Republic of Bulgaria

The First National Communication on Climate Change

The United Nations Framework Convention on Climate Change

Sofia, February 1996

EXECUTIVE SUMMARY

1. Introduction

The climate of our planet has been changing continuously but while in the past these changes had been natural, now the scientists believe that the industrial and agricultural emissions of carbon dioxide and other gases may cause irreversible change of global climate. The drastic increase of concentration of these gases known as “greenhouse gases” may lead not only to a substantial temperature rise but also to a new climate pattern in the future.

The United Nations Framework Convention on Climate Change (UN FCCC) is the first and major international legal instrument to address climate change issues at a global scale. It was signed in June 1992 at the Rio de Janeiro Earth Summit by more than 150 countries. The Convention entered in force on 21st March 1994. 135 countries have ratified the Convention by June 1995.

Bulgaria signed FCCC in Rio de Janeiro in June 1992 and the Parliament ratified it in March 1995. In compliance with Article 4.6 and 4.2(b) of the FCCC, Bulgaria has adopted as a base year for the anthropogenic emissions of CO2 and other GHG not subject to control by the Montreal Protocol not the emission levels in 1990 but in 1988.

As a Party of FCCC the Republic of Bulgaria announced its target to stabilise emissions of greenhouse gases by 2000 at a level not exceeded that in 1988.

In complience with the FCCC requirements Bulgaria presents the First National Communication to the Conference of the Parties. It comprises all relevant information that concerns the FCCC process in Bulgaria and was developed according to the INC/FCCC Guidelines. The Communication emphasises the efforts Government has made to meet the Convention requirements and the high political priority of environmental problems, especially of the climate change issues in the current national policy.

The First National Communication of Bulgaria was elaborated by the Interministerial Committee supported by independent organisations and experts. The work is co-ordinated by the Ministry of Environment and Energoproekt PLC. The present report was adopted by the Government on 1996.

2. Natural and socio-economic circumstances in the Republic of Bulgaria

The Republic of Bulgaria is a middle-size country situated in the Southeast of Europe on the Balkan peninsula. The surface area of the country is 110 993.6 km^2.

Bulgarian geography profile determines the climate as belonging to the mild continental zone with regular rotation of four seasons. In the eastern and southern parts of the country the climate demonstrates Mediterranean features related to the impact of large water basins. The diversity of terrain altitudes affects the temperature and precipitation schedules and provokes further weather variability.

The average temperatures during the 1983-92 period were about 10-12^{o}C within the range of maximum 42.2^{o}C to minimum - 27.3^{o}C.

The annual precipitation figures for the country are 500-550 mm in some parts of the Danube valley and in Trakia and to 1000-1400 mm in the highest mountain areas.
The population of Bulgaria in 1993 was 8’459’723 inhabitants

Bulgaria is among the countries in transition. As a consequence of this transition process from centrally planned to market economy a drastic decline in GDP is observed with some indications for stabilisation in 1994. The GDP dynamics during the past few year is represented on Figure S.1.1 (1992 prices, exchange rate 1 USD=23.34 BGL).

The Bulgaria GDP growth rate is similar to the rate in some countries as Hungary or Slovak Republic which achieved positive GDP rates in 1994, either.

Major structural changes in the GDP structure took place during the transition period. The service sector passed through a real boom resulting in increase of its share in the GDP from 22% in 1987 to over 38% in recent years. Just the opposite, the industrial sector reduced its share from 61% in 1987 to less than 45%.The structural changes of economy and the drastic decrease in industrial production have resulted in negative social consequences such as increasing unemployment. The level of unemployment is relatively stable about 20% and is among the highest in Europe. The key macroeconomic indicators for Bulgaria concerning the 1990-1994 period are given in Table S.1.1.

Fig. S.1.1. GDP dynamics

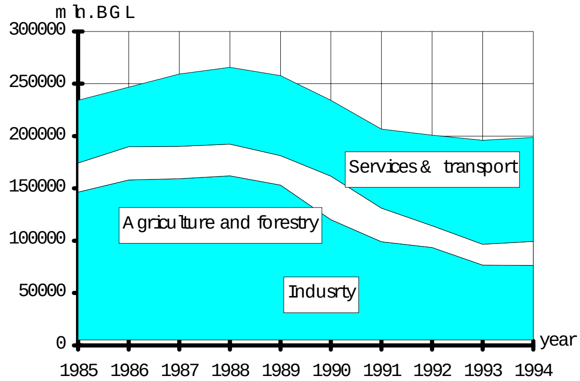


Table S.1.1.Key macroeconomic indicators

		1990	1991	1992	1993	1994
GDP change	%	-9.1	-11.7	-7.3	-2.4	1.4
Inflation (annual)	%	23.8	338.5	79.4	56.1	87.1
Industrial Production	%	-16.8	-22.2	-15.9	-6.9	2.9
Unemployment (end of year)	%	1.5	10.9	15.6	17.0	20.1
Exports	$US mln	2615	3737	3956	3727	3935
Imports	$US mln	3372	3769	4169	4612	3952
Current Account balance	$US mln	-860	-77	-360	-1098	-25
Budget balance	% GDP	-9.5	-5.1	-4.6	-10.9	-6.7
Gross debt	$ billion	10.9	12.0	12.1	12.5	10.4

3. Inventory of greenhouse gas emissions in Bulgaria

The following greenhouse gases are addressed: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O). The emissions of other gases controlled by the Montreal protocol such as chlorofluorocarbons (CFCs) and Halons are also included. Emission data on precursors (NO_x, CO and NMVOCs) are also given in the chapter.

The emission figures for 1988 and 1990 are presented according to the IPCC Guidelines for reporting national greenhouse gas emissions. In addition historical trends are given for all greenhouse gases and precursors.
All emissions are expressed in full molecular mass (e.g. Gg CO_2).

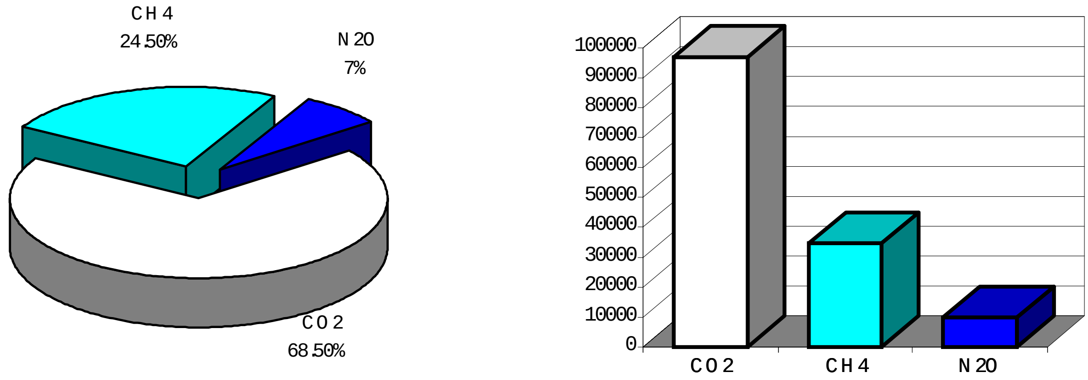
Different GHG have different impact on the global warming. The concept of *Global Warming Potential* (GWP) is used to compare the influence on the climate of other GHG with that of CO_2 on weight-to-weight basis over certain time horizon. The period of 100 years have been chosen for GWP estimates that is near to the estimated mean life-time of CO_2.

Emissions in 1988 and 1990

Data on emissions in 1988 (that is a base year adopted in Bulgaria for the Framework Convention on Climate Change) are given in Table S.3.1. The emissions per capita and per unit GDP are shown in the Table S.3.3.

Table S.3.4 shows the aggregated emissions while considering both the direct and indirect effects of CO_2, CH_4 and N_2O emitted in 1988.

Figure S.3.1. Aggregated greenhouse gas emissions in Bulgaria, 1988



%

Gg

Data on emission of GHG for 1990 which is the internationally accepted base year for Climate Change Framework Convention are given in Table S.3.2

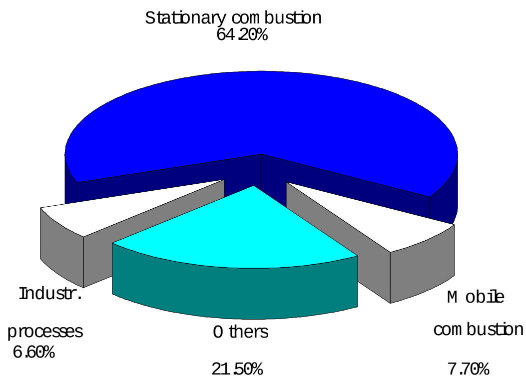
Figure S.3.1 illustrates the aggregated GHG emissions given in Gg CO_2 equivalent and in percent of the total emissions. The results indicate that CO_2 is the most important GHG in Bulgaria, accounting for the 68.5% of the total GHG emissions, followed by methane (24.5%) and nitrous oxide (7%).

The sectorial shares of the aggregated greenhouse gas emissions are shown on Figure S.3.2. The stationary combustion is the most important GHG emission source in Bulgaria. It accounts for 64.2% of the total emissions. Relatively small in comparison with western countries is the mobile combustion share - 7.7%, followed by the emissions from industrial processes - 6.6 %.

Bulgaria electric power system has had electricity exchange with neighbouring countries and the former Soviet Union. The total electricity exchange balance (import 4450 GWh, export 304 GWh) resulted in import of 4146 GWh in 1988.

In order to produce the same quantity of electricity that was imported in 1988 in its own plants the Bulgaria Electric Power System would have to consume more fossil fuel. The least-cost production schedule of the electricity generating units to produce in addition the insufficient electricity shows that an additional CO_2 amount of 6321 Gg CO_2 would have to be emitted.

Figure S.3.2. Sectoral share of aggregated greenhouse gas emissions in Bulgaria, 1988



CO_2 emissions by sources are given on Figure S.3.3.

The fossil fuels prevail in the structure of primary energy used in Bulgaria. As a consequence fossil fuel combustion is the most important source of CO_2 in Bulgaria that accounts for 93.9 of the total CO_2 emissions.

Figure S.3.3. CO_2 emissions in Bulgaria in 1988 by sources

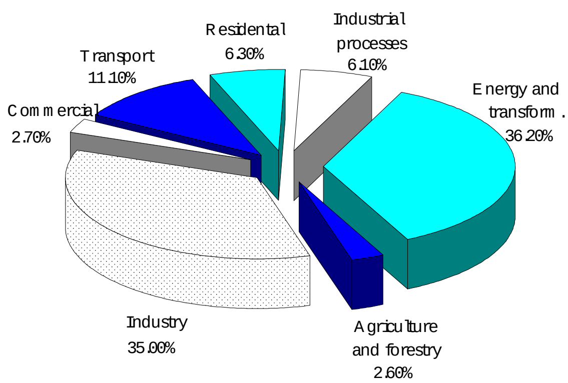


Table S.3.1. Emissions of greenhouse gases in Bulgaria in 1988, Gg

GREENHOUSE GASES	CO_2	CH_4	N_2O	NOx	CO	NMVOC
TOTAL NATIONAL EMISSION	**96878**	**1412.7**	**30.80**	**486.35**	**826.59**	**132.3**
NET NATIONAL EMISSION (including sinks)	**92221**	**1412.7**	**30.80**	**486.35**	**826.59**	**132.3**
1. ALL ENERGY (fuel combustion + fugitive)	**90327**	**371.43**	**6.964**	**485.35**	**789.59**	**68.78**
A Fuel combustion	**90327**	**56.328**	**6.964**	**485.35**	**789.59**	**68.78**
1. Energy&tranformation industry.	35079	0.31	2.713	255.2	58.87	
2. Industry (ISIC)	33881	52.3	3.5	97.3	15.3	
3. Transport (Mobile comb.)	10753	2.84	0.195	88.93	445.9	64.5
4. Small combustion	8941	0.417	0.29	39.784	161.14	4.28
Commercial / institutional	315	0.053	0.066	0.394	1.58	
Residential	6112	0.14		9.11	144.5	
Agriculture / forestry	2513.6	0.224	0.224	30.28	15.06	4.28
5.Others	1672.6	0.041	0.266	3	2.98	
6. Biomass incineration for energy	630	0.42		1.14	105.4	
B Fugitive fuel emission	**0**	**315.1**	**0**	**0**	**0**	**0**
1. Coal mining		113.6				
2. Oil and natural gas systems		201.5				
2. INDUSTRIAL PROCESSES	**5890**	**2.44**	**10.4**	**0**	**0**	**0**
A Iron and steel	172	2.4				
B Non-ferrous metals						
C Inorganic chemicals	1157		10.4			
D Organic chemicals		0.04				
E Non-metallic mineral products	4561					
F Others (methanol)						
3. SOLVENT USE	**0**	**0**	**0**	**0**	**0**	**63.54**
A Paint application						35.9
B Degreasing and dry cleaning						2.14
C Chemical products manufacturing and processing						13.4
D. Others (vegetable oils)						3.11
E. Residential solvent use						8.99
4. AGRICULTURE	**0**	**306.56**	**13.44**	**1**	**37**	**0**
A Enteric fermentation		196.4				
B Animal wastes		102.4				
C Rice cultivation		5.96				
D Agricultural soils			13.44			
E Savannah burning						
F. Agricultural waste burning		1.8		1	37	
G Others						
5. LAND USE CHANGE & FORESTRY	**-4657**	**0**	**0**	**0**	**0**	**0**
A Forest clearing	-4657					
B Grassland conversion						
C Abandonment of managed lands						
D Others						
6. WASTE	**661**	**732.3**	**0**	**0**	**0**	**0**
A Landfills	661	661				
B Waste water treatment		71.3				
C Wastes incineration						
D Others						
7. OTHERS						
International bunkers	162.4					

Table S.3.2. Emissions of greenhouse gases in Bulgaria in 1990, Gg

GREENHOUSE GASES	CO_2	CH_4	N_2O	NOx	CO	NMVOC
TOTAL NATIONAL EMISSION	**82990**	**1370**	**22.46**	**499.3**	**893**	**102.1**
NET NATIONAL EMISSION (including sinks)	**77189**	**1370**	**22.46**	**499.3**	**893**	**102.1**
1. ALL ENERGY (fuel combustion + fugitive)	**76535**	**260.5**	**4.67**	**498.2**	**852**	**67.2**
A Fuel combustion	**76535**	**11.1**	**4.67**	**498.2**	**852**	**67.2**
1. Stationary combustion	64220	8.1	4.43	374.2	415	
2. Transport (Mobile comb.)	12315	3	0.24	124	437	67.2
B Fugitive fuel emission	**0**	**249.4**	**0**	**0**	**0**	**0**
1. Coal mining		155				
2. Oil and natural gas systems		94.4				
2. INDUSTRIAL PROCESSES	**5680**	**2**	**9.62**	**0**	**0**	**0**
A Iron and steel	131	2				
B Non-ferrous metals						
C Inorganic chemicals	1359		9.62			
D Organic chemicals						
E Non-metallic mineral products	4190					
F Others (methanol)						
3. SOLVENT USE	**0**	**0**	**0**	**0**	**0**	**34.9**
A Paint application						23.5
B Degreasing and dry cleaning						
C Chemical products manufacturing and processing						2.4
D. Others (vegetable oils)						
E. Residential solvent use						9
4. AGRICULTURE	**0**	**251.4**	**8.17**	**1.1**	**41**	**0**
A Enteric fermentation		157				
B Animal wastes		88				
C Rice cultivation		4.5				
D Agricultural soils			8.17			
E Savannah burning						
F. Agricultural waste burning		1.9		1.1	41	
G Others						
5. LAND USE CHANGE & FORESTRY	**-5801**	**0**	**0**	**0**	**0**	**0**
A Forest clearing	-5801					
B Grassland conversion						
C Abandonment of managed lands						
D Others						
6. WASTE	**775**	**856.1**	**0**	**0**	**0**	**0**
A Landfills	775	775				
B Waste water treatment		81.1				
C Wastes incineration						
D Others						
7. OTHERS						
International bunkers						

Table S.3.3. Anthropogenic emissions, kg per capita and per 1000 $US GDP, 1988

GAS	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Emission per capita	10780	157.2	3.42	54.1	92.0	14.6
Emissions per 1000 $ GDP	8495	123.9	2.7	42.7	72.5	11.6

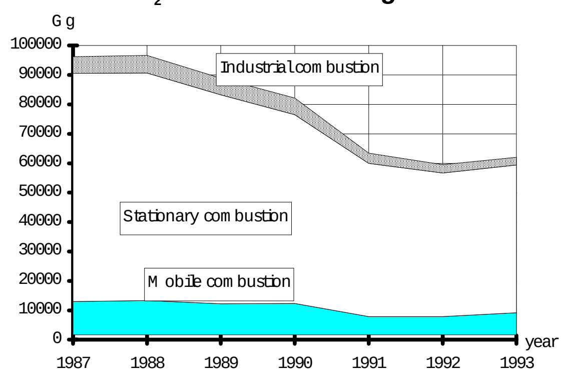
Table S.3.4. Aggregated emissions of CO_2, CH_4 and N_2O in 1988 considering both the direct and indirect effects

	CO_2	CH_4	N_2O	Aggregated
	(Gg)	(Gg CO2 equivalent)		
Total emissions	96878	34612	9856	141347
All energy	90327	9099	2228	101654
incl.:				
Stationary combustion	79574	9029	2166	90769
Mobile combustion	10753	70	62	10885
Industrial processes	5890	60	3328	9278
Others	661	25453	4301	30415

Among the fossil fuel combustion sources of CO_2 the energy transformation industry is the major one. The second important source is transportation sector but its share of 11.1% is smaller compared to the Annex II Parties of FCCC.

The historical trend of CO_2 emissions and their split stationary combustion, mobile combustion and industrial processes in the period 1985-1995 is shown in Figure S.3.4.

Figure 3.4. Historical trend of CO_2 emissions in Bulgaria



CO_2 sinks

About 30% of Bulgaria's area is covered by forests. Data for calculation of forest sink capacity are based on the forests inventories carried out every five years, as well as on statistics for annual forest harvesting. The balance between increment and harvest in 1988 resulted in 4 657 Gg CO2 stored.

Emission of other GHGs

From the group of greenhouse gases controlled by the Montreal Protocol and its annexes only CFCs and Halons are used in Bulgaria.

The estimates on emissions of CFCs and Halons are based on their import and consumption since they are not manufactured in Bulgaria. The data on consumption of these gases by sectors are given in Table S.3.7 for the period 1986-1994.

Table S.3.7. Montreal protocol controlled gases consumption in Bulgaria

User sector	Consumption, Mg					
	1986	**1989**	**1990**	**1992**	**1993**	**1994**
Refrigeration	600	550	515	275	260	256
Foams	1180	1300	750	960	335	335
Solvents	595	330	385	182	205	205
Aerosols	850	700	310	50	55	50
Fire extin-guishing	6	6	11	2	2	2
Total	**3231**	**2886**	**1971**	**1469**	**857**	**848**

Bulgarian share in the global anthropogenic greenhouse gases emissions is approximately 0.4%. The annual CO_2 emissions per capita were 10.8 tons in 1988 and 9.1 tons in 1990. These figures are lower than the OECD average but nevertheless they put Bulgaria among the countries having high per capita emissions.

The data on greenhouse gas emissions presented in this report cannot be considered as final. In Bulgaria the first studies on this problem started in 1992 on the base of the IPCC methodology. With regard to the limited financial resources, the national statistics shortcomings and the specific fuels characteristics more information on sources and emissions can be obtained only step by step.

4. Policies and measures to mitigate ghg emissions

The UN FCCC and the scientific understanding of the greenhouse effect serve to formulate the basic principles of the Bulgarian policy to address climate change. The underlying principles of our national climate change policy lay on the basis of Bulgaria joining the international efforts towards solving climate change problems to the extent that is adequate to both the possibilities of national economy and the options to attract foreign investments that might promote implementation process. In compliance with these principles and because of the grave economic crisis in the county, the measures to be implemented at both national and international level should be as cost-effective as possible.

Legislative framework and environmental strategy

- The principles and legislative instruments to achieve the objectives of the National ecology strategy are formulated in the **Environmental Protection Act** adopted in 1991 (State Gazette No. 86/1991) and amended in 1992 (State Gazette No. 84/1992).

The **Clean Air Act** was drafted in 1992-94 and it was adopted by the Parliament in the end of January 1996. In linkage with this act a series of subordinate legislation ordinances have to be elaborated including Ordinance on licensing, Ordinance to regulate the emissions from large stationary installations, Ordinance on the level of critical concentrations, Ordinance for the best techniques to specify the stack height, Ordinance for organisation of National air quality control system, etc.

Although the environmental regulations address only levels of particulate, sulphur dioxide (SO2) and nitrogen oxides (NOx), and does not concern directly the major greenhouse gases - carbon dioxide (CO2) and methane (CH4) as well as precursors it is expected the regulations to have positive impact in suppressing the greenhouse emissions as far as the regulation requirements can be met by increasing overall efficiency of stationary combustion process and by implementation of new technologies.

With regard to the implementation of integrated management of municipal wastes a **National Policy and Program** is under development.

In addition to the National Policy a Draft law addressing waste treatment and technological requirements for landfill construction is elaborated, that includes measures for absorption and detoxification / liquidation of landfill emissions.

National Energy Strategy

As in many countries, in Bulgaria climate change policy and strategies are largely based on the national energy policy due to the high energy intensity of GDP and very high share of greenhouse emissions that originate from energy sector.

The underlying principles of Bulgaria energy policy are consequently elaborated in the **Energy Charter** adopted by the Committee of Energy in 1993 and the **National Energy Strategy by 2020** adopted by the Government on 2 December 1995 and currently being discussed by the Parliament.

The target of the National Energy Strategy is to ensure continuous and high quality energy supply to the economy and households based on the rational use of indigenous and imported energy resources, existing energy units and national scientific and labour potential. This target can be achieved by:

- Reduced energy intensity of GDP through efficient energy production, transmission, distribution and end use consumption;
- Optimal use of indigenous energy resources, such as coal, hydro and renewables to guarantee highest possible level of country energy independence;
- Maximal use of existing energy capacities, extension of technical life-time,

improvement of their technical, economic and environmental indicators by in time rehabilitation and refurbishment;

- Retirement of old units and their replacement by new ones state-of-the-art technologies;
- Completion of construction and engineering works on the units that have been temporarily cancelled through a Governmental decision;
- Emission mitigation and maximal abatement of the adverse environmental impacts caused by energy facilities;
- Improving population life-style through wide application of centralised heating system optimisation, penetration of natural gas supply to the households and better quality of fuel supply;
- Improvement of legislative and regulatory framework;
- Establishing of market orientated energy policy controlled by the Government that will ensure gradual transition to real market driven energy prices and limitation of the natural monopoly;
- Attracting of foreign investments as well as municipal and private capital for rehabilitation of old plants and commissioning of new generation units.

In December 1994 Bulgaria joined the **European Energy Chart** and the **Energy Efficiency Protocol**. For their implementation it is necessary the Government to establish the legal and regulatory framework that will ensure:

- Efficient performance of the market mechanisms in the field of energy production and consumption;
- Overcoming of barriers for energy efficiency improvement and promotion of investment incentives for energy efficiency projects;
- Facilitation of energy efficiency financing.

The draft of **Energy Efficiency Law** was elaborated in 1995 by the Government and it is expected to be adopted by the Parliament in 1996. This law will impetus energy efficiency projects, will increase the overall energy efficiency of economy and as a consequence GHG emissions will be stabilised.

Energy efficiency related projects will be financed using resources allocated in the State Energy Efficiency Fund at lower interest rate (twice lower) and about three years pay-back period.
Another important legislative tool is the Draft **Energy Law** that sets the new institutional and regulatory framework in the energy field.

Regulations

The Regulation No.1 of the Committee of Energy sets the conditions and procedures for licensing an activity in the field of electricity and heat generation (State Gazette No. 14/1992).

In the period to 1998 the following regulations and standards for energy equipment are to be updated in order to meet stronger technical requirements with emphasis to the energy efficiency indicators.

Insulation and standards for buildings

Regulation No.1 from July 28, 1992 (State Gazette 104/1992) sets forth the requirements concerning heat insulation efficiency of the buildings. The analysis indicates that in general Bulgaria heat insulation standards correspond to the EU countries standards and no major changes are needed.

Energy and fuel prices

Changes of structure and the level of energy prices are fundamental to promote energy efficiency, to conserve energy, to reduce GHG emissions emitted at the end-use energy consumption, as well as for reorganisation of the Bulgaria energy sector. At present, when the process of price liberalisation affects all economy, the energy prices are still controlled by the Government. Prices of liquid, solid and gaseous fuel as well as prices for heat and electricity are updated by the Government based on recommendations of the Price Commission or the Committee of Energy.

Imported coal prices for households and industry completely correspond to the international market prices, while indigenous coal prices are subsidised. It is expected the Government to continue subsidising of coal mining due to the national strategic interests and employment issues. Therefore, the introduction of carbon tax is not relevant to the conditions of Bulgaria energy market where the fuels with high carbon content such as coal are subsidised.

Tax system

The tax system is changing now in order to promote energy efficient technologies and technologies aimed to reduce GHG.

In order to harmonise Bulgarian tax and import duty system with the Member States in the European Union, a Regulation No. 237 is issued on 12 December 1995 for adoption of Custom tariff of Republic of Bulgaria (State Gazette 109/15.12.1995) and Regulation No.266 from 29 December 1995 (State Gazette 15/5.01.1996).

The measures that are already in place are related to the import duty concession for efficient equipment, equipment to reduce and prevent air and water pollution, and waste treatment.

The Committee of Energy has put on discussion a set of measures for tax and import duty stimulation of alternative energy sources and energy conservation.
By Law on the Charges for Liquid Fuels for the Republic Road Network Fund and for the National Environmental Protection Fund adopted on 14 February 1996, the level of taxes levied on the production and import of gasoline, diesel and residual with sulphur content over 1% is updated.

Climate change strategy and policy

Bulgaria is in process of establishing a consistent climate change policy to achieve FCCC goals and greenhouse gas emissions reduction target. Contemporary climate change policy is largely based on national energy and environmental policy, but in a near future a systematic national program and action plan will be developed.

Measures and projects to mitigate greenhouse gas emissions

Due to the high energy intensity of Bulgarian economy the greenhouse gas mitigation measures are predominantly aimed to reduce CO_2 emissions and other energy related greenhouse gases. At the same time special attention is given to the transportation sector since major changes in the transportation pattern are expected and as a consequence transport related GHG emissions will grow substantially. The potential of forest to absorb CO_2 emissions and to reduce emissions from agriculture through better management practices is also in focus in this section.

Potential for energy savings

The development pattern that Bulgaria has followed under the conditions of centrally planned economy was highly energy intensive. The energy intensity of GDP was more than twice higher compared to the West European countries due to the prevailing share of industry in the GDP structure.

Energy intensity of economy as a whole is expected to decrease driven by structural changes among economic sectors and within sectors, high prices of energy and penetration of new state-of-art technologies.

Industrial sector that accounts for 52.5% of final energy consumption in 1992 has the highest potential for energy efficiency improvement through measures and specific projects.

Only by reducing industrial energy intensity 15.7% of the current fuel use could be saved.

Renewable sources

The share of renewable sources in the primary energy consumption in Bulgaria is less than 1%. According to the expert judgements the share of the renewable sources will grow up to 7% in 2020. This could be achieved by purposeful Government policy considering renewable sources as economically and technically feasible energy sources.

Programs and projects in energy sector

Series of projects and programs consistent with the objectives of the National Energy Strategy are underway in the energy sector focusing on options to improve energy efficiency to reduce the negative effect of energy sector to the environment and therefore to mitigate greenhouse gas emission.

The major programs and projects are as follows:

⇒ National program for natural gas supply to the households

- The program is developed based on studies carried out by the Energoproekt PLC, Industrial Energy PLC and Haskoning (Netherlands). Two scenarios and time schedules are elaborated: realistic and optimistic. According to the realistic scenario 1’200’000 people or 400’000 households will be supplied with natural gas by 2020, while according to the optimistic scenario they are 2’000’000 people and 670’000 households respectively.

⇒ National program for development of central heating system

The central heating system supplied heat and hot water to 1’550’000 inhabitants or 18% of the total population of the country at the end of 1993. Rehabilitation of existing plants and networks as well as upgrading of co-generation plants (CHP) and heating boilers (HB) by combined cycle natural gas systems is a problem that is considered in the series of feasibility projects.

⇒ PHARE program for Bulgaria energy sector

PHARE program supports a lot of activities, feasibility studies and projects aimed to improve overall energy efficiency, to promote new state-of-the-art technologies and renewable energy technologies. The major projects that are implemented or are underway are listed below. Their total amount is 6'500'000 ÅKU:

⇒ European Union TERMIE special electricity conservation program in Bulgaria

- The program embodies demonstration projects that have to prove the efficiency of technical decisions and measures targeting energy efficiency options in different sectors.

⇒ National program for energy efficiency and economic lighting

The program is elaborated by the Technical University of Sofia under co-ordination and supervision of the National electric company. The first specific project - Replacement of the old 250 W mercury street lighting by 150 W sodium based on this program is already underway.

⇒ Program for energy sector assistance provided to Bulgaria by the US Agency for International Development

The program includes several projects some of which are relevant to the energy efficiency, energy saving and energy demand management.

⇒ Project Energy efficiency demonstration zone in Gabrovo

- The project is prepared by EnEfect and the Municipality of Gabrovo and this is the first project to be financed by the Global Environmental Facility in Bulgaria aimed to support municipal authorities to elaborate and implement energy efficient strategy to reduce greenhouse gas emissions.

⇒ In compliance with the National energy supply side strategy there exists a significant potential for GHG emissions reduction through implementation of projects such as:

- Completion and commitment of NPP Belene by 2002;
- Rehabilitation of existing thermal electricity generating capacities;
- Building of new electricity generating plants on indigenous coal using advanced technologies such as fluidized-bed combustion;
- Reducing of heat and electricity losses in networks;
- Increasing of the share of renewables in the structure of national energy balance;
- Maximal use of existing hydro potential in Bulgaria for electricity generation in conventional and small hydro plants.

Policy and measures in industry

Due to the high energy intensity of the industrial production there are lots of opportunities to implement new technologies that may lead to both energy consumption and GHG emission reduction as well as to mitigation of ozone depleting substances.

A survey of measures is given according to the business programs of different industries (Tzvetanov and others, 1995). It reveals a potential for energy savings in industry of about 44 PJ in the period 1996-2000, that increases to 159 PJ in the period 2016-2020. This potential could be adopted by measures applied in different sectors: iron and steel production, non-ferrous metallurgy, building materials, food processing industry, construction, agriculture.

The successful implementation of the foreseen measures to increase energy efficiency and reduce energy related GHG emissions will strongly depend on the availability of financial resources. The Bulgaria Government will therefore strongly support foreign investments that are proven to be efficient in this field. The Government also encourages voluntary agreements with industry targeting GHG emission reduction.

The **Centre of Energy Efficiency in Industry** created by Government Decree No.397 from 22 September 1995 on the basis of Bulgaria-Japan Government agreement is going to co-ordinate the accelerated implementation of energy efficiency projects. The establishment of general information system in the energy efficiency field is expected as well as commitment of projects on the base of energy researches and observations in particular industrial enterprises.

Transport

There is a special focus on measures in the transport sector because of the expected rapid growth in the sector, change in the transportation pattern with a shift from public to private transport, three to four times increase in fuel consumption by 2020 and as a consequence - steep upward trend of emissions.

Forestry

The realisation of the afforestation in quantitative as well as in qualitative sense, i.e. the combination of gradual change of the coniferous plantations improperly established in the low forest vegetation zone with deciduous and expanding of forest lands through afforestation of devastated lands and establishment of forest shelter belts would bring to a considerable reduction of the CO_2 amounts emitted in the atmosphere.

A **Forestry Development Strategy** is drafted now.

Agriculture

The mitigation measures will penetrate gradually in agriculture managing practice of Bulgaria because the attractive in them is the increase of the effective productivity directly concerning the economical interests of the farmers. In near future it could be expected an improvement of the way of nutrition of the domestic animals as well as of the foods and of the species.

Waste management

Human activities inevitably generate municipal wastes. Currently the only waste treatment is the disposals in landfills. Up to now there exist 2000 such depots most of which are not controlled and technologically improperly designed. There are also lots of small village landfills. The total area used for waste disposal is about 1.5 ha.

The integrated management of the wastes and at first place their reduction and construction of regional centres for their treatment and detoxification require substantial investments which could not be entirely provided by the state and some opportunities for financial support by international institutions and organisations will be seek for.

Ozone depleting substances

Bulgaria has ratified the Vienna Convention to preserve ozone layer and Montreal Protocol to phase out ozone depleting substances (ODS). A **National program for gradual reduction of ODS** mainly Chlorofluorocarbons (CFCs) and Halons that account to 93% of ODS consumption in Bulgaria has been developed and is under implementation. Global Environmental Facility ensures the financial support for the program of about 10.5 million $ US.

5. Greenhouse gas emission projections and evaluation of the effect of some mitigation policies and measures

The most significant contributors to GHG emissions in Bulgaria are the energy production sector and the energy-intensive sectors of the national economy. Therefore, the main effort in the GHG emission forecasting are directed towards these sectors, while the studies that address non-energy sectors are much more limited.

The GHG projections have two main targets:

- To identify whether Bulgaria will be able to meet its obligations in regard to the FCCC;
- To identify the most efficient policies and measures at macro-economic level, sectoral level, utility and enterprise level and household level that may lead to GHG emission reduction.

Three basic scenarios are elaborated - *1) baseline scenario, 2) mitigation scenario and 3) energy policy scenario* with specific assumptions at each stage. The energy policy scenario corresponds to the underlying assumptions and key results given in the National Energy Strategy - section 4.3.1. The baseline scenario and mitigation scenarios are constructed in the way that allows to identify potential effects of policies and measures with special attention to the energy efficiency issues. The baseline scenario is rather *likely-to-be* future scenario than *frozen* efficiency scenario which means that it incorporates all policies and measures adopted before 1993.

Macro-economic projections

The development of macroeconomic scenarios is based on methodology and software designed at the Institute of Economy to BAS. Using this methodology the macroeconomic trends are obtained up to the year of 2020 for both scenarios: base line and mitigation (energy efficiency) scenario.

The general assumptions in building of the two scenarios are as follows:

- Accelerating of the privatisation process and drastic reconstruction of public sector;
- Bulgarian economy will become more attractive for foreign investments;

- International trade increase and diversification of foreign markets for Bulgarian products;
- Expected economic growth of traditional Bulgarian partners - Central and Eastern European countries, neighbouring Balkan countries and EU;
- Assumptions about expected economic growth and GDP dynamics, including moderate rates of investment activity, exchange rate and so on.

Using these assumptions a GDP forecast is accomplished. The results are represented in figures S.5.1 and S.5.2 in constant 1992 BGL prices.

Fig. S.5.1. Structure of the gross domestic product by sectors, million BGL (Baseline scenario)

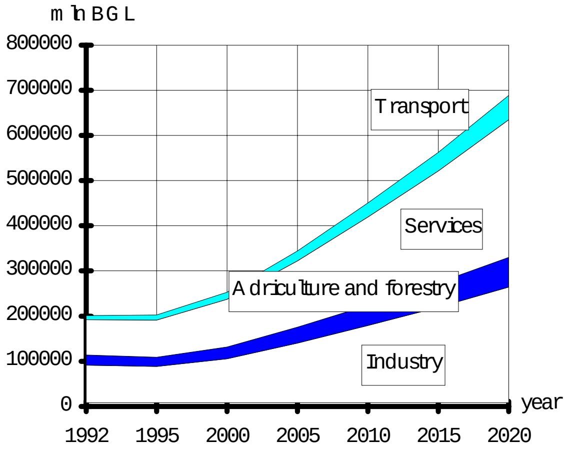
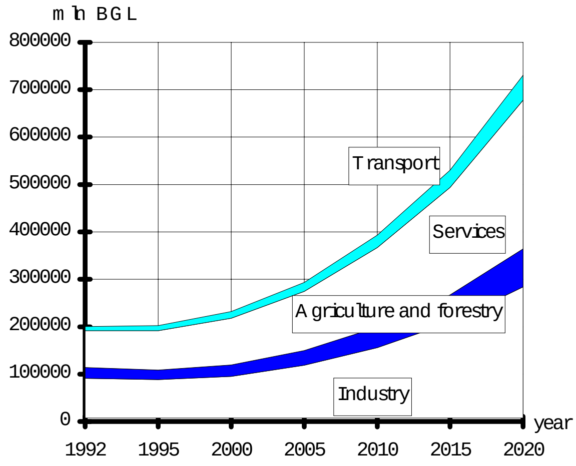


Fig. S.5.2. Structure of the gross domestic product by sectors, million BGL (Mitigation scenario)



In general, the mitigation scenario implies higher investment activities to enable the penetration of new technologies and to increase import that makes it more expensive compared to the baseline scenario.

The four main economic sectors have been analysed as follows: industry (including iron and steel, chemistry, building materials production and others); transport; services (including production, non-production and public sector and commerce); agriculture and forestry.

As a whole, the projected development trends are moderate. It is in accordance with the limited indigenous resources, the foreign trade balance expectations and the financial indicators.

Socio-demography projections

A serious socio-economic problems that arose few years ago and the recent emigration waves have resulted in a substantial decrease of population. Using the demographic tendency analysis and the basic demographic indicators for 1992, a forecast is prepared for the period to 2020 - figure 5.3 and table S.5.1. It predicts a decrease of the Bulgarian population by about 2.7% from 1992 to 2020 with an average annual rate of -0.1%.

Table S.5.1. Socio-demographic forecast

Indicator / Year	1992	1995	2000	2005	2010	2015	2020
Population, 10^3	8484	8416	8379	8358	8321	8283	8253
Number of households, 10^3	3005	3012	3109	3160	3211	3260	3310
Average households size	2.8	3	2.9	2.8	2.7	2.6	2.5
Employment, 10^3							
base-line scenario	3273	3040	2870	2905	3004	2918	2861
mitigation scenario	3273	3040	2849	2880	2930	2960	2990

Projection on the final energy demand

The results obtained at first stage of the analysis in terms of GDP growth rate and structural changes, industrial production values, investment level, import-exports, population growth and employment serve to project the final energy demand.

