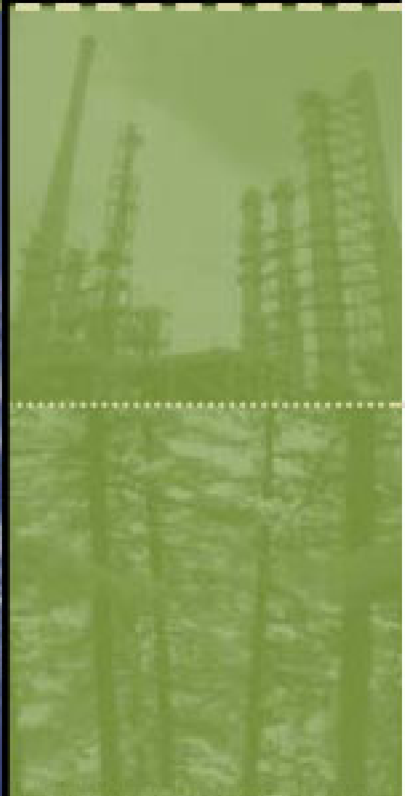
MINISTRY OF ENVIRONMENT AND PHYSICAL PLANNING



# MACEDONIA'S FIRST NATIONAL COMMUNICATION

## UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

MINISTRY OF ENVIRONMENT AND PHYSICAL PLANNING

# MACEDONIA'S FIRST NATIONAL COMMUNICATION

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## THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

SKOPJE, 2003

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National project web site: **www.unfccc.org.mk**

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# ABBREVIATIONS

| | |
|---|---|
| **CHP** | Combined Heat and Power |
| **CoP** | Conference of the Parties |
| **DOC** | Degradable Organic Component |
| **GDP** | Gross Domestic Product |
| **GEF** | Global Environmental Facility |
| **GHG** | Greenhouse Gases |
| **GWP** | Global Warming Potential |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **LPG** | Liquefied Petroleum Gas |
| **LUCF** | Land Use Change and Forestry |
| **MSW** | Municipal Solid Waste |
| **NAP** | National Action Plan |
| **NCSP** | National Communication Support Programme |
| **NCCC** | National Climate Change Committee |
| **NEAP** | National Environmental Action Plan |
| **NGO** | Non-Governmental Organization |
| **RES** | Renewable Energy Sources |
| **SWDS** | Solid Waste Disposal Sites |
| **UN** | United Nations |
| **UNDP** | United Nations Development Program |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **WHO** | World Health Organization |
| **WMO** | World Meteorological Organization |

## Chemical Symbols

| | |
|---|---|
| **CO** | Carbon monoxide |
| **$CO_2$** | Carbon dioxide |
| **$CO_2$-eq** | Carbon dioxide equivalent |
| **$CH_4$** | Methane |
| **$N_2O$** | Nitrous oxide |
| **NMVOC** | Non Methane Volatile Organic Compound |

# FOREWORD

*Acknowledging the significance of the climate change problem and the necessity to take effective actions for its mitigation, the Republic of Macedonia ratified the UN Framework Convention on Climate Change (UNFCCC) on December 04, 1997 (Official Gazette of Republic of Macedonia – International agreements 61/97), and became Party to the Convention on April 28, 1998. As a Party to the Convention, the country has committed to produce the First National Communication to the Conference of the Parties (CoP).*

*The First National Communication of Macedonia is the very first national report on the country's conditions regarding climate change issues, prepared following the guidelines adopted by CoP for preparation of national communications by Parties not included in the Annex I to the Convention. Preparation of the National Communication is seen as an initial step in the actual implementation of the UNFCCC in the country. It allowed development of expertise in each sector involved in the preparation of the National Communication, enhanced institutional and technical capacities in these fields and increased the public awareness concerning the UNFCCC and climate change related issues. This report contains the analyses, results and recommendations of technical expertise undertaken by expert institutions in the country that implemented complex activities in the thematic areas, fully utilizing the resources and results of relevant prior or ongoing national and international related activities. At the same time, the report will serve as a basis for future action, research and upgrading, offering opportunities for policy improvement related to climate change and the process of preparation of future National Communications.*

*Having the pleasure to launch the National Communication, on my behalf and on behalf of the Government of the Republic Macedonia, I would like to express my highest appreciation to the Global Environment Facility, to the United Nations Development Programme, and to the National Communication Support Programme for their support to enable Macedonia to prepare this strategic document.*

***Ljubomir Janev**,*
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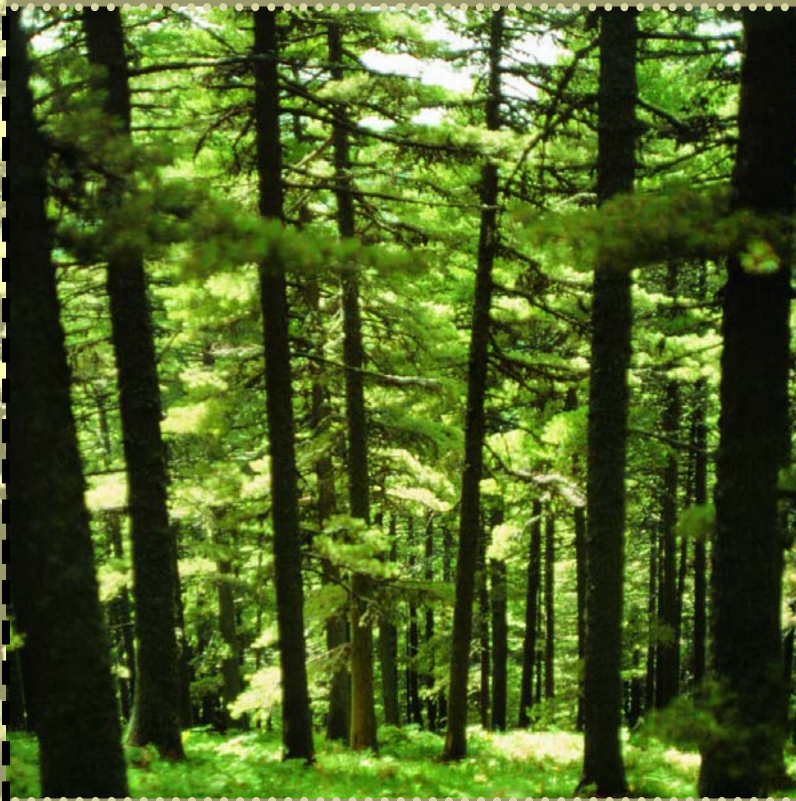


chapter

1

CHAPTER 1

# EXECUTIVE SUMMARY

## 1.1. INTRODUCTION

The human activities have been substantially increasing the atmospheric concentrations of greenhouse gases, these increases enhance the natural greenhouse effect, and this will result on average in an additional warming of the Earth's surface and atmosphere and may adversely affect natural ecosystems and humankind. By the official report (2001) of the Intergovernmental Panel on Climate Change (IPCC), projections show a rise in global temperature ranges from 1.4 to 5.8°C till 2100.

The first internationally binding instrument that addresses the issue of response to climate change is the UN Framework Convention on Climate Change (Rio, 1992). The ultimate objective of the Convention is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The Republic of Macedonia ratified the UNFCCC on December 04, 1997. As Party to the Convention, the country has committed to produce the First National Communication. It allowed development of expertise in each sector involved in the preparation. It is prepared following the guidelines adopted by CoP for preparation of national communications by Parties not included in Annex I to the Convention.

## 1.2. NATIONAL CIRCUMSTANCES

The Republic of Macedonia became an independent state on September 8, 1991, following the disintegration of the former Socialist Federal Republic of Yugoslavia. The main political and economic strategy is integration to the European Union.

The leading role in the implementation of the Convention on climate change falls within the competence of the Ministry of Environment and Physical Planning, in cooperation with other ministries. To address the problem of climate change more effectively, a Climate Change Project Unit within the Ministry of Environment and Physical Planning is established. The Macedonian Government has also appointed the National Climate Change Committee entitled to supervise and co-ordinate the implementation of the projects and climate change related issues.

In Macedonia, in the year of 2000 the population was 2,026,000, out of which 59% lived in urban settlements. The natural increase in 1994 was 9.1 per 1000 inhabitants and in 2000 this figure was 5.9. Life expectancy for men is 70 and for women 75. The literacy rate of the population is 94.6%.

Total surface area of Macedonia is 25,713 $km^2$. Although it is small in size, Macedonia is a very diverse country. Participations of plains in the total surface area is 19.1%, the figure of reddish and mountain terrains is 79%, while water surfaces are 1.9%. The agricultural areas cover 25% of the total territory of the country.

The territory is characterized by different types of climate: continental, changed continental, sub-Mediterranean (changed maritime), mountainous climate, as well as various their subtypes. The average annual air temperature in the settlements is between 11 and 14°C, and the average annual precipitations 500 to 1,000 mm.

Due to the specific conditions, a high level of biodiversity richness characterizes Macedonia. Eight out of nine biomes known for the Balkan Peninsula can be recognized in Macedonia.

The economy of the Republic of Macedonia in the late 1980s was confronted by a variety of shocks caused by the transformation of the political and economic systems; these were exacerbated by the loss of former Yugoslav markets. The GDP in 2000 was USD $3{,}901 \cdot 10^6$ and GDP/Capita USD 1,925. Despite many obstacles during the 10 years' transition, there was a growth rate of GDP 3-5% in the period of 1997 - 2001.

During the last five years the shares of sectors were: agriculture 12%, industry 25% and services 63%. Due to the small size of the national market, the Macedonian economy is firmly embedded in the international economic flows.

The energy supply in Macedonia is based primarily on the domestic lignite, imported liquid fuels and natural gas, hydro potential and wood biomass. The electricity power system consists of thermal power plants on lignite 730 MW net, thermal power plant on residual oil 198 MW and hydro power plants 441 MW net.

Since last three years the central natural gas pipeline was put into operation. In the year of 2000, less than 10% of total pipeline capacity of natural gas was used. The consumption of natural gas is expected to raise in all energy sectors.

The role of renewable energy sources is symbolic (except hydro potential), mainly represented by geothermal and solar energy.

There is a well-developed road infrastructure in the Republic of Macedonia. The territory itself means a crossroads of significant European routes. The motorization is at low level compared to the European countries. In 1992 the number of cars was 157.6 per 1000 people. That figure was increased to 165 by 1998. Public transportation is mainly performed by buses which are at a low technical level.

The structure of industry consists of: mining, metallurgy (steel, lead, zinc, ferroalloys), mining, refinery, metals manufacture, non-metallic mineral products, food products, beverages, tobacco products, textile etc. Unfortunately, as a result of transition to market economy which started in 1990 and is still going on, as well as of the effect of many external and internal factors, the growth rate of total industrial production has dropped. However, there is expansion of small and medium enterprises.

The total agricultural land had been decreased from average of 1319 kha in 1984-1994 to 1280 kha in 1999. Between 630 and 665 kha from total area is arable agricultural land, and about 649 kha are covered with permanent pastures. The forest area is 906 kha.

In 1996 the livestock was as following: cattle and buffalos 295,000, sheep 1,814,000, pigs 192,400 and poultry 3,360,800.

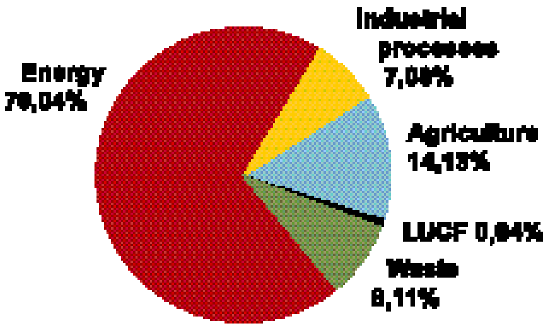
## 1.3. INVENTORY OF GREENHOUSE GASES EMISSIONS

The inventory was prepared according to IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1996), taking into consideration the three main GHGs: carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$).

A short overview of emissions according to the IPCC methodology is shown in Table 1.1 and Fig. 1.1.

**Table 1.1.** Sectorial $CO_2$-equivalent emissions [kt]

| Sector | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | Average % |
|---|---|---|---|---|---|---|---|---|---|---|
| Energy | 10,596 | 9,932 | 9,382 | 9,925 | 9,802 | 10,086 | 9,921 | 10,451 | 11,204 | 70 |
| Industrial processes | 1,632 | 1,371 | 1,281 | 1,105 | 992 | 848 | 895 | 1,102 | 1,064 | 8 |
| Agriculture | 2,025 | 1,953 | 1,967 | 1,942 | 1,977 | 1,912 | 1,766 | 1,665 | 1,577 | 13 |
| LUCF | 88 | 7 | 144 | 221 | 89 | 2 | 15 | 54 | 29 | 1 |
| Waste | 1,170 | 1,202 | 1,198 | 1,201 | 1,136 | 1,148 | 1,177 | 1,182 | 1,213 | 8 |
| Total | 15,512 | 14,466 | 13,973 | 14,394 | 13,995 | 13,995 | 13,775 | 14,454 | 15,086 | 100 |



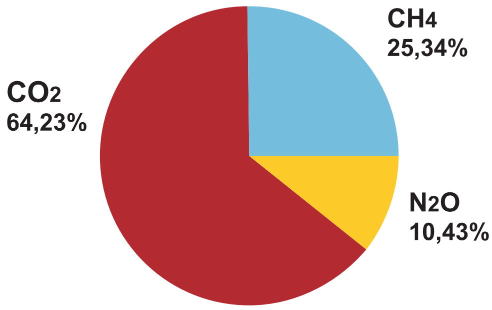




**Figure 1.1.** Contribution to $CO_2$-eq emissions in 1994 by sectors and by gases

The main sources of $CO_2$ emissions are the electricity production, heat production and transport. GHG emissions exhibit decreasing trends within the industrial processes (by 35%) and agriculture (by 22%) sectors over the analyzed period due to the reduction of activities within the national economy. In the LUCF sector the emissions are oscillating and in the waste sector they are invariable. An increase in the GHG emissions occurred only in the energy sector (by 6%).

## 1.4. GHG ABATEMENT ANALYSIS AND PROJECTIONS OF EMISSIONS

The GHG abatement measures were projected in such a way that they follow the present status of the Macedonian economy and its possibilities for development. This is very important for their successful implementation as it was foreseen with the abatement analysis.
The analysis of the energy sector is elaborated in a most advanced way, especially concerning the electricity production. In that analysis an assessment of the abatement cost for each analyzed strategy is given.

In the overall assessment of various scenarios for the future development of the electric power system, internationally recognized and standardized models were used.

**Electricity production**
The abatement analysis is developed in three scenarios: baseline scenario, first and second mitigation scenario for the period 2001-2030.

The baseline scenario is based on the annual load demand growth rates for 10 year time periods, i.e., 3.75% for 2001-2010; 3.25% for 2011-2020; and 2.75% for 2021-2030 (all growth rates are taken from the study “Energy Sector Development Strategy for Macedonia”).

In the expansion planning till 2020, there are new hydro power plants with a total capacity of 673 MW. The lignite fired thermal power plants will use residual oil up to 30% of their thermal capacities. Two new gas fired power plants with combined cycle (270 MW) are planned, one CHP (180 MWe) and a nuclear power plant (600 MW) is possible after 2020.

The first mitigation scenario is based on the baseline one, and in addition, two big hydro plants are planned to be built as pumped storage plants.

At the beginning of the 21 century, as a consequence of the exhaustion of lignite reserves, Macedonia has to start with activities for reconstruction and substitution of the existing thermal power plants. So, in the second mitigation scenario, in addition to the pumped storage plants, a mixed fuel (lignite/residual fuel) in the existing lignite thermo power plants will be used. The measures described in the second mitigation scenario will start to be used from the year 2003 which is more realistic, compared with other scenarios in 2001.

Based on the results of the electricity system expansion planning, following the IPCC methodology, the GHG emissions ($CO_2$, $CH_4$ and $N_2O$) were calculated for each of fossil fueled thermal plants for the baseline and both mitigation scenarios.

In order to see the overall environmental performance of the national electric power system, the specific $CO_2$ emissions were calculated in terms of kg per kWh produced. The specific GHG emissions are constantly decreasing reaching the level of 0.25 kg/kWh in the year 2030 which is five times less than the present emissions and almost six times less than the emissions in the year 1990. These emissions are lower in the first mitigation scenario compared to the baseline scenario, and significantly lower, for about 33% in the second mitigation scenario.

All of the above expansion plans should be taken with some reservations, since there is a number of uncertainties related to technological development, potentials and costs of measures, the political situation in the region, international assistance and a number of other concerns.

**Heat production**

Looking at the present primary-energy sources consumption pattern, the residual fuel oil is a major contender, supplying about 47% of primary-energy for heat production. Next, gas/diesel oil supply is around 19%, wood 14%, natural gas 7%, LPG 6%, coal 4% and geothermal 2%. This means that current fossil fuel supply is about 84% of the primary-energy used for heat production in Macedonia.

In the baseline scenario, the heat production projection until 2030 was made considering the “pessimistic” and “optimistic” scenarios with an average annual growth rate of 3.7% and 4.1% for oil and oil products respectively in energy system. An average growth of Gross Domestic Product in industry of 6% over the period 2000-2010 and 8% over the period 2010-2020 is predicted according to the *Strategy for Economic Development of the Republic of Macedonia until 2020*.

The mitigation scenarios for heat production are based on the findings from the mitigation scenarios for electricity production scenarios, published forecasts of the economic and energy development and internal investigations. The average growth of the heat production over the period 2000/2030 was reduced from 3.77% to 3.14%. This reduction can be achieved by implementation of economic instruments for restructuring the industry from energy intensive to energy depressive, basically by increasing the energy prices and introduction of emission taxes. Reduction of the heat energy consumption for buildings heating can be achieved by improvement of the standards concerning the building construction including the insulation.

**Transport**

This section gives a brief review of the general framework of trends in the transport sector in Macedonia on the base of the survey on the conditions in various type of transport.

For the GHG abatement in the road transport the following measures are suggested: (1) Energy efficiency improvements of the vehicles by replacement of old ones with new environmentally friendly vehicles through tax, custom and regulatory measures, as well as application of European fuel standards, (2) Reduced increase of vehicle-kilometres by use of public transport; investments in transport center for easy transfer between road, rail and air transport; introduction of electrical transport, especially tramway in Skopje; better traffic control and reduction of cargo transport in the cities.

Concerning the railway transport, the main mitigation activity will be to complete the electrification of the rail network.

The GHG emission reduction in the air transport could be realized following the worldwide trend of engines with improved performances and with improving airport operations in order to reduce the aircraft waiting for take-off and landing approvals.

**Industrial Processes**

The GHG emissions are primarily consisting of $CO_2$ emission from the mineral production (cement production, lime and soda ash production and limestone and dolomite use) and metal production (iron and steel, ferroalloys and non-ferrous metals).

Some of the mitigation measures are: increasing the efficiency of fuel utilization, fuel replacement in favor of fuels with more convenient $H_2O$ to $CO_2$ ratio, the use of waste heat contained in the effluent gases and liquids (heat recovery), more efficient combustion in the metallurgical furnaces for ferroalloys production with a lower emission of carbon monoxide (CO).

In future, while building new industrial facilities, a special attention will have to be paid to the production technologies. A clean technology with less energy consumption per unit product has to be chosen.

**Waste**

The GHG emission from waste sector includes the following three areas: solid waste disposal sites, wastewater handling (domestic and industrial wastewater) and human sewage.

For the reference year a value of 0.79 [kg/person/day] solid waste disposed on SWDS (Solid Waste Disposal Sites) was taken and then linearly decreased to the value of 0.5 [kg/person/day] for the mitigation scenario. Another scenario, which incorporates possible recovery of methane starting from the year 2005, with increment of 1 kt recovered methane per year, was also calculated.

In order to diminish the rate of waste production in near future, certain activities are possible, such as: improvement of public awareness to promotion of reduction, recycling and reuse of waste, as well as the importance of primary waste selection. Other activities are: improving of waste management, increasing of individual interest and motivation for waste primary selection and commercial recycling.

The present legislative should become more stringent and strictly applied in order to achieve a higher level of waste dissipation control.

Projections of all GHG emissions according to the second mitigation scenario for the sectors electricity production, heat production, transport, industry and waste are shown on the figure 1.2.

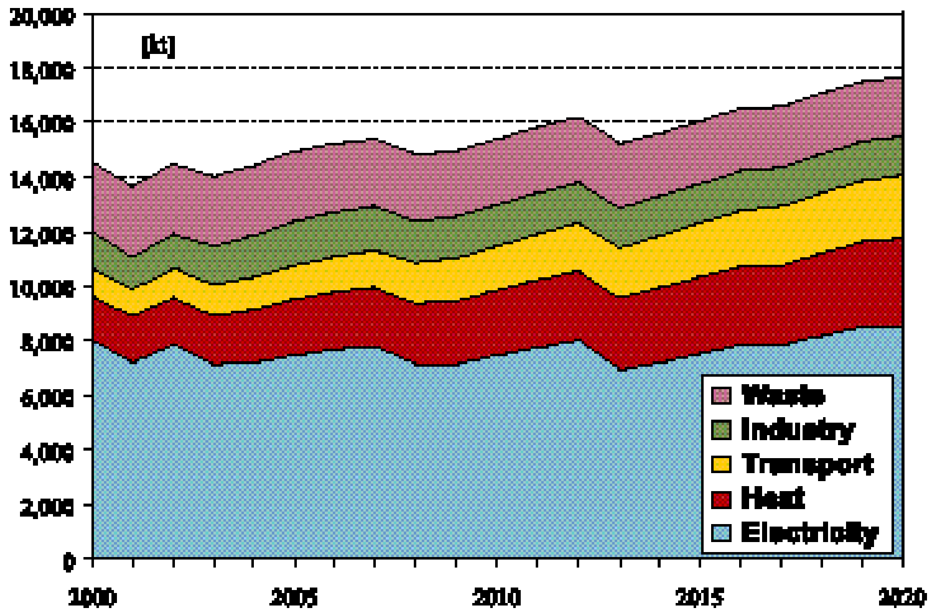



**Figure 1.2.** Projections of all GHG emissions according to the second mitigation scenario

**Agriculture**
GHG emissions from the agriculture sector are emissions of $CH_4$ and $N_2O$, originating from the following sources: enteric fermentation ($CH_4$ and $N_2O$ emissions), manure management ($CH_4$ and $N_2O$ emissions), rice cultivation ($CH_4$ emissions) and agricultural soils ($N_2O$ emissions). Concerning the animal production subsector, there is a lack of diary and meet products, as a result of which in the year 2020 increasing number of cattle and sheep is foreseen. Simultaneously, some measures related to improvement the productive capacities of the animals, treatment of the animals, feeding and manure management, are proposed.

The combined use of synthetic fertilizers and manure, as well as incorporation of N fertilizers in the soil immediately after the application, are options for improving the use of fertilizers aimed at abatement of the polluting emissions.

**Land Use Change and Forestry (LUCF)**
GHG emissions and $CO_2$ removals by sinks within the LUCF sector are mainly affected by the following two activities: changes in forest and other woody biomass stocks, and forest conversion caused by incidental of forests' fires.

The relevant official document regarding development strategies of forest sector and corresponding mitigation measures is "Strategy for the Development of Agriculture, Forestry and Water Utilization in Macedonia" prepared by the Ministry of Agriculture.

There ares activities for further improvement of the forestry sector in Macedonia: enlargement of the forest area by afforestation, increasing the annual biomass increment by improving the floristic forest structure, and decreasing the annual amounts of traditional fuelwood consumption as much as possible.

## 1.5. VULNERABILITY ASSESSMENT AND ADAPTATION MEASURES

According to the IS92a scenario (prepared by IPCC) the average annual temperature in Macedonia by 2100 could increase for 4.6°C and the average summer temperature could increase for 5.1°C.

For the same scenario, the average sum of precipitation will be decreased for 6.3% in 2100 in comparison with the period from 1961 to 1990. The most concerning is the sum of precipitation in summer which could be decreased for 25%.

The increasing of air temperature will cause increasing of the quantity of water and water vapor in the atmosphere, which will influence the global hydrological cycle. Air temperature increase will cause evaporation increase as well as potential evapotranspiration. It will lead to faster soil drought.

The expected climate changes in the 21st century will negatively reflect upon all main sectors of influence in the country.

Due to the importance of future climate change, special projects for modernization and establishment of the whole monitoring system should be made in Macedonia, as well as local climate monitoring systems.

**Agriculture**

Agricultural production strongly depends on climate conditions. Thus, the climate change will have negative influence on agriculture in all its subsectors. Especially the global warming will have severe negative effects on the soil productivity and could cause its degradation and erosion. The result could be in organic matter supply from biomass, soil temperature regime and soil humidity.

All the activities and adaptation measures should be combined by the governmental officials and the farmers as direct producers.

The limiting factor of the crop production in the major agricultural regions in Macedonia is water shortage.

Adaptation measures should be taken at two levels: at the farm level and at the national level. Adaptation measures at the national level can be divided in 3 major groups: irrigation, agricultural practice and plant breeding.

Climate change affects livestock and poultry production by two mechanisms, directly (to the animals) and indirectly (through the forage - feed). Response of the animals to the climate changes is related to physiological reactions in order to adapt to the new conditions and maintain homeostatic balance.

The adaptation measures should be primarily focused on redirections of the breeding programs goals towards adaptation of the new genetic proveniences to different climate conditions, application of new feed and feeding management programs, and proper farmhouse construction and farmhouse equipment.

**Forestry**

According to the investigations in several regions in Macedonia, it is evident that the health condition of oak and fir, especially the oak, at the last decade from the 20st century is rapidly getting deteriorated. There are more massive oak, pine, fir etc. declining (especially at the worse soil conditions and sought expositions) and their migration to the north and to the higher mountain areas, that will completely change the phytrocenological condition in Macedonia.

Adaptation measures for the forestry should be implemented by permanent controls of the oak dieback process, as well as the other tree spices. A sanitary cut should be performed that would lead to prevention of development of some specific tree diseases, harmful insects and animals. An increase of the protection degree of the forests from forest fires at much higher level than the present one is also necessary.

**Biodiversity**

Macedonia is characterized by a high level of biodiversity richness due to the specific geographical position, geological history, composite geology, well-developed relief, as well as the climate characteristics.

As a result of climate change, it can be expected that some types of refugial communities will not be able to move either horizontally or vertically. It is more likely that most of them will disappear. Vegetation belts on most of the mountains will have the possibility to move in vertical direction. There are many animal species strongly dependent on the temperature, either directly or indirectly (vegetation changes, food resources etc.). Temperature increase will cause problems in feeding of some vertebrates and changes in their life cycles.

It is necessary to integrate the adaptation measures into general and specific action plans from different aspects of the environment (forestry, agriculture, water economy, industry, etc.). Some undertaken measures should be: establishment of scientific infrastructure for evaluation of climate change impact on biodiversity and terrestrial ecosystems, establishment of data base for the impact on biodiversity, elaboration of biocorridores and migration paths of different species, increasing of the surface of protected areas in Macedonia.

**Hydrology and water resources**

The analysis of available water resources and estimation of their change have been performed by hydrological stations at four rivers and three lakes. Reduction of characteristic flows and water levels for all analyzed stations is obvious. For all analyzed rivers for the observed period 1961-2000, the average discharges have decrease of 10%¸20% and the maximum discharges reduction is up to 80%. According to the carried out investigations and analysis it can be concluded that the most vulnerable regions in Macedonia are east and south-east part, while the most susceptible water economy sectors are water supply and irrigation.

Water resources problems have to be solved institutionally, systematically, and gradually. Following activities have to be accepted as priorities: (i) modernization of the hydro-meteorological network, (ii) data monitoring establishment, (iii) reconstruction and rehabilitation of the built structures and systems and (iv) water resources management.

**Human health**

All climate and weather variables have some influence on human health. The effect may be either directly on the human body or indirectly through effects on disease-causing organisms or their vectors.

During the last period the cause of death in Macedonia in the total mortality rate has been significantly changed. The cardiovascular and malignant diseases have noticed significant increase in mortality. Mortality from circulatory system diseases had been among the causes of death during the last 25 years. Mortality from ischaemic heart diseases has increased both in males and females. It has been noticed that salmonellosis has an increasing trend in the period 1980-2000, particularly in the last decade. In the first decade it has been registered a relatively constant morbidity from 5-10/100,000.

The primary objective of adaptation is to reduce disease burdens, injuries, disabilities, suffering and deaths. The key determinants of health, as well as the solutions, lie primarily outside the direct control of the health sector. They are rooted in areas such as sanitation and water supply, agriculture, food, trade, tourism, transport, development and housing. A prerequisite for a successful adaptation is to launch or improve health monitoring and surveillance systems that will concern the above mentioned sectors and influences.

## 1.6. NATIONAL ACTION PLAN

The National Action Plan (NAP) sets out the objectives and starting points for the reduction of GHG emissions and includes many measures aimed at reducing emissions.

The NAP is based and adapted on the following criteria: to generate positive effects on the national economy; to minimize the costs of reducing greenhouse gas emissions; to act in compliance with financial capacities; to achieve reliability and competitiveness in the energy supply; food and other strategic resources and to develop medium and long-term solutions.

The authorized state bodies will prepare economic and other instruments for carrying out the actions for emission reduction of greenhouse gases, such as tax and customs incentives and benefits.

The Ministry of Environment and Physical Planning has the leading role in the climate change activities. The National Climate Change Committee is established in order to observe and coordinate the implementation of UNFCCC, and issues concerning the climate change. A Climate Change Project Unit is established within the Ministry of Environment and Physical Planning which coordinates the preparation of the First National Communications on climate change.

The following are the existing documents with some strategies and measures related to GHGs emissions reduction:

- *National development strategy for Macedonia, development and modernization*, Macedonian Academy of Sciences and Arts (MANU), 1997.
- *Law on energy, 1997, revised in 2000.*
- *Energy sector development strategy for Macedonia*, prepared by (MANU) for the Ministry of Economy, 2000.
- *Strategy of energy efficiency of the Republic of Macedonia until 2020*, under preparation.
- *Investment possibilities in energy sector in the Republic of Macedonia*, Phare project.
- *National Environmental Action Plan*, Ministry of Environment and Physical Planning, 1997 (under revision).
- *Law on Environment and Nature Protection and Improvement*, revised version, 2000.

According to the new law for local self government, the communities will have larger competence and bigger financial potential.

**Energy sector**

The $CO_2$-eq. emissions from the energy sector are about 70%; this is the reason for their priority in the NAP.

The optimal expansion plan of the electro power system for the next 30 years is projected, building new hydro power plants (power 673 MW, cost USD 1092.9 million), two new gas fired power plants with combined cycle (270 MW) and one CHP (180 MW). The nuclear option may become attractive after the year 2020. It is very important for the projected plan to be followed by adequate investments and timetable.

The introduction of the natural gas is very important in the sector of heat production in order to substitute the presently used solid and liquid fuels. The secondary gas pipelines and city networks have to be constructed as soon as possible.

In domestic, commercial and public sector, major energy savings measures comprise: reducing energy demands (heat insulation), rational use of all available energy sources, promotion of energy conservation and energy efficiency.

The electrical heating in domestic and commercial sector should be replaced with district heating or use of natural gas.

The energy efficiency of the heating equipment, air-conditioning and cooling should have a priority in further activities.

Enlarged and permanent promotion of the RES (Renewable Energy Sources): hydro, solar, geothermal, wind and biomass is recommended. Hydro energy is already being used in Macedonia in a relatively large scale. According to the intensity and durability of solar radiation, there is a great potential in Macedonia for using solar energy, especially for hot water. There are some technical and economic experiences of using geothermal energy in agriculture for greenhouse heating. There is good potential to widen its exploitation in district heating too. A study for techno-economic potentials of biomass and biogas is necessary to be prepared.

**Transport**

The reduction of fuel consumption in transport can be achieved by improvement and promotion of public transport, improvement of traffic management and control systems, development and implementation of city logistic systems. It is recommended improvement of the structure of vehicles by promoting faster substitution of old vehicles with new ones, environmentally more friendly vehicles that consume and pollute less.

**Industrial Processes**

Some of the basic planed measures are: increase of fuel utilization, fuel replacement in favor of fuels with more convenient $H_2O$ to $CO_2$ ratio, utilization of waste heat contained in the effluent gases, liquids and solids (heat recovery). The existing technologies have to be renewed or replaced towards low energy consumption per product unit.

**Waste**

The relatively low level of the organized treatment of the waste materials should be considered in more details and concrete undertaken actions. Different aspects of waste management, as Reduction, Recycling, Reuse, the importance of primary waste selection etc., are to be promoted. Nowadays, new projects are initiated at the local level which promise an improvement.

**Agriculture**

Improvement of the cattle's productive capacities, treatment of the animals, food and manure management is proposed. The combined use of synthetic fertilizers and manure is recommended. Improvement of dams and irrigation, tillage systems, new crop adoption and opening new lands are projected.

**Forestry**

The main measures are related to the increase of the forests' absorption capacities: enlargement of the forest area by afforestations, the increase of the annual biomass capacity through improving of floral forest structure, permanent control of the forests' health conditions, organizing of database and overtaking preventive actions against forest fires.

**Biodiversity**

It is important to revise the Physical Plan of the Republic of Macedonia, establishment of data and scientific infrastructure for evaluation of climate change impact on biodiversity, elaboration of biocorridores and migration paths, increasing of the surface of protected areas, establishment of seed bank of endemic and other important species from aspect of biodiversity.

**Hydrology and water resources**

The analyzed problems in different sectors connected to water resources and hydrology and adaptation measures are: modernization of the network, data monitoring establishment of hydrological and water quality parameters, water loss reduction, improvement of irrigation by introduction of dripand micro-spray.

**Financial support**

The following basic funding sources are planned: national budget, greenhouse gases emission taxes, soft bank loans, investments of companies, international grants, financing programs supported by GEF, international bilateral financial and technical assistance.

**Barriers to implementation of NAP**

The problems and constraints are of institutional, technical, methodological and financial nature: lack of regulations, low price of electricity, lack of knowledge and accessibility of technology, lack of knowledge about market and financing mechanisms, lack of interest of the banking sector, poor information accessibility and low interest at the local level, insufficient knowledge about the potentials of Renewable Energy Sources, socio-economic aspect.

## 1.7. RESEARCH AND SYSTEMATIC OBSERVATION

Atmospheric observations and research are carried out by the Hydro-Meteorological Service (HMS) of Macedonia within the Ministry of agriculture, forestry and water management.

Climate-meteorological observations are carried out by 270 stations as follows: 16 main, 6 meteorological hail suppression stations, 21 regular (two of them are for urban climatology), 26 phenological, 1 aerological and 200 precipitation stations.

In order to improve the existing databases and to carry out the research of mezo-scale and micro-scale climate systems, the number of measure points for hydro-meteorological parameters need to be increased. Modernization of the hydro-meteorological network for information exchange archives and publication is needed, as well as establishment and renewal of observations that are not yet in function.

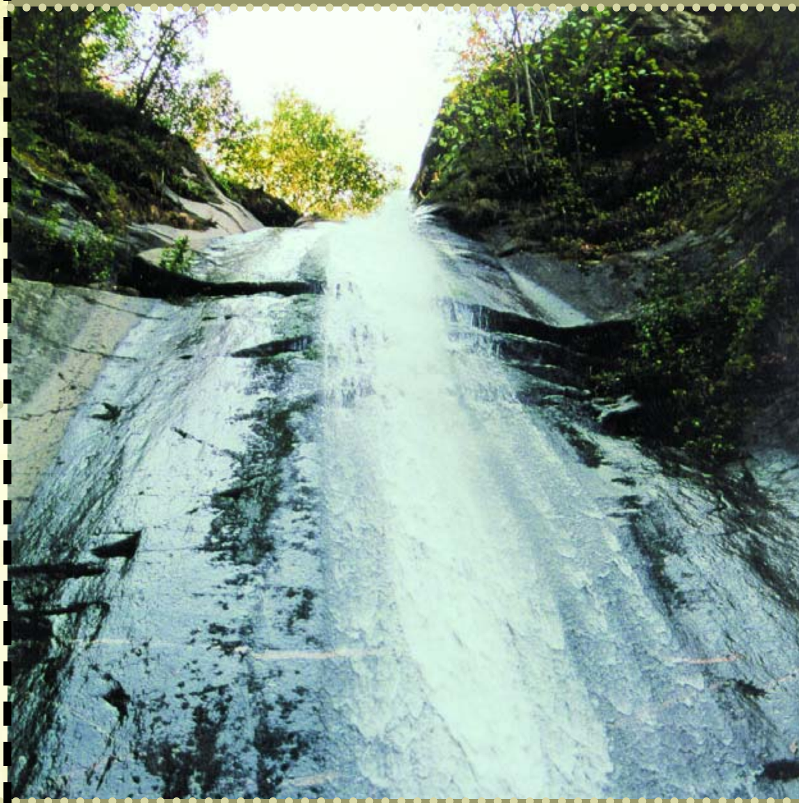
It is necessary to carry out permanent activities for systematic observation and monitoring of GHG emissions and their reductions. For this purpose a capacity building is projected within the Ministry of Environment and Physical Planning, through opening a permanent office within the Ministry in order to coordinate and initiate activities at national level.

## 1.8. PUBLIC AWARENESS, EDUCATION AND TRAINING

Unfortunately, the awareness about climate change issuess in Macedonia has not been raised at a sufficient level until now. The process for the preparation of the First National Communication on Climate Change has positively contributed to awareness rising among all relevant stakeholders. Within the preparation of the National Communication, a public awareness campaign was carried out.

In all educational degrees, through various educational matters, the environmental issues are partially introduced. However, it does not correspond to the real needs. Preparation of special programmes for environmental education is recommended to start as soon as possible. Publishing books and other printed materials with topics related to the environment, as well as climate change, should be a good contribution to the education of students, engineers, and the public in general.

In Macedonia the NGOs did not have much an active role in any activities on the climate change programme, neither did the professional associations. It is to be expected that they would contribute to widen more information about climate change, especially after the promotion of the First National Communication.



chapter

# 2

**CHAPTER 2**

# INTRODUCTION

The greenhouse effect, which for millions of years was a blessing for Earth, seems to have turned into a serious threat over the last century as it is being enforced by human activities. With industrialization and population growth, the greenhouse gas (GHG) emissions from burning fossil fuels, deforestation and clearing of land for agriculture have consistently increased. There is new and stronger evidence that the most of the warming observed over the past 50 years is attributable to human activities. In its Third Assessment Report of 2001, the Intergovernmental Panel on Climate Change (IPCC) stipulates that projections using emission scenarios in a range of climate models result in an increase in globally averaged surface temperature of 1.4 to 5.8$^{o}$C over the period to 2100. This is about two to ten times larger that the central value of observed warming over the 20$^{th}$ century and the projected rate of warming is very likely to be without precedent during the last 10,000 years, based on paleoclimate data. Global mean sea level is projected to rise by 9 to 88 cm between the years 1990 and 2100 for the full range of SRES scenarios, but with significant regional variations.

Acknowledging the significance of the climate change problem and the necessity to take effective actions for its mitigation, the Republic of Macedonia ratified the UN Framework Convention on Climate Change (UNFCCC) on December 4, 1997 (Official Gazette of RM – International agreements 61/97), and became party to the Convention on April 28, 1998. As a Party to the Convention, the country has committed to produce the First National Communication to the Conference of the Parties (CoP).

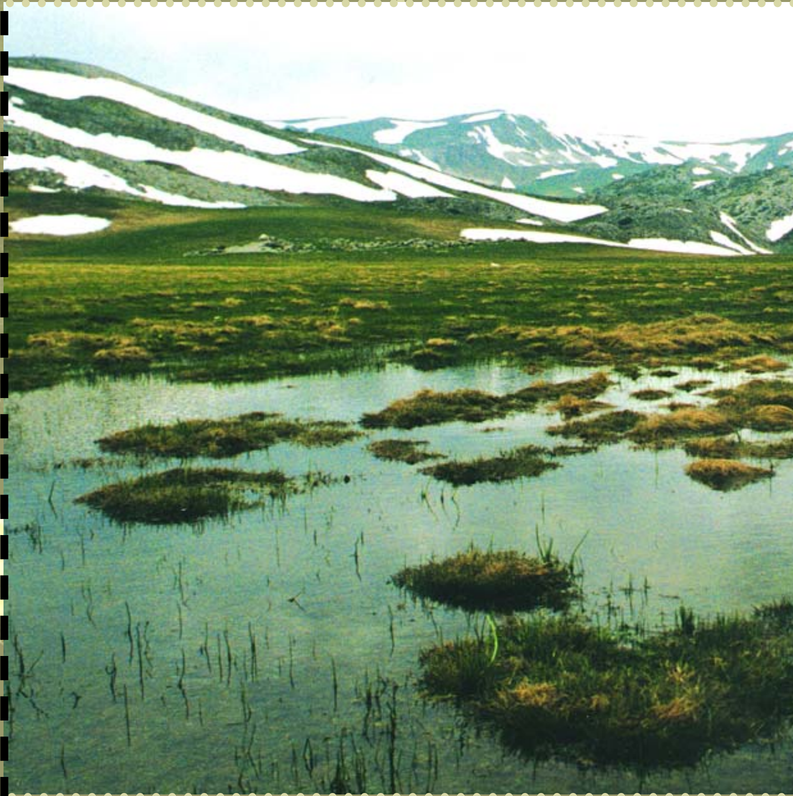
The National Communication of Macedonia is the first national report on the country's conditions regarding climate change issues, prepared following the guidelines adopted by CoP for preparation of national communications by Parties not included in Annex I to the Convention. Preparation of the National Communication is seen as an initial step in the actual implementation of the UNFCCC in the country. It allowed development of expertise in each sector involved in the preparation of the National Communication, enhanced institutional and technical capacities in these fields and increased the public awareness concerning the UNFCCC and climate change related issues. This report contains the analyses, results and recommendations of technical expertise undertaken by expert institutions in the country that implemented complex activities in the thematic areas, fully utilizing the resources and results of relevant prior or ongoing national and international related activities.

The three main thematic areas in the National communication are following: (1) the inventory of GHG emissions by sources and removals by sinks, following the guidelines from IPCC, for the base year 1994 and periodical series for 1990-1998 for the three main greenhouse gases - $CO_2$,

$N_2O$ and $CH_4$; (2) the assessment of potential impacts of climate change on the most vulnerable sectors of the country - agriculture, forestry, water resources, natural ecosystems and human health, and adaptation measures for each sector, considering the specific geographical and climatological characteristics of the country; (3) the GHG abatement analysis and potential measures to abate the projected increase in GHG emissions, for both energy and non-energy sectors.

During project implementation, several workshops were organized on the thematic areas of the National Communication. The workshops were divided in two phases: in the first phase methodologies, tools, experiences and approaches of the countries in the region for analysis in particular thematic areas were presented. In the second phase, results from analysis and related response measures were presented and discussed. The workshops contributed to strengthening technical capacity, enhancing knowledge and exchange of experience about climate change issues among academic sector, civil servants in relevant state institutions, private sector and NGOs in the country. National experts participated in the regional workshops, organized by the National Communications Support Programme, which contributed to experience accumulation and establishing links for information exchange among experts on the particular thematic areas.

The First National Communication of Macedonia will serve as a basis for future action, research and upgrading, offering opportunities for policy improvement, as well as a basis for the sustainability of the process of preparation of future National Communications.



chapter

# 3

CHAPTER 3

# NATIONAL CIRCUMSTANCES

The Republic of Macedonia is an independent country situated in southern Europe, in central part of the Balkan Peninsula, and its borders are with Greece, Bulgaria, Yugoslavia and Albania. Basic figures for the population, economy, agriculture etc. of the Republic of Macedonia are presented in Table 3.1.

