development of mixed SM-JD-BK stands, transfer of the upper limit of forest	• reduction of SM occurrence, general reduction, transfer of the upper limit of forest	• sufficient precipitation for SM occurrence

Supramontane zone
From the aspect of precipitation assurance of spruce, this zone has sufficient amount of precipitation during the whole year.

The summary results for the model area show that the existing tree species composition of forest stands, considered by their position to natural bioclimatic zones in the model territory is relatively favourable. Unfavourable evaluation scales (3 to 5) cover "only" 4% of forest zones according to IT index and 18% according to IQ index, while from the aspect of the most important tree species (spruce, fir, beech) these values are even more positive. A different situation is under conditions of climate change, where temperature conditions dramatically change, especially for conifers such as fir (92% of area covered by zones 3 to 5), less for spruce (38%). Beech has come off well from this evaluation; it should remain the key tree species in this area and constitute the skeleton of the future stands.

The evaluation clearly shows that in Slovakia, especially for spruce and fir, there is non-compliance between their bioclimatic requirements and present occurrence. This has shown significantly in the values of climate change conditions, where 71% of spruce stands, 82% of fir stands and 32% of beech stands are situated at zones 3 to 5 of the IT index. The IQ index indicates the most important changes for beech at its lower limit.

The core issue is the identification of processes by which tree species will respond to the change of bioclimatic conditions. Valuable knowledge in this area come from analyses of provenance tests, the analysis of which in relation to climate change has identified especially increased mortality and changes in the growth process (Matyas 1994, Šindelář 1993). Similar model analyses are based particularly on knowledge of the environmental (in this case bioclimatic) requirements of individual species or communities, and results of these models both at the national and regional level now form the basis for the evaluation of climate change impacts and subsequent need for adoption of adaptation measures in forestry (Lenihan, Neilson 1993, Neilson 1993, Noble 1993).

6.5.2 Climate changes and action of noxious agents

Abiotic noxious agents
The montane forest stands of central and northern Slovakia represent the most endangered areas. Forest stands bordering the said region are medium-endangered.

Biotic noxious agents – insect
Among biotic noxious agents subcortical insect prevails. Since 1990, due to attack by subcortical noxious agents, the amount of calamity wood substance increased from the value of 100 thousand m^3 up to more than 900 thousand m^3 in 1995. Since then it has been slowly decreasing to the level of 450 thousand m^3 in 1999.

Similar situation occurred in the case of folivoracious insect, but with faster culmination. For example, for *Lymantria dispar* this damage culminated in the years 1993–1994, which is also caused by different bionomy of individual species.

Changes in population dynamics
Climate changes already show by cases of excessive reproduction of species which were until now considered as indifferent or beneficial (*Melasoma*

vigintipunctata, Altica quercetorum). However the change of conditions is not positive for all species, which can be documented by the fact that some species that were considered as noxious agents have become beneficial in the recent period.

Changes of stands

Climate warming may significantly show by the move of optimum occurrence of some species to higher altitudes above sea level.

Folivoraceous insect

Among folivoraceous insect the most significant species are bound to beech communities. Actually beech forests on the area of 30 to 50% of their actual occurrence are potentially endangered by the examined species. The situation changes in case of the application of the climate scenario CCCMprep (Lapin, Melo 2000), particularly for the species *Operophtera brumata*, where the rise of mean annual air temperatures will lead to deterioration of conditions of occurrence of this species in relation to the actual occurrence of beech in Slovakia. A different situation is for other two species, where the percentage of area coverage will increase by about 9% against the existing level.

6.5.3 Conception of integrated forest protection and adaptation measures

To ensure environmental stability in the country it is necessary to restore disorganised and destroyed forest communities. Upon their restoration (whether natural or artificial) another system of noxious agents appears, which prevents the origin of a new forest community or impedes or complicates its development. We are referring especially to competition of undesirable vegetation at the initial forest stage.

On the basis of available knowledge of interactive links between climate and forest community, their thorough analysis, professional and scientific discussions, it is necessary to postulate basic principles of an adaptation strategy which in the area of forest protection should include particularly:

- solution of the conception of forest protection in relation to changes in expected migration and to population gradation of noxious insects,
- analysis of the importance of climate changes in relation to occurrence of abiotic noxious agents,
- ensurance of protection of natural regeneration from nibbling by protective means and optimisation of game stands.

6.5.4 Proposal for adaptation measures in the forestry sector

Afforestation of non-forest areas unfit for agricultural use

Objective – to increase carbon sequestration in biomass of forest trees and in soil. Assumed effect 42 Gg CO_2 for afforestation of 40 thousand ha up to 2015.

Enhanced protection of forest and agricultural land stock

This measure is aimed to the increase of carbon sequestration in soil. Assumed effect – reduction of emissions by 142 Gg CO_2 by the mitigation of reduction of arable land and forest areas by about 63 thousand ha up to 2015.

Tree species composition change in Slovakia

This measure is aimed to carbon sequestration in biomass of forest trees (increase of unit carbon stock) and enhancement of forest adaptability to climate change. This will result in reduction of emissions by 900 Gg CO_2 by a change of tree species composition on the area of approximately 200 thousand ha (replacement of conifers with hard broad-leaved trees) until 2015 to 2020.

Enhancement of energy-related utilisation of forest tree biomass

This measure is aimed to replacement of fossil fuels based on renewable energy sources (forest biomass) Time horizon: 2001–2015.

Tree species composition change in Slovakia

The measure will bring the enhancement of adaptation of forest stands to climate change. This will result in mitigation of negative impacts of climate change on the functional potential of Slovak forests and the increase of carbon stock in forests.

Strengthening of genetic and species diversity of forests in Slovakia

This measure will be aimed to enhancement of adaptability of forest ecosystems to climate change. The enhancement of biodiversity will result in the enhancement of adaptation potential of forest ecosystems.

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7. Review of climate change research

This Chapter provides a brief review of research projects in Slovakia related to climate changes, their negative impacts and adaptation measures for their mitigation.

7.1 CLIMATE CHANGE IMPACTS ON CLIMATIC CONDITIONS AND HYDROLOGICAL REGIME

Several scientific and research grants in institutions of the Slovak Academy and at universities were devoted to problems of potential impacts of climate change, variability and changes of climate, and on changes of climatic conditions and hydrological cycle, water resources and water management of Slovakia.

Projects of VEGA grants completed in 1999:

- Temporal and Spatial Variability of the Characteristics of Soil Water and their Trends on the East Slovakian Lowland (ÚH SAV).
- Determination of Areal Evapotranspiration as the Element of Water Balance in Selected Catchments of Slovakia (ÚH SAV).
- Spatial Analysis of Changes of Ground Runoff from Slovak River Basins (Faculty of Natural Sciences of University Comenius (PrF UK).
- In 2000 the following VEGA grants will be completed:
- Sensibility of the System of Slovak Climatic Conditions to Climate Change… (FMFI UK).