The mitigation scenario differs from the baseline scenario by higher penetration of new technologies, higher energy efficiency, successful implementation of DSM and maximal number of households supplied by natural gas.

For the four major sectors and the relevant sub-sectors expert judgements are used to identify long-term development of the sector that is consistent with the output of macroeconomic analysis, potential for new technologies penetration, corresponding energy demand, options for fuel substitution and better energy efficiency.

The final energy demand projections for the base-line scenario and for the mitigation scenario are given in tables S.5.2 and S.5.3.

The comparison between the baseline and the mitigation scenarios reveals a substantial energy saving potential of 61 PJ in the year of 2000, 132 PJ in the year of 2010 and 177 PJ in 2020, that could be implemented in case of purposeful governmental policy in regard to energy efficiency

The econometric approach and elasticity parameters are used to project final energy consumption for the energy policy scenario as a function of the projected macro-economic variables consistent with the baseline scenario for development of macro-economy -table S.5.4.

Table S.5.2 Final energy demand projection for base-line scenario, PJ

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuels	81.3	85.6	84.4	83.8	85.3	86.3	87.8
Oil and oil products	117.6	122.5	188.8	249.7	299.6	347.4	389.2
Gaseous fuels	83.3	92.4	106.7	129.5	162.4	200.9	240.8
Electricity	94.3	97.1	103.6	112.9	126.3	140.5	155.7
Heat	121.4	121.8	132.6	153.3	186.1	227.4	273.6
Total	497.9	519.5	616.0	729.3	859.7	1002.5	1147.2

Table S.5.3 Final energy demand projection for mitigation scenario, PJ

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuels	81.3	85.7	81.6	74.5	71.7	70.0	69.9
Oil and oil products	117.6	122.5	170.6	218.5	251.6	284.0	311.2
Gaseous fuels	83.3	92.4	97.4	112.6	129.7	158.2	204.7
Electricity	94.3	97.1	90.4	99.5	113.3	129.9	149.0
Heat	121.4	121.8	113.9	126.5	151.6	181.2	228.5
Total	497.9	519.6	553.9	631.7	718.0	823.2	963.3

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Table S.5.4 Final energy demand projection for energy policy scenario, PJ

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuels	81.3	79.1	84.8	94.0	104.5	115.4	126.3
Oil and oil products	117.6	113.1	139.4	182.0	238.0	302.1	378.4
Gaseous fuels	83.3	79.7	108.3	144.2	181.8	214.0	252.5
Electricity	94.3	97.4	113.4	120.8	128.2	134.8	139.1
Heat	121.4	101.8	113.6	132.4	153.7	176.1	198.5
Total	497.9	471.1	559.5	673.3	806.1	942.4	1094.8

Primary energy demand projections. Long-term development of energy sector

GHG emissions from energy sector depend not only on the final energy consumption but on the structure of energy supply system and the primary energy demand as well. Given the final energy demand growth, it is important to design future development of energy supply system in a way that will minimise its contribution to global warming.

Three scenarios, i.e. baseline, mitigation and energy policy scenarios, and a set of sub-scenarios have been elaborated.

The following options to mitigate GHG emissions are studied in the Communication: increased use of hydropower, renewables, nuclear energy, fuel switching to natural gas, rehabilitation of existing plants and reduction of losses in electricity and heat distribution networks.

The results for primary energy demand forecast for the baseline, mitigation and energy policy scenarios are given in tables S.5.5, S.5.6, S.5.7 respectively.

Table S.5.5 Primary energy demand projection for base-line scenario

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuel	332.7	376.1	322.6	376.8	430.7	441.8	493.3
Oil and oil products	249.5	281.2	376.1	600.3	631.0	699.5	810.0
Gaseous fuel	173.3	178.7	191.3	227.0	247.8	278.7	318.5
Hydro energy	7.6	8.2	8.3	9.6	10.2	10.2	10.2
Nuclear energy	129.7	174.0	212.7	191.4	191.4	222.1	222.1
Imp. electricity	3.9	0.6	0.7	0.8	0.4	0.2	0.2
Total	896.7	1018.7	1111.7	1405.9	1511.4	1652.5	1854.3

Table S.5.6 Primary energy demand projection for mitigation scenario

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuel	332.7	364.5	270.8	259.1	261.0	232.3	240.4
Oil and oil products	249.5	285.3	349.8	429.5	510.8	588.8	675.3
Gaseous fuel	173.3	181.3	154.2	184.7	216.0	259.4	330.4
Hydro energy	7.6	8.3	5.9	9.7	10.5	7.2	6.1
Nuclear energy	129.7	176.3	212.1	191.4	191.4	222.1	222.1
Imp. electricity	3.9	0.6	0.7	0.8	0.4	0.2	0.2
Total	896.7	1016.2	993.5	1075.1	1190.0	1310.0	1474.5

Table S.5.7 Primary energy demand projection for energy policy scenario

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuels	332.7	343.0	350.6	389.1	401.6	378.5	376.5
Oil and oil products	249.5	245.0	291.3	367.0	451.3	563.0	694.2
Gaseous fuel	173.3	135.5	167.6	200.5	250.7	313.3	333.5
Hydro energy	7.6	8.0	9.3	9.4	11.3	16.9	15.6
Nuclear energy	129.7	192.2	245.7	211.5	211.1	180.9	226.6
Imp. electricity	3.9	0.6	0.7	0.8	0.4	0.2	0.2
Total	896.7	924.2	1065.2	1178.4	1326.3	1452.7	1646.6

GHG emission projections

The total GHG emissions are calculated as a sum of energy related emissions and process emissions.

The difference between the levels of GHG emissions for the baseline scenario and the mitigation scenario serves to estimate the effect of all measures incorporated within a single scenario, that is not a simple sum of effect of all measures put together. In order to evaluate the potential contribution of each measures some sub-scenarios have been designed that are compared with the baseline scenario.

CO_2 emission projections

The results for CO_2 emission projections for the three scenarios are given in tables S.5.8, S.5.9 and S.5.10.

Some projections on other GHGs as N_2O and CH_4, as well as on the precursors have been accomplished for the baseline and mitigation scenario following the same assumptions as for CO_2 projections and the same structure of emission resources.

Table S.5.8 SUMMARY TABLE OF THE ÑÎ$_2$ EMISSIONS FORECAST FOR THE BASELINE SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**91560**	**76414**	**62187**	**63518**	**68501**	**88412**	**100948**	**117504**	**132576**
1. Energy sector (combustion and fugitive emissions)			59352	60700	65101	83933	95184	110047	123157
À. Fuel combustion			59352	60700	65101	83933	95184	110047	123157
1. Energy industry and fuel transformation			37665	37871	36831	50003	55843	65240	73262
2. Industry			8021	8767	10134	11990	14705	17479	20635
3. Transport			5972	6689	11026	14970	17914	20813	22929
4. Services			906	895	872	866	876	908	939
5. Agriculture and forestry industry			1074	841	960	1135	1152	1140	1148
6. Households and others			5714	5637	5278	4969	4694	4467	4244
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			2835	2818	3400	4479	5764	7457	9419
À. Iron and steel			93	108	110	134	160	181	194
B. Non ferrous metals									
C. Inorganic chemicals			902	923	1083	1319	1696	2138	2625
D. Organic chemicals									
E. Non-metallic mineral products			1840	1787	2207	3026	3908	5138	6600
F. Others									

Projections on ozone-depleting substances

Projections on the consumption of ozone-depleting substances in Bulgaria are accomplished only for the mitigation scenario because according to the National program, i.e. to phase out consumption of the ozone-depleting substances supported by GEF and the World bank, the quantities of the ozone-depleting substances will gradually diminish by 2001. Estimates on the ODS consumption are given in table 5.24. It is predicted the level of consumption of CFC-22 to increase in the sectors where it will substitute more hazardous substances with higher global warming potential such as CFC-11, CFC-12 and CFC-502.

Summary on the GHG emissions

The projections on the overall GHG emissions is based on the concept of the Global Warming Potential (GWP) within a 100 years time horizon.

Table S.5.9. SUMMARY TABLE OF THE ÑÎ$_2$ EMISSIONS FORECAST THE MITIGATION SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**91560**	**76414**	**62187**	**62720**	**58711**	**66102**	**73448**	**81013**	**95608**
1. Energy sector (combustion and fugitive emissions)			59352	59902	55690	62322	68578	74576	86750
À. Fuel combustion			59352	59902	55690	62322	68578	74576	86750
1. Energy industry and fuel transformation			37665	37131	29521	32548	36000	38519	46484
2. Industry			8021	8712	8591	8967	9922	11825	15097
3. Transport			5972	6689	10527	13889	16238	18204	19492
4. Services			906	895	906	945	940	955	986
5. Agriculture and forestry industry			1074	841	855	973	1030	1096	1102
6. Households and others			5714	5634	5290	5000	4448	3977	3589
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			2835	2818	3021	3780	4870	6437	8858
À. Iron and steel			93	108	104	126	154	177	214
B. Non ferrous metals									
C. Inorganic chemicals			902	923	1014	1172	1506	1938	2597
D. Organic chemicals									
E. Non-metallic mineral products			1840	1787	1903	2482	3210	4322	6047
F. Others									

Table S.5.10 .SUMMARY TABLE OF THE CO_2 EMISSIONS FORECAST FOR THE ENERGY POLICY SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**91560**	**76414**	**62187**	**61412**	**69898**	**85941**	**101197**	**117076**	**133640**
1. Energy sector (combustion and fugitive emissions)			59352	58604	66510	81376	95421	109577	124182
À. Fuel combustion			59352	58484	66360	81199	95205	109313	123894
1. Energy industry and fuel transformation			37665	37138	39861	46403	49728	51933	52186
2. Industry			8021	7542	8579	10352	12275	14119	16122
3. Transport			5972	6028	7337	9938	13189	16932	21385
4. Services			906	799	1248	1417	1373	1288	1235
5. Agriculture and forestry industry			1074	1060	1396	1686	2026	2393	2787
6. Households and others			5714	5755	6937	8520	10236	11901	13905
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			2835	2809	3395	4588	5826	7576	9579
À. Iron and steel			93	78	84	102	123	142	156
B. Non ferrous metals				0	0	0	0	0	0
C. Inorganic chemicals			902	741	868	1141	1460	1834	2240
D. Organic chemicals				0	0	0	0	0	0
E .Non metallic mineral products			1840	1984	2451	3384	4317	5719	7352
F. Others									

Table S.5.11 Total greenhouse gas emissions expressed by GWP values - baseline scenario, Gg

GWP/year	1992	1995	2000	2005	2010	2015	2020
CO_2	62187	63518	68501	88412	100948	117504	132576
CH_4	5081	5267	4929	6174	6884	7538	10123
N_2O	5024	4870	5229	6730	8195	9984	11328
Total	72292	73655	78659	101316	116027	135026	154027

Table S.5.12 Total greenhouse gas emissions expressed by GWP values - mitigation scenario, Gg

GWP/year	1992	1995	2000	2005	2010	2015	2020
CO_2	62187	62720	58711	66102	73448	81013	95608
CH_4	5081	5267	3981	4530	5177	5748	7085
N_2O	5024	4870	4480	5024	5955	6765	8672
Total	72292	72857	67172	75656	84580	93526	111365

The emissions of CO_2, CH_4 and N_2O expressed by their GWP values for both the baseline and the mitigation scenarios are given in tables S.5.11 and S.5.12 respectively.

The analysis of the projected emission quantities indicates a crucial contribution of CO_2 in the total emissions within the range of 86-87% for the baseline scenario and 85.5-87% for the mitigation scenario.

Projections on the forest sink capacity

According to the estimates in Chapter 3, Bulgaria forests had a potential to sequester 5.8% of the total CO_2 emissions in 1988.

There are two options available to increase the forest sink capacity: through transformation of part of the coniferous to deciduous tree species and by expansion of the forest vegetation areas.

Three scenarios are elaborated that allow to estimate the potential impact of these options:

- Scenario for transformation of the coniferous to deciduous forests;
- Scenario for expansion of the forest vegetation areas;
- Mixed scenario, that is a combination of the previous two scenarios.

The highest level of forest sink capacity could be achieved in case of mixed scenario.

In case of implementation of the mixed scenario the capacity of the forest CO_2 sink will increase by 1.430 million tons as this increment could be reached in 2020-2025 (increase of the CO_2 absorption by 0.600 million tons at the expense of qualitative scenario and by 0.830 million tons at the expense of quantitative scenario).

That results in the quantity of the CO_2 absorbed in the next century (in 2020-2025) will be increased compared to the year 1990 by 23%.

Estimation of effect of different GHG mitigation options

Different options for GHG mitigation have been identified and evaluated in regard to their technical feasibility, necessary investments and effect on CO_2 reduction. In general options aim directly or indirectly at fossil fuel combustion reduction and therefore lead to all GHG emission reduction but since CO_2 is the main GHG the options are evaluated versus it.

Energy supply

The emission reduction from electricity and heat generation systems is based on restructuring of production capacities and reduction of losses in electricity and heat transmission and distribution. The impact of some changes in the structure of energy transformation system is also evaluated.

In order to compare the effectiveness of different mitigation options the annual emission reduction potential of the measures and the investment cost to reduce 1 ton of CO_2 per life cycle of a measure are estimated. Table S.5.13 shows energy supply options ranked by specific investment cost per ton CO_2 emission reduction.

The enumerated measures could be combined into an aggregated scenario for the development of electricity system. This scenario would have 4800 MW less produced from coal fired TPP compared to the baseline scenario.

The above mentioned technical and economic assessments of the mitigation measures are based just on the investments required for their

implementation. The financial assessment uses the following indicators:

- average cost of 1 ton CO_2 emission reduction for the 2000-2020 period expressed in $US and calculated as ratio of total emission reduction for the period via the total change of production cost of energy supply due to the mitigation measures within the same time period;

- discounted at year 2000 costs of 1 to CO_2 reduction for 2000-2020 period, calculated as ratio of total emission reduction for the period via the sum of discounted change of production cost of energy supply due to the mitigation measures within the same time period;

Table S.5.13. CO_2 reduction potential and investment cost per ton CO2 emission reduction

No	Measure	Annual potential 10^9 t CO_2	Investment		
			Total 10^6\$US	\$US/t $CO_{2\text{ - life cycle}}$	Life cycle
1	**Reduction of electrical losses**	3.2	91	1.9	15
2	**Reduction of thermal losses**	1.0	50	2.55	20
3	**Upgrading of heat production plants**	3.1	246	4.0	20
4	**Micro-hydro potential**	1.1	275	5.0	50
5	**Hydro power projects**	4.3	1 335	6.2	50
6	**Belene NPP**	9	1 300	8.5	30
7	**TPP rehabilitation**	1.3	585	28.0	15
8	**Fluidized-bed technology**	1.6			30

Table S.5.14 represent the ranking of measures with regard to their financial indices - discounted at constant 2000 prices reduction costs of ton CO_2. The negative value indicates that the measure is efficient even without reduction of CO_2 emissions.

Energy demand

Options aimed to diminish GHG emissions through energy demand are summarised in three groups as follows:

- Demand Side Management (DSM) programs in households and industry,
- Improvement of energy efficiency in industry by improved technology processes and penetration of new advanced efficient technologies,
- Natural gas supply to the households.

A complete DSM implementation in households and industry in Bulgaria would allow conservation of more than 611 million kWh in households and 1137 million kWh in industry

compared to 1992 consumption. The corresponding amounts of CO_2 saved are 855'000 tons CO_2 in household and 1.6 million tons CO_2 in industry. The elements of DSM, their CO_2 emission reduction potential together with investments per unit carbon saved are shown in Table S.5.15 for DSM in households and in Table S.5.16 for DSM in industry.

Energy efficiency increase in industry is one of the most efficient mitigation options that will allow to diminish energy intensity of GDP through drastic improvement and modernisation in all sectors of national economy. The new energy efficient technologies, equipment and devices could allow to save more than 10% in 2000 and 16 of the total final energy demand % in 2020 (Tzvetanov 1995). Preliminary estimates of these measures indicate that they will result in 11.6 million tons CO_2 conserved in 2000 and 34.1 million tons CO_2 conserved in 2020. It is very difficult to assess this option in terms of necessary investments. Estimates on macro-level indicate that the energy efficient development as

a result of drastic improvement and reduction of 7.3 $US/ton CO_2 saved. Modernisation in all sectors of national economy would lead to a decrease of GDP of more than 12% compared to the baseline scenario.

Natural gas supply to the households. This option aims to replace electricity and coal consumption in households with natural gas. The program for household natural gas supply is elaborated and it projects 400’000 households to be supplied by 2020. If the same lifestyle in the households is assumed the CO_2 emission reduction due to the fuel switching will be 3 million tons CO_2 annually at a cost of emission.

Table S.5.14 Financial assessment of mitigation measures

No	Scenario	Reduction potential in 2020 - Mg	Cost of emission reduction	
			Average $US/t CO_2	Discounted $US/t CO_2
1	**Losses reduction**	4.4	-38.2	-11.59
2	**Upgrading**	3.7	-15.41	-5.76
3	**Hydro**	3.2	-39.78	-5.58
4	**Renewable energy**	9.1	3.2	1.56
5	**Nuclear**	13.9	4.72	2.25
6	**Combined cycle**	5.8	11.36	2.58
7	**Aggregated**	23659	-19.83	-4.91

Table S.5.15 DSM in households

Measures	Cost of saved electricity		Reduction potential	Costs of 1 ton CO_2 reduction	
	Average US c/kWh	Discounted d=10% USc/kWh		*Averag e* $US/t	Discounte d d=10% $US/t
1. Plastic to windows	1.2	1.4	36051.12	8.27	9.97
2.Compact fluorescent light	2.4	3.3	76195	17.01	23.43
3. Conversion from electricity to gas (hot water)	2.5	4.1	158760	17.86	29.06
4. Conversion from electricity to gas (space heating)	2.0	4.7	55020	14.29	33.56
5. Additional insulation of boilers	3.1	5.1	46804.8	22.32	36.33
6. Thermostat\regulator	4.0	5.3	75106.5	28.57	37.69
7. More efficient	5.0	5.8	10885	35.71	41.16

incandescent					
8. Economic showers	4.4	5.9	35103.6	31.75	41.87
9. Conversion from electricity to gas (cooking)	4.1	8.1	128860	29.33	57.85
10. Modernisation of the heating elements	6.2	14.5	34090	44.00	103.37
11. Direct load control of boilers	8.3	16.4	11701.2	59.52	117.39
12. High efficiency refrigerators	14.8	29.2	186165	105.82	208.69

Table S.5.16 DSM in industry

Measures	Cost of saved electricity		Reduction potential	Costs of 1 ton CO_2 reduction	
	Average US c/kWh	**Discounted d=10% USc/kWh**		***Average*** **$US/t**	**Discounted d=10% $US/t**
1. Energy audits and analyses of power demand	0.5	0.8	980000	3.57	5.8
2. Changes in the running mode of motors	2.2	3.6	88200	15.71	25.8
3. Effective lighting	2.7	4.3	73500	19.29	31.0
4. Drives and rotating elements improvement	3.3	5.4	147000	23.57	38.7
5. Highly effective motors	4.2	6.8	117600	30.00	48.4
6. Self energy production	3.1	7.3	67200	22.14	52.4
7. System for load control	5	8.1	98000	35.71	58.1
8. Maintenance of the equipment for ventilation and compressed air	5	8.1	19600	35.71	58.1

6. Vulnerability to climate change and adaptive strategies

During the past years of our century, in Bulgaria there is a clearly determined tendency to climatic warming in the winter, due to temperature rise in January and February. In North Bulgaria, as well as in South Bulgaria a relatively monotonous trend to the annual precipitation amounts decrease is observed.

Climatic scenarios for Bulgaria for the next century

The future climate change is usually related to the probable changes in the meteorological weather, which are expected to come due to the CO_2 concentration doubling (2*ÑÎ$_2$). The output results obtained from three GCMs models - CCC, GISS and GFDL for CO_2 concentration doubling show that the average annual air temperature in Bulgaria is expected to rise with 4.0-4.4°Ñ. As concerned to the annual precipitation sums there is no agreement in these simulations models. In spite of this, there is a tendency the precipitation quantity to increase during winter period and a tendency to precipitation deficit during the warm period of the year.

The climatic scenarios for Bulgaria in 2006 and 2036 developed by the GFDL model show average annual air temperature in 2006 and 2036 1.2°Ñ and 2.1°Ñ higher from the temperatures characteristic for the recent climate (1951-1980). For the same period the tendency in the precipitation is to an increase during the cold period (December and January) which compensates in some extend the less precipitation amount during the months from April to September.

Having in mind the existing unclear moments concerning the future climate (especially the regional changes in the precipitation, the climate fluctuations as well as the temporary intervals of climate change), it must be pointed out, that the climatic scenarios in this study can not be used as a prognosis. They are created to help to identify the sensitivity of a particular sector to the climate change.

Climate change influence on forest ecosystems

The analysis on the condition of the forest vegetation from the last decade in Bulgaria show that the coniferous forest vegetation which was widely introduced during the last decades under 800 m a.s.l., i.e. out of its natural habitats, forms very hardly stable forest ecosystems. The main reason is the discrepancy between the ecological conditions (mainly rainfalls) and the requirements of the coniferous tree species

The tendency follows the direction: the high fields of West Bulgaria - North Bulgaria - South Bulgaria - Black Sea Coast - Southern parts of

the country. In this sequence grows the vulnerability of the forest vegetation from the adverse dry climate.

The problem with the discrepancy of the ecological conditions of the forest vegetation is not a new one in Bulgaria forestry. During the last years decay of the conifer plantations (*Pinus sylvestris, P. nigra*, more rarely *Picea abies* and *Pseudotsuga menziesii*) is observed due to the improper introduction of these species in the low part of the country. The main reason for this dangerous phenomenon is the discrepancy between the climatic conditions in this part of the country and the ecological requirements of newly afforestated coniferous species (Raev, 1989). If the projections about the carbon dioxide doubling during the next century come true the ecological conditions in Bulgaria will drastically go worse.

The changes are from “cool temperate moist forest” to “warm temperate dry forest” for North Bulgaria, and for South Bulgaria the “warm temperate dry forest” will remain typical. In the warmest country regions (station Sandansky) “subtropical dry forest” could be expected, which means drastic warming and droughts. Since 60.6% of forests are in the zone below 800 m (Kostov et. all, 1976), it is clear, the biggest part of Bulgarian forests would be vulnerable to the drastic climate change under the eventual doubling of carbon dioxide in the near future.

The changes in the mountain regions of the country (station Smoljan, 1180 m a.s.l.) would pass from “cool temperate wet forest” to “warm temperate moist forest”.

Therefore, a change in the forest strategy is necessary for adaptation of the forest vegetation to the changed ecological conditions in the country.

Climate change influence on agriculture

The increase of temperatures at an effective doubling of the CO_2 concentration leads to the increase of the agroclimatic thermal potential in Bulgaria - longer growing period and bigger amount of effective temperatures during the same time interval. The precipitation amounts increase or slightly decrease during the potential growing period and decrease in the non-growing period due to the shifting of the dates of sustainable air temperature transition in autumn and spring to the beginning and the end of the winter season.

The high temperatures result in earlier germination of the maize and wheat, which is connected with limitation of their reproductive period during which the grain ripening process comes to fruition. At the same technological level of production and precipitation deficit in the warm half-year the average crop from the experimental crop stations in Bulgaria at 2*ÑÎ$_2$ GFDL and CCC climatic scenarios decreases with more than 29% compared to the crop calculated for the present climate conditions. In spite of the bigger precipitation amount expected in autumn and winter the winter wheat crops decrease by about 15-17%.

With the help of transient climatic scenarios of the GFDL model (at which greenhouse gases increase their concentrations gradually) it was found out that in the middle of the next decade the beginning of the potential growing period is expected with 11-13 days earlier, while its end shifts to the winter season with 4 days later. The prolongation of this period with 15-17 days increases the effective temperatures amount average with about 250°C. The lower temperatures increase in the first decade (+1.2° Ñ) and the middle of the 30s (+2.1°Ñ) of the next century will have slight influence on the development and productivity of the maize and wheat compared to the 2*ÑÎ$_2$ climatic scenarios.

Adaptation forestry strategies

If there are any climate changes in the next century, they will most probably affect negatively the lower forest vegetation zone in our country. In the upper mountain areas relatively favourable conditions will probably remain. This asks for a differentiated approach in the future strategy.

Lower forest vegetation zone (from 0 to 800 m a.s.l.)

The strategic task of the forestry in this most vulnerable area of the forests in the country at the threshold of eventual climatic changes must be as follows: an attempt for forests adaptation to the climatic aridisation, for preserving the forests from unfavourable ecological conditions.

In the forests of the higher parts of the country (over 800 m a.s.l.)

Thanks to the possibilities for conservation of the comparatively favourable ecological conditions in the higher parts of the mountains, the purposes of the forestry here must be more different: biodiversity conservation in the forests,

stable ecosystems development, multifunctional usage, developing of the system of protected natural territories.

Adaptation measures of agriculture in Bulgaria under climate change

Generally, the results obtained in this study, although they have hypothetical character and there are also some limitations, give the opportunity to recommend some adaptation measures in respect to the adverse effect of climate change in Bulgaria.

Mitigation strategies in forestry

The main purpose of the choice for the mitigation in the forestry is to reduce the greenhouse gases accumulation in the atmosphere through reducing of their emissions in the forest sector and absorbing of the atmospheric CO_2 and its storage in the earth biosphere.

The realisation of the afforestation in quantitative as well as in qualitative sense, i.e. the combination of gradual change of the coniferous plantations improperly established in the low forest vegetation zone with deciduous and expand of forest fund lends through afforestation of devastated lands and establishment of forest shelter belts would bring to a considerable reduction of the CO2 amounts emitted in the atmosphere.

Mitigation measures in agriculture

The mitigation measures will penetrate gradually in the agriculture managing practice of Bulgaria because they are attractive because of the increase of the effective productivity directly concerning the economical interests of the producer. In near future it could be expected an improvement of the way of nutrition of the domestic animals as well as of the foods and of the races.

It could be summarised that the tendencies in the agricultural sector are towards a decrease of the greenhouses gases emissions despite the direction of development of the sector.

7. Joint implementation of the FCCC commitments

Pursuant to Article 3.3 of the UN Framework Convention on Climate Change efforts to address climate change may be carried out co-operatively by the interested Parties.
With respect to the mechanism of joint implementation of FCCC commitments, the viewpoint of the Republic of Bulgaria is as follows:

- JI is economically effective because it allows the achievement of least-cost maximum global emission reduction of GHGs;
- JI mechanism should facilitate the state-of-the-art technologies penetration in the countries in transition and in the developing countries;
- JI is a voluntary activity under the responsibility of two or more parties. Such an activity must be undertaken or accepted by the Governments concerned;
- An initial three-year pilot phase is recommended in order to gain experience;
- During the pilot phase grants are preferable but credits under better conditions are also acceptable. Credits could be apply after
- 2000, i.e. in case of further commitment related to the possible GHG reduction;
- The criteria for the pilot phase should be flexible.

At present, Bulgaria has a set of projects to be implemented through the joint implementation mechanism awaiting for partners interested in application of JI mechanism.

8. Climate change research in Bulgaria

Most of the researches register the climate change in Bulgaria during the last decade, the impact on the forests, agriculture and water resources and the relationship with the global climate change

A major part of these studies has been performed by the National Institute of Meteorology and Hydrology (NIMH) to the Bulgarian Academy of Science (BAS). NIMH has initiated and is a co-ordinator of the National Climate Program (NCP) developed in 1992 that is consistent to the World Climate Program of the World Meteorological Organisation. Some other Institutes of BAS - the Institute of Forestry, Institute of Geography, as well as Nikola Pushkarov Institute of Soil Science and Agroecology, High Institute of Forestry, etc. are also participants in the NPC.

Bulgaria Country Study to Address Climate Change is a multidisciplinary study under the US DOE financial support and aimed to study GHG emissions by sources and sinks and to evaluate alternative options for GHG mitigation as well as

vulnerability and adaptation to the climate change. Energoproekt Research Institute is a national co-ordinator of the Bulgarian Country Study to Address Climate Change in which NIMH, the Institute of Economy (BAS), Institute for Nuclear Research and Nuclear Energy (BAS) are also taking part.

9. Education and public awareness

The global warming is one of the most serious environmental concerns in the history of mankind. Despite this, it seems that Bulgarian society is not aware of the consequences of the global climate change. Better environmental education and public awareness are primary objectives of the corresponding responsible institution. Public interest and support can turn crucial for the application of the long-term governmental strategy and climate change policy. The measures to be implemented require co-ordinated joint implementation by the governmental organisations and NGOs.

Country study to address climate change

The objective of element 5 of the *Bulgaria Country Study To Address Climate Change* incorporates preparation of data to be reported to the society.

A series of seminars are organised for the experts in the governmental administration, industry and in the research institutes. The goals of these seminars are to identify the core of the problem, the possibilities for its technical solution, to discuss the required investments for emission reduction, as well as the measures for the national economy and environment to adapt to the climate change

A survey on the study result is going to be issued that will be disseminated among the governmental organisations and NGOs. Some results are being published in the periodic scientific editions and are reported at national and international scientific happenings. Some papers are published in the magazines and newspapers. A series of reports, TV and radio programs will be performed.

NGOs

In Bulgaria there exist about 200 NGOs related to the environment. Few of them are interested in the climate change and its dissemination. The ENEFECG, the national movement Ecoglasnost and Ecomonitoring club have organised activities in this field.

ENEFECT is an active participant in the elaboration of projects related to the introduction of the energy efficient technologies in industry and households and it represents initiative for joint implementation of projects for prevention of climate change.

The scientific and technical energy institutes in Bulgaria and their energy and forestry organisations are interested in the climate change problems and they take part in the organisation and submission of discussions with other NGOs. Widening of the number of NGOs taking part is the climate change discussions is forthcoming.

CHAPTER 1

INTRODUCTION

The climate of our planet has been changing continuously but while in the past these changes had been natural, now the scientists believe that the industrial and agricultural emissions of carbon dioxide and other gases may cause irreversible change of global climate. The drastic increase of concentration of these gases known as "greenhouse gases" may lead not only to a substantial temperature rise but also to a new climate pattern in the future.

To some extent the climate change is driven by the a natural phenomenon, the so called "greenhouse effect" - the molecules of some atmospheric gases disperse and absorb infrared radiation emitted from the Earth's surface. The gases causing greenhouse effect are known as greenhouse gases. They may be divided into three different categories: (1) gases that have only a direct influence on the climate - such as CO2, PFCs, SF6 and HFCs; (2) gases which influence climate both directly and indirectly - such as CH4 and CFC, and (3) gases, such as NOx, CO and NMVOC, which only have an indirect effect through their effect on other greenhouse gases, especially ozone.

A substantial effort has been made in the past several years in the field of measurement and comparative assessment of the greenhouse effect due to the listed gases. Scientists have made a progress in trying to incorporate all key factors within a global models of temperature changes. There are, however, a lot of questions that are still open and researchers are working hard to find their solution. Despite all uncertainties in the climate change projections, especially in time terms, magnitude and regional deviations, the Governments of lots of countries proclaim the Global change and the related adverse effects to be mutual concern of the mankind and have decided that the risks are too serious to be neglected.

The United Nations Framework Convention on Climate Change (UN FCCC) is the first and major international legal instrument to address climate change issues at a global scale. It was signed in June 1992 at the Rio de Janeiro Earth Summit by more than 150 countries. The Convention entered in force on 21st March 1994. 135 countries have ratified the Convention by June 1995.

The ultimate goal of the Convention is to implement a global strategy to conserve the climate system for present and future generations. This goal could be achieved by stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

Such a level has to be achieved within a time frame sufficient to allow ecosystems to adopt naturally to climate change, that will ensure sufficient food production and will enable sustainable economic development.

Bulgaria signed FCCC in Rio de Janeiro in June 1992 and the Parliament ratified it in March 1995. In compliance with Article 4.6 and 4.2(b) of the FCCC, Bulgaria has adopted as a base year for the anthropogenic emissions of CO2 and other GHG not subject to control by the Montreal Protocol not the emission levels in 1990 but the level in 1988 to be used for future projections and evaluation.

As a Party of FCCC the Republic of Bulgaria announced its target to stabilize emissions of greenhouse gases by 2000 at a level not exceeded that in 1988.

Bulgaria is included in Annex I of the Convention. These Parties are obliged to present a National Communication with detailed description of adopted national policies and measures to mitigate climate change within a six months period after it entering into force. The Communication should also include an inventory and projections on the greenhouse gas emissions.

In compliance with the FCCC requirements Bulgaria presents the First National

Communication to the Conference of the Parties. It comprises all relevant information that concerns the FCCC process in Bulgaria and was developed according to the INC/FCCC Guidelines. The Communication emphasises the efforts Government has made to meet the Convention requirements and the high political priority of environmental problems, especially of

the climate change issues in the current national policy.

The First National Communication of Bulgaria was elaborated by the Interministerial

Committee supported by independent organisations and experts. The work is co-ordinated by the Ministry of Environment and Energoproekt PLC.

Georgi Georgiev,
Minister of Environment
of
Republic of Bulgaria

CHAPTER 2

NATIONAL CIRCUMSTANCES

This chapter contains a brief description of Bulgaria natural and economic conditions that are related to the subject of FCCC. The basic information for geography, hydrology, climate and demographic profile as well as for economy, energy and transportation is included here. The key priorities and objectives of the environmental policy adopted before the base year are presented briefly.

2.1 Basic data

2.1.1. Geography and climate profile

The Republic of Bulgaria is a middle-size country situated in the Southeast of Europe on the Balkan peninsula. The surface area of the country is 110 993.6 km^2.

The land boundary to the North with Romania is 609 km long and it mainly runs alongside the Danube river. Bulgaria has land boundary with Turkey - 259 km, with Greece - 493 km and with ex-Yugoslavia - 506 km. In the East Bulgaria borders the Black sea. The shore is predominantly flat with cliffs concentrated to the North (Kaliakra).

The location of the extreme points of the Bulgarian Republic's borders are as follows:

Southern point: 41° 14' N; 25° 21' E

Northern point: 44° 12' N; 22° 40' E

Western point: 42° 19' N; 22° 21' E

Eastern point: 43° 32' N; 28° 30' E

The connecting line between the northernmost and southernmost points is 396 km long, and between the westernmost and easternmost points 522 km.

31.45% of Bulgaria's surface is below 200 m above sea level. Hills within the range of 200-600 m above sea level cover 40.90% of the area. The highlands' (600-1600 m) percent is 25.13% and mountains over 1.600 m account for 2.52% of the country area. Bulgaria is located alongside the 600 km long chain of Stara Planina (Balkan) with the highest point of 2.376 m above sea level (the Botev peak). In the south there are several mountains belonging to the Thrakian-Macedonian System: Vitosha, Pirin, Rodopy, Strandga, and Rila. The highest point in Bulgaria is the Musala peak - 2.925 m above sea level.

Bulgarian geography profile determines the climate as belonging to the mild continental zone with regular rotation of four seasons. In the eastern and southern parts of the country the climate demonstrates Mediterranean features related to the impact of large water basins. The diversity of terrain altitudes affect the temperature and precipitation schedules and provokes further weather variability.

Absolute extremes give an idea of the temperature conditions. The highest temperature was measured on August 5, 1916 in Sadovo (45.2°C), and the coldest day was January 25, 1947 in Thrun (-38.3°C).

The average temperatures during the 1983-92 period were about 10-12°C within the range of maximum 42.2°C to minimum - 27.3°C.

The average annual temperature in Northern Bulgaria is about 10.8°C in the areas up to 800 m above sea level The most close to these values are the mean temperatures of Gramada (10.8°C), Buzovetz (10.9°C), Razgrad (10.8°C), Tzarev brod (10.8°C), Krushary (10.7°C), Slavjanovo (10.7°C), Suvorovo (10.8°C) and others.

The mean annual temperature in Southern Bulgaria is about 11.7°C in the areas under 800 m above sea level. The most close to these values are the temperatures in St. Karadjovo (11.8°C), Ivailo (11.7°C), Pazardjik (11.9°C), Gotze Deltchev (11.4°C) and others.

The average annual temperatures in the mountain regions with altitude 1000 -1500 m above sea level are: Vejen - (4.9°C), Mazalat (5.0°C), Persenk (4.7°C), Vihren (3.5°C),

Osogovo(5.1°C), Musala(0.5°C), Selimitza (7.0°C), Boeritza (4.0°C), Musala [-3.0°C], Botev - [-0.7°C], Tcherny vruh - [-3.0°C], Murgash (3.0°C).

The average number of sunny days is between 259 (the city of Lom) and 319 (the region of Sandansky), Sofia - 301 days, Varna - 300 days, the Musala peak - 279 days.

For mountains areas the number of hours of bright sunshine are at the maximum in the summer months (July, especially in August, and in September).

The highest number of days without sunshine occurs in December (especially), January and February. The daily maximum intensity of sunshine in the summer occurs between 11 and 14. The annual number of hours of sunshine ranges between 1848 (peak of Botev) and 2506 (the city of Sandanski) hours annually.

Most of the rivers in the Republic of Bulgaria have a limited flow. The necessity of water conservation promotes construction of reservoirs. For example, there exist series of dams on the Arda River . There are six large natural water reservoirs, with the water volume that amounts to 211.8 million m^3 and twenty one large artificial water reservoirs with water volume of 5335 million m^3.

Snow cover is various in regard to altitude and prolonging. The mean snow cover for Sofia stays in the period of December till March, for Plovdiv - December till February, the peak of Musala - October till May. The thickness of the cover in Sofia is within the range of 2 to 6 sm, Plovdiv - 2-5 sm, Musala - 10 sm respectively.

The annual precipitation figures for the country are as follows:

500-550 mm in some parts of the Danube valley and in Trakia;

to 1000-1400 mm in the highest mountain areas.