**Table 3.1.** Basic figures of the Republic of Macedonia

| Year: | 1990 | 1994 | 1998 |
|---|---|---|---|
| Population (millions) | 2,028 | 1,937 | 2,008 |
| Total land ($km^2$) | 25.713 | 25.713 | 25.713 |
| GDP x 106 USD | 4.252 | 3.389 | 3.575 |
| GDP/Capita USD | 2.235 | 1.742 | 1.781 |
| Share of industry in GDP (%) | 46,1 | 36,8 | 21,3 |
| Share of agriculture in GDP (%) | 9,9 | 14,3 | 10,5 |
| Share of services in GDP (%) | 44,0 | 48,9 | 68,2 |
| Agricultural land (x 1000 ha) | 666 | 661 | 635 |
| Forest area | 912 | 966 | 969 |
| Urban population (% of total population) | 59 | | |
| Literacy (%) | 94,6 | | |

## 3.1. POLITICAL AND ADMINISTRATIVE BASES FOR THE IMPLEMENTATION OF THE CONVENTION

The Republic of Macedonia became an independent state on 8 September 1991, following the disintegration of the former Socialist Federal Republic of Yugoslavia. The political system of Macedonia is parliamentary democracy. The Macedonian Parliament, which consists of 120 deputies with a four-year term in office, elects the prime minister. The prime minister proposes members of the government (ministers), who have to be approved by the Republic Parliament.

The Republic of Macedonia has signed an Agreement for Stabilization and Association with the European Union. The main political and economic strategy for the future is including Macedonia in the EU.

In the framework of its efforts aimed at integration into the modern trends going on in the field of environment in Europe and wider, as a significant integral part of the process of reforms, the Government of the Republic of Macedonia has established the Ministry of Environment (The Law on Amendment and Supplement of the Law on Administrative Bodies, "Official Gazette of RM" No: 63/98). The Ministry develops a system of environmental management by an adequate institutional capacity and appropriate legislative framework. The Law on Environment and Nature Protection defines the Ministry's following responsibilities:

- monitoring of the state of the environment;
- proposing measures and activities to protect waters, soil, air and ozone layer, protection against noise and radiation, protection of biological diversity, geological diversity, national parks and protected areas;
- rehabilitation of polluted parts of environment;
- cooperation with scientific institutions for the purpose of developing standards, norms, rules of procedure to regulate the environment protection;
- development of a system of self-financing from independent sources, types and amounts of environmental compensations and other charges;
- cooperation with civil associations, civil initiatives and other forms of civil activity;
- inspection supervision within its scope of activity;
- carrying out other activities specified in the law.

In 1997 the National Environmental Action Programme was prepared by many working groups, ranking air protection as one of the priority areas within environmental protection. The related objective is to continue already-introduced air protection programmes and to supplement these programmes with programmes of reduction of tropospheric ozone and greenhouse gas emissions.

Taking into consideration the importance of the climate change problem and the necessity to undertake effective actions for mitigation, the Republic of Macedonia ratified the UN Framework Convention on Climate Change (UNFCCC) on December 4, 1997 (Official Gazette of RM – International agreements 61/97), and it became an equal member of the Convention on April 28, 1998. As a Party to the Convention, the state has committed to prepare the First National Communication to the Conference of the Parties (CoP).

Pursuant to the Ratification of the UNFCCC Act, responsibility for its implementation falls within the competence of the Ministry of the Environment and Physical Planning, in cooperation with other relevant ministries.

For the purpose of addressing the problem of climate change more effectively, the Government established a National Climate Change Committee (NCCC), consisting of representatives from relevant Ministries, academic, private sector and NGOs. NCCC is responsible for overseeing the national policy and the process of implementation of the UNFCCC at a national level, developing negotiating positions and strategies for the Government of Macedonia for meetings of the CoP of the UNFCCC, etc.

For daily management and coordination of the implementation of the project for preparation of the First National Communication, the Project office was established within the Ministry of Environment and Physical Planning. Preparation of the National Communication is the first step in the actual implementation of the UNFCCC in the country. The intention is this office to become an integral part of the Ministry. Further capacity building activities with regard to climate change issues are of the highest priority, including activities for strengthening institutional capacities to prepare analyses related to thematic areas of the communication, as well as activities for strengthening the capacity of the country to contribute on the international negotiations related to climate change, and to analyze the opportunities and obligations that the new initiatives and commitments are posing at national level.

Within the Ministry of Environment and Physical Planning an Ozone Unit was established in 1997. The Macedonian Parliament ratified the Montreal Protocol; so many activities are undertaken for phase-out of the ozone depleting substances (ODS). The following project activities are carried out: phase-out of ODS at the biggest consumers by change of technologies, alternatives to use of metylbromide in agriculture and refrigerant management plan (training for good practice in refrigeration and air conditioning, establishing of system for recovery and recycling of refrigerants).

The Republic of Macedonia is divided into 123 municipalities. According to the new law for local government municipalities will have larger competence and greater financial potential. With their own administration and own income, local communities will have jurisdiction over different areas that have an impact on greenhouse gas emissions. Their jurisdiction will include spatial planning and local transport arrangements, public passenger transport, the preparation of local energy concept designs, and compulsory public utility waste management services.

## 3.2. POPULATION

In Macedonia 2,028,000 people were living in 1990; and in 2000 the population was 2,026,000.

| Year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Population | 2028 | 2039 | 2056 | 2066 | 1946 | 1966 | 1983 | 1997 | 2008 | 2017 | 2026 |

**Annual value of population (1000 persons) in Macedonia**

The natural increase in 1994 was 9.1 per 1000 inhabitants and in 2000 this figure was 5.9. Life expectancy for men is 70 and for women 75. The participation of people over 60 in structure of population is approaching 11%. In 1991 the average number household had 4.05 members; in 1994 this figure was 3.85.

The literacy rate of the population is 94.6%.

Population density is amounting to 80 inhabitants/km$^2$. Macedonia is characterized with 59% of the population which are living in urban settlements: 23% are in the capital Skopje and other 36% are living in other 29 cities. Migrations of the population to the towns are permanently since several decades.

A district heating is used only in a part of the capital Skopje, based on a consumption of residual oil and natural gas. In the urban area (59%) for the heating of dwellings mostly electricity is used, and in the rural area it is mostly the wood as well as electricity.

Households mostly live in their own housing units, which is favourable for the adoption of decisions on investment in the renovation of heating systems and heat insulation.

## 3.3. GEOGRAPHIC PROFILE


**Figure 3.1.** Map of the Republic of Macedonia

The Republic of Macedonia is situated in southern Europe, in central part of the Balkan Peninsula, at latitude of approximately 42 North and a longitude of 22 East. Total surface area of Macedonia is 25,713 $km^2$. Macedonia borders with Greece, Bulgaria, Yugoslavia and Albania.

Although it is small in size, Macedonia is a very diverse country. Participation of plains in the total surface area is 19.1%; the figure of reddish and mountain terrains is 79%, where water surfaces are 1.9%.

From the aspect of relief, Macedonia is mountainous country. Forests cover more than one third of the total territory of the country. Agricultural areas cover 25%. Forest areas have been increasing at the expense of agricultural land.

Macedonian territory is covered by different types of climate: continental, changed continental, sub-Mediterranean (changed maritime), mountainous climate, as well as their various subtypes. According to the experiences of the climate classifications and adequate access for the territory of the Republic of Macedonia, it differs the following more homogeneous climate regions and sub-regions: sub-Mediterranean climate (50 - 500 m), moderate-continental-sub-Mediterranean climate (to 600 m), hot continental climate (600 - 900 m), cold continental climate (900 - 1100 m), sub-forest-continental-mountainous climate (1100-1300 m), forest-continental mountainous climate (1300 - 1650 m), sub-alpine mountainous climate (1650 - 2250 m), alpine mountainous climate ( $h_S$>2250 m).

The complex orography is also the cause of substantial microclimate differences, dictated chiefly by the pronounced surface and elevated inversions in basins and valleys.

The average annual air temperature in the settlements is between 11 and 14°C. The average temperature need for heating is about 2,500 degree-days in the most of the settlements. Macedonia is characterized with very extreme temperatures, in winter down to -30°C (even in settlements in plain regions) and in summer above 40°C.

The climate diversity is also reflected in the substantial differences in rainfall volumes. The average annual precipitations in the settlements are between 500 to 1,000 mm, and in alpine regions more than 1,000 mm.

The average number of hours of sunshine is between 2,000 and 2,400 hours a year. The average cloudness in the last five years was about 60%.

A high level of biodiversity richness due to the specific geographical position, geological history, composite geology, well-developed relief, as well as the climate characteristics are found in Macedonia.

Eight out of nine biomes known for the Balkan Peninsula can be recognized in Macedonia. All other organisms (animals, fungi and microorganisms) are directly or indirectly connected to the vegetation, thus the distribution of the living organisms in Macedonia as a whole is more or less climazonal. Protected natural regions cover 6.6% of the total territory. It is planned this participation to be gradually expanded.

## 3.4. ECONOMIC DEVELOPMENT

The economy of the Republic of Macedonia in the late 1980s was confronted by a variety of shocks caused by the transformation of the political and economic systems; this was exacerbated by the loss of former Yugoslav markets. All this resulted in a fall in GDP, a fall in the employment rate and investments, and a high inflation rate. Since 1996 the Macedonian economy has begun to revive, on average exceeding an annual growth rate facilitated by well-balanced public finances. Besides many obstacles during the 10 year of transition, according to figures by World Bank there was a growth rate of GDP 3-5% during 1997 – 2001.

Due to the small size of the Macedonian market, the Macedonian economy is firmly embedded in international economic flows.

Some important economic indicators are presented in the tables 3.2 and 3.3.

**Table 3.2.** Basic indicators of economic development

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GDP x$10^6$ USD | 4.252 | 3.990 | 3.728 | 3.450 | 3.389 | 3.351 | 3.390 | 3.458 | 3.575 | 3.730 | 3.901 |
| GDP/Capita USD | 2.235 | 2.083 | 1.937 | 1.785 | 1.742 | 1.705 | 1.709 | 1.732 | 1.781 | 1.848 | 1.925 |
| GDP growth rates % | - | -6,2 | -6,6 | -7,5 | -1,8 | -1,1 | 1,2 | 1,4 | 3,4 | 4,3 | 4,3 |
| Inflation % | - | - | - | 349,8 | 121,8 | 15,9 | 3,0 | 4,4 | 0,8 | -1,1 | 5,8 |

*Sources: Ministry of Finance; Statistical Office*

**Table 3.3.** Economic structure by sectors – Shares of GDP in %

| Sector | 1990 | 1992 | 1994 | 1996 | 1998 | 2000 |
|---|---|---|---|---|---|---|
| Trade | 9,1 | 8,2 | 10,9 | 11,7 | 10.7 | 11.6 |
| Industry/Mining | 46,1 | 40,0 | 36,8 | 35,9 | 21.3 | 21.9 |
| Tourism/Crafts/Services | 6,3 | 5,9 | 6,3 | 7,0 | 4.3 | 4.3 |
| Financial Services | 4,2 | 7,1 | 8,3 | 7,2 | 11.3 | 11.5 |
| Transport/Communications | 9,4 | 8,7 | 9,0 | 8,9 | 6.7 | 7.1 |
| Construction | 10,3 | 10,2 | 8,8 | 8,8 | 5.8 | 5.9 |
| Agriculture/Fisheries | 9,9 | 14,3 | 14,3 | 14,6 | 10.5 | 10.4 |
| Other Economic | 4,7 | 5,6 | 5,6 | 5,8 | 25.3 | 25.3 |
| Total Percent | 100,0 | 100,0 | 100,0 | 100,0 | 100,0 | 100,0 |

*Based on constant 1990 prices. Non-economic activities excluded.*

Since 1990, due to the new political and economic situation in Europe, Macedonia has lost the traditional market for industrial products in East-European countries. This is the reason for the drastic fall of the industry production, from 46% of GDP in 1990 to 22% of GDP in 2000. Since the last decade, there is an intensive expansion of small and medium size enterprises, which is contented in the strategy for the future development of the country.

## 3.5. ENERGY

The energy supply in Macedonia is based primarily on the domestic lignite coal, imported liquid fuels and natural gas, hydro potential and wood biomass.

The biggest lignite mine is located in the Bitola region where three thermo power plants are built with the power of 220 MW each. The other lignite mine is located in the Kicevo region where one thermo power plant is built with the power of 125 MW. By the investigations and estimation of the coal sources, their reserves will be exhausted by 2015.

Depending on hydrological conditions in the year, 15 to 18% of the annual electricity production comes from hydro power plants. There are six hydro power plants and some small ones with the total net capacity of 441 MW.

One thermo power plant (Negotino) with 210 MW capacity, which uses a residual oil, is not in operation regularly because of the high price of the produced electricity. But it is very useful in peak load conditions of the electricity consumption.

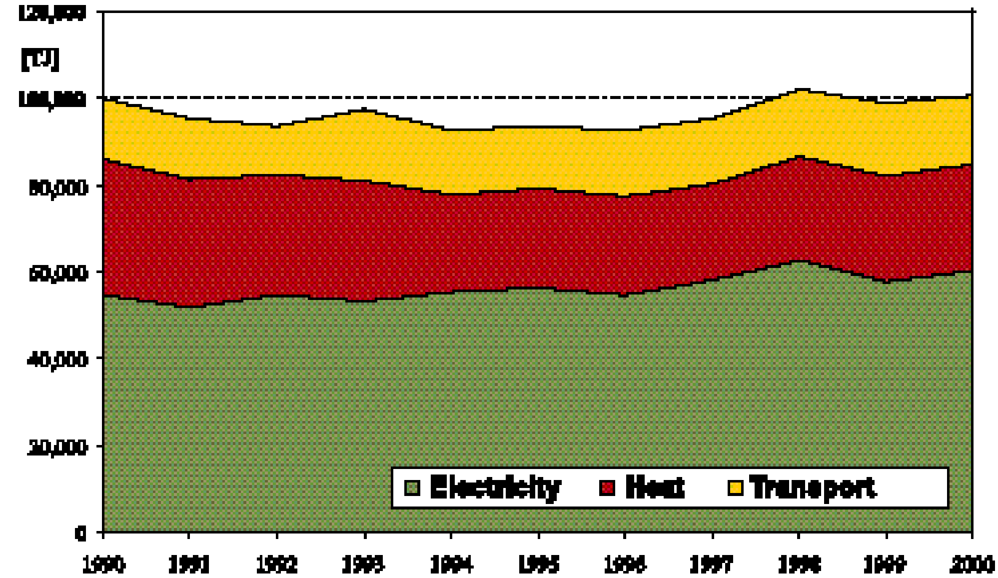



**Figure 3.2.** Consumption of fossil fuels in Macedonia

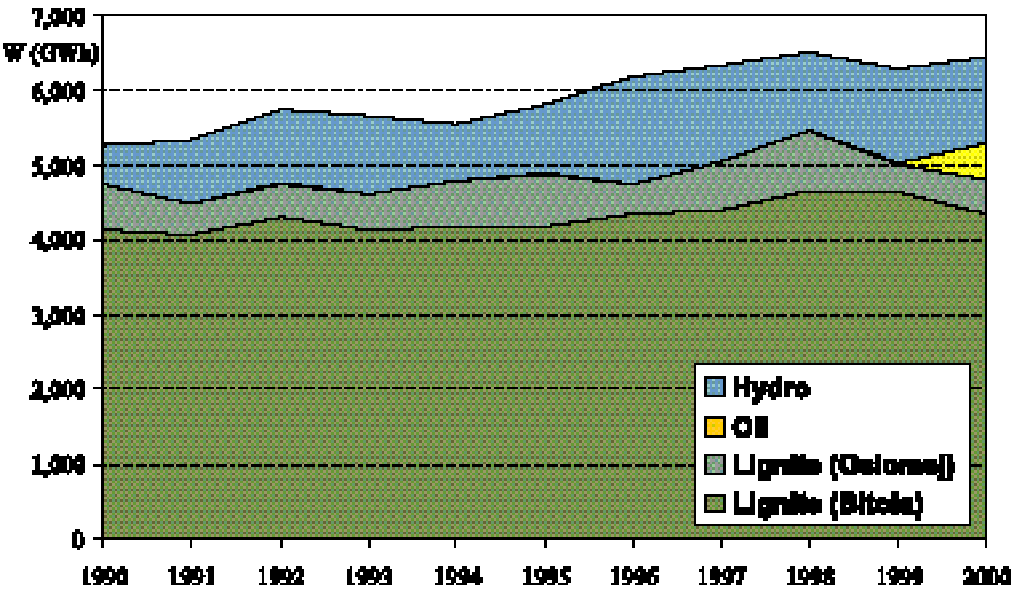



**Figure 3.3.** Electricity production by energy sources in Macedonia

There is one refinery company (OKTA) in Macedonia with a low efficient technology. Its production of light derivatives is followed by a production of a considerable amount of residual oil (about 40% of the total production). The residual oil is mostly used for heat production. In the future planning, it is projected the use of residual oil in existing lignite thermo power plants.

A construction of the central pipeline for natural gas has been put in operation for three years. In the year 2000, less than 10% of total pipeline capacity of natural gas is used. The consumption of natural gas is expected to rise in all energy sectors, especially in the heat production and Combined Heat and Power units.

Electricity consumption has been both absolutely and relatively increased by households, and even more so by the public and service sectors.

The increasing consumption of liquid fuels has been the result chiefly of the growth in road traffic.

Regarding to the renewable sources, the greatest share is held by hydroelectric power. In the next two decades building of new hydro power plants is projected with the total new capacity of 673 MW.

The geothermal energy accounts for 2.4% in the heat production sector. There are possibilities for increasing the exploitation of existing and new geothermal sources.

The use of solar energy is represented at a symbolic level (for hot water). But the geographical position and climate in Macedonia offer a very good perspective to intensify the use of solar collectors.

The utilization of wind power is not yet in the planning stage in Macedonia.

The strategic document “Energy Sector Development Strategy for Macedonia”, prepared by the Macedonian Academy of Sciences and Arts for the Ministry of Economy, is crucial document where the energy development for the future is projected.

## 3.6. TRANSPORT

The Republic of Macedonia has relatively well-developed road transport infrastructure. The road infrastructure in 1996 by road category is given in table 3.4.

**Table 3.4.** Infrastructure supply in 1996

| Road category | Length (km) | % Paved | Density km/per 100 km$^2$ |
|---|---|---|---|
| Main road | 909 | 91,20 | 3,53 |
| Regional | 3.058 | 77,92 | 11,90 |
| Local | 5.656 | 39,03 | 22,00 |
| Total | 9.623 | 56,40 | 37,42 |

Macedonia has a low level of motorization. In 1992 the number of cars per 1,000 people was 157.6; by 1998 this figure had increased to 165.

The number of registered road vehicles by type, over the period of 1992 to 1998 is given in table 3.5.

**Table 3.5.** Registered road vehicles and trailers in Macedonia

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|
| Cars | 279.861 | 289.979 | 263.181 | 285.907 | 284.022 | 289.204 | 288.678 |
| Other vehicles | 44.183 | 46.863 | 35.760 | 40.362 | 40.975 | 41.569 | 41.477 |
| Total | 324.044 | 336.842 | 298.941 | 326.269 | 324.997 | 330.773 | 330.155 |

Figure 3.4 shows the trend of annual fuel consumption in Macedonia by type of fuel over the period 1993-2000.

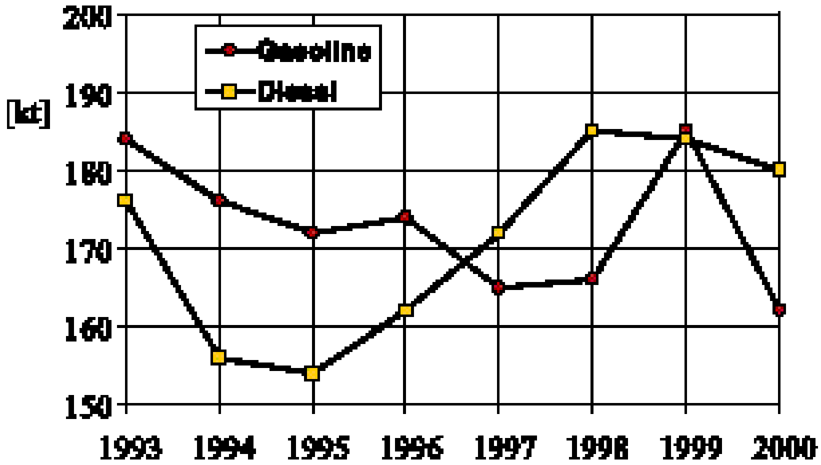



**Figure 3.4.** Trend of consumption of gasoline and diesel in Macedonia

The railway transport in Macedonia is on a very low level. Only 33.3% of the total railway network is electrified. Diesel locomotives have been operating within the remaining part of the rail network.

Public transportation is mostly done by buses which are at low technical level with great emissions of gases.

## 3.7. INDUSTRY

Industry plays an important role in the economy of the Republic of Macedonia as a whole. Its share in building the GDP of the national economy approximates more than 20%. Since Macedonia became independent, the traditional markets in the former Yugoslavia were lost. The change in the political and economic system and greater involvement in international trade made economic conditions more difficult.

The structure of industry consists of: metallurgy (steel, lead, zinc, ferro-alloys), mining, refinery, metals manufacture, non-metallic mineral products, ceramic, cement, chemicals, food products, beverages, tobacco products, textile, etc.

Unfortunately, as a result of transition process which started in 1990 and is still going on, as well as of the effect of many external and internal factors, growth rate of total industrial production has flattened and even declined in some specific sectors. Many of production capacities are facing uncertain future. Restarting of production process in industry sector will depend on both governmental economic and political guides. However, there is expansion of small and medium enterprises.

**Industrial production growth (annual change in %)**

| 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|
| -11 | 3,2 | 1,5 | 4,5 | -2,6 | 3,5 |

It is high priority to prepare a strategy of future development towards new clean technologies. Especially attention has to be paid to low energy consumption per product units which will contribute to lower GHG emissions.

## 3.8. WASTE

Waste management is one of Macedonia's most pressing environmental issues. Waste management practices employed until now have been more or less confined to the simple disposal of waste only.

Due to the lack of evidences for the existing rate of waste production, this sector is ungrateful for precise forecasting. According to a rather rough estimation for the reference year, a value of 0.79 [kg/person/day] solid waste disposed on SWDS (Solid Waste Disposal Sites) is taken.

The utilization of waste is not practiced. The primary waste selection is symbolic, it concerns only waste paper. The disposal sites are not equipped for a waste selection too. Also, they are not fitted with a system for retrieving deposited gas.

It is expected that amendments of the existing laws, which regulate the waste management, will contribute to improvement of the state of environment.

sIn the National Environmental Action Programme the waste management is one of the priority environmental issues. Also, the high priority is to improve waste management and to adopt adequate regulations on waste selection and recycling.

## 3.9. AGRICULTURE

The agriculture has very important role in the total economy of the Republic of Macedonia. In the Strategy for the Development of Agriculture in the Republic of Macedonia to the year 2005, (MANU, 2001), the second place, just after industry, is elaborated for agriculture in contribution to the GDP of the national economy (>10%).

As a result of the large diversities of agro-ecological properties (climate, relief, soils and water economy), there is a wide spectrum of agricultural production (crop production, vegetables, vineyards, orchards, livestock and others).

The total agricultural land was changed from average of 1319 kha in 1984-1994 to 1280 kha in 1999. Between 630 and 665 kha from total area are arable agricultural land, and about 649 kha are covered by permanent pastures.

The limiting factor of the crop production in the major agricultural regions in the Republic of Macedonia is water shortage. The vulnerability of agriculture could be very high because of climate change.

The priority is to renew the existing irrigation systems and to expand irrigated area, implementing new modern irrigation techniques to cover more agriculture land.

Development of livestock and poultry in Macedonia is at medium level, but it is not followed with appropriate level of production per capita.

It is very important to work on redirections of the breeding programs goals toward adaptation of the new genetic proveniences with a high productivity, and to develop proper farmhouse construction and farmhouse equipment.

**Table 3.6. Livestock population (x 1000)**

| Year: | 1990 | 1994 | 1998 |
|---|---|---|---|
| **Cattle** | 284,0 | 280,3 | 266,6 |
| **Pigs** | 179,0 | 171,6 | 196,8 |
| **Sheep** | 2297,0 | 2466,1 | 1315,2 |
| **Poultry** | 5729,0 | 4685,0 | 3338,8 |

## 3.10. FORESTRY

Forests cover more than one third of the total territory of the Republic of Macedonia. The forestry reserves in Macedonia are not on a satisfactory level and lag considerably behind other countries, especially those of Central and Northern Europe.

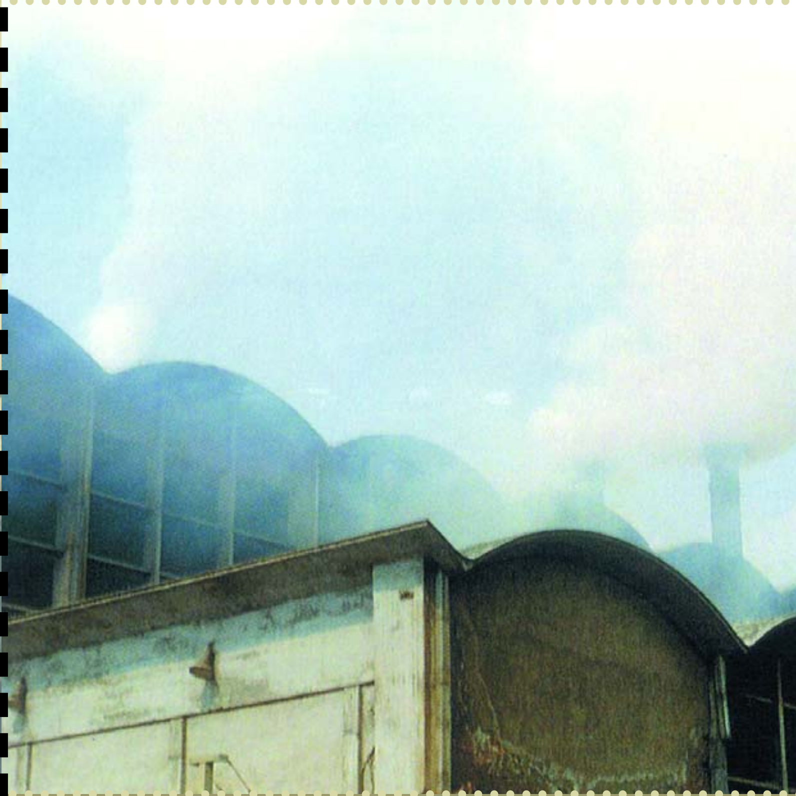
There are three main types of forests in Macedonia: highstem forest, with about 28% from the total forest area and annual growth rate from 2.0 to 2.6 t dm/ha; lowstem forest, with 61% of the total area and annual growth rate of about 1.0 t dm/ha; other, with about 10% of the total area and annual growth rate below 1.0 t dm/ha.

The most present tree species in Macedonia are the oak and the birch, then the fir and the spruce.

The high quantity of short trunked offspring trees many of which are highly degraded, together with the small quantity of conifers, results in relatively low timber reserves, low timber mass, and low annual growth per unit of land.

Forests in private ownership are scattered on small plots and are low productive in terms of timber mass. These forests are largely defoliated and degraded. There are approx. 220,000 plots of an average size of 0.4 ha owned by approx. 65,000 households in Macedonia. Moreover, there are many unclear issues of a legal and proprietary nature.

It is necessary to undertake actions to control the health condition of the forests, to afforestate the bare place areas and to prevent from forest fires.



chapter

# 4

CHAPTER 4

# INVENTORY OF GREENHOUSE GASES EMISSIONS

## INTRODUCTION

The inventory is prepared according to IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1996), taking into consideration the three main GHGs: carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$). The conversion rates being used to express equivalent $CO_2$ emission are: 21 for $CH_4$ and 310 for $N_2O$. The period 1990-1998 was analyzed, and 1994 is the base year. The investigations were conducted by three working teams: the first team dealt with the energy sector, the second team focused on the industrial processes and waste sectors, and the third team worked on the agriculture and land use change and forestry sectors. The sufficiency and applicability of the existing annual and monthly publications of the State Statistical Office were checked for each sector. Complete and high quality input data concerning the economic activities in the country were provided, to remove all initial uncertainties. The correlation factors which determine the quality of the processes were mostly taken as prescribed by the methodology. Within all sectors, the annual reports of the State Statistical Office were main information sources, although for the waste and agriculture sectors (where lack and uncertainty of data were prevalent) other sources and local experts had to be extensively consulted.

Special treatment was applied to the energy sector, considering the complexity of this sector and its contribution to the total emissions with about 70%. The analyses were performed according to the type of final energy used: electricity production, heat production and transformation of mechanical energy for transport. Furthermore, separate detailed analyses were made for solid, liquid and gaseous fuels. The approach ensured the quality of input data for annual fuels demand, determined by the structure and type of consumers. In addition, this approach is fully compatible with the longstanding practice of data collection in Macedonia.

The results of the GHG emissions calculations are presented according to the sectoral and subsectoral division in the IPCC methodology. At the end of this publication, an integral overview of GHG emissions in tables and figures for all sectors and all years of the period 1990-1998 is presented. It is worth pointing out the excellent matching (in range of 0.2%) of the results for the energy sector for all years obtained by the reference and by the sectoral approaches, being an indicator of high quality approach and accuracy in the calculations.

## 4.1. ENERGY SECTOR

The preparation of input data for the energy sector was divided into categories according to the final use of energy: electricity, heat energy and mechanical energy for transport. Within each of these three categories further division by fuel types (solid, liquid and gaseous) was made. The results, i.e. GHG emissions are presented following the sectors and subsectors definition subscribed by IPCC methodology.

### 4.1.1. FUELS USED FOR ELECTRICITY PRODUCTION

The review of the conversion and emission factors suggested by the IPCC methodology showed that the factors for the liquid and gaseous fuels were suitable for Macedonia and could be applied without modifications, while for the solid fuels they should be calculated, taking into account the local conditions. There are two types of lignite used in the thermal power plants Bitola and Oslomej, while in the IPCC methodology only one type of lignite is defined. For that reason, parameters for equivalent lignite had to be calculated, i.e. equivalent heating value, equivalent carbon content and emission factor for the total lignite consumption. The calculated values are presented in the table 4.1.

**Table 4.1.** Lignite consumption and heating values of lignite

| Year | Bitola (kt) | Oslomej (kt) | Total [kt] | Bitola (TJ/kt) | Oslomej (kt) | Equiv. [TJ/kt] |
|---|---|---|---|---|---|---|
| 1990 | 6.111 | 998 | 7.109 | 8,619 | 7,384 | 8,446 |
| 1991 | 5.810 | 787 | 6.597 | 8,443 | 6,927 | 8,262 |
| 1992 | 5.630 | 779 | 6.409 | 8,147 | 7,111 | 8,021 |
| 1993 | 5.863 | 712 | 6.575 | 8,114 | 7,821 | 8,082 |
| 1994 | 5.876 | 1.100 | 6.976 | 8,018 | 7,932 | 8,004 |
| 1995 | 6.058 | 1.170 | 7.228 | 7,824 | 7,750 | 7,812 |
| 1996 | 6.271 | 641 | 6.912 | 7,562 | 7,476 | 7,554 |
| 1997 | 6.368 | 1.046 | 7.414 | 7,831 | 7,597 | 7,798 |
| 1998 | 6.793 | 1.256 | 8.049 | 7,570 | 7,348 | 7,535 |

### 4.1.2. FUELS USED FOR HEAT PRODUCTION

The estimates of the quantities of different primary-energy sources consumption for heat production over the analyzed period are based on some published and unpublished documents, as well as on experts' investigations. The evaluation of different primary-energy sources consumption over the analyzed period is shown in the table 4.2, where the liquid fuel consumption is given by subsectors, while fossil fuels consumption is summarized.

For calculation of GHG emissions, conversion and emissions factors subscribed by the IPCC methodology were used.

**Table 4.2.** Primary energy sources consumption [kt] for heat production

| | Energy industries | | | Manufacturing industries and construction | | | Commercial/ Institutional & Residential | | | Agriculture/ Forestry/ Fishing | | | All sectors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Resid. fuel oil | Gas/ Diesel oil | LPG | Resid. fuel oil | Gas/ Diesel oil | LPG | Resid. fuel oil | Gas/ Diesel oil | LPG | Resid. fuel oil | Gas/ Diesel oil | LPG | Solid fossil fuels |
| 1990 | 113,2 | 0,0 | 0,0 | 202,8 | 44,6 | 31,0 | 87,9 | 31,1 | 13,1 | 46,2 | 25,3 | 6,0 | 190,0 |
| 1991 | 108,2 | 0,0 | 0,0 | 193,7 | 41,9 | 26,0 | 84,0 | 29,3 | 11,0 | 44,1 | 23,8 | 5,0 | 160,0 |
| 1992 | 100,6 | 0,0 | 0,0 | 180,2 | 35,3 | 18,0 | 78,1 | 24,6 | 7,6 | 41,0 | 20,1 | 3,5 | 174,0 |
| 1993 | 94,3 | 0,0 | 0,0 | 169,0 | 49,4 | 14,2 | 73,3 | 34,5 | 6,0 | 38,5 | 28,1 | 2,7 | 175,0 |
| 1994 | 66,9 | 0,0 | 0,0 | 119,9 | 43,7 | 9,9 | 52,0 | 30,5 | 4,2 | 27,3 | 24,8 | 1,9 | 148,0 |
| 1995 | 69,2 | 0,0 | 0,0 | 123,9 | 43,2 | 9,9 | 53,7 | 30,2 | 4,2 | 28,2 | 24,6 | 1,9 | 144,0 |
| 1996 | 74,2 | 0,0 | 0,0 | 132,9 | 45,9 | 9,9 | 57,6 | 32,0 | 4,2 | 30,3 | 26,1 | 1,9 | 109,0 |
| 1997 | 77,7 | 0,0 | 0,0 | 139,2 | 48,5 | 11,8 | 60,4 | 33,9 | 5,0 | 31,7 | 27,6 | 2,3 | 117,0 |
| 1998 | 76,5 | 0,0 | 0,0 | 137,0 | 52,1 | 14,9 | 59,4 | 36,3 | 6,3 | 31,2 | 29,6 | 2,9 | 142,0 |

### 4.1.3. FUELS USED FOR TRANSPORT

The estimates of GHG emissions from the transport sector were performed for each transport mode, as well as for each type of fuel.

The consumption of different types of fuel in the transport sector is given in the table 4.3. A different approach was applied to air transport, basing the calculations on the annual number of take-offs and landings at the airports in Skopje and Ohrid, and on the average consumption of fuel per take-off/landing per airplane. Considering the types of aircraft that fly from these airports, it is estimated that the average consumption of jet kerosene per take-off is roughly 400 kg, and per landing 300 kg per aircraft. These data, combined with the number of operations at both Macedonian airports, lead to the estimates given in column related to air transport in the table 4.3.

**Table 4.3.** Fuel consumption [kt] in the transport

| Year | Road | | | Air | Rail | Water | |
|---|---|---|---|---|---|---|---|
| | Gasoline | Gas/Diesel Oil | LPG | Jet Kerosene | Gas/Diesel Oil | Gasoline | Gas/Diesel Oil |
| 1990 | 161,00 | 152,00 | 0,00 | 1,32 | 7,00 | 0,30 | 0,06 |
| 1991 | 163,00 | 143,12 | 0,00 | 2,66 | 6,88 | 0,30 | 0,06 |
| 1992 | 132,00 | 121,41 | 0,00 | 3,12 | 4,59 | 0,30 | 0,06 |
| 1993 | 182,00 | 178,00 | 0,00 | 4,17 | 3,92 | 0,30 | 0,06 |
| 1994 | 176,00 | 154,00 | 0,00 | 3,99 | 3,51 | 0,30 | 0,06 |
| 1995 | 171,00 | 153,00 | 0,00 | 4,40 | 3,86 | 0,30 | 0,06 |
| 1996 | 175,00 | 162,00 | 0,01 | 3,98 | 3,70 | 0,30 | 0,06 |
| 1997 | 163,00 | 171,00 | 0,27 | 3,59 | 3,91 | 0,30 | 0,06 |
| 1998 | 164,00 | 187,00 | 0,65 | 4,05 | 3,80 | 0,30 | 0,06 |

### 4.1.4. GHG EMISSIONS FROM THE ENERGY SECTOR

The GHG emissions from the energy sector are calculated by two approaches: reference (global) and sectorial. The discrepancy of the results is less then 0.2% for all years, which indicates a good accuracy in calculations.

$CO_2$, $CH_4$, $N_2O$ and $CO_2$-eq emissions are presented numerically in table 4.4 and graphically in figure 4.1.

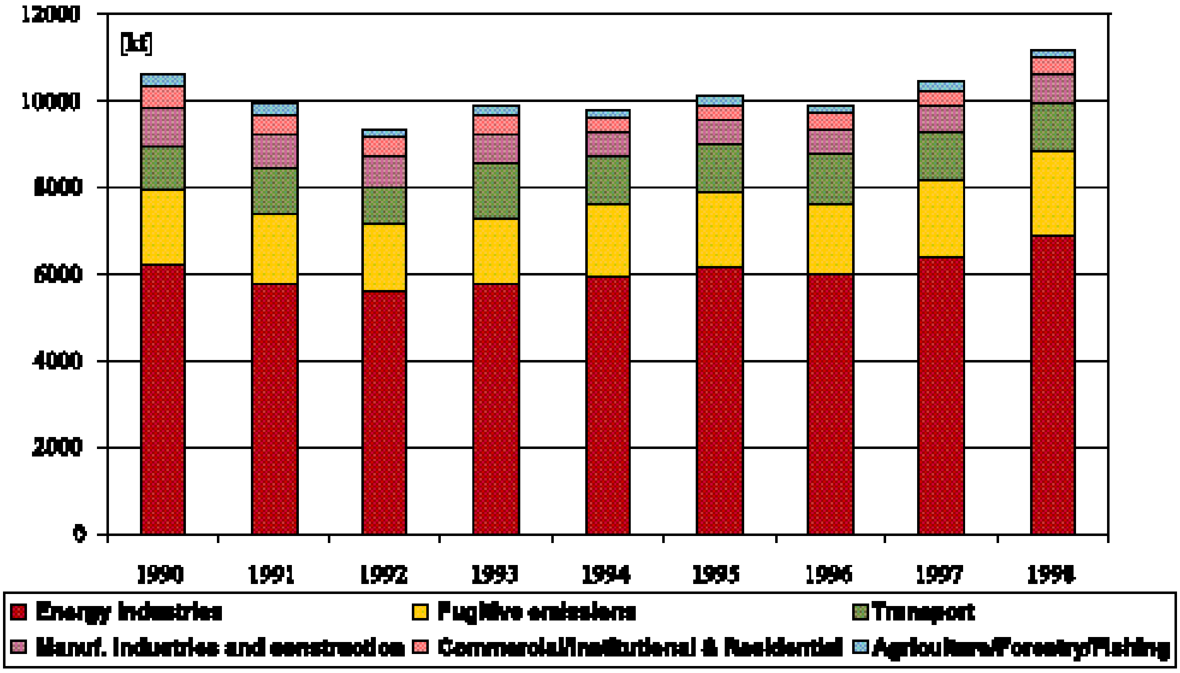



**Figure 4.1.** Contribution of energy subsectors to total $CO_2$-eq emissions in the energy sector

**Table 4.4.** GHG emissions [kt] from the energy sector

| | Subsector | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ | Energy industries | 6.208,28 | 5.783,52 | 5.603,62 | 5.729,65 | 5.943,99 | 6.155,81 | 5.956,81 | 6.349,69 | 6.857,25 |
| | Transport | 1.048,48 | 1.026,04 | 854,50 | 1.201,63 | 1.089,85 | 1.088,20 | 1.138,08 | 1.115,45 | 1.176,44 |
| | Manufacturing industries and construction | 864,68 | 814,02 | 727,67 | 727,06 | 544,86 | 556,25 | 592,62 | 626,21 | 639,93 |
| | Commercial/Institutional & Residential | 408,31 | 384,16 | 341,35 | 352,97 | 269,23 | 273,69 | 291,61 | 308,23 | 316,95 |
| | Agriculture/Forestry/Fishing | 240,21 | 226,31 | 200,28 | 215,77 | 168,48 | 170,57 | 181,65 | 191,92 | 198,49 |
| | **Total** | **8.769,97** | **8.234,05** | **7.727,43** | **8.227,08** | **8.016,41** | **8.244,53** | **8.160,77** | **8.591,49** | **9.189,07** |
| $CH_4$ | Energy industries | 0,074 | 0,068 | 0,064 | 0,065 | 0,064 | 0,065 | 0,061 | 0,067 | 0,070 |
| | Fugitive emissions | 81,019 | 75,188 | 73,046 | 74,937 | 79,500 | 82,375 | 78,776 | 84,493 | 91,726 |
| | Transport | 0,179 | 0,179 | 0,146 | 0,203 | 0,192 | 0,188 | 0,193 | 0,184 | 0,189 |
| | Manufacturing industries and construction | 0,023 | 0,022 | 0,019 | 0,019 | 0,015 | 0,015 | 0,016 | 0,017 | 0,017 |
| | Commercial/Institutional & Residential | 3,362 | 3,281 | 3,452 | 3,488 | 3,175 | 2,989 | 2,836 | 1,906 | 1,960 |
| | Agriculture/Forestry/Fishing | 0,016 | 0,015 | 0,013 | 0,014 | 0,011 | 0,011 | 0,012 | 0,013 | 0,013 |
| | **Total** | **84,674** | **78,752** | **76,741** | **78,726** | **82,957** | **85,643** | **81,894** | **86,681** | **93,975** |
| $N_2O$ | Energy industries | 0,087 | 0,079 | 0,074 | 0,077 | 0,080 | 0,081 | 0,075 | 0,083 | 0,087 |
| | Transport | 0,010 | 0,010 | 0,008 | 0,011 | 0,010 | 0,010 | 0,011 | 0,011 | 0,011 |
| | Manufacturing industries and construction | 0,007 | 0,007 | 0,006 | 0,006 | 0,004 | 0,004 | 0,005 | 0,005 | 0,005 |
| | Commercial/Institutional & Residential | 0,047 | 0,046 | 0,048 | 0,049 | 0,044 | 0,042 | 0,040 | 0,027 | 0,028 |
| | Agriculture/Forestry/Fishing | 0,002 | 0,002 | 0,002 | 0,002 | 0,001 | 0,001 | 0,001 | 0,002 | 0,002 |
| | **Total** | **0,153** | **0,143** | **0,138** | **0,144** | **0,140** | **0,139** | **0,132** | **0,127** | **0,133** |
| $CO_2$-eq | Energy industries | 6.236,73 | 5.809,40 | 5.628,02 | 5.754,77 | 5.970,06 | 6.182,19 | 5.981,31 | 6.376,77 | 6.885,61 |
| | Fugitive emissions | 1.701,41 | 1.578,94 | 1.533,98 | 1.573,68 | 1.669,50 | 1.729,87 | 1.654,29 | 1.774,36 | 1.926,25 |
| | Transport | 1.055,28 | 1.032,78 | 860,10 | 1.209,43 | 1.097,04 | 1.095,38 | 1.145,57 | 1.122,59 | 1.183,86 |
| | Manufacturing industries and construction | 867,33 | 816,51 | 729,89 | 729,27 | 546,52 | 557,94 | 594,42 | 628,12 | 641,89 |
| | Commercial/Institutional & Residential | 493,60 | 467,37 | 428,77 | 441,31 | 349,55 | 349,35 | 363,46 | 356,73 | 366,83 |
| | Agriculture/Forestry/Fishing | 241,15 | 227,20 | 201,06 | 216,61 | 169,14 | 171,24 | 182,36 | 192,67 | 199,27 |
| | **Total** | **10.595,51** | **9.932,20** | **9.381,81** | **9.925,08** | **9.801,81** | **10.085,98** | **9.921,41** | **10.451,24** | **11.203,71** |

## 4.2. INDUSTRIAL PROCESSES SECTOR

The industrial processes sector is divided in the following three subsectors: mineral production, chemical processes and metal production. Annual production by items within each subsector is presented in the table 4.5. The corresponding GHG emissions together with equivalent $CO_2$ emissions are given in the table 4.6 and graphically presented in the figure 4.2.