Projects of VEGA grants launched in 1999:

- Regional Hydrological Scenarios for the Integrated Management of the Quantity and Quality of Surface Water Resources in Slovakia (ÚH SAV).
- The Influence of Global Changes of Environment on Water Storage of Soil Aeration Zone (ÚH SAV).
- In 2000 the following projects of VEGA grants were launched:
- Changes in Natural Environment and their Impact on Utilisability of Surface and Ground Water Resources (PrF UK).
- Stationarity of Discharges on Streams of the Small Carpathians and its Impact on Water Resources (SvF STU).
- Quantification of Interaction Phenomena in the Hydrosphere of the Lowland of East Slovakia (ÚH SAV).
- Hydrogeographical Regional Types in the Slovak Republic – Issue of Extrapolation of Values of Hydrological Response and Rational Utilisation of Water Resources (GÚ SAV).
- In 2001 the following projects of VEGA grants will be launched:
- Complex Monitoring Research and Information System of Natural Disasters in the Slovak Republic (PrF UK).
- Comparative Analysis of the Conceptions of Regional Assessment of Projected Maximum Discharges (SvF STU).
- Research of Sensibility of the System of Climatic Conditions in Slovakia to Climate Change … (FMFI UK).
- Ground Ozone on Slovak Territory (FMFI UK).

Projects of the National Climate Program of the Slovak Republic solved in the years 1997 and 2000:

- Elaboration and Interpretation of Global Climate Change Scenarios in the region of Slovakia until 2100.
- Reconstruction of Long Climatic Time Series
- Climate Change Impacts on Water Balance Components.
- Potential Climate Change Impacts on Selected Sectors and Adaptation Measures (water management, agriculture, forestry, environment).

8. Education and enhancement of public awareness

While in the period of preparation of the First and the Second National Communications on Climate Change, Slovak Republic, the phenomenon of global warming was mostly perceived as the specific problem of a small group of experts, the development and impacts of climate changes in the recent period directly in our territory caused significant change of the general public's attitude as well. An important input in this context was the adoption of Act No. 211/2000 Coll. on Free Access to Information ("Act on Information Freedom"), which repealed the existing Act on Access to Environmental Information (Act No. 171/1998 Coll.). By this Act, Article 45 of the Constitution of the Slovak Republic is executed, according to which everybody has the right to timely and full information about the condition of environment, as well as the reasons for and consequences of this condition. A significant improvement was achieved also in the area of collaboration of governmental and non governmental organisations and institutions in adoption of new conceptions and important legal norms. However, in connection with the enhancement of public awareness, the new communication technology – Internet – has played the decisive role both in Slovakia and in the world.

The Second National Communication on Climate Change

- ***The Second National Communication on Climate Change, Slovak Republic*** in its Slovak version was distributed to members of Slovak Parliament, ministries, state administration, schools, research institutes, libraries, non governmental organisations. The Communication was also distributed in an English version and it is available on the web site of the UNFCCC Secretariat – www.unfccc.de.

The Third National Communication on Climate Change

- This Communication will be made available in Slovak version on the website of the Slovak Ministry of Environment: www.lifeenv.gov.sk.

Information materials

- Final report to the project ***Country Study, Slovakia, 1997*** was issued in 500 copies both in English and Slovak versions and distributed to all secondary schools and universities in Slovakia, together with promotion materials and educational video cassette. The material was also sent to non governmental organisations.
- ***Report on Air Quality and Share of Individual Sources in Its Pollution in the Slovak Republic, SHMÚ and MŽP SR*** has been published and distributed every year and since 1997 it is also available to the general public on the website www.shmu.sk.

Publication activity

Summary of research reports, studies, articles.

Reviews of the National Climate Program of the Slovak Republic – in 1997 (No. 6, 7), in 2000 (No. 8, 9).

Periodicals available on the website www.sazp.sk:

- ***Enviromagazín*** – issued by the Slovak Environmental Agency (SAŽP) in collaboration with the Slovak Ministry of Environment.
- ***Report on the Environment of the Slovak Republic*** – prepared and annually issued by the Slovak Ministry of Environment.
- ***Sieťovina (Mesh)*** – bulletin for open informal association of governmental and non governmental organisations dealing with environmental education.

Other periodicals in the area of air protection and energy efficiency:

- ***21st Century – magazine for industrial ecology***, published since 1998.

- ***Energy – magazine on strategy, trends and policy in the energy sector***, updated information from the area of energy efficiency enhancement, etc…

Media-related policy of the Slovak Ministry of Environment – lies within the responsibility of the Press Department of the Slovak Ministry of Environment:

Press conferences:

- Representatives of the Slovak Ministry of Environment regularly update media and the public on the results of international discussions at conferences of concerned parties and expert groups to the UN FCCC.

Radio

- Representatives of the relevant departments of the Slovak Ministry of Environment and SHMÚ have presented the issues of global warming in many radio transmissions and talks.

Press

- In the past period, interviews and articles dealing with greenhouse gas emissions and global warming were published, based on monitoring, in all important dailies and revues.

Festivals

- ***Envirofilm*** – international festival of films, TV programs and video programs dealing with environmental protection and development, years 1997 to 2000, information available also on the website www.sažp.sk.
- ***Ekotopfilm*** – the oldest environmental film festival in the world, which comprises archives with more than thousand films and has been regularly organised for 27 years in Bratislava.

Conferences and seminars:

International workshop:

- *Strategy of Slovakia In Mitigation of GHG Emissions, March 24–26, 1998*. Seminar to the project: Study on Slovak Strategy for GHG Reduction, June 1998.
- *Annex I Expert Group Workshop – Transition Country Perspectives on the Kyoto Protocol, Bratislava, SR – May 17–19, 2000*; The Slovak Ministry of Environment participated in organisational assurance of the AIXG meeting and workshop of OECD and IEA.

Other activities:

- *The Office of the Slovak Ministry of Environment for public relations* – established directly in the premises of the Ministry provides for:

1. **Information about decisions on environmental issues:**
   - authorities of institutions within operation of the Slovak Ministry of Environment and organisational units of the Ministry of Environment,
   - decision making processes and procedures,
   - list of ongoing processes of environmental impact assessment (EIA),
   - environmental laws and regulations,
   - strategic documents, conceptions and programs.
2. **Information on condition of environment:**
   - information on condition of environment components,
   - information on regulations, limits and standards in environment,
   - information on impacts of the condition of environment on health and quality of human life.
3. **Other environmental information:**
   - information on events organised by the Slovak Ministry of Environment and other environmental organisations,
   - information on environmental products and technologies, certification,
   - data bases and lists, such as list of authorised persons for EIA assessment, auditors of environmental management systems,
   - information and educational materials.

Contact:

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Guidance and information activity in the area of energy savings:

- ***Cogeneration Centre*** in the framework of the Slovak Energy Agency SEA – established to promote the conception and implementation of power and heat cogeneration projects.
- ***Energy Consulting and Information Centres (EKIS)*** – their mission is to enhance awareness of the general public on potential for energy savings in dwelling houses and apartments.
- ***Energy Institute of SEA*** – ensures further education in the area of effective utilisation of energy, including training courses for auditors in the energy sector.