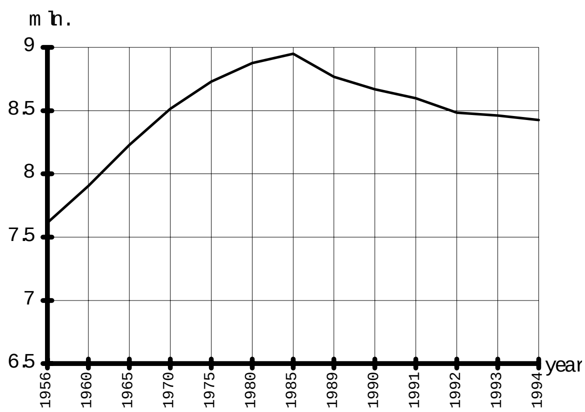
The lowest precipitation (below 500 mm annually) can be found in the most northern and eastern parts of the Danube valley. The average relative humidity is within the range of 60-84%. The precipitation is unevenly distributed during the year. It has its maximum in May-June and its minimum in February-March.

In the continental zones the maximal sum of day and night precipitation can be defined at the north and north-west slopes of the mountains. It is in the range of 35-40 mm during the summer months in the Stara Planina regions below 1000 m. For the Mediterranean zone the maximum is observable in November and December, and the minimum - during the spring and summer months - 15-22 mm. The maximum figure for Bulgaria is 342 mm precipitation for August 8, 1951. 1945 and 1985 are considered the driest years.

2.1.2 Demographic profile

The population of Bulgaria in 1993 was 8'459'723 inhabitants, which is higher than in 1960 but lower compared to the number of population during the following decades (1970s, 1980s and the beginning of 1990s). The social and economic problems in Bulgaria during the transition period caused the negative development of the natural increase since 1988. The downward trend is related to events such as the recent emigration waves. As a consequence, the annual decrease in 1992 was equal to 13%. Just for the 1993-94 time period the inhabitants decreased by 32 000 people. Figure 2.1 shows the population development of Bulgaria from 1960 to 1994.

Fig.2.1. Population growth rates in Bulgaria



Most of the population is concentrated in the urban areas. Sofia - the largest city and the capital of the country - has a population of 1'114'476 inhabitants. The next largest cities - Plovdiv and Varna - have population in excess of 300 000 people. Despite the positive natural rate for the urban population the emigration waves led to a decrease by 107 000 people in the period of 1985-1992. At the same time the rural population declines by approximately 50'000 inhabitants annually. The average population density in the country is 76.4 inhabitants per km^2

that makes Bulgaria a moderate populated country.

Another negative tendency is the ageing of population due to the decline in birth rates. The average population age in 1992 was 38.1 years while the birth rate dropped to 10.4 new-born to 1000 people. The relative share of the population in working age decreases. Currently every forth person in Bulgaria is a pensioner.

The number of households in 1985 was 3'030'303 and it decreased to 2'964'577 in 1992. The trend is assumed to be temporary. The average size of household also decreased from 2.9 persons per household in 1985 to 2.8 in 1992. It is expected this tendency to continue due to the preference to individual lifestyle common in our century.

2.1.3 Economy

Bulgaria is among the countries in transition. This fact leads to lots of similarities with the rest of the ex-socialist countries but at the same time there exist some peculiarities in the Bulgarian development model. Besides the common process of overcoming the recession and achieving an increase of the GDP rate Bulgaria differs with its lower pace of changes.

Until 1991 actually all sectors of economy had been controlled by the Government. Although the economy of the country was open and the share of import-export amounted to 80% of the 1989 GDP, in fact it was isolated from direct international competition through subsidies, taxes and exchange rationing. The economy growth rates and therefore GDP growth rate for 1980s have been decreasing remaining still positive with first negative drop of GDP by 0.3% in 1989. Since 1989 Bulgaria entered a situation of grave economic recession caused by the following factors:

- Political and economic collapse of the socialist system;
- Unfavourable external factors, including world recession, some political events, ex-Yugoslavia embargo etc.;
- Losses of major external markets.

Bulgaria had to develop new distribution channels and to find new partners outside the former socialist relationships. Its interests are predominantly towards the neighbouring countries and the EU countries.

The transition process in Bulgaria is extremely slow and complicated and some of the explanation can be found in the following directions:

⇒ Slow and unsatisfactory rate of privatisation;

The increase of private sector share is comparatively slow and Bulgaria is far behind the Central European countries with regard to this indicator. In the Check Republic, Hungary and Poland the private sector is in charge of more than half of the GDP. In Bulgaria privatisation is the greatest in the commercial field. Approximately 62% of trade in 1994 was due to it.

It is expected the private sector to continue to increase as a consequence of the legislation improvements and the decline of the interest rate which stimulates the economic activity.

⇒ Liberalisation of prices (except for the energy prices which are still under the control of the Government);

⇒ High inflation rate. It tends to become more moderate. At the end of 1994 it was still 121,9%, which is extremely high compared to the international standards of 3-5%.

In 1995 the inflation rate droped to 32.4%. This high inflation rate is due mainly to the higher goods' prices.

It should be stressed out that in Bulgaria there is a great difference between the rates of increase of the producers' and consumers prices. Producers' price change usually follows the increase in consumers prices. That peculiarity is due to the significant role of the distribution and redistribution processes in our economy.

⇒ The investments are scarce and they have unfavourable structure.

This fact delays the modernization of assets in industry and agriculture sectors. Currently the funds are predominantly used for maintenance and repairing of existing facilities instead of spending them for implementation of new technologies.

⇒ The foreign investments in Bulgaria are limited and investors are waiting for better legislative conditions.

A promising activity could be observed during the last two years. The direct foreign investments have increased 5 fold;

⇒ The rate of reconstruction of public sector which is still leading in national economy is quite unsatisfactory.

The relative share of private sector in the GDP and the consumer prices indices are given in Tables 2.1 and 2.2 respectively.
As a consequence of transition process from commanded to market economy a drastic decline in GDP is observed with some indications for stabilisation in 1994. The GDP dynamics during the past few year is represented on Figure 2.2 (1992 prices, exchange rate 1 USD=23.34 BGL).

As it is shown, the GDP trend used to be constantly downward since 1989 and finally in 1994 the GDP growth rate became positive. It is 1.4% higher than in the preceding year. Similar tendency can be observed for the GDP per capita as shown in Table 2.3. It is 1.7% higher in regard to the year of 1993.

Table 2.1. Relative share of private sector in GDP (%)

	1990	1991	1992	1993
Private sector (total)	9.1	11.8	15.3	19.4
Agriculture and forestry	6.0	5.5	5.7	5.3
Industry	1.9	2.8	4.0	4.9
Services	1.2	3.5	5.6	9.2

Table 2.2. Consumer price indices, 1992-94

December prices of preceding year=100

	1992	1993	1994
TOTAL	**179.5**	**163.9**	**221.9**
Food	182.5	160.4	239.5
Other goods	171.6	155.9	218.0
Services	185.7	193.7	160.6

Although the GDP growth is not quite significant it should be compared to the results obtained for the last few years and to the GDP growth rates reported for the rest countries in transition. Such comparison reveals the crucial importance of this positive rate as a indicator for economic activity and for overcoming of the recession.

It should be pointed out that one of the main reasons for the positive rate in 1994 is the introduction of value added tax of 18% that forms 5.6% of the 1994 GDP value.

Fig. 2.2 GDP dynamics

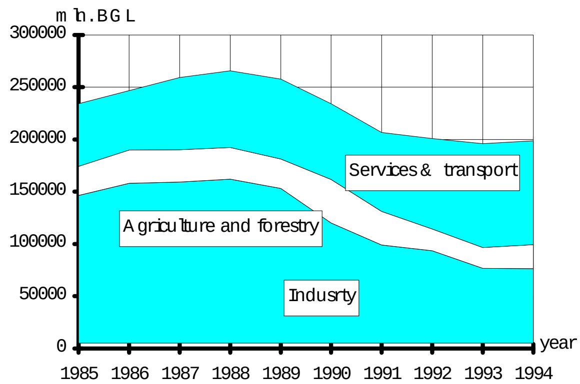


Table 2.3. GDP indices

	Base years									
	1989		1990		1991		1992		1993	
	GDP	GDP/per capita	GDP	GDP/per capita	GDP	GDP/per capita	GDP	GDP/per capita	GDP	GDP/per capita
1989	100	100								
1990	90.9	94.3	100	100						
1991	83.3	87.2	91.6	92.4	100	100				
1992	77.2	81.8	84.9	86.8	92.7	93.9	100	100		
1993	75.4	80.2	82.9	85.0	90.5	92.0	97.6	97.9	100	100
1994	76.4	81.5	84.1	86.5	91.8	93.5	99.0	99.6	101.4	101

The Bulgaria GDP growth rate is similar to the rate in some countries as Hungary or Slovak Republic which achieved positive GDP rates in 1994, either.

Major structural changes in economy and as consequence in the GDP structure took place during the transition period. Before the crisis the economic production structure was characterised by strong development of processing industry, mining and quarrying as a result of industrialisation performed in the past several decades.

During the transition period the share of industry tends to decline and its production level is much lower compared to its capacity. At the same time service sector has passed through a real boom resulting in increase of its share in the GDP from 22% in 1987 to over 38% in recent years. Just the opposite, the industrial sector reduced its share from 61% in 1987 to less than 45%. Figure 2.3 illustrates the changes of Bulgaria GDP structure and a comparison with the GDP structure of OECD countries.

The structural changes of economy and the drastic decrease in industrial production have resulted in negative social consequences such as increasing unemployment. The level of unemployment is relatively stable about 20% and is among the highest in Europe.

The key macroeconomic indicators for Bulgaria concerning the 1990-1994 period are given in Table 2.4.

Fig.2.3 Structure of GDP

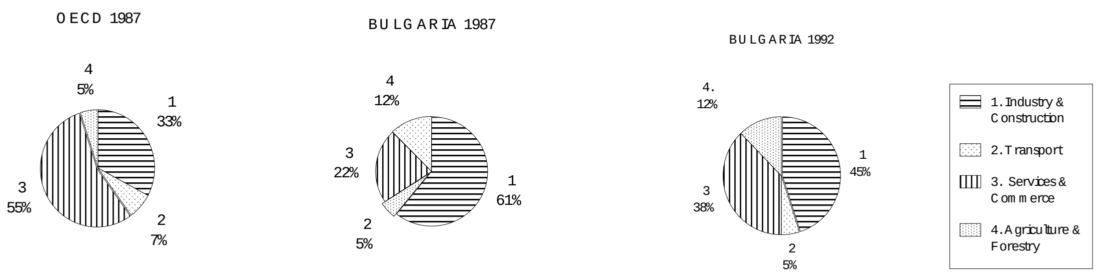


Table 2.4.Key macroeconomic indicators

		1990	1991	1992	1993	1994
GDP change	%	-9.1	-11.7	-7.3	-2.4	1.4
Inflation (annual)	%	23.8	338.5	79.4	56.1	87.1
Industrial Production	%	-16.8	-22.2	-15.9	-6.9	2.9
Unemployment (end of year)	%	1.5	10.9	15.6	17.0	20.1
Exports	$US million	2615	3737	3956	3727	3935
Imports	$US million	3372	3769	4169	4612	3952
Current Account balance	$US million	-860	-77	-360	-1098	-25
Budget balance	% GDP	-9.5	-5.1	-4.6	-10.9	-6.7
Gross debt	$ billion	10.9	12.0	12.1	12.5	10.4

2.1.4 Industrial structure

Bulgaria is an industrial country with exploration of natural resources (mainly coal industry), heavy industry (ferrous and non-ferrous metallurgy, mechanical engineering, chemical and oil processing industry, electrical and electronic engineering industries and light industry (mainly food processing industry, textile, clothing industry).

The industrial output of individual industrial brunches is given in Table 2.5. At the end of 1980s the mechanical engineering, metal processing, electrical and electronic engineering industries were key sectors of industry that accounted for 32% of the gross industrial output, followed by food processing industry - 21.6%, chemical and oil processing industry - 13.4%.

Substantial changes in industrial structure have been observed since 1990 as a consequence of imbalance of the internal and traditional Bulgaria external markets.

In 1994 the share of chemical, oil processing and food processing industries amounted to 45% of the gross industrial output of the country, while leather, fur, footwear, pulp, paper, glass, china, textile, knitwear, oil and gas extracting industries together accounted only for 7% of the industrial output of the country.

This tendency continues in 1995 when the iron and steel industry achieved 19% growth, chemical industry has grown by more than 15% and pulp and paper industry has increased by 20% due to the increased market share of these products in US, Japan and China and to the new investments.

Table 2.5. Gross industrial output, million BGL

Year	1991	1992	1993	1993	1994*	1992	1993	1994*
	at current prices					*at prices of preceding year*		
Gross output	181535	235156	272770	253513	456203	150638	211726	259895
Electrical and thermal power industry	15749	21136	25658	25645	34611	12967	18678	24484
Coal industry	4020	6211	6808	6807	8981	3858	6165	6707
Oil and gas extracting	90	223	372	371	535	89	338	329
Ferrous metallurgy	10833	8854	13631	13618	27931	6106	11405	15887
Non-ferrous metallurgy	5800	9026	10285	10282	24557	5713	10286	10462
Mechanical engineering and metal processing	20579	26662	30405	30034	46761	16061	21372	26151
Electrical and electronic	13605	14169	14632	14234	22874	9261	13439	12575
Chemical and oil processing	37597	47076	53783	45689	112003	30769	45885	61747
Building materials	4137	4950	6492	6449	11353	3278	4968	6756
Timber and wood processing	4709	6594	8636	8192	12780	4173	6058	8247
Pulp and paper ind.	3181	2884	3335	3279	7326	2884	2594	3878
Glass, china and earthenware	1850	2741	3341	3265	7045	1506	2609	4000
Textile and knitwear	7038	9743	10414	9872	18010	6127	8112	9542
Clothing industry	2619	3784	4755	4445	7001	2308	3442	4257
Leather, fur and footwear industry	2170	3480	4050	3757	7204	1923	2955	3577
Printing and publishing industry	1482	1789	3102	3032	6659	1193	2275	3416
Food industry	43353	60818	65931	57598	90282	38986	45570	51955
Other branches	2723	5016	7140	6944	10290	3436	5575	5925
Intermediate consumption	126154	160151	178038	178038	318548	101507	137990	182259
Gross value added	55381	75005	94732	75475	137655	49131	73736	77636

*) Preliminary data

2.1.5. Transportation

Bulgaria has a central position in the traffic connecting Europe with Asia and Africa. This fact turns the transport system into an important sector of the national economy. The density of the networks can be considered appropriate but their quality is much lower than the required. The entire Bulgarian infrastructure needs urgent measures for reconstruction and innovation of the existing networks.

The total length of the railway tracks in 1992 was 6560 km of which 4294 km operating. The total length of the roads in the same year was 36 900 km of which 33 900 paved. Sea and river passenger ship routs were 100 000 and 119 000 km respectively but they are considerably shorter compared to the previous years and decades. Basic data for transportation sector are given in table 2.6, and the classification of the vehicles by type is given in table 2.7.

Table 2.6. Basic data transport development

Year	1960	1970	1980	1990	1991	1992	1993
Length of railway lines operated - km	5620	6040	6419	6604	6607	6560	6556
Roads - thous. km	33	36.1	36.4	36.9	36.9	36.9	36.9
Airlines - tous.km	5.4	28.1	77.5	153.1	136.2	134.4	175.4
Towns with trolleys lines - number	2	2	2	13	14	15	16

Table 2.7. Vehicles by type

Year	1990	1991	1992	1993
Locomotives	1111	965	943	939
Rail motor vehicle	94	93	90	90
Passenger carriages	1932	2009	1905	1722
Wagons	40918	40451	38347	37045
Lorries	37830	35062	27014	22326
Buses	13232	12716	11360	10122
Trolleys	863	844	845	836
Trams	444	459	449	431
Passenger cars	1317437	135876	1411278	
Sea cargo ships	13	13	10	9
Passenger liners	59	73	75	69

As a whole the trends of the freight and passenger transportation are decreasing during the years of economy transition. The breakdown between different transportation modes for passengers and freight is given on Figures 2.4 and 2.5 respectively.

FIg.2.4. Passenger transport

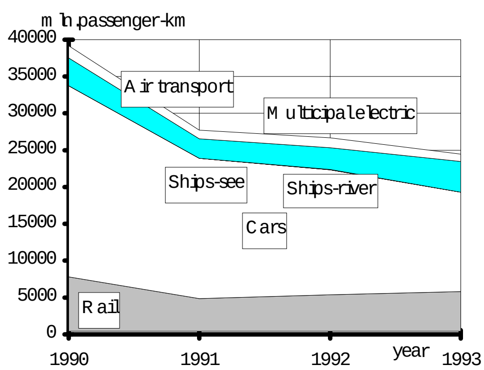
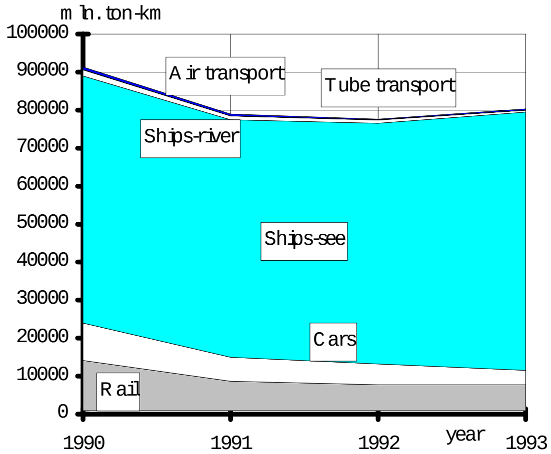


Fig.2.5. Freight transport



2.1.6. Agriculture

In Bulgaria there are about 4643 thousand ha arable land. In the past this land was centralised into co-operatives. Lately a process of privatisation took place and the land became property of private farmers or joint companies. Agriculture employs 676,7 thousand people, i.e. 20.7% (1992) of the labour force. The gross agricultural output is given in table 2.8.

Table 2.8. Gross agricultural output, million BGL

Year	1991	1992	1993	1993	1994*	1992	1993	1994*
	at current prices					*at prices of preceding year*		
Gross output	37342	51327	70053	69837	125921	36662	41318	71838
plant-growing	17630	24297	31388	31325	59087	18474	17888	36048
livestock breading	14957	22167	33810	33730	57141	15238	20384	30093
agricultural services	2129	2383	2951	2939	6900	1635	1923	4105
other	2626	2480	1904	1843	2793	1315	1123	1592

2.1.7. Forestry

The total forest area in Bulgaria was about 3,871 million ha in 1990, i.e. 34% of the country territory. The territory of forests with national importance is 97.4% of the total forest area. The review of the forest land in the 1955-1990 period indicates increment due to afforestation procedures and protecting policy of the Government. The total area of the coniferous forest in the above period increased from 14% in 1955 up to 37% in 1990. Annually the afforestrated areas varied from 28 040 ha up to 89 660 ha and thus allowed 1 million ha of new forests to be established over the past 35 years.

Another direction of forestry policy is the increase of the share of protected forests. In 1955 they were 8.4% and in 1990 - 30.9% of the total forest area. Some of the largest European national parks are located in Bulgaria, e.g. Rila - over 100 000 ha, Central Balkan - over 72 000 ha. This is of great importance for conserving biological diversity and for development of tourism.

Basic statistical data on the Bulgarian forests that are of national importance and account for 97.4% of the total forest area for 1955-1990 period are given in table 2.9

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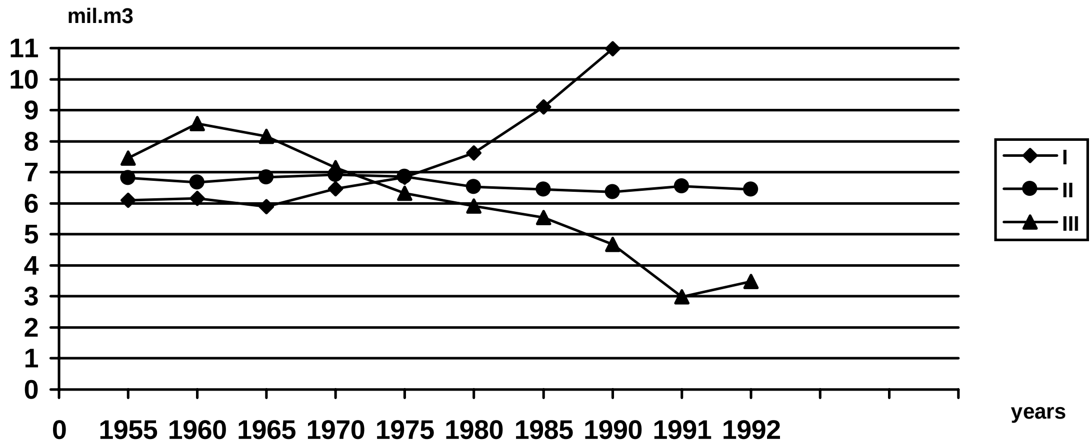
Table 2.9.Basic data on Bulgaria forests

Characteristics	1955	1960	1965	1970	1975	1980	1985	1990
1. Total area, million ha	3.670	3.635	3.511	3.604	3.694	3.743	3.768	3.772
2. Afforestated area, million ha	3.153	3.190	3.049	3.066	3.134	3.200	3.241	3.259
3. Percentage of conifers	14.0	16.7	23.5	26.5	29.7	33.1	36.1	37.0
4. Protected forests (%)	8.4	10.3	12.2	15.6	19.0	25.9	29.2	30.9
5. Mean increment (mil.m^3)	6.10	6.15	5.90	6.47	6.83	7.62	9.11	10.97
6. Cut (planned) (mil.m^3)	6.82	6.68	6.84	6.92	6.86	6.54	6.45	6.37
7. Cut (actual) (mil.m^3)	7.45	8.57	8.16	7.14	6.32	5.91	5.53	4.68
8. Produced seedlings (mill)	414.3	1357.7	598.0	766.7	637.2	385.9	351.0	347.0
9. Afforestation (ha)	34.337	89.660	40.284	50.825	48.972	41.54	29.62	28.04

The creative policy in the field of forestry resulted in a quick increase of the total volume of above-ground mass of wood in the forest of Bulgaria.

Figure 2.6. contains information about mean increment, foreseen and actual cut. It indicates that the mean annual increment of wood in the Bulgarian forest has increased for 35 years by 80.3%, because of the high rates of afforestation and the improvement of the general state of the forests in the country while the planned cut has been relatively constant within the range of 6.37 - 6.92 mil. m^3/year. Only for the period until 1970 the actual cut had exceeded the planned cut.

Fig. 2.6. Mean increment (I), foreseen cut (II) and actual cut (III) in the forests of Bulgaria for the period 1955 - 1993, in mil.m3.



The consequences of the forestry long-term policy in Bulgaria are positive: the erosion in all large water-catchment basins in the country has been liquidated; the conditions of life in enormous territories in the country have been improved, as well as the forests' micro-climatic, hydrological, recreative, meliorative and other conditions have been positively influenced, i.e. all the peerless favourable functions of the forests in Bulgaria.

The data on the distribution of the forests in the country, for 1990, according to the tree species, are presented in table 2.10

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Table 2.10. Distribution of the forests of Bulgaria according to tree species, areas, volumes of timber and annual increments, for 1990.

No	Tree species	Areas thousand ha	Volumes thousand m^3	Increments thousand m^3
1.	*Pinus sylvestris L.*	562.73	84,508.7	3,246.5
2.	*Pinus nigra Arn.*	313.64	21,934.9	997.2
3.	*Picea abies (L.) Karst.*	153.87	34,583.2	545.0
4.	*Abies alba Mill.*	30.53	9.984.0	125.7
5.	Other conifers	38.30	5,649.1	162.1
	Total conifers	1,099.08	156,659.9	5,076.5
6.	*Quercus sp.*	1,286.04	99,029.1	2,676.8
7.	*Fagus sylvatica L.*	477.66	101,977.3	1,610.7
8.	*Robinia pseudoacacia L.*	90.28	4,918.7	411.2
9.	*Carpinus betulus L.*	86.82	15,015.7	416.9
10.	*Tilia sp.*	41.77	5,676.4	208.2
11.	*Populus sp.*	22.32	1,771.4	186.1
12.	Other broad-leaved	155.11	12,350.7	519.6
	Total broad-leaved	2,159.99	240,379.3	6,029.5

2.1.8. Energy sector

The Bulgarian energy sector holds a key position in the national economy. Some problems which are connected to this sector's development are the limited national energy resources, the high share of imported energy resources of about 76% in the general structure of the international trade balance of Bulgaria, the high energy intensity of industrial production, and the subsidies to some energy carriers.

Energy resource deposits in Bulgaria are very limited. The only indigenous energy resource that is important for Bulgarian economy is coal. The deposits and mining of low quality coal (1500 kcal/kg heat rate at average) with a high sulphur content (2%) have the largest share in the coal sector. These deposits are situated mainly at the Maritza East Coal Fields (about 95% of the lignites) and at the Sofia Coal Field (about 3%). Sub-bituminous coal deposits (with average heat rate of 2000 kcal/kg) are concentrated in the Western Bulgaria (Bobov dol, Pernik, Pirin mines) as well as in the Eastern Bulgaria (the Black sea mine). Bituminous and anthracite coal deposits are scarce. They can only be found in the centre of Bulgaria, not far from the Stara Planina region, and in the Sofia Coal Field near Svoge.

The indigenous resources of crude oil and natural gas are very limited. Even in 1992 when some problems concerning the import of crude oil and natural gas occurred, the indigenous crude oil production was only 2% and the indigenous natural gas was only 0.07% compared to the imported.

Bulgarian hydro resources are limited also because of the relatively small sizes of the country's rivers. The only exception is the Danube river, which forms the northern boundary of the county. The potential use of the Danube as a source of hydro electricity is problematic due to the insufficient river falls and the necessity of international agreements to be signed with the neighbouring countries.

The total primary energy consumption for the period 1985 - 1993 is given on Figure 2.7. It has been relatively steady for the period of 1985 - 1988 followed by steep decrease of 38% in 1992 compared to 1988.

The energy end use presented on Figure 2.8. follows the primary energy consumption trends but the decrease in 1992 was 44% compared to 1988.

The total primary energy and final energy consumption follows the trend for primary energy consumption but it is diminished as a consequence of both GDP decline and the structural changes of some energy intensive industrial sectors such as ferrous metallurgy, machine manufacturing, building materials and others. A growing tendency is observed in both primary and final energy demand in 1993 that precedes the economic and industrial revival.

Fig.2.7 Total primary energy consumption for the 1985-1993 period

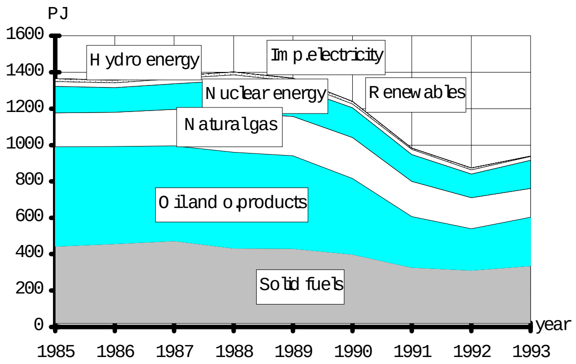
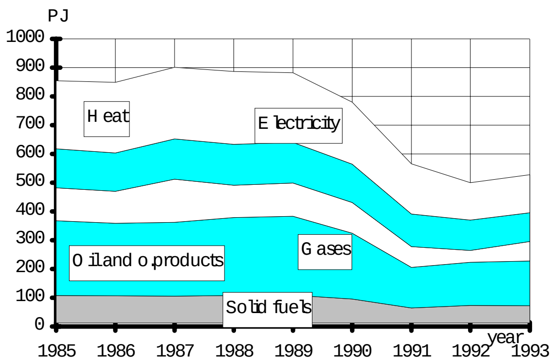


Fig. 2.8. Energy end use



Oil and oil products prevail in the structure of primary energy consumption but their share has diminished from 40.1% in 1985 to 28.6% in 1993 mainly on account of the natural gas with the share of 13.6% and 16.8% respectively. The share of solid fuels is relatively constant of about 33-35%, while the nuclear energy has increased from 10.8% in 1985 to 12.8% in 1988 and 15.1% in 1991 due to the first and second 1000 MW units coming in operation at the Nuclear Power Plant of Kozloduy.

Primary energy is used for final energy consumption in the economic sectors as well as for energy transformation and conversion processes such as coke, briquettes, petroleum products, electricity and heat production.

In Bulgaria electricity is produced out of coal, nuclear energy and in hydro power plants. The trend of primary energy consumption for electricity production, including nuclear and hydro energy presented as fuel equivalent is given on figure 2.9 and the contribution by type of power plants is given on figure 2.10.

Fig. 2.9 Primary energy carriers for electricity production

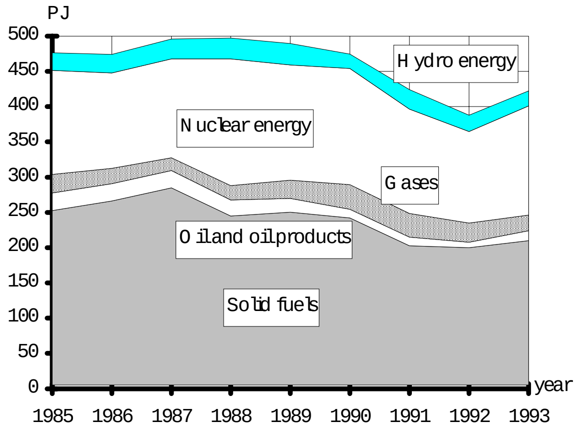
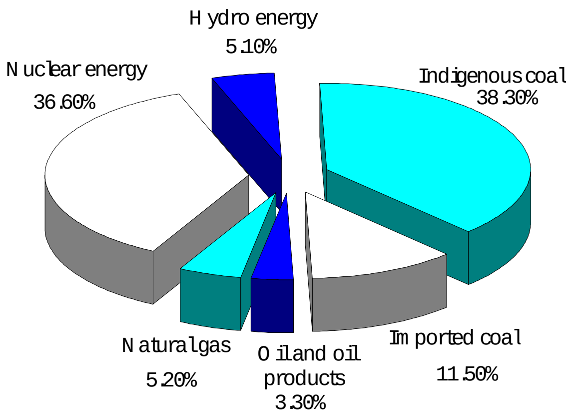


Fig.2.10 Structure of the primary energy carriers for electricity production



Solid fuels, mainly indigenous lignite and nuclear energy prevail in the structure of primary energy for electricity production with 49.8% and 36.6% in 1993 respectively.

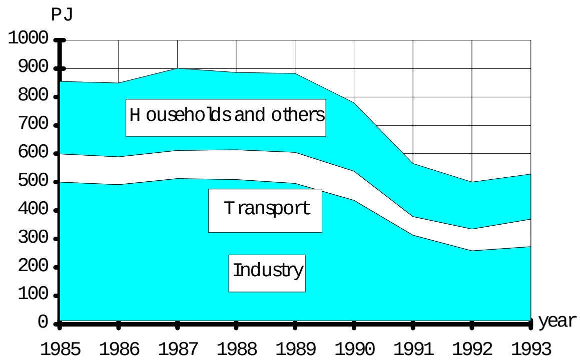
The portion of the utilised liquid fuels for electricity production is extremely small 3.3%.

Oil processing industry in Bulgaria has a high priority since it allows not only to meet the demand for oil products on the internal market but for export as well. The total capacity of Bulgaria refineries amounts to 13 million tons crude oil although in 1992 the crude oil processed was at less than the half of the refineries capacity.

The final energy consumption of Bulgaria is characterised by relatively stable share of solid fuels (13%), oil and oil products (30%), heat (27%), while the electricity tends slightly to an increase and natural gas consumption has decreased strongly since 1992 due to the cut

down of production output in chemical, rubber, glass, ceramic, iron and steel industries. The trend of the final energy consumption on figure 2.11 indicates that despite the industrial production decrease within the transition period, industry remains the major energy consumer with the share of 58.6% in 1985 and 51.7% in 1993. This is also true for the final electricity consumption by economic sectors presented on figure 2.12. Industry accounts for 44% of the electricity consumption.

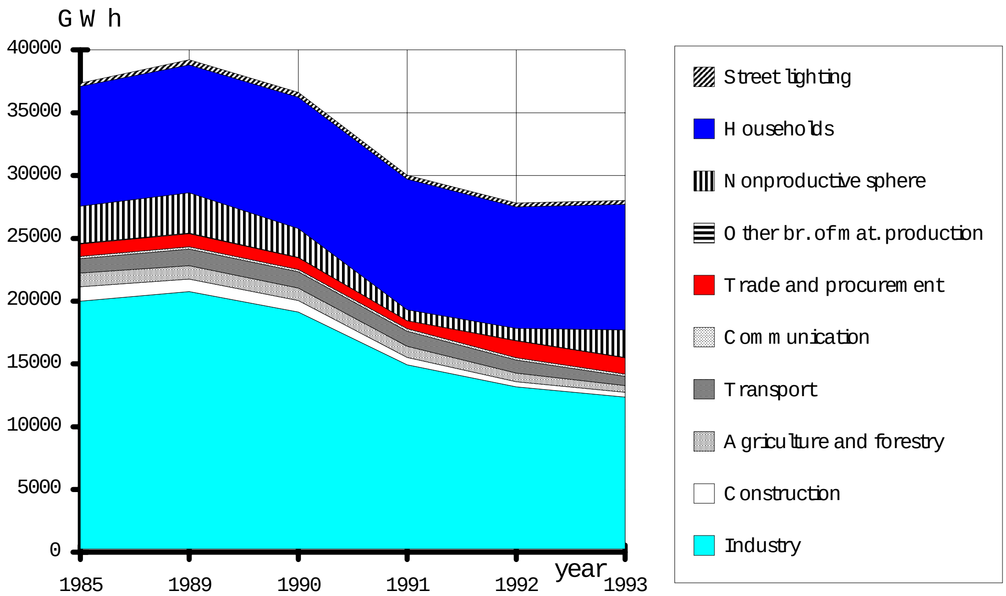
Energy prices have an important role in the economy of the country. Under centrally planned economy conditions the energy prices were set by the Government and most of these prices were substantially subsidised, in particular prices paid by households for heat and electricity. At present, when the process of price liberalisation takes place, the energy prices are still controlled by the Government. The new pricing system aims at gradual decrease of the subsidies with the ultimate goal of their complete elimination.



A new tariff structure for electricity was introduced in 1992 with three zones for industry and two zones for public sector consumption. Energy prices are regularly updated by the Government under the Committee of Energy and Price Commission suggestion.

Fig.2.11. Electricity end use trends

Fig.2.12 Electricity final consumption by economic sector



2.2. Environmental strategies and policies adopted before the base year

The Bulgarian environmental policy is based on the Constitution of the Republic of Bulgaria, proclaiming in Article 15 the obligation of the country to ensure environmental protection, conservation and rational usage of the natural and other resources in the county. In amendment in Article 5 it is stated that the international documents ratified and in force should also have the power of national legislation. It is the responsibility of the Ministry of Environment to formulate and implement policy aimed to ensure environmental balance, conservation of natural resources and effective environmental protection.

The national environmental policy in short-term horizon till the year of 2000 is formulated within the National Environmental Strategy and Action Plan that were adopted in January 1992.

The major part of the Action Plan was implemented in the period 1992-1994. The Ecological Strategy was updated in March 1994 and its preparation was completed in December 1994. In the Strategy a special emphasis is given to the human health care and criteria are drawn to identify priorities on the basis of the most frequent diseases due to a limited number of pollutants such as:

- high lead concentration in the air and soils;
- high dust concentration in the air;
- high concentration of sulphur dioxide and other gases, especially in combination with dust particles.

Efforts to reduce sulphur dioxide emissions are directed to power generation and industry which are the major pollutants. The relative share of sulphurous compounds by sectors is as follows:

- from steam power stations for the production of heat and electricity in power generation and industry - 85%;
- from households heating - 10%;
- from industry - 4-5%;
- from transport - 0.8-1%.

In these sectors the necessary measures will be implemented at the extent consistent with the available investment opportunities. Priority is given to the following measures:

- decreasing the energy consumption;
- increasing the energy efficiency;
- stimulating the use of fuels with lower sulphur contents and smokeless fuels.

Implementing the decision No. 203/1994 of the Council of Ministers, an interdepartmental group has drafted a National Program for diminishing the sulphur emissions till 2010. Some preliminary studies address the sectors where certain measures have to be taken in the following areas:

Energy

- reassessment of the fuel use and fuel switching to ecologically cleaner fuels
- (natural gas, low-sulphur solid and liquid fuels, fuel mixture);
- utilisation of renewable energy sources;
- maintenance and further development of nuclear plant;
- rehabilitation of the existing power plants and commitment of new replacing units if proved necessary.

The necessary investments for rehabilitation of the existing power plants by 2010 are evaluated differently - from 870 million US dollars up to 1.6 billion US dollars.

For example, the first sulphur-cleaning installation on unit 8 of the power station complex Maritza east No.2 which is foreseen to be built up is evaluated at the amount of 60-70 million US dollars and the more favourable scenario with building of sulphur-cleaning installations for both unit 7 and unit 8 - 40-50 million dollars.

Industry

- decreasing the energy consumption
- increasing the energy efficiency;
- improving the quality of produced diesel fuel for internal-combustion engines with content of sulphur 0.05% (now according to the Bulgaria standards the sulphur content is 0.2-0.3%) and diesel oil with content of sulphur 0.2% (now according to the Bulgaria standards - 1.25%). The measures should be implemented by 2004-2006, providing the necessary investments evaluated to be 100 million US dollars.
- decreasing the emissions from non-ferrous metallurgical companies; for the non-ferrous works near the town of Plovdiv and the copper-mining company Eliseina 100 million US dollars are allocated by the Japanese government; as for the copper-mining company in the town of Pirdop, through financing by the World Bank pre-feasibility study will be performed for the construction of a new line for sulphur acid production and for making the company environment friendly. It is envisaged that investments of 65-100 million US dollars will be needed for the construction of a new line for production of zinc and sulphurous acid under a project of a western company to 200 million US dollars in the lead-zinc works in the town of Kardjaly.

Household sector

- increasing the share of district heating systems;

- providing coal briquettes with low contents of sulphur, through building up replacing units in the briquette factory in Galabovo, which is carried out under the Power engineering program of PHARE;
- natural gas supply to the households.

In 1995 with the help of the World bank and USAID pre-feasibility studies are to be fulfilled for the realisation of a pilot demonstration project for the gasification of the household sector in the cities of Stara Zagora and Plovdiv. The necessary investments for each city are evaluated to 10-15 million US dollars.