**GHG emissions from mineral production**
In this subsector $CO_2$ emissions are dominant from production and use of cement, lime, limestone-dolomite and natrium carbonate.

When calculating the $CO_2$ emissions, input data are the annual amounts of the above items.

**GHG emissions from chemical processes**
The input data used for calculation of GHG emissions from this subsector are the annual production of ammonia, calcium carbide, adipic acid, carbon black, methanol and coke.

**GHG emissions from metal production**
The input data for calculation of GHG emissions from this subsector are the annual production of iron and steel, ferronickel, ferroalloys and non-ferro metals.

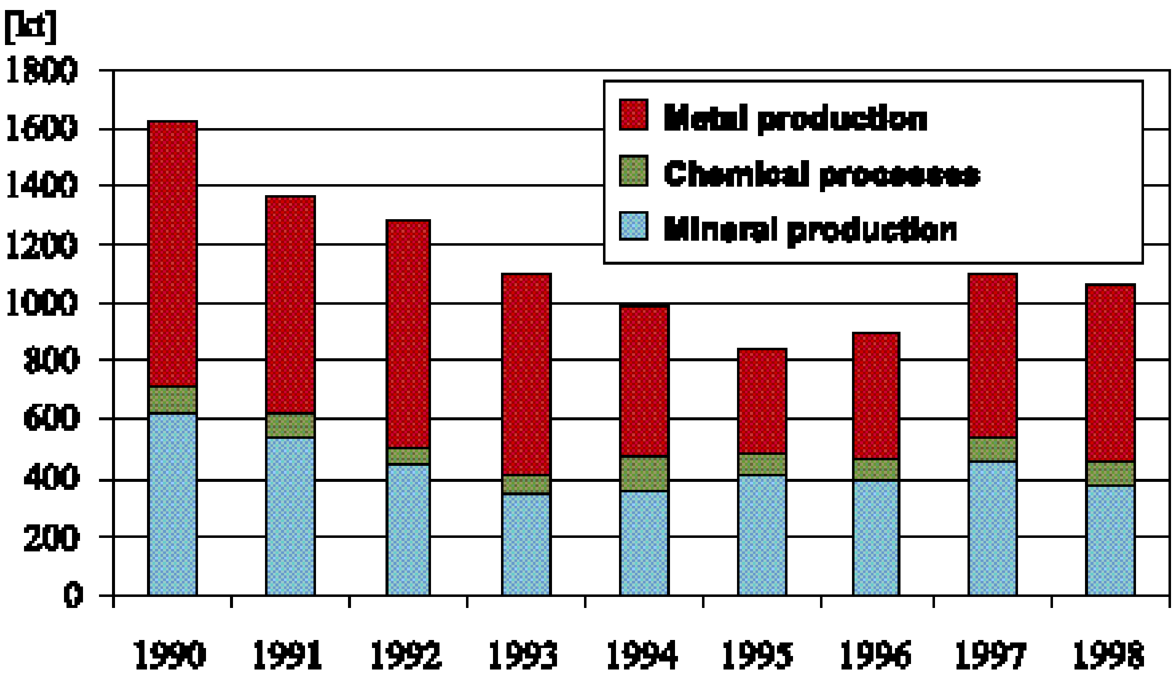



**Figure 4.2.** $CO_2$-eq emissions from the industrial processes sector

**Table 4.5.** Amounts of industrial products [kt]

| Year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|
| **Mineral production** | | | | | | | | | |
| Cement | 639,02 | 605,74 | 516,05 | 499,09 | 486,45 | 523,50 | 490,86 | 610,76 | 461,20 |
| Lime | 37,45 | 29,19 | 33,87 | 24,90 | 14,10 | 12,36 | 9,71 | 4,34 | 0,96 |
| Limestone-dolomite | 123,17 | 122,73 | 110,55 | 68,89 | 98,81 | 97,24 | 77,03 | 81,96 | 76,43 |
| Natrium carbonate | 6,46 | 5,15 | 4,56 | 4,37 | 5,82 | 8,25 | 3,72 | 3,92 | 3,68 |
| **Chemical processes** | | | | | | | | | |
| Ammonia | 7,95 | 7,31 | 7,18 | 7,74 | 6,08 | 4,93 | 6,60 | 5,14 | 6,99 |
| Calcium carbide | 3,01 | 2,61 | 2,03 | 2,28 | 1,95 | 2,68 | 2,52 | 2,20 | 1,94 |
| Adipic acid | 0,76 | 0,77 | 0,48 | 0,59 | 1,10 | 0,55 | 0,57 | 0,68 | 0,73 |
| Carbon black | 0,75 | 0,53 | 0,08 | 0,03 | 0,05 | 0,00 | 0,01 | 0,00 | 0,00 |
| Methanol | 0,00 | 4,44 | 4,96 | 2,80 | 2,61 | 3,97 | 1,10 | 1,23 | 1,23 |
| Coke | 0,14 | 0,00 | 0,01 | 0,08 | 0,05 | 0,07 | 0,03 | 0,01 | 0,01 |
| **Metal production** | | | | | | | | | |
| Iron and steel | 358,70 | 237,63 | 212,69 | 159,05 | 85,64 | 58,57 | 54,90 | 72,44 | 72,45 |
| Ferrosilicon (75%) | 51,81 | 49,63 | 51,56 | 47,16 | 44,54 | 50,34 | 47,11 | 53,80 | 61,17 |
| Silicon metal | 0,76 | 3,91 | 6,79 | 8,19 | 7,14 | 2,46 | 4,43 | 5,14 | 0,00 |
| Ferromanganese | 11,29 | 6,48 | 15,03 | 6,29 | 0,13 | 3,47 | 16,43 | 2,00 | 4,23 |
| Silicon manganese | 12,04 | 11,30 | 23,14 | 6,00 | 3,18 | 7,10 | 17,03 | 18,78 | 36,69 |
| Ferrochromium | 5,09 | 3,36 | 3,96 | 4,37 | 3,28 | 3,95 | 3,78 | 1,06 | 0,00 |
| Zinc (Zn,Ag,Cd,Pb) | 34,15 | 37,53 | 42,36 | 53,72 | 45,02 | 12,20 | 21,40 | 50,03 | 48,57 |

**Table 4.6.** GHG emissions [kt] from the industrial processes sector

| Year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|
| **Mineral production** | **624,54** | **538,25** | **441,17** | **343,83** | **360,44** | **420,22** | **399,84** | **457,34** | **378,27** |
| Cement ($CO_2$) | 318,55 | 301,95 | 257,25 | 248,79 | 242,49 | 260,96 | 244,69 | 304,46 | 229,90 |
| Lime ($CO_2$) | 29,59 | 23,06 | 26,75 | 19,67 | 11,13 | 9,76 | 7,66 | 3,43 | 0,76 |
| Limestone-dolomite ($CO_2$) | 273,72 | 211,10 | 155,28 | 73,56 | 104,41 | 146,08 | 145,95 | 147,82 | 146,08 |
| Natrium carbonate ($CO_2$) | 2,68 | 2,14 | 1,89 | 1,81 | 2,41 | 3,42 | 1,54 | 1,63 | 1,53 |
| **Chemical processes** | | | | | | | | | |
| Ammonia ($CO_2$) | 11,92 | 10,95 | 10,77 | 11,61 | 9,11 | 7,39 | 9,89 | 7,70 | 10,48 |
| Calcium carbide ($CO_2$) | 5,60 | 4,86 | 3,77 | 4,23 | 3,62 | 4,98 | 4,68 | 4,09 | 3,60 |
| Adipic acid ($N_2O$ ) | 0,23 | 0,23 | 0,14 | 0,17 | 0,33 | 0,16 | 0,17 | 0,20 | 0,22 |
| Other chemicals ($CH_4$ ) | 0,008 | 0,014 | 0,010 | 0,005 | 0,005 | 0,007 | 0,002 | 0,002 | 0,002 |
| **Metal production** | **919,78** | **745,12** | **780,51** | **690,21** | **515,63** | **364,35** | **427,48** | **569,41** | **602,94** |
| Iron and steel ($CO_2$) | 538,05 | 356,44 | 319,03 | 238,57 | 128,46 | 87,84 | 82,34 | 108,65 | 108,67 |
| Ferroalloys ($CO_2$) | 250,27 | 244,18 | 298,40 | 244,84 | 213,86 | 229,56 | 262,77 | 268,15 | 307,29 |
| Zinc (Zn,Ag,Cd,Pb) ($CO_2$) | 131,46 | 144,50 | 163,08 | 206,80 | 173,31 | 46,95 | 82,37 | 192,61 | 186,98 |
| **Mineral production ($CO_2$-eq.)** | **624,54** | **538,27** | **441,19** | **343,84** | **360,46** | **420,23** | **399,86** | **457,36** | **378,28** |
| **Chemical processes ($CO_2$-eq.)** | **88,01** | **88,02** | **59,50** | **70,47** | **115,43** | **63,23** | **67,45** | **74,72** | **82,40** |
| $CO_2$ | 17,53 | 15,82 | 14,54 | 15,85 | 12,73 | 12,38 | 14,58 | 11,8 | 14,09 |
| $CO_2$-eq. of $CH_4$ | 0,17 | 0,31 | 0,23 | 0,13 | 0,12 | 0,17 | 0,05 | 0,05 | 0,05 |
| $CO_2$-eq. of $N_2O$ | 70,31 | 71,89 | 44,73 | 54,50 | 102,58 | 50,69 | 52,82 | 62,87 | 68,26 |
| **Metal production ($CO_2$-eq.)** | **919,79** | **745,13** | **780,53** | **690,22** | **515,65** | **364,37** | **427,5** | **569,44** | **602,95** |
| **Total ($CO_2$-eq.)** | **1.632,34** | **1.371,42** | **1.281,22** | **1.104,53** | **991,55** | **847,84** | **894,82** | **1.101,52** | **1.063,63** |

## 4.3. AGRICULTURE SECTOR

The agriculture sector is divided in the following four subsectors: enteric fermentation, manure management, rice fields and agricultural soils. The GHG emissions from this sector are mainly $CH_4$ and $N_2O$ emissions.

**GHG emissions from enteric fermentation**
In this subsector $CH_4$ emissions are dominant, and depend on the number of animals (Table 4.7). The emission factors are assumed to be constant over the whole analyzed period.

**Table 4.7.** Number of animals [in 1000's] in the period 1990 - 1998

| Year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|
| Dairy Cattle | 165,0 | 163,7 | 164,6 | 165,3 | 165,8 | 166,4 | 175,6 | 177,4 | 165,6 |
| Non-dairy Cattle | 119,0 | 117,1 | 119,2 | 113,9 | 114,5 | 115,8 | 117,7 | 117,1 | 101,0 |
| Buffalo | 2,0 | 1,5 | 1,2 | 1,1 | 1,0 | 1,0 | 1,0 | 1,0 | 0,9 |
| Sheep | 2.297,0 | 2.250,5 | 2.351,4 | 2.458,6 | 2.466,1 | 2.319,9 | 1.813,9 | 1.631,0 | 1.315,2 |
| Goats | 214,0 | 214,0 | 214,0 | 214,0 | 214,0 | 214,0 | 214,0 | 214,0 | 214,0 |
| Horses | 66,0 | 65,2 | 64,6 | 61,7 | 61,8 | 61,7 | 66,5 | 65,9 | 59,8 |
| Mules and Asses | 49,4 | 49,4 | 47,4 | 49,4 | 49,4 | 49,4 | 49,4 | 49,4 | 49,4 |
| Swine | 179,0 | 171,0 | 173,0 | 184,9 | 171,6 | 175,1 | 192,4 | 184,3 | 196,8 |
| Poultry | 5.729,0 | 4.562,5 | 4.297,4 | 4.392,7 | 4.685,0 | 4.879,9 | 3.360,8 | 3.274,6 | 3.338,8 |

**GHG emissions from manure management**
This subsector counts for $CH_4$ and $N_2O$ emissions. The following are manure management systems in Macedonia: solid storage and drylot pasture range and paddock and other types.
Within this subsector, $CH_4$ and $N_2O$ emissions depend on the number and type of animals in the manure management system.

**GHG emission from flooded rice fields**
The GHG emissions from this subsector are all $CH_4$ emissions. The input data is the area of intermittently flooded rice fields since the rice fields in Macedonia are of that type.
The $CH_4$ emissions from this subsector are so small, that can be neglected compared to emissions from the other subsectors.

**GHG emission from agricultural soils**
The GHG emissions from this subsector are merely $N_2O$ emissions. The most significant are the direct $N_2O$ emissions from soil, dependent on the amount of nitrogen input from different sources (table 4.8). Nitrogen from crop residues also contributes to the total $N_2O$ emissions. The input data within this subsector are production of non-fixing crops, as well as production of pulses and soybeans.

Emission factors are assumed constant for the whole analyzed period. Direct $N_2O$ emissions depend on the cultivated area, which also has not been changed over the analyzed period.

**Table 4.8.** Amounts of nitrogen (N) input [kt] of different sources

| Type of N input to soil | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|
| Synthetic fertilizer | 27,3 | 19,4 | 22,4 | 18,5 | 17,8 | 14,8 | 15,7 | 11,0 | 14,7 |
| Animal waste | 34,6 | 13,2 | 33,3 | 34,4 | 35,7 | 34,5 | 13,2 | 28,2 | 24,6 |
| N-fixing crops | 5,7 | 7,1 | 3,3 | 5,4 | 5,7 | 6,0 | 6,0 | 6,6 | 6,6 |
| Crop residue | 12,7 | 19,2 | 17,5 | 13,6 | 16,7 | 18,4 | 15,8 | 16,8 | 17,1 |

**Equivalent emissions from the agriculture sector**

Summarized, annual GHG emissions from all subsectors are given in table 4.9 and graphically presented in figure 4.3. The agriculture sector does not count for significant emissions of NOx, CO, NMVOC.

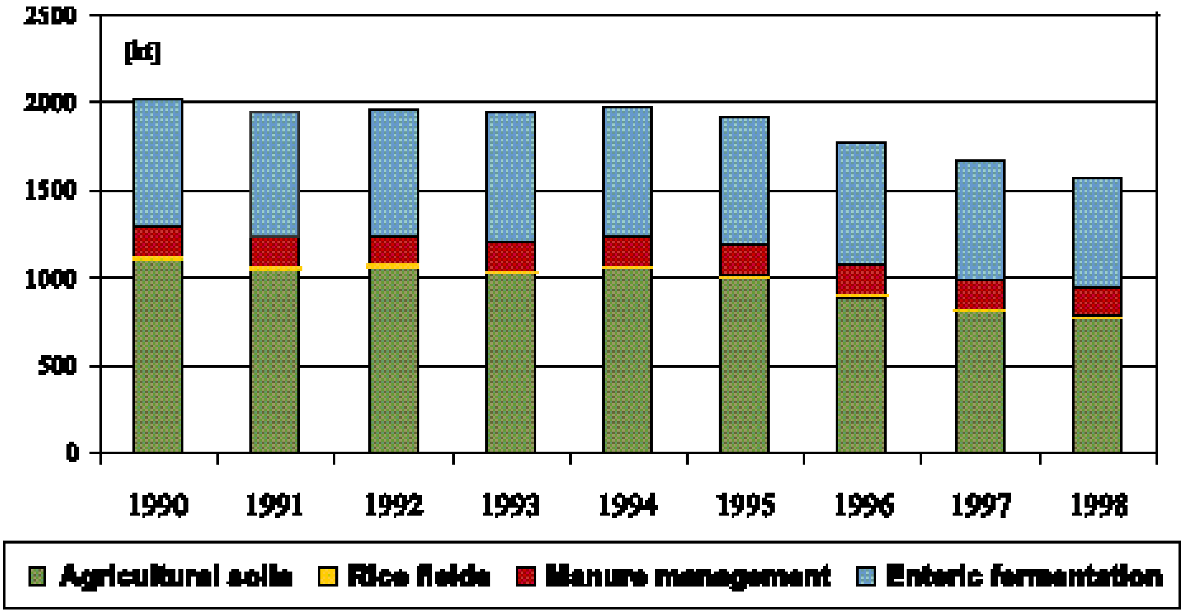



**Figure 4.3.** $CO_2$-eq emissions from the agriculture sector

**Table 4.9.** GHG emissions [kt] from the agriculture sector

| | Subsector | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|
| $CH_4$ | Enteric fermentation | 34,67 | 34,06 | 34,73 | 34,98 | 35,08 | 34,47 | 32,89 | 32,07 | 30,19 |
| | Manure management | 3,02 | 2,87 | 2,88 | 2,92 | 2,90 | 2,92 | 2,89 | 2,84 | 2,76 |
| | Rice fields | 0,45 | 0,43 | 0,42 | 0,26 | 0,09 | 0,06 | 0,21 | 0,26 | 0,22 |
| | Agricultural soils | | | | | | | | | |
| | **Total** | **38,14** | **37,36** | **38,03** | **38,16** | **38,07** | **37,45** | **35,99** | **35,17** | **33,17** |
| $N_2O$ | Enteric fermentation | | | | | | | | | |
| | Manure management | 0,38 | 0,37 | 0,35 | 0,35 | 0,37 | 0,37 | 0,38 | 0,38 | 2,49 |
| | Rice fields | | | | | | | | | |
| | Agricultural soils | 3,57 | 3,40 | 3,42 | 3,33 | 3,43 | 3,26 | 2,88 | 2,61 | 0,35 |
| | **Total** | **3,95** | **3,77** | **3,77** | **3,68** | **3,80** | **3,63** | **3,26** | **2,99** | **2,84** |
| $CO_2$-eq | Enteric fermentation | 728,07 | 715,26 | 729,33 | 734,58 | 736,68 | 723,87 | 690,69 | 673,47 | 633,99 |
| | Manure management | 181,22 | 174,97 | 168,98 | 169,82 | 175,60 | 176,02 | 178,49 | 177,44 | 166,46 |
| | Rice fields | 9,45 | 9,03 | 8,82 | 5,46 | 1,89 | 1,26 | 4,41 | 5,46 | 4,62 |
| | Agricultural soils | 1.106,70 | 1.054,00 | 1.060,20 | 1.032,30 | 1.063,30 | 1.010,60 | 892,8 | 809,10 | 771,90 |
| | **Total** | **2.025,44** | **1.953,26** | **1.967,33** | **1.942,16** | **1.977,47** | **1.911,75** | **1.766,39** | **1.665,47** | **1.576,97** |

## 4.4. LAND USE CHANGE AND FORESTRY (LUCF) SECTOR

GHG absorption and emissions from this sector are result of two processes, i.e. changes in biomass stocks, and conversion of forests and grassland.

**Changes in biomass stocks**
Input values for calculation of changes in biomass stocks, annual biomass increment and total carbon uptake increment are the area of forest/biomass stocks and the annual growth rate. Carbon fraction of dry matter is taken constant, equal to 0.5, being the same value for each type of trees, for all years of the analyzed period.

For estimation of total biomass removed, input data taken into account are the following: commercial harvest, total traditional fuelwood and other wood consumed. Biomass conversion/expansion ratios are calculated for each type of harvest categories, for all years of the analyzed period.

The results for the balance between absorption and emission are presented in table 4.10.

**Table 4.10.** $CO_2$ absorption and emission from changes in biomass stocks

| Year | Absorption [kt C] | Emission [kt C] | Absorption - emission [kt C] | Absorption - emission Conversion to $CO_2$ [kt] |
|---|---|---|---|---|
| **1990** | 820,45 | 415,37 | 405,08 | 1485,28 |
| **1991** | 851,38 | 414,08 | 437,30 | 1603,44 |
| **1992** | 867,20 | 413,96 | 453,24 | 1661,86 |
| **1993** | 867,94 | 405,21 | 462,73 | 1696,69 |
| **1994** | 868,92 | 389,52 | 479,40 | 1757,80 |
| **1995** | 863,09 | 371,05 | 492,04 | 1804,16 |
| **1996** | 845,17 | 359,29 | 485,88 | 1781,57 |
| **1997** | 855,03 | 254,11 | 600,92 | 2203,36 |
| **1998** | 875,61 | 264,01 | 611,60 | 2242,52 |

**Forest and grassland conversion**
Forest and grassland conversion causes loss of biomass which is calculated using the following input data: annually converted area and amounts of biomass before and after the conversion. In addition, when estimating $CO_2$ emissions, the amounts of the released carbon by on-site and off-site burning were taken into account. The summarized results for $CO_2$ emissions from forest and grassland conversion are given in the table 4.11. The total carbon released is taken as a sum of carbon released by burning and delayed emissions from decay.

**Table 4.11.** $CO_2$ emissions from forest and grassland conversion

| Year | Carbon emissions [kt C] | $CO_2$ emissions (kt $CO_2$) |
|---|---|---|
| **1990** | 22,81 | 83,64 |
| **1991** | 1,77 | 6,48 |
| **1992** | 37,18 | 136,31 |
| **1993** | 57,11 | 209,41 |
| **1994** | 22,97 | 84,22 |
| **1995** | 0,42 | 1,52 |
| **1996** | 3,88 | 14,24 |
| **1997** | 14,00 | 51,32 |
| **1998** | 7,48 | 27,44 |

**GHG absorption and emissions from the LUCF sector**
The annual amount of the released $CO_2$ by burning slightly reduces the amount of absorbed $CO_2$ by the forests. The balance is presented in table 4.12, while graphically the trends are displayed in figure 4.4. It should be noted that, in spite of its relatively low value, the absorption of $CO_2$ by the soil is counted within the balance.

**Table 4.12.** $CO_2$ [kt] from the LUCF sector

| Year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|
| Biomass (abs.) | 1.485 | 1.603 | 1.662 | 1.697 | 1.758 | 1.804 | 1.782 | 2.203 | 2.243 |
| Soils (abs.) | 62 | 62 | 62 | 62 | 62 | 62 | 62 | 62 | 62 |
| Burning and conv. (emiss.) | 84 | 6 | 136 | 209 | 84 | 2 | 14 | 51 | 27 |
| **Abs. emiss.** | **1.463** | **1.659** | **1.588** | **1.550** | **1.736** | **1.864** | **1.830** | **2.214** | **2.278** |

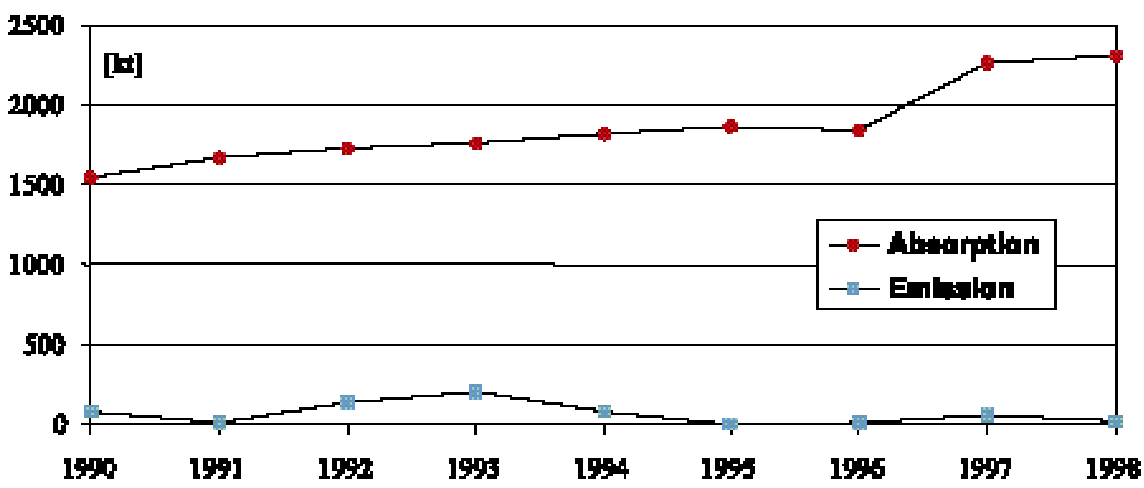



**Figure 4.4.** $CO_2$ from the LUCF sector

## 4.5. WASTE SECTOR

GHG emissions from the waste sector include mainly $CH_4$ emissions. In addition, this sector is accountable for $N_2O$ emissions from human sewage.

**$CH_4$ emissions from solid waste disposal sites**

For estimation of $CH_4$ emissions from solid waste disposal sites (SWDSs) the following input data are used: total municipal solid waste (MSW) disposed to SWDSs, $CH_4$ correction factor (MCF), fraction of degradable organic component (DOC) in MSW, fraction of DOC which actually degrades, fraction of carbon released as $CH_4$, conversion ratio, recovered $CH_4$ per year and $CH_4$ oxidation correction factor.

To estimate the total annual MSW disposed to SWDSs, the number of population whose waste goes to SWDSs (total persons) and the MSW disposal rate are needed. The weighted average MCF depends on proportion of waste which goes to each type of SWDSs (managed, unmanaged-deep, and unmanaged-shallow) and MCF corresponding to each type of SWDSs.

**$CH_4$ emissions from residential/commercial wastewater and sludge**

For estimation of residential/commercial wastewater and sludge the following input data are used: annual population, DOC and fraction of DOC removed as sludge.

To calculate the emission factors for wastewater/sludge in this subsector, values for fraction of wastewater/sludge treated by both types of handling systems - aerobic and anaerobic, are considered.

The calculated data for the above mentioned waste with emission factors are presented in table 4.13.

**Table 4.13.** Input data for residential/commercial wastewater and sludge

| Year | Residen./Commerc. wastewater [kt BOD] | Residen./Commerc. sludge [kt BOD] | Fraction of wastewater treated aerobically | Emission factor ($kgCH_4/kgBOD$) |
|---|---|---|---|---|
| 1990 | 35,160 | 1,850 | 0,60 | 0,10 |
| 1991 | 35,351 | 1,860 | 0,60 | 0,10 |
| 1992 | 35,646 | 1,876 | 0,65 | 0,09 |
| 1993 | 35,819 | 1,885 | 0,65 | 0,09 |
| 1994 | 33,583 | 1,767 | 0,70 | 0,08 |
| 1995 | 34,085 | 1,794 | 0,70 | 0,08 |
| 1996 | 34,380 | 1,809 | 0,75 | 0,06 |
| 1997 | 34,623 | 1,822 | 0,75 | 0,06 |
| 1998 | 34,814 | 1,832 | 0,75 | 0,06 |

**$CH_4$ emissions from industrial wastewater and sludge**

For estimation of $CH_4$ emissions from industrial wastewater and sludge, total wastewater and sludge from industrial sources are calculated. Input values for these calculations are total industrial output of: fertilizer, food and beverage, paper and pulp, petrochemicals and rubber. The table 4.14 summarizes the relevant data for this subsector.

**Table 4.14.** Input data for estimation of $CH_S$ emissions from industrial wastewater and sludge

| Year | Total industrial output [kt] | | | | | Wastewater [kt COD] | Sludge [kt COD] |
|---|---|---|---|---|---|---|---|
| | Fertilizer | Food and Beverage | Paper and Pulp | Petroche-micals | Rubber | | |
| **1990** | 99,873 | 306,220 | 12,697 | 1.172,740 | 3,627 | 52,299 | 4,174 |
| **1991** | 79,246 | 340,487 | 14,581 | 909,006 | 3,326 | 55,742 | 4,282 |
| **1992** | 65,470 | 320,365 | 12,962 | 545,079 | 3,276 | 50,331 | 3,745 |
| **1993** | 64,989 | 257,519 | 16,654 | 969,283 | 2,997 | 46,050 | 3,838 |
| **1994** | 68,827 | 287,799 | 13,456 | 157,470 | 2,139 | 58, 946 | 3,966 |
| **1995** | 45,762 | 259,701 | 13,456 | 109,958 | 1,154 | 30,711 | 2,543 |
| **1996** | 53,596 | 380,691 | 7,489 | 655,495 | 881 | 65,391 | 3,853 |
| **1997** | 45,677 | 471,943 | 7,035 | 348,891 | 719 | 55,547 | 3,191 |
| **1998** | 54,677 | 451,078 | 9,315 | 714,518 | 701 | 100,256 | 6,739 |

Emission factors which are not taken from the IPCC methodology are particularly analyzed and determined.

**$N_2O$ emissions from human sewage**

The required input data in this subsector are: number of population, per capita protein consumption, fraction of nitrogen in proteins and emission factors.

**Summarized GHG emissions from the waste sector**

First part of the table 4.15 contains $CH_4$ and $N_2O$ emissions from the waste sector. Second part of the table gives the emissions expressed in $CO_2$-eq, which are also presented graphically in figure 4.5.

**Table 4.15. GHG emissions [kt] from the waste sector**

| | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|
| $CH_4$ | Solid waste | 43,9 | 45,2 | 45,6 | 45,8 | 43,4 | 44,6 | 45,4 | 45,8 | 46,0 |
| | Residen./Commerc. wastewater and sludge | 3,6 | 3,6 | 3,2 | 3,2 | 2,6 | 2,7 | 2,2 | 2,3 | 2,3 |
| | Industrial wastewater and sludge | 1,4 | 1,5 | 1,4 | 1,3 | 1,6 | 0,8 | 1,7 | 1,5 | 2,7 |
| | Total | 48,9 | 50,3 | 50,1 | 50,3 | 47,6 | 48,0 | 49,4 | 49,5 | 51,0 |
| $N_2O$ | Human sewage | 0,5 | 0,5 | 0,5 | 0,5 | 0,4 | 0,5 | 0,5 | 0,5 | 0,5 |
| $CO_2$-eq | Solid waste | 922,1 | 948,8 | 956,8 | 961,4 | 911,4 | 935,6 | 954,2 | 961,0 | 966,2 |
| | Residen./Commerc. wastewater and sludge | 75,8 | 76,2 | 67,4 | 67,8 | 54,8 | 55,7 | 47,0 | 47,5 | 47,7 |
| | Industrial wastewater and sludge | 29,6 | 31,5 | 28,4 | 26,3 | 33,0 | 17,4 | 36,3 | 30,9 | 56,1 |
| | Human sewage | 142,6 | 145,7 | 145,7 | 145,7 | 136,4 | 139,5 | 139,5 | 142,6 | 142,6 |
| | Total | **1170,1** | **1202,2** | **1198,2** | **1201,2** | **1135,6** | **1148,1** | **1177,1** | **1181,9** | **1212,6** |

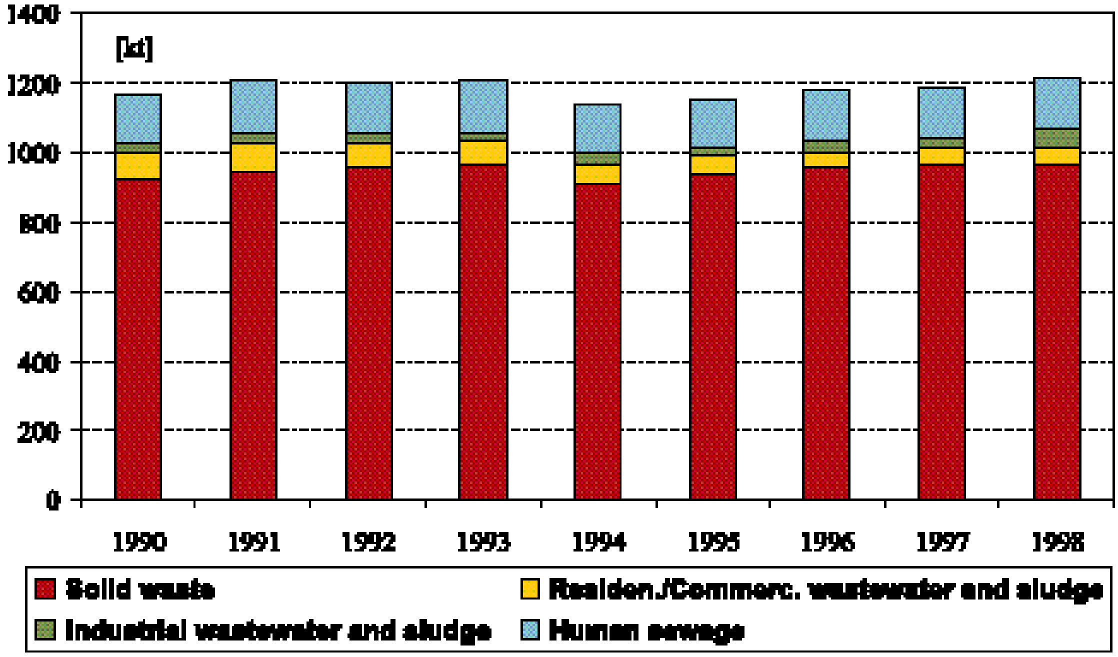



**Figure 4.5.** $CO_2$-eq emissions from the waste sector

## 4.6. INTEGRAL RESULTS

In the previous chapters, the process of data collection and the determination of conversion and emission factors for each sector defined within IPCC methodology were elaborated. Accordingly, the corresponding results of GHG emissions calculations for the sectors and subsectors were presented.

In this chapter the intensity of total GHG emissions is presented, with sectors ranked in accordance with their contribution to total emissions.

The first part of the table 4.16 contains the amounts of GHG emissions for each sector separately, as well as the total emissions for the period 1990 - 1998. The second part of the table 4.16 presents the absolute and percental values of $CO_2$-equivalent emissions for all sectors. These values are also graphically displayed in figure 4.6

As it can be seen in figure 4.6, GHG emissions exhibit decreasing trends within the industrial processes (by 35%) and agriculture (by 22%) sectors over the analyzed period, while in the LUCF sector the emissions are oscillating and in the waste sector they are invariable. An increase in the GHG emissions occurred only in the energy sector (by 6%). Comparatively, the share of the energy sector in the total GHG emissions is particularly high (almost 3/4), followed by the agriculture, waste, and industrial processes sectors (amounting to 10%, 8% and 7%, respectively), while the contribution of the LUCF sector is less then 2%. The decreasing trend of GHG emissions from the industrial process and agriculture sectors is due to the reduction of activities within the national economy over the observed period.

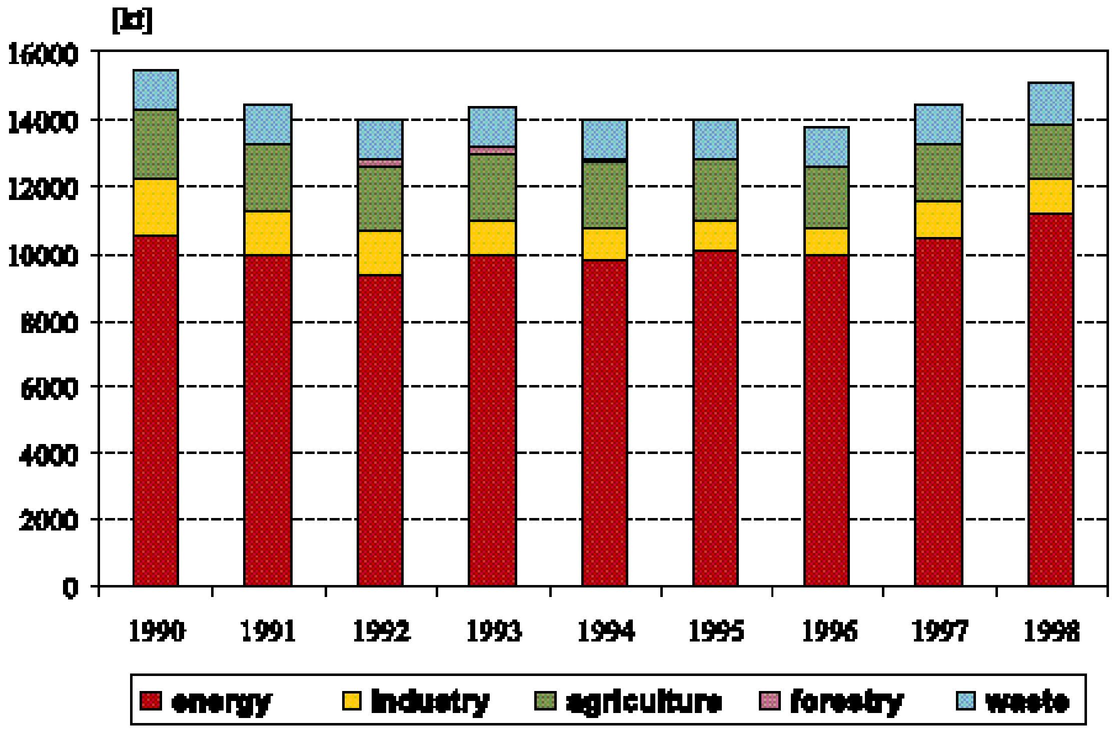



**Figure 4.6.** $CO_2$-eq emissions by sectors

The obtained results constitute a basic input for the follow-up GHG abatement analysis.

**Table 4.16.** GHG emissions [kt] by sectors

| Sector | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ | Energy | 8.769,96 | 8.234,05 | 7.727,42 | 8.227,08 | 8.016,41 | 8.244,52 | 8.160,77 | 8.591,50 | 9.189,06 |
| | Industrial processes | 1.561,86 | 1.299,22 | 1.236,26 | 1.049,91 | 888,84 | 796,98 | 841,94 | 1.038,60 | 995,32 |
| | Agriculture | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| | Forestry | 83,64 | 6,48 | 136,31 | 209,41 | 84,22 | 1,52 | 14,24 | 51,32 | 27,44 |
| | Waste | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| | **Total** | **10.415,46** | **9.539,75** | **9.099,99** | **9.486,40** | **8.989,47** | **9.043,02** | **9.016,95** | **9.681,42** | **10.211,82** |
| $CH_4$ | Energy | 84,67 | 78,75 | 76,74 | 78,73 | 82,96 | 85,64 | 81,89 | 86,68 | 93,98 |
| | Industrial processes | 0,01 | 0,01 | 0,01 | 0,01 | 0,01 | 0,01 | 0,00 | 0,00 | 0,00 |
| | Agriculture | 38,14 | 37,36 | 38,03 | 38,16 | 38,07 | 37,45 | 35,99 | 35,17 | 33,17 |
| | Forestry | 0,23 | 0,02 | 0,37 | 0,57 | 0,23 | 0 | 0,04 | 0,14 | 0,07 |
| | Waste | 48,93 | 50,31 | 50,12 | 50,26 | 47,58 | 48,03 | 49,41 | 49,49 | 50,95 |
| | **Total** | **171,98** | **166,46** | **165,27** | **167,72** | **168,84** | **171,13** | **167,34** | **171,48** | **178,17** |
| $N_2O$ | Energy | 0,15 | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 | 0,13 | 0,13 | 0,13 |
| | Industrial processes | 0,23 | 0,23 | 0,14 | 0,18 | 0,33 | 0,16 | 0,17 | 0,20 | 0,22 |
| | Agriculture | 3,95 | 3,77 | 3,77 | 3,68 | 3,8 | 3,63 | 3,26 | 2,99 | 2,84 |
| | Forestry | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| | Waste | 0,46 | 0,47 | 0,47 | 0,47 | 0,44 | 0,45 | 0,45 | 0,46 | 0,46 |
| | **Total** | **4,79** | **4,61** | **4,52** | **4,47** | **4,71** | **4,38** | **4,01** | **3,78** | **3,65** |
| $CO_2$-eq | Energy | 10.595,51 | 9.932,20 | 9.381,81 | 9.925,08 | 9.801,81 | 10.085,98 | 9.921,41 | 10.451,24 | 11.203,71 |
| | Industrial processes | 1.632,34 | 1.371,42 | 1.281,22 | 1.104,53 | 991,55 | 847,84 | 894,82 | 1.101,52 | 1.063,63 |
| | Agriculture | 2.025,44 | 1.953,26 | 1.967,33 | 1.942,16 | 1.977,47 | 1.911,75 | 1.766,39 | 1.665,47 | 1.576,97 |
| | Forestry | 88,47 | 6,90 | 144,08 | 221,38 | 89,05 | 1,52 | 15,08 | 54,26 | 28,91 |
| | Waste | 1.170,13 | 1.202,21 | 1.198,22 | 1.201,16 | 1.135,58 | 1.148,13 | 1.177,11 | 1.181,89 | 1.212,55 |
| | **Total** | **15.511,8** | **14.465,99** | **13.972,66** | **14.394,31** | **13.995,46** | **13.995,22** | **13.774,81** | **14.454,38** | **15.085,77** |
| $CO_2$-eq[%] | Energy | 68,31 | 68,66 | 67,14 | 68,95 | 70,04 | 72,07 | 72,03 | 72,31 | 74,27 |
| | Industrial processes | 10,52 | 9,48 | 9,17 | 7,67 | 7,08 | 6,06 | 6,50 | 7,62 | 7,05 |
| | Agriculture | 13,06 | 13,50 | 14,08 | 13,49 | 14,13 | 13,66 | 12,82 | 11,52 | 10,45 |
| | Forestry | 0,57 | 0,05 | 1,03 | 1,54 | 0,64 | 0,01 | 0,11 | 0,38 | 0,19 |
| | Waste | 7,54 | 8,31 | 8,58 | 8,34 | 8,11 | 8,20 | 8,55 | 8,18 | 8,04 |
| | **Total** | **100,00** | **100,00** | **100,00** | **100,00** | **100,00** | **100,00** | **100,00** | **100,00** | **100,00** |

chapter

# 5

CHAPTER 5

# GHG ABATEMENT ANALYSIS AND PROJECTIONS OF EMISSIONS

In $CO_2$ equivalent, the energy sector has shown to contribute with 70.04% (in 1994) within the total GHG emissions. This sector is followed by agriculture, waste, industrial processes, land use change and forestry which have a relatively low significance.

Preliminary results have shown that the order of importance of each sector practically is not changing. The sector of energy holds for the most superior GHG emitter, requiring the most extensive actions and measures for GHG abatement. For this reason, it is considered to be with the highest priority in abatement analysis, opening possibilities for the most effective measures for GHG emission reduction.

## METHODOLOGY

In accordance with the local conditions, availability of input data and previous experience of the working teams for each sector, the steps for performing abatement analysis have been defined. Particular attention has been paid to the energy sector, especially electricity production. In order to support the analytical work needed to carry out the overall assessment of the competitiveness of various scenarios for the future development of the electric power system, internationally recognized and standardized models WASP, VALORAGUA and OPTIM were used. The WASP model is a comprehensive planning tool for electric power system expansion analysis. The VALORAGUA model as well as OPTIM (internal originally improved model) are used to enhance the WASP analysis (concerning the hydro plants), being models for detailed simulation of a mixed hydro-thermal power system.

The WASP model is designed to find the economically optimal generation expansion policy for an electricity generation system with user-specified constraints. It uses probabilistic estimation of system's production costs, energy not served costs and reliability, and the dynamic optimization method for comparison of different alternatives for system expansion. The stochastic nature of the hydrology is treated by means of hydrological conditions, each defined by its probabilities of occurrence and corresponding available capacity and energy for each hydro plant. The energy generated by each unit in the system is calculated by probabilistic simulation. In that approach, the forced outages of the thermal plants are convoluted with the load duration curves, and the effect of unexpected outages of thermal plants are taken into account in a probabilistic way. In the WASP model the changing nature of the load from one year to another is taken into account by specifying the peak load for each year in the study.

Concerning the other sectors, no standard methodology for abatement analysis exists. The experiences of other countries are used. The proposed mitigation activities for each sector in the methodological guidelines “Economics of Greenhouse Gas Limitations” were investigated, determining the extent to which they could be applied in Macedonian conditions. In addition, some specific procedures for each sector were analyzed and applied.

The GHG emissions have been calculated following the IPCC methodology. The conversion rates being used to express equivalent $CO_2$ emission are: 21 for $CH_4$ and 310 for $N_2O$.

## 5.1. ENERGY SECTOR

Development of a baseline scenario commenced with energy sector, having the highest activity level. It has been analyzed by types of final energies:

- Electricity production
- Heat production
- Mechanical energy (for transport)

For each of these three types of final energies, requirements of certain fossil fuels (solid, liquid and gaseous) have been determined. In the expansion plans for the period 2001-2030 measures for GHG emissions abatement are incorporated.

### 5.1.0. RENEWABLE ENERGY SOURCES

The renewable energy sources reduce GHG emissions through substitution of the energy obtained by fossil fuel combustion.