List of used symbols and abreviations

AIJ	Activities Implemented Jointly
BATNEEC	Best available technology not entailing excessive costs
BAU	Business as usual
BC	Brown coal
CC	Combined cycle
CDM	Clean Development Mechanism
CFC	Freons, halogens and fully halogenated hydrocarbons containing F, Cl or Br
CHP	Combined Heat and Power Plant
COP	Conference of the Parties
COPERT	Emission factors for types of vehicles in transportation; software to estimate emissions from transport, CORINAIR program
CORINAIR	EU system for emission inventory of atmosphere pollutants (Co-ordination of Information on the Air Pollution)
CZT	Centralised district heating
DH	District heating
DSM	Demand Side Management
EF	Emission factor
EL	Emission limit
EL ZZL	Emission limit of basic pollutants
ENPEP	Energy and Power Evaluation Program
ERU	Emission Reduction Unit
ET	Emissions Trading
EU	European Union
EVO	Power plant in Vojany
GATT	General Agreement on Tariffs and Trade
GEF	Global Environmental Facilities
GDP	Gross domestic product
GHG, GHGs	Greenhouse gas/gases
GWP	CO_2 equivalent – Global Warming Potential
HC	Hard coal
HCFCs	Partially halogenated freons and halogens (hydrogen atoms remain in the molecule)
HFCs	Partially fluorinated hydrocarbons
IPCC	Intergovernmental Panel on Climate Change
ISPA	Instrument for Structural Policies for pre-Accession
JI	Joint Implementation
LPG	Liquified Petroleum Gas
LUCF	Land – Use Change and Forestry
MERO	Metylester of Colza Oil Plant
MDPT SR	The Slovak Ministry of Transport, Posts and Telecommunications
MF SR	The Slovak Ministry of Finance
MH SR	The Slovak Ministry of Economy
MP SR	The Slovak Ministry of Agriculture
MV RR SR	The Slovak Ministry of Construction and Regional Development
NMVOC	Non-methane Volatile Organic Compounds
NO_x	sum of $NO+NO_2$
OECD	Organisation for Economic Cooperation and Development
OSN	United Nations Organisation
PES	Primary energy sources
PFCs	Perfluorocarbons
POP	Persistent organic pollutants
RES	Renewable energy sources
REZZO	Register of emissions and sources of air pollution in SR
RISO	Regional Information System on Wastes
SF_6	Sulphur hexafluoride
STN	Slovak technical standard
UN FCCC	United Nations Framework Convention on Climate Change
VOC, VOCs	Volatile organic compounds
WMO	World Meteorological Organisation
WTO	World Trade Organisation
ZZL	Basic pollutant

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Faculty of Forestry, TU – UTVS Zvolen
Slovak Statistical Office
Customs Directorate of the Slovak Republic

Appendix

P.1 Chapter 3

Inventory of greenhouse gas emissions

Table 10 *Emission trends (SUMMARY) – Slovakia 1999*

Greenhouse gas emissions	Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)										
Net CO_2 emissions/sinks	57,180	57,180	50,007	46,466	43,574	39,816	41,235	40,644	41,072	41,911	42,248
CO_2 emissions (without LUCF) [6]	59,606	59,606	52,432	48,892	46,000	43,051	44,470	44,877	45,157	43,594	44,875
CH_4	6,767	6,767	6,182	5,635	5,253	5,114	5,212	5,336	5,056	4,688	4,658
N_2O	5,885	5,885	4,976	4,378	3,643	3,694	3,867	3,201	3,181	3,026	2,745
HFCs	0	0	0	0	0	3	25	45	70	44	65
PFCs	272	272	267	249	156	132	114	35	33	24	14
SF_6	0.03	0.03	0.03	0.04	0.06	9.27	9.91	10.76	11.34	12.24	12.68
Total (with net CO_2 emissions/sinks)	**70,104**	**70,104**	**61,431**	**56,728**	**52,627**	**48,768**	**50,462**	**49,272**	**49,423**	**49,706**	**49,743**
Total (without CO_2 from LUCF) [6]	**72,530**	**72,530**	**63,857**	**59,154**	**55,053**	**52,003**	**53,697**	**53,505**	**53,509**	**51,389**	**52,370**

Categories of GHG emissions and sinks	Base year [1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)										
Energy sector	57,771	57,771	51,327	47,373	44,522	41,439	42,756	43,383	43,594	41,852	43,099
Industrial processes	4,731	4,731	3,755	3,901	3,662	4,045	4,271	3,415	3,546	3,658	3,704
Utilisation of solvents	0	0	0	0	0	0	0	0	0	0	0
Agriculture	7,860	7,860	6,662	5,810	4,878	4,541	4,679	4,579	4,392	4,070	3,731
Forest ecosystems [7]	–2,345	–2,345	–2,345	–2,345	–2,345	–3,173	–3,173	–4,211	–4,038	–1,670	–2,612
Waste	2,088	2,088	2,032	1,989	1,909	1,916	1,929	2,106	1,930	1,796	1,821
Other	0	0	0	0	0	0	0	0	0	0	0

[6] Information in this line is provided for better comparison among countries, with regard to different methods for determination of CO_2 emissions and sinks from forest ecosystems; LUCF = Land-Use Change and Forestry.

[7] Net emissions.

New gases, total	272	272	267	249	156	144	148	91	114	80	93

Table 10 *Trends of CO_2 emissions – Slovakia 1999*

Categories of GHG emissions and sinks	Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				(Gg)							
1. Energy sector	**55,724**	**55,724**	**49,487**	**45,731**	**42,907**	**39,802**	**41,062**	**41,628**	**41,803**	**40,089**	**41,326**
A. Fossil fuel combustion (RA)	55,724	55,724	49,487	45,731	42,907	39,802	41,062	41,628	41,803	40,089	41,326
1. Power and heat generation	50,654	50,654	45,061	41,615	38,878	35,613	36,846	37,464	37,212	35,139	36,505
2. Combustion in industry	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3. Transport	5,070	5,070	4,426	4,116	4,029	4,189	4,216	4,164	4,591	4,950	4,821
4. Other sectors	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
5. Others	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid fuels											
2. Oil and natural gas											
2. Industrial processes	**3,882**	**3,882**	**2,945**	**3,161**	**3,093**	**3,249**	**3,408**	**3,249**	**3,354**	**3,505**	**3,549**
A. Mineral products	3,882	3,882	2,945	3,161	3,093	3,249	3,408	3,249	3,354	3,505	3,549
B. Chemical industry	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
C. Metallurgy	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
D. Other production	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
E. Production of halocarbons and SF_6											
F. Consumption of halocarbons and SF_6											
G. Others	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3. Solvents and other products	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4. Agriculture	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric fermentation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Animal waste	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Rice production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Savannah burning off	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Combustion of agricultural remainders	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Others	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