A number of economic restrictions are applied, including increases in electricity and heating prices, energy efficiency measures, etc.

In 1990 emissions of nitrogen oxides (NOx) came from heat and electricity generating installations (23%), road and other transport (44.1%), and industrial processes (19%). Efforts to reduce NOx emissions are directed mainly to heat generation and industry. Prospects to reduce them in transport sector within a short-term time horizon (until 2000) are vague.

Starting in 1994, the drafting of two national long-term programs has begun: one on the reduction of emissions of sulphur and nitrogen oxides and the second, on the reduction of emissions of greenhouse gases until 2010. They are envisaged to be completed in 1996. The program on the greenhouse gas emission is sponsored by the American Department of Energy and the program on the sulphurous oxides is expected to be sponsored by the World Bank.

There were no specific policies and measures adopted by Government that address climate change problems before the base year. Climate change issues have begun to be implemented at national policy making process since 1992. It is considered that climate change policies and measures should be as cost-effective as possible.

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CHAPTER 3

INVENTORY OF GREENHOUSE GAS EMISSIONS IN BULGARIA

This chapter provides a summary of the greenhouse gas emissions and sinks in Bulgaria. Emissions and sinks estimates are based on the IPCC Guidelines.

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3.1. Introduction

This chapter gives an outline of the national anthropogenic emissions of greenhouse gases and data on the CO_2 sinks in Bulgaria.

The following greenhouse gases are addressed: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O). The emissions of other gases controlled by the Montreal protocol such as chlorofluorocarbons (CFCs) and Halons are also included. Emission data on precursors (NO_x, CO and NMVOCs) are also given in the chapter.

The emission figures for 1988 and 1990 are presented according to the IPCC Guidelines for reporting the national greenhouse gas emissions. In addition historical trends are given for all greenhouse gases and precursors.

3.2. Methods of estimation

3.2.1. IPCC method

In general, the estimation methods for GHG follows the IPCC Guidelines for National Greenhouse Gas Inventory (IPCC, 1995). The 1988 GHG emissions are calculated in compliance to the final IPCC Guidelines, while the projections for emission changes are made on the ground of the IPCC Draft Guidelines. The MINERGG software (Methodology for an Inventory of National Emissions and Sinks of Greenhouse Gases), as well as spreadsheet models are used in calculations. Other estimation methods have been used whereas appropriate in order to achieve better estimates for example, GHG emissions for transport sector.

According to the IPCC Guidelines the GHG emissions sources are classified into six major categories:

- Energy
- Industrial processes
- Solvent use
- Agriculture
- Land use change and forestry
- Waste

GHG emissions are estimated based on the activity data for each category and economic sector multiplied by emission factors. The key data source are the statistics of Bulgarian National Statistics Institute.

The low heat values of fuels and CO_2 emission factors proposed by IPCC Guidelines differ from the values measured and calculated in Bulgaria for coal and natural gas that are consumed in the country. These differences in some cases are higher than 10%. The emission factors and heat values of the fuels recommended by the IPCC usually are lower.

All emissions are expressed in full molecular mass (e.g. Gg CO_2).

GHG emissions from fuel combustion are calculated in three steps based on the above mentioned categories and data. At the first step, total CO_2 emissions are calculated following the IPCC top-down approach. At the second step, emissions from mobile sources are calculated according to the CORINAIR method (CORINAIR, 1991). The mobile sources are split into 30 categories according to their type (e.g. passenger cars, buses, trucks, aircraft, ships) and engine type and volume. Different emission factors are used for different mobile categories except for the CO_2 where emission factor depends only on the type of fuel used, e.g. gasoline, diesel fuel and kerosene. The third step - emissions by economic sectors are

calculated in a proportion to the different types of fuel and combustion technologies used.

3.2.2. GWP values used in calculations

Different GHG have different impact on the global warming. The concept of *Global Warming Potential* (GWP) is used to compare the influence on the climate of other GHG with that of CO_2 on weight-to-weight basis over certain time horizon. The period of 100 years have been chosen for GWP estimates that is near to the estimated mean life-time of CO_2.

The GWP values used to estimate CO_2, CH_4 and N_2O emissions are given in table 3.1. with regard to the IPCC recommendations from 1994 (IPCC, 1994). Estimates on NOx, CO, NMVOC, CFCs and Halons are not included at this stage because of their small contribution to the total emissions of GHG in Bulgaria.

Table 3.1. GWP for a 100 years time horizon

GAS	CO2	CH4	N2O
GWP	1	24.5	320

3.3. Total emissions of GHG

This chapter presents an overview of greenhouse gas emissions in Bulgaria in 1988, 1990 and the historical trends from 1987 to 1993.

3.3.1. Emissions in 1988 and 1990

Data on emission of GHG for both 1988 that is Bulgaria base year and 1990 that is internationally accepted base year for Climate Change Framework Convention are given in Table 3.2 and 3.3 respectively (Bogdanov, 1995). Appendix 1 presents data tables with emissions, activity data and aggregated emission factors for GHG sources and sink according to the IPCC Guidelines.

The emissions per capita and per unit GDP are shown in the Table 3.4. for 1988, given the total population of Bulgaria in 1988 of 8’986’600 and the GDP of 11 398 million 1992 $US for the same year.

The values of aggregated emissions of CO_2, CH_4 and N_2O for 1988 considering both the direct and indirect effects are given in Table 3.5. Figure 3.1 illustrates the aggregated GHG emissions presented in Gg CO_2 equivalent and in percent of the total emissions. The results indicate that CO_2 is the most important GHG in Bulgaria, accounting for the 68.5% of the total GHG emissions, followed by methane (24.5%) and nitrous oxide (7%).

The sectorial shares of the aggregated greenhouse gas emissions are shown on Figure 3.2. The stationary combustion is the most important GHG emission source in Bulgaria. It accounts for 64.2% of the total emissions. Relatively small in comparison with western countries is the mobile combustion share - 7.7%, followed by the emissions from industrial processes - 6.6 %.

Sector “others” in this case stands mainly for methane emissions from agriculture and landfills.

The annual variation of emissions are dependant not only on the economic activities but also on:

- how much the temperature deviates from a normal year;
- how much precipitation has fallen compared to a normal year;
- how much electricity has been imported and exported.

Figure 3.2. Sectorial share of aggregated greenhouse gas emissions in Bulgaria, 1988

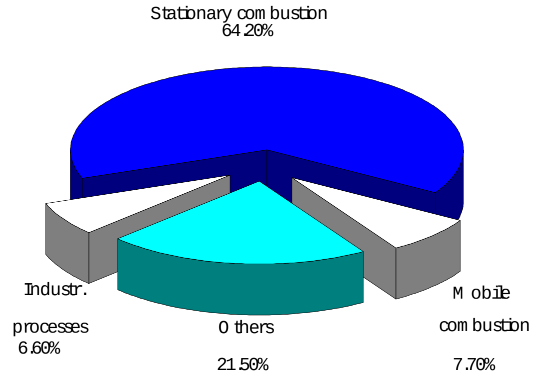


Table 3.2. Emissions of greenhouse gases in Bulgaria in 1988, Gg

GREENHOUSE GASES	CO_2	CH_4	N_2O	NOx	CO	NMVOC
TOTAL NATIONAL EMISSION	**96878**	**1412.7**	**30.80**	**486.35**	**826.59**	**132.3**
NET NATIONAL EMISSION (including sinks)	**92221**	**1412.7**	**30.80**	**486.35**	**826.59**	**132.3**
1. ALL ENERGY (fuel combustion + fugitive)	**90327**	**371.43**	**6.964**	**485.35**	**789.59**	**68.78**
A Fuel combustion	**90327**	**56.328**	**6.964**	**485.35**	**789.59**	**68.78**
1. Energy&tranformation ind.	35079	0.31	2.713	255.2	58.87	
2. Industry (ISIC)	33881	52.3	3.5	97.3	15.3	
3. Transport (Mobile comb.)	10753	2.84	0.195	88.93	445.9	64.5
4. Small combustion	8941	0.417	0.29	39.784	161.14	4.28
Commercial / institutional	315	0.053	0.066	0.394	1.58	
Residential	6112	0.14		9.11	144.5	
Agriculture / forestry	2513.6	0.224	0.224	30.28	15.06	4.28
5. Others	1672.6	0.041	0.266	3	2.98	
6. Biomass incineration for energy	630	0.42		1.14	105.4	
B Fugitive fuel emission	**0**	**315.1**	**0**	**0**	**0**	**0**
1. Coal mining		113.6				
2. Oil and natural gas systems		201.5				
2. INDUSTRIAL PROCESSES	**5890**	**2.44**	**10.4**	**0**	**0**	**0**
A Iron and steel	172	2.4				
B Non-ferrous metals						
C Inorganic chemicals	1157		10.4			
D Organic chemicals		0.04				
E Non-metallic mineral products	4561					
F Others (methanol)						
3. SOLVENT USE	**0**	**0**	**0**	**0**	**0**	**63.54**
A Paint application						35.9
B Degreasing and dry cleaning						2.14
C Chem. prod.manif./processing						13.4
D. Others (vegetable oils)						3.11
E. Residential solvent use						8.99
4. AGRICULTURE	**0**	**306.56**	**13.44**	**1**	**37**	**0**
A Enteric fermentation		196.4				
B Animal wastes		102.4				
C Rice cultivation		5.96				
D Agricultural soils			13.44			
E Savannah burning						
F. Agricultural waste burning		1.8		1	37	
G Others						
5. LAND USE CHANGE & FORESTRY	**-4657**	**0**	**0**	**0**	**0**	**0**
A Forest clearing						
B Grassland conversion						
C Abandonment of managed lands						
D Managed forests	-4657					
6. WASTE	**661**	**732.3**	**0**	**0**	**0**	**0**
A Landfills	661	661				
B Waste water treatment		71.3				
C Wastes incineration						
D Others						
7. OTHERS						

International bunkers	162.4					

Table 3.3. Emissions of greenhouse gases in Bulgaria in 1990, Gg

GREENHOUSE GASES	CO_2	CH_4	N_2O	NOx	CO	NMVOC
TOTAL NATIONAL EMISSION	**82990**	**1370**	**22.46**	**499.3**	**893**	**102.1**
NET NATIONAL EMISSION (including sinks)	**77189**	**1370**	**22.46**	**499.3**	**893**	**102.1**
1. ALL ENERGY (fuel combustion + fugitive)	**76535**	**260.5**	**4.67**	**498.2**	**852**	**67.2**
A Fuel combustion	**76535**	**11.1**	**4.67**	**498.2**	**852**	**67.2**
1. Stationary combustion	64220	8.1	4.43	374.2	415	
2. Transport (Mobile comb.)	12315	3	0.24	124	437	67.2
B Fugitive fuel emission	**0**	**249.4**	**0**	**0**	**0**	**0**
1. Coal mining		155				
2. Oil and natural gas systems		94.4				
2. INDUSTRIAL PROCESSES	**5680**	**2**	**9.62**	**0**	**0**	**0**
A Iron and steel	131	2				
B Non-ferrous metals						
C Inorganic chemicals	1359		9.62			
D Organic chemicals						
E Non-metallic mineral products	4190					
F Others (methanol)						
3. SOLVENT USE	**0**	**0**	**0**	**0**	**0**	**34.9**
A Paint application						23.5
B Degreasing and dry cleaning						
C Chem. prod.manif./processing						2.4
D. Others (vegetable oils)						
E. Residential solvent use						9
4. AGRICULTURE	**0**	**251.4**	**8.17**	**1.1**	**41**	**0**
A Enteric fermentation		157				
B Animal wastes		88				
C Rice cultivation		4.5				
D Agricultural soils			8.17			
E Savannah burning						
F. Agricultural waste burning		1.9		1.1	41	
G Others						
5. LAND USE CHANGE & FORESTRY	**-5801**	**0**	**0**	**0**	**0**	**0**
A Forest clearing						
B Grassland conversion						
C Abandonment of managed lands						
D Managed forests	-5801					
6. WASTE	**775**	**856.1**	**0**	**0**	**0**	**0**
A Landfills	775	775				
B Waste water treatment		81.1				
C Wastes incineration						
D Others						
7. OTHERS						
International bunkers						

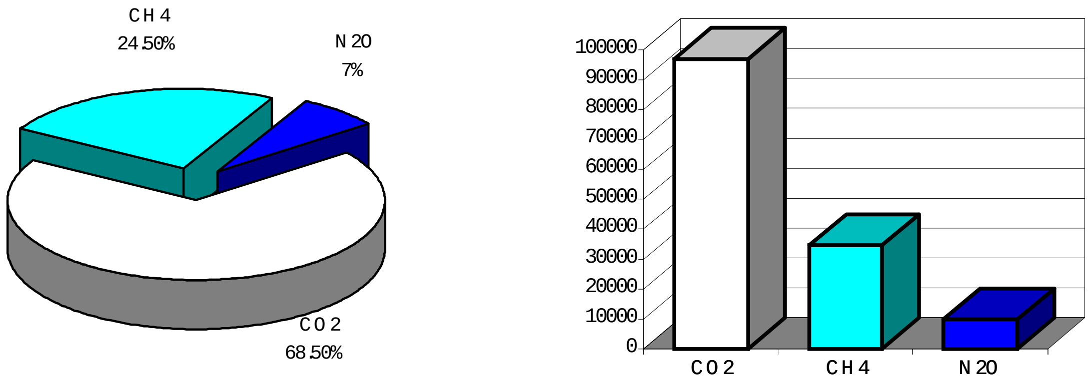
Table 3.4. Anthropogenic emissions, kg per capita and per 1000 $US GDP, for 1988

GAS	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Emission per capita	10780	157.2	3.42	54.1	92.0	14.6
Emissions per 1000 $ GDP	8495	123.9	2.7	42.7	72.5	11.6

Table 3.5. Aggregated emissions of CO_2, CH_4 and N_2O for 1988 considering both the direct and indirect effects

	CO_2	CH_4	N_2O	Aggregated
	(Gg)	(Gg CO2 equivalent)		
Total emissions	96878	34612	9856	141347
All energy	90327	9099	2228	101654
incl.:				
Stationary combustion	79574	9029	2166	90769
Mobile combustion	10753	70	62	10885
Industrial processes	5890	60	3328	9278
Others	661	25453	4301	30415

Figure 3.1. Aggregated greenhouse gas emissions in Bulgaria, 1988



%

Gg

There is no reliable information on temperature deviations and their impact on fossil fuel consumption in Bulgaria. In 1988 the mean annual temperature in the South of Bulgaria was equal to the standard level which is 11.7 to 11.8 ^{0}C. In the Northern Bulgaria the mean annual temperatures for the same year were by 0.3-0.4 ^{0}C higher than the standard temperature figures which are 10.7-10.8 ^{0}C. These slight deviations from the standard could not bring considerable differences in the fossil fuel consumption.

In 1988 the precipitation in Bulgaria were by 10-15% lower compared to the mean annual index which is 500-600 mm. Nevertheless the electricity production of HPPs was 2596 GWh in 1988 which is about 10% higher than the average annual production of 2343 GWh for the 1985-1992 period. The increased production can be attributed to the water stored in reservoirs. The difference of 253 GWh accounts for 0.5% of the annual electricity production and it is insignificant. Therefore, the assessments of the temperature impacts on the emission level are dispensable.

Bulgaria electric power system has had electricity exchange with neighbouring countries and the former Soviet Union. The total electricity exchange balance (import 4450 GWh, export 304 GWh) resulted in import of 4146 GWh in 1988. In the past few years the electricity import has been reduced that resulted in the exchange balance near to zero.

In order to produce the same quantity of electricity that was imported in 1988 in its own plants the Bulgaria Electric Power System would have to consume more fossil fuel. The least-cost production schedule of the electricity generating units to produce in addition the insufficient electricity shows that an additional CO_2 amount of 6321 Gg CO_2 would have to be emitted. The real 1988 operation conditions of the electricity generation units and additional electricity consumption for auxiliaries have been considered when the emission quantity was calculated.

3.4. Emissions of CO_2, CH_4, N_2O and CO_2 sinks

3.4.1. CO_2 emissions

The global carbon cycle consists of large carbon dioxide emissions and sinks. Fossil fuel combustion and land use change are two primary sources of the observed increase of the atmospheric CO_2. Cement, lime, glass, steel, ammonia and soda production are other important sources. Forestry activities and land use change are both CO_2 emitters and sinks.

Table 3.6 shows the total CO_2 emissions and sinks in Bulgaria in 1988 and in 1990.

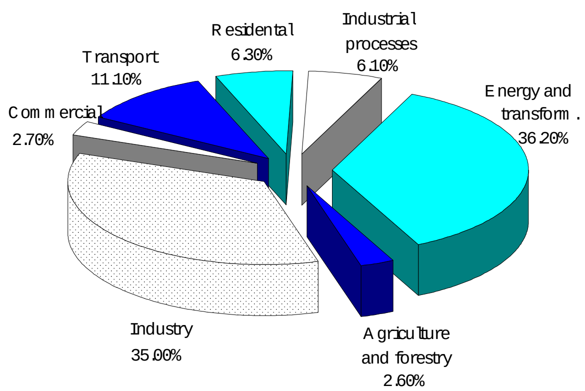
Table 3.6. Total CO_2 emissions and sinks in Bulgaria, 1988 and 1990

	1988	1990
National CO_2 emission (Gg)		
Energy (stationary combustion)	79574	64220
Transport (mobile combustion)	10753	12315
Industry (process emissions)	5890	5680
Others	661	775
National CO_2 sinks (Gg)		
Managed forests	4657	5801

CO_2 emissions by sources are given on Figure 3.3.

The fossil fuels prevail in the structure of primary energy used in Bulgaria. In 1988 their share amounted to 83.9% of the total primary energy. As a consequence fossil fuel combustion is the most important source of CO_2 in Bulgaria that accounts for 93.9 of the total CO_2 emissions followed by the industrial process that accounts for the rest 6.1 % of the total CO_2 emission.

Figure 3.3. CO_2 emissions in Bulgaria in 1988 by sources



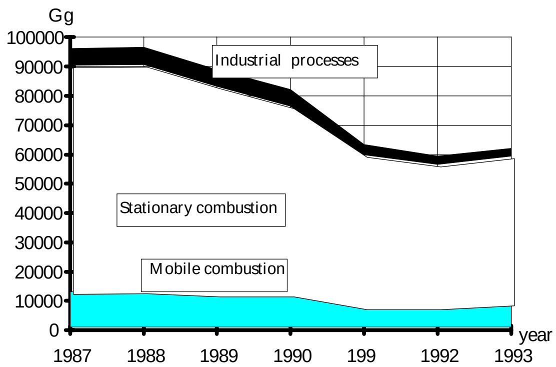
Among the fossil fuel combustion sources of CO_2 the energy transformation industry is the major one. The second important source is transportation sector but its share of 11.1% is

smaller compared to the Annex II Parties of FCCC.

The historical trend of CO_2 emissions and their split among stationary combustion, mobile combustion and industrial processes in the period 1985-1995 is shown in Figure 3.4.

A stabilisation of CO_2 emissions level was achieved in 1987 and 1988 due to the commitment of 1000 MW nuclear unit. In 1989 the first signs of the economic recession appeared, and a CO_2 emission decrease started. It lasted till 1992, although the lowest level of GDP was achieved in 1993. In 1993 and later on the CO_2 emission level was increasing due to the economy recovery.

Figure 3.4. Historical trend of CO_2 emissions in Bulgaria



3.4.2. CO_2 sinks

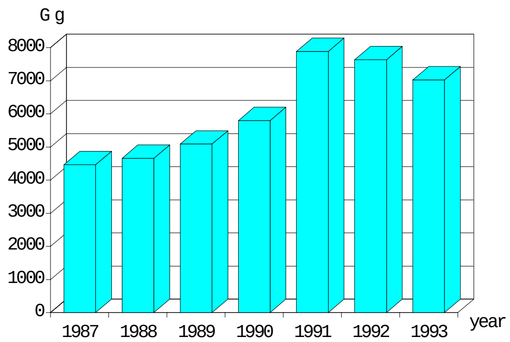
The Bulgaria's area is about 110 994 sq. km. including approximately 30% forests.

Forest clearing and land use changes are not observed in Bulgaria and therefore only managed forests are considered as emission/source category. Due to the intensive process of aforestration after 1950 and normalisation of wood harvesting since 1985, the annual increment of Bulgarian forest exceeds substantially annual cut. Therefore, managed forest acts as a net sink.

Data for calculation of forest sink capacity are based on the forests inventories carried out every five years, as well as on statistics for annual forest harvesting. There is a relatively steady increment of forest. In 1988 it amounted to 6 136 Kt dry matter. The balance between increment and harvest for that year resulted in 4 657 Gg CO2 stored.

The historical trend of forest CO_2 sinks capacity within the period 1987-1993 is shown on figure 3.5. Since 1990 a positive tendency of increase in CO_2 absorption by the forest became more obvious due to the lower actual cut compared to the foreseen cut.

Figure 3.5. Historical trends of forest CO_2 sinks in Bulgaria

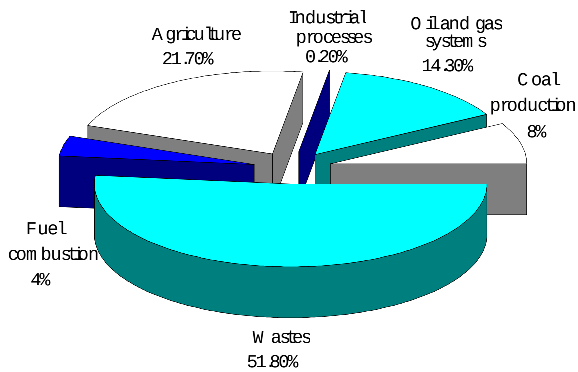


3.4.3. Emissions of methane

Methane emissions in Bulgaria in 1988 by sectors are displayed on Figure 3.6. Waste sector is the major source of methane and the major part is emitted by landfills. The second important source is the coal mining and oil and natural gas production. More than 77.7% of the coal in Bulgaria is extracted by opencast mining. The fugitive methane emissions per unit production in coal extraction from open mines is 15 times less than from underground mines. Therefore, the emissions from coal production are small - 8% from the total sum.

The emissions from natural gas and oil systems are also low - 14.3%, due to the fact that the natural gas and oil systems are not quite developed yet.

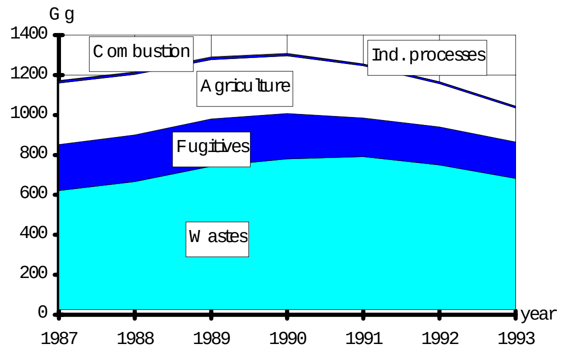
Figure 3.6. CH_4 emissions in Bulgaria in 1988 by sectors



The livestock breeding in the agricultural sector is the third important methane source.

The historical trends of methane emissions in Bulgaria in the period 1987-1993 are given on figure 3.7.

Figure 3.7. CH_4 emission trends in Bulgaria by sectors



3.4.4. N_2O emissions

Figure 3.8 shows the N_2O emissions by sources in 1988. Three major sources of N2O emissions are identified in Bulgaria. The application of mineral fertilizers is the main source. Production of nitric acid is the second important source of N_2O emissions and the stationary combustion is the third one.

Figure 3.8. N_2O emissions in Bulgaria in 1988

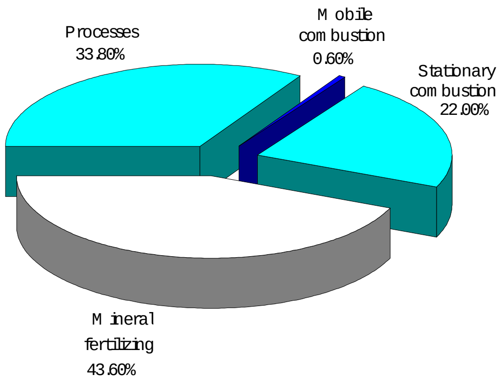
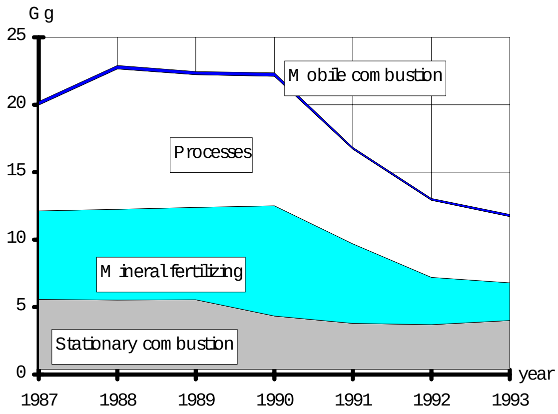


Figure 3.9 shows the N_2O emissions trends. A significant decrease of emissions from mineral fertilizers use is observed due to the economic crisis and to the structural changes in agriculture. Therefore, at the end of the period the stationary combustion has become the second important N_2O emission source.

Figure 3.9. N_2O emissions trend in Bulgaria



3.5. Emission of other GHGs

From the group of greenhouse gases controlled by the Montreal Protocol and its annexes only CFCs and Halons are used in Bulgaria. They have a very high GWP and a very long life-time in the atmosphere.

The estimates on emissions of CFCs and Halons are based on their import and consumption since they are not manufactured in Bulgaria. The data on consumption of these gases by sectors are given in Table 3.7 for the period 1986-1994. The observed reduction in consumption is due rather to the decrease in industrial output than to the substitution by less hazardous gases.

Table 3.7. Montreal protocol controlled gases consumption in Bulgaria

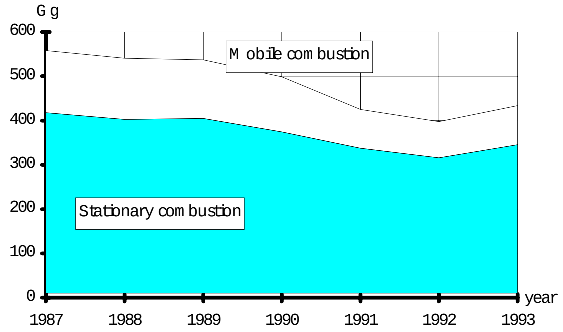
User sector	Consumption, Mg					
	1986	**1989**	**1990**	**1992**	**1993**	**1994**
Refrigeration	600	550	515	275	260	256
Foams	1180	1300	750	960	335	335
Solvents	595	330	385	182	205	205
Aerosols	850	700	310	50	55	50
Fire extin-guishing	6	6	11	2	2	2
Total	**3231**	**2886**	**1971**	**1469**	**857**	**848**

3.6. Emission of precursors CO, NOx and NMVOC

The greenhouse gases precursors are also addressed in the inventory. The main NO_x

emission sources identified in Bulgaria are the stationary and mobile combustion. Figure 3.10 shows the NO_x emissions trends.

Figure 3.10. NO_x emissions trends in Bulgaria



There are three main CO emitters in Bulgaria - transport, stationary combustion, and agricultural waste and biomass burning. In 1988 the shares of these sources in the total CO emissions was estimated as follows:

53.9% - transport;
29% - stationary combustion;
4.5% - agricultural waste burning;
12.6% - biomass burning.

Figure 3.11 shows the CO emissions trends.

Figure 3.11. CO emissions trends in Bulgaria

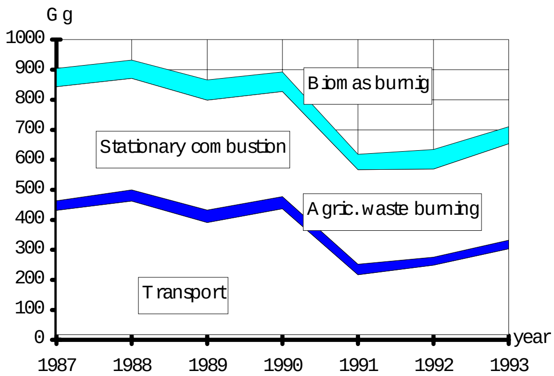
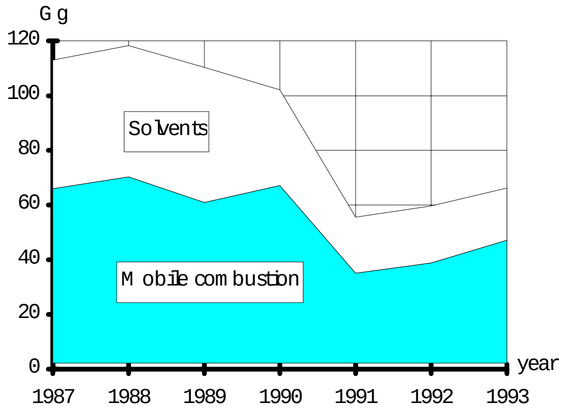


Figure 3.12. NMVOCs trends in Bulgaria



The anthropogenic emissions of NMVOCs in 1988 were estimated for two major sources - transportation (49%) and solvent use (48%). As there is no available data on solvents import, only the local production is considered. Figure 3.12 shows NMVOCs emission trends.

3.7. Conclusions

Bulgarian share in the global anthropogenic greenhouse gases emissions is approximately low - 0.4%. The annual CO_2 emissions per capita were 10.8 tons in 1988 and 9.1 tons in 1990. These figures are lower than OECD average but nevertheless they put Bulgaria among the countries having high per capita emissions.

The data on greenhouse gas emissions presented in this report cannot be considered as final. In Bulgaria the first studies on this problem started in 1992 on the base of the IPCC methodology. With regard to the limited financial resources, the national statistics shortcomings and the specific fuels characteristics more information

on sources and emissions can be obtained only step by step.

Therefore, the inventory of GHG is an ongoing process and further improvements are expected to be made.

References:

1. Bogdanov, S. Inventory of Greenhouse Gas Emissions in Bulgaria: 1987-1990. Interim Synthesis Report on National Greenhouse Gas Emission Inventories, Pre-Publication Draft, February, 1996.

CHAPTER 4

POLICIES AND MEASURES TO MITIGATE GHG EMISSIONS

This chapter provides a general survey of strategies, legislation instruments and measures to mitigate GHG emissions that have been proposed, in preparation or adopted after 1991. The mitigation policies and measures in Bulgaria pay attention primary to options for stabilisation or reduction of GHG emissions and then for forest sinks management. Basic information on programs and major projects which are relevant to the climate change policies and measures is presented. Due to the fact that in the past decades Bulgaria has followed a high energy intensive development pattern of economy, the primary objective of the current climate change policies and measures is to improve energy efficiency. Most of the important measures resulting in energy savings are directly related to the CO2 and other greenhouse gases reduction since the fossil fuels prevail within the structure of primary energy consumption.

4.1. Overall policy context

The UN FCCC and the scientific understanding of the greenhouse effect serve to formulate the basic principles of the Bulgarian policy to address climate change. The underlying principles of our national climate change policy lay on the basis of Bulgaria joining the international efforts towards solving climate change problems to the extent that is adequate to both the possibilities of national economy and the options to attract foreign investments that might promote implementation process. In compliance with these principles and because of the grave economic crisis in the county, the measures to be implemented at both national and international level should be as cost-effective as possible.

In signing the UN FCCC and its ratifying by the Parliament, Bulgaria has demonstrated its concern to climate change problems and its political will to fulfil the commitment of the Convention, i.e. to return to the base year emission level by the end of this decade.

At the Third Ministerial Conference "*Environment for Europe"* held in Sofia in October 1995, Bulgaria clearly stated the high priority of environmental issues including the climate change issues within the general context of the national overall policy.

4.2.Legislative framework and environmental strategy

The principles and legislative instruments to achieve the objectives of the National ecology strategy are formulated in the **Environmental Protection Act** adopted in 1991 (State Gazette No. 86/1991) and amended in 1992 (State Gazette No. 84/1992). This is a comprehensive act that specifies the responsibilities of executive bodies at both national and local level toward environmental protection problems and points out the increased power of the municipal authority in this regard (Pelovski and Kandev, 1995).

The Environment Protection Act sets the right of each citizen of clean environment and access to information concerning both the environmental issues and assessments about the environmental impact in construction, reconstruction or expansion of a wide range of projects, including energy project as well.

This act also arranges the financial mechanisms mend to support environmental projects by the assistance of the **National Environmental Fund** and the **Municipal Environmental Protection Funds** (State Gazette No. 5/1993). The main sources to form the National Environmental Protection Fund are: part of the

import duty for old cars (more than 10 years), 5% of the privatisation revenues from privatization of state enterprises and 70% of the charges for violation of MAC standards enforced by the Ministry of Environment.

Two other environmental funds are also established in order to support the projects in the environmental field:

- **Environmental Projects in Mountain Regions** funded from percent of the producers prices of liquid fuels, custom taxation base increased by import duties and taxes for liquid fuel. Through the adoption of Law on liquid fuel taxes for Republic road network fund and for the National environmental protection fund (14 February 1996), the Environmental Projects in Mountain Regions fund was transmitted to the National Environmental Protection Fund which is used to support environmental projects and for reduction of the pollutions from transport and energy sectors. The same law sets the Republic Road Network funds. About 30% of the funds will be used for construction, repair and winter maintenance of the networks in the mountain regions and to finance environmental projects in the mountain and semimountain regions.

- **Environment Trust Fund** for the money get as debt-for-environment and debt-for-nature swap, e.g. with Switzerland for 20 million Swiss francs (State Gazette No. 74/1975), as target funds from the national budget and so on.

The **Clean Air Act** was drafted in 1992-94 and it was adopted by the Parliament at the end of January 1996. In linkage with this act a series of subordinate legislation ordinances have to be elaborated including Ordinance on licensing, Ordinance to regulate the emissions from large stationary installations, Ordinance on the level of critical concentrations, Ordinance for the best techniques to specify the stack height, Ordinance for organisation of National air quality control system, etc.

Although the environmental regulations address only levels of particulates, sulphur dioxide (SO_2) and nitrogen oxides (NO_x), and does not concern directly the major greenhouse gases - carbon dioxide (CO_2) and methane (CH_4) as well as precursors it is expected the regulations to have positive impact in suppressing the greenhouse emissions as far as the regulation requirements can be met by increasing overall efficiency of stationary combustion process and by implementing new technologies. In 1995 emission control regulations have become more strict since Bulgaria has moved toward market-driven economy.

Regulations that will contribute substantially to limit some of the greenhouse gas emissions are:

- Additional import duties on used cars introduced in 1995;
- Lower level of excise on unleaded gasoline introduced in 1994 by Act on Excise;
- Duty-free import of environmental equipment, installations and know-how;
- Since January 1, 1996 the ozone depleting substances, as well as refrigerators, freezers, air conditioners using or produced by using ODS has been included in the import prohibited articles list.
- Regulations on waste treatment.

In 1994 the environmental friendly equipment that amounted to 95 million BGL has been imported using import tax concession.

With regard to the implementation of integrated management of municipal wastes a **National Policy and Program** is under development, that is going to include the following main elements:

- Reduction of generated wastes;
- Improved collection and transportation of wastes;
- Waste utilisation (recycling) to the possible extent;
- Reducing the risk of pollutions.

In addition to the National Policy a Draft law addressing waste treatment and technological requirements for landfill construction is elaborated, that includes measures for absorption and detoxification / liquidation of landfill emissions.

4.3.Policy, legislation and regulations for energy sector and for ozone depleting substances use

4.3.1. National Energy Strategy

As in many countries, in Bulgaria climate change policy and strategies are largely based on the national energy policy due to the high energy

intensity of GDP and very high share of greenhouse emissions that originate from energy sector.

The underlying principles of Bulgaria energy policy are consequently elaborated in the **Energy Charter** adopted by the Committee of Energy in 1993 and the **National Energy Strategy by 2020** adopted by the Government on 2 December 1995 and currently being discussed by the Parliament.

The target of the National Energy Strategy is to ensure continuous and high quality energy supply to the economy and households based on the rational use of indigenous and imported energy resources, existing energy units and national scientific and labour potential. This target can be achieved by:

- Reduced energy intensity of GDP through efficient energy production, transmission, distribution and end use consumption;
- Optimal use of indigenous energy resources, such as coal, hydro and renewables to guarantee highest possible level of country energy independence;
- Maximal use of existing energy capacities, extension of technical life-time, improvement of their technical, economic and environmental indicators by in time rehabilitation and refurbishment;
- Retirement of old units and their replacement by new ones, state-of-the-art technologies;
- Completion of construction and engineering works on the units that have been temporarily cancelled through a Governmental decision;
- Emission mitigation and maximal abatement of the adverse environmental impacts caused by energy facilities;
- Improving population life-style through wide application of centralized heating system optimization, penetration of natural gas supply to the households and better quality of fuel supply;
- Improvement of legislative and regulatory framework;
- Establishing of market orientated energy policy controlled by the Government that will ensure gradual transition to real market driven energy prices and limitation of the natural monopoly;
- Attracting of foreign investments as well as municipal and private capital for rehabilitation of old plants and commissioning of new generation units.

4.3.2. Energy legislation

Several legislation tools are available or under consideration to achieve the goals of the National Energy Strategy.

In December 1994 Bulgaria joined the **European Energy Chart** and the **Energy Efficiency Protocol**. For their implementation it is necessary the Government to establish the legal and regulatory framework that will ensure:

- Efficient performance of the market mechanisms in the field of energy production and consumption;
- Overcoming of barriers for energy efficiency improvement and promotion of investment incentives for energy efficiency projects;
- Facilitation of energy efficiency financing.

The draft of **Energy Efficiency Law** was elaborated in 1995 by the Government and it is expected to be adopted by the Parliament in 1996. This law will have impetus on energy efficiency projects, will increase the overall energy efficiency of economy and as a consequence GHG emissions will be stabilised through:

- Setting standards for energy efficiency of technologies and equipment, introduction of obligatory energy efficiency labelling of equipment;
- Mandatory energy audits should be accomplish for all new large industry projects that are high energy consuming, including new energy capacity building;
- Establishment of **State Energy Efficiency Fund** that should serve as financial mechanism to implement the energy efficiency policy at national level.