**Hydropotential**
In the Republic of Macedonia there is a long-lasting tradition in utilization of the hydropotential, in ancient times for corn melting and over 80 years for operation of hydro plants for electricity production. For certain locations there are studies representing a conceptual project on technical and economic assessment of the new possible hydro plants. Presented analyses pay particular attention to hydropotential, since in the perspective energy sector development some concrete hydro plants- candidates for building are foreseen.

**Wind potential**
In the Republic of Macedonia there is no tradition in utilization of energy potential from the wind. So far no locations for wind plants have been determined. Also, there are not existing studies or analysis which point out some locations, and even worse is the situation with existence of technical and economical indicators required for building wind plants for electricity or other energy type production. However, there are some published materials reporting the measured values of the wind intensity, which shown to be low and unattractive from economical technical aspect. Consequently, until some more comprehensive studies regarding technical and economic potential of some locations are undertaken, it is not possible in this moment to include the wind potential in energy balance and energy sector development up to the year 2020.

**Geothermal potential**
Geothermal waters from the territory of the Republic of Macedonia cannot be used for electricity production. However, several decades the geothermal heat has been intensively used and there are some technical and economic experiences in building and usage of geothermal plants for obtaining heat from geothermal waters. At present, the contribution of the geothermal energy to the total energy consumption of the country is 0.5% (210,000 MWh/year) mainly in agriculture for greenhouse heating, and small part in space heating and hot water supply. There are projects for expansion of geothermal use from new sources on other applications. In the further analyses, proper attention should be paid to geothermal potential within planning and balancing the heat energy needs.

**Solar energy**

Solar energy potential can be used for direct conversion to electricity and for production of hot water. There is certain experience for both processes in the Republic of Macedonia, which indicates that so far activities are still not enough to result in favorable technical and economic indicators in the course of same more significant capacities. During the preparatory phase of the abatement, there are not conceptual projects or studies where the locations and technical and economic indicators of some solar electrical or heat plants are determined. Consequently, the extent of investigation of the solar potential is not enough to account for it within energy balances of electricity and heat. In order to change the situation and enable the most hopeful energy source to find its proper place in energy balances, it is necessary in the near future to realize proper studies, which will precisely determine the possibilities for building and operation of solar plants and solar collectors for hot water.

**Energy potential of biomass**

Biomass is a renewable energy source, because use of biomass as a fuel does not produce the greenhouse gases emission if the entire cycle is taken into consideration: wood stock increment, burning of the biomass and assimilation of $CO_2$. The wood carbon content is about 50 percent, and it is released during burning as $CO_2$, which is again fixed in biomass.

In the Republic of Macedonia, since ancient time wood has been used for heating of dwellings, which is the reason for paying proper attention to it within this research.

Stabilizing the economical operation of the animal facilities is of highest priority and prerequisite for perspective upgrading with energy facilities which would use the biological waste as biogas. To introduce this potential within the energy balance, proper studies are necessary to define the technical and economic parameters.

### 5.1.1. ELECTRICITY PRODUCTION

Until 1991 the Macedonian Power System was an integral part of the European Power Transmission System. At present, it is working isolated from the main portion of the UCTE network, connected only with the neighboring power systems on the Balkans. However, being the central area of the Balkans, where the transmission systems from the North to the South and from the East to the West are crossing up, Macedonian Power System will become an important part of the integral European system in a near future.

After independence, the electricity generation in Macedonia was on the level of its needs. Dominant contribution was by the thermal power plants with about 85%, the rest being covered by hydro plants. The import of electricity was on low level, based only on functional electricity exchange between the neighboring electric power systems.

For the period 1990-2000, due to the intensive transition processes in the national economy and politics, drop in the GDP growth rate occurred. This was a consequence of the disturbances in the large industrial companies, which resulted in intensive decrease of electricity consumption in the group of direct consumers. The stabilization process of the activities in the industry is still on, so that the establishment of correlation between growth rates of electricity consumption and GDP is impossible. This status does not influence the calculation of GHG emissions because the lignite fired thermal plants, which are the main emitters of GHG, have been operating at their maximum capacities in the past decade. In the future period, hydro plants and gas fired thermal plants with relatively low GHG emissions will be built.

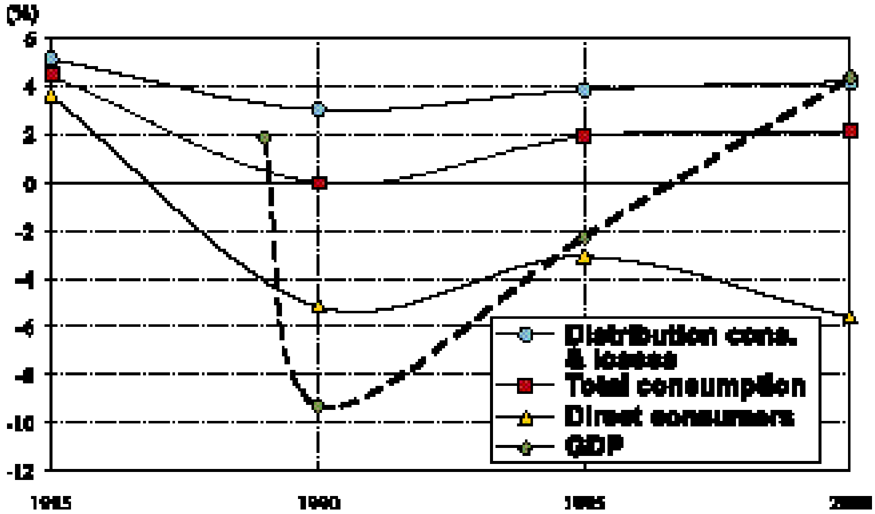



**Figure 5.1.** Annual growth rates for GDP and electricity consumption (Average values for five-year periods)

In the figure 5.1 (source: *National Development Strategy for Macedonia, Development and Modernization*) average values of the growth rates for GDP and electricity consumption for periods of five years are presented. The electricity consumption growth rates are given separately for distribution and direct consumers, as well as for the total consumption. From the figure 5.1 the influence of increase rate of direct consumption on GDP growth rate is evident and one can conclude that the process is not stabilized yet. In the period 1990-2000 GDP growth rate is constantly increasing, which is indicator for restructuring of industry from energy intensive to energy depressive.

### 5.1.1.1. BASELINE SCENARIO FOR ELECTRICITY PRODUCTION

For the electricity production planning the Macedonian Power System will be analyzed for the period 2001-2030. The annual increase of electricity production between 1994 and 1998 was about 4.1%. At the same time, the net electricity demand had an increase of 3.5% per year. There are no indications that this trend of increasing of electricity consumption will be reduced in the next period. The expected growth rate of national economy is an additional argument to that.

Nowadays, the electric power system in Macedonia has only three fossil fuel thermal power plants: Negotino, Oslomej and Bitola (three units), six large hydroplants and 15 small hydroplants. The operation time of the oil fired power plant Negotino in the period 1991-1998 was on a very low level. Both the electricity production and the very high capacity factors for the lignite fired power plants, show that the maximum production possibilities of mines and power plants have already been achieved.

The only possibility to increase the electricity production in the present system is provided by the oil-fired power plant Negotino. There is no other way of cheap electricity production in the existing thermal power plants. In addition to that, at the beginning of the 21$^{st}$ century, as a consequence of the exhaustion of lignite reserves, Macedonia has to start with activities for substitution of the existing thermal power plants. List of existing plants in the Macedonian power system together with their main characteristics is given in table 5.1.

**Table 5.1.** Existing Power Plants in the Macedonian Power System

| Thermal plants | | | |
|---|---|---|---|
| Name | Net capacity (MW) | Energy (GWh) | On-line year |
| 1. Negotino | 198 | 1200 | 1978 |
| 2. Oslomej | 109 | 720 | 1980 |
| 3. Bitola 1 | 207 | 1410 | 1982 |
| 4. Bitola 2 | 207 | 1410 | 1984 |
| 5. Bitola 3 | 207 | 1410 | 1988 |
| TOTAL | 928 | 6150 | |

| Hydro plants | | |
|---|---|---|
| Name | Net capacity (MW) | Energy (GWh) |
| 1.Vrben | 12,8 | 38,9 |
| 2.Vrutok | 150,0 | 317,3 |
| 3.Raven | 19,2 | 38,4 |
| 4.Globocica | 42,0 | 164,6 |
| 5.Spilje | 84,0 | 241,4 |
| 6.Tikves | 92,0 | 135,6 |
| 7.Small hydro | 41,0 | 92,8 |
| TOTAL | 441,0 | 1029,0 |

For the electricity system expansion planning, it is established planning period which starts with the year 2001 and ends with the year 2030. Electricity consumption of 7,000 GWh and peak load of 1,267 MW in the year 2001 is used, while the annual load demand growth rates were defined for 10 year time periods, i.e., 3.75% for 2001 through 2010; 3.25% for 2011 through 2020; and 2.75% for 2021 through 2030 (all growth rates are taken from the study "Energy Sector Development Strategy for Macedonia"[1].

The analysis was conducted on monthly intervals. The following input data and assumptions were used:

- LDCs (Load Duration Curves) have been prepared from the hourly loads for one year including pumping in six consecutive hours with minimum loads (for three cases: without pumping, pumping with Hydro Power Plant - HPP Galiste and pumping with both HPP Galiste and HPP Cebren). Note that the electricity production in the first and second mitigation scenario is bigger than in the baseline scenario for about 1 TWh/year or 5%, but the electricity consumption at the consumers is the same for all three scenarios. The 1 TWh increase is due to pumped storage plants operation, which are present in both mitigation scenarios. The pumped storage plants introduction reduces the need of thermal peak plants, which make them even more environmentally friendly.
- Probabilities of the three hydro conditions (dry, normal and wet) have been obtained processing the average monthly inflows of the hydro power plants for the period 1946-1996.
- Possibility of Import/Export is considered through the interconnection with the neighboring power systems introducing virtual thermal plant with peak power of 100 MW and production costs of 3c/kWh.

The existing hydropower plants and candidates were divided into two groups, HYD1 and HYD2, based on operating and maintenance costs. The HYD1 group consists of the existing hydro power plants: Globocica, Spilje, Tikves, Vrutok and Kozjak (under construction; on-line year 2002), as well as the hydro candidates: pump-storage plants Galiste and Cebren. The HYD2 group consists of the existing hydro power plants: Vrben, Raven, Matka 1 (reconstruction) and Matka 2 (under construction; on-line year 2004), as well as the candidates: Boskov Most, Veles and Gradec. The list of the hydro plant candidates is given in table 5.2.

[1] "Energy Sector Development Strategy for Macedonia", Research Center for Energy and Informatics of MASA, Electrotek Concepts, Skopje, 2000, prepared for: Ministry of Economy, USAID/ENI/EEUD/EI, Washington, D.C., USAID/Macedonia).

**Table 5.2.** Hydro plants candidates

| Name | Capacity (MW) | Electricity production (GWh) | Capital costs (M$) | Comments |
|---|---|---|---|---|
| Matka 2 | 33,2 | 53,0 | 39,4 | main project |
| Boskov Most | 45,0 | 155,5 | 54,6 | innovation of the main project |
| Lukovo Pole | 0,0 | 115,0 | 35,6 | solution for the border line with Yugoslavia |
| Galiste | 193,5 | 257,0 | 218,3 | Conventional hydroplants in the baseline scenario Pumped-storage hydroplants in the mitigation scenario |
| Cebren | 253,8 | 292,0 | 37,1 | |
| Veles | 93,0 | 301,0 | 251,1 | railway dislocation and environmental problems |
| Gradec | 54,6 | 252,4 | 156,8 | |
| **Total** | **673,1** | **1425,9** | **1092,9** | |

■ In the expansion planning analysis, the existing thermal power plants are grouped according to fuel type in order to identify and quantify its contribution to the expansion planning as well as their environmental performances. Group one consists of TPP Bitola 1, 2 and 3, group two is the TPP Oslomej and group three TPP Negotino.

■ Extensions of the existing mines: Oslomej West and Oslomej North - “Popovjani”, a new layer in Suvodol named “Podinski”, and Brod-Gneotino. For the new mines the old equipment will be transferred at the new locations and new will be added in a small portion. Import of lignite from Greece using the same conveyor belt of Brod-Gneotino will be possible.

■ No refurbishment of the equipment is considered for the usage of third type of fuel in the existing thermal power plants. The lignite fired thermal power plants in Bitola and Oslomej are capable to use liquid fuel up to 30% of their thermal capacities, but there is no direct railway connection for the fuel transport. Having in mind that the equipment in Bitola and Oslomej is in the second half of its lifetime, justifiability of such connection will be analyzed. In case of favorable conditions (low fuel price) for the use of liquid fuel it can be done in the thermal power plant Negotino which was not used at all in the past decade. The thermal power plant Negotino can use natural gas, but it has only 33% efficiency, which is significantly lower than 55% efficiency of the combined cycle gas plants. In addition, there is no gas pipeline connection to Negotino, for which additional investments are needed. That situation makes Negotino even worse compared to a gas plant with a combined cycle.

■ There are no thermal power plant candidates on domestic lignite or imported lignite, coal or liquid fuel because there are no new lignite deposits in Macedonia.

■ The list of the thermal plant candidates is given in table 5.3. It is taken into account reconstruction of existing thermal power plants during extended scheduled maintenance. In addition, three types of thermal power plants are selected as candidates for new facilities: CCC 180 - co-generation with combined cycle gas fired plant with average annual capacity of 180 MWe and efficiency of 60%; CC 270 - combined cycle gas fired thermal plant with installed capacity of 270 MW and efficiency of 57.6% and AP 600 - advanced nuclear plant with installed capacity of 600 MW and efficiency of 33.4%. For combined cycle power plants there exists a natural gas pipeline with a capacity of 800 million $m^3$/year, with the possibility for increasing its capacity to 1,200 million $m^3$/year. About 70 to 80% of the total capacity for electricity generation will be used.

**Table 5.3.** Thermal plants candidates

| Name | Capacity (MW) | Production costs ($/MWh) | Capital costs ($/kW) | Construction period (years) |
|---|---|---|---|---|
| CCC 180 | 180 | 25,6 | 600 | 3 |
| CC 270 | 270 | 26,2 | 582 | 3 |
| AP 600 | 600 | 8,0 | 2034 | 7 |

- An interest of 8% is used during construction for all candidates; two different discount rates: 4% for the domestic costs (capital costs, operating and maintenance costs, and fuel costs) and 10% for the foreign costs (capital costs). In addition, escalation rates for the operating and maintenance costs 1% is used and fuel costs escalation rates as follows: for lignite and oil 2% and for the gas 3%. It is applied foreign costs multiplier 1.5 and energy not served costs 0.50 USD/kWh. For the hydro plants candidates capital costs are mainly domestic, therefore for their discount rate the interest rate given by the domestic banks should be used, which is not bigger than 4%. (All interest and discount rates are taken from the study "Energy Sector Development Strategy for Macedonia".)

The electricity production for all plants in the baseline scenario is graphically presented in figure 5.2.

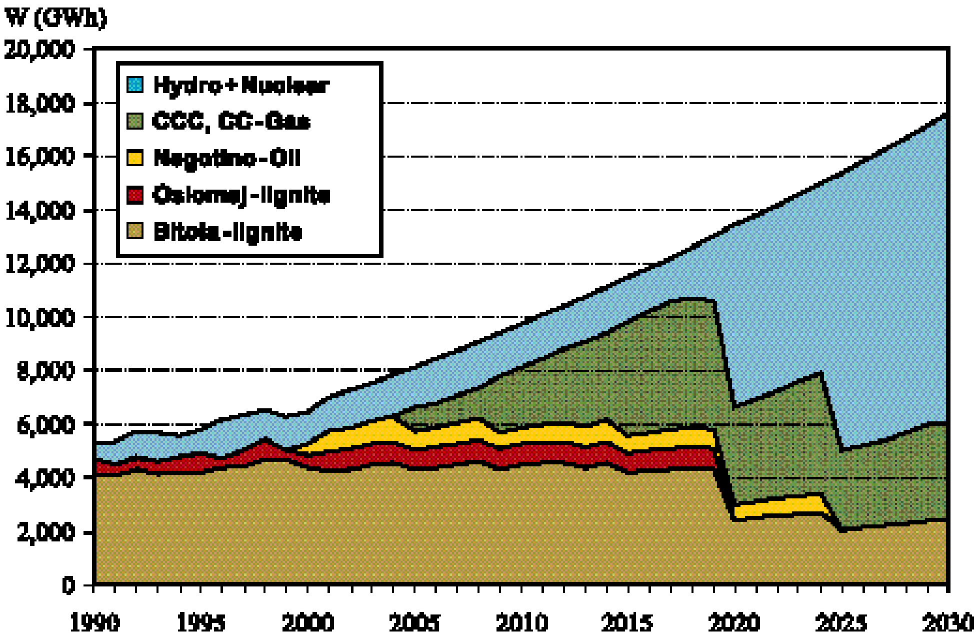



**Figure 5.2.** Electricity production by fuel types (Baseline scenario)

## 5.1.1.2. MITIGATION SCENARIOS FOR ELECTRICITY PRODUCTION

It is evident that in the Macedonian power system, nowadays and in the future, electricity production from thermal plants (lignite, gas and nuclear) will be dominant. In the interconnected systems of South East Europe (Albania, Bulgaria, Greece, Romania and Yugoslavia) thermal power plants are also dominant which is favorable condition for import of electricity and its usage for pumping in pump-storage plants.

### A. FIRST MITIGATION SCENARIO

At the first mitigation scenario for GHG abatement, it is proposed planned hydro plants Galiste and Cebren to be built as pump-storage plants. These two plants have good predisposition for such conversion into pump-storage plants and central position in the region.

Electricity production for all plants in the first mitigation scenario is graphically presented in figure 5.3. Besides the environmental benefits, the improvement of efficiency in the use of national hydropotential by transforming HPP Galiste and Cebren from classical into pump-storage, shifts their optimal introduction from the end to the first half of the study period. In this way, construction of gas fired plants is within the capacity of the existing gas pipeline and their introduction in the power system is delayed for a few years compared with the base case (classical HPP Galiste and Cebren), at the same time the need of nuclear power plants is postponed to the period after the year 2020.

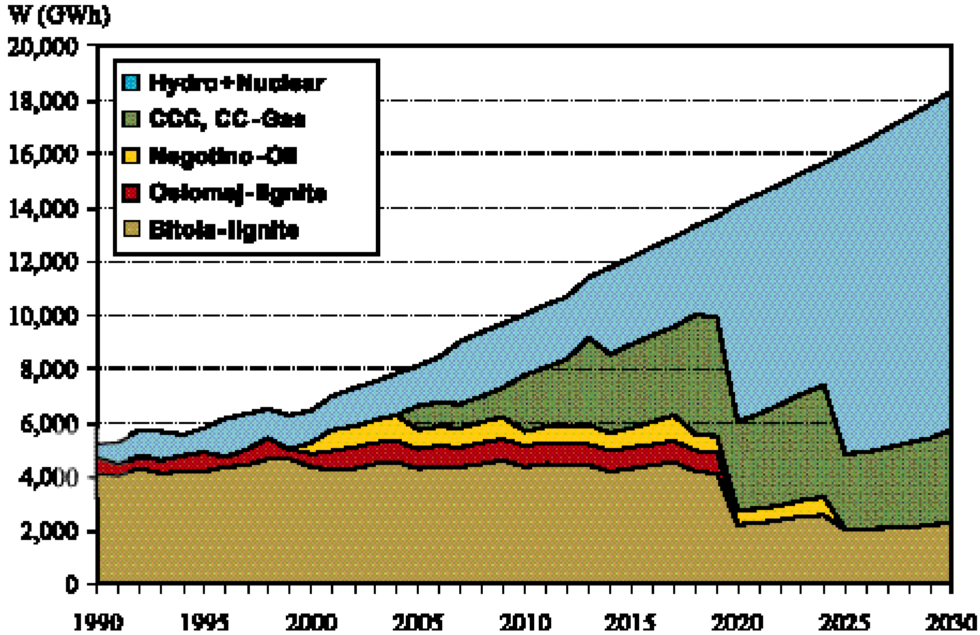



**Figure 5.3.** Electricity production by fuel types (First mitigation scenario)

**B. SECOND MITIGATION SCENARIO**

In the second mitigation scenario, beside transformation of HPP Galiste and Cebren from classical into pump-storage, the possible use of mixed fuel in the TPP Bitola and Oslomej is investigated. It is proposed to replace about 1/3 of the lignite with residual fuel oil, which can be done without additional adjustments since TPP Bitola and Oslomej are already capable to use such combination of fuels.

In addition, investments for the construction of a new railway for the residual fuel oil transport to all three units in Bitola amounting 200 $/kW were added.

Bearing in mind that in the last years significant changes in the national economy and energy sectors have occurred, a revision in this mitigation scenario is made. Firstly, the study period by two years is shortened, so that now it is 2003-2030. For the year 2001 real data are put and assume that the situation in the year 2002 will follow the predictions of the baseline scenario. The measures described in this mitigation scenario will start to be used from the year 2003.

In the past three years due to restructuring of the economy, especially in the biggest electricity consumers the metallurgy companies Fenimak and Jugohrom, there was no growth in electricity consumption considering the whole power system. There was an increase in other sectors for about 4% per year, mainly in the households, but that increase was cancelled by the industry failure. This situation enabled to shift the starting point of the electricity system expansion planning by two years, so 7000 GWh in the year 2003 is put, which is the same as in all previous scenarios, but the start is from the year 2003 instead from the year 2001. The corresponding peak load is 1,267 MW. In addition, new annual growth rates are defined: 3.5% for the period 2003-2010, 3% for the period 2011-2020 and 2.5% for the period 2021-2030.

Since in the past two years there has been a stagnation of Kozjak construction, it is not possible to count on Kozjak in the year 2002 as it was predicted in the baseline and first mitigation scenario. The hydro power plant Matka 2 which is intermediate plant in the cascade Kozjak-Matka 2-Matka1 is directly dependant on the Kozjak construction, so it can be put into operation at least two years after the Kozjak plant. For that reason, the on-line years specified for the hydro power plants Kozjak and Matka 2 are now changed to 2004 and 2006 respectively taking into account real possibilities for its constructions.

Concerning the gas plant with combined cycle and combined heat and power production, taking into account that there is still no firm decision for its construction, and even no financial plan, its on-line year is changed from 2005 to 2008.

All other economic parameters such as discount rates, fuel prices escalation rates, operation and maintenance cost and non-delivered energy cost are the same as in all other scenarios. Despite that, it is not going to make any economic comparisons with other scenarios, since the electricity consumption growth rates in this scenario are different, so abatement cost can not be defined. This scenario has more real conditions for its realization in practice.

The optimal expansion plan, along with the electricity production by plants are given in the figure 5.4.

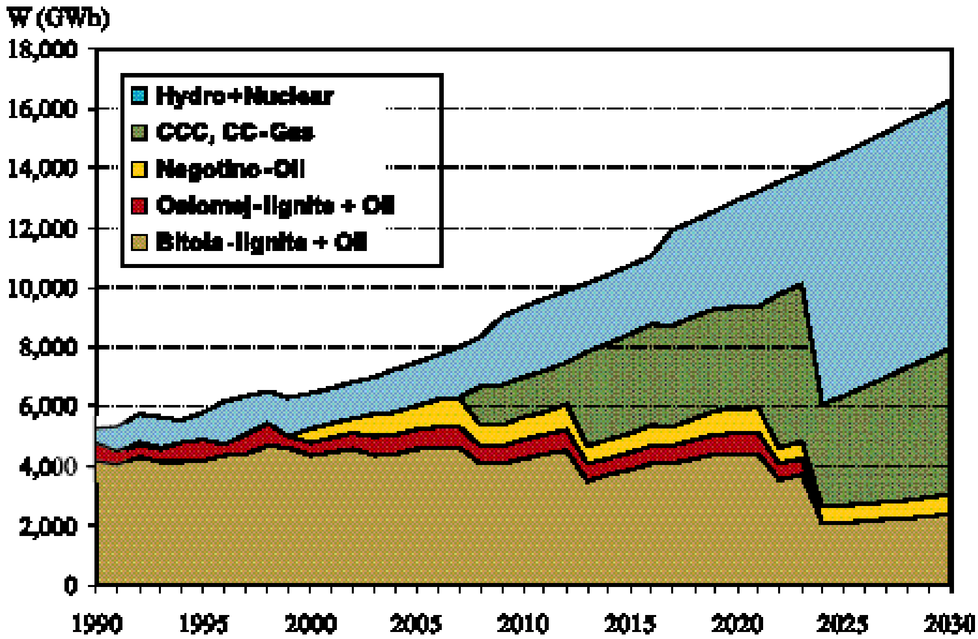



**Figure 5.4.** Electricity production by fuel types (Second mitigation scenario)

### 5.1.1.3. GHG EMISSIONS CALCULATION

Based on the result of the electricity system expansion planning, following the IPCC methodology the GHG emissions ($CO_2$, $CH_4$ and $N_2O$) are calculated for each of fossil fueled thermal plants for the baseline and both mitigation scenarios. The values of conversion and emission factors suggested in the IPCC methodology are revised. The factors for the liquid and gaseous fuels are suitable for Macedonia, so they are applied without modifications, while for the solid fuels they are calculated taking into account local conditions.

Fugitive emissions are consequence of the surface lignite mining for the electricity production, and they are calculated following the IPCC methodology using the lignite quantities, obtained from the electricity system expansion planning. Consequently, the reduction of these emission appears in those scenarios where less lignite usage is proposed.

In figure 5.5 the lignite consumption for electricity production is presented. It is evident that in the baseline and in the first mitigation scenario, the consumption is almost constant at a level of about 7.5 million tones for the period 1990-2020, afterwards a big drop (4 million tones) occurs as a consequence of shutdown of one unit in Bitola and Oslomej. On the contrary, in the second mitigation scenario, the lignite consumption is significantly lower (about 33% lower) due to mixed fuel used, leading to smaller fugitive emissions from lignite mining.

The residual fuel oil consumption presented in figure 5.6. in the period 1990-2000 is negligible, while later on in the baseline and in the first mitigation scenario it is oscillating between 150,000 and 250,000 tones with significant drops in the years when gas fired plants are to be introduced. After the year 2025 when thermal power plant Negotino will be shut down due to the end of the equipment lifetime (around 50 years), residual fuel oil will be used only as an additional fuel for the lignite fired plants. In the second mitigation scenario, as it was expected due to the mixed fuel used, residual fuel oil consumption is about three times bigger than in the other two scenarios, but it is still within the capacity of the oil refinery.

Having in mind that in the figures 5.5 and 5.6 a quantity of fuel is presented, it is possible for some years to have bigger fuel consumption in the mitigation that in the baseline scenario.

Natural gas (figure 5.7.) will be introduced in the electric power system in the year 2005 and its consumption constantly increases reaching the level of 800 million $m^3$ for the first mitigation scenario and even more for the baseline and second mitigation scenario in the years when three gas fired plants will be present in the electricity system. There are drops in the gas consumption in the years when nuclear plants eventually appear .

The main contribution is from solid fuels (lignite) both from direct $CO_2$ emission and $CH_4$ emission from lignite mining and handling, and it is evident that the second mitigation scenario has the least emissions mainly due to small fugitive emissions from lignite mining. For the liquid and gaseous fuels only $CO_2$ emission from fuel burning are comparable with the emissions from the solid fuels, while the $CH_4$ and $N_2O$ emissions are completely negligible.

In order to see the overall environmental performance of the national electric power system, the specific $CO_2$ emission in terms of kg per kWh produced is presented (figure 5.8). The specific emissions are constantly decreasing reaching the level of 0.25 kg/kWh in the year 2030 which is five times less then the present emissions and almost six times less then the emissions in the year 1990. These emissions are lower in the first mitigation scenario compared to the baseline scenario, and significantly lower, for about 33% in the second mitigation scenario.

In figure 5.9 total emissions for all electricity production scenarios are compared. It is evident that only in the second mitigation scenario, the emission levels in the period 2001-2020 could be maintained at a level approximately the same as the emission level from the year 2000. It is recommended this scenario to be followed toward environmental friendly power system.

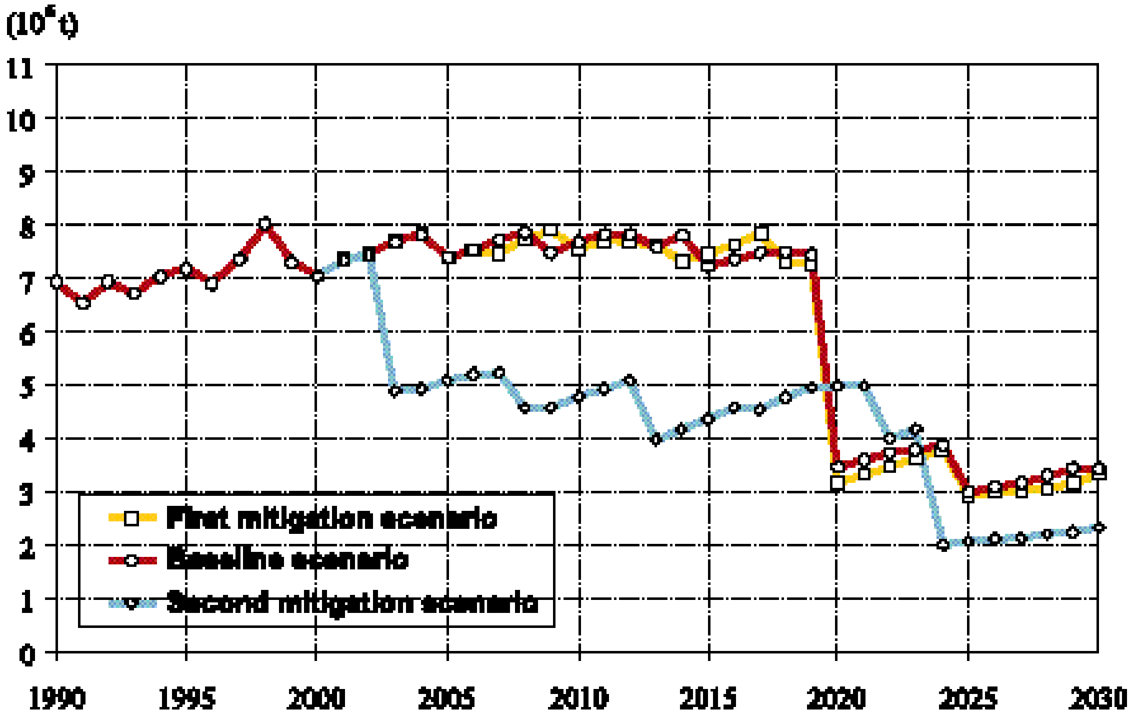



**Figure 5.5.** Lignite consumption for electricity production

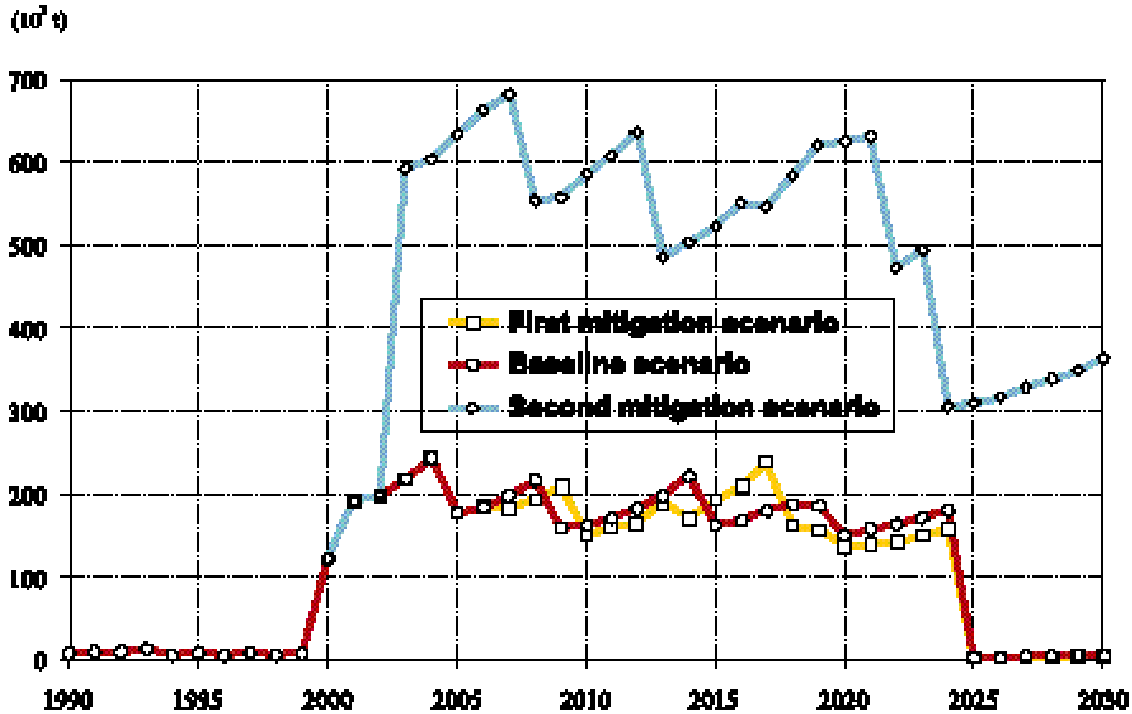



**Figure 5.6.** Residual fuel oil consumption for electricity production

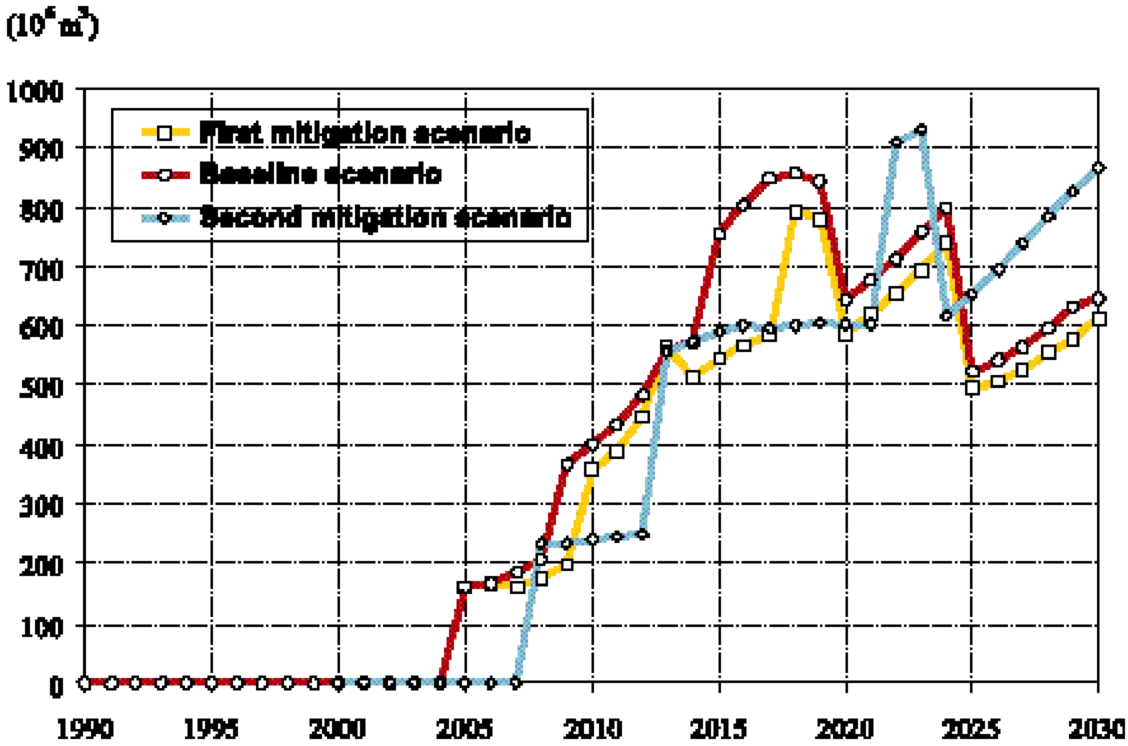



**Figure 5.7.** Natural gas consumption for electricity production

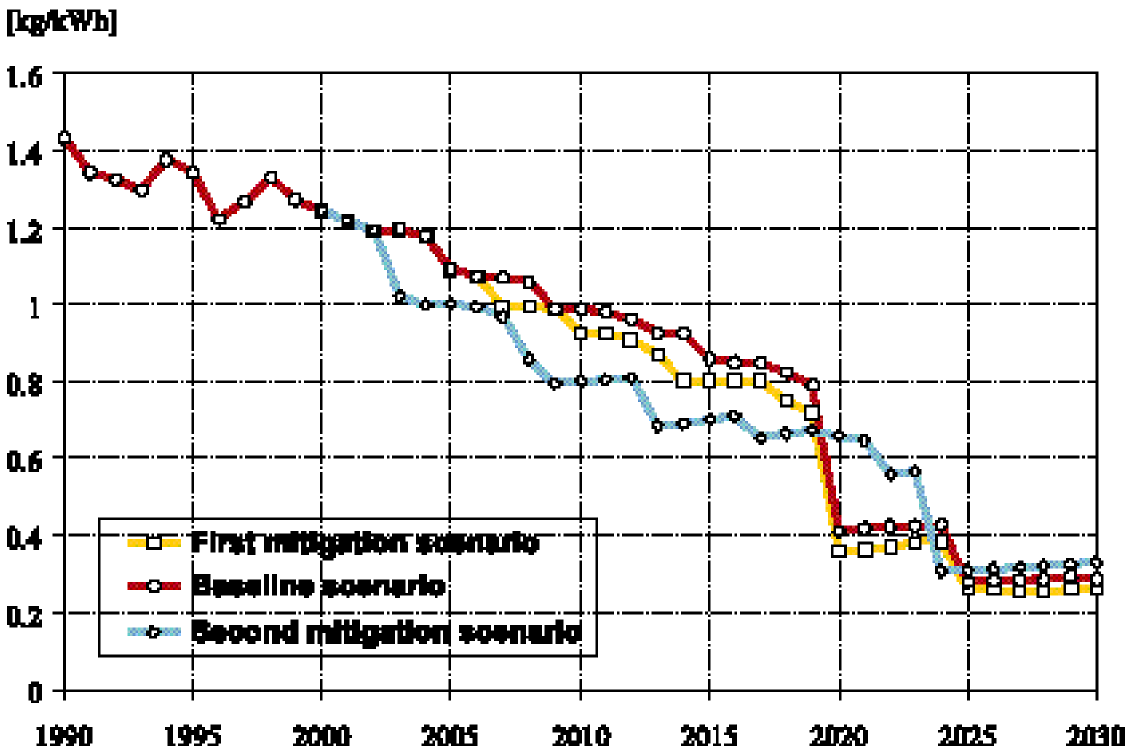



**Figure 5.8.** Specific $CO_2$-equivalent emissions from electricity production

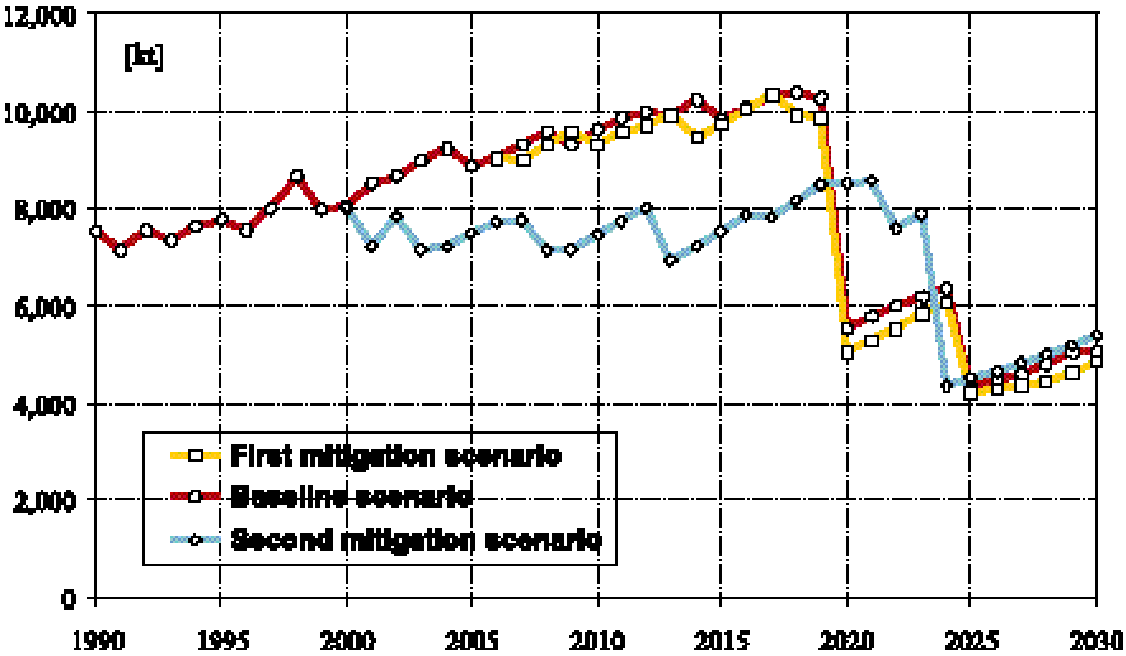



**Figure 5.9.** Equivalent $CO_2$ emissions from electricity production (all scenarios)

In table 5.4 the total equivalent emissions and costs for all scenarios as well as abatement cost are given.

For the period 2001-2020 the first mitigation scenario has 3,370 kt less emissions, but it is 20.258 million dollars more expensive then the baseline scenario, so that the abatement cost is 6.01 \$/t $CO_2$-eq. which is acceptable. The second mitigation scenario has 34,812 kt less emission, and it is 784.247 million dollars more expensive then the baseline scenario, so that the abatement cost is 22.53 \$/t $CO_2$-eq. On the other hand, comparing the scenarios for a longer period (2001-2030), when contribution of the new hydro plants is significant and their investments valorized in a longer period, the first mitigation scenario has 6,491 kt less emissions and it is even 81.787 million dollars cheaper than the baseline scenario. In this case the abatement cost is negative and amounts -12.06 \$/t $CO_2$-eq. For the same period, the second mitigation scenario has 24,454 kt less emissions, but it is 1,177.799 million dollars more expensive than the baseline scenario, leading to abatement cost of 48.16 \$/t $CO_2$-eq. The high abatement costs for the second mitigation scenario can be explained by the higher fuel prices for the TPP Bitola and Oslomej, and suppressed use of nuclear plants.

**Table 5.4.** Abatement costs

| Period 2001-2020 | Total $CO_2$-eq. emissions (kt) | Total system costs ($10^3$\$) |
|---|---|---|
| Baseline scenario | 187,644 | 4,615,040 |
| First mitigation scenario | 184,274 | 4,635,298 |
| Difference | 3,370 | -20,258 |
| Abatement costs | 6,01 \$/t $CO_2$-eq. | |
| **Period 2001-2030** | **Total $CO_2$-eq. emissions (kt)** | **Total system costs ($10^3$\$)** |
| Baseline scenario | 240,241 | 6,805,029 |
| First mitigation scenario | 233,751 | 6,723,242 |
| Difference | 6,491 | 81,787 |
| Abatement costs | -12,60 \$/t $CO_2$-eq. | |

### 5.1.1.4. ABATEMENT RECOMMENDATIONS FOR ELECTRICITY PRODUCTION

Following the findings of the research presented in this report, it can be concluded that significant reduction in fossil-fueled plants construction is possible through forced construction of pumped storage hydroplants. The conversion of certain classical hydroplants into pumped storage can cover the electricity needs without additional increase in fossil fuel consumption. The reduction of GHG emissions from the existing fossil-fueled plants can be realized with the introduction of residual fuel oil as a secondary fuel. This measure is economically justified as well, since it ensures long-term fuel supply of the existing thermal plants and reduces the investments for new plant construction.

By the undertaken analyses, the thermal power plants candidates are using natural gas with high efficiency, so that they have low specific GHG emissions. The nuclear option, which both economically and technically may become attractive after the year 2020, is the best solution concerning the GHG emissions. In the planning period, up to the year 2030, beside the hydropotential the other renewable resources will not have significant contribution in the electricity production.