continued on next page

Table 10 *Trends of CO_2 emissions – Slovakia 1999*

Categories of GHG emissions and sinks	Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
5. Land change and forests	**–2,426**	**–2,426**	**–2,426**	**–2,426**	**–2,426**	**–3,235**	**–3,235**	**–4,233**	**–4,085**	**–1,683**	**–2,627**
A. Changes of forest and other stock of wood biomass	–401	–401	–401	–401	–401	–1,056	–1,056	–2,149	–2,245	185	–684
B. Conversion of forest, meadows and pastures	141	141	141	141	141	126	126	111	111	131	140
C. Recultivation of land used for economic purposes	–1,352	–1,352	–1,352	–1,352	–1,352	–1,371	–1,371	–1,391	–1,405	–1,407	–1,415
D. CO_2 emissions and sinks from soil	–814	–814	–814	–814	–814	–934	–934	–804	–547	–592	–669
E. Forest fires and combustion of post-harvest remainders											
6. Waste	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
A. Solid waste storage											
B. Waste water	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Waste combustion	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
D. Others	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Others *(to be specified)*	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (with net CO_2 emissions/sinks)	**57,180**	**57,180**	**50,007**	**46,466**	**43,574**	**39,816**	**41,235**	**40,644**	**41,072**	**41,911**	**42,248**
Total (without CO_2 from LUCF) (6)	**59,606**	**59,606**	**52,432**	**48,892**	**46,000**	**43,051**	**44,470**	**44,877**	**45,157**	**43,594**	**44,875**
Memo Items:											
International transport	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Air	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Maritime	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Multilateral operations	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
CO_2 emissions from biomass combustion	**1,686**	**1,686**	**1,382**	**1,253**	**720**	**717**	**326**	**316**	**349**	**303**	**269**

Legend to table: NO – not occurring, NE – not estimated, IE – included elsewhere.

Table 10 *Trends of CH_4 emissions – Slovakia 1999*

Categories of GHG emissions and sinks	Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				(Gg)							
Total Emissions	**322**	**322**	**294**	**268**	**250**	**244**	**248**	**254**	**241**	**223**	**222**
1. Energy sector	**85**	**85**	**77**	**69**	**68**	**68**	**70**	**72**	**73**	**71**	**71**
A. Fossil fuel combustion (RA)	17.33	17.33	14.88	13.43	11.69	10.70	9.48	9.80	9.48	8.87	9.31
1. Power and heat generation	16.39	16.39	13.98	12.54	10.69	9.83	8.67	8.63	8.41	7.74	8.21
2. Combustion in industry											
3. Transport	0.94	0.94	0.90	0.90	1.00	0.87	0.81	1.18	1.07	1.13	1.10
4. Other sectors											
5. Others											
B. Fugitive emissions from fuels	68	68	62	55	57	57	60	63	64	62	62
1. Solid fuels	33.40	33.40	29.00	24.70	24.80	25.40	26.30	26.80	27.40	27.70	26.20
2. Oil and natural gas	34.70	34.70	33.10	30.40	31.70	31.50	34.10	35.70	36.10	34.40	35.50
2. Industrial processes	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
A. Mineral products	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metallurgy	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Other production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Production of halocarbons and SF_6											
F. Consumption of halocarbons and SF_6											
G. Others	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvents and other products	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
4. Agriculture	**135**	**135**	**118**	**103**	**88**	**83**	**85**	**81**	**75**	**67**	**64**
A. Enteric fermentation	116.3	116.3	100.89	86.83	73.94	69.21	70.80	67.86	62.36	55.99	53.60
B. Animal waste	18.85	18.85	17.50	15.82	14.51	13.73	13.87	13.38	12.27	10.86	10.40
C. Rice production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Savannah burning off	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Combustion of agricultural remainders	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Others	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land change and forests	**3.20**	**3.20**	**3.20**	**3.20**	**3.20**	**2.35**	**2.35**	**0.89**	**1.86**	**0.53**	**0.61**
A. Changes of forest and other stock of wood biomass	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Conversion of forest, meadows and pastures	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Recultivation of land used for economic purposes	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. CO_2 emissions and sinks from soil	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Forest fires and combustion of post-harvest remainders	3.20	3.20	3.20	3.20	3.20	2.35	2.35	0.89	1.86	0.53	0.61
6. Waste	**98**	**98**	**96**	**94**	**90**	**91**	**91**	**100**	**91**	**85**	**88**
A. Solid waste storage	50.27	50.27	50.27	50.27	50.27	50.27	50.89	59.60	50.99	45.80	46.54
B. Waste water	48.19	48.19	45.52	43.69	40.05	40.36	40.38	40.04	40.31	39.11	39.63
C. Waste combustion	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
D. Others	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Others *(to be specified)*	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:											
International transport	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Air	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Maritime	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Multilateral operations	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
CO_2 emissions from biomass combustion											

Table 10 *Trends of N_2O emissions – Slovakia 1999*

Categories of GHG emissions and sinks	Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					(Gg)						
Total Emissions	**18.98**	**18.98**	**16.05**	**14.12**	**11.75**	**11.92**	**12.47**	**10.33**	**10.26**	**9.76**	**8.86**
1. Energy sector	**0.82**	**0.82**	**0.72**	**0.65**	**0.59**	**0.70**	**0.73**	**0.76**	**0.83**	**0.88**	**0.91**
A. Fossil fuel combustion (RA)	0.82	0.82	0.72	0.65	0.59	0.70	0.73	0.76	0.83	0.88	0.91
1. Power and heat generation	0.60	0.60	0.52	0.46	0.43	0.40	0.40	0.39	0.38	0.35	0.37
2. Combustion in industry											
3. Transport	0.21	0.21	0.20	0.19	0.16	0.31	0.34	0.37	0.45	0.53	0.54
4. Other sectors											
5. Others											
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid fuels											
2. Oil and natural gas											
2. Industrial processes	**1.86**	**1.86**	**1.75**	**1.59**	**1.33**	**2.10**	**2.31**	**0.24**	**0.25**	**0.24**	**0.20**
A. Mineral products											
B. Chemical industry	1.86	1.86	1.75	1.59	1.33	2.10	2.31	0.24	0.25	0.24	0.20
C. Metallurgy											
D. Other production											
E. Production of halocarbons and SF_6											
F. Consumption of halocarbons and SF_6											
G. Others	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvents and other products	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
4. Agriculture	**16.20**	**16.20**	**13.47**	**11.79**	**9.75**	**9.03**	**9.36**	**9.27**	**9.11**	**8.60**	**7.70**
A. Enteric fermentation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Animal waste	3.61	3.61	3.26	2.84	2.45	2.29	2.32	2.24	2.05	1.80	1.73
C. Rice production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils	12.59	12.59	10.21	8.95	7.30	6.74	7.04	7.03	7.06	6.80	5.97
E. Savannah burning off	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Combustion of agricultural remainders	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Others	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land change and forests	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.04**	**0.04**	**0.01**	**0.03**	**0.01**	**0.01**
A. Changes of forest and other stock of wood biomass	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Conversion of forest, meadows and pastures	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Recultivation of land used for economic purposes	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. CO_2 emissions and sinks from soil	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Forest fires and combustion of post-harvest remainders	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.01	0.03	0.01	0.01
6. Waste	**0.07**	**0.07**	**0.07**	**0.05**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**
A. Solid waste storage											
B. Waste water	0.07	0.07	0.07	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04
C. Waste combustion	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
D. Others	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Others *(to be specified)*	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:											
International transport	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Air	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Maritime	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Multilateral operations	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
CO_2 emissions from biomass combustion											