The Committee of Energy is responsible for the Government policy in the field of energy efficiency, while the regional energy efficiency centres will be in charge at local level for energy efficiency implementation.

Energy efficiency related projects will be financed using resources allocated in the State Energy Efficiency Fund at lower interest rate (twice lower) and about three years pay-back period. The fund resources are projected to be used according to the law objectives and with

regard to the annual energy efficiency programs elaborated by the Committee of Energy and approved by the Government. The main activities to be supported are as follows:

- Licensing procedures and energy audits;
- Development and investment in energy efficiency projects;
- Lending long-term credits with interest rate defined by the Funds council, which has to be not less than 50% of the base interest rate;
- Encouraging of introduction of non-traditional energy sources;
- Efficient substitution of fuel and energy types.

The draft law suggests control procedures and administrative enforcement and penalties.

After receiving the final commentsof the stakeholders and their consideration, the project will be submitted to the Government and the Parliament for discussion and adoption.

Another important legislative tool is the Draft **Energy Law** that sets the new institutional and regulatory framework in the energy field. This law states the following key principles:

- State regulation of natural monopolies such as energy sector;
- Activities in the energy field in Bulgaria are supposed to be performed on the state concession or licence basis;
- Regulatory body is founded called State Energy Regulatory Commission that is responsible for energy sector long-term policy, energy prices and energy technology policies.

4.3.3. Regulations

The Regulation No.1 of the Committee of Energy sets the conditions and procedures for licensing an activity in the field of electricity and heat generation (State Gazette No. 14/1992).

In the period to 1998 the following regulations and standards for energy equipment are to be updated in order to meet stronger technical requirements with emphasis to the energy efficiency indicators:

- Standards for specific energy consumption in industry;
- Standards for fuel combustion processes;
- Standards and labelling for households electric appliances;
- Regulations for space heating and insulation of buildings.

4.3.4. Insulation and standards for buildings

Regulation No.1 from July 28, 1992 (State Gazette 104/1992) sets forth the requirements concerning heat insulation efficiency of the buildings. The construction of new building has to be in compliance with the heat related constructions and physical criteria in order to reduce energy cost for heating.

The comparison of Bulgarian heat insulation standards in residential construction to the standards adopted in the EU countries (EURIMA, 1991) is given in table 4.1. using the heat transition coefficient K (W/m2 K).

Standards for Designing of Building Heat Insulation" edited in 1987 and amended in 1991 are now in force in Bulgaria. They set a heat resistance Ro (m2 ^{0}C/W) of the wall construction of a building to be higher or equal to the economically expedient heat resistance Ro $_{EC}$ (m2 ^{0}C/W). The Ro $_{EC}$. values are given in table 4.2.

The analysis indicates that in general, Bulgaria heat insulation standards correspond to the EU countries standards and no major changes are needed. Problems arise however because the existing building stocks and great part of those in construction does not meet the heat insulation standards.

Construction control, specific programs for energy efficiency in buildings and new building technologies are foreseen as the most promising measures to conserve energy and therefore to reduce GHG originating from Building sector.

Table 4.1 Comparison of Bulgaria heat insulation standards to the standards adopted by the EU countries

	Walls		Roofs		Floors	
Country	**Level Ê /W/m^{2}K/**	**recommended insulation thickness, mm**	**Level Ê /W/m^{2}K/**	**recommended insulation thickness, mm**	**Level Ê /W/m^{2}K/**	**recommended insulation thickness, mm**
Belgium	-	75-100	-	80-120	-	40
Denmark	0.35	125-150	0.20	200	0.30	150
Finland	0.28	150	0.22	200	0.22	200
France	0.54	70	0.35	120	1.00	40-50
Germany	1.2-1.5	60	0.30	140	0.55	60
Ireland	0.60	40	0.40	100	0.60	-
Italy	-	-	-	-	-	-
Holland	0.374	70	0.374	85-100	0.68	40
Norway	0.30	125	0.20	200	0.30	150
Spain	1.4-1.8	-	0.7-1.4	-	0.7-1.0	-
Sweden	0.30	125	0.20	200	0.30	150
Great Britain	0.45	50	0.25	150	0.45	25
Bulgaria	**0.89**	**-**	**0.48**	**-**	**0.72**	**-**

Table 4.2 Economically expedient heat resistance values - Ro_{EC} (m^2 $^0C/W$)

Types of buildings and wall constructions	**Adopted winter outdoor temperatures (^0C)**										
	-10	-11	-12	-13	-14	-15	-16	-17	-18	-19	-20
1.Residential buildings; hotels											
-Outside walls brickworks and one layer walls of light concrete	0.84	0.87	0.90	0.93	0.96	0.98	1.01	1.04	1.07	1.1	1.12
-Deck-roofs	1.55	1.6	1.66	1.71	1.76	1.81	1.86	1.91	1.96	2.04	2.07
-Floors	1.03	1.07	1.1	1.14	1.17	1.21	1.24	1.28	1.31	1.34	1.38
2.Clinics and schools											
-Outside walls brickworks and one layer walls of light concrete	0.76	0.78	0.81	0.83	0.86	0.88	0.91	0.94	0.96	0.99	1.01
-Deck-roofs	1.38	1.42	1.47	1.52	1.56	1.61	1.66	1.7	1.75	1.79	1.84
-Floors	0.83	0.86	0.88	0.91	0.94	0.96	0.99	1.02	1.05	1.08	1.1
3. Public buildings, exc. those in 1 and 2											
-Outside walls brickworks and one layer walls of light concrete	0.63	0.65	0.67	0.7	0.72	0.74	0.76	0.78	0.80	0.82	0.84
-Deck-roofs	1.24	1.28	1.32	1.36	1.41	1.45	1.49	1.53	1.57	1.61	1.66
-Floors	0.83	0.86	0.88	0.91	0.94	0.96	0.99	1.02	1.05	1.08	1.1

* the Ro reciprocal value is the heat transition coefficient Ê

4.3.5. Energy and fuel prices

Changes of structure and the level of energy prices are fundamental to promote energy efficiency, to conserve energy, to reduce GHG emissions emitted at the end-use energy consumption, as well as for reorganisation of the Bulgaria energy sector. At present, when the process of price liberalisation affects all economy, the energy prices are still controlled by the Government. Prices of liquid, solid and gaseous fuel as well as prices for heat and electricity are updated by the Government based on recommendations of the Price Commission or the Committee of Energy.

Mediterranean spot prices in USD serve as a basis to form liquid fuel, LPG and natural gas prices. Current exchange rate, freight, insurance and premium as well as VAT excises, duties and taxes set by the regulations are applied to receive the selling prices of different liquid fuels. A steep increase of the liquid fuel prices can be observed in 1994 when VAT was introduced and in 1995 when the excise duties went upward from 35% to 70% for gasoline up to A93 and 110% for gasoline over A93 and from 25% to 30% for diesel fuel. The price of unleaded gasoline is 6% lower compared to the ordinary gasoline to encourage the use of more environmentally friendly fuel. Natural gas price is formed as 70% of the price of residual oil with 3.5% sulphur content. The tendency is to use a price of residual with 1% sulphur content as a base to determine the natural gas prices.

Imported coal prices for households and industry completely correspond to the international market prices, while indigenous coal prices are subsidised. It is expected the Government to continue subsidising of coal mining due to the national strategic interests and employment issues. Therefore, the introduction of carbon tax is not relevant to the conditions of Bulgaria energy market where the fuels with high carbon content such as coal are subsidised.

A process of gradual removing of subsidies of electricity and heat prices has started since 1992. The ultimate goal of this process is to bring prices of heat and electricity to full market level that could be achieved by following step:

- Recognition of mechanism to form the electricity prices at the level consistent to the inflation;
- Adoption of mechanism for heat and electricity price setting providing necessary funds for investment in energy system development;
- Formation of funds for supporting low income families with their electricity and heat bills;
- Diminishing and ultimate elimination of subsidies for heat supply to households;
- Because of the future market setting of natural gas prices once the Iamburg agreement with Russian Federation will be over, establishment of a tariff structure for natural gas supply with differentiation approach towards different consumers is expected;
- Upgrading of electricity tariffs in order to diminish the cross subsidising and to follow the heat rate parity, that requires correspondence between the prices of mutually substitutional energy sources used to satisfy identical needs.

The electricity tariffs are characterised by a structure that went into effect in 1992. For households the electricity is priced on time-of-day basis. Businesses are charged on a more complex tariff considering season of year and peak usage, but the prices for low voltage power are about the same as for households.

The new tariff levels for business and households in force since 1 September 1995 are given on table 4.3 and 4.4 respectively (exchange rate 1 USD = 67.935 BGL).

Table 4.3 Demand of the industrial customers

Zone	Winter						Summer					
	supply voltage						supply voltage					
	high		medium		low		high		medium		low	
	BGL/kWh	$/kWh	BGL/kWh	$/kWh	BGL/kWh	$/kWh	BGL/kWh	$/kWh	BGL/kWh	$/kWh	BGL/kWh	$/kWh
Peak	3.55	0.052	3.68	0.054	3.85	0.057	3.10	0.046	3.19	0.047	3.35	0.049
Day	1.93	0.028	1.99	0.029	2.07	0.03	1.67	0.025	1.73	0.026	1.81	0.027
Night	0.95	0.014	0.98	0.015	1.02	0.015	0.81	0.012	0.86	0.013	0.88	0.013
1-zone	2.86	0.042	2.91	0.043	3.10	0.046	2.48	0.037	2.57	0.038	2.69	0.04

Table 4.4 Residential demand

Zone	Price	
	BGL/kWh	US$/kWh
Day	1. 56	0.023
Night	0. 83	0.012

Although the current electricity tariff has a quite comprehensive structure further improvements are foreseen to provide incentives for energy savings. This is especially true for the level of electricity prices because currently they are at so low level that pay-beck period for the major part of energy efficient technologies is much longer than it could be expected.

4.3.6. Tax system

The tax system is changing now in order to promote energy efficient technologies and technologies aimed to reduce GHG.

In order to harmonise Bulgarian tax and import duty system with the Member States in the European Union, a Regulation No. 237 is issued on 12 December 1995 for adoption of Custom tariff of Republic of Bulgaria (State Gazette 109/15.12.1995) and Regulation No.266 from 29 December 1995 (State Gazette 15/5.01.1996).

The measures that are already in place are related to the import duty concession for efficient equipments, equipments to reduce and prevent air and water pollution, and waste treatment.

In future:

⇒ On the ground of the Montreal Protocol to the Vienna Convention on Ozone layer Conservation the import of the following substances and goods is prohibited:

- Dangerous ozone depleting substances;
- Equipment and machinery for air conditioning using freon-12;
- Refrigerators, freezers and other devices containing freon-12 or freon-11.

Machines, appliances and equipment operating with freon other than freon-11 or freon-12 can be imported after written approval by the Ministry of Environment.

⇒ Import of the following equipment is duty-free up to 31 December 1996:

- Substances and compounds, materials and investment equipment for ozone depleting technologies substitution;
- New and unused special installations and equipments and attached devices for waste treatment, detoxification and disposal;
- Installations, equipment and materials for energy generation from non-traditional alternative energy sources (solar, wind, geothermal water and biomass).

The Committee of Energy has put on discussion a set of measures for tax and import duty stimulation of alternative energy sources and energy conservation.

⇒ The following products are suggested to be exempt from import duty and value-added tax:

- equipment to collect and use biogas;
- water turbines with a capacity of no more than 100 kW;
- heat pumps;
- solar equipments;
- wind turbines with a capacity of no more than 75 kVA;
- compact fluorescent lamps, discharge lamps and discharge lamp parts;
- meters for heat consumed in households.

⇒ The operation of the following installations should be exempt from income tax in five year period after they are put into operation:

- Small hydro power plants of up to 1 MW
- Wind powered electric power plants;
- Heat pumps;
- Solar equipment;
- Biogas production equipment;
- Equipment for using geothermal energy.

By Law on the Charges for Liquid Fuels for the Republic road network fund and for the National Environmental Protection Fund adopted on 14 February 1996, the level of taxes levied on the production and import of gasoline, diesel and residual with sulphur content over 1% is updated. The new tax level are as follows:

- For car gasoline - 19% of the producer price or of the custom taxable value increased by import duties and taxes. 14% of the sum is accumulated in the Republic Road Network Fund and 5% - in the National Environmental Protection Fund.
- For diesel fuel - 15% allocated as follows: 11% in the Republic Road Network Fund and 4% - in the National Environmental Protection Fund.

4.4. Climate change strategy and policy

Bulgaria is in process of establishing a consistent climate change policy to achieve FCCC goals and greenhouse gas emissions reduction target. Contemporary climate change policy is largely based on national energy and environmental policy, but in a near future a systematic national program and action plan will be developed.

The research project **Bulgaria Country Study to Address Climate Change** is being currently performed within the US Country Study Initiative to Address Climate Change. Bulgaria was among the first round countries participating in the US Governmental program and the project is co-sponsored by the US Department of Energy.

In regard to the policies and measures the project is a first attempt to identify the key areas to address climate change problems according to the sustainable development principles. It incorporates the relevant activities originally devoted to goals different from greenhouse emission mitigation, as well as highlights new activities, policies and measures addressing climate change. Thus the study provides consistent basis for further development of the national climate change policy.

4.5. Measures and projects to mitigate greenhouse gas emissions

Due to the high energy intensity of Bulgarian economy the greenhouse gas mitigation measures are predominantly aimed to reduce CO_2 emissions and other energy related greenhouse gases. At the same time special attention is given to the transportation sector since major changes in the transportation pattern are expected, and as a consequence transport related GHG emissions will grow substantially. The potential of forest to absorb CO_2 emissions and to reduce emissions from agriculture through better management practices is also in focus in this section.

4.5.1. Energy sector

4.5.1.1. Overall potential for energy savings

The development pattern that Bulgaria has followed under the conditions of centrally planned economy was highly energy intensive. The energy intensity of GDP was more than twice higher compared to the West European countries due to the prevailing share of industry in the GDP structure, while the energy intensity of the industrial output was 50% higher. The primary energy consumption per capita was also high and in 1990 it amounted to 139 GJ (Kantor, 1994).

Energy intensity

Energy intensity of economy as a whole is expected to decrease driven by structural changes among economic sectors and within sectors, high prices of energy and penetration of new state-of-art technologies. According to the last projections the share of industry within GDP structure will decrease from 45.5% in 1992 to 38.9% in 2000 (Minassian and others, 1995) on account for the services.

Industrial sector that accounts for 52.5% of the final energy consumption in 1992 has the highest potential for energy efficiency improvement through measures and specific projects. Experts judgements indicate that the potential for energy savings within industrial sector amounts to 30.2 PJ in the period 1996-2000 and 159 PJ in the period 2016-2020 (Tzvetanov and others, 1995). This potential could be achieved by:

- Efficient operation, better organization and energy saving activities with minimal financial resources - about 15% of the estimated potential;
- New investments and more restrictive Government policy toward fuel and energy savings - about 50% of the estimated potential.

Only by reducing industrial energy intensity 15.7% of the current fuel use could be saved.

Renewable sources

The share of renewable sources in the primary energy consumption in Bulgaria is less than 1%. According to the expert judgements the share of the renewable sources will grow up to 7% in 2020. This could be achieved by purposeful Government policy considering renewable sources as economically and technically feasible energy source as well as an important option to mitigate GHG emissions by substitution of fossil fuels.

High potential of renewable resources is proven in Bulgaria. The total accessible and usable potential that could be implemented in current technologies is given in table 4.5.

Table 4.5 Renewable energy potential for different resources in Bulgaria in TWh

Resources	Solar	Wind	Biomass	Hydro	Geothermal
Total	171000	125000	57-61	21	-
Accessible	95000	62300	-	-	-
Reserve (high)	214	21-33	10-11	12	0.03
Reserve (low)	4.7	0.32	3	12	0.03

Different parts of the country are suitable to implement different types of renewable technologies. For example, most high mountain regions, along with the Black Sea coastline are appropriate to install wind mills, solar resources are higher in the southern and eastern part of the country, while biomass resources related to agricultural production are most widely spread in the northern and north-eastern part of the country.

Analysis of the current options to implement renewable energy sources shows that they are most efficient to meet the energy demand on-site - for electricity production with back-up supply, corn milling, water pumping, space and water heating especially for remote areas. Only in case these options are exhausted the use of renewables for off-site energy supply, for electricity on grid for instance, could be considered.

Expert estimates indicate that a significant drop in renewable technologies prices is expected due to the increase of their market share. This tendency together with the domestic production of part of necessary equipment will speed up the penetration of renewables in Bulgaria.

4.5.1.2. Programs and projects in energy sector

Series of projects and programs consistent with the objectives of the National Energy Strategy are underway in the energy sector focusing on options to improve energy efficiency to reduce the negative effect of energy sector to the environment and therefore to mitigate greenhouse gas emission.

The major programs and projects are as follows:

Programs:

⇒ **National program for natural gas supply to the households**

The program is developed based on studies carried out by the Energoproekt PLC, Industrial Energy PLC and Haskoning (Netherlands). Two scenarios and time schedules are elaborated: realistic and optimistic. According to the realistic scenario 1’200’000 people or 400’000 households will be supplied with natural gas by 2020, while according to the optimistic scenario they are 2’000’000 people and 670’000 households respectively. The energy, economic and environmental benefits of natural gas use in households compared to the current situation are proven in the studies.

The program is an inherent part of the National Energy Strategy and serves as a starting point to develop projects for specific cities such as:

- **Natural gas supply in the city of Stara Zagora**. The project amounts to 1 million $US and is financed by the US AID as a part of the program for Bulgaria “Action Plan for Environment in the Countries in Transition”. The major objective of the project is to improve the energy use efficiency, air quality improvement through emission reduction and to implement the financial mechanism to be used further as a model for financial support for similar projects in future in other cities.
- **Natural gas supply in the city of Plovdiv**. Some preliminary researches are under way sponsored by the World bank. The objectives are just the same as in the previous project.

⇒ **National program for development of central heating system**

The central heating system supplied heat and hot water to 1'550'000 inhabitants or 18% of the total population of the country at the end of 1993. Rehabilitation of existing plants and networks as well as upgrading of cogeneration plants (CHP) and heat boilers (HB) by combined cycle natural gas systems is a problem that is considered in the series of feasibility projects for: CHP Sofia, HB Zemliane, CHP Plovdiv, HB Plovdiv south, HB Burgas, HB Iambol, HB Mladost, HB Vratza, HB Veliko Turnovo, CHP Sofia South, HB Liulin, HB VL.Varnenchik and CHP Rousse West. The program has short-term and mid-term objectives to meet the demand for heat and hot water of the population already supplied by this system at improved technical, economic and environmental conditions.

⇒ **PHARE program for Bulgaria energy sector**

PHARE program supports a lot of activities, feasibility studies and projects aimed to improve overall energy efficiency, to promote new state-of-the-art technologies and renewable energy technologies. The major projects that are implemented or are underway are listed below. Their total amount is 6'500'000 ÅKU:

- Regional energy concept/Regional Energy Centre for Pilot Region of Lovetch

The main long-term objective is to facilitate the transfer of energy management on regional level. The project comprises two phases. Phase I covers analyses of institutional and legal framework, present energy demand and supply, environmental impact, potentials on increasing the energy efficiency etc. Phase II covers elaboration of regional energy plan, demonstration projects (procurement of equipment for energy centre and activities for strengthening its role and image).

- Regional energy concept/Regional Energy Centre for Pilot Region of Haskovo - the objectives and project description are the same as for the previous project.

- Demonstration Project for Energy Efficiency in Multi-dwelling Buildings with Centralized Heating.

By means of implementing a demonstration project in such building (by introducing effective energy measuring equipment, financial, economic and other reorganisations) to show the possibilities to increase energy efficiency. Project results are to be disseminated.

- Demonstration Project for Energy Efficiency in Multi-dwelling Buildings with Individual Heating

By means of implementing a demonstration project in such building (by introducing effective energy measuring equipment, improvement of sealing, improvement of heat distribution system, installation of energy saving lamps, financial, economic and other reorganisations) to show the possibilities to increase energy efficiency. Dissemination of information on results of the project.

- Demonstration Project for Energy Efficiency in Hospitals

The project objectives are the same as for the previous project but for the conditions in hospitals.

- Demonstration Project for Energy Efficiency in Public Buildings

The project objectives are the same as for the previous project but related to the public buildings.

- Demonstration Project for Energy Management

Implementation of effective management organisation in a typical municipality of 100 000 inhabitants. Results should be reported to the public. The results from the above projects should be summarised and energy efficiency strategy should be elaborated.

- Technical and Economic Assessment of the Bulgarian Renewable Energy Resources

Preparation of proposals for plants for utilisation of each renewable energy resource in regard of increasing its share in the energy balance to 2% up to the year 2010, recommendation of measures on legal, organisation, financial and other issues in relation to this problem.

- Quantitative Energy Scenarios for Bulgaria

The goals of the project is by using different computer models (macro-economic, energy demand, energy supply and assessment of limited national resources) to develop energy scenarios up to the year 2010 and to assess its impact on the energy sector development.

⇒ **European Union TERMIE special electricity conservation program in Bulgaria**

The program embodies demonstration projects that have to prove the efficiency of technical decisions and measures targeting energy efficiency options in different sectors (buildings, industry, heating, electricity generation, energy industry) and different fields such as:

- Improvement of offices, halls and industrial sector lighting, as well as operation control system for street lighting and daylight-linked control lighting in a factory;
- Integrated electricity savings in hospitals and residential buildings;
- Advanced process control in brick and ceramics production, monitoring and targeting in the brewery, electricity savings in the engineering industry, installation of temperature measurement equipments for induction furnaces;
- Automated control of reactive power compensation installations, reduction of apparent power consumption for selected enterprises;
- Demonstration of electricity savings in district heating and industrial boiler installation, improvement of combustion geometry in boilers through the use of appropriate monitoring system;
- Replacement of 100 electric immersion water heaters by a central solar water heating, implementation of solar collectors and heat pumps in buildings;
- Low cost measures to reduce electricity consumption of motors;
- Energy savings in pumping stations.

⇒ **National program for energy efficiency and economic lighting**

The program is elaborated by the Technical University of Sofia under co-ordination and supervision of the National electric company. The first specific project - Replacement of the old 250 W mercury street lighting by 150 W sodium based on this program is already underway.

⇒ **Program for energy sector assistance** provided to Bulgaria by the US Agency for International Development

The program includes several projects. Some of them are relevant to the energy efficiency and energy saving alternatives such as:

- Bulgaria electricity study. Management of electricity demand. The project is performed by RCG/Hagler, Bailly, USA and focuses on the demand for electricity in Bulgaria and options to improve its management. It serves as key source to identify the most efficient measures for energy and carbon savings in the project Bulgaria country study to address climate change.
- Program to promote energy efficiency in KATEKS factory in Kazanlak. The program aims to identify and implement a series of small projects to ensure energy savings at the factory. The program is implemented on bilateral basis by the National Electric Company and Central Main Power US supported by US AID.

⇒ **Project Energy efficiency demonstration zone in Gabrovo**

The project is prepared by EnEfect and the Municipality of Gabrovo and this is the first project to be financed by the Global Environmental Facility in Bulgaria aimed to support municipal authorities to elaborate and implement energy efficient strategy to reduce greenhouse gas emissions. The project objectives will be achieved by two groups of activities:

- Capacity and institutional building to work out and implement energy management strategies and to ensure sustainable market orientated development;
- Demonstration programs for energy savings that address greenhouse gas emission reduction of about 22 300 t ÑÎ2 annually according to preliminary estimates.

⇒ In compliance with the **National energy supply side strategy** there exists a significant potential for GHG emissions reduction through implementation of projects such as:

- Completion and commitment of NPP Belene by 2002;
- Rehabilitation of existing thermal electricity generating capacities;
- Building of new electricity generating plants on indigenous coal using advanced technologies such as fluidized-bed combustion;
- Reducing of heat and electricity losses in networks;
- Increasing of the share of renewables in the structure of national energy balance;

- Maximal use of existing hydro potential in Bulgaria for electricity generation in conventional and small hydro plants.

More information on projects listed above is given in Chapter 5 where they are incorporated within mitigation scenarios and evaluated in regard to their impact to reduce GHG emissions.

4.5.2. Industry

4.5.2.1. Measures targeting reduction of the energy related GHG emissions

Due to the high energy intensity of the industrial production there are lots of opportunities to implement new technologies that may lead to both energy consumption and GHG emission reduction as well as to mitigation of ozone depleting substances. A survey of measures is given according to the business programs of different industries (Tzvetanov and others, 1995). It reveals a potential for energy savings in industry of about 44 PJ in the period 1996-2000, that increases to 159 PJ in the period 2016-2020. This potential could be adopted by measures applied in different sectors:

Iron and steel - loading up to full capacity of existing steel production plants, improved technology control, modernisation and automation, use of non-destructive product quality testing, use of flue gas analysers for combustion control, reduction of energy losses through better building insulation and pipelines insulation, use of electric load control.

Non-ferrous metallurgy - construction of new electrolyte production facility, construction of 3rd sulphur acid production installation in order to utilise the SO_2 containing gases from the metallurgy; increased the share of recycled metals; implementation of the following investment projects: construction of 130 000 t/a capacity for electrolyte copper, leading to 1.5 times reduction of the specific electricity consumption per unit production (up to 350 kW/t) and efficiency factors of 95 to 98%; increase in the production of recycled zinc, leading to 10% reduction of electricity consumption and 15% reduction in coke consumption; construction of zinc producing plant utilising the autoclave metal extraction and transfer from sulphuric acid to sulphur production - the total consumption is reduced by factor of 1.5; implementation of new lead production technologies in order to couple the existing two main technological processes into one hermetic facility - expected reduction of coke use is about 300 kg/t.

Chemical industry - decommissioning of some old high energy and material consuming technologies such as industrial plastics and implementation of new ones such as thermoplastics; expand the production of antibiotics, leading to reduction of energy consumption per unit production, reconstruction of soda ash installations.

Building materials industry - adoption of new dryers and furnaces with improved control, use of ashes from electricity generation plants, metallurgy and chemical industry in the current production.

Food processing industry - There are 98 projects for modernisation and renovation, including modernisation and installation of new steam station and their gasification; replacement of pipelines and measurement systems; repair of equipments and installations; installation of condense collectors for technological and heating systems; replacement of the old refrigerating installation; implementation of technologies for deep processing of raw materials.

Construction industry - upgrading of the existing technologies especially for concrete works and liming that may lead to 20-25% energy efficiency improvement.

Agriculture - reduction of energy losses in irrigation by use of more efficient pumping and water saving approaches; use of renewable energy sources for pumping driving; increase in the efficiency of agricultural machinery by use of new machines or minimisation of land processing; use of biofuels; use of solar energy for drying and water heating in the animal farms and in greenhouses; use of integrated energy systems with both conventional and renewable sources; reduction of fertilisers import.

The successful implementation of the foreseen measures to increase energy efficiency and reduce energy related GHG emissions will strongly depend on the availability of financial resources. The Bulgaria Government will therefore strongly support foreign investments that are proven to be efficient in this field. The Government also encourages voluntary agreements with industry targeting GHG emission reduction.

The **Centre of Energy Efficiency in Industry** created by Government Decree No.397 from 22 September 1995 on the basis of Bulgaria-Japan

Government agreement is going to co-ordinate the accelerated implementation of energy efficiency projects. The establishment of general information system in the energy efficiency field is expected as well as commitment of projects on the base of energy researches and observations in particular industrial enterprises.

4.5.2.2. Ozone depleting substances

Bulgaria has ratified the Vienna Convention to preserve ozone layer and Montreal Protocol to phase out ozone depleting substances (ODS). A **National program for gradual reduction of ODS** mainly Chlorofluorocarbons (CFCs) and Halons that account to 93% of ODS consumption in Bulgaria has been developed and is under implementation. Global Environmental Facility ensures the financial support for the program of about 10.5 million $ US. The program is to be accomplished in two phases. During the first phase by 1998 Bulgaria will reduce the total consumption of ODS by 87%, i.e. by 487 t annually.

The program addresses the following sectors:

- *Aerosols*. The use of ODS was reduced by manufacture restructuring to the minimal extent possible in medical and cosmetic goods production in 1992.
- *Solvents*. Several steps towards manufacture restructuring to substitute ODS by other substances are already made. One of the GEF supported projects is in this sector.
- *Fire extinguishers*. The ODS consumption in this sector is diminished up to 2 tons annually and further reduction is impossible due to the lack of substitutors.
- *Refrigeration and foams*. The ultimate goal of the projects in these sectors supported by GEF is to phase out by the end of 1998 all CFCs used but CFC-22.

The program embodies also a series of regulatory measures already mentioned in section 4.3.6.

4.5.3. Transport

There is a special focus on measures in the transport sector because of the expected rapid growth in the sector, change in the transportation pattern with a shift from public to private transport, three to four times increase in fuel consumption by 2020 and as a consequence - steep upward trend of emissions (Tzvetanov and others, 1995).

Measures that are specific for different transportation modes are:

- **Railway transport** - to continue electrification of the railways and to update locomotive stock with electric engines and with improved electricity fraction, tiristor devices and microprocessor control systems.
- **Road transport** - better maintenance of the existing roads and improving transportation infrastructure by building new high-ways. This is especially important measure because calculations indicate that driving at rough roads may lead to increase of fuel by more then twice.
- **Water transport -** to update existing stock by vessels with bigger loading capacity and higher velocity.
- **Air transport** - optimisation of flights and upgrading of existing stock.

The following measures have positive impact on the overall transportation sector in terms of increased energy efficiency, reduction of fuel economy and hence mitigation of greenhouse emissions:

- The import duties and purchase taxes on cars are at level that corresponds to the average European taxes and they are differentiated according to the volume of engine;
- The maximal speed limits are lower compared to the international standards aimed to reduce fuel economy;
- The public transport in the cities is subsidised, the private car traffic in the central zones of large cities is limited thus contributing to larger use of public transport that is proven to be twice more energy efficient and less polluting;
- Mandatory maintenance and checking of vehicles and decommissioning of old inefficient vehicles;
- Improvement of cities infrastructure to promote better conditions for pedestrians and bicyclists;
- The railway transport is given high priority and it will continue to be subsidised to keep its share at current level;

- Options to implement road pricing are considered now that are regarded as an efficient instrument to reduce the local and intercity road traffic;
- Development of new infrastructure projects for integrated transportation systems; including ships, rail and road transport.

4.5.4. Forestry

The mitigation options could be classified into two main types. The first alternative is to enlarge the areas with stands, which will bring to increase sink capacity of the carbon from the atmosphere and the storage of its larger amounts on the earth and extending the carbon contents in the products using the timber as a source. The second option is to maintain the existing stands and to keep the proportion of the present forest production. The maintenance of the existing stands, no matter how it is achieved (e.g. through lower rate of deforestation, forest protection measures or more effective conversion and forest products utilisation) detains the greenhouse gases emissions from penetrating in the atmosphere.

Another way for the carbon emission reduction is to use timber from renewable source, for example forest plantations, to replace the non-renewable sources, having in view the fossil fuels. The shift from solid and liquid fuel to wood will detain the carbon release from the fuels as long as the usage of timber continues.

The realisation of the afforestations in quantitative as well as in qualitative sense, i.e. the combination of gradual change of the coniferous plantations improperly established in the low forest vegetation zone with deciduous and expanding of forest lands through afforestation of devastated lands and establishment of forest shelter belts would bring to a considerable reduction of the CO_2 amounts emitted in the atmosphere.

A **Forestry Development Strategy** is drafted now. It incorporates lots of the listed measures, policies and strategies for adaptation and alleviation of the impact on climate.

Two projects for afforesteration are to be financed by the Global Environment Facility to UN. These projects are beyond the scheduled activities of the Committee of Forests:

- Stabilisation of Pripek river catchment area;
- Afforestation and biological recultivation of spoiled banks from open mining in the region of Maritza East mine fields.

If one takes into consideration only the cost per ton CO_2 stored these projects seem expensive compared to the available technical measures. They may prove to be attractive if additional impacts such as recreational, microclimatic, hydrological and living condition improvements are taken into account. They are also pilot projects that should identify the adaptation and resistance rates of the tree species in Bulgaria to climate changes. The analysis of the results to be obtained will help to update the existing standards and governmental policy for sustainable development of the forestry sector.

4.5.5. Agriculture

The mitigation measures will penetrate gradually in agriculture managing practice of Bulgaria because the attractive in them is the increase of the effective productivity directly concerning the economical interests of the farmers. In near future it could be expected an improvement of the way of nutrition of the domestic animals as well as of the foods and of the species.

The collection and utilisation of the methane from the manure is a problem which solution is at initial stages. The experience in this field in Bulgaria was limited even in the past under the centrally planned economy conditions when the predominant part of the animals was gathered in the co-operatives and there were a lot of opportunities to realise such projects. At present, the dispersion of the animal units in the numerous private farms hinders the construction of installation for collection and use of methane.

Meanwhile the manure fertilisation is considered a mitigation measure. This manure is spread out on the field and as a result of the aerobic oxidation of the matter methane emissions are diminished. At the same time manure replaces the artificial fertilizers (which are more expensive) which leads to the direct storage and accumulation of carbon in the soil and to reducing the N_2O emissions. The nitrogen fertilizers used in agriculture are in compliance with the instructions in the conception which prescribes soil sampling and analysis before defining the required dose of fertilised and therefore any overdose is slightly probable.

Bulgaria has developed an institutional structure to apply this concept.

In this way the impact of the new economic instruments especially on the private sector contribute to the reduction of the GHG effect. This can be defined as a tendency as far as quantitative evaluations assessments are not yet possible.

Other mitigation options are connected predominantly with the devastated lands treatment. To date these lands has increased with about 5-6% compared to 1990. As a problem in the agriculture the increase of the untillaged areas has been pointed out - form 1.5% in 1989 they became 9.6% in 1993. The amount of untillage areas grows in the private farms as well - 9.2% in 1993. The untillage of this lands is connected with the conserving technologies of the mitigation choices, i.e. increasing of the accumulated and stored carbon quantity in the soil. The reclamation of this lands (afforestation) would lead to other mitigation options.

4.5.6. Waste management

Human activities inevitably generate municipal wastes. Currently the only waste treatment is the disposals in landfills. Up to now there exist 2000 such depots most of which are not controlled and technologically improperly designed. There are also lots of small village landfills. The total area used for waste disposal is about 1.5 ha.

There is not separate waste collection applied yet. Such a measure will enable secondary use of some of the wastes and thus will decrease the waste volume and the needed disposal area.

The morphological wastes analysis shows that food wastes comprise 30-40% of the wastes. They consist organic matter and in the process of biodegradation methane and CO_2 are emitted.

The separation of the specific waste flow from wastes such as glass, paper, plastics, minerals and so on will decrease the total amount of waste but will increase the methane and CO_2 emissions per unit of disposed waste because the stored amounts will have mainly organic origin. This survey shows that National Program should include measures to close the uncontrolled landfills and for construction of new environmentally friendly landfills not more than 100 on the country territory.

The integrated management of the wastes and at first place their reduction and construction of regional centres for their treatment and detoxication require substantial investments which could not be entirely provided by the state and some opportunities for financial support by international institutions and organisations will be seek for.

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CHAPTER 5

GREENHOUSE GAS EMISSION PROJECTIONS AND EVALUATION OF THE EFFECT OF POLICIES AND MEASURES

The chapter presents results of GHG emission projections based upon scenarios of future development of economy, energy demand and supply in Bulgaria. Different methods and approaches are used at different stages of the forecasting process and key mitigation options are identified and evaluated according to the data discussed in chapter 4. The results obtained indicate that the aim of Framework Convention of Climate Change (FCCC) to have year 2000 GHG emissions below the base year 1988 emissions will be achieved. The mitigation options that will allow to reduce GHG emissions and to enhance sinks are assessed. The implementation of these options have to start now in order to prevent the GHG emission increase in the decades immediately after 2000.

5.1. Methodology for GHG emission projection and scenario definition

The most significant contributors to GHG emissions in Bulgaria are the energy production sector and the energy-intensive sectors of the national economy. Therefore, the main effort in the GHG emission forecasting are directed towards these sectors, while the studies that address non-energy sectors are much more limited.

The GHG projections have two main targets:

- To identify whether Bulgaria will be able to meet its obligations in regard to the FCCC;
- To identify the most efficient policies and measures at macro-economic level, sectorial level, utility and enterprise level and household level that may lead to GHG emission reduction.

In order to achieve these goals, a methodology is used, that allows to exhaust the interrelationships between macroeconomic development, sector development (including the energy sector), and GHG emissions. Therefore, according to this methodology forecasting procedures have been carried out in four major stages within the relevant institutions responsible for them:

- Macroeconomic and socio-economic analysis and projections - Institute of Economics to the Bulgarian Academy of Sciences (BAS) - (Minassian and others 1995);
- Final energy demand analysis and projections - Institute of Nuclear Research and Nuclear Energy to BAS - (Tzvetanov and others 1995);
- Energy sector long-term development - ENERGOPROEKT Research Institute - (Christov and others 1995);
- GHG emission projection - ENERGOPROEKT Research Institute and Institute of Meteorology and Hydrology to BAS - (Christov and others 1995).

Three basic scenarios are elaborated - *1) baseline scenario, 2) mitigation scenario and 3) energy policy scenario* with specific assumptions at each stage. The energy policy scenario corresponds to the underlying assumptions and key results given in the National Energy Strategy - section 4.3.1. The baseline scenario and mitigation scenarios are constructed in the way that allows to identify potential effects of policies and measures with special attention to the energy efficiency issues. The baseline scenario is rather *likely-to-be* future scenario than *frozen* efficiency scenario which means that it incorporates all policies and measures adopted before 1993.

5.1.1. Macro-economic projections

The development of macroeconomic scenarios is based on methodology and software designed at the Institute of Economy to BAS. This methodology that includes both modelling approach and expert estimates is implemented using simulating econometric model of neokeynesian-monetary type on macro and inter-branches level. Using this methodology the macroeconomic trends are obtained up to the year of 2020 for both scenarios: base line and mitigation (energy efficiency) scenario.