In all analyses, mitigation measures are incorporated in the power system development strategies taking into account technical and economical criteria, that is why additional activities and financial means are not necessary. The analyses show that the proposed measures are with substantial environmental benefits and most economical ones at the same time. That kind of approach is applied for the other forms of finally used energy.

### 5.1.2. HEAT PRODUCTION

The primary-energy sources consumption for heat production over the period 1990 – 2000 have been analyzed, in order to identify the dynamics in heat production. In the early years of the transition process in Macedonia the decline in industrial production had significant implications in the heat consumption.

The Annual Growth Rate ranged from –33% to 110 % depending on the energy sources and the economic disturbances in the analyzed period. Nevertheless, between 1997 and 2000, the tendency of increasing the heat production by an estimated average of 3,77% is evident.

Looking at the present primary-energy sources consumption pattern, it can be noticed that residual fuel oil is a major contender, supplying about 47% of primary-energy for heat production. Next, gas/diesel oil supply is around 19%, wood 14%, natural gas 7%, LPG 6%, coal 4% and geothermal 2%. This means that current fossil fuel supply is about 84 % of the primary-energy used for heat production in Macedonia.

At present, coal used for heat production represents less than 2% of coal production in Macedonia, and therefore the coal resources for heat production can be considered as unlimited. The natural gas used for heat production represents 7% of the gas pipeline capacity of about $800 \cdot 10^6$ $Nm^3$ per annum and 4,5% of the gas pipeline capacity of $1200 \cdot 10^6$ $Nm^3$ per annum. The liquid fuels (Residual Fuel Oil, Gas/Diesel Oil and LPG) used for heat production represents about 49% of the overall liquid fuels consumption in Macedonia and around 18% of the OKTA Refinery capacity.

### 5.1.2.1. BASELINE SCENARIO FOR HEAT PRODUCTION

The scenarios for heat production sub sector are based on the findings from the baseline electric energy production scenarios (presented in chapter for GHG Inventory of this report), published forecasts of the economic and energy development (documents: “*Possibilities for Development of the Energy Sector in the Republic of Macedonia over the period of 1996 – 2020”*, and *“Participation of Oil and Oil Product in Energy System of the Republic of Macedonia”*) and expert investigations.

The heat production projection until 2030 is made within the “pessimistic” and “optimistic” variant of energy sector development with an average annual growth rate for oil and oil products in energy system of 3.7% and 4.1% respectively. An average growth of gross domestic product in industry of 6% over the period 2000/2010 and 8% over the period 2010/2020 is predicted according to the Strategy for Economic Development in the Republic of Macedonia until 2020.

Contribution of different primary-energy sources for heat production are based on the findings for 2000 and the average annual growth rates for the different primary-energy sources are adjusted with the mentioned studies above.

The annual consumption growth rates for different fuels are based on the expected demand for heat. But in the current political and economic situation in Macedonia any further division in the analysis leads up to more uncertainty than information and can cause significant inaccuracies.

The resources of the natural gas for heat production are based on the results of the baseline electric energy production scenarios and the gas pipeline capacity of $1200 \cdot 10^6$ $Nm^3$ per annum.

*GHG emissions calculation (Baseline scenario)*

The GHG ($CO_2$, $CH_4$ and $N_2O$) emissions have been calculated by using the same methodology and the values of the conversion and emission factors used for the electric energy production sub-sector. $CH_4$ emission from lignite mining and handling is included also. Figure 5.10 shows $CO_2$ – equivalent emissions from heat production by fuel types.

### 5.1.2.2. MITIGATION SCENARIOS FOR HEAT PRODUCTION

#### A. FIRST MITIGATION SCENARIO

The scenarios for heat production sub sector are based on the findings from the mitigation electric energy production scenarios, published forecasts of the economic and energy development and own investigations. Contribution of different primary-energy sources for heat production are based on the findings for 2000 and the Average Annual Growth Rates for the different primary-energy sources are adjusted with the above mentioned study.

- Two general mitigation measures regarding to the control of the GHG emissions from heat production are taken in the analysis:
- Reduction of the heat consumption, and
- Improvement of the fuel structure to a less polluting one.

Since the emission of the GHG is proportional to the consumed fuel for heat production, basic reduction of the GHG emission can be achieved by reduction of the heat consumption. The average growth of heat production over the period 2000/2030 from 3.77% in the baseline scenario is reduced to 3.14% in the mitigation scenario. That leads up to reduction of the primary-energy sources consumption for heat production in 2030 from 77,111 TJ in the baseline scenario to 64,297 TJ in the mitigation scenario, or reduction of the primary-energy sources consumption for heat production in 2030 for 17%. This reduction can be achieved by implementation of economic instruments for restructuring of industry from energy intensive to energy depressive in the analyzed period, basically by increasing of the energy cost and introduction of emission taxes. Reduction of the heat energy consumption for buildings heating can be achieved by improvement of the standards concerning the building construction including the insulation.

A natural gas pipeline of $800 \cdot 10^6$ $Nm^3$/year capacity exists in Macedonia with the possibility to increase up to $1200 \cdot 10^6$ $Nm^3$/year. In the year of 2001, the natural gas consumption represents only 4.5% of the gas pipeline capacity of $1200 \cdot 10^6$ $Nm^3$ per annum. From the economic point of view the tendency of increasing the natural gas consumption for heat production with an average annual growth higher than for the other fuels is expected without additional actions at a policy level. Very high Average Annual Growth Rate in the period 2000 - 2005 is expected due to the very low level of the natural gas consumption in the 2000.

Due to the limited gas pipeline capacity (maximum $1200 \cdot 10^6$ $Nm^3$ per annum), the consumption of the natural gas for heat production depends on the consumption of the gas for electric energy production and so the scenarios for heat production directly depend on the electric energy production scenarios.

The GHG emissions have been calculated by using the same methodology and values used for the electric energy production sub-sector. The Figure 5.10 shows $CO_2$ - equivalent emissions from heat production by fuel types.

### B. SECOND MITIGATION SCENARIO

The second mitigation scenario for heat production sub sector is based on the second mitigation electric energy production scenario. The forecast of the total energy consumption for heat production is same for all of the heat production mitigation scenarios. Also the consumption of all the primary-energy sources, except for the natural gas and residual fuel oil are same for all of the heat production mitigation scenarios. The resources of the natural gas for the heat production are limited by the gas pipeline capacity of $1200 \cdot 10^6$ $Nm^3$ per annum and the natural gas consumption for electric energy production. If more energy is needed the remainder is obtained by residual fuel oil combustion. It has been supposed that the large heat production units will alternatively use natural gas or residual fuel oil.

Figure 5.10 shows $CO_2$ – equivalent emissions from heat production by fuel types.

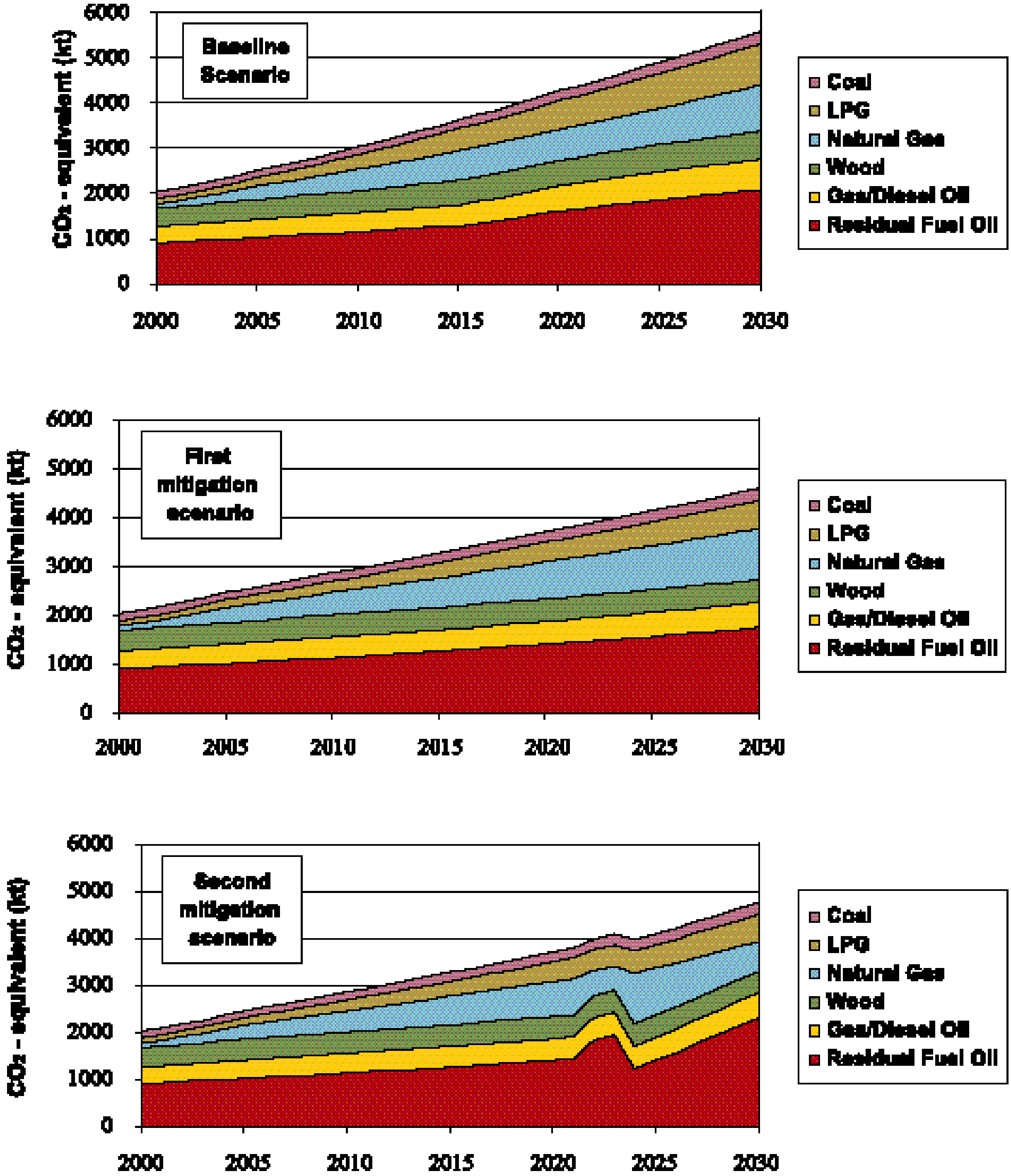



**Figure 5.10.** $CO_2$ – equivalent emissions from heat production by fuel types

The $CO_2$ equivalent emissions for the baseline and mitigation scenarios are compared in Figure 5.11. The figure 5.11 shows the $CO_2$ equivalent emissions from the combustion of all fuels. The specific $CO_2$ equivalent emissions in tons per TJ used for heat production is also given. It can be seen that the specific emissions decrease in all of the analyzed scenarios. It can be also concluded that there are not considerable differences in the $CO_2$ equivalent emissions between the analyzed mitigation scenarios for heat production. Consequently, the conclusion concerning the superiority of the analyzed mitigation scenarios depends on the findings from the mitigation electric energy production scenarios.

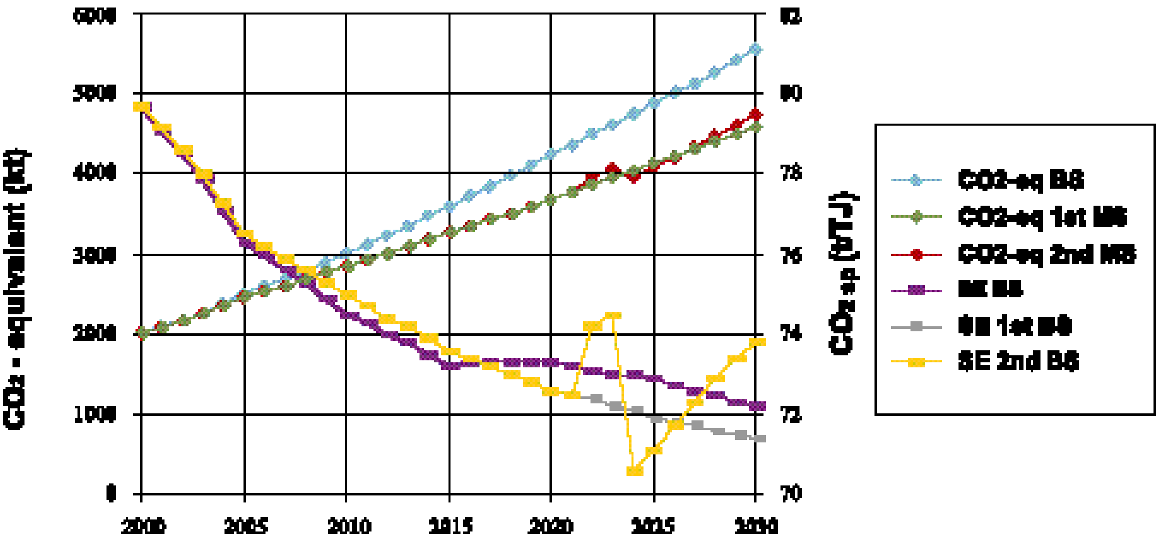



**Figure 5.11.** $CO_2$ -equivalent and specific $CO_2$ -equivalent (SE) emissions for the baseline (BS) and mitigation ($1^{st}$ MS and $2^{nd}$ MS) scenarios

### 5.1.2.3. ABATEMENT RECOMMENDATIONS FOR HEAT PRODUCTION

Nowadays, the introduction of natural gas as a fuel for heat production is going very rapidly. In the first phase of the natural gas penetration in the energy sector, replacements and reconstruction of the equipment took place with main accent on efficiency increasing, which reduces the GHG emissions. This reduction will be more important when the use of natural gas for electricity production will start. For both electricity and heat production the limited capacity of the existing gas pipeline should be taken into account.

Having in mind that the district-heating network covers only a part of Skopje, its extension is recommend to the other parts of the city, as well as to other towns in Macedonia. This will enable more efficient heat production and significant GHG emission reduction. Significant investments will be required to support such activity.

In the sector of heat production, the proposed measures are environmentally, technically and economically acceptable. Their realization is based upon necessary introduction of the natural gas in the energy sector, so that additional financing is not required. The environmental benefits are inevitable with the natural gas introduction.

### 5.1.3. TRANSPORT

According to the undertaken analysis, the transport sector contributes with 8.76% of all emissions of $CO_2$ in Macedonia in 1994.

Macedonia is a crossroad of two important European transport corridors, i.e. north-south and east-west. It is to be expected that the transit transport through Macedonia will arise significantly after the stabilization of conditions in the Balkan region and the completion of the construction of the Macedonian motorway network.

The Republic of Macedonia has relatively well-developed road transport infrastructure. In 1996 the total length of roads was 9,623 km, main roads 909 km and regional 3,058 km. The total number of registered road vehicles in 1998 was 330,155, of which 288,678 cars, that means 144.4 cars/1000 inhabitants.

There are two airports in Macedonia, Skopje with overall 5864 flights in 1998, and Ohrid with 514 ones. The total rail length in the country is 699 km, where 33.3% is electrified. Since the Republic of Macedonia is a landlocked country, the share of the water transport is very symbolic.

Due to the low level of public rail and bus transport, the car traffic permanently grows at the expense of public transport. The highest rate of growth was indicated in the use of urban car traffic. The volume of freight traffic on roads has a substantial share of total transport. Regarding to the year of production of vehicles, the condition is unfavorable.

**Structure of the motor vehicles by year of production on 31/12/1998**

| Before 1990 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|
| 235.450 | 13.940 | 14.545 | 5.870 | 4.889 | 9.799 | 13.953 | 13.247 | 8.234 | 6.661 |

### 5.1.3.1. IDENTIFICATION OF THE KEY OBJECTIVES FOR REDUCTION OF GHG EMISSIONS

Since the emissions of $CO_2$ are proportional to the quantity of the consumed fuel, the basic strategies toward reduction of these emissions from the transport sector have been aimed at the reduction of the fuel consumption. This reduction can be achieved in several different ways:

- Reduction of vehicle-kilometers
- Energy - efficiency improvements of the vehicles
- Vehicles that use alternative energy sources.

Taking into consideration the objectives to the mitigation of the GHG emissions, specific objectives, measures and actions will be identified in the following text. The definition of these objectives have been based on own research, as well as on the results of the project:*" Approach to the problem of transport and environment: Planning, Economic and Legal Aspect"*. In addition, these objectives are in compliance with the recommendations issued by the European Commission trough its Phare Multi Country Transport and Environment Program Unit.

### 5.1.3.2. MODELING THE LEVEL OF $CO_2$ EMISSIONS

In general, there are varieties of models for estimation of the levels of emission from motor vehicles. Given the purpose of this project, as well as the availability of the data, the IPCC approach (Tier 1) has been considered as the most suitable model for GHG inventory analysis in Republic of Macedonia. An exemption of this approach has been made in case of the GHG emission estimation from the air transport mode.

The estimates of the GHG emissions from the railway transport are related to the operation of diesel locomotives on the sections of the railway network that is not electrified. Compared to the emissions of the road vehicles, these quantities can really be neglected.

### 5.1.3.3. GHG ABATEMENT - BASELINE SCENARIO

**Road transport**

It is well-known fact that the change of rate of vehicle ownership over a longer period follows an S – shaped curve. This is because the number of vehicles increases slowly during the period of initial motorization, then it begins to increase rapidly, and finally it reaches the period of saturation. If the rate of vehicle ownership is expressed as number of vehicles per 1000 inhabitants, then its saturation rate takes values between 450 and 700 depending on the specific factors of each country. The Republic of Macedonia should reach a saturation value at approximately 450 vehicles per 1000 inhabitants.

An assumption has been made that Macedonia will return to its economic development with a rate of growth of 4% per year (“Possibilities for development of the energy sector in the Republic of Macedonia over the period of 1996 - 2020") which will cause a return of the trend of the rate of vehicle ownership to its initial curve, in 2003 (optimistic scenario) or in 2007 (pessimistic scenario). The values of the rate of vehicle ownership combined with the projected population can be used to predict the number of vehicles.

The predicted total number of vehicles in Macedonia is shown in figure 5.12.

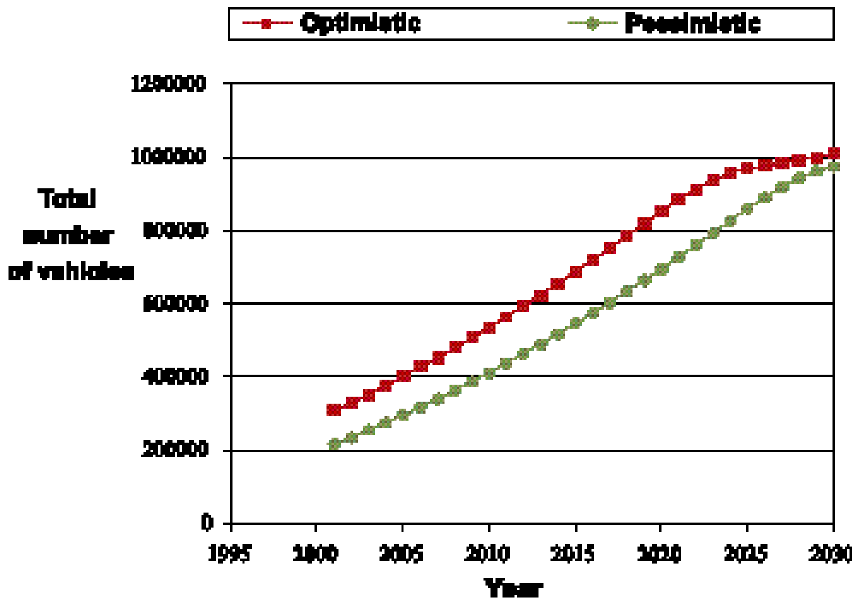



**Figure 5.12.** Prediction of the total number of road vehicles

In order to estimate the quantity of gasoline expected to be consumed by the road transport by year 2030, in addition to the forecast results and statistical data, several other assumptions have been made. It is assumed that the average annual distance traveled by a car would increase by 2% per year, thus reaching the value from 10000 km/year/vehicle in 2001 to 17500 km/year/vehicle in 2030. In addition, it is assumed that there are about 30% of diesel and 70% of gasoline passenger cars.

In the baseline scenario annual increase rate of 5%, defined by the experts following the forthcoming expected growth of vehicle ownership, was used. This yields to 5-time greater emissions in the year 2030, but taking into account that the period analyzed was 2001-2020; in the year 2020 the emissions will be 3-time higher.

### Air transport

The general trend of fast growth of air travel in Macedonia has been noticed. Since 1990, the air travel from the airports in Skopje and Ohrid has increased several times.

Nevertheless, the best forecast that can be done at this moment is to assume that the average annual increase of the number of passengers and number of operations at the airports will be kept reasonably stable over the period of forecast. In the case of the Skopje airport, the trend analysis has shown that the average annual increase of the number of airport operations (take-offs plus landings) is about 1566 operations per year (or about 4 per day in average). The same increase for the Ohrid airport is 164 per year (or about 0,45 per day in average). These figures have been checked for the capacity of the airports at the horizon year. This trend analysis is given in Figures 5.13.

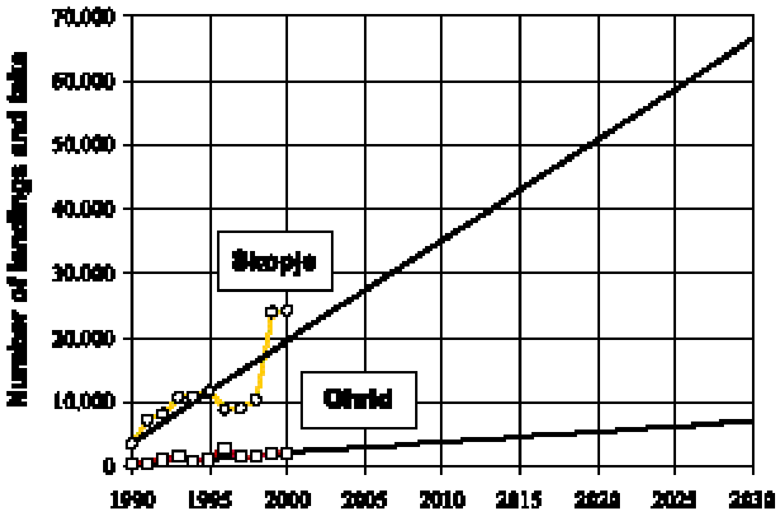



**Figure 5.13.** The trend of the annual number of operations at the Skopje and Ohrid airports

## 5.1.3.4. GHG ABATEMENT – MITIGATION SCENARIO

Since the transport system is such a complex system, the transport-related problems, including those of environmental nature, can be addressed only by developing a system approach to those problems. This requires a well-planned and coordinated national policy.

***Mitigation measures in the road transport***

The experience from the developed countries has shown that it is very difficult to make even small progress in this direction. As it has been mentioned above, there are three ways to reduce GHG emissions from the transport sector.

The measures listed within the first group are the most difficult to implement, since they require a system approach to the problem. There have been no studies in the country that will relate the implementation of such measures to the decrease of the pollution. One national study in the Netherlands suggests that measures like promotion of public transport and bicycling, introduction of tolls, increased fuel taxes, all combined together, can lead to a reduction of about 15% of the existing vehicle-kilometers.

Mitigation measures from the second group are easier to implement, since the vehicle industry itself is making efforts to increase the efficiency and to reduce the pollution from vehicles. In this case, the country should find a way to support replacement of old vehicles by new ones. Within this project, an assumption will be made that the existing old vehicles will be gradually replaced by new ones that consume less and pollute less. In addition, it is assumed that while the efficiency of the vehicles will increase, the average annual distance per vehicle will increase too.

The measures from the third group are neglected since the portion of vehicles that use alternative fuel is not expected to be significant by the horizon year.

The expected reductions of GHG emissions from road transport when mitigation measures are applied, have been obtained by taking the following assumptions:

- Energy-efficiency improvement of vehicles

  **a/** The policy measures will be taken in order to speed up the renewal of the vehicles in Macedonia. This is important since the new vehicles consume less and pollute less compared with the old vehicles. These policy measures in general will include measures like tax and custom discounts for new vehicles, tax and custom incentives for commercial vehicles and buses etc.

**b/** The European standards of the quality of fuels will be applied.

- Reduction of the level of increase of vehicle-kilometers

**c/** Practice of integrated land-use and transport planning.

**d/** Support and development of urban public transport that would attract more car users to public transport - planning and investing in improvement of public transport, combined with measures of support such as priority treatment and parking policy.

**e/** Planning and development of integrated multi-modal transport system. Investing in transport terminal centers with transfers between air, railway, road, developing of container system, etc.

**f/** Support of electric modes of transport. Electrifying of the railway, and greater use of railway. Introducing tramway in Skopje.

**g/** Improvement of traffic management and control system. Improvement of traffic flows (urban and interurban).

**h/** Development of city logistic systems that have great potential to reduce the movement of supply commercial vehicles in cities.

By application of measures (a) and (b), it is expected that the average fuel consumption per vehicle will decrease by following percents: 1.6% per year for passenger cars, 2.0% per year for buses, 1,5% per year for commercial vehicles, 0,5% per year for motorcycles, 2,0% per year for special vehicles and tractors.

Thus, for example, if in 2000 the average fuel consumption for a passenger car is 8 l/100 km, then under this assumption, its average consumption will decrease to 5 l/100 km in 2030. This complies with the industry expectances regarding the development of the vehicle technology.

By application of all measures from (c) to (h), and based on experiences of other countries, it is assumed that the annual distance traveled by a passenger car will not increase to 17500 km/year per vehicle what would happen if nothing is done, but will increase to 15500 km/year (20% smaller increase).

The average distance traveled by buses and commercial vehicles is expected to change insignificantly. However, there will be an increase of the traveled vehicle-kilometers that would come from the increase of the vehicle fleet.

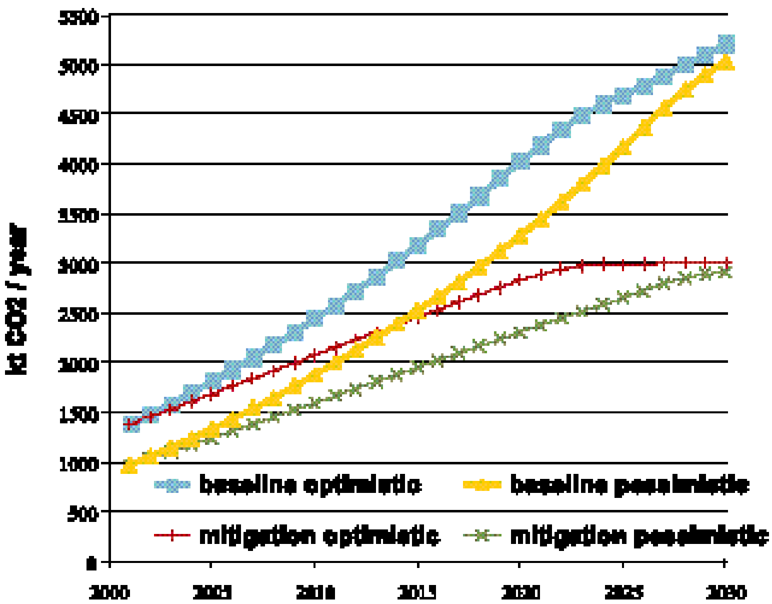



**Figure 5.14.** Estimated emissions from road transport according to the baseline and mitigation scenarios

**Mitigation measures in air transport**

The two main options for reduction of $CO_2$ emissions from the air transport are:

- To improve the fuel efficiency and the environmental features of the airplane engines.
- To improve airport operations in other to reduce the aircraft waiting for landing approval.

Since there are no relevant data for the influence of these options on the reduction of $CO_2$ emissions, a rough estimation has been done, assuming that by increased average fuel economy of the planes, the consumption for landing/take-off will be reduced for 25% by the year of 2030 compared to the average consumption in 2000.

The $CO_2$ emissions from air transport according to the baseline and mitigation scenario are given in figure 5.15.

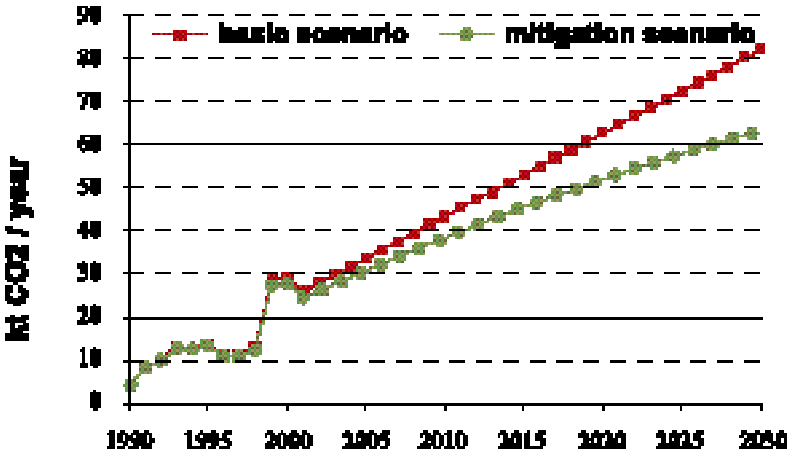



**Figure 5.15.** $CO_2$ emissions from air transport (baseline and mitigation scenarios)

## 5.1.3.5. PROJECTION OF THE TOTAL $CO_2$ EMISSIONS FROM THE TRANSPORT SECTOR

Based on the forecasted emissions of $CO_2$ per each mode of transport over the period of 2001 to 2030, presented in the previous sections, the total emissions from the transport sector can be computed. These totals have been computed for the baseline and mitigation scenarios, by summing the corresponded values for each mode of transport. The total emissions of $CO_2$ from the transport sector in Macedonia are given in Figure 5.16.

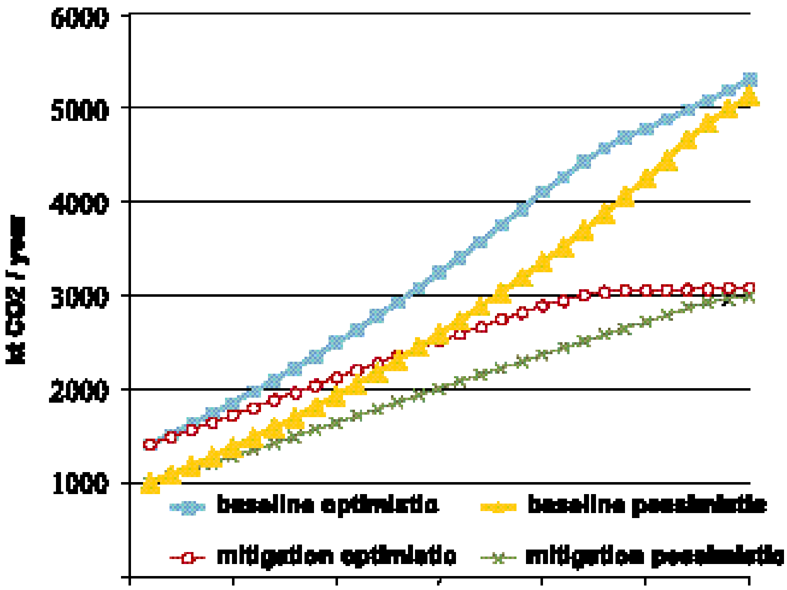



**Figure 5.16.** The total emissions of $CO_2$ from the transport sector in Macedonia

### 5.1.3.6. ABATEMENT RECOMMENDATIONS FOR TRANSPORT

For GHG emission reduction in the road transport the following two groups of measures are suggested:

- Energy efficiency improvements of the vehicles by replacement old ones with new environmentally friendly vehicles through tax, custom and regulatory measures, as well as application of European fuel standards.
- Reduced increase of vehicle-kilometers by use of public transport; investments in transport center for easy transfer between road, rail and air transport; introduction of electrical transport, especially tramway in Skopje; better traffic control and reduction of cargo transport in the cities.

Concerning the railway transport, the main mitigation activity will be to complete the electrification on those sections of the rail network that are not yet electrified.

The GHG emission reduction in the air transport could be realized following the worldwide trend of engines with better performances and by improving airport operations in other to reduce the aircraft waiting for take-off and landing approvals.

## 5.2. INDUSTRIAL PROCESSES

Industry plays an important role in the economy of the Republic of Macedonia as a whole. Its share in building the GDP of the national economy approximates cca 20%. Unfortunately, as a result of transition process which started in 1990 and is still going on, as well as of the effect of many external and internal factors, growth rate of total industrial production has flattened and even declined in some specific sectors. Many of production capacities are facing uncertain future. Re-starting of production process in industry sector will depend on both government's economic and political guides. The GHG emissions are primary consisting of $CO_2$ emission from the following main production activities:

- Mineral Production
- Metal Production

Emission from the chemical industry sector ($CO_2$, $CH_4$ and $N_2O$) is avoided due to its neglecting share in total emission from industrial processes sector. So, this sector was excluded from abatement analyses.

### 5.2.1. MINERAL PRODUCTS

Emissions from mineral products subsector takes into account the $CO_2$ emission from:

- Cement production
- Lime and soda ash production
- Limestone and dolomite use

Values for the period 1999-2001 were taken directly from production capacities and data for the period 2002-2020 were estimated according to their production plans. For the cement production (values taken from USJE-Skopje, the exclusive cement production capacity in Macedonia) in the period 2001- 2020 stable production of cca 600,000 t cement per year was taken. For lime production linear growth, with final estimated production of 40,000 t quicklime in year 2020, was taken. For the limestone and dolomite use a linear increment of production with a final value of 120,000 t and 300,000 t of used limestone and dolomite, respectively, was supposed. The emission from soda ash production and use is very small (0.4%) in the total emissions from mineral products and therefore was excluded of this analysis.

The perspective production growth of USJE cement factory is planned to cover the future needs of Macedonian market only. According to the latest partnership strategy, foreign investment is expected to raise the cement production in Macedonia's neighbors. This is the main reason why future USJE's cement production is forecasted to modest 600,000 tons per year, after experiencing record as high as 882,000 tons in the year 2000.

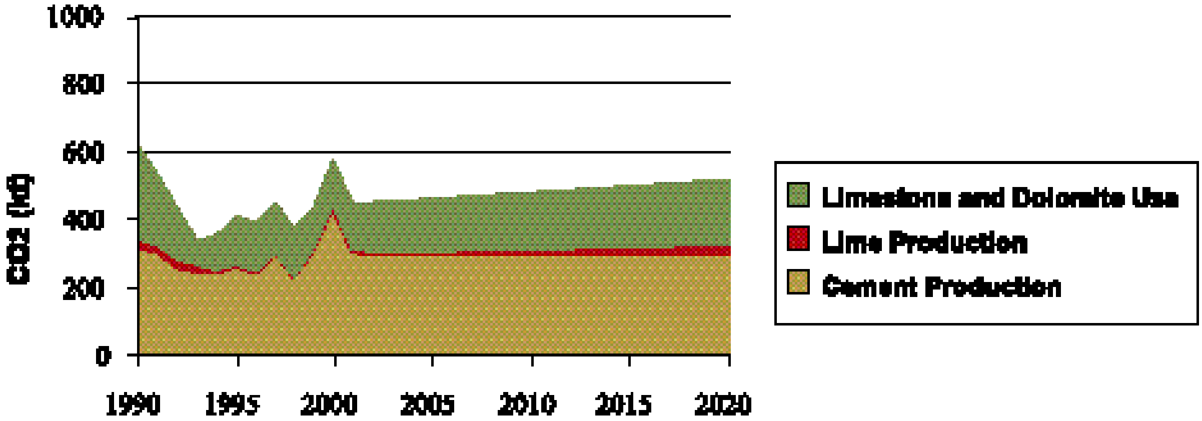



**Figure 5.17.** Share of specific sectors into the total $CO_2$ emission from mineral production in period 1990-2020

## 5.2.2. METAL PRODUCTION

This subsector is the principal contributor (with 59% in the total GHG emissions) among all industrial processes in Republic of Macedonia. Emissions of $CO_2$ come from:

- Iron and Steel Production
- Ferroalloys Production
- Production of non-ferrous metals (Zn, Pb, Ag, Cd)

Using the same methodology as in the "Inventory of GHG emissions", ferronickel production is incorporated in the iron and steel production and the remaining ferroalloys are represented as a part of non-ferrous metals (Zn, Pb, Cd, and Ag) production.

For the iron and steel production, using data provided from production capacity Macsteel-Skopje, emissions were calculated for the period 1999-2001. For the period 2002-2020 a predicted value of 400,000 t iron and steel per year was taken. For estimation of emission from ferronickel production data provided from Fenimak, were taken. For the period 2002-2020 they are 16,000 t nickel (as ferronickel) per year.

For estimation of emission from non-ferrous metals (Zn, Pb, Ag, Cd) production in the period 1999-2001, the realized production figures from the smelter MHK "ZLETOVO" - Veles were used. For the period 2002-2020 a linear growth was taken with the final projected value of 85,000 t zinc in the year 2020. Calculated values of GHG emissions from Zn also contain emissions for other non-ferrous metals (Ag, Cd, and Pb) production.

Most uncertain is the future situation with the Jugochrom capacity, the largest ferroalloys producer (95% of total emission from ferroalloys). Therefore, two possible scenarios were analyzed: one with a total closure of this capacity and the second with privatization and restart of currently closed capacity.

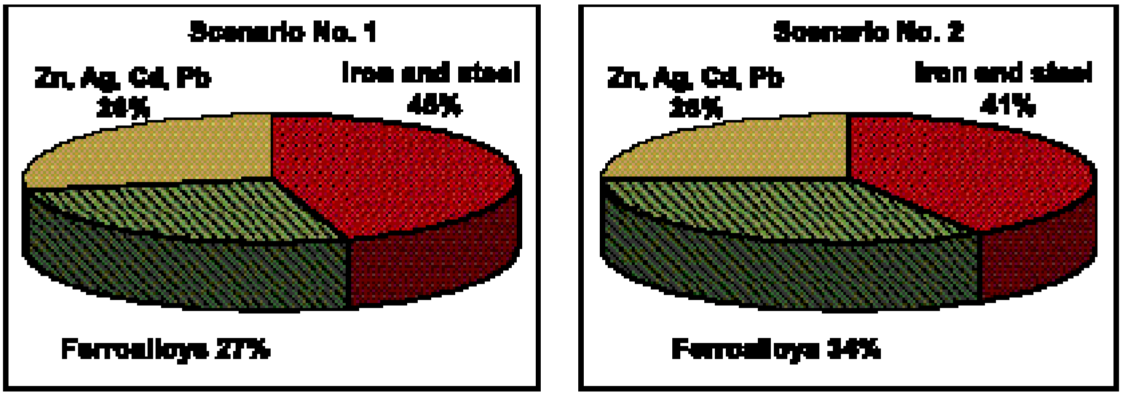



**Figure 5.18.** Forecasted structure of GHG emission in metal production sector over the period 1990-2020 *(Scenario No.1 - Closure of Jugohrom; Scenario No. 2 – Jugohrom restarted)*

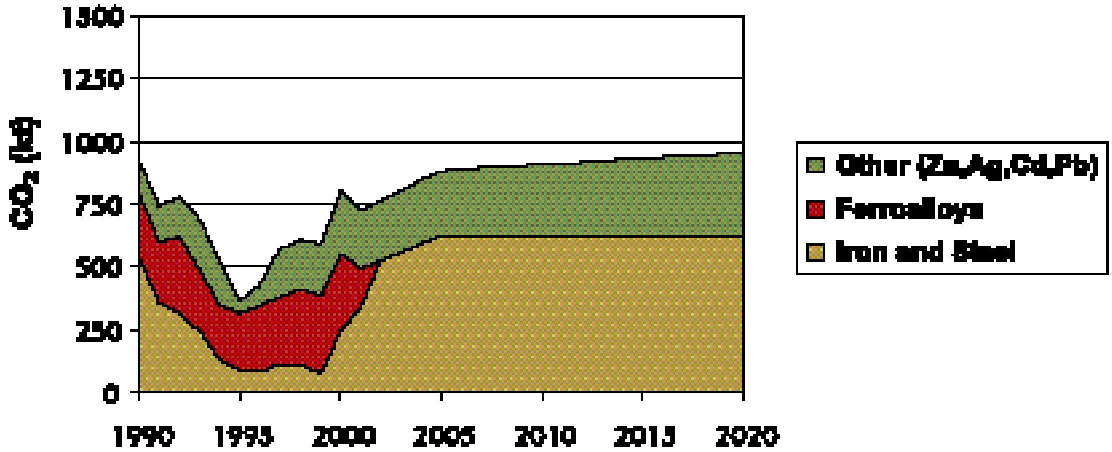



**Figure 5.19.** Emission of $CO_2$ in sector metal production in analyzed period (kt) *(Scenario No.1 - Closure of Jugohrom)*

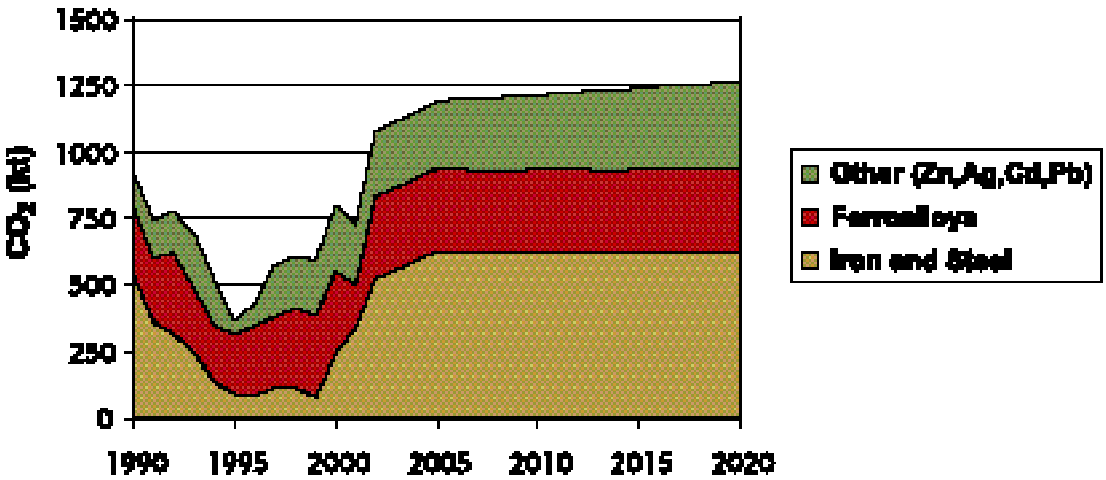



**Figure 5.20.** Emission of $CO_2$ in sector metal production in analyzed period (kt) (Scenario No.2 - Jugohrom restarted)

### 5.2.3. GHG ABATEMENT RECOMMENDATIONS FOR THE INDUSTRIAL PROCESSES SECTOR

Under the supervision of the Ministry of Environment and Physical Planning a project called “Strengthening of the capacity for cleaner production in Macedonia” is running. A list of activities is planned, disseminated and expected to be fruitful over the next period in reducing the main pollutants. Some of the basic planed measures are as follows:

- Fuel utilization increase,
- Fuel replacement in favor of fuels with more convenient $H_2O$ to $CO_2$ ratio (“more Joules per unit quantity of produced $CO_2$”).
- Utilization of waste heat contained in the effluent gases, liquids and solids. Gases emitted from the metallurgical furnaces for ferroalloys production could contain as much as 25% of carbon monoxide (CO). Thus, these gases are not at all combustion waste products but indeed are low calorific fuels, apart of their high physical heat content.

If one succeeds in accomplishing lower $CO_2$ emission for only 2% per year, significant effects will be produced over next 10 to 15 years, as graphically presented in Fig. 5.21. In any case, one could expect a lot of benefits if a cleaner and more effective production is achieved in the next period.