Table 10 *Trends of emissions (HFCs, PFCs and SF_6) – Slovakia 1999*

Categories of GHG emissions and sinks	Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Substance	GWP
							(Gg)						
Emissions of HFCs – CO_2 equivalent (Gg)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2.91**	**24.52**	**44.86**	**69.83**	**43.58**	**66.01**	HFCs	
HFC-23	NO	NO	NO	NO	NO		0.0000014	0.00007	0.00007	0.00005	0.00005	HFC-23	11700
HFC-32	NO	NO	NO	NO	NO			0.00002	0.00011	0.00007	0.0001	HFC-32	650
HFC-41	NO	NO	NO	NO	NO							HFC-41	150
HFC-43-10mee	NO	NO	NO	NO	NO							HFC-43-10mee	1300
HFC-125	NO	NO	NO	NO	NO		0.00000912	0.00008	0.00026	0.00043	0.00076	HFC-125	2800
HFC-134	NO	NO	NO	NO	NO							HFC-134	1000
HFC-134a	NO	NO	NO	NO	NO	0.000007	0.01098	0.02545	0.04180	0.02918	0.04443	HFC-134a	1300
HFC-152a	NO	NO	NO	NO	NO			0.0000017	0.00014	0.00032	0.000608	HFC-152a	140
HFC-143	NO	NO	NO	NO	NO							HFC-143	300
HFC-143a	NO	NO	NO	NO	NO			0.00012	0.00031	0.00046	0.000804	HFC-143a	3800
HFC-227ea	NO	NO	NO	NO	NO	0.0010	0.0035	0.0035	0.0044	0.0007	0.000803	HFC-227ea	2900
HFC-236fa	NO	NO	NO	NO	NO							HFC-236fa	6300
HFC-245ca	NO	NO	NO	NO	NO							HFC-245ca	560
Emissions of PFCs – CO_2 equivalent (Gg)	**271.94**	**271.94**	**267.12**	**249.03**	**155.82**	**132.26**	**113.90**	**35.15**	**33.19**	**23.81**	**13.93**	PFCs	
CF_4	0.037	0.037	0.036	0.034	0.021	0.018	0.015	0.005	0.005	0.003	0.002	CF_4	6500
C_2F_6	0.0037	0.0037	0.0036	0.0034	0.0021	0.0018	0.0015	0.0005	0.0004	0.0003	0.0002	C_2F_6	9200
C_3F_8												C_3F_8	7000
C_4F_{10}												C_4F_{10}	7000
$c\text{-}C_4F_8$												$c\text{-}C_4F_8$	8700
C_5F_{12}												C_5F_{12}	7500
C_6F_{14}												C_6F_{14}	7400
Emissions of SF_6 – CO_2 equivalent (Gg)	**0.03**	**0.03**	**0.03**	**0.04**	**0.06**	**9.27**	**9.91**	**10.76**	**11.34**	**12.24**	**12.68**	SF_6	23900
SF_6	0.000001	0.000001	0.000001	0.000002	0.000003	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005		

P.2 Chapter 4

Policy and measures to mitigate greenhouse gas emissions

Characteristics of new gas emissions – HFCs, PFCs and SF_6,

Under the term *New gases* we analyse emissions of substances which can be classified by their effect to greenhouse gases, but prior to COP3 in Kyoto they were not taken into account in the inventory and projections of GHG. This category consists of the following gases:

P.2.1 Partially fluorinated hydrocarbons HFCs

They are used as:

- coolants, individually or in mixtures,
- extinguishing agents,
- insulation gases,
- detection gases, solvents, detergents
- aerosols,
- blowing agents,
- sterilizers, sterile mixtures.

This subcategory includes:

HFC 23 CHF_3 – trifluormethane
As an extinguishing agent for stable extinguishers, it has not been used in the Slovak Republic and no request for its approbation was presented. As a coolant it is used in cooling systems at low temperatures and as a component in mixtures of coolants R503 and R508. An expected slight increase in R23 consumption has not been confirmed yet.

HFC 152a $C_2H_4F_2$ 1,1 – difluorethane
Component in cooling mixtures 401A, B, C replacing the coolant R12; aerosol, blowing agent of PUR polystyrene. A slight increase of consumption as a component in coolant mixtures is expected by 2000.

HFC 32 CH_2F_2 – difluormethane
Coolant in heat pumps, component in cooling mixtures R407A, B, C, R504, R410A. In the future its consumption should increase, especially with regard to the perspective mixtures R407C and R410A. Following the years 2008 to 2010, in connection with the higher utilisation of natural coolants, its consumption should not raise any further.

HFC 125 C_2HF_5 – pentafluorethane
Component in cooling mixtures R407A, B, C, R507, R410A, R402A, B. In the future we expect an increase of its consumption as a significant component of cooling mixtures. After the years 2008 to 2010, in connection with the higher utilisation of natural coolants, its consumption should not rise any further.

HFC 143a $C_2H_3F_3$ 1,1,1 – trifluorethane
Blowing agent in polystyrene, polyolefin, coolant, component in cooling mixtures R507, R404A. We expect an increase of its consumption as a component of the said cooling mixtures, which may gradually substitute the coolant R410A, as well as natural coolants, especially carbon dioxide and ammonium.

HFC 134a CH_2FCF_3 1,1,1,2 – tetrafluorethane
Coolant, extinguishing agent, aerosol, blowing agent for PUR foam, extruded polystyrene, adhesive coats, steriliser, significant component of mixtures R407A, B, C, R404A. We expect a general increase in consumption, particularly in relation to substitution of the coolant R12, and as a coolant in air-conditioning systems in vehicles, until the arrival of the coolant CO_2. As an extinguishing agent it is designed for stable extinguishers. In the Slovak Republic it has not yet been used as an extinguishing agent, but there will be efforts for its approbation, with an expected increase of its consumption.

HFC 227ea C_3HF_7 1,1,1,2,3,3,3 – heptafluorpropane
Coolant, extinguishing agent, aerosol, component of sterile mixtures. As an extinguishing agent it is designed for stable cooling systems. It is approved in the Slovak Republic and actually it constitutes the only alternative under conditions of the Slovak Republic to H 1301 (known under marking FM 100, imported until the end of 1993). The extinguishing agent HFC 227ea is known under the marking FM 200. Its import in the Slovak Republic started in 1994. As a coolant it has not yet been used in the Slovak Republic. In the future, a slight increase of its consumption is expected, in spite of the decrease of consumption observed in 1998.

P.2.2 PFCs – perfluorocarbons

They have been produced for 30 years. They are used in special cooling and heating systems and in the gaseous phase in electrotechnical industry. In the electronics industry they serve as protection from explosion and as insulation and detection gases. In addition, they are used for cleaning, solution, fluor etching in glass production and as extinguishing agents.

PFC14 – CF_4 – perfluormethane

PFC116 – C_2F_6 – perfluorethane

They are developed as by-products in aluminium production in Žiar nad Hronom. PFC 14 is used for fluor etching in glass production.

PFC218 – C_2F_6 – perfluorethane

There is an effort to use PFC 218 experimentally as a component in cooling mixtures.

PFC410 – C_4F_{10} – perfluorbutane

In electronics it is used as protection from explosion, insulation or detection gas. In Slovakia it is still not used as an extinguishing agent for stable extinguishers, but there will probably be an effort for its approbation.