The general assumptions in building of the two scenarios are as follows:

- Accelerating of the privatisation process and drastic reconstruction of public sector;
- Bulgarian economy will become more attractive for foreign investments;
- International trade increase and diversification of foreign markets for Bulgarian products;
- Expected economic growth of traditional Bulgarian partners - Central and Eastern European countries, neighbouring Balkan countries and EU;
- Assumptions about expected economic growth and GDP dynamics, including moderate rates of investment activity, exchange rate and so on.

Using these assumptions a GDP forecast is accomplished. The results are represented in figures 5.1 and 5.2 and tables 5.1 and 5.2 in constant 1992 BGL prices.

Table 5.1. Structure of the gross domestic product by sectors, million BGL (Base-line scenario)

Years	Industry	Agriculture and forestry	Services	Transport	GDP Total
1992	91364	23092	77308	9036	200800
1995	88449	20442	82579	10930	202400
2000	105248	26818	105501	15433	253000
2005	140212	35484	146413	22393	344500
2010	178928	45070	195604	31098	450700
2015	219531	54601	247676	41092	562900
2020	264384	65408	305006	53703	688500

Table 5.2. Structure of the gross domestic product by sectors, million BGL (Mitigation scenario)

Years	Industry	Agriculture and forestry	Services	Transport	GDP Total
1992	91364	23092	77308	9036	200800
1995	88449	20442	82579	10930	202400
2000	95202	24613	98453	13932	232200
2005	118614	31415	125074	18497	293600
2010	156533	42476	168332	25958	393300
2015	209429	57792	226395	36584	530200
2020	284126	80344	313342	52589	730400

Fig. 5.1. Structure of the gross domestic product by sectors, million BGL (Baseline scenario)

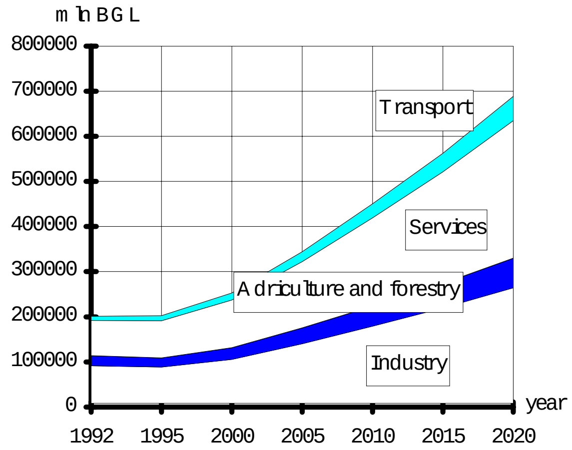
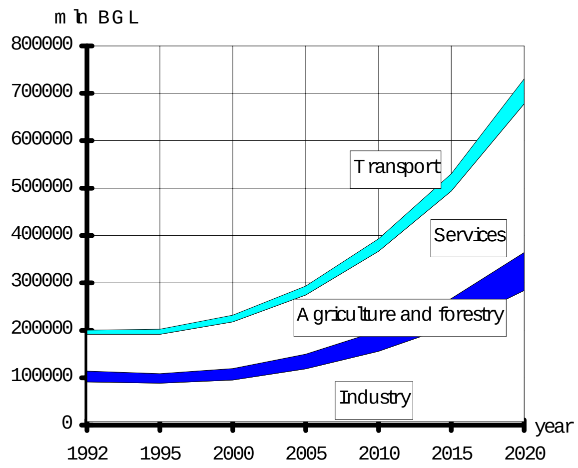


Fig. 5.2. Structure of the gross domestic product by sectors, million BGL (Mitigation scenario)



The mitigation scenario at this stage differs from the base-line scenario by lower growth rates at mid-term horizon needed for a society to change its behaviour and to adopt quite different economic pattern, and more rapid growth of energy prices to promote energy efficiency. Once the economic patterns are changed in long-term horizon the mitigation scenario is characterised by higher growth rate compared to the base-line scenario.

In general, the mitigation scenario implies higher investment activities to enable the penetration of new technologies and to increase imports that makes it more expensive compared to the baseline scenario.

The four main economic sectors have been analysed as follows: industry (including iron and steel, chemistry, building materials production and others); transport; services (including production, non-production and public sector and commerce); agriculture and forestry.

The forecast assumes stable growth rates for all sectors after overcoming the drastic downfall of the 1990-1994 period. Throughout the entire period, the industry growth rates are less than the GDP growth rates. The fastest growth rates belong to the transport and service sector. The situation is more complicated in the agriculture and forestry sector, which has higher growth rates compared to the GDP at the beginning of the period. After 2000 the trends go down and fall lower than the GDP growth rates.

As a whole, the forecasted development trends are moderate. It is in accordance with the limited indigenous resources, the foreign trade balance expectations and the financial indicators.

Given the GDP forecast for both scenarios relevant scenarios for foreign trade balance (exports and imports) and financial indicators such as foreign debt, exchange rate, basic interest rate, real wage in public sector, direct foreign investments have been projected.

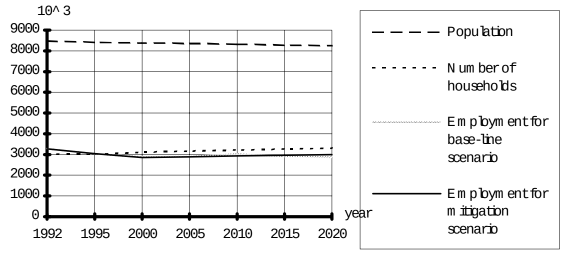
5.1.2. Socio-demography projections

A serious socio-economic problems that arose few years ago and the recent emigration waves have resulted in a substantial decrease of population. Using the demographic tendency analysis and the basic demographic indicators for 1992, a forecast is prepared for the period to 2020 - figure 5.3 and table 5.3.

Table 5.3. Socio-demographic forecast

Indicator / Year	1992	1995	2000	2005	2010	2015	2020
Population, 10^3	8484	8416	8379	8358	8321	8283	8253
Number of households, 10^3	3005	3012	3109	3160	3211	3260	3310
Average households size	2.8	3	2.9	2.8	2.7	2.6	2.5
Employment, 10^3							
base-line scenario	3273	3040	2870	2905	3004	2918	2861
mitigation scenario	3273	3040	2849	2880	2930	2960	2990

Fig 5.3. Socio-demographic forecast



It predicts a decrease of the Bulgarian population by about 2.7% from 1992 to 2020 with an average annual rate of -0.1%. The total employment, employment by economic sectors, unemployment, number of households are also considered in the forecast. Projections on the key macro-economic indicators are given in table 5.4.

Table 5.4. Projections of key macroeconomic indicators

		1995	2000	2005	2010	2020
GDP change						
base-line scenario	%	2.5	5.9	6.4	5.5	4.1
mitigation scenario	%		3.4	4.8	6.0	6.6
Inflation (annual)						
base-line scenario	%	63.0	25.0	20.0	15.0	8.0
mitigation scenario	%		24.0	20.0	15.0	10.0
Industrial Production						
base-line scenario	%	3.8	6.1	6.0	4.9	3.5
mitigation scenario	%		3.1	4.7	6.8	6.8
Unemployment (end of year)						
base-line scenario	%	12.7	11.7	5.4	4.4	5.2
mitigation scenario	%		12.2	12.1	9.2	6.1
Exports						
base-line scenario	$ million	5066	6567	9399	12133	17367
mitigation scenario	$ million		5850	8024	11229	19568
Imports						
base-line scenario	$ million	4582	5763	7587	11034	18206
mitigation scenario	$ million		5777	7911	10053	17243
Current Account balance						
base-line scenario	$ million	250	200	172	-56	195
mitigation scenario	$ million		-257	109	368	205
Budget balance						
base-line scenario	% GDP	-7.0	-4.2	-3.5	-2.8	-2.0
mitigation scenario	% GDP		-5.0	-3.0	-1.6	0.0
Gross debt						
base-line scenario	$ billion	11.4	11.6	12.1	12.7	14.6
mitigation scenario	$ billion		11.0	11.9	12.0	13.5

5.2. Projection on the final energy demand

The results obtained at first stage of the analysis in terms of GDP growth rate and structural changes, industrial production values, investment level, import-exports, population growth and employment serve to project the final energy demand. Two different approaches are used at this stage: bottom up approach for base-line and mitigation scenario and econometric approach for energy policy scenario.

Bottom-up approach - methodology and results for the baseline and mitigation scenarios

According to this approach the energy demand in terms of useful and final energy depends on economic activities and social needs. In long term horizon the energy demand will be influenced by socio-economic development patterns (economic growth, life style, society behaviour), expected technology mix in all sectors of economy and energy prices increase (Tzvetanov, 1995)).

The mitigation scenario differs from the baseline scenario by higher penetration of new technologies, higher energy efficiency, successful implementation of DSM and maximal number of households supplied by natural gas.

For the four major sectors and the relevant subsectors expert judgements are used to identify long-term development of the sector that is consistent with the output of macroeconomic analysis, potential for new technologies penetration, corresponding energy demand, options for fuel substitution and better energy efficiency. Dealing with the chemical industry , for instance, the following main technologies are considered: fertilisers, inorganic chemicals, rubber and plastics, organic chemicals and fibres production as well as their expected levels for the entire period by 2020.

Special attention is paid to the households and service sectors as far as a great potential exists for energy conservation and fuel switching. The energy demand forecast in households in the energy efficiency scenario accounts for higher penetration of new efficient electrical appliances and increasing the share of the natural gas for households. 2’000’000 inhabitants are foreseen to be supplied with natural gas for heating, hot water and cooking by 2020 in the mitigation scenario while for base-line scenario they are 1’200’000.

To evaluate the potential for Demand Side Management (DSM) in households and industry, the Integrated Resource Planning Manager (IRPM) is used (Kanev, 1995). The application of IRPM allows the comparative assessment of different mitigation measures that address energy demand.

The final energy demand projections for the base-line scenario and for the mitigation scenario are given on figures 5.4 and 5.5, tables 5.5 and 5.6.

Table 5.5 Final energy demand projection for base-line scenario, PJ

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuels	81.3	85.6	84.4	83.8	85.3	86.3	87.8
Oil and oil products	117.6	122.5	188.8	249.7	299.6	347.4	389.2
Gaseous fuels	83.3	92.4	106.7	129.5	162.4	200.9	240.8
Electricity	94.3	97.1	103.6	112.9	126.3	140.5	155.7
Heat	121.4	121.8	132.6	153.3	186.1	227.4	273.6
Total	497.9	519.5	616.0	729.3	859.7	1002.5	1147.2

Table 5.6 Final energy demand projection for mitigation scenario, PJ

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuels	81.3	85.7	81.6	74.5	71.7	70.0	69.9
Oil and oil products	117.6	122.5	170.6	218.5	251.6	284.0	311.2
Gaseous fuels	83.3	92.4	97.4	112.6	129.7	158.2	204.7
Electricity	94.3	97.1	90.4	99.5	113.3	129.9	149.0
Heat	121.4	121.8	113.9	126.5	151.6	181.2	228.5
Total	497.9	519.6	553.9	631.7	718.0	823.2	963.3

Fig. 5.4 Final energy demand projection for base-line scenario, PJ

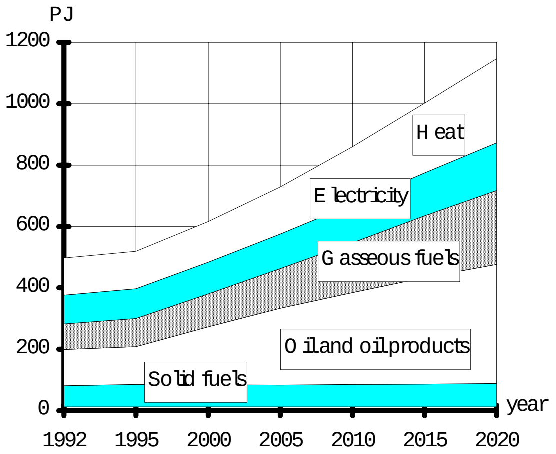
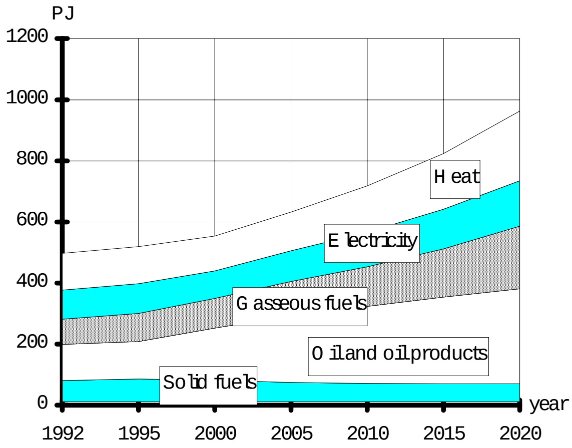


Fig. 5.5 Final energy demand projection for mitigation scenario, PJ



The comparison between the baseline and the mitigation scenarios reveals a substantial energy saving potential of 61 PJ in the year of 2000, 132 PJ in the year of 2010 and 177 PJ in 2020.

This potential could be achieved in case of purposeful governmental policy in regard to energy efficiency. Not only the total amount of energy consumed but its structure as well will be influenced by this policy. The share of electricity by the end of the period is going to increase by 16.6% in the energy efficiency scenario compared to the 14.3% in the baseline scenario, because the new technologies will consume more energy compared to the current technologies. The implementation of the program for natural gas supply to the households will result in an increase from 13.8% in 1995 to 16.6% in 2020 in the share of gaseous fuels on the expense of the solid fuels.

Econometric approach for energy policy scenario

The econometric approach and elasticity parameters are used to project final energy consumption for the energy policy scenario as a function of the projected macro-economic variables consistent with the baseline scenario for macro-economic development of - figure 5.6 and table 5.7.

Fig. 5.6 Final energy demand projection for energy policy scenario, PJ

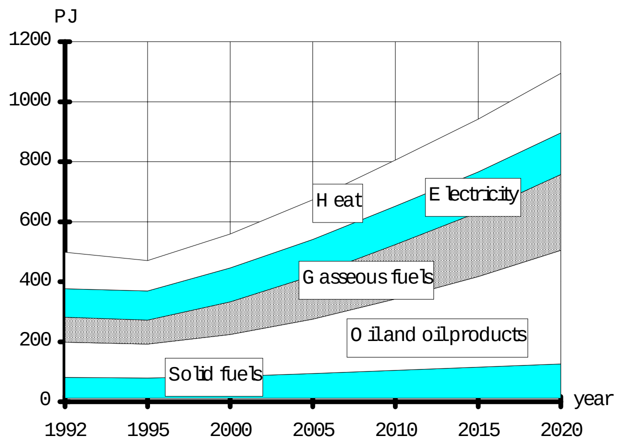


Table 5.7 Final energy demand projection for energy policy scenario, PJ

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuels	81.3	79.1	84.8	94.0	104.5	115.4	126.3
Oil and oil products	117.6	113.1	139.4	182.0	238.0	302.1	378.4
Gaseous fuels	83.3	79.7	108.3	144.2	181.8	214.0	252.5
Electricity	94.3	97.4	113.4	120.8	128.2	134.8	139.1
Heat	121.4	101.8	113.6	132.4	153.7	176.1	198.5
Total	497.9	471.1	559.5	673.3	806.1	942.4	1094.8

The energy demand pattern here is similar to the pattern produced using the bottom-up approach because of the consistency in the major assumptions used by both the approaches.

5.3. Primary energy demand projections. Long-term development of energy sector

GHG emissions from energy sector depend not only on the final energy consumption but on the structure of energy supply system and the primary energy demand as well. Given the final energy demand growth, it is important to design future development of energy supply system in a way that will minimise its contribution to global warming. Therefore, alternative energy configurations to balance energy demand and supply aimed at GHG emission reduction are evaluated at the third stage of the study.

Three scenarios, i.e. baseline, mitigation and energy policy scenarios, and a set of sub-scenarios have been elaborated using ENPEP methodology and program that gives the opportunity to carry out mitigation analysis using a non-linear equilibrium approach to determine the energy supply and demand balance, to estimate the emission level and the system cost for each scenario (Cirillo 1994).

The following options to mitigate GHG emissions are studied in the Communication: increased use of hydropower, renewables, nuclear energy, fuel switching to natural gas, rehabilitation of existing plants and reduction of losses in electricity and heat distribution networks.

A scenario, that is completely consistent with Bulgarian energy sector long-term development goals is the so called “energy policy scenario”.

The results for primary energy demand forecast for the baseline, mitigation and energy policy scenarios are given in tables 5.8, 5.9, 5.10 and on figures 5.7, 5.8 and 5.9 respectively.

Table 5.8 Primary energy demand projection for base-line scenario

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuel	332.7	376.1	322.6	376.8	430.7	441.8	493.3
Oil and oil products	249.5	281.2	376.1	600.3	631.0	699.5	810.0
Gaseous fuel	173.3	178.7	191.3	227.0	247.8	278.7	318.5
Hydro energy	7.6	8.2	8.3	9.6	10.2	10.2	10.2
Nuclear energy	129.7	174.0	212.7	191.4	191.4	222.1	222.1
Imp. electricity	3.9	0.6	0.7	0.8	0.4	0.2	0.2
Total	896.7	1018.7	1111.7	1405.9	1511.4	1652.5	1854.3

Table 5.9 Primary energy demand projection for mitigation scenario

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuel	332.7	364.5	270.8	259.1	261.0	232.3	240.4
Oil and oil products	249.5	285.3	349.8	429.5	510.8	588.8	675.3
Gaseous fuel	173.3	181.3	154.2	184.7	216.0	259.4	330.4
Hydro energy	7.6	8.3	5.9	9.7	10.5	7.2	6.1
Nuclear energy	129.7	176.3	212.1	191.4	191.4	222.1	222.1
Imp. electricity	3.9	0.6	0.7	0.8	0.4	0.2	0.2
Total	896.7	1016.2	993.5	1075.1	1190.0	1310.0	1474.5

Table 5.10 Primary energy demand projection for energy policy scenario

Year	1992	1995	2000	2005	2010	2015	2020
Solid fuels	332.7	343.0	350.6	389.1	401.6	378.5	376.5
Oil and oil products	249.5	245.0	291.3	367.0	451.3	563.0	694.2
Gaseous fuel	173.3	135.5	167.6	200.5	250.7	313.3	333.5
Hydro energy	7.6	8.0	9.3	9.4	11.3	16.9	15.6
Nuclear energy	129.7	192.2	245.7	211.5	211.1	180.9	226.6
Imp. electricity	3.9	0.6	0.7	0.8	0.4	0.2	0.2
Total	896.7	924.2	1065.2	1178.4	1326.3	1452.7	1646.6

Fig. 5.7 Primary energy demand projection for base-line scenario

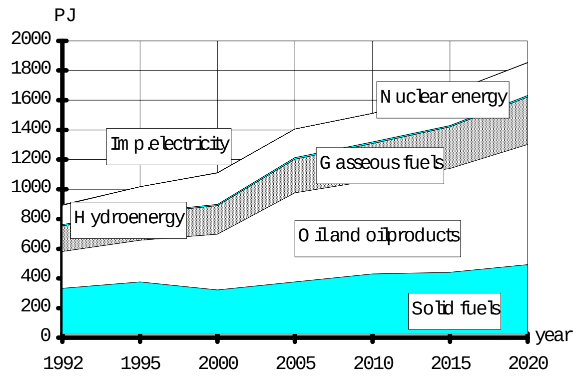


Fig. 5.8 Primary energy demand projection for mitigation scenario

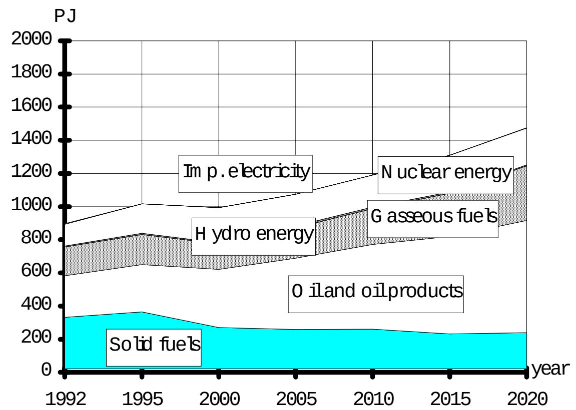
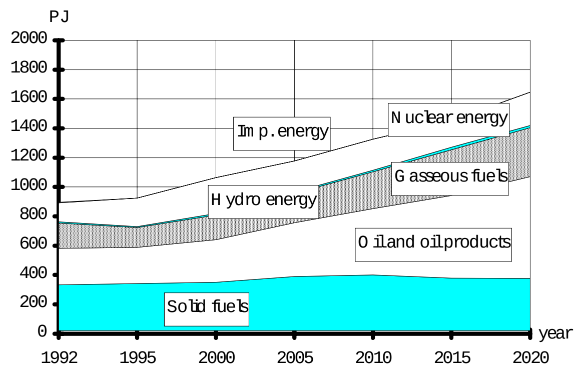


Fig. 5.9 Primary energy demand projection for energy policy scenario



Comparison of the projected primary energy demand up to the year of 2020 reveals 1.65 times lower growth rate for the period in case of baseline scenario against 2.8 times for the mitigation scenario. The difference is not only quantitative but structural as well. Thus the share of solid fuels for the baseline scenario is 26% in 2020 while in the mitigation scenario it was possible to reduce it to the level of 16% in 2020 on account of increased share of natural gas, nuclear and hydro energy.

Results obtained for energy policy scenario are in the middle between baseline and mitigation scenarios, but with regard to the growth rate for the entire period and to the structure of the primary energy consumption it comes closer to the baseline scenario.

The analysis of the results shows that even for the baseline scenario the primary energy consumption increases more slowly compared to the increase in the final consumption because of the expected improvement of the structure and the efficiency of the energy production system in medium and long-term horizon.

5.4. GHG emission projections

GHG inventory results reported in Chapter 3 reveals the following major GHG emission sources relevant to the Bulgarian conditions:

- Energy, including stationary and mobile combustion - for CO_2, CH_4, N_2O, NOx, CO and NMVOC
- Industrial processes - for CO_2, CH_4 and N_2O
- Solvent use - for NMVOC
- Agriculture - for CH_4, N_2O, NOx and CO
- Land use change and forestry - for CO_2
- Landfills - for CH_4

Due to the change in ownership in agriculture as well as to the expected change in agricultural practice and structure it is very hard to project emissions originating from agriculture (Raev and others, 1995). No quantitative scenario is elaborated although comprehensive analysis of current situation indicates downward trend in GHG emissions as a sequence of a decrease in rice cultivation and other measures or tendencies discussed in Chapter 4.

In regard to the GHG emissions from landfills, two contradictory tendencies exist - slight drop in population according to the projections given in section 5.1.2 and a slight increase in waste per capita having 950 kg waste per capita in 1992 as a starting point. Under these assumptions waste quantity and corresponding emissions will decrease by 2% in the period up to 2020.

It is also difficult to project emissions from solvent use.

Therefore, at the fourth stage of the analytical process the GHG emissions are projected for all three scenarios exercising IMPACT module of ENPEP model for emissions from energy sector including energy resources mining, transmission and distribution. A spreadsheet model is used to project the emissions from industrial process. In general, the emission categories and emission factors used in both ENPEP model and the spreadsheet model, follow the IPCC methodology. The ultimate goal of this approach is to make results for GHG inventory consistent with the GHG projections.

To project CO_2 and other GHG for the baseline, mitigation and energy policy scenarios, the emission factors from the GHG inventory are used (Bogdanov, 1995) and the following activities are considered:

- for GHG from energy combustion - projection on the quantities of fuels consumed in different sectors of economy; and fuels for energy transformation;
- for GHG from coal mining, oil and gas systems - projection on the quantities of coal mined in underground and open mines as well as quantities of oil and gas production, transportation, distribution and refining;
- for GHG from industrial processes - projection on the quantities of industrial output for cement, lime, ammonia, soda ash, glass, steel.

The total GHG emissions are calculated as a sum of energy related emissions and process emissions.

The difference between the levels of GHG emissions for the baseline scenario and the mitigation scenario serves to estimate the effect of all measures incorporated within a single scenario, that is not a simple sum of effect of all measures put together. In order to evaluate the potential contribution of each measures some sub-scenarios have been designed, e.g. Renewable energy sub-scenario or Nuclear energy sub-scenario that are compared against the baseline scenario (Christov, 1995).

5.4.1. CO_2 emission projections

5.4.1.1. CO_2 emission projections for the baseline scenario

The results for CO_2 emission projections for the baseline scenario are given in table 5.11. The comparison between total CO2 emission projections for the end of the study period and those in the base year for projections (1992) shows 2.13 times increase in the emission level, while the GDP and the final energy demand growths are 3.44 and 2.3 respectively. Therefore, the expected structural changes in Bulgarian economy and GDP will lead to reduction of energy intensity and CO_2 emissions even in the baseline scenario.

At the other hand the comparison to the emission level in 1988 which is the base year for Bulgarian implementation of FCCC requirements shows that in the year 2000 the CO_2 emissions will reach 71% of the base year level, in 2007 they reach the level of the base year and at the end of the period they are already 1.37 times higher than the emissions in the base year

5.4.1.2. CO_2 emission projections for the mitigation scenario

The results for CO_2 emission projections for the mitigation scenario are given in table 5.12. The comparison between total CO_2 emission projections for the end of the study period and those in the base year for projections (1992) shows 1.54 times increase, while the GDP and final energy demand growths are 3.4 and 1.94 respectively. Therefore, due to the expected macroeconomic restructuring, intensive penetration of new efficient technologies in the mitigation scenario and the restructuring of energy supply sectors towards limitation of shares of fossil fuels the pace of CO2 emission increase will be lower as by the end of the period they are expected to be 28% lower than in the base-line scenario.

The comparison to the emission level in 1988 which is base year for the Bulgarian implementation of FCCC requirements shows that in 2000 the CO_2 emissions will be 64% of the emissions in the base year and at the end of the period they will be just at the same level. Therefore, a complex implementation of mitigation measures in all economic sectors,

including energy, would lead to a long-term stabilisation of the CO_2 emission level.

Table 5.11 SUMMARY TABLE OF THE ÑÎ$_2$ EMISSIONS FORECAST FOR THE BASELINE SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**91560**	**76414**	**62187**	**63518**	**68501**	**88412**	**100948**	**117504**	**132576**
1. Energy sector (combustion and fugitive emissions)			59352	60700	65101	83933	95184	110047	123157
À. Fuel combustion			59352	60700	65101	83933	95184	110047	123157
1. Energy industry and fuel transformation			37665	37871	36831	50003	55843	65240	73262
2. Industry			8021	8767	10134	11990	14705	17479	20635
3. Transport			5972	6689	11026	14970	17914	20813	22929
4. Services			906	895	872	866	876	908	939
5. Agriculture and forestry industry			1074	841	960	1135	1152	1140	1148
6. Households and others			5714	5637	5278	4969	4694	4467	4244
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			2835	2818	3400	4479	5764	7457	9419
À. Iron and steel			93	108	110	134	160	181	194
B. Non ferrous metals									
C. Inorganic chemicals			902	923	1083	1319	1696	2138	2625
D. Organic chemicals									
E. Non-metallic mineral products			1840	1787	2207	3026	3908	5138	6600
F. Others									

Table 5.12 SUMMARY TABLE OF THE ÑÎ$_2$ EMISSIONS FORECAST THE MITIGATION SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**91560**	**76414**	**62187**	**62720**	**58711**	**66102**	**73448**	**81013**	**95608**
1. Energy sector (combustion and fugitive emissions)			59352	59902	55690	62322	68578	74576	86750
À. Fuel combustion			59352	59902	55690	62322	68578	74576	86750
1. Energy industry and fuel transformation			37665	37131	29521	32548	36000	38519	46484
2. Industry			8021	8712	8591	8967	9922	11825	15097
3. Transport			5972	6689	10527	13889	16238	18204	19492
4. Services			906	895	906	945	940	955	986
5. Agriculture and forestry industry			1074	841	855	973	1030	1096	1102
6. Households and others			5714	5634	5290	5000	4448	3977	3589
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			2835	2818	3021	3780	4870	6437	8858
À. Iron and steel			93	108	104	126	154	177	214
B. Non ferrous metals									
C. Inorganic chemicals			902	923	1014	1172	1506	1938	2597
D. Organic chemicals									
E. Non-metallic mineral products			1840	1787	1903	2482	3210	4322	6047
F. Others									

5.4.1.3. CO_2 emission projections for the energy policy scenario

The results for CO_2 emission projections for the energy policy scenario are given on table 5.13.

The comparison for CO2 emission projections for the end of the study period and those for the base year of the projection 1992, shows 2.14 times increase in the emission level as in the baseline scenario. The explanation of the results could be found in the fact that both scenarios for CO_2 emission projections - the baseline scenario and the energy policy scenario are based on the same baseline scenario for macroeconomic development as well as on the assumption of moderate reconstruction and penetration of new technologies and energy efficiency improvement.

Table 5.13 SUMMARY TABLE OF THE CO_2 EMISSIONS FORECAST FOR THE ENERGY POLICY SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**91560**	**76414**	62187	61412	69898	85941	101197	117076	133640
1. Energy sector (combustion and fugitive emissions)			59352	58604	66510	81376	95421	109577	124182
À. Fuel combustion			59352	58484	66360	81199	95205	109313	123894
1. Energy industry and fuel transformation			37665	37138	39861	46403	49728	51933	52186
2. Industry			8021	7542	8579	10352	12275	14119	16122
3. Transport			5972	6028	7337	9938	13189	16932	21385
4. Services			906	799	1248	1417	1373	1288	1235
5. Agriculture and forestry industry			1074	1060	1396	1686	2026	2393	2787
6. Households and others			5714	5755	6937	8520	10236	11901	13905
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			2835	2809	3395	4588	5826	7576	9579
À. Iron and steel			93	78	84	102	123	142	156
B. Non ferrous metals				0	0	0	0	0	0
C. Inorganic chemicals			902	741	868	1141	1460	1834	2240
D. Organic chemicals				0	0	0	0	0	0
E .Non metallic mineral products			1840	1984	2451	3384	4317	5719	7352
F. Others									

5.4.2. Projections on other GHGs

Projections on other GHGs as N_2O and CH_4, as well as on the precursors have been accomplished for the baseline and mitigation scenario following the same assumptions as for CO_2 projections and the same structure of emission resources.

5.4.2.1. Projections on other GHGs for the baseline scenario

Projections on N_2O, CH_4, CO, NOx and NMVOC for the baseline scenario are given in tables 5.14, 5.15, 5.16, 5.17 and 5.18 respectively.

Table 5.14. SUMMARY TABLE OF THE N_2O EMISSIONS FORECAST FOR THE BASELINE SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	17.36	14.29	15.696	15.227	16.341	21.028	25.608	31.2	35.375
1. Energy sector (combustion and fugitive emissions)			10	9.4	9.5	12.7	14.9	17.7	18.8
À. Fuel combustion			10	9.4	9.5	12.7	14.9	17.7	18.8
1. Energy industry and fuel transformation			9.31	8.73	8.73	11.85	14.09	16.81	17.85
2. Industry			0.03	0.03	0.03	0.04	0.05	0.07	0.09
3. Transport			0.1	0.1	0.2	0.26	0.3	0.36	0.4
4. Services			0.5	0.5	0.5	0.5	0.4	0.4	0.4
5. Agriculture and forestry industry			0.06	0.04	0.04	0.05	0.06	0.06	0.06
6. Households and others			0	0	0	0	0	0	0
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			5.696	5.827	6.841	8.328	10.708	13.5	16.575
À. Iron and steel									
B. Non ferrous metals									
C. Inorganic chemicals			5.696	5.827	6.841	8.328	10.708	13.5	16.575
D. Organic chemicals									
E. Non-metallic mineral products									
F. Others									

The comparison of the results for the N_2O emissions at the end of the study period and at the base year 1992, reveals 2.25 fold rise mainly due to the process emissions. Their share increases from 36% at the beginning of the period to 47% at its end. The growth rate of N_2O emission from fossil fuel combustion follows the CO_2 emission rate.

The comparison of the results for the CH_4 emissions at the end of the study period and at the base year 1992, shows that the emissions doubled mainly at the expense of emissions from coal mining as well as from natural gas and oil extraction and transportation system. These emissions keep their share of 97% of the total emissions during the entire study period. The emissions from coal mining slightly rise from 37% at the beginning of the period to 40% at its end. This is consequence of the orientation of the base-line scenario towards maximal utilisation of the existing fields of indigenous coal and opening of new ones The total increase of CO emissions at the end of the study period is three folds. This figure exceeds the rate of increase of the fossil fuel consumption.

The total increase of NOx emissions at the end of the study period is 2.7 folds. This figure exceeds a bit the rate of increase of the fossil fuel consumption.

The NMVOC emitters are the fossil fuel combustion processes and the consumption of solvent which have shares of 65% and 35% respectively in 1992. It is assumed that the emission from solvent use will keep constant during the study period.

The NMVOC emission increase 4.2 folds at the end of the study period mainly due to the emission rise in the transport sector - 5.45 times.

5.4.2.2. Projections on other GHGs for the mitigation scenario

Projections on N_2O, CH_4, CO, NOx and NMVOC for the mitigation scenario are given in tables 5.19, 5.20, 5.21, 5.22 and 5.23 respectively.

In general the emission growth rate in the mitigation scenario is moderate when compared to the baseline scenario, due to the complex impact of mitigation measures at macro-economic and sector level.

Table 5.15 SUMMARY TABLE OF THE CH_4 EMISSIONS FORECAST FOR THE BASELINE SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**373.8**	**262.5**	**207.376**	**215**	**201.222**	**251.984**	**280.768**	**307.678**	**413.174**
1. Energy sector (combustion and fugitive emissions)			206	213.4	199.6	250	278.4	305	410.3
À. Fuel combustion			5.2	5.9	6.9	9.5	11.4	12.6	14.2
1. Energy industry and fuel transformation			3.17	3.67	3.17	4.17	4.67	4.67	5.27
2. Industry			0.4	0.4	0.5	0.6	0.8	1	1.2
3. Transport			1.3	1.5	2.9	4.3	5.5	6.5	7.4
4. Services			0.11	0.11	0.11	0.11	0.11	0.11	0.11
5. Agriculture and forestry industry			0.2	0.2	0.2	0.3	0.3	0.3	0.2
6. Households and others			0.02	0.02	0.02	0.02	0.02	0.02	0.02
B. Fugitive fuel emissions			200.8	207.5	192.7	240.5	267	292.4	396.1
1. Crude oil and gas system			123.9	128	138	164	179	202	231
2. Coal mining			76.9	79.5	54.7	76.5	88	90.4	165.1
2. Industrial processes			1.376	1.6	1.622	1.984	2.368	2.678	2.874
À. Iron and steel			1.376	1.6	1.622	1.984	2.368	2.678	2.874
B. Non ferrous metals									
C. Inorganic chemicals									
D. Organic chemicals									
E. Non-metallic mineral products									
F. Others									

Table 5.16 SUMMARY TABLE OF THE CO EMISSIONS FORECAST FOR THE BASELINE SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**789.6**	**852**	**487**	**511**	**732**	**939**	**1135**	**1301**	**1457**
1. Energy sector (combustion and fugitive emissions)			487	511	732	939	1135	1301	1457
À. Fuel combustion			487	511	732	939	1135	1301	1457
1. Energy industry and fuel transformation			16.7	18.9	20	22.9	24.4	28.3	31.2
2. Industry			38	36	44	53	69	88	110
3. Transport			204	228	449	654	844	1000	1142
4. Services			2	2	2	1.9	1.9	1.8	1.8
5. Agriculture and forestry industry			28.3	31.1	36	38.2	37.7	35.9	35
6. Households and others			198	195	181	169	158	147	137
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			0	0	0	0	0	0	0
À. Iron and steel									
B. Non ferrous metals									
C. Inorganic chemicals									
D. Organic chemicals									
E. Non-metallic mineral products									
F. Others									

Table 5.17 SUMMARY TABLE OF THE NOx EMISSIONS FORECAST FOR THE BASELINE SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**485.5**	**498.2**	**183**	**189**	**214**	**280**	**322**	**374**	**438**
1. Energy sector (combustion and fugitive emissions)			183	189	214	280	322	374	438
À. Fuel combustion			183	189	214	280	322	374	438
1. Energy industry and fuel transformation			76.6	83.5	73.7	106.54	119.5	141.7	177.1
2. Industry			29	28	34	40	52	65	82
3. Transport			48.2	53	81	105.5	122.7	140	152
4. Services			2.2	2.2	2	1.96	1.9	1.9	1.9
5. Agriculture and forestry industry			16.9	12.3	14	17.3	17.7	17.7	17.8
6. Households and others			10.1	10	9.3	8.7	8.2	7.7	7.2
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			0	0	0	0	0	0	0
À. Iron and steel									
B. Non ferrous metals									
C. Inorganic chemicals									
D. Organic chemicals									
E. Non-metallic mineral products									
F. Others									

Table 5.18.SUMMARY TABLE OF THE NMVOC EMISSIONS FORECAST FOR THE BASELINE SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**68.76**	**67.2**	**47.2**	**51.7**	**86**	**118**	**149**	**175**	**199**
1. Energy sector (combustion and fugitive emissions)			47.2	51.7	86	118	149	175	199
À. Fuel combustion			47.2	51.7	86	118	149	175	199
1. Energy industry and fuel transformation			6.7	8	8.3	8.5	10	10.1	10.3
2. Industry			6.4	6	7.4	8.8	11.5	14.6	18.5
3. Transport			30.5	34	66	96	123	146	166
4. Services			0	0	0	0	0	0	0
5. Agriculture and forestry industry			3.6	3.7	4.3	4.7	4.5	4.3	4.2
6. Households and others			0	0	0	0	0	0	0
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			0	0	0	0	0	0	0
À. Iron and steel									
B. Non ferrous metals									
C. Inorganic chemicals									
D. Organic chemicals									
E. Non-metallic mineral products									
F. Others									

Table 5.19 SUMMARY TABLE OF THE N_2O EMISSIONS FORECAST FOR THE MITIGATION SCENARIO,Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**17.36**	**14.29**	**15.696**	**15.227**	**14.002**	**15.699**	**18.612**	**21.141**	**27.099**
1. Energy sector (combustion and fugitive emissions)			10	9.4	7.6	8.3	9.1	8.9	10.7
À. Fuel combustion			10	9.4	7.6	8.3	9.1	8.9	10.7
1. Energy industry and fuel transformation			9.31	8.73	6.84	7.53	8.32	8.11	9.99
2. Industry			0.03	0.03	0.02	0.03	0.03	0.04	0.05
3. Transport			0.1	0.1	0.2	0.2	0.3	0.3	0.3
4. Services			0.5	0.5	0.5	0.5	0.4	0.4	0.3
5. Agriculture and forestry industry			0.06	0.04	0.04	0.04	0.05	0.05	0.06
6. Households and others			0	0	0	0	0	0	0
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			5.696	5.827	6.402	7.399	9.512	12.241	16.399
À. Iron and steel									
B. Non ferrous metals									
C. Inorganic chemicals			5.696	5.827	6.402	7.399	9.512	12.241	16.399
D. Organic chemicals									
E. Non-metallic mineral products									
F. Others									

The comparison of the results for the N_2O emissions at the end of the study period and at the base year 1992, reveals 1.7 fold rise due to the process emissions mainly. Their share increases from 36% at the beginning of the period to 60% at its end. The N_2O emission from fossil fuel combustion growth rate follows the CO_2 emission rate.