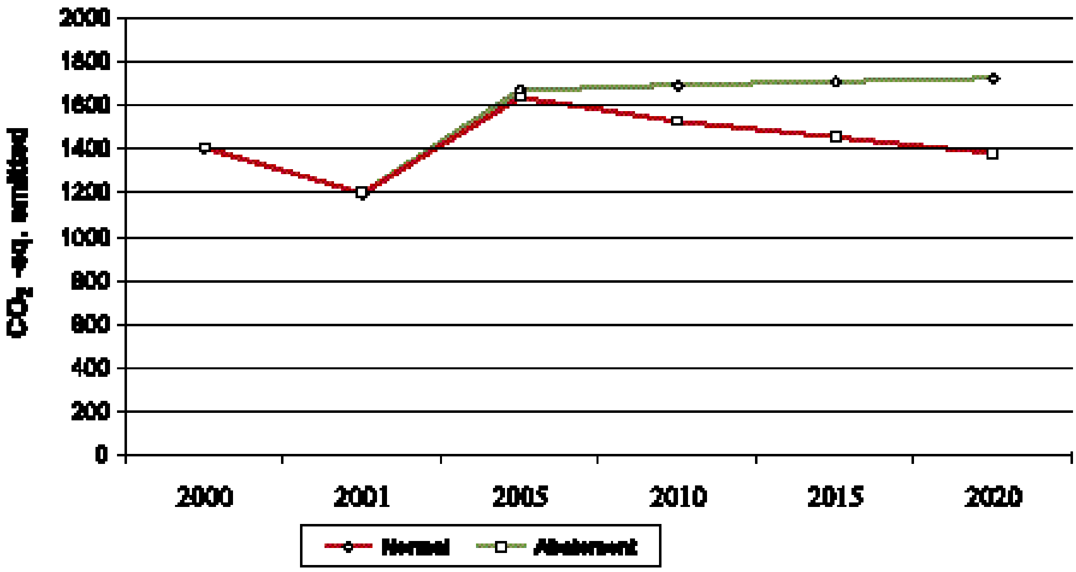



**Figure 5.21.** Emission of $CO_2$ in industrial processes sector

## 5.3. WASTE SECTOR

GHG emission in the waste sector comprises formation of methane ($CH_4$) and nitrous oxide ($N_2O$) during the waste decomposition in anaerobic conditions. The GHG emission inventory includes the following three areas:

- Solid waste disposal sites
- Wastewater handling (domestic and industrial wastewater)
- Human sewage

### 5.3.1. METHANE EMISSIONS

**Methane Emissions from Solid Waste Disposal Sites (SWDSs)**

In order to estimate the methane emission from solid waste disposal sites (SWDS), it is necessary to be familiar with the value of total annual municipal solid waste (MSW) disposed to

SWDSs (kt MSW) in specific year and corresponding corrections factor and fractions. Main input figures for estimation of total annual amount of municipal solid waste are the number of population and the mean quantity of solid waste disposed on sites, expressed as [kg/person/day]. In order to forecast the demographic growth, an annual growth rate of 0.07% (starting with the year 1998) was adopted. For the reference year (1998) a value of 0.79 [kg/person/day] solid waste disposed on SWDS was taken (according to a rather rough estimation) and then linearly decreased to the value of 0.5 [kg/person/day], taken as the goal value declared by the local experts. Using corrections factor and fractions from the year 1998 for the calculations, the emission was estimated for the period 1999-2020. Another scenario, which incorporates possible recovery of methane starting from the year 2005, with increment of 1 kt recovered methane/per year was also calculated (Fig. 5.22).

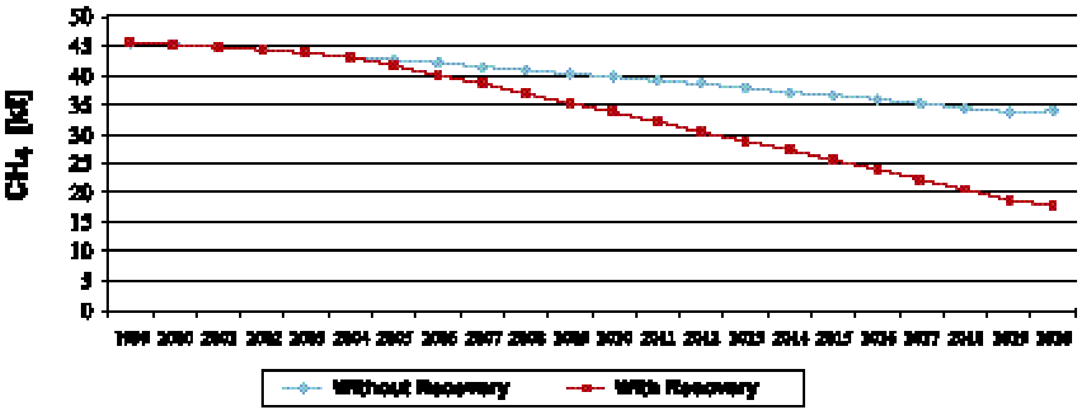



**Figure 5.22.** Methane emissions from the solid waste in case of recovery and without recovery

**Methane emissions from domestic and commercial organic wastewater and sludge**

In order to estimate emissions from organic wastewater and sludge it is necessary to know the size of population, the quantity of degradable organic component (kg BOD/1000 persons/yr), which was taken as a constant for all analyzed period and equal to 18,250 kg BOD/1000 persons/yr and the fraction of degradable organic component removed as sludge (equal to of 0.05 in the analyzed period). Demographic chart of the population in Macedonia (1000 persons) is given in the Table 5.5.

**Table 5.5.** Annual value of population (1000 persons) in Macedonia

| Year | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Population | 2028 | 1966 | 2026 | 2108 | 2183 | 2261 | 2341 |

For the forecasted period 1999-2020 values for the year 1998 were taken and corresponding corrections factor and fractions were applied.

***Methane emission from industrial wastewater and sludge***

In order to estimate the methane emission from industrial wastewater and sludge, total organic wastewater from industrial source (kg COD/yr) and total organic sludge from industrial source (kg COD/yr) were calculated in advance. As a basis for these quantities statistical data for the period 1990-1998 were used, while for the period 1999-2020 corresponding proportion (correlation) between estimated growth of production and growth of the amount of wastewater and sludge was performed. The estimated emission of $CH_4$ is given in Figure 5.23:

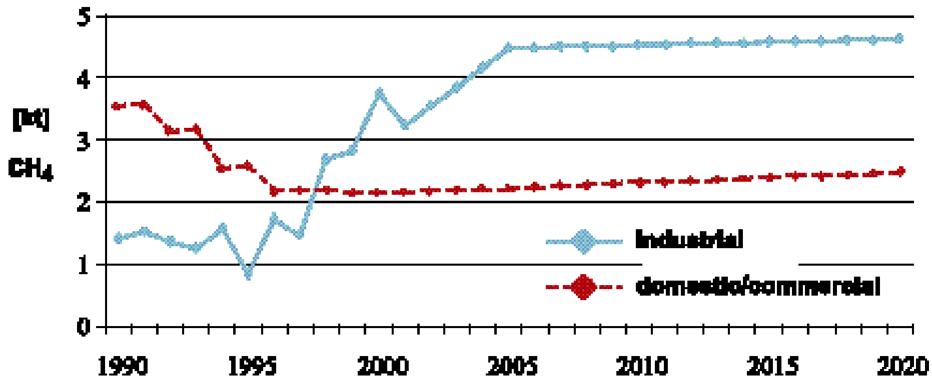



**Figure 5.23.** Emission of $CH_4$ from wastewater and sludge

### 5.3.2. INDIRECT $N_2O$ EMISSIONS FROM HUMAN SEWAGE

In order to estimate emission of $N_2O$ from human sewage, it is necessary to know the size of population (number) in a specific year. Corresponding corrections factor and fractions (per capita protein consumption, fraction of nitrogen in protein and emission factor) are constant for all analyzed period 1990-2020. Total estimated emission of $N_2O$ is given in the Figure 5.24:

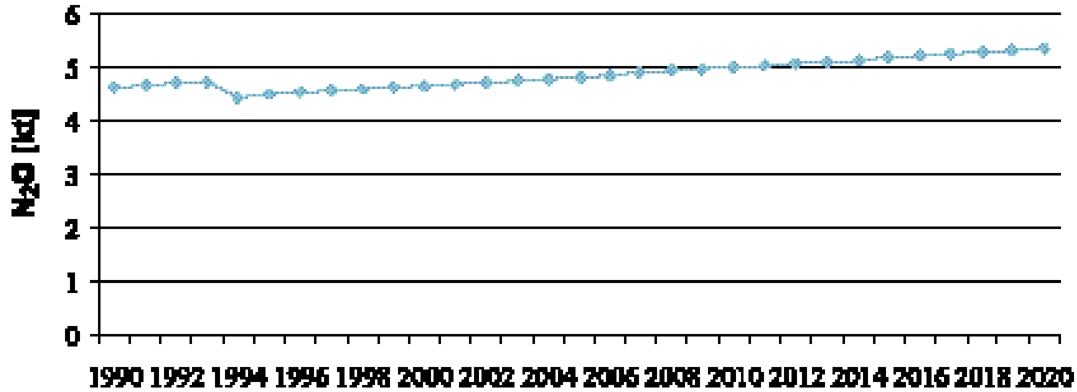



**Figure 5.24.** Total emission of $N_2O$ from human sewage

### 5.3.3. GHG ABATEMENT RECOMMENDATIONS FOR THE WASTE SECTOR

Present rate of waste production in Macedonia is rather high, despite of the fact that Macedonia is an underdeveloped and poor country. Present value of 0.79 [kg/person.day] is to be lowered to a reasonable 0.5 [kg/person.day] over the next 10 to 15 years. This is a decrease of almost 37% and it will take strong efforts to realize it. The increase of environmental conscience, together with the strengthening of the legislative (and control) is in favor of such strong expectation. If one fails to do it, a rather constant quantities of solid waste are expected to be produced, leading to practically unchanged emission figures.

Due to the lack of experimental evidences for the existing rate of waste production, this sector is unrewarding for precise forecasting. Further efforts of investigation are on the way to eliminate this obscure situation.

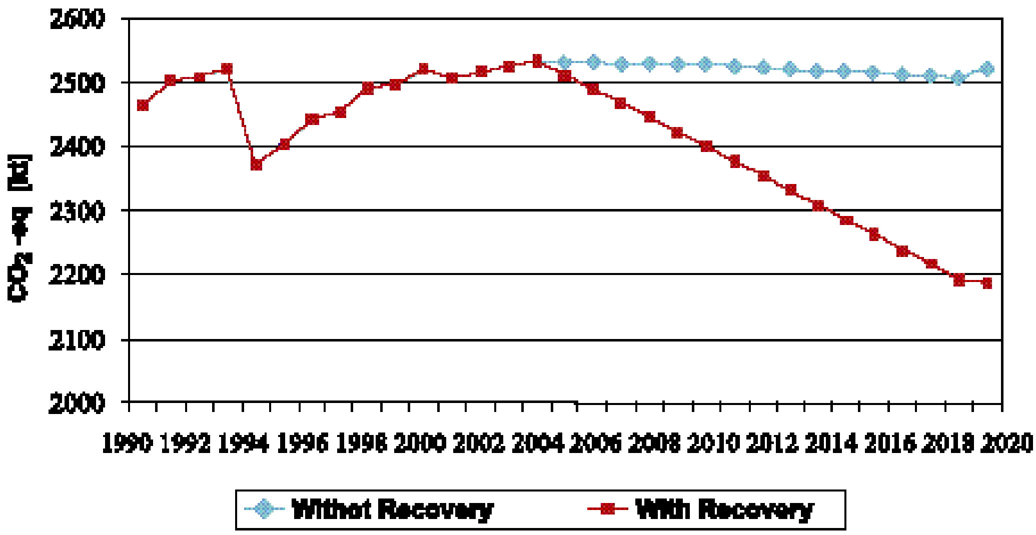



**Figure 5.25.** Time series of $CO_2$ -eq emissions from waste sector in case of recovery and without recovery of $CH_4$

In order to diminish the rate of waste production in near future, a number of activities are possible. Among the most plausible ones are:

- ***Improvement of public awareness***

  Applying a proper planed, long term and persistent activity of public education and conscience, improvement of public awareness could be realized. NGOs, schools, churches and similar institutions could play leading roles in performing this activity. Different aspects of SMW management as, e.g. reduction, recycling, reuse, the importance of primary waste selection etc., are to be promoted.

- ***Tightening the legislative***

  The present legislative should become more stringent and strictly applied in order to achieve a higher level of waste dissipation control. Littering is to be systematically monitored and measures against violators are to be properly determined (starting with court warnings and ending with fines or legal procedures). Special attention is to be paid to prevent waste disposal to illegal sites existing (and growing in their number) around the major urban areas.

- ***Increasing personal motivation for waste recycling***

  An increased level of individual interest and motivation for waste primary selection and commercial recycling could be a target of Waste Management. This measure could be fruitful taking account for the high unemployment rate in Macedonia and rather low average income. At least some of the selected waste components (non-ferrous metals, paper and cardboard, glass and plastics) will be accepted as secondary raw materials, thus reducing the quantity of waste at disposal sites. It will also be beneficial in increasing the family income.

## 5.4. AGRICULTURE

Agriculture plays a very important role in the total economy of the Republic of Macedonia. In the Strategy for the development of agriculture in the Republic of Macedonia to the year 2005, (MANU, 2001), a second place, just after industry, is elaborated for agriculture in contribution to the GDP of the national economy (>10%).

As a result of the large diversities of agro-ecological properties (climate, relief, soils, and water economy) there is a wide spectrum of agricultural production (crop production, vegetables, vineyards, orchards, livestock and others).

The total agricultural land has been reducing from average of 1319 kha in 1984-1994 to 1280 kha in 1999. Between 630 and 665 kha from total area are arable agricultural land, and about 649 kha are covered by permanent pastures.

### 5.4.1. GHG EMISSIONS FROM THE AGRICULTURE SECTOR

GHG emissions from the agriculture sector are emissions of $CH_4$ and $N_2O$, originating from the following sources:

- Enteric fermentation (CH$_4$ and N$_2$O emissions)
- Manure management (CH$_4$ and N$_2$O emissions)
- Rice cultivation (CH$_4$ emissions)
- Agricultural soils (N$_2$O emissions).

The main input data determining the emissions from agriculture sector are a number of animals and inputs of synthetic nitrogen fertilizers. The calculated emissions from this sector (according to IPCC) are presented in table of Chapter 4: GHG Inventory. As it can be seen, the contribution of the agricultural soils subsector is the highest (about 50%) followed by the enteric fermentation subsector with about 38% contribution to total emissions.

### 5.4.2. PROJECTION OF GHG EMISSIONS FROM THE AGRICULTURE SECTOR

Ruminant animals (cattle and sheep), in average, produce nearly 93% from the total annual emission of $CH_4$. Accordingly, future trends of $CH_4$ emissions will depend, primarily, on changes of the number of ruminant animals.

Cattle breeding and other animal production in the Republic of Macedonia, from economical standpoint, are still on low level, in comparison with the ones in Western Europe. According to the National strategy for economic development of the Republic of Macedonia (MANU, 1997), there is expectable increasing of the number of cattle, sheep and pigs (table 5.6), but emission factors for cattle will remain on the same level. In such a situation there will be slight increase in annual $CH_4$ emissions.

**Table 5.6.** Projection of number of animals

| | Number of animals (1000) | |
|---|---|---|
| **Livestock type** | 1990-1998 | 2020 |
| **Dairy cattle** | 167.84 | 178.00 |
| **Non-dairy cattle** | 116.32 | 122.00 |
| **Buffalo** | 1.20 | 1.02 |
| **Sheep** | 2139.93 | 2666.00 |
| **Horses** | 63.93 | 64.00 |
| **Pigs** | 178.88 | 350.00 |
| **Poultry** | 4297.09 | 4470.00 |

There are shortages of milk and meat products, especially from cattle, in the Republic of Macedonia. For that reason, the number of ruminant animals (cattle end sheep) is planed to be increased by 2020, with proposed measures for improvement of their productive abilities.
The rice cultivation in the Republic of Macedonia, traditionally, has been practiced with continuously flooded fields, mostly with single aeration. For that reason, for estimation of $CH_4$ emissions

scaling factor of 0.5 per unit of cultivated area is used. However, $CH_4$ emissions from rice cultivation in the Republic of Macedonia are negligible, in comparison with the $CH_4$ emissions from enteric fermentation and manure management.

Five sources of $N_2O$ emissions from agricultural activities are identified in the Republic of Macedonia: Synthetic fertilizers, animal waste, N-fixing crops, crop residue and area of cultivated organic soils (histosoils).

Although the reduction of the inputs of synthetic fertilizer and their substitution with natural sources (sustainable agriculture) scientifically and, in some cases, practically are in some progress, still, for better stability and better profitability, agriculture in Macedonia needs inputs of synthetic fertilizers. Furthermore, the Republic of Macedonia belongs to the group of countries with very small inputs of synthetic fertilizers per unit arable land.

For ensuring optimum conditions for more stable crop production to 2020, increasing the input of N-fertilizer to 65 kg N/ha is proposed. However, some improvements in the technology of N–synthetic fertilizers application with possibilities for reduction of N-gasses emissions could be applied: combine the usage of synthetic fertilizers with manure and incorporation of N fertilizers in the soil immediately after the application.

Having in mind the above considerations, the future GHG emissions from the sector agriculture are calculated and summarized in the table 5.7 and graphically in the figure 5.26.

**Table 5.7.** Projected GHG emissions by gases from the agriculture sector [kt]

| Year | $CH_4$ | $N_2O$ | $CO_2$-eq |
|---|---|---|---|
| **2005** | 35.67 | 3.15 | 1726.47 |
| **2010** | 37.58 | 3.40 | 1842.48 |
| **2015** | 39.58 | 3.66 | 1966.85 |
| **2020** | 41.70 | 3.95 | 2100.20 |

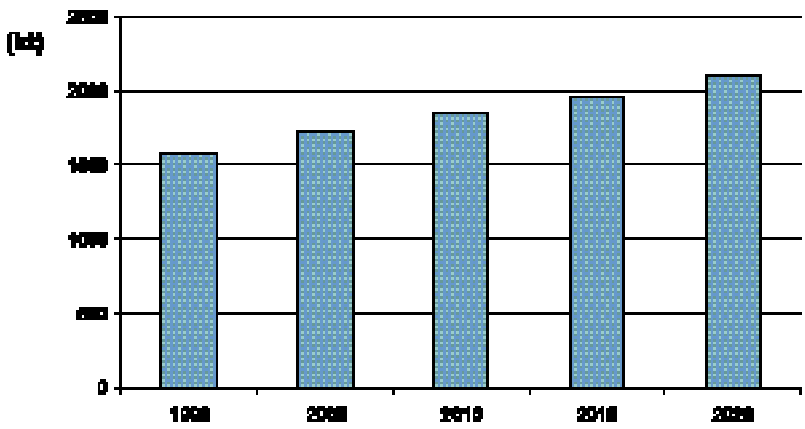


**Figure 5.26.** Projected total $CO_2$-eq from the agriculture sector [kt]

It should be stressed that all the projections are in accordance with the *National Strategy for Economic Development of the Republic of Macedonia, Sector Agriculture* (MANU, 1997). Within this document, the following principal, global priority objectives for the future development of agriculture to the year of 2020 are stated:

- To utilize the natural resources potentials to optimal extent;
- To meet the domestic demand for agricultural products and products made by them;

- To increase the export of agricultural products and products made by them;
- To provide agricultural producers with a more favorable and more stable economic and social status; and
- To adopt the developmental trends of developed countries.

### 5.4.3. ABATEMENT RECOMMENDATIONS FOR THE AGRICULTURE SECTOR

The recommendations for GHG emissions reduction are based on the current situation in the Republic of Macedonia and projected development of this sector. Within the agriculture, GHG emissions originate mainly from animal production, rice cultivation and agricultural fertilizers. Accordingly, the recommendations regard all these subsectors separately.

Concerning the animal production subsector, there is a lack of dairy and meet products, as a result of which in the year of 2020, increase in the number of cattle and sheep is foreseen. Simultaneously, some measures related to improvement of the productive capacities of the animals, treatment of the animals, feeding and manure management, are proposed.

In spite of the insignificant methane emissions from rice cultivation, there are possibilities for their reduction. One is multiplication of the aeration in intermediately flooded rice fields, defined as more than 3 day aeration during the vegetation period. In that way, it is possible to decrease methane emissions for about 60% in comparison with the traditional technology.

Regarding the use of synthetic fertilizers, it should be stressed that the use has to be enlarged in order to provide optimal conditions for more stable agricultural production. However, the combined use of synthetic fertilizers and manure, as well as incorporation of N fertilizers in the soil immediately after the application, are options for improving the use of synthetic fertilizers aimed at abatement of the polluting emissions.

It is concluded that the reduction of GHG emission from agricultural sector can be achieved, first of all, by improvement of the applied technology. In this phase of the analyses some rigid ecological measures which would require additional financing are not foreseen.

## 5.5. LAND USE CHANGE AND FORESTRY (LUCF)

GHG emissions and $CO_2$ removals by sinks within the land use change and forestry sector are mainly affected by the following two activities:

- Changes in forest and other wood biomass stocks;
- Forest conversion caused by incidental burning of forests.

The first activity - changes in forest and other wood biomass stocks, concerns the calculations of the balance between annual increment of forest biomass in kt dm (dry matter) and annual loss of biomass by consumption from stocks in kt dm, as input data for estimation of difference between carbon uptake and carbon released in the forest area. Carbon fraction of dry matter of biomass is taken to be constant valued 0.5.

The second activity - forest conversion, deals with the findings of annual loss of biomass in kt dm affected by burning of certain forest area and calculates the annual carbon release in kt C per burned area.

### 5.5.1. $CO_2$ REMOVAL BY CHANGES IN FOREST AND OTHER BIOMASS STOCKS

Forest area in the Republic of Macedonia, from 1990 to 1998, varied from 912 kha in 1990 to 990 kha in 1998 (average 958 kha.) It covers about 37% of total area of the country.

Annual changes in the forest area have been influenced by the deforestation (commercial harvest) and by afforestation. Total wood biomass in average is about 101.4 $m^3$/ha, ranging between

50 and 226.1 $m^3$/ha (For sake of comparison, in Switzerland the amount is 257 $m^3$/ha, in Austria is 162 $m^3$/ha and in Slovenia is186 $m^3$/ha)

The Spatial Plan of the Republic of Macedonia elaborates the data for forest area [ha] and difference between annual biomass increment and annual biomass consumption accompanied with projections of these values for the years 2010 and 2020. Considering these data, it is estimated that 30-50% from the total carbon uptake is released through the biomass consumption from stocks. In average 86.55% (82.36-88.83%), of the total annual carbon release is affected by traditional fuelwood consumption.

In such conditions the forests of the Republic of Macedonia in average remove 1804 kt/yr $CO_2$. This value ranges from 1403 kt $CO_2$ in 1991 up to 2243 kt $CO_2$ in 1998 (figure 5.27).

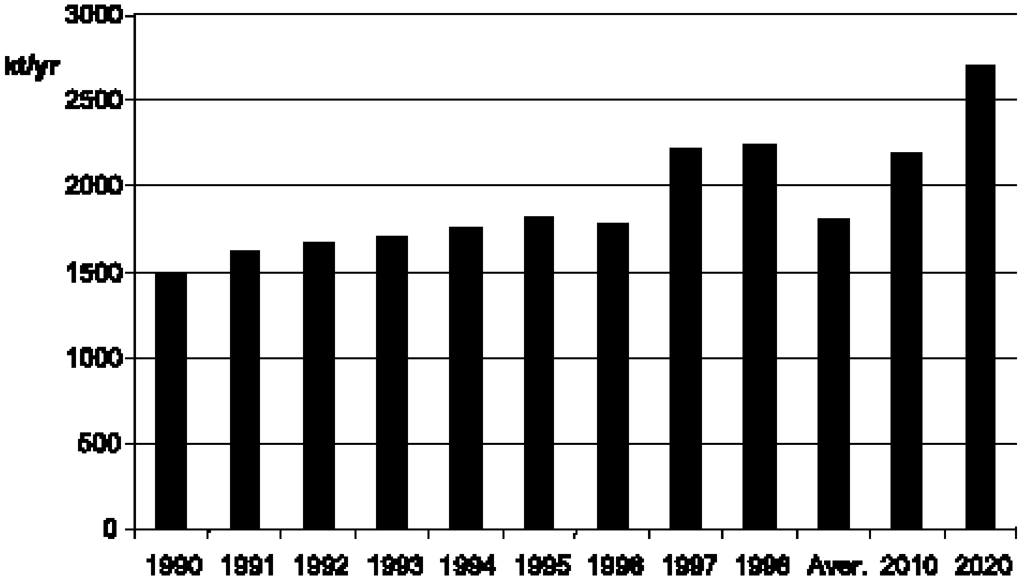



**Figure 5.27.** Annual removal of $CO_2$ by the forests

Annual $CO_2$ removal by the forests places the Republic of Macedonia among the countries with low to medium annual biomass increment per unit area. Annual growth rate for deciduous forests is taken to be 1.3 t dm/ha, for evergreen (which is 10% of the total forest area) the amount is 6 t dm/ha. There are three main types of forests in Macedonia: high-stem forest, with about 28% from the total forest area and annual growth rate from 2.0 to 2.6 t dm/ha; low-stem forest, with 61% of the total area and annual growth rate of about 1.0 t dm/ha; other, with about 10% of the total area and annual growth rate below 1.0 t dm/ha. For comparison, forest area in the Republic of Macedonia is about 3.93 times smaller than forest area in Republic of Bulgaria, but annual $CO_2$ removal is 2.8 to 3.4 times smaller.

There are some activities for further improvement of the forestry sector of the Republic of Macedonia. Three main measures are basic factors for increasing the sink capacity of the forests:

- **Enlargement of the forest area by afforestation;**

  The afforestation projects are usually the most effective mitigation measure in forestry sector. But experiences from countries with economy in transition showed that transformation of land ownership could lead to difficulties with realization of such projects. In the first phase, the measures should be oriented on state ownership lands. This measure is particularly important and applicable for Macedonia since the ratio between state and private ownership of forest land is 87:13.

- **Increasing the annual biomass increment by improving the floristic forest structure;**

  Improving the “floristic” forest structure or change in forest tree species composition is generally less effective than afforestation activities. But when additional impacts (bio-diversity aspects, ecological and environmental forest functions) of these measures are taken into account, such projects can be very useful for sustainable forestry in Macedonia.

- **Decreasing the annual amounts of traditional fuelwood consumption as much as possible.**

The third type of mitigation measures strongly depends on the system changes in rural landscape and can only be implemented within a broader context of social changes in rural areas of Macedonia (e.g. rural development programs).

The relevant official document regarding development strategies of forest sector and corresponding mitigation measures is “Strategy for the Development of Agriculture, Forestry and Water Utilization in Macedonia” prepared by the Ministry of Agriculture, Forestry and Water Utilization, in 1996. Within this document a special chapter is dedicated to forestry comprising natural characteristics of forestry in the country, legal regulations and organization in forestry, production, reproduction and protection, as well as objectives and measures for future forestry development.

Projected forest area and the forest productivity for 2010 and 2020 are presented in table 5.8.

**Table 5.8.** Projected forest improvements for 2010 and 2020

| | 1996 | | 2010 | | 2020 | |
|---|---|---|---|---|---|---|
| | [kha] | % | [kha] | % | [kha] | % |
| **High-stem forest** | 274 | 28 | 395 | 40.5 | 465 | 44.7 |
| **Low-stem forest** | 582 | 61 | 505 | 51.7 | 499 | 48.0 |
| **Other** | 97 | 10 | 76.44 | 7.8 | 75.56 | 7.3 |
| **Total** | 953 | 100 | 976.44 | 100 | 1039.56 | 100 |
| | | | | | | |
| **Annual biomass increment [kt dm]** | 1690.3 | 100 | 2079.8 | 122 | 2494.9 | 146 |
| **Annual growth rate [t dm/ha]** | 1.77 | | 2.13 | | 2.40 | |

According to the enlarged areas and the increased annual growth rate there will be a significant increase in $CO_2$ removals (figure 5.28). Also within the Spatial Plan of the Republic of Macedonia a change in the ratio between technical wood and traditional fuelwood consumption from current 18:82 is foreseen to 25:75, accompanied by the following measures for decreasing the traditional fuelwood consumption: usage of the waste from technical wood for heating; substitution of wood by other energy sources in the rural areas; enhanced control over harvesting. This will additionally contribute to increasing of the $CO_2$ removals.

Realization of the predicted measures would result in increase of 21% for 2010 and of 49% for 2020, compared to the average 1990-1998 $CO_2$ removal. However, a slight decrease is expected in 2010 with respect to the $CO_2$ removal in 1998, which further is transformed into increase reaching the value of 2691 kt $CO_2$ removal in 2020.

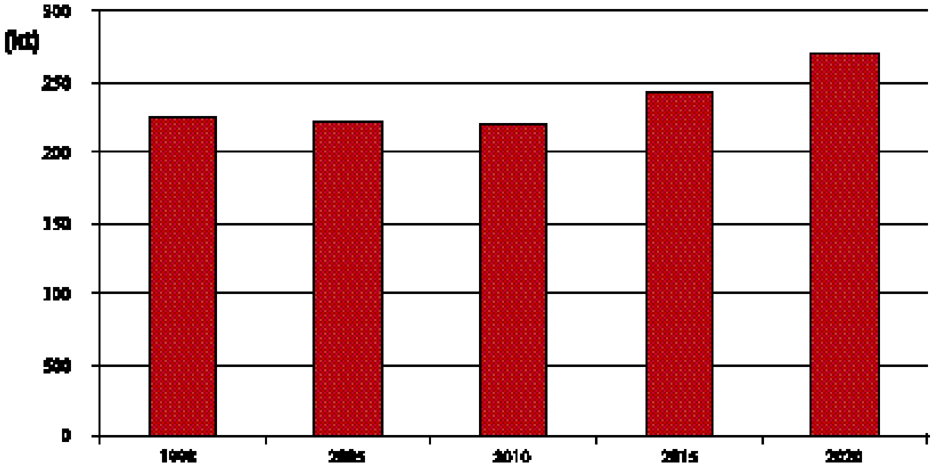



**Figure 5.28.** Projected $CO_2$ removals by the forests [kt]

Realization of the predicted measures would result in increase of 21% for 2010 and of 49% for 2020 compared to the average 1990-1998 $CO_2$ removal. However, a slight decrease is expected in 2010 with respect to the $CO_2$ removal in 1998, which further is transformed into increase reaching the value of 2691 kt $CO_2$ removal in 2020.

### 5.5.2. $CO_2$ EMISSIONS BY FOREST AND GRASSLAND CONVERSION

There is no evidence for conversion of managed forest and grassland in the Republic of Macedonia. However, emissions are related to the on-site and off-site burning of forest caused incidentally.

In average, 4700 ha/yr were burned. Due to large differences, the average value is not applicable for valid prediction. Roughly, it can be expected that every year burning of forests will release about 2 to 50 kt carbon. It is expected that in the next period $CO_2$ emissions caused by forests burning will be similar to those from the last decade.

Annual amount of released $CO_2$ by burning, reduces in a little scale the net annual amount of removed $CO_2$ by forests. Balance between $CO_2$ removals from forests and $CO_2$ emissions from burning of forests is presented in table 5.9.

**Table 5.9.** Balance between $CO_2$ removals and emissions in kt/year

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | Aver. | 2010 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Removals | 1485 | 1603 | 1662 | 1667 | 1759 | 1804 | 1782 | 2203 | 2243 | 1804 | 2189 | 2691 |
| Emissions | 83,64 | 6,49 | 136,3 | 209,4 | 84,22 | 1,54 | 14,23 | 51,33 | 27,33 | 68,27 | 68,27 | 68,27 |
| Balance | 1401 | 1597 | 1526 | 1358 | 1675 | 1802 | 1768 | 2152 | 2216 | 1736 | 2121 | 2623 |

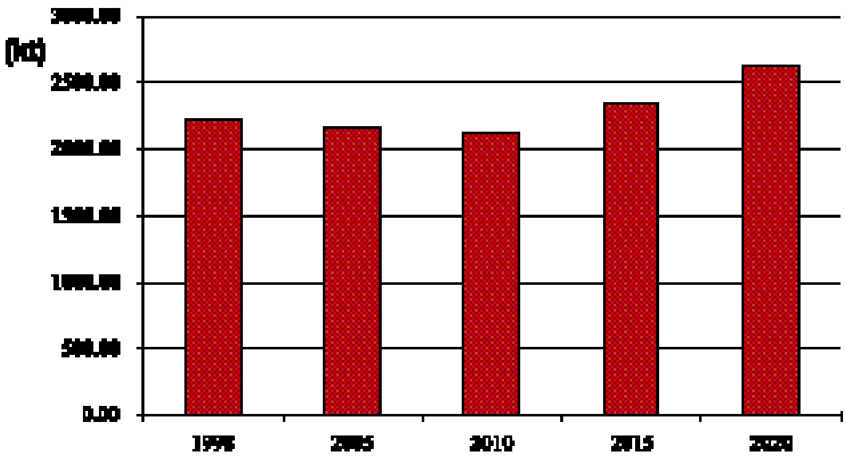



**Figure 5.29.** Projected $CO_2$ balance in the sector LUCF [kt]

### 5.5.3. ABATEMENT RECOMMENDATIONS FOR THE LUCF SECTOR

The measures within the LUCF sector are general and mainly include increasing of the absorption capacity of the forests. The basic measure is to increase the forest area through afforestation. Consequently, it is necessary to work on public awareness rising in order to provide mass participation in afforestation projects. At the same time, the floristical structure of the forests should be improved with final result of increase in annual growth rate of biomass. For this purpose forests with higher biomass density should be favored.

Along with the increasing of the absorption capacity, the forests should be preserved through reducing the usage of biomass as fuelwood, controlling and decreasing the forests cutting for other purposes, as well as preventive activities and awareness rising aimed at protection of forests from burning.

Investments in the forest sector development besides economic have more indispensable ecological aspects, since in every period of the society development afforestation and forests preserving are of ecological character. However, since the forest economy in the Republic of Macedonia is not particularly advanced, ecological injection for improving the forest fund are always more than welcome.

## 5.6. GENERAL REMARKS ON THE ABATEMENT MEASURES

The GHG abatement measures were tailored in such a way that they follow the present status of the Macedonian economy and its possibilities for development. This is very important for their successful implementation as it was foreseen with the abatement analysis. If the proposed measures for each sector are implemented, significant level of environmental suitability will be achieved, which will be improved by undertaking additional studies. In the next phases more sophisticated measures will be proposed and elaborated following the new conditions in the economy, a process that will require additional financing.

The analysis of the energy sector is mostly advanced, especially concerning the electricity production. In that analysis an assessment for the abatement cost for each analyzed strategy is given. In such a way, it is practically given a financial plan for GHG emissions abatement for about 50% of all GHG emitters in the country. For the other 50% of the emitters, other studies are necessary as a preparatory stage for implementation of additional abatement measures, and further, more sophisticated adjustment of the environmental standards should be undertaken.

Software tools used for the GHG emissions abatement analysis are not inherently capable for automatic abatement costs handling, so it was necessary to make additional calculations and combine both results in an iterative process. For future analysis, the software tools have to be upgraded with a module for assessment of the environmental performances (both emissions and cost) for the power system development scenarios. For other forms of final energy (heat and transport), practical development of a new software tools is necessary, taking into consideration their transition from energy intensive to energy depressive one.

chapter

# 6

CHAPTER 6

# VULNERABILITY ASSESSMENT AND ADAPTATION MEASURES

Climate change will have an impact on ecosystems, on national economies, and on human health and welfare. The purpose of the vulnerability assessment is to identify the negative impacts on individual segments of the natural environment and society, to estimate their adaptability, and to give an assessment of the impacts of expected climate change. In this chapter the vulnerability assessment of impacts is given and adaptation measures are proposed for agriculture, forestry, biodiversity, water resources, and human health.

## 6.1. CLIMATE AND CLIMATE CHANGE

### 6.1.1. CLIMATE AND CLIMATE VALORIZATION IN THE REPUBLIC OF MACEDONIA

Although Macedonia is a relatively small country, its territory is covered with different types of climate: continental, changed continental, sub-Mediterranean (changed maritime), mountainous climate, as well as their various subtypes. At the territory of Macedonia the influences of the Mediterranean and the continent overlap, with different spectrum of influences.

According to the experiences of the climate classifications and adequate access to the territory of Macedonia, estimating the orographic and altitude change of the main climate elements, the following more homogeneous climate regions and sub-regions are defined:

- Region with sub-Mediterranean climate (50 - 500 m) (Gevgelija-Valandovo region)
- Region with moderate-continental-sub-Mediterranean climate (to 600 m)
- Region with hot continental climate (600 - 900 m)
- Region with cold continental climate (900 - 1100 m)
- Region with sub-forest-continental-mountainous climate (1100-1300 m)
- Region with forest-continental mountainous climate (1300 - 1650 m)
- Region with sub-alpine mountainous climate (1650 - 2250 m)
- Region with alpine mountainous climate ($h_s$ >2250 m)

## 6.1.2. VARIATIONS AND FLUCTUATIONS OF CLIMATE ELEMENTS IN THE REPUBLIC OF MACEDONIA IN 20$^{th}$ CENTURY

The analyzes of variations and fluctuations of the main climate elements (air temperatures and precipitations) are made for Bitola and Skopje, the meteorological stations which have the longest series of data period from 1926 to 2000.

Changes of annual air temperature are shown at Graphs (Figure 6.1). The hottest years in the 20$^{th}$ century "happened" in Macedonia in the period of the beginnings of the analysis 1926 to 1966, when period with determined decreasing of air temperature had begun and lasted to 1991. From that period certain trend of increasing of annual air temperature has appeared. The lowest value of air temperature appeared in 1975 when the following annual values were recorded: 10.1°C in Bitola and 12.0 °C in Skopje.

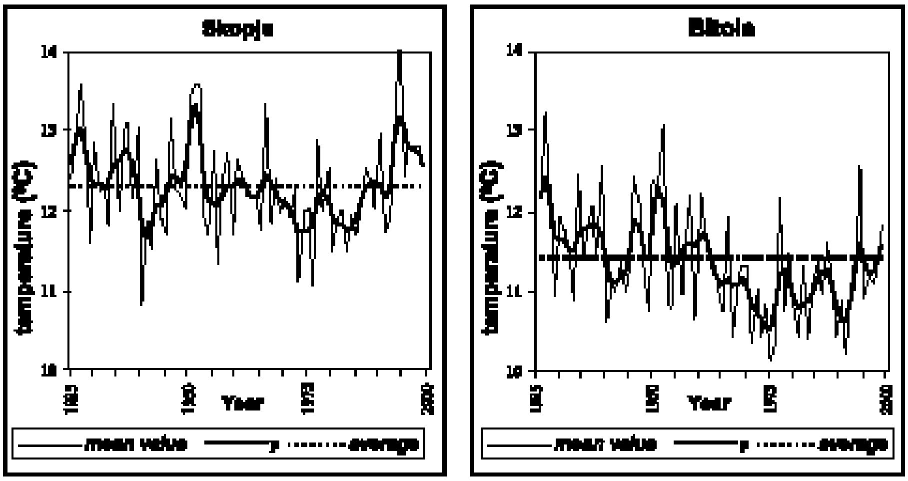



**Figure 6.1.** Many years uncertainties and variations of average annual air temperature for the period of 1926 to 2000

On the basis of annual sums of precipitation (Figure 6.2.), common trend of precipitation decreasing can be marked especially from 1984, more expressive in the eastern parts of Macedonia. The common precipitation decreasing occurred in May, especially from 1980 (for example in Prilep and Stip) as well as in November in the period since 1984. August monthly sums of precipitation are very changeable values and they vary from year to year at every station. The change of precipitation in Bitola and Prilep is characteristic. The most characteristic dry period was between 1984 and 1994.

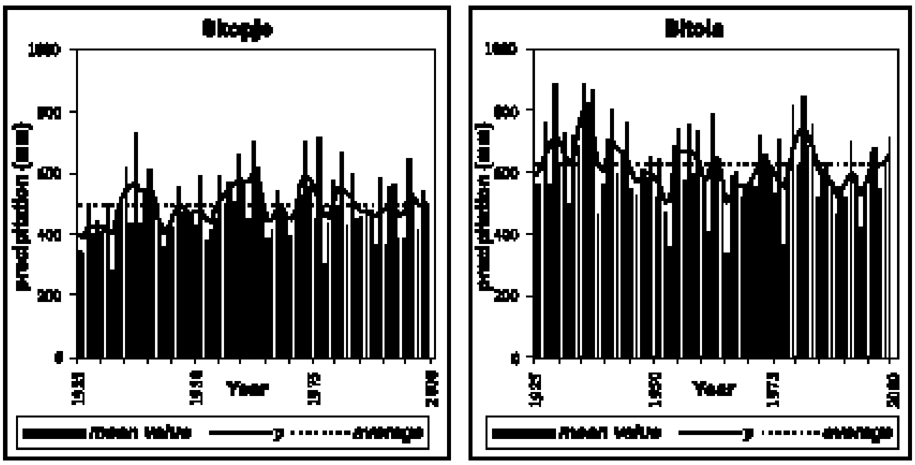



**Figure 6.2.** Many years uncertainties and variations of annually sums of precipitation for the period of 1926 to 2000

### 6.1.3. CLIMATE CHANGE SCENARIOS FOR THE TERRITORY OF REPUBLIC OF MACEDONIA

For investigation of climate change in 21st century, six climate models are used according to software package MAGICC SCENGEN (Hulme at al. 1995) as well as MAGICC (version 2.4 dated 2000) published by IPCC (Second Assessment, 1996), by which the assessment of average values is performed, as well as the values of low and high climate sensitivity.

Separately, those climate models (which are used in the analysis) are: HadCM2 and UKTR used by Hadley Center, UKHI-EQ used by Meteorological Service of United Kingdom, CSIRO1-EQ and CISIRO2-EQ used by Australian Scientific Investigation Institute, and CCC-EQ used by Canadian Climate Center.

On the basis of the above-mentioned scenarios, the sum predictions of main climate elements (air temperature and precipitation) are made for the following period in 21st century: 2025, 2050, 2075 and 2100.

Climate change scenarios in Macedonia are made supposing that the current policy of increasing the $CO_2$ concentration will be kept. Two projections of socio-economic development IS92a and IS92c are chosen. Emission scenario IS92a is a scenario of “the best estimation” of climate sensibility and IS92c is scenario of “low” climate sensibility.

According to the results given in Table 6.1, significantly worse results are obtained according to the IS92a emission scenario, where the average annual increases of air temperatures are in the range between 2.5°C in 2075 and 3.2°C in 2100. For the same scenario the average sum of precipitation will decrease between -3.4% in 2075 and -4.4% in 2100 in comparison with the period from 1961 to 1990.

According to the emission scenario IS92c the average annual air temperatures will increase in the range from 1.6 °C in 2075 to 1.7 °C in 2100. For the same emission scenario the average sum of precipitation will decrease between -2.2% in 2075 to -2.4% in 2100 in comparison with the period from 1961 to 1990.

Results of other analyses by seasons (spring, summer, autumn and winter) are presented in Tables 6.2 to 6.5. According to them significant changes of climate are expected in 21st century (for the air temperature and precipitation).