PFC318 – c-C_4F_8 – perfluorcyclobutane

There will be an effort for approbation of PFC318 for cleaning and solution purposes as one of the substitutes for 1,1,1 – trichlorethane.

P.2.3 SF_6 – sulphur hexafluoride

Its useful life is up to 3200 years, GWP (100 years) to 23,900 [kgCO_2/kg] – it is used as an extinguishing agent in electronics, protection from explosion, insulation, sterilising, detection gas, for founding Al and Mg, in tobacco production. In addition to its utilisation as a substitute for halons, it is used up to 80% as an insulant in HV and LV electrical equipment due to the higher protection and reduction of dimensions of this equipment, and up to 10% as metals finish etc. One HV interrupter installation may contain several thousand kg of SF_6. At temperatures above 400 °C high-toxic products occur. An alternative for lower voltage is vacuum and air. In the past it was used in Slovakia in older types of extinguishers and in aluminium production. Currently it is used mostly as an insulation gas in HV switchboards, in HV switches, especially in Slovak power plants, with expected leakage of 1% of charge per year. The charge is dimensioned for a useful life of 30 years without recharging. In the company Nitrasklo, s.r.o., SF_6 has been used since 1993, particularly as sound and thermal insulation in windows. It is mixed in proportion 30 to 70 with argon, due to which its consumption is lower and production less expensive, so no increase of its consumption is expected in the future. It is filled in closed cycle, in fact without leakage. In Slovakia, 10kg of 80 kg SF_6 remain in windows every year.

P.3 CHAPTER 5

Projections and evaluation of measure effects

P.3.1 Input data for projections of CO_2 emissions

Table P3.1 *Expected dynamics of GDP growth in constant prices of 1995 [bill. SKK]*

Indicator	1998	2000	2005	2010	2015
GDP total(1) in constant prices of 1995	612.7	634.3	724.7	864.9	1022.2
GDP formation in industry(2) c. p. 1995	142.1	139.4	132.2	137.1	162.1
Share of industry in GDP formation [%]	23.2	22.0	18.2	15.9	15.9

(1) Source: Economic, Environmental and Social Impacts of Early Shutdown of Units V1 in Nuclear Power Plant of Jaslovske Bohunice SE, a.s., Bratislava, 2000.

(2) Source: P. Karász – Prognosis of the Development of Selected Macroeconomic Indicators of Slovak Economy, Economic Consulting, Bratislava, 1998.

Table P3.3 *Annual growth rate of electricity consumption [%]*

Increase level	1999–2005	2005–2010	2010–2015
Minimum	0.76	1.40	2.67
Maximum	2.26	2.50	4.87
Reference	1.50	2.02	2.00

Source: Economic, Environmental and Social Impacts of Early Shutdown of Units V1 in Nuclear Power Plant of Jaslovske Bohunice SE, a.s., Bratislava, 2000.

Table P3.2 *Annual growth rate of heat consumption [%]*

Sector	1995–2000	2000–2005	2005–2010	2010–2015
Industry	0.69	0.08	–0.85	–0.85
District heating	–0.25	0.19	0.00	0.00
of which: – individual heating	–0.65	0.00	0.00	0.00
– centralised DH system	0.33	0.46	0.00	0.00
Total	**0.31**	**1.49**	**–1.84**	**–1.84**

Source: Energy Policy of SR, The Slovak Ministry of Economy, 2000.

Table P3.4 *Expected volumes of crude oil and oil products processing [t/t of crude oil]*

Raw material/Product	1998	1999	2000	2005	2010	2015
Crude oil [k tones]	5,344	5,315	5,134	5,400	5,500	5,600
Gasoline	0.17	0.191	0.257	0.27	0.265	0.268
Diesel oil	0.349	0.342	0.399	0.407	0.4	0.4
Kerosene	0.015	0.008	0.012	0.009	0.009	0.009
Light fuel oil	0.007	0.004	0.005	0.004	0.004	0.004
Heavy fuel oil	0.2	0.19	0.037	0.027	0.027	0.026
Lubricants	0.008	0.0075	0.0075	0.0075	0.0075	0.0075
Bitumene	0.033	0.038	0.032	0.015	0.015	0.015
LPG	0.006	0.004	0.001	0.001	0.001	0.001
Petrochemicals	0.059	0.052	0.062	0.048	0.045	0.036
Plastics	0.047	0.044	0.045	0.057	0.082	0.08

Source: Slovnaft, a.s., Department of strategy and business activities.

Table P3.5 *Overview of measures and key assumptions of modelling their impact on production of* CO_2 emissions

Measure	Sector	Application	2000–2005	2005–2010	2010–2015
Fuel switching	Public	NG for BC	90%		
	Industrial CHP	HC	change to low-sulphur coal		
	DH and services	NG for HFO	100%		
Utilisation of combined cycles(1) (CC)	Industrial CHP	Mono production	126 MWe	283 MWe	440 MWe
		Cogeneration	19 MWe	29 MWe	29 MWe
	Public PP	TEKO	Replacement of sources		
		Heat plants (HP)	preserving the heat / electricity ratio		
		SSEZ	Year of execution 2004		
Utilisation of biomass(2)	Industrial CHP		2–9%	10–18%	19–24%
	Centralised DH and individ. heating		2–9%	10–14%	15–21%
Geothermal energy	Centralised DH(3)	Replacement of HP	102 MWt	229 MWt	255 MWt
Thermal insulation of buildings	Centralised DH	Decrease in energy consumption	0–6%	7–30%	30%
Solar energy(4)	Individual heat supplies		163 TJ	326 TJ	490 TJ
Transfer of outputs to public transport mode	Transport(5)	Gasoline	1.31%	2.00%	1.92%
		Diesel oil	–0.10%	0.70%	0.79%
	Transport(6)	Gasoline	0.14%	1.62%	1.65%
		Diesel oil	0.28%	1.76%	1.83%

(1) Data on installed output correspond to the level in cross years, i.e. 2005, 2010 and 2015.
(2) The level of utilisation represents the volume of primary heat from biomass in relation to total volume of primary produced heat, i.e. steam or hot water (for HP).
(3) Data on heat savings in buildings supplied from CZT systems (centralised district heating systems).
(4) 15% of usable potential should be reached in 2015.
(5) It corresponds to the level without introduction of measures in transport (% represents annual increase of consumption).
(6) The situation after introduction of the considered measure.