The comparison of this figures and the base-line emissions presents a 8300 t reduction due to the more efficient end use of the energy resources. The comparison of the results for the CH_4 emissions at the end of the study period and at the base year for projections 1992, shows that the emissions increase by 1.4 mainly due to the emissions from natural gas and oil extraction and transportation systems.

The comparison with the baseline emissions reveals saving potential of 124 kt which has to do with the lower fuel consumption level due to the improved energy efficiency and the smaller share of solid and liquid fuels in the energy balance

The total increase of CO emissions at the end of the study period is 2.3 folds compared to the 1992 results. This figure exceeds the rate of increase of the fossil fuel consumption. At the end of the period the emissions for this scenario are 330 kt less than in the base-line scenario.

The total increase of NOx emissions at the end of the study period is 1.67 times the emissions in 1992. This figure slightly exceeds the rate of increase of the fossil fuel consumption. At the end of the study period the emissions are by 133 kt less than in the base-line scenario.

Table 5.20 SUMMARY TABLE OF THE CH_4 EMISSIONS FORECAST FOR THE MITIGATION SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**373.8**	**262.5**	**207.37**	**215.6**	**162.54**	**184.87**	**211.28**	**234.62**	**289.17**
1. Energy sector (combustion and fugitive emissions)			206	214	161	183	209	232	286
À. Fuel combustion			5.2	5.4	6.3	7.5	8.7	9.6	10.9
1. Energy industry and fuel transformation			3.17	3.17	2.77	2.87	3.17	3.27	3.98
2. Industry			0.4	0.4	0.4	0.4	0.5	0.6	0.8
3. Transport			1.3	1.5	2.8	3.8	4.7	5.4	5.8
4. Services			0.11	0.11	0.11	0.11	0.11	0.11	0.1
5. Agriculture and forestry industry			0.2	0.2	0.2	0.3	0.2	0.2	0.2
6. Households and others			0.02	0.02	0.02	0.02	0.02	0.02	0.02
B. Fugitive fuel emissions			200.8	208.6	154.7	175.5	200.3	222.4	275.1
1. Crude oil and gas system			123.9	130.4	110.8	133.2	156	187.7	239.4
2. Coal mining			76.9	78.2	43.9	42.3	44.3	34.7	35.7
2. Industrial processes			1.376	1.6	1.541	1.866	2.277	2.616	3.172
À. Iron and steel			1.376	1.6	1.541	1.866	2.277	2.616	3.172
B. Non ferrous metals									
C. Inorganic chemicals									
D. Organic chemicals									
E. Non-metallic mineral products									
F. Others									

Table 5.21 SUMMARY TABLE OF THE CO EMISSIONS FORECAST FOR THE MITIGATION SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**789.6**	**852**	**487**	**511**	**686**	**840**	**965**	**1060**	**1127**
1. Energy sector (combustion and fugitive emissions)			487	511	686	840	965	1060	1127
À. Fuel combustion			487	511	686	840	965	1060	1127
1. Energy industry and fuel transformation			16.3	18.9	16.8	16.6	17.2	18.7	21.2
2. Industry			38.5	36	32.3	35.6	40.6	51	68
3. Transport			203.9	228	421.8	585.3	727.4	828.8	893.6
4. Services			2	2	2	1.9	1.8	1.6	1.5
5. Agriculture and forestry industry			28.3	31.1	32.1	33.6	34	35.9	35.7
6. Households and others			198	195	181	167	144	124	107
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			0	0	0	0	0	0	0
À. Iron and steel									
B. Non ferrous metals									
C. Inorganic chemicals									
D. Organic chemicals									
E. Non-metallic mineral products									
F. Others									

Table 5.22 SUMMARY TABLE OF THE NOx EMISSIONS FORECAST FOR THE MITIGATION SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**485.5**	**498.2**	**183**	**186**	**185**	**215**	**238**	**267**	**305**
1. Energy sector (combustion and fugitive emissions)			183	186	185	215	238	267	305
À. Fuel combustion			183	186	185	215	238	267	305
1. Energy industry and fuel transformation			76.3	80.8	60.1	65.2	72.9	82.3	99.7
2. Industry			29.3	27.8	24.5	27.1	28.6	36.3	48.5
3. Transport			48.2	53	76.4	97.1	111	123	131.8
4. Services			2.2	2.1	2.1	2	1.9	1.7	1.7
5. Agriculture and forestry industry			16.9	12.3	12.6	14.9	16	17	17.4
6. Households and others			10.1	10	9.3	8.7	7.6	6.7	5.9
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			0	0	0	0	0	0	0
À. Iron and steel									
B. Non ferrous metals									
C. Inorganic chemicals									
D. Organic chemicals									
E. Non-metallic mineral products									
F. Others									

Table 5.23 SUMMARY TABLE OF THE NMVOC EMISSIONS FORECAST FOR THE MITIGATION SCENARIO, Gg

GREENHOUSE GAS EMISSION SOURCES AND SINKS	1988	1990	1992	1995	2000	2005	2010	2015	2020
Total emissions and sinks	**68.76**	**67.2**	**47.2**	**51.5**	**78.8**	**103**	**124**	**140**	**153**
1. Energy sector (combustion and fugitive emissions)			47.2	51.5	78.8	103	124	140	153
À. Fuel combustion			47.2	51.5	78.8	103	124	140	153
1. Energy industry and fuel transformation			6.7	7.6	7.1	6.5	6.6	6.1	7.1
2. Industry			6.4	6	5.2	5.8	6.4	8.1	10.8
3. Transport			30.5	34.2	62.7	86.7	107	121.6	130.9
4. Services			0	0	0	0	0	0	0
5. Agriculture and forestry industry			3.6	3.7	3.8	4	4	4.2	4.2
6. Households and others			0	0	0	0	0	0	0
B. Fugitive fuel emissions			0	0	0	0	0	0	0
1. Crude oil and gas system			0	0	0	0	0	0	0
2. Coal mining			0	0	0	0	0	0	0
2. Industrial processes			0	0	0	0	0	0	0
À. Iron and steel									
B. Non ferrous metals									
C. Inorganic chemicals									
D. Organic chemicals									
E. Non-metallic mineral products									
F. Others									

The NMVOC emissions increase 3.25 folds at the end of the study period mainly due to the emission rise in the Transport sector - 4.6 folds which corresponds to the energy efficiency option. The growth rate of NMVOC emissions in this scenario is comparatively lower than the base-line rates as a consequence to the accelerated implementation of new technologies and efficiency improvement in the transportation sector.

5.4.3. Projections on ozone-depleting substances

Projections on the consumption of ozone-depleting substances in Bulgaria are accomplished only for the mitigation scenario because according to the National program, i.e. to phase out consumption of the ozone-depleting substances supported by GEF and the World bank, the quantities of the ozone-depleting substances will gradually diminish by 2001. Estimates on the ODS consumption are given in table 5.24. It is predicted the level of consumption of CFC-22 to increase in the sectors where it will substitute more hazardous substances with higher global warming potential such as CFC-11, CFC-12 and CFC-502.

Table 5.24 Estimated annual ODS - consumption in Bulgaria

USER SECTOR	SUBSTANCES	ANNUAL CONSUMPTION t						
		1995	1996	1997	1998	1999	2000	2001
Refrigeration	CFC -11,12,502	209	86	60	1	-	-	-
	CFC - 22	48	65	90	115	125	125	125
Foams	CFC - 22	30	40	50	60	80	100	120
Solvents	MCF	45	40	40	35	35	30	30
	CTC	20	20	20	18	18	15	15
Aerosols	CFC - 12	50	50	35	25	20	20	15
Fire extinguishers	Halons	2	2	2	2	2	2	2
Total ODS used in all sectors	CFC-11,12.502	259	136	95	26	20	20	15
	CFC - 22	78	105	140	175	205	225	245
	MCF	45	40	40	35	35	30	30
	CTC	20	20	20	18	18	15	15
	Halons	2	2	2	2	2	2	2

5.4.4. Summary on the GHG emissions

The projections on the overall GHG emissions is based on the concept of the Global Warming Potential (GWP) within a 100 years time horizon. The GWP values used for emission projection are shown in table 3.1, Chapter 3.

The emissions of CO_2, CH_4 and N_2O expressed by their GWP values for both the baseline and the mitigation scenarios are given in tables 5.25 and 5.26 respectively. The analysis of the projected emission quantities indicates a crucial contribution of CO_2 in the total emissions within the range of 86-87% for the baseline scenario and 85.5-87% for the mitigation scenario.

A significant reduction of the total emissions after 2000 is observed in the case of mitigation scenario when compared to the baseline scenario. The level of total emissions for the mitigation scenario is 28-31% lower.

Table 5.25 GWP - baseline scenario, Gg CO_2 equ.

GWP/year	1992	1995	2000	2005	2010	2015	2020
CO_2	62187	63518	68501	88412	100948	117504	132576
CH_4	5081	5267	4929	6174	6884	7538	10123
N_2O	5024	4870	5229	6730	8195	9984	11328
Total	72292	73655	78659	101316	116027	135026	154027

Table 5.26 GWP - mitigation scenario, Gg CO_2 equ.

GWP/year	1992	1995	2000	2005	2010	2015	2020
CO_2	62187	62720	58711	66102	73448	81013	95608

CH_4	5081	5267	3981	4530	5177	5748	7085
N_2O	5024	4870	4480	5024	5955	6765	8672
Total	72292	72857	67172	75656	84580	93526	111365

Fig 5.10 Total greenhouse gas emissions presented by GWP values - baseline scenario, Gg CO_2 equ.

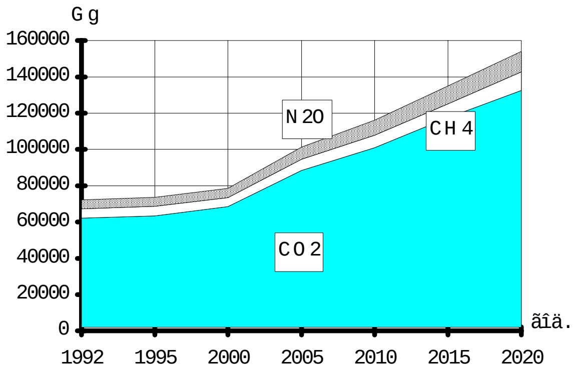
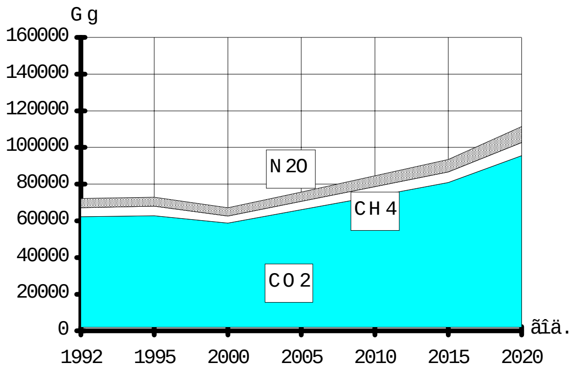


Fig 5.11 Total greenhouse gas emissions presented by GWP values - mitigation scenario Gg CO_2 equ.



5.5 Projections on the forest sink capacity

According to the estimates in Chapter 3, Bulgaria forests had a potential to sequester 5.8% of the total CO_2 emissions in 1988.

There are two options available to increase the forest sink capacity: through transformation of part of the coniferous to deciduous tree species and by expansion of the forest vegetation areas (Raev and others, 1995).

Three scenarios are elaborated that allow to estimate the potential impact of these options:

- Scenario for transformation of the coniferous to deciduous forests;
- Scenario for expansion of the forest vegetation areas;
- Mixed scenario, that is a combination of the previous two scenarios.

The highest level of forest sink capacity could be achieved in case of mixed scenario.

According to the mixed scenario, the combination of gradual change of a part of coniferous plantations improperly established in the low forest vegetation zone with deciduous and expansion of afforestated area through afforestation of devastated land as well as establishment of forest shelter belts would bring to a considerable reduction of the CO_2 amounts emitted in the atmosphere.

In case of implementation of the mixed scenario the capacity of the forest CO_2 sink will increase by 1.430 million tons as this increment could be reached in 2020-2025 (increase of the CO_2 absorption by 0.600 million tons at the expense of qualitative scenario and by 0.830 million tons at the expense of quantitative scenario).

In this case the quantity of the CO_2 absorbed in the next century (in 2020-2025) will be increased compared to the year 1990 by 23%.

If the implementation barriers for afforestration will be overcome, that will not only increase the forest sink but also will have additional positive impact in terms of employment and income increase of local population.

5.6. Estimation of effect of different GHG mitigation options

Different options for GHG mitigation have been identified and evaluated in regard to their technical feasibility, necessary investments and effect on CO_2 reduction. In general options aim directly or indirectly at fossil fuel combustion reduction and therefore lead to all GHG emission reduction but since CO_2 is the main GHG the options are evaluated versus it. The effect of each measure is evaluated and used in the total estimate of emission mitigation trying to avoid the overlapping.

5.6.1. Energy supply

The emission reduction from electricity and heat generation systems is based on restructuring of production capacities and reduction of losses in electricity and heat transmission and distribution. The impact of some changes in the structure of energy transformation system is also evaluated (Simeonova, 1995).

Development of nuclear energy

The nuclear energy is considered as one of the most efficient technologies for electricity generation from the GHG-related point of view. It is expected some of the nuclear units at NPP Kozloduy to be decommissioned at the beginning of next century. Several major projects aimed to improve the safe operation of the rest units of NPP Kozloduy have been already implemented. In order to keep the share of nuclear energy a modified nuclear plan of energy system development is designed. It envisages to continue construction works on 1000 MW unit that has been stopped by the Governmental decision in 1990 and construction of new nuclear units at NPP Belene.

Accelerated development of hydro energy

As far as the GHG emissions are considered hydro energy can be evaluated as one of the most clean methods of electricity generation. Besides hydro energy is a renewable energy source. In order to assess the CO_2 reduction potential in case of accelerated development of hydro energy in Bulgaria, by 2020 there are 878 MW hydro energy units added to the baseline scenario at the following generating hydro energy sites and years of commitment:

- Gorna Arda cascade - 156 MW - 2008;
- Mesta cascade - 122 MW - 2014;
- Danube hydro complex - 400 MW - 2015;
- Micro-HPPs with total capacity 200 MW committed gradually by the year 2020

Upgrading of cogeneration plants and district heating boilers by natural gas combined cycle

The lately developed new steam-gas modules which include gas turbines, steam turbines and boilers-utilizers facilitate electricity production at very low level of fuel consumption. An option for energy system development is examined which envisage commitment of 1180 MW units in cogeneration plants and district heating plants.

Natural gas combined cycle for electricity generation

Recently electricity generating units have been designed which combust natural gas in gas turbines and use exhausted gases for steam production to feed steam turbines for electricity generation.

The electricity unit commitment plan envisages implementation of natural gas combined cycle units with unit capacity 450 MW and 1800 MW total capacity and electricity production of approximately 12 billion kWh.

Increase of renewable energy sources in country energy balance

The renewable sources are ÑÎ$_2$ emission free energy source. The study on renewable sources potential in Bulgaria shows that theoretically they can meet the overall energy demand. Practically available potential, however, is considerably smaller. Taking into account the economic indices of applicable technologies in the study period the renewable sources turn to be able to provide up to 7% of the total energy balance.

The electricity production from solar and wind energy and biomass scenario has been studied under conditions of total installed capacity of 840 MW and 3200 million kWh annual production by 2020. Heat generation by solar energy and biomass - total of 17444 TJ/year is also considered.

Reduction of electricity and heat losses in transmission and distribution networks

The level of electricity and heat losses in transmission and distribution networks forms considerable potential for energy economy and therefore for CO2 emissions reduction. At the ground of expert judgement a schedule has been designed for electricity losses and auxiliaries reduction by 6%, and by 4% for heat network for the period after 2000.

Key issue in electric sector development in the next decade is the choice of **new technology** of Maritza East TPP that operates on the only important indigenous energy resource - low quality lignites. Existing TPPs have been operating for 30 years and it is necessary to choose technologies for new TPP building at the same site. Due to the lignites high sulphur contents two options are feasible: pulverised coal with flue gas desulphurization and fluidized-bed combustion.

Comprehensive study of the **rehabilitation of TPP** that are in operation had been carried out last three years. Seven TPP are addressed in the study at average cost of rehabilitation 130 $US/kW. The rehabilitation will result in extension of unit life-time by 10-15 years, increasing plants availability by 3-5%, decreasing auxiliaries to 10% and CO_2 emission reduction by 3.75-4.75% for the plants on local lignites and 1.8% on the plants on imported coal.

The total capacity to be rehabilitated is 4500 MW.

In order to compare the effectiveness of different mitigation options, the annual emission reduction potential of the measures and the investment cost to reduce 1 ton of CO_2 per life cycle of a measure are estimated. Table 5.27 shows energy supply options ranked by specific investment cost per ton CO_2 emission reduction.

Table 5.27 CO_2 reduction potential and investment cost per ton CO2 emission reduction

No	Measure	Annual potential 10^6 t CO2	Investment		
			Total 10^6\$US	\$US/t CO_2 life cycle	Life cycle
1	**Reduction of electrical losses**	3.2	91	1.9	15
2	**Reduction of thermal losses**	1.0	50	2.55	20
3	**Upgrading of heat production plants**	3.1	246	4.0	20
4	**Micro-hydro potential**	1.1	275	5.0	50
5	**Hydro power projects**	4.3	1 335	6.2	50
6	**Belene NPP**	9	1 300	8.5	30
7	**TPP rehabilitation**	1.3	585	28.0	15
8	**Fluidized-bed technology**	1.6			30

From an investment point of view the upgrading of district heating and cogeneration plants turns to be the most efficient option followed by the micro-HPP and large hydro projects. The NPP Belene construction finalization is the most powerful measure with reduction potential of more than 10% of the total CO_2 emissions of the country.

The TPPs rehabilitation and fluidized-bed combustion technology application of the new TPPs have their main benefits out of CO_2 emission reduction and the CO_2 reduction achieved is an additional benefit of these actions.

These measures could be combined in an aggregated electric system development scenario. As a result the aggregated mitigation scenario for energy supply has 4800 MW less coal fired TPPs compared to the baseline scenario which is compensated through 1000 MW NPP, 450 MW natural gas fired TPPs, 1180 MW cogeneration plants, 840 MW units utilising renewable resources, 690 MW reduced losses, 900 MW less peak load due to utilization of renewable resources and increased capacity with higher availability during the peak load of energy system.

Financial assessment of mitigation scenarios in energy supply

The above mentioned technical and economic assessments of the mitigation measures are based just on the investments required for their implementation. A series of important economic indicators are not taken into account, such as:

- The implementation of a measure entails reduction of the funds invested in other projects, postponed as a consequence of the option ranking.
- The operational costs of energy system change as a result of implementation for CO_2 reduction.
- The financial profit of measure implementation.

The financial assessment uses the following indicators:

- average cost of 1 ton CO_2 emission reduction for the 2000-2020 period expressed in $US and calculated as ratio of total emission reduction for the period via the total change of production cost of energy supply due to the mitigation measures within the same time period;

- discounted at year 2000 costs of 1 to CO_2 reduction for 2000-2020 period, calculated as ratio of total emission reduction for the period via the sum of discounted change of production cost of energy supply due to the mitigation measures within the same time period;

Table 5.28 represent the ranking of measures with regard to their financial indices - discounted at constant 2000 prices reduction costs of ton CO_2. The negative value indicates that the measure is efficient even without reduction of CO_2 emissions.

Table 5.28 Financial assessment of mitigation measures

No	Scenario	Reduction potential in 2020 10^6 t CO_2	Cost of emission reduction	
			Average $US/t CO_2	Discounted $US/t CO_2
1	**Losses reduction**	4.4	-38.2	-11.59
2	**Upgrading**	3.7	-15.41	-5.76
3	**Hydro**	3.2	-39.78	-5.58
4	**Renewable energy**	9.1	3.2	1.56
5	**Nuclear**	13.9	4.72	2.25
6	**Combined cycle**	5.8	11.36	2.58
7	**Aggregated**	23.7	-19.83	-4.91

The best option with regard to the financial parameters is the losses reduction, followed by the upgrading of the cogeneration power plants and district heating boilers and the hydro option. The natural gas utilization for electricity production by combined cycle power plans is the most expensive option.

5.6.2. Energy demand

The GHG mitigation programs are interrelated to a list of measures for management and reduction of energy demand. These measures are the so called Demand-Side Management (DSM). Options aimed to diminish GHG emissions through energy demand are summarised in three groups as follows:

- Demand Side Management (DSM) programs in households and industry,
- Improvement of energy efficiency in industry by improved technology processes and penetration of new advanced efficient technologies,
- Natural gas supply to the households.

While the economic and social impetus and the organisation possibilities of the industrial sector facilitate the implementation of DSM measures, the peculiarities of household sector hinder the implementation of the measures and promote a delayed application in this sector. At first stage the reduction of energy demand should be due to introduction of new up-to-date efficient appliances to households, better heat insulation and heat management.

A complete DSM implementation in households and industry in Bulgaria would allow conservation of more than 611 million kWh in households and 1137 million kWh in industry compared to 1992 consumption. The corresponding amounts of CO_2 saved are 855'000 tons CO_2 in household and 1.6 million tons CO_2 in industry. The elements of DSM, their CO_2 emission reduction potential together with investments per unit carbon saved are shown in Table 5.29 for DSM in households and in Table 5.30 for DSM in industry.

The following measures can be recommended for application in industry just now:

- Energy audits;
- Electric motor operation improvement;
- Efficient lighting.

The total market potential of these measures corresponds to over 1 million ton of CO_2 reduction annually. The total market CO_2 reduction potential of the DSM in the industry is more than 1'500'000 t CO_2.

Energy efficiency increase in industry is one of the most efficient mitigation options that will allow to diminish energy intensity of GDP

through drastic improvement and modernisation in all sectors of national economy. The new energy efficient technologies, equipment and devices could allow to save more than 10% in 2000 and 16% of the total final energy demand in 2020 (Tzvetanov 1995). Preliminary estimates of these measures indicate that they will result in 11.6 million tons CO_2 conserved in 2000 and 34.1 million tons CO_2 conserved in 2020. It is very difficult to assess this option in terms of necessary investments. Estimates on macro-level indicate that the energy efficient development as a result of drastic improvement and modernisation in all sectors of national economy would lead to a decrease of GDP of more than 12% compared to the baseline scenario.

Table 5.29 DSM in households

Measures	Cost of saved electricity		Reduction potential t	Costs of 1 ton CO_2 reduction	
	Average US c/kWh	Discounted d=10% USc/kWh		Average $US/t	Discounted d=10% $US/t
1. Plastic to windows	1.2	1.4	36051	8.27	9.97
2.Compact fluorescent light	2.4	3.3	76195	17.01	23.43
3. Conversion from electricity to gas (hot water)	2.5	4.1	158760	17.86	29.06
4. Conversion from electricity to gas (space heating)	2.0	4.7	55020	14.29	33.56
5. Additional insulation of boilers	3.1	5.1	46804	22.32	36.33
6. Thermostat\regulator	4.0	5.3	75106	28.57	37.69
7. More efficient incandescent	5.0	5.8	10885	35.71	41.16
8. Economic showers	4.4	5.9	35103	31.75	41.87
9. Conversion from electricity to gas (cooking)	4.1	8.1	128860	29.33	57.85
10. Modernization of the heating elements	6.2	14.5	34090	44.00	103.37
11. Direct load control of boilers	8.3	16.4	11701	59.52	117.39
12. High efficiency refrigerators	14.8	29.2	186165	105.82	208.69

Table 5.30 DSM in industry

Measures	Cost of saved electricity		Reduction potential t	Costs of 1 ton CO_2 reduction	
	Average US c/kWh	Discounted d=10% USc/kWh		Average $US/t	Discounted d=10% $US/t
1. Energy audits and analyses of power demand	0.5	0.8	980000	3.57	5.8
2. Changes in the running mode of motors	2.2	3.6	88200	15.71	25.8
3. Effective lighting	2.7	4.3	73500	19.29	31.0
4. Drives and rotating elements improvement	3.3	5.4	147000	23.57	38.7
5. Highly effective motors	4.2	6.8	117600	30.00	48.4
6. Self energy production	3.1	7.3	67200	22.14	52.4
7. System for load control	5	8.1	98000	35.71	58.1
8. Maintenance of the equipment for ventilation and compressed air	5	8.1	19600	35.71	58.1

Table 5.31 Potential for fuel and energy conservation in the production sector, TJ/year

Period	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020
Total energy intensity impact, incl.:	40912	54537	85619	108623	141502
- Iron and steel	327	15904	13074	14155	15091
- Chemistry	5453	-	6771	5374	4227
- Building materials	4494	3589	4803	6504	8562
- Other industries	24913	29088	53726	75413	100605
- Construction	2359	1655	2448	2944	4015
- Agriculture and forestry	3366	4302	4797	4233	9003
Structure impact	2734	9812	8802	15838	17793
TOTAL	43646	643449	94421	124461	159295

Natural gas supply to the households. This option aims to replace electricity and coal consumption in households with natural gas. The program for household natural gas supply is elaborated and it projects 400’000 households to be supplied by 2020. If the same lifestyle in the households is assumed the CO_2 emission reduction due to the fuel switching will be 3 million tons CO_2 annually at a cost of emission reduction of 7.3 $US/ton CO_2 saved.

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CHAPTER 6

VULNERABILITY TO CLIMATE CHANGE AND ADAPTIVE STRATEGIES

This chapter provides a summary of the climate change in Bulgaria for the last century and the climate scenarios for the next century. The impact of the changes on the forest ecosystems and on agriculture is projected. The framework of the adaptation strategy in the forestry and agriculture are outlined. The opportunities for mitigation of the effect of the forests, agriculture and municipal wastes are exploited.

6.1. Introduction

The climate profile of Bulgaria is determined by its belonging to the mild continental zone with regular rotation of four seasons. The diversity of terrain altitudes affect the temperature and precipitation schedules and provokes significant weather variability. Chapter 2 “Natural and socio-economic circumstances in Bulgaria” presents the main peculiarities of the country climate. The enumerated characteristic allow the territory to be divided into two basic climatic zones - Northern and Southern Bulgaria with 0.9 ^{0}C average temperature deviation - 10.8 ^{0}C in Northern Bulgaria and 11.7 ^{0}C in the Southern Bulgaria.

6.2. Climatic fluctuations and tendencies in Bulgaria

On Figure 6.1, the deviations of the mean annual air temperature in the period 1901-1993 in South and North Bulgaria are presented according to their average values for the period 1951-1980.

The period of the first decade of the present century appears to be relatively cold. After it a period of well determined warming begins which lasts till 1939. From 1940 to 1944 a short cooling interval has been observed, after which a slight warming has begun until 1968. The 1970s decade as well as the first half of the 1980s can be characterised colder compared to the climatic standard for 1951-1980. These years have the lowest temperature amplitudes during the 93-years long research period. Since 1988 a warming period begins which is more distinguish in the North of the Stara planina mountain. The mean annual temperature fluctuations in Bulgaria differ from the fluctuations of the global air temperature at the Earth surface

During the past years of our century, in Bulgaria there is a clearly determined tendency to climatic warming in the winter, due to temperature rise in January and February. Almost 40 years - since 1953/54 up to now, the warm winters are predominant in Bulgaria. With the exception of one temperature decline in the winter of 1986/87, the average temperatures vary approximately harmonically with small amplitudes around the standard for the period 1981-1993. This is considerably rare compared to the typical severe winders in the first half of the century in the country. While in North Bulgaria a positive trend in the temperature during the warm half-year can be observed mainly due to the low temperatures in the beginning of the century, the temperatures in South Bulgaria have decreased. The months July and August in North Bulgaria incline to a slight warming and in the stations to the South of the Stara planina mountain the temperatures trend to decrease. As a result of the warming that has occur since the second half of the 1980s for the warmer part of the year a upward trend can be observed for the country as a whole for the period 1961-1993 in July and August as well as in June and September. The spring (April - June) and the autumn (October - December) months have similar tendencies. In the stations in North Bulgaria a warming during the three spring months during the years 1901 to 1993 has been observed, as well as in October

and December. At the same time this time interval in South Bulgaria and for the next two periods (1931-1993 and 1961-1993) also for the most stations in the country, a cold spell in these two seasons is typical

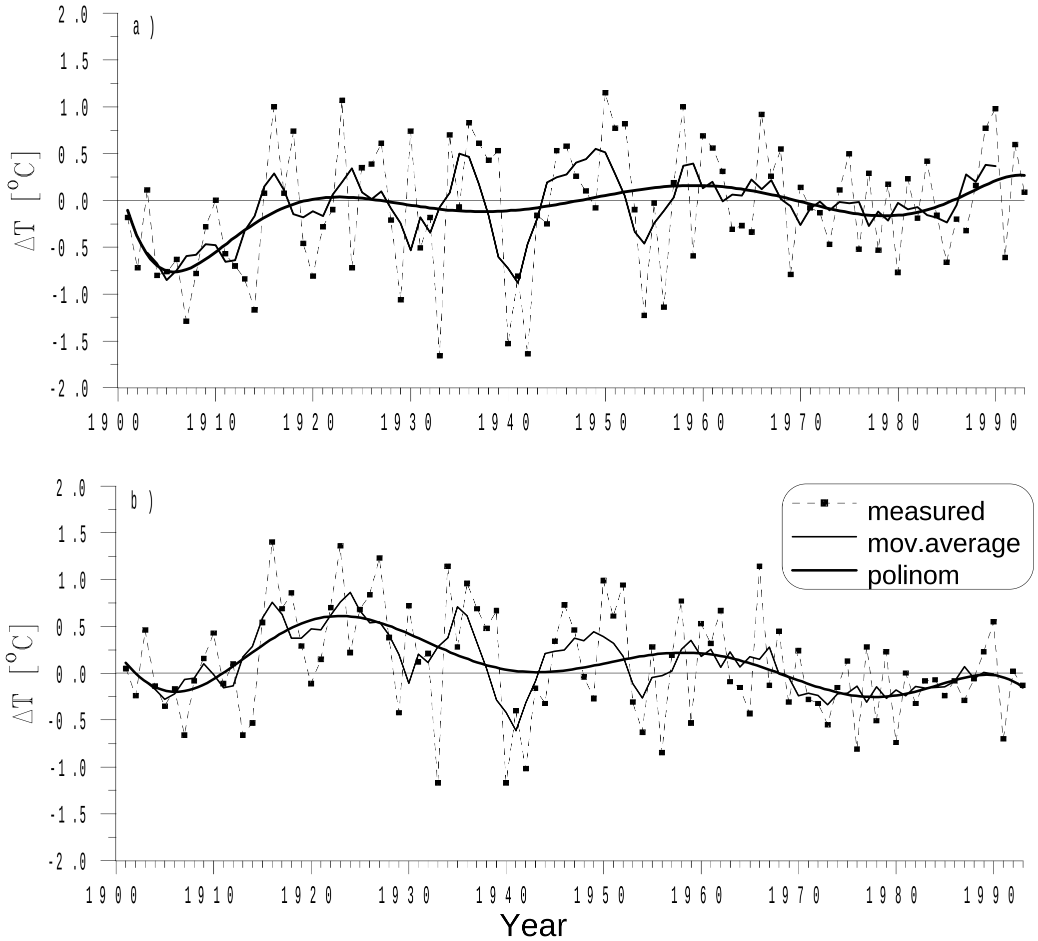


Figure 6.1. Anomalies of the mean annual air temperature in North (a) and South (b) Bulgaria compared to the standard for the period 1951-1980. [Alexandrov, 1995à].

In North Bulgaria, as well as in South Bulgaria a relatively monotonous trend to the annual precipitation amounts decrease is observed (Figure 6.2).

This trend is too vivid from the beginning of the 1980s to the end of the studied period (1993). Another temporary interval with small precipitation are the years from 1945 to 1953 inclusive. Of course, there are some incidental cases observed, in which the positive anomalies of the annual precipitation amounts exceed the basic standard (1951-1980) by 50 mm, 100 mm and even 200 mm. There are even some cases with consecutive positive deviations from the relative standard (1954-1957, 1971-1973 and 1978-1980).

In the warm and cold half-year the precipitation amount trend in the country is negative, i.e. a decrease of the precipitation amount is observed. Analogical to the trend mentioned above is the trend in the development of the precipitation amount in the different seasons but the winter months (January-March) in the stations of North Bulgaria during two intervals of time: 1901-1993 and 1931-1993. The observations for the following months - January, June, July, September and October - also prove the negative trend for most of the meteorological stations included in this study. During the months of February, April, August and December there is a tendency of slight increase of the precipitation amount for the whole study period 1901-1993. This trend stays just in April and August during the 63-years-long period from 1931 to 1993.

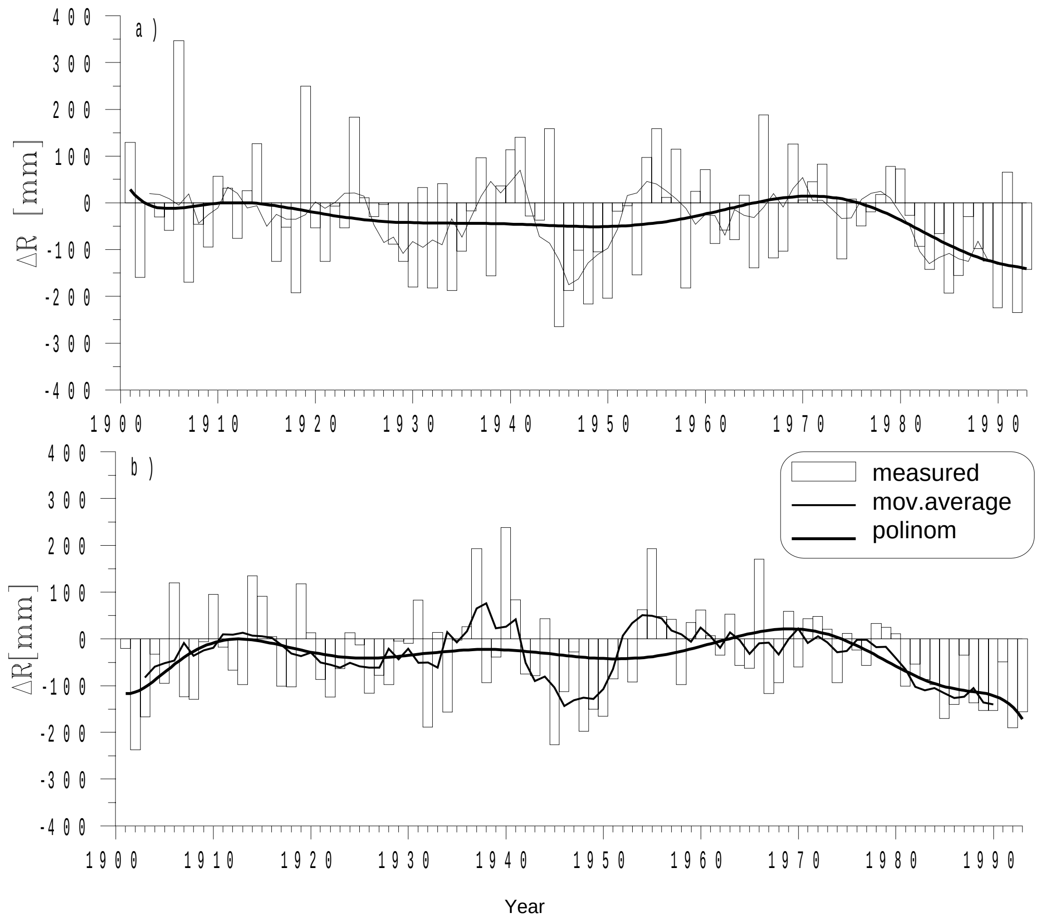


Figure 6.2. Anomalies of the annual precipitation amounts in the observed stations in North (a) and South (b) Bulgaria compared to the standard for the period 1951-1980 [Alexandrov, 1995à].

On the basis of the results mentioned above a conclusion is made, that the climate in the North of Bulgaria has become warmer and in the South of Bulgaria it has become colder. The precipitation trend is to more dry climate in the country's territory in the end of this century.

6.3. Climatic scenarios for Bulgaria for the next century

To determine the baseline climatic scenarios or the so called "modern climate", a thirty years meteorological data row is used. Usually the modern climate is based on the observations for 1951 - 1980 or 1961 - 1990 time periods.

The future climate change is usually related to the probable changes in the meteorological weather, which are expected to come due to the CO_2 concentration doubling (2*ÑÎ$_2$). An import part of the study of the climate in the conditions of a growing a greenhouse effect are the mathematical models of the global atmosphere circulation - GCMs. In this direction the GCMs have been developed describing the physical processes in the atmosphere the ocean and in the ground layer - GFDL, CCC, GISS, NCAR, UKMO etc.

The output results obtained from three GCMs models - CCC, GISS and GFDL for CO_2 concentration doubling show that the average annual air temperature in Bulgaria is expected to rise with 4.0-4.4°Ñ (Table 6.1). As concerned to the annual precipitation sums there is no agreement in these simulations models. In spite of this, there is a tendency the precipitation quantity to increase during winter period and a tendency to precipitation deficit during the warm period of the year (Table 6.1). It is necessary to be pointed out that there are differences between the separate GCMs both in the air temperature and precipitation change within the year

Table 6.1 2*ÑÎ$_2$ climatic scenarios for Bulgaria (diversion of the mean month air temperature in (°Ñ) and month precipitation amounts (in %) according to the recent climate: 1951-1980).