**Table 6.1.** Changes of annual air temperature and precipitation during 21st century, according to the emission scenarios IS92a and IS92c

| Year | IS92a | | | | | | IS92c | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | temperature °C | | | precipitation % | | | temperature °C | | | precipitation % | | |
| | L | M | H | L | M | H | L | M | H | L | M | H |
| 2025 | 0,7 | 1,0 | 1,4 | -1,0 | -1,4 | -1,9 | 0,6 | 0,8 | 1,2 | -0,8 | -1,2 | -1,6 |
| 2050 | 1,2 | 1,7 | 2,4 | -1,7 | -2,4 | -3,4 | 0,9 | 1,3 | 1,8 | -1,2 | -1,8 | -2,5 |
| 2075 | 1,7 | 2,5 | 3,5 | -2,3 | -3,4 | -4,9 | 1,0 | 1,6 | 2,3 | -1,5 | -2,2 | -3,2 |
| 2100 | 2,2 | 3,2 | 4,6 | -3,0 | -4,4 | -6,3 | 1,1 | 1,7 | 2,5 | -1,6 | -2,4 | -3,5 |

Climate sensitivity: L-low; M-medium; H-high

**Table 6.2.** Changes of air temperature (°C) in the 21st century, according to the emission scenario IS92a for four seasons (spring, summer, autumn and winter)

| Year | Spring | | | Summer | | | Autumn | | | Winter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | M | H | L | M | H | L | M | H | L | M | H |
| 2025 | 0,6 | 0,8 | 1,1 | 0,8 | 1,1 | 1,5 | 0,7 | 1,0 | 1,4 | 0,7 | 1,0 | 1,4 |
| 2050 | 1,0 | 1,4 | 2,0 | 1,4 | 1,9 | 2,7 | 1,2 | 1,8 | 2,5 | 1,2 | 1,8 | 2,5 |
| 2075 | 1,4 | 2,0 | 2,9 | 1,9 | 2,8 | 3,9 | 1,8 | 2,5 | 3,6 | 1,7 | 2,5 | 3,6 |
| 2100 | 1,8 | 2,6 | 3,8 | 2,4 | 3,5 | 5,1 | 2,2 | 3,3 | 4,8 | 2,2 | 3,2 | 4,7 |

**Table 6.3.** Changes of air temperature (°C) in the 21st century, according to the emission scenario IS92c for four seasons (spring, summer, autumn and winter)

| Year | Spring | | | Summer | | | Autumn | | | Winter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | M | H | L | M | H | L | M | H | L | M | H |
| 2025 | 0,5 | 0,7 | 1,0 | 0,6 | 0,9 | 1,3 | 0,6 | 0,9 | 1,2 | 0,6 | 0,9 | 1,2 |
| 2050 | 0,7 | 1,0 | 1,5 | 1,0 | 1,4 | 2,0 | 0,9 | 1,3 | 1,9 | 0,9 | 1,3 | 1,9 |
| 2075 | 0,9 | 1,3 | 1,9 | 1,2 | 1,8 | 2,6 | 1,1 | 1,6 | 2,4 | 1,1 | 1,6 | 2,3 |
| 2100 | 0,9 | 1,4 | 2,1 | 1,3 | 1,9 | 2,8 | 1,2 | 1,8 | 2,6 | 1,1 | 1,7 | 2,6 |

In Tables 6.2 and 6.3 the results of investigations of expected air temperature changes are represented according to two characteristic emission scenarios (IS92a and IS92c), which will happen during the 21st century in spring months ( March, April and May), summer months (June, July and August), autumn months (September, October and November), as well as winter months (December, January and February).

In all seasons the annual average air temperature increase will appear in the ranges between 0.8°C (in spring), 1.1 °C (in summer), 1.0°C (in autumn), to 1.0 °C (in winter) during 2025, 1.4°C (in spring), 1.9°C (in summer), 1.8°C (in autumn), to 1,8 °C (in winter) during 2050, to 2.6°C (in spring), 3.5°C (in summer), 3.3°C (in autumn), to 3.2 °C (in winter) during 2100. The former recognitions are made on the basis of emission scenario IS92a. On the other hand, according to the emission scenario IS92c, in 2100 the average air temperature will increase in range between 1.4°C (in spring), 1.9°C (in summer), 1.8°C (in autumn), to 1.7°C (in winter).

**Table 6.4.** Changes of precipitation during 21st century, according to the emission scenario

| Year | Spring | | | Summer | | | Autumn | | | Winter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | M | H | L | M | H | L | M | H | L | M | H |
| 2025 | -0,7 | -1,0 | -1,4 | -3,8 | -5,4 | -7,5 | -0,9 | -1,3 | -1,8 | 0,7 | 1,0 | 1,4 |
| 2050 | -1,2 | -1,7 | -2,4 | -6,6 | -9,5 | -13,3 | -1,6 | -2,3 | -3,2 | 1,2 | 1,7 | 2,4 |
| 2075 | -1,7 | -2,5 | -3,5 | -9,2 | -13,4 | -19,2 | -2,2 | -3,2 | -4,6 | 1,7 | 2,4 | 3,5 |
| 2100 | -2,2 | -3,2 | -4,6 | -11,8 | -17,3 | -25,0 | -2,8 | -4,2 | -6,0 | 2,1 | 3,1 | 4,5 |

**Table 6.5.** Changes of precipitation during 21st century according to the emission scenario IS92c for four seasons (spring, summer, autumn and winter)

| Year | Spring | | | Summer | | | Autumn | | | Winter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | M | H | L | M | H | L | M | H | L | M | H |
| 2025 | -0,6 | -0,8 | -1,2 | -3,2 | -4,6 | -6,4 | -0,8 | -1,1 | -1,5 | 0,6 | 0,8 | 1,1 |
| 2050 | -0,9 | -1,3 | -1,8 | -4,8 | -7,0 | -10,0 | -1,1 | -1,7 | -2,4 | 0,9 | 1,3 | 1,8 |
| 2075 | -1,0 | -1,6 | -2,3 | -5,8 | -8,6 | -12,5 | -1,4 | -2,0 | -3,0 | 1,0 | 1,5 | 2,3 |
| 2100 | -1,1 | -1,7 | -2,5 | -6,2 | -9,3 | -13,9 | -1,5 | -2,2 | -3,3 | 1,1 | 1,7 | 2,5 |

According to the emission scenarios IS92a and IS92c, the precipitation during the 21st century will change in the ranges shown in Tables 6.4 and 6.5. According to the six mentioned models of climate changes during the 21st century the precipitation decreasing will appear in spring, summer and autumn, while in winter the precipitation quantity will increase. The amounts of decreasing and increasing are shown in mentioned Tables and will be in the ranges, which are given in % of the average sums during the period 1961 to 1990. It can be remarked that the significant changes will appear during the summer according to the emission scenario IS92a. During the summer, according to the mentioned scenario, precipitation will decrease in the range of -25.0% that is 11.8% less comparing with the period 1961 to 1990.

**Table 6.6.** Changes of annual cloud cover during 21st century according to the emission scenarios IS92a and IS92c

| | IS92a | IS92c |
|---|---|---|
| **Year** | N, % | N, % |
| **2025** | -2,0 до -1,0 | -1,8 до -0,9 |
| **2050** | -3,7 до -1,8 | -2,7 до -1,3 |
| **2075** | -5,2 до -2,5 | -3,4 до 1,6 |
| **2100** | -6,8 до -3,2 | -3,8 до -1,7 |

According to the emission scenarios IS92a and IS92c, the annual cloud cover during the 21st century will change in the ranges shown in Table 6.6. Cloudiness is expected to decrease in the range of -6.8% to -3.2% according to the emission scenario IS92a, and in the range of -3.8 % to -1.7% according to the emission scenario IS92c in 2100, in comparison with the period from 1961 to 1990.

## 6.1.4. BASIC CONCLUSIONS MADE UPON RESULTS OF GLOBAL MODELS

According to the results of global models, air temperature increasing will not be equal for all parts on the Earth. The greatest warming will appear at the poles, while the least warming will appear at the equator.

At the north latitude between 45-70°N, the length of vegetation period will be averagely increased between 12 and 18 days.

It is predicted that air temperature over the land will warm up more than over the oceans. The air temperature difference between the day and the night will also decrease.

On the other hand, with air temperature increasing the quantity of water and water vapor in the atmosphere will also increase, which will influence the global hydrological cycle. The air temperature increase will cause increasing of evaporation as well as potential evapotranspiration.

That will lead to faster soil drought. At some parts of the Earth precipitation increasing or decreasing will appear (that means change of pluviometric regime).

It will enable increased precipitation intensity, which will influence the appearance of increased soil erosion and it will have harmful effects on the whole life and property as well as on human life.

The expected climate changes in the 21st century will reflect negatively upon all main sectors of influence in the state as follows: agriculture, forestry; water resources, as well as on human health and biodiversity, i.e. on all fields of human life (in spatial and urban planning, in tourism, recreation, transport), as well as the whole economic development of Macedonia.

### 6.1.5. ADAPTATION MEASURES

According to the UNFCCC, the final goal is to implement stabilization of gases concentrations, which cause the "greenhouse" effect in the atmosphere, at the level, which would prevent dangerous anthropogenic mixing in the climate system.

However, besides the atmosphere and climate components, land, oceans, ice and snow cover as well as their mutual connections are included in the climate system.

According to the dimension of the investigation, the climate system could be analyzed on the global scales (global climate system), on regional scales, at continental or ocean level (regional climate system) and at the level of each state (national, that is state climate system).

Climate system of local (micro) scales, so-called local climate system, can also be determined.

In accordance with this analysis for the territory of Macedonia there are state (Macedonian) climate system, as well as some local climate systems for some parts with mesoclimate conditions.

Classification can also be made according to catchments such as: basins of the river Treska, Lepenec, upper course of the river Vardar.

One of the climate system components can serve the analysis of meteorological-climatological elements and phenomena, agrometeorological elements and phenomena, hydrological elements of surface and ground water, as well as elements of water, air and soil quality in Macedonia.

According to the former climate investigations, there are many meteorological investigations by classic meteorological instruments and the investigation of atmospheric phenomena, which are monitored in the network of main, regular, and precipitation stations.

However, the existing network of meteorological stations does not satisfy the modern necessity of determination of climate system components on national and local scale.

Determination of climate system components, which is called "climate monitoring", should be modernized by establishment of new revised (modern) climate monitoring, which will be established on the whole territory of Macedonia, that is in all climate areas along with their climate parameters. That means automated climate monitoring system should be established, by which monitoring of all climate system components would be performed in the moment of their changes: daily, decade, monthly, seasonal and lasting several years in all climate areas in Macedonia. Climate monitoring system should also be established at local level for city Skopje and Skopje valley; for city Veles; Bitola and Pelagonia valley; for Ohrid-Prespa region; for Polog valley; for Gevgelia-Valandovo region etc.

For this issue, special projects for modernization and establishment of the whole climate system, as well as local climate monitoring systems should be made in Macedonia.

# 6.2. AGRICULTURE

The risk associated with climate change lies in the interaction of several systems with many variables that have to be collectively considered. Agriculture (including crop agriculture, animal husbandry, forestry and fisheries) can be defined as one of the systems, since soil is a system where all agricultural activities take place, and climate is another one. If these systems were treated independently, this would lead to an approach, which is too fragmentary. It is now held as likely that human activities can affect climate, one of the components of the environment. Climate in turn affects soil as a natural source for all agricultural and industrial activities

## 6.2.1. SOIL

**The influence of climate changes on the soil properties**

The soil has a lot of very important characteristics, which made it more or less very suitable for different roles in natural and controlled ecosystems, such as agricultural. In the Republic of Macedonia the soil is a very limited natural source, especially the arable land, which as a controlled ecosystem is exposed to many negative influences of the man's activity. There are lot of other important roles of soil in terrestrial and aquatic ecosystems. The most important are: soil is resource for a food production, soil influence on climate conditions, and the hydrological role.

**Table. 6.7.** Most important soil types in % and ha from the total arable land in Macedonia

| Soil type | ha | % |
|---|---|---|
| **Soils on lake terraces and hilly landscap** | | |
| Regosols | 92.705 | 10,12 |
| Regosols, rendzinik soils | 218.585 | 23,86 |
| Regosols and albic luvisols | 6.346 | 0,69 |
| Vertisols | 61.900 | 6,76 |
| Rendzinas | 2.100 | 0,23 |
| Chernozems | 32.800 | 3,58 |
| Cinemeonic soils | 113.359 | 12,37 |
| Cinemonic and albic luvisols | 4.068 | 0,44 |
| Albic luvisols | 21.617 | 2,36 |
| **T o t a l** | **553.478** | **60,42** |
| **Soils on a sloppy sites** | | |
| Deluvial and aluvial-deluvial | **159.593** | **17,42** |
| **Soils on flat sites** | | |
| Alluvial soils | 130.207 | 14,21 |
| Hydromorphyc, gleic soils | 39.395 | 4,30 |
| Paddy and paddy-gleic soils | 28.100 | 3,07 |
| Gleic soils | 2.100 | 0,23 |
| Hallomorphyc soils | 3.200 | 0,35 |
| **T o t a l** | 203.002 | 22,16 |
| **Total for all categories** | **916.073** | **100,00** |

The main potential changes in soil-forming factors (greenhouse efect), resulting directly from global climate change would be less provided in organic matter supply from biomass, soil temperature regime and soil humidity, because of shifts in rainfalls as well as changes in potential evapotranspiration.

### Conclusions and adaptation measures

Defining the parameters of sustainability and their limits are one of the most important challenges of the soil science in the years to come. The conclusions of the last conference of ISCO (International Soil Conservation Association) held in 1996 and conclusions of the 16-th World Congress of Soil Science held in 1998 very clearly emphasized the importance to develop a sustainable systems of soil use. Combat against soil degradation as a condition for a future sustainable development in agriculture is defined in Agenda 21.

Climate change, especially the global warming, can have severe negative effects on the soil productivity and could cause its degradation, desertification and erosion in the Republic of Macedonia. These changes have to be understood as a process but the effects which originate from them, can be very severe and irreversible. This means that the mitigating

and combat against these climate changes and its negative effects should be immediate and uncompromising. A special emphasis should be paid to the soil degradation and soil erosion as most dangerous, fast and unrepairable effects of the climate change. All the activities and adaptation measurements should be combinations of governmental officials and the farmers as direct producers. All human activities related with soil (especially crop production, forestry, pastures etc.) will have to be adapted in soil conservation manner. A separate legislative has to be adopted which will coordinate all the activities concerning this matter.

## 6.2.2. CROP PRODUCTION

Crop production strongly depends on climate conditions. It is well known that abiotic factors of agricultural production are with equal importance. Any of the abiotic factors cannot be replaced with other factor. The human activities can improve some of the abiotic factors trough agricultural practice (fertilization, irrigation, etc.). The climate conditions cannot be easily improved, so vulnerability of crop production on climate changes is very sensitive. The expected climate changes (increasing of temperature and decreasing of precipitation during the growing season) will affect crop production.

**Table 6.8.** Land use by categories in Macedonia for 1998.

| Category of land | ha | % |
|---|---|---|
| **Cultivable area** | **658.000** | **50,62** |
| Arable land and gardens | 550.000 | 42,31 |
| Orchards | 21.000 | 1,61 |
| Vineyards | 32.000 | 2,46 |
| Meadows | 55.000 | 4,23 |
| **Pastures** | **640.000** | **49,23** |
| **Ponds, reed, beds and fishponds** | **2.000** | **0,15** |
| **T o t a l** | **1.300.000** | **100,00** |

The limiting factor of the crop production in the major agricultural regions in the Republic of Macedonia is water shortage. According to the scenarios in the research, the average temperature will increase and precipitation will slightly decrease. The concentration of carbon dioxide will increase. So even though it is expected that higher temperature, higher solar radiation and higher carbon dioxide concentration, longer growing period and other effects of climate changes should increase crop production, the limiting factor - water decreases, so crop production will decrease.

The expected climate changes will affect crop production trough increased aridity of the agricultural regions. The Drought index of De Martonne shows that all agricultural regions will be more arid. The annual drought index will decrease from present average of 28.54 to 17.01 in year 2100 for Bitola region, from 20.56 to 16.23 for Stip region, from 23.21 to 15.81 for Demir Kapija region, from 27.30 to 15.56 for Gevgelija region. It means that all agricultural regions in the country from semi arid environment in present will became arid regions up to year 2100. The monthly values of drought index show that in some regions (especially the southern part of the country) July and August will be very arid and in some cases very close to the desert environment - August for Demir Kapija with 6.4. The soil water balance by Thornthwhite shows that the water deficit for normal crop growth will increase for more than 30% in all regions, up to year 2100.

The referent evapotranspiration according to FAO 56 method will increase for about 10%. The crop water requirement for winter wheat, alfalfa and grape will also increase for about 10%. The effective rainfalls will decrease for about 6%. In such situation the irrigation water requirement will increase for about 13% for alfalfa, and for 14% for winter wheat and grape.

According to FAO 33 method the decrease of the yield will be from 4% in year 2025 to 10% in year 2100 for winter wheat. The same yield decrease is expected for alfalfa. The grape is more drought resistant crop and yield will decrease from 3% in year 2025 to 8% in year 2100.

**Conclusions and adaptation measures**

The positive effect of climate changes can be achieved in irrigated agriculture if proper irrigation management is applied and irrigation water is supplied according to crop needs. There is about 120 000 ha that can be irrigated in the R. Macedonia. In the last period the irrigated area is about 30 000 ha that is less than 5% of the arable land or less than 2,5% of total agricultural land. Because of this situation, proper utilization of irrigation schemes should be considered as a main factor of adaptation. The better utilization of present capacities for irrigation should be of high priority, because only with that activity positive effects can be achieved for about 20% of arable land. This activity, despite present approach of rehabilitation of irrigation channels and networks, should be done at the farm level and at the water users level through direct work with crop producers by agricultural experts.

Because climate change will influence irrigated and rainfeed agriculture in different manner, it is necessary to apply different adaptation strategies in both cases. The most important is to provide proper adaptation strategy at the farm level, especially in term of education of the farmers how to improve their agricultural practice in order to overcome problems caused from the climate changes and if possible, to turn such changes into advantage through better use of irrigation water, improved agricultural practice, planting crops and cultivars that are adapted to expected changes, changes in soil cultivation in order to conserve soil.

Adaptation measures have to be taken in two directions:

- On the farm level
- On the national level

Certainly some global actions should be also taken but it is not topic for discussion in national reports.

On the farm level adaptation measures in two directions are recommended:

- In irrigated agriculture
- In dry farming

In irrigated agriculture there are a lot of possibilities to increase agricultural production as a result of climate changes with proper adaptation measures. The aim of adaptation measures in irrigated agriculture should be emphasized towards better use of available water, better use of soil fertility and better use of prolonged growing period. That is the way to benefit from the increased carbon dioxide concentration and to increase crop yield and bio production.

Major adaptive measures at the farm level can be divided in 3 major groups.

Irrigation with two main directions: to increase water use efficiency trough modern irrigation techniques and to spread irrigated area.

Agricultural practice that should be related towards water and soil conservation techniques.

Plant breeding that should be directed in developing species and cultivars with high genetic potential and efficient use of water and nutrients. Developing of drought tolerant cultivars should also be one of the priorities.

Despite adaptation at the farm level it is necessary to have adaptation at the state level, where systems for supporting of farmers with education, loans, building of new irrigation schemes, rehabilitation of present irrigation schemes, promoting of conservation soil cultivation, promoting of high efficient irrigation techniques will exist.

The FAO in the book "*Global climate change and agricultural production"* is dealing with socio economic conditions to adapt agriculture to climate changes. The strategy recommended by FAO experts is very close to the used approach herein. In order to prepare a national action plan to adapt Macedonian agriculture to climate change, it is proposed as follows:

| | **years** |
|---|---|
| ■ Variety adaptation | 3-14 |
| ■ Dams and irrigation | 50-100 |
| ■ Tillage systems | 10-12 |
| ■ New crop adaptation | 15-30 |
| ■ Opening new lands | 3-10 |
| ■ Irrigation equipment | 20-25 |
| ■ Transportation system | 3-5 |
| ■ Fertilizer adaptation | 10 |

### 6.2.3. LIVESTOCK AND POULTRY PRODUCTION

Climate affects livestock and poultry production by two mechanisms. Directly (to the animals) and indirectly (through the forage - feed).

If the number situation of domestic animals is analyzed according to statistic information of R. Macedonia, conclusion can be made that development is at medium level, but it is not followed by appropriate level of production per capita. Information about the number situation can be found in the table 6.9.

**Table 6.9.** Number of animals by species of domestic animals

| | Година | | | |
|---|---|---|---|---|
| | 1970 | 1980 | 1990 | 1996 |
| **1. Cattle and buffalos** | | | | |
| - total | 282.333 | 282.173 | 282.394 | 294.613 |
| Cows and brood heifers | 106.265 | 154.219 | 163.733 | 175.621 |
| - big farms | 11.738 | 21.030 | 27.943 | 22.118 |
| **2. Sheep** | | | | |
| - total | 1.862.737 | 2.057.524 | 2.297.115 | 1.813.895 |
| * for reproduction | 1.391.085 | 1.401.433 | 1.612.527 | 1.232.890 |
| - big farms | 159.624 | 168.271 | 208.835 | 143.879 |
| **3. Pigs** | | | | |
| - total | 83.266 | 167.778 | 178.537 | 192.396 |
| * for reproduction | 10.388 | 25.861 | 22.584 | 28.596 |
| - big farms | 19.166 | 84.824 | 82.302 | 69.709 |
| **4. Poultry** | | | | |
| - total | 2.136.008 | 4.690.522 | 5.728.981 | 3.360.801 |
| - big farms | 1.348.158 | 2.344.793 | 3.531.763 | 1.293.663 |

Through analysis of the amount, intensity and possible ways for improving the livestock and poultry production, followed by amount and intensity of plant, especially forage production, certain estimation can be made about the influences of climate changes to the current level of production and possible influences on future projected levels of development.

When estimation is made, direct influence on the animals that are subject of exploitation and their production and indirect influence on the livestock and poultry production through effects on plant or forage production should be taken into account. So, when the influence of the climate changes on the livestock and poultry production is taken into account, it should be evaluated as an indirect influence on the quantities of produced forage products that are used as feeding staffs mainly for ruminants and as grain for all species of domestic animals. Fluctuations in forage and grain production influence the profitability of the livestock and poultry production, but also the quantity and intensity of production (decreasing the number of animals and production per animal).

Estimation of climate factors on the livestock and poultry production should be focused on the direct effects that temperature and humidity have, as more important elements of the climate. This approach is justified because of the fact that production level and physiological activity are the best in temperature neutral zone between 18-28°C. Out of these frames, domestic animals as homoeothermic organisms react through adaptations of physiological regulation mechanisms with trying to save or exhaust energy in order to maintain their body temperature. Homeostatic and homeoretic mechanisms of regulation give priority to reactions by stages of importance. Then basic life functions take place, and all other functions are on the second place (primarily production and reproduction functions, e.g. functions that are of the highest importance for the breeder, because they influence the profitability of the production).

**Conclusions and adaptation measures**

Farm production records indicate long and short-term influence of climate changes on production and reproduction performances in all species of farm animals. Response of the animals to these climate changes is related to physiological reactions in order to adapt themselves to the new conditions and maintain homeostatic balance.

- New approaches are needed for overcoming the negative effects of the climate on animal production. These approaches should be primarily focused on:
- Redirections of the breeding programs' goals towards adaptation of the new genetic proveniences to different climate conditions;
- Application of new feed and feeding management programs;
- Proper farmhouse construction and farmhouse equipment that will enable keeping the farmhouse microclimate inside the range of thermo neutrality.

## 6.3. FORESTRY

Although Macedonia is a country with a relatively small territory, it is nevertheless characterized by a very heterogeneous climate, orography and vegetation. From the aspect of relief, Macedonia is a mountainous country, with altitude ranging from 40 m a.s.l. to 2764 m a.s.l.

According to the vertical spreading of the main (from phytochenological and economical point of view) tree species in the country, there situation is as follows:

- The oak area is spreading from the lowest parts of the state to about 1100 m. As it can be seen previously, the oak is most spread tree species in this area, and according to the climate and orographic conditions, it builds up different phytocenosyes.
- The birch area that is spread at:
  - submontainus forest birch area (from 1100 to 1300 m.),
  - mountainous forest birch area ( from 1300 to 1600 m) were the fir (Abies spp) and spruce (Picea spp) can be found,
  - sub-alpine area ( from 1600 to 2700 m)

Besides these tree species, the black pine (*Pinus nigra*) and white pine (*Pinus silvestris*) are of a big importance. These species are of bigger ecological value and can be found at: black pine from 700 to 1700 m and the white pine from 900 to 1500 m.

Macedonia has a semi-developed hydrographic network. One of its principal shortcomings is that the major part of the rivers, primarily the 1st, 2nd and 3rd class tributaries are dry during the summer, which has a negative effect on the forest vegetation.

### 6.3.1. FOREST AS A NATURAL RESOURCE

Forests cover more than one third of the total territory of the Republic of Macedonia. The basic characteristics of the forests in table 6.10 are presented.

**Table 6.10.** The forest reserves in the Republic of Macedonia

| | Forms of forests | S U R F A C E | | |
|---|---|---|---|---|
| | | ha | % | Total |
| 1. | **Tall-trunked** | | 100 | 262.790 |
| | - even-aged | 95.883 | 36 | |
| | - various-aged | 166.907 | 64 | |
| 2. | **Short-trunked** | | 100,0 | 642.653 |
| | - short-trunked | 557.592 | 86,6 | |
| | - shrub forest | 77.567 | 12,1 | |
| | - bushland | 6.099 | 1,1 | |
| | - pseudo maquis | 1.605 | 0,2 | |
| | **Total:** | | 100 | 905.653 |

The above data show that the forestry reserves in Macedonia are not at a satisfactory level and lag considerably behind other countries, especially those of Central and Northern Europe. The high quantity of short trunked offspring trees, many of which are highly degraded, together with the small quantity of conifers, results in relatively low timber reserves, low timber mass, and low annual growth per unit of land.

**Legal regulations and organization in forestry**

The status of forests is basically defined by the Constitution of the Republic of Macedonia as a natural resource of public interest placed under special protection regulated by law.

The forest resources in Macedonia are managed by the  Ministry of Agriculture, Forestry and Water Supply, in coordination with the Public Enterprise Macedonian Forests - Skopje. There are 30 regional forestry units dispersed throughout, governed by the Public enterprise.

**Forest protection**

One of the most important sectors in the forestry in Macedonia is forest protection. The "*Department of forest and wood protection"* at the Faculty of Forestry in Skopje, has been involved in matters of forest protection from pests and diseases throughout Macedonia, predominantly with expert advice, consulting, and controls. This Department is responsible for the *Information, Diagnostics and Prognostics Service of Macedonia*. The above service has existed very successfully for the last 25 years.

As a result of the long dry period (1984-2000), the damage caused by forest fires has recently been greater, especially in 1993 and 2000. In the period 1978-1997 the average annual fired forest land, caused by 111 outbreaks of fire, amounted to 3271 ha.

Since 1990, considerable attention on investigation of forest dieback in Macedonia has been focused, which has also been a problem in recent years in Europe as well. According to carried out researches, it is concluded that the most threatened tree species is oak *Quercus spp*. For illustration, some results from the research in which an assessment of oaks health condition is made, 50.2% of investigated trees had no symptoms of crown transparence, while only 28.4% had no symptoms of dieback. Also, 35% of oak trees had a dead top.

## 6.3.2. VULNERABILITY ASSESSMENT

The climate change at the global level, caused from the air pollution and increased concentration of $CO_2$ in the atmosphere that leads to the greenhouse effect, can be seen through the temperature increase and the precipitations decrease.

The fact that the effects of forest dieback are due to the climate change is confirmed by the IUFRO report (International Union of Forestry Research Organization) under the title: "*Long-term Implications of Climate Change and Air Pollution on Forest Ecosystems*". For attending of this action, a unique criterion for estimation of the forest health in the European countries has been done. More precisely, a Commission for Forestry of the European Union, for this purpose has prepared a manual: "Assessment of the Tree Condition", that is used in Macedonia too. According to this methodology, some evaluation of the health condition of the oak and fir forests in Macedonia has been done in the years 1991, 1994, 1996 and 1999. The assessment of tree condition has been done for areas of Strumica, Kavadarci, Bitola, Resen, Kicevo and Mavrovo. The oak health assessment has been done at ass. *Orno-Querecentum petracae* Em., and for the fir at ass. *Abieti-fagetum macedonicum* Em.

According to this investigation it can be seen that the health condition of the oak and the fir, especially the oak, in the last decade from the 20$^{th}$ century is rapidly getting deteriorated. This deterioration of the health is in addition to the climate change in Macedonia during the same period.

More precisely, according to the Hydrometeorological Institute of Macedonia, the decreasing of the annual sum of precipitations in Macedonia (for the same period, and according to the period of 1951-2000) is about 1 to 7 mm. If it is regarded by months, in separate regions in Macedonia, the decrease goes to 35% (Lazaropole - January).

On the other hand, this is induced by increasing of the air temperature. For separate regions in Macedonia, the increasing of the average annual temperature (for the period 1991 - 2000 and in correlation of 1951 - 2000) it is about 0.05 to 0.35 °C. At several regions the increase of the average monthly air temperature (in June) goes to 1°C. On the other hand, at other locations there is a decrease of the average monthly temperatures at the winter months down to 0.7°C.

This shows that during the last ten years the average air temperatures in the summer months have increased, and in winter months they have decreased, or the annual air temperature amplitude had raised. On the other hand, the decreasing of the precipitations makes the whole situation even more complicated. The result from this condition is a "stress" at the plants.

Movement of the tree species can happen to the regions with higher altitudes. If the health condition of oak and fir in Macedonia is observed, then the data about the air temperature and the precipitations change, the table data about the possible scenario in Macedonia in the next 100 years, taking in consideration the previous, the future of some tree species and communities is very pessimistic. If the anthropogenic effects throughout the history and today (forest harvesting, forest fires, act) is added to the previous, the condition becomes even more difficult. More precisely, it can face more massive declining of oak, pine, fir (especially in worse soil conditions and sought expositions) and their migration to the north and to the higher mountain areas, that will change the phytocenological condition in Macedonia completely. These will increase the quantity of dry wood material (forest fuel material) more appropriate for fires, at one piece of area, and because of the air temperature increasing and precipitations decreasing, it would face a larger number of forest fires and a large area of burned species, that could lead even more to fastening of the previous described process. As an example of this, there are data for 2000 year, when 2,656 fires occurred and 48,104 ha burned area.

### 6.3.3. ADAPTATION MEASURES

The forest is a very specific and complex plant and animal community, and the forestry is almost as much complex as an economic activity too. According to this, the measurements in the forestry that should be done for mitigation of the climate change effects on the forest and the adaptation are influenced (negative or positive) by larger number of factors. Besides this situation, the forestry should take two emergency measures for mitigation of the effects of the climate change adaptation, as:

- Permanent control of the oak dieback process, as well as the other tree species, and a sanitary cut should be performed that could lead to prevention of development of some specific tree diseases, harmful insects and animals.
- Increase of the protection degree of the forests from forest fires at much higher level from the present one.

During the past 50 years in Macedonia about 120,000 ha of skinned area has been afforested, and almost the same area is left over for afforestation too. If all of the bare areas are afforested, than Macedonia could possess forest fund of about 1,150,000 ha, that is about 15% more than in the present. The effects of those forests can be seen trough:

- Decrease of the erosion processes and regulation of the water regime;
- Affection of the climate at the forestation regions;
- Storage of $CO_2$ at the timber, a gas that is one of the causes of climate change.

During the forestation that should be undertaken a special attention has to be paid to the choice of the tree species. The practice has shown that the present monocultures from Pinus silvestris, Pinus nigra and Arizona cypress are not so much qualitative. They have been attached by a large number of insects and illnesses, and especially suffer from forest fires. Because of these, it is necessary to be turned to autochthon leave tree species, as the oak, and especially the areas ready for forestation are areas with oak forest.

The cost expense of one hectare forestation is relatively high and for that reason reactivation of the Fund for afforestation of bare areas in Macedonia is necessary (that have been in good function in the past) at the Ministry of Agriculture, Forestry and Water Resources.

The aim of the new forests should not be of economic importance only, but it should also be of ecological and protection importance, meaning the state should provide a special treatment.

Taking into consideration everything previously mentioned, condition of forests in the country has to be permanently monitored, so that it can be acted at time with appropriate actions.

**Table 6.11.** Adaptation measures in forestry

| | Identified problem | Measures of action | Some other measures correlated with the suggested activities |
|---|---|---|---|
| 1. | **Forest dieback process, especially for oak** | Permanent control of the health condition of the forests and building of data base | |
| | | Realization of sanitary cutting | - Providing financial resources.<br>- Removing and using of the waste during cutting. |
| 2. | **Forest fires** | Undertaking of preventive actions | |
| | | Undertaking of pressuppresive actions | |
| | | Preparation of National strategy for protection of the forests from firs | |
| 3. | **Large bare place areas** | Afforestation | Reactivation of the Fund for afforestation of the bare areas. |

## 6.4. BIODIVERSITY

Macedonia is characterized by a high level of biodiversity richness due to the specific geographical position, geological history, composite geology, well-developed relief, as well as the climate characteristics. The vegetation in Macedonia is distributed in belts, limited by the climate characteristic changes along the vertical gradient, from the lowland (river valleys) up to the high mountain picks. On the other hand, there exist azonal plant communities, characteristic for the river valleys and deep gorges.

There are many attempts to divide the Macedonian territory in different biomes of similar categories. According to the biome division of Matvejev (Lopatin and Matvejev 1995) there are: biomes of Mediterranean evergreen woodlands and maquis, biomes of submediterranean broad-leaved woodlands and shrubs, biomes of south-European mostly broad-leaved woodlands, biomes of European mostly coniferous forests of boreal type, biomes of high mountain rocks and pastures, biomes of steppes and woodland steppes, and biomes of stony grounds, pastures and woods on stony grounds of (oro) Mediterranean mountains. According to Filipovski et al. (1996), Macedonia is divided into eight climate-vegetational-pedological zones (regions): submediterranean zone, continental-submediterranean zone, warm continental zone, cold continental zone, piedmont continental-mountain zone, mountain-continental zone, sub-alpine mountain zone and alpine mountain zone.

For certain areas, the changes of the temperature regime might be more important factor causing the disturbances of the characteristics and the composition of the ecosystems, while for others, that factor might be the change of the precipitation quantity, i.e. the available humidity. Especially important factor for the biodiversity in individual areas in Macedonia will be the perturbances of the precipitation distribution through the year.

Considerable movement of plant and animal species in south - north direction, as well as along the vertical gradient are expected, without taking into account what model for climate change in the next 50 or 100 years should be applied and no matter how big temperature changes are foreseen. In any case, large dislocations of vegetational zones will happen, or a certain redistribution of ecosystems and organisms along with zones. The size of damages and species loss will depend on the rate of the changes of the climate, since the change of the species areals depends on their adaptation ability and mobility, or the possibility of parallel shift of the areal with the climate change. This is especially important for the long life plant perennial species as trees, which actually determine the ecosystem to the highest degree, and along with it almost all other species.

**Methodological approach:**
Summary of the methodology used in climate change predictions concerning biodiversity is given in Malcolm et al. (1998). It is necessary to moderate and estimate different studied methods for species, communities, ecosystems etc. Concerning the climate change impacts on species, the method of *expert judgment* is the most adequate one, combined with method of analogues studies. The method of *species assemblages* is more appropriate one for the determination of climate change impact on communities. The *biome modeling* should be the most appropriate method to assess the climate change impact on biomes and ecosystems.

### 6.4.1. VULNERABILITY ASSESSMENT

Although Macedonia is small country, it is difficult to analyze it integrally because of the highly diverse relief (mostly mountainous, existence of shorter and longer river valleys, narrow gorges with different expositions of the slopes. As subjects of analyses target regions (refugial zones Treska and Nidze), target ecosystems (alpine pastures and pseudomaquis) and target species were chosen. On the basis of these analyses, conclusions for the climate change impact on biodiversity in Macedonia can be derived.

**Vulnerability of target regions**

Within the framework of the climatogenic (zonal) forest communities there are “islands” with specific floristic composition that might be included in the azonal plant communities. They are very interesting sites because of their microclimatological characteristics and unique floristic composition (numerous relict species and biodiversity). Some refugia are grouped on relatively small areas called refugial zones.

The phenomenon of refugia might be used as a model of changing vegetation during climate changes in the past period. The dominant vegetation cover, after significant changes, was sheltered places with lower temperature and higher humidity and other areas with appropriate microclimate.

In Macedonia there are 11 refugial zones: Vardar-Valandovo-Strumica-Dojran refugial zone, Tikvesh refugial zone, Taor gorge and Pchinja gorge refugial zone, The River Treska canyon refugial zone, the River Crna with Raec and Blashnica gorge refugial zone, Jama refugial zone, Mavrovo-Radika refugial zone, Strazha refugial zone, Pelister refugial zone, Ohrid-Prespa refugial zone and Nidzhe-Kozhuf refugial zone.

**REFUGIAL ZONE TRESKA:** Most of the relict communities develop in the sheltered, more humid places on the northern slopes of the small gorges, perpendicular to the main valley. Since the drop of the precipitation will follow the foreseen raise of the temperature, it is most likely that the new ecological conditions would be unfavourable for these communities. The redistribution of the precipitation throughout the year will also have negative effect. The result might be that the changes would be so great that the species will be unable to adapt to the new conditions. Because of their restricted distribution, it is to be expected that they will not have possibilities to move either horizontally, or vertically (to shift their areal) to meet their ecological requirements along the latitudinal or altitudinal gradient. One can expect that most of these communities will disappear. Other communities, which have broader distribution, would not be so endangered since they have more possibilities to move in available space.

**REFUGIAL ZONE OF NIDZHE MOUNTAIN**: It is very suitable for analysis of climate change impact on biodiversity in Macedonia. Seven biomes out of eight characteristic for Macedonia are distributed on this mountain. Other geographic features of the area correspond to the easy movement of species distribution (the slopes are northern faced, cut by south-north flowing streams and rivers, which create smaller or larger valleys and canyons). In order to assess the impact of future climate change on the living organisms on mountains more accurate, it is necessary to know more about micro- and mesoclimate conditions in the area. The most important parameters are the differences between the north and south slopes concerning temperature and rainfall, the vertical gradient of temperature and precipitation on both north and south slopes etc.). These are data that are not available in Macedonia (there is only one meteorological station in alpine zone and only one in sub-alpine zone on the whole territory of Macedonia).

The distribution of different communities in this region is restricted in small areas, mostly in the river gorges and other hardly accessible areas. This is especially true for the lower altitudes and termophyllous broadleaf, mostly oak, zonal communities. If the changes will be with the predicted speed, it is not likely that the migration speed of the species would be able to follow it. In addition to that, the future land use pattern is very important for the final process of surviving of the natural communities.

### Vulnerability of ecosystems

**ALPINE PASTURES**: The alpine zone in Macedonia is distributed above 2,100-2,300 m above sea level, depending on the exposition of the slope and the latitude. Thus, only the highest mountains in Macedonia have a real alpine zone (Shar Planina, Korab, Pelister, Jakupica, Nidzhe and maybe some other mountains with the highest peaks 2,100 to 2,350 m a.s.l.). Only Shar Planina and Korab have peaks above 2,700 m. They are also characterized by the large areas with altitude above 2,500 m. Very important factor for the species living in alpine zone is temperature. This can be concluded not only through the knowledge of their ecology, but also by taking into consideration the historic moment. These species are mostly arctic and glacial relicts, as well as endemics, products of recent speciation. If one consider the rise of the temperature of about 3.2°C (IS92a) for the next 100 years, it is obvious that even the highest peaks will have higher average annual temperatures than present temperatures in the upper sub-alpine zone. According to the Hopkins Bioclimate Law (Beniston and Fox 1995) the rise of the temperature of 3°C corresponds to the change of the altitude of 500 m. In that case, most of the present alpine communities will disappear. We can only hope that the situation in the sheltered and north-faced slopes will still offer ecological conditions for survival of some alpine communities.

**PSEUDOMAQUIS:** Climate change in the first period will have favourable effects on the spreading dynamics of sub-mediterranean oak forests - pseudomaquis in Macedonia. Pseudomaquis will occupy the areas that are covered by submediterranean oak forest. In the next period, some parts of the pseudomaquis can be expected to disappear and these sites will be covered by grassy vegetation of Mediterranean type.

**SPECIES:** There are many animal species that are strongly dependent on temperature. Some of them directly and some indirectly because of the changes in vegetation, food resources.

One of the examples of homoeothermic animals that will be affected by climate change is Snow finch. The increase in temperature of 3 °C (a vertical shift of 500 m) means that this species will be climbing to the highest peaks of the mountains (Shar Planina and Jakupica). The greatest problem for the Snow Finch will be during the nesting period because of the impossibility to feed the nestlings with the insects from the edges of melting snow. Some insect species are directly dependent on the temperature. It can be noticed that many species appear during spring on the high mountains and finish their life cycle in the beginning or middle of the summer. The climate change impact (temperature increase) will be expressed by the shift in the appearance of the species and sooner ending of their life cycle. The vertical shift can be expected as well.

### 6.4.2 MEASURES FOR ADAPTATION AND MITIGATION

The basic mitigation measures should concern the incorporation of possible climate change impacts to ecosystems, communities and species into general measures for biodiversity protection. This mainly refers to integration of the Convention for Biological Diversity (CBD) demands with the requirements of Climate Change Convention (CCC). It is quite clear that this is almost impossible in the case of Macedonia due to the diverse limiting factors: inappropriate scientific base, undeveloped or underdeveloped, or more exact inappropriate infrastructure - scientific, material . . .

Besides the integration of CBD and CCC, it is necessary to integrate the requirements of mitigation of negative effects and adaptation measures into general and specific action plans from different aspects of the environment (forestry, agriculture, water economy, industry, etc.), i.e. with the overall policy for sustainable development on the country level. It is especially important to revise the Physical Plan of the Republic of Macedonia and to implement the demands of negative impact mitigation of climate change on biodiversity in the land use pattern.

The intersectorial approach is the only right way. There is conflict of interests between the different sectors that are exploiting natural resources or refer to the environment. Water economy sector is using flowing and stagnant waters without taking care of the organisms living in the water ecosystems; forestry uses forest biomass in way which is mostly unfavorable for biodiversity preservation; agriculture land use pattern is mostly adverse to biodiversity preservation. These conflicts will increase in the future parallel with climate change.

As general, long-term activities the following are proposed:

- Establishing scientific infrastructure for evaluation of climate change impact on biodiversity and terrestrial ecosystems and training of experts for climate change issues and implementation of modern technologies

- Collection of data necessary for the estimation of climate change impact on biodiversity and establishment of database with a detailed study of the distribution and origin of refugial communities in Macedonia and migration paths
- Establishment of intersectorial body between the sector of water resources management and biodiversity
- Elaboration of the climate change impact on biodiversity and terrestrial ecosystems in Macedonia and preparation of National Strategy
- Public awareness raising concerning climate change issues.

Special action plans:

- Elaboration of biocorridores and migration paths of different species in climate change condition
- Establishment of seed bank of endemic and other important species
- Evaluation of the possibilities for preservation of vulnerable animals in captivity
- Increasing the surface of protected areas in Macedonia (National Parks, reservations) and establishment of new protected areas and preparation of network of protected areas in accordance with the recommendations of NATURA 2000, EMERALD etc.
- Establishment of network of climatological stations in the region of Nidzhe and Mariovo in order to obtain more detailed data of the changes in the climazonal ecosystems.

## 6.5. HYDROLOGY AND WATER RESOURCES

In the Republic of Macedonia no organized examination of the climate changes impact on the water resources has been carried out until now. the Republic of Macedonia is a small country by area, but has different climate characteristics. Climate differences can be, generally, described through annual amounts of rainfalls, that are 400 mm in the Ovche Pole region up to 1,300 mm in the western Macedonia. From the hydrological aspect the differences are described with average annual runoff coefficients in range 0.50 - 0.10.

With the water resources analysis of some basin or region, it is often hard to extract and evaluate separately climate changes impacts from the impact of the human activities. Exact evaluation of the climate changes impact on the water resources, depends on the climate scenario precision and knowledge of the processes regulating the water balance in the river basin. Quantitative knowledge about the hydrological cycle is generally insufficient, and the reasons are: (i) climate changes and/or variety of the climate, (ii) dilemmas caused by time and physical measures regulating the hydrological cycle, (iii) human activities impact on the water regime and (iv) operation difficulties with maintenance and operation with the hydrological, hydro-geological and meteorological observing network.

The objectives that have to be attained with this section are: determination of the water regime in main rivers, determination of the water regime in natural lakes, determination of the change in water regime and adaptation measures and draft action plan with activities and strategies.