Table P3.6 *Level of activity and projections of fugitive CH_4 emissions [Gg CH_4] from coal mining in cross years*

	Measure	2000	2005	2010	2015
Scenario without measures					
Activity	Mt	2.86	3.00	3.10	3.04
CH_4 emissions					
Mining total	Gg CH_4	**20.02**	**20.98**	**21.73**	**21.25**
– Underground activities	Gg CH_4	19.16	20.08	20.80	20.34
– Post-mining activity	Gg CH_4	0.86	0.90	0.93	0.91
Scenario with measures					
Activity	Mt	2.86	1.91	1.94	1.79
CH_4 emissions					
– Mining total	Gg CH_4	**20.0**	**13.4**	**13.6**	**12.5**
– Underground activities	Gg CH_4	19.14	12.80	13.00	11.99
– Post-mining activity	Gg CH_4	0.86	0.57	0.58	0.54
Scenario with additional measures					
Activity	Mt	2.86	1.71	1.66	1.51
CH_4 emissions					
– Mining total	Gg CH_4	**20.02**	**11.96**	**11.60**	**10.58**
– Underground activities	Gg CH_4	19.16	11.45	11.10	10.12
– Post-mining activity	Gg CH_4	0.86	0.51	0.50	0.45

Emission factors for considered activities:

Mining total – 7.0 kg CH_4 / t of coal
Underground activities – 6.7 kg CH_4 / t of coal
Post-mining activity – 0.3 kg CH_4 / t of coal

Table P3.7 *Level of activity and projections of fugitive emissions of CH_4 [Gg CH_4] from crude oil extraction and processing in cross years*

	Measure	2000	2005	2010	2015
Activity					
Extraction	PJ	1.62	1.25	1.04	1.04
Refinery	PJ	215	226	230	234
Storage	PJ	145	146	149	151
CH_4 emissions					
Extraction	Gg CH_4	0.004	0.003	0.003	0.003
Refinery	Gg CH_4	0.16	0.17	0.17	0.17
Storage	Gg CH_4	0.02	0.02	0.02	0.02
Total		**0.184**	**0.191**	**0.194**	**0.198**

Emission factors for considered activities:

Extraction – 0.002650 [kg / GJ]
Refinery – 0.000745 [kg / GJ]
Storage – 0.000135 [kg / GJ]

Table P3.8 *Level of activity and projections of fugitive emissions of CH_4 [Gg CH_4] from natural gas extraction, transit and distribution in cross years*

	Measure	2000	2005	2010	2015
Scenario without measures					
Activity					
Extraction and processing	PJ	9.9	9.2	9.2	9.2
Transit	PJ	3,119.5	3,120.8	3,183.5	3,238.9
Distribution	PJ	237.9	239.1	301.9	357.2
CH_4 emissions					
Extraction and processing	Gg CH_4	0.66	0.62	0.62	0.62
Transit	Gg CH_4	5.30	5.31	5.41	5.51
Distribution	Gg CH_4	35.68	35.87	45.28	53.59
Total		**41.65**	**41.79**	**51.31**	**59.71**
Scenario with measures					
Activity					
Extraction and processing	PJ	9.9	9.2	9.2	9.2
Transit	PJ	3,123.5	3,148.9	3,185.1	3,202.9
Distribution	PJ	241.9	267.2	303.4	321.2
CH_4 emissions					
Extraction and processing	Gg CH_4	0.66	0.62	0.62	0.62
Transit	Gg CH_4	5.31	5.35	5.41	5.44
Distribution	Gg CH_4	36.28	40.08	45.51	48.18
Total		**42.25**	**46.06**	**51.55**	**54.25**
Scenario with additional measures					
Activity					
Extraction and processing	PJ	9.9	9.2	9.2	9.2
Transit	PJ	3121.4	3136.3	3154.4	3167.0
Distribution	PJ	239.7	254.6	272.7	285.4
CH_4 emissions					
Extraction and processing	Gg CH_4	0.66	0.62	0.62	0.62
Transit	Gg CH_4	5.31	5.33	5.36	5.38
Distribution	Gg CH_4	35.96	38.19	40.91	42.80
Total		**41.93**	**44.14**	**46.89**	**48.81**

Emission factors for considered activities:

Extraction and processing – 0.002650 [kg/GJ]
Transit – 0.000745 [kg/GJ]
Distribution – 0.000135 [kg/GJ]

P.3.2 Projections of new gas emissions – description of method

Approximation of direct and aggregated emissions of new gases was based on assumptions of the trends of coolant consumption, according to the existing development characterised by the decline of coolants and CFCs, HCFCs and the arrival of HFCs coolants. The following analyses have served as a basis:

- Development of reduction of CFCs and HCFCs coolants in charges of equipment, in stock with share of recycling in relation to emissions.
- Approximation of the development of total consumption and emissions of halogenated coolants until 2008.
- Approximation of the development of total consumption and emissions of individual halogenated coolants until 2008.

Based on the stated analyses, conditions for control of projection of HFC coolant up to 2015 were created using total sums of purchased and accumulated CFC, HCFC and HFC coolants.

The purchase, emission factor, depreciation of equipment and level of coolant recycling determine the accumulation of coolants in equipment, which according to the projection, should not exceed the value of 600 tones in 2015, which is the approximate level of coolants in equipment in 1990. Considering the arrival of natural coolants and reduction of charges of coolants in equipment in relation to achieved cooling output, this is adequate space for extension of the utilisation of cooling and air-conditioning systems.

The decrease of purchase of affected coolants is expected only after 2010, because of saturated demand for new equipment with HFC coolants, following removal of CFC and HCFC coolants and the expected more significant utilisation of natural coolants after completion of the development of equipment with such coolants and after their introduction in series production. We are referring mainly to CO_2 coolant in air-conditioning system of vehicles and in heat pumps and to pure hydrocarbons in domestic, medium cooling in heat pumps etc. The share of ammonium and water may increase by their utilisation in lower cooling outputs.

This development may be particularly affected by:

- faster arrival and more significant utilisation of natural coolants already in the years 2005–2010,
- faster arrival and more significant utilisation of HFC coolants in the substitution of CFC coolants with culmination of accumulated HFC coolants in equipment already in the years 2002–2008, subject to intensive development of Slovak economy,
- emission factor,
- level of coolant recycling for repairs and liquidation of equipment.

The first two impacts would transfer culmination of HFC coolant consumption to the years 2002–2008 and accelerate the more significant reduction of their consumption already after the year 2010. These impacts could also influence the shares of individual HFC coolant in total volume, where the arrival of the coolant R410A will probably play the dominant role.

The third and fourth effect – higher emission factor and failed assurance of coolant recycling – in both cases would lead to an increase of HFC coolant consumption. The projections until 2015 count on a significant reduction of the emission factor depending on plans of cooling and air conditioning system manufacturers and the prepared legislation in relation to regular controls of technical condition and the ban on emission of HFC coolant in the atmosphere. If the implementation of these plans in the Slovak Republic fails, total consumption of HFC coolants could increase by about 10 to 30%.