Model GCMs		Month											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
GFDL	T	2.0	6.2	4.0	4.3	3.8	5.2	5.9	4.3	3.5	3.6	4.7	5.3
	R	24	74	5	-30	-2	-40	-27	42	26	7	5	23
CCCM	T	3.7	3.2	3.7	3.4	3.7	5.0	5.7	4.9	4.2	3.8	3.6	3.3
	R	5	-18	-13	-11	-23	-44	-29	-17	-39	13	16	17
GISS	T	4.2	4.8	4.2	5.5	4.4	3.0	3.0	3.9	4.7	3.8	5.1	3.6
	R	13	-5	25	5	14	7	21	-10	-38	50	10	11

Legend: T - temperature; R - precipitation

The transition climate scenarios are based on the assumption that the gases contributing in the "greenhouse effect" continuously increase their concentrations. In this way with the help of the linear interpolation climatic scenarios could be determined describing the status of meteorological conditions for each year or decade for the 1994-2075 period. That helps the experts to get an idea about the influence made on the ecosystems by the climate changes in the nearest future - in 10, 20 years.

The GFDL model is one of the GCMs simulating transitional climatic scenarios. Tables 6.2 and 6.3 present the climatic scenarios for Bulgaria in 2006 and 2036. According to the climatic scenarios of this model the average annual air temperature in 2006 and 2036 is expected to be with 1.2°Ñ and 2.1°Ñ higher from the temperatures characteristic for the recent climate (1951-1980). For the same period the tendency in the precipitation is to an increase during the cold period (December and January) which compensates in some extend the less precipitation amount during the months from April to September (Tables 6.2 and 6.3).

There are also incremental climatic scenarios in which the air temperature and the precipitation change with determined lag. They are used mainly in the study of the climatic changes influence on a particular sector in local and regional aspect because the global trend in the climate change could be in contradiction with the regional peculiarities of the climate conditions

Table 6.2 Transitional climatic scenarios for Bulgaria through 2006 (diversion of the mean month air temperature (in °Ñ) and month precipitation (in %) according to the recent climate: 1951-1980).

Model GCMs		Month											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
GFDL	Ò	1.2	0.4	2.8	0.9	0.0	1.6	-0.2	2.0	2.6	1.0	0.4	1.3
	R	33	-1	1	0	-22	9	29	-41	-29	-21	-10	48

Legend: T - temperature; R - precipitation

Table 6.3 Transitional climatic scenarios for Bulgaria through 2036 (diversion of the mean month air temperature (in °Ñ) and month precipitation (in %) according to the recent climate: 1951-1980).

Model GCMs		Month I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
GFDL	Ò	3.3	1.6	2.7	0.9	1.3	2.7	1.8	3.3	3.2	1.8	0.9	2.4
	R	38	-5	24	-20	-15	-14	63	-4	-52	-30	-23	28

Legend: T - temperature; R - precipitation

Having in mind the existing unclear moments concerning the future climate (especially the regional changes in the precipitation, the climate fluctuations as well as the temporary intervals of climate change), it must be pointed out, that the climatic scenarios in this study can not be used as a prognosis. They are created to help to identify the sensitivity of a particular sector to the climate change. Therefore, with the help of the climatic scenarios, it is possible to identify the types of influence which could be observed at different changes of the future climate and to determine which climate changes seem to be a real risk and which are favourable for the forests and agriculture.

6.4. Climate change influence on forest ecosystems and on agriculture

6.4.1. Forest ecosystems

In order to define the forest ecosystem vulnerability under the possible climate changes, as well as to find measures for their adaptation to the new conditions, an information is necessary for the Bulgarian forests calibrated to a basic period, valid for all the countries taking part in the project. 1990 has been chosen for a base year in that investigation (IPCC, 1992). The meaning "status of Bulgarian forests" includes information about the areas, tree species, growth rate, total volume etc.

The total area of the Bulgarian forests, for the concerned period of 35 years, is a comparatively constant value which varies from 3,511 up to 3,772 mil.ha with a trend as to gradually increase from 31.7% up to 34.0% of the territory of Bulgaria belongs to the forest lands. This is a positive fact indicative of the fact that the total area of the forests in the country does not diminish.

Another, more important circumstance is that the percentage of woodiness, i.e. of the woody area on the territory of Bulgaria has increased from 27.5% up to 29.4%. This is due to the mass afforestations in the reported period and to the policy for protecting and increasing the forests, which has been reliably based on the Bulgarian forestry legislation and traditions.

In the period 1955-1990, the total area of the coniferous forests increased from 14.0% (1955) up to 37.0% (1990). This was due to the mass afforestations, with mainly coniferous species, which changed the landscapes of a number of regions in the country and brought back to life territories enormous for the size of Bulgaria.

The areas of annual afforestations have varied from 28,040 ha up to 89,660 ha, and this allowed over 1 million ha of new forests be established in the past 35 years, hence, over 1/3 of the country's forests were re-established. This is a great achievement of the Bulgarian forests science, and of the Bulgarian nation, which has and will be having an enormous positive effect on the microclimate and economy of this country.

Besides the phenomenon of establishing new forests, the quick increase of the protected territories in Bulgaria, i.e. national parks, reserves, etc., has been reported. The percentage of their total area increased from 8.4% (in 1955) up to 30.9% (in 1990). In the recent years, some of the largest national parks in Europe were

established: Rila - of an area of over 100,000 ha; The Central Balkan - of over 72,000 ha and other ones. This has a great importance for conserving the biological diversity and for the development of tourism in Bulgaria.

The creative policy in the field of forestry resulted in a quick increase of the total volume of above-ground mass of wood in the forests of Bulgaria. The total volume of wood in the Bulgarian forests has increased from 244.68 mil. m^3 (in 1955) up to 396.02 mil. m^3 (in 1990), i.e. the amount of standing wood has increased for 35 years by 61.8%. As stated above, this is due to the enormous afforestations carried out in this period. In this way, the average volume per unit of woody area increased from 77.6 m^3/ha up to 122.2 m^3/ha.

The consequences of this favourable effect on the forests in Bulgaria are obvious: the erosion in all the large water-catchment basins in the country was liquidated; the living conditions in enormous territories in the country were improved, as well as the forests' microclimatic, hydrological, recreative, meliorative and other positive effects, i.e. all the peerless favourable functions of the forests in Bulgaria are improved.

The climate change scenarios derived for Bulgaria were used to evaluate potential changes in forest vegetation. The altered temperature and precipitation databases corresponding to each of the climate change scenarios were used to run the Holdridge life zone (1967) classification model.

The analysis on the condition of the forest vegetation from the last decade in Bulgaria show that the coniferous forest vegetation which was widely introduced during the last decades under 800 m a.s.l., i.e. out of its natural habitats, forms very hardly stable forest ecosystems. The main reason is the discrepancy between the ecological conditions (mainly rainfalls) and the requirements of the coniferous tree species. Due to this reason they are physiologically in a chronic water deficit and in drought periods like this one in 1983-1994 they begin to disintegrate (Raev, 1995).

The tendency follows the direction: the high fields of West Bulgaria - North Bulgaria - South Bulgaria - Black Sea Coast - Southern parts of the country. In this sequence grows the vulnerability of the forest vegetation from the adverse dry climate.

The problem with the discrepancy of the ecological conditions of the forest vegetation is not a new one in Bulgaria forestry. During the last years decay of the conifer plantations (*Pinus sylvestris, P. nigra*, more rarely *Picea abies* and *Pseudotsuga menziesii*) is observed due to the improper introduction of these species in the low part of the country. The main reason for this dangerous phenomenon is the discrepancy between the climatic conditions in this part of the country and the ecological requirements of newly afforestated coniferous species (Raev, 1989). If the projections about the carbon dioxide doubling during the next century come true the ecological conditions in Bulgaria will drastically go worse.

The changes are from "cool temperate moist forest" to "warm temperate dry forest" for North Bulgaria, and for South Bulgaria the "warm temperate dry forest" will remain typical. In the warmest country regions (station Sandansky) "subtropical dry forest" could be expected, which means drastic warming and droughts. Since 60.6% of forests are in the zone below 800 m (Kostov et. all, 1976), it is clear, the biggest part of Bulgarian forests would be vulnerable to the drastic climate change under the eventual doubling of carbon dioxide in the near future.

The changes in the mountain regions of the country (station Smoljan, 1180 m a.s.l.) would pass from "cool temperate wet forest" to "warm temperate moist forest".

Therefore, a change in the forest strategy is necessary for adaptation of the forest vegetation to the changed ecological conditions in the country. At an eventual climate warming a moving of the species composition from South to North could be expected, which means shifting of tree and shrub vegetation from the South-Bulgarian into the North-Bulgarian and from the South-Bulgarian borderside into the South-Bulgarian forest vegetation area respectively. That means that it could be expected that the South-Bulgarian borderside area will be settled by typical Mediterranean vegetation, a part of which is to be seen there even in the present. More important representatives of this vegetation are *Cercis siliquastrum L., Cupressus sempervirens L., Olea europaea L., Pinus brutia Ten., P. halepensis Mill., P. pinaster Ait., P. pinea L., Quercus aegilops L., Q. ilex L., Q. suber L., Q. trojana Webb.*

6.4.2. Agriculture

The increase of temperatures at an effective doubling of the CO_2 concentration leads to the increase of the agroclimatic thermal potential in Bulgaria - longer growing period and bigger

amount of effective temperatures during the same time interval. The precipitation amounts increase or slightly decrease during the potential growing period and decrease in the non-growing period due to the shifting of the dates of sustainable air temperature transition in autumn and spring to the beginning and the end of the winter season.

Table 6.5 Departures of phenological stages and grain yield of maize and winter wheat under 2*CO_2 scenarios (GFDL, CCC è GISS), relative to the current climate.

model	crop	GCM	silking/anthesis [days]		full maturity [days]		grain yield [%]	
			NB	SB	NB	SB	NB	SB
CERES-		GFDL	-18	-18	-30	-32	-36.3	-36.9
Maize	maize	CCC	-17	-17	-29	-31	-29.0	-37.6
V 2.1		GISS	-16	-16	-18	-25	-0.4	-7.6
CERES-		GFDL	-20	-20	-23	-22	-15.0	-13.5
Wheat	wheat	CCC	-17	-18	-21	-20	-16.0	-16.6
V 2.1		GISS	-22	-22	-25	-25	-17.4	-16.0

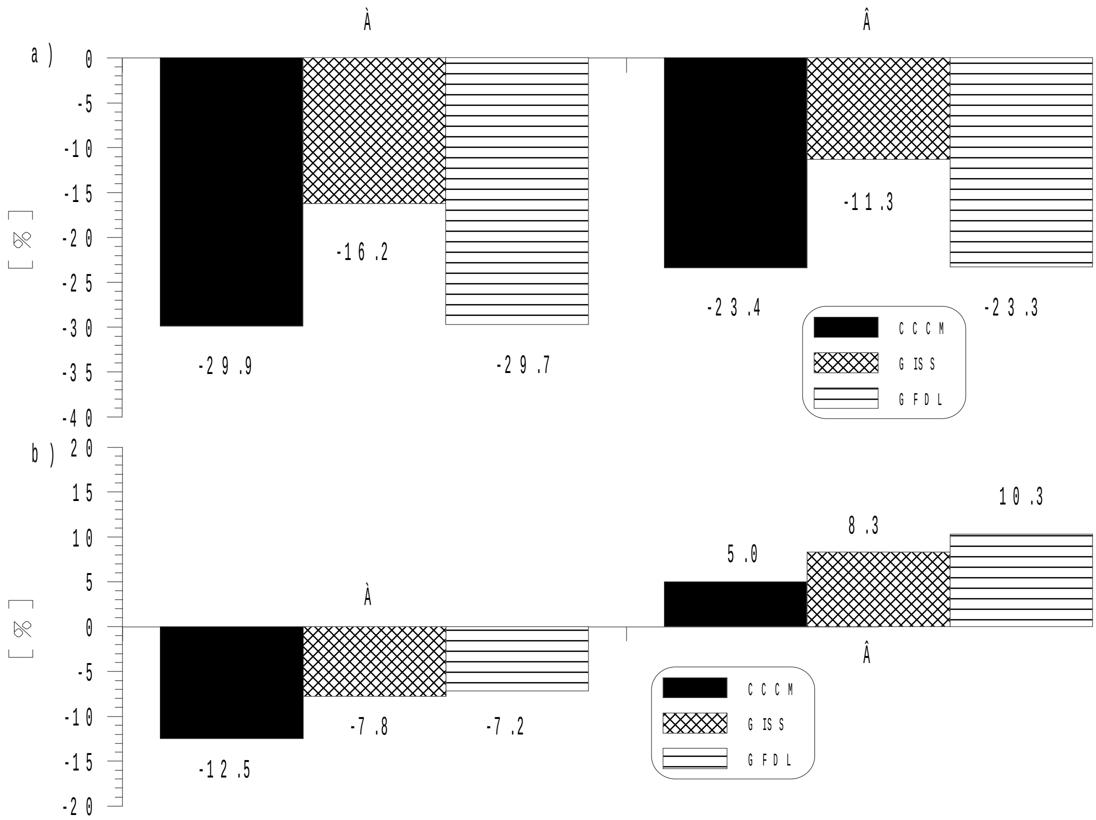
Legend: NB, SB - North and South Bulgaria (-) - phenological stages occurred earlier than averages.

The influence of the climate change under the 2*CO_2 on the beginning of some basic phenophases and grain yield of maize and winter wheat in the experimental crop stations in Bulgaria is shown in Table 6.4. The assessment is based on the simulated results from the adapted dynamic models of these two crops: CERES-Maize and CERES-Wheat.

The high temperatures result in earlier germination of the maize and wheat, which is connected with limitation of their reproductive period during which the grain ripening process comes to fruition. At the same technological level of production and precipitation deficit in the warm half-year the average crop from the experimental crop stations in Bulgaria at 2*ÑÎ$_2$ GFDL and CCC climatic scenarios decreases with more than 29% compared to the crop calculated for the present climate conditions. In spite of the bigger precipitation amount expected in autumn and winter the winter wheat crops decrease by about 15-17%.

It is necessary to underline that the above-mentioned results were obtained at the so called variant "A" where the direct influence of the temperature and precipitation on the growth, development and productivity formation of the two crops has been studied. Taking into account also the direct "fertilizing" effect of effective increase ÑÎ$_2$ (variant "B") on the two crops (ÑÎ$_2$ influence directly on processes like photosynthesis and evapotranspiration) the yield decrease of the maize is reduced with more than 5% and higher wheat yields could be obtained (Figure 6.3). A preposition for this is also the increase of precipitation amount during the autumn-winter season when the soil water accumulates.

With the help of transient climatic scenarios of the GFDL model (at which greenhouse gases increase their concentrations gradually) it was found out that in the middle of the next decade the beginning of the potential growing period is expected with 11-13 days earlier, while its end shifts to the winter season with 4 days later. The prolongation of this period with 15-17 days increases the effective temperatures amount average with about 250°C. The lower temperatures increase in the first decade (+1.2° Ñ) and the middle of the 30s (+2.1°Ñ) of the next century will have slight influence on the development and productivity of the maize and wheat compared to the 2*ÑÎ$_2$ climatic scenarios (Table 6.5).



Legend: À, Â - without/with direct influence of ÑÎ$_2$ on development, growth and yield formation of maize and winter wheat

Figure 3. Departures of grain yield of maize (a) and winter wheat (b) under 2*CO_2 scenarios (GFDL, CCC è GISS), relative to the current climate at 2 experimental crop stations - Kojnare (a) and Zinmica (b).

Using 169 incremental climatic scenarios the vulnerability of the agroclimatic resources and the grain yield from maize and wheat to the conditions of combinations between dry, moist, warm and cool climate has been studied. The cool and moist climate from one side is a precondition for the limitation of the thermal resources during the potential growing period but from the other side they bring to prolongation of the reproductive period during which the grain ripens. The grain yields from maize and wheat decrease at precipitation deficit and high temperatures (Figure 6.4).

Table 6.5 Departures of phenological stages and grain yield of maize and winter wheat under transient scenarios (GFDL, year 2006 and 2036), relative to the current climate.

model	crop	silking/anthesis [days]		full maturity [days]		grain yield [%]	
year - 2006							
		NB	SB	NB	SB	NB	SB
CERES-Maize	maize	-2	-2	-4	-7	-1.4	-4.1
CERES-Wheat	wheat	-6	-7	-7	-7	2.0	1.0
year - 2036							
		NB	SB	NB	SB	NB	SB
CERES-Maize	maize	-8	-8	-13	-16	-2.5	-7.3
CERES-Wheat	wheat	-10	-11	-12	-12	-3.6	-2.5

Legend: NB, SB - North and South Bulgaria (-) - phenological stages occurred earlier than averages.

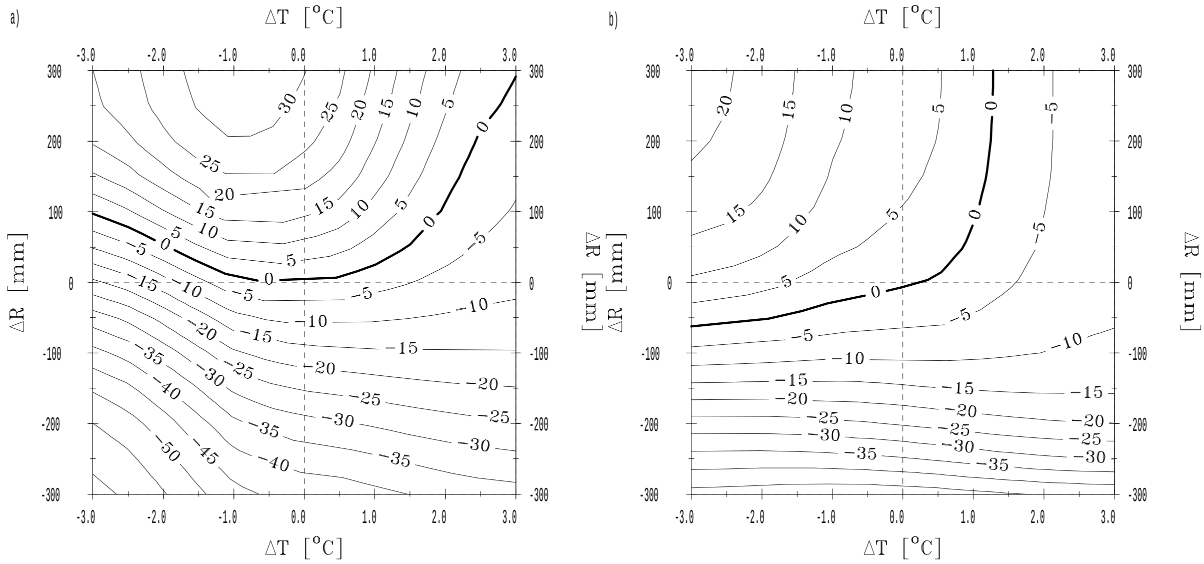


Figure 6.4. Change (in %) of the average grain yield from maize (a) and wheat (b) at a present climate change (1961-1990).

5. Adaptation strategies

5.1. Forestry

As a main component of the adaptive strategy in the forests world-wide, the following definition at the International conference for assessment of the forests adaptation to the climatic changes held in St. Petersburg on May 22-25, 1995, was given: “sustainable usage of the forest resources for preventing the dynamics of the natural systems and the biodiversity”.

If there are any climate changes in the next century, they will most probably affect negatively the lower forest vegetation zone in our country. In the upper mountain areas relatively favourable conditions will probably remain. This asks for a differentiated approach in the future strategy.

A. Lower forest vegetation zone (from 0 to 800 m a.s.l.)

The strategic task of the forestry in this most vulnerable area of the forests in the country at the threshold of eventual climatic changes must be as follows: an attempt for forests adaptation to the climatic aridisation, for preserving the forests from unfavourable ecological conditions.

The ways to achieve this object could be:

1.1. Tolerating the native dry-resistant and thermophyllic tree and shrub species;

1.2. Tolerating the naturalized exots with proved resistance to semi-arid conditions;

1.3. Introduction of new species for afforestation in semi-arid conditions with a provenance from the neighbouring geographical areas;

1.4. Differentiated approach in the afforestations in the different regions of the country taking into account that the aridisation is expected to be more intensive in the following ascending order: Western fields - North Bulgaria - South Bulgaria - Black Sea coast - Southwest region;

1.5. Preventing and enlarging the mixed character of the forests in the lower area of the country with the preference of all tree and shrub species resistible to the changed climate;

1.6. In all more favourable ecological conditions, multi-storey forest ecosystems of different ages to be established, which have the highest ecological effect;

1.7. A serious transition of the coppice stands into seed ones is demanded with the help of introduction of more dry-resistant and thermophyllic tree and shrub species;

1.8. A special attention to the forest shelter belts which should be established with the help of more dry-resistant to the semi-arid climate species and which should cover considerably larger territories;

1.9. The nursery production is expected to provide a gradual change in the native and introduced tree and shrub species with suitable ones for the new conditions and polluted air;

1.10. New technologies concerning the soil preparation, afforestation, cuttings are needed according to the new ecological conditions as well as the new tree and shrub species;

1.11. Developing of new methods for selective cuttings on the basis of changed ecological conditions and new tree species;

1.12. Intensive usage of the cutting for improving the health status of the forests to eliminate all damaged forests;

1.13. A change in the forms and technologies of the main cuttings in the lower regions in the new conditions;

1.14. Intensive development of the system for preventing, fast detection and eliminating of the wildfires;

1.15. A development of a system against pests and diseases on the forest vegetation in unfavourable climatic conditions;

1.16. Development and realization of a system for forests protection from infringements and criminal violations.

B. In the forests of the higher parts of the country (over 800 m a.s.l.)

Thanks to the possibilities for conservation of the comparatively favourable ecological conditions in the higher parts of the mountains, the purposes of the forestry here must be more different: biodiversity conservation in the forests, stable ecosystems development, multifunctional usage, developing of the system of protected natural territories. The following strategic measures are possible:

2.1. Total preventing and enlarging of the mixed feature of the mountain forest ecosystems through using all native deciduous and coniferous species. This is also the way to respond to the demand to extend the biological diversity in the forests;

2.2. Developing of a program for establishment and maintenance of multi-storey and of different ages coniferous and deciduous forests with a highest ecological potential;

2.3. Extending the tree-line with about 100-200 m together with the climate change in our mountains;

2.4. The nursery production to provide possibly the best planting material of species and ecotypes with highest productive quality and resistance to polluted air;

2.5. A particular attention should be paid to the selective cuttings in the young stands to increase their resistance and productivity;

2.6. Forest fire suppression is on of the main priorities as well as the developing of a system for diseases and pests protection in these forests;

2.7. Modern methods for main cuttings should be developed and applied with prior advanced natural regeneration. Tree and shrub species should be introduced to enrich the dendrocomposition and to increase the ecosystems resistance and productivity. The moratorium on the clear cuttings should be continued to prevent the most valuable high-stem forests.

2.8. The mountain watersheds management to be directed to multifunctional usage: highest level of biological productivity together with the highest level of water regulation, soil protective, recreational and climate formatting functions;

2.9. Total development of the system of protected natural territories: national parks, reserves, protected forests etc., with the help of which the biodiversity, the high productivity level as well as the forests protective functions are preserved.

For the success of this strategy the following conditions will be necessary:

- improving of the forestry legislation and establishment of new requirements for protection and sustainable development of the forestry; for keeping the biodiversity in the forests; for helping the forests adaptation to unfavourable climatic changes; for the forest resources multifunctional usage;

- developing and realization of a scientific program to resolve all important and urgent problems of the forestry for forests adaptation to the climatic changes and for realization of the strategic purposes of the forestry;

- co-ordinated efforts of the scientific workers in the forestry problems of the country together with the specialist from the Committee of Forest, the Forest Enterprises, the Regional Forest Offices, the Ministry of Environment, the Nongovernmental Environment Protection Organizations in the national and international level, for the new problem resolutions;

- serious investments on national and international level for financing of programs for adaptation of the Bulgarian forests and forestry to the challenges of the next century;

- a change in the research program of the Forest Research Institute and Forestry University including the training of the specialists about the new problems in the forestry; and

- intensive collaboration with the national and regional media (TV, radio, press etc.), with the state governmental structures (the Council of Ministers, the President Institution, the Parliament, the Municipalities etc.), with the Nongovernmental Organizations, the Political Parties and the whole people to be concerned with the protection and improvement of the Bulgarian forests.

6.5.2. Adaptation measures of agriculture in Bulgaria under climate change

Generally, the results obtained in this study, although they have hypothetical character and there are also some limitations, give the opportunity to propose next adaptation measures to climate change in Bulgaria:

1. change in the agricultural strategy is necessary for preserving the stability of the agroecosystems, which provide main foods for the Bulgarian nation, under climate change conditions.

2. zoning of crop production in agricultural land areas with elevation bellow 1000 m.

3. change in crop hybrids and cultivars.

4. growing of new hybrids more adaptive to the future climatic changes.

5. change in crops. Cultivation of new crops (oil and citrus trees, etc.).

6. change in agricultural management practices (e.g., change in planting date, fertilization, irrigation, tilling, etc.).

7. change in management of diseases and pest control.

8. economic activity and action of the government, which can help agricultural production. Monitoring of agricultural land areas is necessary, although Bulgaria is now under market economy. Government control, plans and subsidies are also necessary for Bulgarian agricultural.

9. development of programs and financial support of investigations in the field of vulnerability and adaptation assessments of agriculture under climate change.

10. inclusion of different institutions to the problem of climate change at national level, such as Ministry of Agriculture, National Institute of Meteorology and Hydrology, Ministry of Environment, Agricultural Academy, etc.

11. inclusion to different programs of EC, FAR and FAO. Continuing collaboration with USA and resuming co-operation with Russia.

6.6. Mitigation strategies

6.6.1. Forestry

The main purpose of the choice for the mitigation in the forestry is to reduce the greenhouse gases accumulation in the atmosphere through reducing of their emissions in the forest sector and absorbing of the atmospheric CO_2 and its storage in the earth biosphere. In this way the predicted influence of the greenhouse gases on the global climate changes will be defined. The mitigation options could be classified into two main types. The first option is to enlarge the areas with stands, which will bring to better sink of the carbon from the atmosphere and the greater amounts stored on land and extending the carbon contents in the products using timber as a raw material. The second option is to maintain the existing stands and to keep the proportion of the present forest production. The maintenance of the existing stands, no matter how itis achieved (e.g. through loewer deforestation, forest protection measures or more effective conversion and forest products utilization), detains the greenhouse gases emissions from penetrating in the atmosphere during the period of their accumulation.

Another way for the carbon emission reduction is to use timber from regenerative source, for example forest plantations, to replace the non-regenerative emission sources, having in view the fuels. The change of fuels with wood fuels will detain the carbon release from the fuels as long as the usage of timber from regenerative sources continues.

The realization of the afforestations in quantitative as well as in qualitative sense, i.e. the combination of gradual change of the coniferous plantations improperly established in the low forest vegetation zone with deciduous and expansion of forest fund lends through afforestation of devastated lands and establishment of forest shelter belts would bring to a considerable reduction of the CO2 amounts emitted in the atmosphere.

In implementation of the mixed scenarios the quality of the sink CO2 will increase by 1.430 million t as this increment could be reached in 2020-2025 (increase of the CO2 absorption by 0.600 million t at the qualitative scenarios and by 0.830 million t at the quantitative scenarios).

That means that the quantity of the absorbed CO_2 in the next century (in 2025) will increase compared to the base year 1990 by about 21%.

6.6.2. Agriculture

The mitigation measures will penetrate gradually in agriculture managing practice of Bulgaria because the attractive in them is the increase of the effective productivity directly concerning the economical interests of the grower. In near future it could be expected an improvement of the way of nutrition of the domestic animals as well as of the foods and of the races.

The collection and utilization of the methane from the manure is a problem which will not be solved soon. The experiments in this field in Bulgaria are limited even under the centrally planned economy conditions when the predominant part of the animals was gathered in the co-operatives and there were big opportunities to realise such projects. At the present situation, at this dispersion of the animal units in the numerous private farms it is not possible to established facilities for collection and burning of the methane.

In the same time a mitigation measure is the use of this manure for fertilizing. This manure is spread out on the field, and the process of aerobic oxidation of the matter is carried out which means reduction of methane emissions and this fertilizing replaces the usage of artificial fertilizers (due to high prices, lack of appropriate equipment, etc.) which leads to the direct storage and accumulation of carbon in the soil and to reducing the N_2O emissions. In this connection it could be hardly expected in the near 25-30 years enlargement of the agricultural cooperations to an extend which will allow the usage of fertilizers in uncontrolled big quantities as it was up to 1990.

In this way the mechanisms of the new economical relationships especially in the ownership sphere contribute to the realization of the mitigation, as on this stage it could be determined only as tentative (the quantitative assessments are not possible).

The other mitigation options are connected predominantly with the devastated lands treatment. The recent area of this lands has increased with about 5-6% compared to 1990. As a problem in the agriculture the increase of

the untillaged areas has been shown - form 1.5% in 1989 to 9.6% in 1993. The amount of untillage areas grows in the private farms as well - 9.2% in 1993. The untillage of this lands is connected with the conserving technologies of the mitigation choices, i.e. increasing of the accumulated and stored carbon quantity in the soil. The reclamation of this lands (afforestation) would bring to other mitigation options.

It could be summarized that the tendencies in the agricultural sector are towards a decrease of the greenhouses gases emissions despite the direction of development of the sector.

6.6.3. Waste management

The technical possibilities connected with reduction of emissions are facing the problem of abatement of the wastes in the landfills through their utilization and recycling. For example the paper wastes are a considerable part from the solid waste - 12.8% for 1989. The paper products could be recycled into various products and the market is the same as for the non-recycled paper products.

For the environmental protection and establishment of better exploitation conditions including CH_4 mitigation and utilization it is recommendable to build regional depots for defusing of the solid wastes and in some cases distributive places must be used in which the useful components such as paper, glass, plastics, packages etc. could be separated.

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CHAPTER 7

JOINT IMPLEMENTATION OF THE FCCC COMMITMENTS

Pursuant to Article 3.3 of the UN Framework Convention on Climate Change, efforts to address climate change may be carried out co-operatively by the interested Parties. Article 4.2(a,b) gives more specific information on the joint implementation options (JI).

With respect to the mechanism of joint implementation of FCCC commitments, the viewpoint of the Republic of Bulgaria is as follows:

- JI is economically effective because it allows the achievement of least-cost maximum global emission reduction of GHGs;
- JI mechanism should facilitate the state-of-the-art technologies penetration in the countries in transition and in the developing countries;
- JI is a voluntary activity under the responsibility of two or more parties; Such an activity must be undertaken or accepted by the Governments concerned;
- An initial three-year pilot phase is recommended in order to gain experience;
- During the pilot phase grants are preferable but credits under better conditions are also acceptable. Credits could be apply after 2000, i.e. in case of further commitment related to the possible GHG reduction;
- The criteria for the pilot phase should be flexible.

A Project Preparation Unit attached to the Bulgaria Ministry of Environment has been established to ensure the effective fulfilment of the FCCC commitments. It will widen its activity by collection, evaluation and implementation of GHG reduction projects. The main goals of the Project Preparation Unit are as follows:

- Retrieval and identification of projects.
- Preparing an offer of top quality projects.
- Retrieval of sources to finance project realisation.
- Evaluation of projects following implementation from the viewpoint of generalising the experience from joint implementation mechanism.

At present, Bulgaria has a set of projects to be implemented through the joint implementation mechanism:

- Reconstruction of ammonia installation in “Himko” PLC - Vratza;
- Construction of installation to utilise the heat and SO_2 of the fume gases;
- Improvement of energy condition and energy efficiency in the “D-r T.Venkova” hospital - Gabrovo;
- Reconstruction of the district heating network in Gabrovo - low case;
- Reconstruction of the district heating network in Gabrovo - Demonstration energy efficiency zone;
- Reconstruction of the district heating network in Gabrovo - high case;
- Automatic system for combustion control in steam boilers KM-12 in the Zemliane heating plant;
- Reconstruction of the street light in Gabrovo;
- Reconstruction of the lighting devices on “Bulgaria” avenue;
- Reconstruction of lighting system in the tunnel of “3rd April” Boulevard in Sofia;
- Energy efficient street lights in the village of Mramor, Sofia region;
- Reconstruction of lightening of tennis field of Tennis-ski-golf club - Sofia;
- Reconstruction and upgrading of the public transport in Gabrovo;
- Construction of management and control system of greenhouses with optimal fuel consumption and adverse emission reduction.

In the energy field the following projects are developed:

- Construction of 1000 MW nuclear unit in NPP Belene;
- Upgrading of district heating boilers and cogeneration plants by natural gas combined cycle units;
- Reduction of losses in electricity and heat networks;
- Renewable energy sources;
- Natural supply to households;

- Establishing regional centres for energy efficiency;
- Energy audits;
- Energy efficiency increase by improved and new technologies;
- DSM programs.

There is no Annex II Party to express an interest for application of the joint implementation mechanism for the projects above listed.

CHAPTER 8

CLIMATE CHANGE RESEARCH IN BULGARIA

A survey of the Bulgarian researches on the climate change issue is given. The basic part of researches addresses the climate change in Bulgaria during the last decade, the impact on the forests, agriculture and water resources and the relationship with the global climate change.

Climate is traditionally one of the main fields of research interest in Bulgaria and a lot of studies on its genesis and characteristics have been carried out. Recently climate change research appears to be the most up-to-date topic in the climate studies. A major part of these studies has been performed by the National Institute of Meteorology and Hydrology (NIMH) to the Bulgarian Academy of Science (BAS). NIMH has initiated and is a co-ordinator of the National Climate Program (NCP) developed in 1992 that is consistent to the World Climate Program of the World Meteorological Organisation. Some other Institutes of BAS - the Institute of Forestry, Institute of Geography, as well as Nikola Pushkarov Institute of Soil Science and Agroecology, High Institute of Forestry, etc. are also participants in the NPC.

The primary objectives of NCP are:

- creation of computerised climate data base;
- research on climate variations and change in Bulgaria as a consequence of the global climate change;
- analysis and optimisation of the use of weather and climate as natural resources;
- improvement of the monitoring system for climate and related environmental elements observation.

The NCP's particular objectives include: forwarding to Bulgarian government information and analyses on climate, climate change and related topics; providing the public and governmental bodies with data and research results in the above respect.

Bulgarian NCP is implemented through different projects at both national and international level such as:

- Bulgaria Country Study to Address Climate Change: Inventory of GHG Emissions, Alternative Energy Balance and Technology Programs - multidisciplinary study under the US DOE financial support and aimed to study GHG emissions by sources and sinks and to evaluate alternative options for GHG mitigation as well as vulnerability and adaptation to the climate change. Energoproekt Research Institute is a national co-ordinator of the Bulgarian Country Study to Address Climate Change in which NIMH, the Institute of Economy (BAS), Institute for Nuclear Research and Nuclear Energy (BAS) are also taking part.
- Droughts in Bulgaria - a complex study of the drought phenomenon in the Balkan Peninsular Region;
- Study of the sea level structure and forecast of its variations along the Bulgarian Black Sea shore - examination of the relations between the sea level and CO_2 emissions by numerical models;
- Regional climate variations and change - application of statistical models and tests to study the behaviour of basic climatic elements over the territory of Bulgaria, Balkan Peninsular and South-Eastern Europe;
- Tendencies in the multi-year changes of the rivers flows in Bulgaria - a study of the tendencies in hydrological regime of the run-offs;

- Simulation model to allocate anthropogenetic climate change by regions - participation in a Project with the EU Environmental and Climate Program;
- Regional model for monitoring and estimation of transboundary air pollution in South-Eastern Europe - Bulgarian contribution to the European Monitoring of Environment Program (EMEP).

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CHAPTER 9

EDUCATION AND PUBLIC AWARENESS

The global warming is one of the most serious environmental concerns in the history of mankind. Despite this, it seems that Bulgarian society is not aware of the consequences of the global climate change. Better environmental education and public awareness are primary objectives of the corresponding responsible institution. Public interest and support can turn crucial for the application of the long-term governmental strategy and climate change policy. The measures to be implemented require co-ordinated joint implementation by the governmental organisations and NGOs.

9.1. Country study to address climate change

The objective of element 5 of the *Bulgaria Country Study To Address Climate Change* which is held with the financial and methodological assistance of the US Country Study To Address Climate Change incorporates preparation of data to be reported to the society.

The methodology recommended by the USA experts emphases that the information should be at the disposal of governmental organizations, NGOs and individuals. This will guarantee objectivity and consistency in data distribution. The study findings are disseminated through seminars, conferences, special literature, educational programmes and by mass media.

A series of seminars are organised for the experts in the governmental administration, industry and in the scientific field. The goals of these seminars are to identify the core of the problem, the possibilities for its technical solution, to discusse the required investments for emission reduction, as well as the measures for the national economy and environment to adapt to the climate change

A survey on the study result is going to be issued that will be disseminated among the governmental organisations and NGOs. Some results are being published in the periodic scientific edditions and are reported at national and international scientific happenings. Some papers are published in the magazines and newspapers. A series of reports, TV and radio programs will be performed.

9.2. NGOs

In Bulgaria there exist about 200 NGOs related to the environment. Few of them are interested in the climate change and its dissemination. The ENEFECG and the national movement Ecoglasnost have organised activities in this field.

NGO's representatives are also involved in the discussions and the dissemination of the study results and they take part in the seminars. The Ecomonitoring NGO has organised meetings and round tables on the climate change issue with other governmental and non-governmental organisations in industry, forestry and soil recultivation.

The scientific and technical energy institutes in Bulgaria and their energy and forestry organizations are interested in the climate change problems and they take part in the organization and submission of discussions with other NGOs. Widening of the scope of NGOs taking part is the climate change discussions is at hand.

ENEFECT is an active participant in the elaboration of projects related to the introduction of the energy efficient technologies in industry and households and it represents initiative for joint implementation of projects for prevention of climate change