Table P3.9 *Basic assumptions and results of CO_2 sinks balance for the reference level*

	Measure	2000	2005	2010	2015
Timber exploitation	m^3	5,411,000	5,926,079	6,051,304	6,000,000
conifers	m^3	2,976,050	3,259,343	3,328,217	3,300,000
broad-leaved	m^3	2,434,950	2,666,736	2,723,087	2,700,000
conifers	%	55	55	55	55
broad-leaved	%	45	45	45	45
LPF – growth soil	ha	1,922,000	1,930,000	1,935,000	1,940,000
Growth soil– conifers	%	40.9	40.7	40.5	40
Growth soil– broad-leaved	%	59.1	59.3	59.5	60
Annual deforestation	ha	1,000	1,500	1,500	1,500
Forest fires	kt	1	2	2	2
Combustion of biomass	kt	79	87	89	88
conifers	kt	24	26	27	27
broad-leaved	kt	55	61	62	61
Permanent grass cover	ha	856,000	830,000	793,000	790,000
Arable land	ha	1,460,000	1,380,000	1,325,000	1,300,000
Other areas	ha	665,604	763,604	850,604	873,604
Changes in forests	Gg CO_2	–2,276	–1,614	–1,562	–1,808
Forest conversion	Gg CO_2	262	342	276	275
Changes of soil stored carbon	Gg CO_2	–626	–164	185	348
CO_2 balance	**Gg CO_2**	**–2,640**	**–1,436**	**–1,101**	**–1,185**

Table P3.10 *Basic assumptions and results of the CO_2 sinks balance for the measure "Soil Protection" (min. and max. scenarios)*

	Measure	2000	2005	2010	2015
Base-line					
LPF – growth soil	ha	1,922,000	1,930,000	1,935,000	1,940,000
Permanent grass cover	ha	856,000	830,000	793,000	790,000
Arable land	ha	1,460,000	1,380,000	1,325,000	1,300,000
Other areas	ha	665,604	763,604	850,604	873,604
Minimum scenario					
LPF – growth soil	ha	1,922,000	1,931,000	1,937,000	1,943,000
Permanent grass cover	ha	856,000	829,000	791,000	787,000
Arable land	ha	1,460,000	1,390,000	1,345,000	1,330,000
Other areas	ha	665,604	753,604	830604	843,604
Maximum scenario					
LPF – growth soil	ha	1,922,000	1,931,000	1,937,000	1,943,000
Permanent grass cover	ha	856,000	829,000	791,000	787,000
Arable land	ha	1,460,000	1,400,000	1,365,000	1,360,000
Other areas	ha	665,604	743,604	810,604	813,604
Baseline	Gg CO_2	**–2,640**	**–1,436**	**–1,101**	**–1,185**
Balance of CO_2 – MIN.	Gg CO_2	**–2,640**	**–1,509**	**–1,152**	**–1,284**
Balance of CO_2 – MAX.	Gg CO_2	**–2,640**	**–1,524**	**–1,181**	**–1,327**
Difference – minimum	Gg CO_2	0	–73	–51	–99
Difference – maximum	Gg CO_2	0	–88	–80	–142

Table P3.11 *Basic assumptions and results of CO_2 sinks balance for the measure "Regulation of Timber Extraction" (min. and max. scenarios)*

	Measure	2000	2005	2010	2015
Timber exploitation	m^3	5,411,000	5,926,079	6,051,304	6,000,000
conifers	m^3	2,976,050	3,259,343	3,328,217	3,300,000
broad-leaved	m^3	2,434,950	2,666,736	2,723,087	2,700,000
Scenario – minimum	m^3		3,159,343	3,128,217	3,000,000
	m^3		2,566,736	2,523,087	2,400,000
Scenario – maximum	m^3		3,059,343	3,028,217	2,900,000
	m^3		2,466,736	2,423,087	2,300,000
Baseline	**Gg CO_2**	**–2,640**	**–1,436**	**–1,101**	**–1,185**
Balance of CO_2 – MIN.	**Gg CO_2**	**–2,640**	**–1,766**	**–1,761**	**–2,175**
Balance of CO_2 – MAX.	**Gg CO_2**	**–2,640**	**–2,096**	**–2,091**	**–2,505**
Difference – minimum	Gg CO_2	0	–330	–660	–990
Difference – maximum	Gg CO_2	0	–660	–990	–1,320

Tab. P3.12 *Basic assumptions and results of CO_2 sinks balance of for the measure "Afforestation of Non-Forest Areas" (min. and max. scenarios)*

	Measure	2005	2010	2015
Minimum	ha	5,000	15,000	30,000
Maximum	ha	7,000	20,000	40,000
Minimum	tC	–369	–2,655	–8,556
Maximum	tC	–516.6	–3,540	–11,408
Balance of CO_2 – minimum scenario	**Gg CO_2**	**–1.4**	**–9.7**	**–31.4**
Balance of CO_2 – maximum scenario	**Gg CO_2**	**–1.9**	**–13.0**	**–41.8**

The sign "–" means the increase of carbon sinks in biomass of forest tree species.

Table P3.13 *Quantitative assumptions of scenarios of CH_4 production from waste – parameters in relation to the year 1998*

Expected representation of biologically degradable waste against the year 1998 [%]	2000	2005	2010	2015
Scenario 1 – without measures	100	100	100	100
Scenario 2 – low impact of measures	100	100	95	90
Scenario 3 – medium impact of measures	100	95	90	85
Scenario 4 – high impact of measures	100	90	75	60
Expected amount of waste [kt] (1)	63.9	67.1	70.3	73.5
Share of bio – gas combustion [%]				
Scenario 1 – without measures	0	0	0	0
Scenario 2 – low impact of measures	0	5	10	15
Scenario 3 – medium impact of measures	0	5	15	25
Scenario 4 – high impact of measures	0	10	25	40

(1) An increase in the volume of communal waste, but also an increase in the share of waste combustion are expected. These two factors act against each other, so their final effect is not included in the projection of scenarios. For waste originating from industrial activities, which contain a large share of biologically degradable waste (paper, textile, wood and foodstuff industries and agriculture), we expect an increase of waste volume of 5%, 10% and 15% for time horizons of 2005, 2010and 2015, respectively. In this respect we expect reduction of the share of biological waste after introduction of legislative measures (harmonisation of legislation with EU).

Table P3.14 *Quantitative assumptions of scenarios of CH_4 production from sewage water – parameters in relation to the year 1998*

Share of population connected to sewerage system [%]	2000	2005	2010	2015
Scenario 1 – without measures	54	54	54	54
Scenario 2 – low impact of measures	54	55	57	60
Scenario 3 – medium impact of measures	54	57	63	70
Scenario 4 – high impact of measures	54	60	70	80
Number of inhabitants [thous.]		5,420	5,399	5,346
Share of used gas from sludge digestion [%]				
Scenario 1 – without measures	10	10	10	10
Scenario 2 – low impact of measures	10	10	15	20
Scenario 3 – medium impact of measures	10	15	25	35
Scenario 4 – high impact of measures	10	20	35	50

Table P3.15 *Quantitative assumptions of scenarios of CH_4 production from industrial waters – parameters in relation to the year 1998*

Increase of produced organic matter in industrial waste waters against the year 1998 [%]	2000	2005	2010	2015
Scenario 1 – without measures	3	3	6	10
Scenario 2 – low impact of measures	3	3	6	10
Scenario 3 – medium impact of measures	3	3	6	10
Scenario 4 – high impact of measures	3	3	6	10
Share of used bio-gas [%]				
Scenario 1 – without measures	5	5	5	5
Scenario 2 – low impact of measures	5	5	10	15
Scenario 3 – medium impact of measures	5	10	20	30
Scenario 4 – high impact of measures	5	15	30	45

Table P3.16 *Expected number of equivalent inhabitants (EIs) connected to sewerage treatment plants with nitrogen elimination until 2015*

Year	Number of EIs
2000	12,000
2005	200,000
2010	450,000
2015	600,000

Note: The number for the year 2000 corresponds to the number of EIs in the base year 1998.

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