### 6.5.1 WATER RESOURCES AND HYDROLOGICAL CHARACTERISTICS

Climate variety in the country can be seen through the general data for physical-geographic, climate-meteorological and hydro-geographic characteristics. Hydro-geographic territory of the Republic of Macedonia belongs to the following basins: the Vardar, the Strumica, the Crn Drim and the Juzna Morava. The basins of the Vardar and the Strumica gravitate towards the Aegean Sea (22,351 $km^2$ or 86.9%), the basin of the Crn Drim gravitates towards the Adriatic Sea (3,318 $km^2$ or 12.9%) and basin of the Juzna Morava belongs to the Black Sea (44 $km^2$ or 0.2%). The longest river is Vardar (302.6 km), with basin area of 22,456 $km^2$, with average rainfalls of 660 mm, with total annual discharging of $4.56 \cdot 10^9$ $m^3$.

Inflow waters in the Republic of Macedonia are rivers: Lepenec, Pchinja and Eleshka. Output waters are rivers: Vardar, Crn Drim, Strumica and Cironska. Available water quantities from the surface input waters are 1,014 millions $m^3$/annum, 6,360 millions $m^3$/annum from output waters and 5,346 millions $m^3$/annum are domicile waters. It can be stated that in the territory of the Republic of Macedonia, 84% of the available water quantities are domicile waters and only 16 % are outside waters.

Three natural lakes have also great significance for the hydro-geography of the Republic of Macedonia and they are: Ohrid Lake with total area of 348.8 $km^2$ (Macedonian part 229.9 $km^2$) and with the maximum depth of 285 m, Prespa Lake with total area of 274.0 $km^2$ (Macedonian part 176.8 $km^2$) and maximum depth of 52.4 m, and Dojran Lake with total area of 43.0 $km^2$ (Macedonian part 27.4 $km^2$) and maximum depth of 10 m. In order to utilize the hydrological potential of the rivers, 19 large and over 100 small reservoirs/ lakes have been constructed, with total volume of 1,854 millions $m^3$ of water.

In Macedonia 4,414 springs with total yield of 991.9 millions $m^3$/annum have been registered. Three of these springs are in the central part of Povardarie, and all others are in the western region. More significant springs are: Izvor (yield over 3 $m^3$/s), Studenchica (yield 0.4 to 4.3 $m^3$/s), Pitran, Peshnica and Belica (yield over 6 $m^3$/s), in the Treska basin, then St. Naum (yield over 10 $m^3$/s), Biljana, Duvlo, Vevchani (yield over 1.5 $m^3$/s), and Rosoki (yield over 2.5 $m^3$/s), in the Crn Drim basin with Ohrid Lake. In the Crna Reka basin, four springs exist and the largest one is Izvor with yield of over 1 $m^3$/s. In the river Vardar basin without river Treska, 19 springs exist and Rashche is the largest one with yield of over 6 $m^3$/s. Eastern Macedonia or the left side of the river Vardar is poor with water and seven springs with very small yields have been registered there.

Ground waters have also been noticed, but insufficient and no appropriate data for their yields and quantities exist. Observation and examination of the ground waters have not been performed systematically and continuously, except for the local demands for certain regions. More detailed examinations have been carried out only within the period 1963–1975, when hydro-geological units for the basins of rivers: upper Vardar, Treska, Crn Drim, Crna Reka, lower Vardar and Eastern Macedonia have been identified. With these examinations static funds of ground waters have been estimated: for Polog - 193 millions $m^3$, for Skopje valley - 925 millions $m^3$, for Kumanovo valley - 675 millions $m^3$, for Ovche Pole - 256 millions $m^3$, for Strumica valley - 850 millions $m^3$, and for Gevgelija-Valandovo valley - 342 millions $m^3$.

Required water quantities in different economy segments, according to the Physical Plan of the Republic of Macedonia (1998), are for water supply 285,600×$10^3$ $m^3$/annum in 2010 and 336,390×$10^3$ $m^3$/annum in 2020. The most increasing water demands are in agriculture for irrigation in amount of 907,376×$10^3$ $m^3$/annum in 2010 and 1,806,711×$10^3$ $m^3$/annum in 2020, that is increase of 100%.

### 6.5.2. VULNERABILITY ASSESSMENT

The analysis of available water resources and estimation of their change in the future have been performed with determination of flow trends for the surface watercourses hydrological stations and with trends of water levels for hydrological stations of the lakes, for the period 1961-2000. The following hydrological stations have been selected: the river Vardar - Skopje, the river Crna - Skochivir, the river Radika - Boshkov Most, the river Strumica - Sushevo, Prespa Lake - Stenje, Dojran Lake - Nov Dojran and Ohrid Lake - Ohrid. The time variation of minimum, average and maximum discharges for the rivers and water levels for the lakes are graphically and analytically defined. Shown diagrams are real hydrographs $Q = f(t)$ and real water level variations $H = f(t)$. Reduction of characteristic flows and water levels for all analyzed stations is obvious. According to the performed analyses of the hydrological observed parameters, the following concluding remarks can be carried out: (i) observed serial of data for 40-50 years is insufficient for more complete analyses and more reliable forecasts for the trends of the hydrological parameters in the following period, that is 21 century, (ii) for estimation of the water resources state in present and future, real data for ground waters are also required, (iii) for all analyzed rivers for the observed period the average discharges have decrease of 10% ¸ 20% and the maximum discharges reduction is up to 80%.

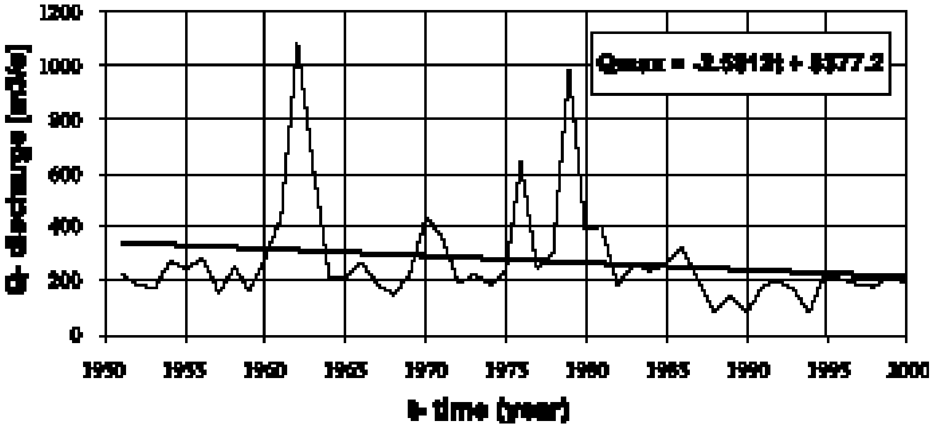



**Figure 6.3.** Annual values of maximum flows for the river Vardar at Skopje

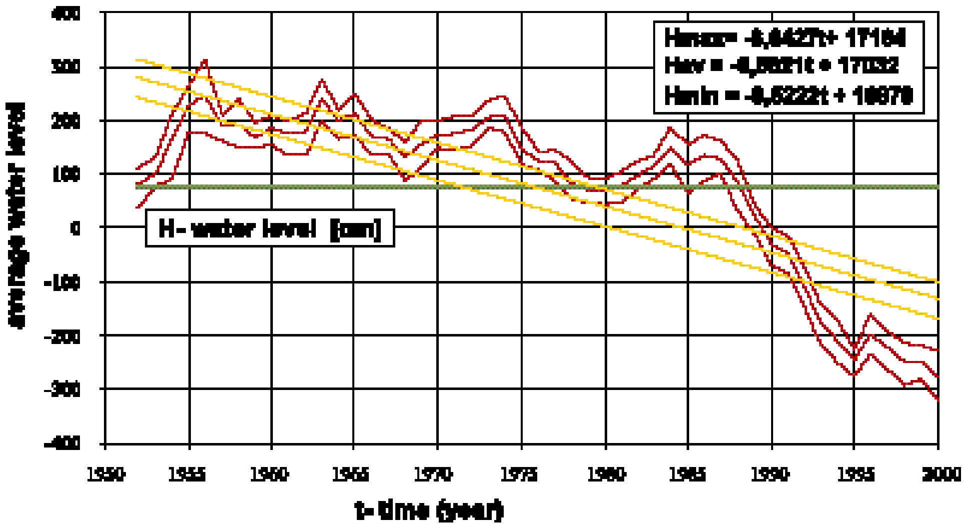



**Figure 6.4.** Characteristic water levels of Dojran Lake

Analysis which are carried out, as well as conclusions and opinions of the impact climate change on hydrology and water resources project, cannot give final answer on this complex question. Required data for the analyses are historical, hydrological and meteorological data series, and the existing ones are relatively short, often inhomogeneous, and it is more than obvious that acceptable answers, solid forecasts and appropriate solutions for negative influence reducing will be waited for a long time.

According to the carried out investigations and analysis, it can be concluded that the most vulnerable regions in Macedonia are east and south-east part, while the most susceptible water economy sectors are water supply and irrigation.

### 6.5.3 ADAPTATION MEASURES

In the National Action Plan for Adaptation, great problem represents the fact that there is large time difference between the climate change influence identification moment and the moment when carried out adjustment measures show some results. First step in adaptation of the water resources to the climate change impacts is certainly the realization of the Action plan for the climate change impacts. Afterwards taking the technical measures for protection of the endangered regions and adaptation of the water management would be possible, so the main functions in that area/region will remain. This protection strategy can be impossible or unacceptable due to neighboring economic and other influences. Therefore, different strategies should be developed and the best, i.e. the most adjustable one, should be chosen. The choice of the most adjustable strategies is possible only if climate changes influences are elaborated in several main segments: (i) economic (production losses, cost of the carried out measures and etc.), (ii) medical (safety, supplying, food quality, and etc.), (iii) social (unemployment, migrations and etc.) and (iv) administrative (legal problems, competency, administrative limits and etc.).

Water resources problems should be solved institutionally, systematically, and gradually. Following activities should be accepted as priorities:

- Modernization of the hydro-meteorological network
- Data monitoring establishment
- Reconstruction and rehabilitation of the built structures and systems
- Water resources management

In the action plan and adaptation measures, identification of the endangered regions should be planned. The discussed problems in different sectors, concerning the water resources and hydrology, and adaptation measures to climate changes as an integral part of the action plan, are systematized as follows.

- In hydrometeorology the measures are:

  modernization of the network, data monitoring establishment of the meteorological, hydrological and water quality parameters, efficient processing of the measured data, implementation of the real time predictive models.

- In water supply sector the measures are:

  water losses reduction, placing of pressure and flow meters, implementation of dual supply systems for potable and non-potable water, recycling of water for non-potable uses, rain water collection for non-potable uses.

- In sewage systems the following activities are necessary:

  water efficient appliances, waste water purification and their re-use, street and car washing with recycled waters.

- In agriculture the most vulnerable sector is irrigation and the measures are:

  cover-lining of the open canals, introduction of the closed conduits, introduction of drip, micro-spray and other low-energy irrigation systems, improvement in measurements, night time irrigation, use of waste water effluent, control and management of the systems.

- In hydropower systems the adaptation measures are also necessary, such as:

  keeping the reservoirs at lower head, implementation of more efficient hydropower turbines, construction of additional reservoirs, taking plants off-line in low flow periods, construction of alternative systems.

The main purpose of the proposed measures, for water resources adaptation with the constructed and/or required infrastructure in the Republic of Macedonia, is to reduce the water losses in conditions of climate changes, various in time and space. Studies for evaluation of the river basin sensitivity and water balance components under different scenarios of unfavorable climate impacts are necessary.

For measures of implementation, previous identification of the endangered regions is required as well as carrying out the law regulation for utilization and maintenance of the structures and systems for water resources utilization under conditions defined in the national action plan for climate change. Besides this, education of the population is required by introduction of the management concepts based on ecological and economic basis.

## 6.6. HUMAN HEALTH

All climate and weather variables have some influence on human health. The effect may be either directly on the human body or indirectly through effects on disease-causing organisms or their vectors. Direct effects involve mostly physical impacts that act to cause physiologic and psychological stress (e.g., temperature) or bodily injury (e.g., storms, floods). Direct effects tend to be observed soon after the causative weather event, and are generally more easily modeled and understood than indirect effects.

On the other hand, indirect effects, such as climate impacts on food supplies and the outbreak of vector- borne diseases, may operate through diverse pathways involving multiple variables. People with chronic diseases, especially the elderly, are very susceptible to aggravation of the disease state from both excessively cold and excessively hot weather. Temperatures in warmer temperate zones are ideal for the survival and propagation of causative agents for some bacterial, viral, and parasitic diseases. Temperature also affects human health by affecting agriculture and water resources. The effects of high temperatures on human health are modified by the amount of moisture in the air (humidity). The extent of thermo-mechanisms that regulates body temperature depends on humidity. Climate change could affect human health through increases in heat-stress morbidity and mortality, tropical vector-borne diseases, urban air pollution problems, and decreases in cold-related illnesses.

At the individual level, a complex mix of factors determines the degree of health vulnerability. These factors include: age, gender, disability, social engagement, income, cultural knowledge, legal rights, access to health services, political power, built and natural environment, and physical resources.

Impact assessment of climate change has to consider both the sensitivity and vulnerability of populations to specific health outcomes from climate change. Vulnerability is a function both of the exposure to changes in climate and on the ability to adapt to the impacts associated with that exposure.

### 6.6.1. VULNERABILITY ASSESSMENT

During the last period the structure of the death in the Republic of Macedonia in the total mortality rate has been significantly changed. The cardiovascular and malignant diseases have noticed significant increase in mortality. In the Republic of Macedonia mortality from circulatory system diseases had been among the causes of death during the last 25 years. Mortality from ischemic heart diseases has increased both in males and females. In the period of 1980-2000 in the Republic of Macedonia existed a general trend of registered cases of Alimentary toxic infections (ATI) and relatively high morbidity rate (in the rank 80-85/100.000) as well as that the salmonellosis has an increasing trend, particularly in the last decade.

Abrupt changes in weather, such as those associated with the passage of a weather front, have been implicated in such things as feelings of discomfort with symptoms such as headaches. These are only few examples showing that weather changes may be related to the onset of some diseases, such as common colds. Wind in combination with temperature and humidity can affect human thermoregulation. It can also be a means of spreading the causative agents of disease, insect vectors, and allergens.

If there is too little or too much precipitation or the timing is wrong, there may be crop damage. This may lead to food shortages or an increase in the cost of food, thus resulting in under- or malnutrition. According to energy value intake in the 30 years monitoring period, it was noticed that the value from 8,700 kJ in 1972 increased to 12,100 kJ in 1984, and afterwards decreasing trend of energy value intake started, reaching value of 10,260 kJ in 1999.

Climate change over the coming decades could have various effects on the health, especially on some groups of human populations. An increased frequency or severity of heat waves would cause an increase in heat-related mortality and illness. Contrary to that, less-severe cold weather would reduce the documented seasonal excess of deaths in winter.

Changes in seasonal and daily temperatures and humidity are likely to affect the concentration of airborne materials that impinge on respiratory health. The production of photochemical smog proceeds more rapidly at higher temperatures. The concentrations, onset and duration of season of allergenic pollens and spores are related to cumulative temperatures and rainfall, though in a complex manner. Organisms and biological systems that determine the spread of infectious diseases typically are sensitive to climate variables. An additional important element for assessing the impact of climate change will be the quality of socio-economic and demographic predictions of vulnerable population. Certain subgroups of a population may be more susceptible than others to health effects from environmental exposures, usually because of physical or behavioural characteristics that typify the group. Age is often a determining factor. The organs and immune systems of very young children may not be fully operational and are therefore less effective in fighting external insults. The elderly also have a reduced capacity to cope due to system failures and onset of the advanced stage of diseases. Gender differences are often apparent in the incidence of certain diseases because of physiological differences between the sexes or behavioural attributes.

Other variables typically considered in epidemiological studies include occupation, place of residence, education, and income.

According to the scenarios for increasing of average year temperature and expected decreasing of precipitation in the future period (to 2100), as well as the following projection of exceeding the population and drinking water needs, increasing of direct and indirect impact of the climate change to the human health among the population can be expected.

In the following period permanent increasing of life expectancy is expected and increasing of the participation of the population aged 65 and over among the total population, which is vulnerable segment to the whether variables (cold and warm). The trend of all non-communicable diseases is permanently increasing. The morbidity rate from alimentary toxinfections as well as salmonellosis has continuous values with potential increase.

### 6.6.2. ADAPTATION MEASURES

The primary objective of adaptation is to reduce disease burdens, injuries, disabilities, suffering and deaths. Many impacts of climate change, including health impacts, can be reduced or avoided by adequate adaptations.

The key determinants of health – as well as the solutions – lie primarily outside the direct control of the health sector. They are rooted in areas such as sanitation and water supply, education, agriculture, trade, tourism, transport, development and housing. Unless these aspects are considered, it will be difficult to make smaller risk in population health.

The most elementary form of adaptation is to launch or improve health monitoring and surveillance systems which will summarize the mechanisms for a comprehensive monitoring scheme for the types of potential health impact of climate change. The monitoring and adaptation will concern:

- Heat stress
- Changes in seasonal patterns of disease asthma, allergies
- Vector-borne diseases
- Natural disasters
- Freshwater supply
- Food supply
- Emerging diseases

Primary and secondary adaptive measures, intersectoral and cross-sectoral adaptation strategies are needed to reduce the potential health impacts arisen from climate change. However, it is very difficult to disentangle most of these measures from the general strategies of public health.

chapter

7

CHAPTER 7

# NATIONAL ACTION PLAN

## 7.1. OBJECTIVES

The National Action Plan (NAP) is mostly oriented towards reduction of GHG emissions which are based on the analyses presented in previous chapters and some new additional recommendations.

It sets out the objectives and starting points for the emissions reduction and includes many measures aimed at reducing emissions. The timetable and intensity of the implementation are specified for major measures only, for the others, a detailed approach is necessary. The development of the energy sector is projected by the strategy of economic development of the country. But many other measures require modifications in the models for production and consumption and adjustments of lifestyle that are more radical than those tackling other environmental protection issues. Thus, the reduction of emissions needs to be achieved by using a method that will be most effective for the national economy.

The NAP is based and adapted on the following criteria:

- Generate positive effects on the national economy
- Minimize the costs of reducing greenhouse gas emissions at the national level
- Provide the economy with international competitiveness
- Act in compliance with financial capacities
- Achieve reliability and competitiveness in the energy supply, food and other strategic resources
- Exercise social fairness and acceptability
- Achieve flexibility and viability of solutions
- Develop medium and long-term solutions

## 7.2 POLICY AND MEASURES

The authorized state bodies have to prepare economic and other instruments for carrying out the actions for emission reduction of greenhouse gases. The government and state administration are responsible for the formulation of the suitable strategy and programme on climate change mitigation.

The leading role in the afore mentioned activities has the Ministry of Environment and Physical Planning of the Republic of Macedonia. A significant role also has to have the Ministry of

Economy, where the Energy sector belongs, as well as the Ministry of Agriculture, Forestry and Water Economy, Ministry of Transport and Communications and Ministry of Health.

Building the institutional capacity for climate change issues is very important. The National Climate Change Committee (NCCC) is established in order to supervise and co-ordinate the implementation of the projects and climate change related issues. The Climate Change Project Unit was established within the Ministry of Environment and Physical Planning. This Unit coordinated the preparation of the First National Communications of Climate Change.

Necessity of capacity building, which is elaborated in Chapter 9, is evident. It is necessary to establish a firm climate change office within the Ministry of environment and physical planning in order to coordinate and initiate activities at national level.

Existing documents with some strategies and developed measures indirectly related to greenhouse gases emission reduction are as follows:

*National Development Strategy for Macedonia, Development and Modernization*, Macedonian Academy of Sciences and Arts (MANU), 1997.

*Energy Sector Development Strategy for Macedonia*, prepared by MANU for the Ministry of Economy, 2000

*Energy efficiency strategy of Macedonia up to 2020,* on going since 2002

*Possibilities for investment in energy sector in Macedonia*, Phare project

*National Environmental Action Plan*, Ministry of Environment and Physical Planning, 1997

*Physical Plan of the Republic of Macedonia*, Spatial Planning Management, 1998

*National Human Development Reports*, supported by UNDP, Skopje, 2001

The legal grounds of the system for environment and nature protection in the Republic of Macedonia are elaborated and specified in the following laws:

*Law on Environment and Nature Protection and Improvement*, revised version, 2000

*Law on Energy Sector*, 1997, revised in 2000

*Law on Waters*, 1998

*Law on Agricultural Land*, 1998

*Law on Waste*, 1998

*Law on the Maintenance of Public Hygiene, Collection and Transportation of Communal Solid and Industrial Waste*, 1998

*Law on Forests*, 1997

*Law on Spatial and Urban Planning*, 1996

*Law on Air Protection against Pollution*, 1993

*Law on Hydrometeorological Matters*, 1992

The National Environmental Action Plan (NEAP) issued in 1997 is under revision. The plan will be completed with new contemporary situations in all concerning areas, as well as in the problems connected with the climate change. It is recommended a special working group to be involved in the preparation of the new NEAP in order to contribute to the climate change issue.

A new law for local government is enacted, according to which the communities have larger competence and financial potential. It is an opportunity for many NAP activities to be put into practice on a local level.

The contribution of NGOs and other professional organizations should be very useful, especially in promotion and arising the awareness about climate change mitigations.

In the regulations concerning the environmental protection, the implementation of so called green tax reform is suggested. The income from that implementation will be used for the purpose of NAP. On the other hand, tax and customs benefits have to be introduced for equipment and projects intended to greenhouse gases emission reduction.

A concrete step has to be made about providing conditions for the electricity purchase from independent power plant producers. The electricity purchase and correction to grid of the independent power producers will be based on the electricity purchase agreement with guaranteed price.

In addition to economic instruments, the use of regulatory instruments is recommended, along with promotional activities, voluntary agreements between commercial associations and the state, and the promotion of research and education.

In the further elaboration of the NAP a sectorial approach is presented.

## 7.3. ENERGY SECTOR

The $CO_2$-eq. emissions from the energy sectors for the year 1998 were about 74% of the total emissions. This estimation is used as a criterion for priority of the NAP in the energy sector.

A special attention has to be paid to the efficiency in energy production, and furthermore in the energy consumption sectors and sub-sectors.

Energy Department in the Ministry of Economy is in charge of the energy policy. The priority is a reorganization of the energy sector which will be based on acts for energy, electricity market, gas market, oil and oil derivatives market and on regulation for energy sector activities.

### 7.3.1. ELECTRICITY PRODUCTION

The electricity production is mainly based on thermal power plants using lignite (more than 80%). As the capacity of the lignite mines is limited and will be exhausted by about 2015, a partial substitution of lignite with liquid fuel (up to 30%) in the existing power plants is recommended. With this activity it is possible to extend the life-period of the existing lignite mines, to utilize the equipment to its projected life-period and to reduce the fugitive emission.

The optimal expansion plan in the electro power system for the next 30 years is projected. New hydro power plants will be built, some of them reversible. The capital cost of the new hydro power plants (673 MW) is 1092.9 million US$.

In addition, two gas fired power plants (2x270 MW) with combined cycle are selected as candidates for new facilities, and one CHP (180 MW).

The nuclear option both economically and technically may become attractive after the year 2020. However, the building of nuclear power plant will depend upon a decision of the Macedonian Parliament. So far, this will also be a subject under the public opinion.

It is very important for the expansion plan to be followed by adequate investments and timetable, due to the very high capital costs and long time necessary for building of hydro power plants.

Decreasing of losses in the electricity distribution system should be done, with improvement of distribution network (priority of the Macedonian Power Enterprise).

### 7.3.2. HEAT PRODUCTION

The introduction of natural gas is very important in the sector of heat production in order to substitute the presently used solid and liquid fuels, which will reduce the GHG emissions. The state has to introduce measures for stimulation of the use of natural gas in all sectors. However, in the same time, technical regulations have to be introduced for safety usage.

The construction of the central pipeline is now completed and put into operation and the supply of natural gas is expected to arise. The secondary pipelines and city networks have to be constructed as soon as possible.

Intensive use of natural gas has to be implemented by a large number of consumers, especially the big ones and the industry.

New projects for further ramifications of the gas system have to be prepared and to start building city gas networks for gas supply to the households and commercial sector. This is especially important for the city of Skopje, where the use of electricity for heating should be substituted by gas.

The possibilities for new CHP plants are open, such as planning of district heating, as well as introduction of CHP in the bigger industrial objects. The state has to prepare regulations for overtaking the surplus produced electricity (guarantees, prices, etc.). The existing prices of electricity do not allow installation of CHP plants with a small power capacity.

A high priority of the Government is to resolve the ownership status of the gas distribution company (GAMA) in order to invest in the gas expansion plan.

The production of light derivatives in the refinery OKTA is followed by a production of a considerable amount of residual oil (about 40% of the total production), resulting in a mutual dependence between the fuel supply in the transport and the use of residual oil in the heat and electricity production. Therefore, a long term planning is needed as well as defining relationships in this field to a better efficiency (in charge: Ministry of Economy and Ministry of Transport).

### 7.3.3. INDUSTRY

The industries, which represent big GHG abatement potential, are certainly the energy consumers of large size, such as: the metallurgy, industry of cement, ceramics, food, drinks etc. There are numerous technological interventions which can be carried out in the technologies of the industrial sectors, for example possibilities for waste heat recovery are recommended. The possible projects have to be justified in terms of techniques and economics. The state support with some beneficial measures is desirable, such as loans with low interest rate (Ministry of Economy).

A wide range of what are usually considered “minor improvements” can be made in the auxiliary operations of industrial units. The most important of these interventions involve the supply of steam and compressed air or even the lighting of the industrial premises.

In future, while building new industrial facilities, a special attention will have to be paid to the production technologies. The implementation of new clean technologies with less energy consumption per unit product has to be preferred. It is recommended:

- to be established an expert body for estimation of energy consumption and efficiency.
- to be introduced eco-taxes depending of the level of GHG emission.
- this income to be used for the climate change activities. For example, to establish a climate change fund for financial support of implementation programs.

The Ministry of Economy has supported many projects (115) concerning the rational use of energy in industry. It is recommended to continue this way of stimulation of energy saving project where technical experts (from university and other institutions) have to be included.

Under the supervision of the Ministry of Environment and Physical Planning a project called “Strengthening of capacity for cleaner production in Macedonia “ is running.

Some of the basic planned measures are as follows:

- Efficiency increase of fuel utilization
- Fuel replacement in favor of fuels with more Joules per unit quantity of produced $CO_2$
- Utilization of waste heat contained in the effluent gases, liquids and solids.
- Applications of heat recovery with a prior cost-effective analysis.
- Choice of technologies with less energy consumption.
- Avoidance of electricity use in metallurgical production.

## 7.3.4. DOMESTIC, COMMERCIAL AND PUBLIC SECTOR

The major energy savings measures consist in:

- Reducing energy requirements, either by ensuring that all new constructions will have enhanced insulation, or by improving the situation in the existing buildings,
- Ensuring the rational use of all available energy sources, including new fuels, and
- Promoting energy conservation with the introduction of new technologies (equipment and appliances of increased efficiency) and with the proper maintenance of existing equipment and appliances.

The design of new buildings and equipment in accordance with energy efficiency criteria can, in long term, reduce the energy sector requirements by about 50%.

Projects have to be undertaken in order to improve the thermal characteristics of the existing (old) buildings. For instance, at first, this has to be done with buildings of the public objects which belong to the state (buildings of the Ministries and others).

Criteria for obligatory use of thermal insulation of the objects and equipment connected with the use of heating have to be implemented. A mechanism for efficient control of the implementation of regulations has to be created.

**Space heating**

In Macedonia, more than 25% of the households, as well as in other sectors, use electricity for space heating. This has to be stopped, because the electricity is the highest quality type of energy, and it is a big waste to be used for heating. Secondly, it influences a bigger $CO_2$ emission because the electricity production in Macedonia is mainly based on coal combustion. But, in order to reduce using it for electrical heating, other preconditions have to be created.

Construction of new heating systems in all populated areas is recommended. This initiative may be more efficient if the heating plants are built as CHP by use of natural gas.

Another alternative solution of electrical heating is the construction of urban gas networks, so the natural gas will be used for hot water boilers and cookers, besides space heating.

The energy efficiency of the heating equipment, air-conditioning and cooling has to be priority in the further activities.

The necessary schemes for training of (energy) engineers and technicians involved in the use of the installation and maintenance of thermal systems are being elaborated.

In near future, labeling measures have to be introduced for the equipment using electrical and thermal energy. Thus, the buyers will be able to choose the product with less energy consumption.

Considerable energy conservation can also be achieved with the gradual switch from incandescent to fluorescent lamps in the homes as well as in other buildings of private and public sectors.

**NOTE:**

1) In the energy consumption sector there are no concrete data for the structure and size of the needs of energy, such as the needs for the households, commercial and public objects. It was not planned to be discussed in this stage of analysis. Those data are very important in order to locate the possibilities of energy saving. Therefore, it is recommended these analyses to be discussed in detail in the further activities as soon as possible, and to be elaborated in the Second Communication.

2) At the end of completion of the First National Communication, the project "*Energy efficiency strategy of Macedonia up to 2020*" has started. The contribution of this project will be of great use in the next activities in energy sector.

## 7.3.5. ENERGY EFFICIENCY INSTITUTION

Given the importance of energy efficiency and Renewable Energy Sources (RES), in the country there is need for establishment of a special body (agency, directorate of some other form) that would be responsible exclusively for issues related to energy efficiency and RES. Organizational charts of this body in other countries could be considered in order to choose the most adequate model and to develop activities for creating financial conditions for its establishment.

The objectives of that special body could include:

To advise the Government on issues related to the formulation and implementation of viable comprehensive and effective strategies and financial incentives programmes for the promotion of rational use of energy and RES, as well as to provide assistance on broader energy policy issues concerning the efficiency of the energy sector as a whole (energy price, taxation, substitution, etc).

To undertake systematic initiatives for providing the necessary financial resources for the implementation of the above programmes, either from the state budget or from other domestic and international sources, including donations, international assistance programmes and bank soft loans.

To co-ordinate and/or manage various financial or technical assistance programmes, promotional activities and other actions relating to energy efficiency improvement, precession strategies, etc, whose implementation will be assigned to the body by the Government (Ministry of Economy).

To provide advice, guidance and technical assistance to industries and to other major energy consumers or producers concerning: energy efficiency policies, energy efficient technologies, energy management techniques, energy audits, materials and equipment, access to incentive schemes and other relevant information.

To become the liaison between the European Commission, the Government and the energy and economic sectors of the Republic of Macedonia at large with a view to enhance and facilitate the co-operation between all sides.

To promote foreign energy-related investments in the country.

## 7.3.6. RENEWABLE ENERGY SOURCES (RES)

Enlarged and permanent promotion of the RES is recommended: hydro, solar, geothermal, wind and biomass. A systematic policy for the development of RES can yield substantial benefits as quickly as activities being to start.

**Hydro energy**

Hydro energy is already being used in Macedonia in a relatively large scope. In the energy development strategy, it is planned to increase the building of new hydro power plants with a total capacity of 673 MW, which is elaborated in detail in Chapter 5.

The project "*Development of mini-hydropower plants*", supported by GEF grant, is at a final stage. Four mini hydropower plants are to be installed on the water supply systems of the towns of Kavadarci and Debar. In order to mainstream the reforms initiated under the bank financed *Power system improvement project*, the proposed operation would also serve as a model for establishing the necessary power off-take arrangements.

Also, the study for building of small hydropower plant HE Bogovinje is prepared, supported by Ecolinks.

**Solar energy**

According to the intensity and durability of solar radiation, there is a great potential in Macedonia for use of this kind of energy. It may be used in two ways: by direct change into electricity (photovoltaic cells) and for getting hot water. In Macedonia now it is difficult to expect broader penetration of the first way due to the present technical and economic facts and figures.

The use of hot water solar collectors in Macedonia, is also only in a symbolic form. The hot water for sanitary purposes in almost all households and commercial objects is acquired by electricity. That is why the promotion of the solar collectors need to be done in vast scopes, by which the electricity consumption will be directly decreased.

It is recommended to the state to issue adequate measures, such as tax release and duty free ones, in order to achieve acceptable price for the consumers and more suitable loans for that purpose etc. There has been some initial production of solar collectors, as well as firms for distribution and installation in Macedonia.

**Wind energy**

In the Republic of Macedonia there is no tradition in utilization of wind potential. There are no studies or analyses which point out some locations, and even worse is the situation with availability of technical and economic indicators required for building wind plants for electricity or other energy type production. However, there are some published materials reporting the measured values of the wind intensity, which show to be low and unattractive from economic and technical aspect. New search for new locations is recommended in the next period.

**Biomass**

The wood for heating of dwellings is used, mainly in households in the rural area in Macedonia. Small district heating systems are recommended instead individual ones because of improved energy efficiency in the boilers with wood fuel. Moreover, combined heat and power plants are one of the best solutions for small rural settlements.

In the development of forestry in Macedonia the increase of wood stock is planned by afforestation expansion plan. The annual growth of wood mass will be higher than the wood consumption as fuel.

The use of biogas in the farms is still at the beginning level. A study for techno-economic potentials of biomass and biogas is necessary to be prepared.

**Geothermal energy**

In the last several decades the geothermal energy is intensively being used and there are some technical and economic experiences in agricultural uses for greenhouse heating.

Rehabilitation of the existing systems is needed in order to increase the energy efficiency, as well as widening the network which uses hot geothermal water for heating households and other commercial objects.

There is a large number of examined locations with geothermal wells, which have not been used yet, but they have good indicators for technical and economic exploitation.

In the project "*Assessment of Macedonia's Geothermal Resources*", World Bank, 2001, detailed analyses are made. Substantial potentials for heating are documented, so it is necessary to undertake activities following this project as soon as possible.

## 7.4. TRANSPORT

The basic strategies towards reduction of GHG emissions from the transport sector have been aimed at the reduction of the fuel consumption. This reduction can be achieved in several different ways:

- Reduced increase of vehicle-kilometers
- Promotion of public transport and cycling
- Electrifying of the railway, and greater use of railway; Introduction of trams in Skopje
- Improvement of traffic management and control systems
- Development and implementation of city logistic systems

**Energy efficiency improvements**

Improvement of the structure of vehicles by promoting faster substitution of old vehicles with new, environmentally more friendly vehicles that less consume and pollute.

Recommended measures: tax and custom discounts for new vehicles.

A drastic intervention can also be achieved in the lighting sector. As far as the public lighting of roads and squares is concerned, the conversion of existing installations and the use of sodium lamps should be rapidly advanced.

The measures of this sector should be undertaken by the Ministry of Transport and Communications. In many projects the local communities should be included, too.

## 7.5. WASTE

The relatively low level of the organized treatment of the waste materials and the lack of data for the past period create particular problem which should be considered in more details and concrete actions should be undertaken.

Application of a proper planned, long term and persistent activity of public education and conscience, improvement of public concern could be realized. NGOs, media, schools and similar institutions could play leading roles in performing this activity. Different aspects of SMW management as, e.g. reduction, recycling, reuse, the importance of primary waste selection etc., are to be promoted.

Present legislation should become very strict, and it should be precisely applied in order to achieve a higher level of waste dissipation control.

Besides the Ministry of Environment and Physical Planning, the municipalities will undertake projects about the waste management. As a “best practice” example is the project *Modernizing solid waste management in Resen*, as well as the Feasibility study for building a regional landfill for 35 municipalities in South-West Macedonia, supported by KfW (Germany). Technical measures and institutional options for the implementation of an integrated solid waste management concept in the project area are proposed.

## 7.6. AGRICULTURE

In the agriculture sector, $CH_4$ and $N_2O$ emissions are dominant, originating mainly from animal production and agricultural soils.

Improvement of the productive capacities of the animals, treatment of the animals, feeding and manure management are proposed.

The use of synthetic fertilizers has to be enlarged in order to provide optimal conditions for more stable agricultural production. However, the combined use of synthetic fertilizers and manure, as well as incorporation of N fertilizers in the soil immediately after the application, are options for improving the use of synthetic fertilizers aimed at abatement of the GHG emissions.

To the vulnerability and adaptation measures, the following are proposed:

- Dams and irrigation
- Tillage systems

- New crop adoption
- Fertilizer adoption
- Opening new lands

The Ministry of Agriculture, Forestry and Water Economy is competent for the above proposed measures, and for the LUCF, too.

## 7.7. LUCF

In the sector Land Use Change and Forestry two main occurrences are considered, when $CO_2$ is absorbed and emitted: changes in forest and other wood biomass stocks and forest conversion caused by incidental burning of forests.

Three main measures concern basic factors for increasing the sink capacity of the forests:

- Enlargement of the forest area by afforestations. Public awareness rising is necessary.
- Increasing the annual biomass increment by improving the floristical forest structure.
- Decrease of the annual amounts of traditional fuelwood consumption as much as possible.
- Permanent control of the health condition of the forests and development of database.
- Undertaking preventive actions against forest fires.

## 7.8. BIODIVERSITY

It is important to revise the Physical Plan of the Republic of Macedonia and to implement the demands for mitigation of negative impact of climate change on biodiversity in the land use pattern.

Other measures that will be undertaken:

- Establishment of scientific infrastructure for evaluation of climate change impact on biodiversity and terrestrial ecosystems
- Development of database for the estimation of climate change impact on biodiversity
- Public awareness raising concerning climate change issues
- Elaboration of biocorridores and migration paths of different species in climate change condition
- Increasing of the surface of protected areas in Macedonia in accordance with the recommendations of EMERALD and NATURA 2000.
- Establishment of seed bank of endemic and other important species concerning biodiversity
- Preservation of vulnerable animals in captivity.

Competent units are Ministry of environment and physical planning and Ministry of agriculture, forestry and water management.

## 7.9. HYDROLOGY AND WATER RESOURCES

The problems analyzed in different sectors connected to water resources and hydrology and adaptation measures to climate changes as integral part of the action plan are:

- *Hydrometeorology*: modernization of the network, data monitoring establishment of hydrological and water quality parameters
- *Water supply*: water losses reduction, dual supply systems (potable and non-potable water)
- *Drainage*: water efficient appliances, street and car washing with recycled waters
- *Irrigation*: covering-lining of canals, introduction of drip, micro-spray and other low-energy irrigation systems, night time irrigation, control and management of the systems

- *Energy*: keeping reservoirs at lower head, more efficient hydropower turbines, control and management of the systems

The character of hydrology and water resources requires sectorial and intersectorial cooperation and actions.

## 7.10. HUMAN HEALTH

The first step of adaptation is to launch health monitoring and surveillance systems for potential impacts of climate change on the human health. Primary and secondary adaptive measures, intersectoral and cross-sectoral adaptation strategies are needed to reduce the potential impacts on the human health.

## 7.11. FINANCIAL SUPPORT

As it is described in the NAP many activities are projected in order to reduce GHGs. Strengthening the capacity and implementation of measures and projects have to be followed by a financial support. The major implementation actors will be the governmental bodies in cooperation with the scientific and technical institutions, public and private sectors, engineering companies, NGOs, etc.

The following basic funding sources are planned for use:

- National budget
- Fund based on greenhouse gases emission taxes
- Commercial bank loans, particularly soft loans
- Investors companies
- International grants
- Financing programs under GEF
- International bilateral financial and technical assistance

In the initial stage of the measure implementation, the assistance from GEF and other international funds would be appreciated for the demonstration projects and programs aimed at creating a positive environment.

The policy priority step will include setting up a stable funding mechanism based on emission taxes (within the Environmental Fund).

## 7.12. BARRIERS TO IMPLEMENTATION OF NAP

Problems and constraints are of institutional, technical, methodological and financial nature. Some of existing possible barriers are listed below:

- Lack of regulations for fostering of measures and self-initiative
- Low price of electricity
- Lack of knowledge and accessibility of technology
- Insufficient information on costs
- Lack of knowledge about market and financing mechanisms
- Lack of interest of the banking sector
- Poor information accessibility and low interest at the local level
- Insufficient knowledge about the potentials of Renewable Energy Sources
- Lack of technical standardization and verification for new technologies
- Lack of trust between the public sector and NGOs

- Privatization process in some companies is followed with problems
- Socio-economic aspect, low financial status of population

**NOTE:**

Action plans in more details are contained in the projects of the working groups that take part in the preparation of the First National Communication of Climate Change.


chapter

# 8

CHAPTER 8

# RESEARCH AND SYSTEMATIC OBSERVATION

## INTRODUCTION

Macedonia is small by its territory, however different climate types are identified, including continental, changed continental, sub-Mediterranean, mountainous climate, as well as various their subtypes. Monitoring and development research of the climate conditions and future trends in the country were carried out by the Hydro-Meteorological Service (HMS) of Macedonia within the Ministry of agriculture, forestry and water management. The impact of climate change on the most vulnerable sectors: agriculture, water resources, forestry, natural ecosystems and human health was analyzed by experts from the particular sectors, in cooperation with the HMS. Considering all data demands, it became obvious that many of needed data were incompatible or lost. From this experience, it became evident that in the near future it would be of the highest importance review and assessment of data quality: length of data records, the homogeneity of series, continuity of observations, and replacement of used instruments.

## RESEARCH AND SYSTEMATIC OBSERVATION OF CLIMATE

Initial sporadic meteorological measurements and observations in the Republic of Macedonia commenced in Skopje in 1891. Organized systematic hydro-meteorological measurements and monitoring started in the 20s of last century, when network of meteorological and hydro stations was established.

At present, atmospheric observations and research are carried out by the HMS, organized as it is described below.

Climate-meteorological observations are carried out by 270 stations as follows: 16 main (two of them are airport meteorological stations), 6 meteorological hail suppression stations, 21 regular (two of them are for urban climatology), 26 phenological, 1 aerological and 200 precipitation stations. The following parameters are measured: air temperature and humidity, air pressure, wind speed and direction, evaporation, soil temperature on different depth, rain and snow falls, radiation, atmospheric conditions and air quality. Research and analyses consist of control, processing and updating of meteorological and agrometeorological data; urban climate research including interactive relations between polluted atmosphere and climate in cities; application of meteorological information and climate knowledge in the field of water management, agriculture, forestry, transportation, urbanism, civil engineering, space planning tourism, protection of environment and human health; research of energy potential from the sun and the wind; phenological observations, measurements and analyses at agricultural crops; agrometeorological operative, informative methodological and research activities; preparing appropriate information and forecasts on weather and climate influence over agricultural production, especially at adverse weather situations (frost, drought and other disasters) etc.

Hydrologic observations are carried out by surface water (110) and groundwater stations (115). Related activities include: measurements of hydrological parameters; permanent monitoring of surface and groundwater level; monitoring of sediment in rivers and lakes; monitoring of water temperature in rivers and lakes; data control, updating and archiving in hydrological data base; public informing and warning on development and appearance of hazardous hydrological phenomena. The country is a part of the system of hydrological data exchange between Mediterranean countries (MED-HYCOS).

On national level 3 automatic meteorological stations operate for special purposes and 2 automatic stations according to MED-HYCOS. Besides these, classical instruments and equipment used for measurements don't comply with contemporary data needs, especially with the requirements of hydro-meteorological information exchange network within the Region VI countries from the WMO.

In view of air and water pollution, ecological observation and research are carried out, including air quality monitoring at 23 measuring points; measuring stationary sources emission; monitoring and assessment of transboundary long-range distribution of air pollutants; assessment of changes in the atmosphere especially of those pollutants which have great impact on human health; monitoring of qualitative and quantitative characteristics of surface water at 20 measuring points; periodical control of domestic and industrial waste water; monitoring of chemical and toxicological water pollution and carrying out radiological and biological analyses periodically.

Weather modification research and analyses refer to numerical modeling in micro and mesoscale as well as research the microphysics of dynamic processes in the atmosphere. This kind of activity covers the essential part of meteorology explaining appearance, development and movement of meteorological phenomena. Activities include investigation and development of new methodologies for weather modification; experimental realization of the project for fog dispersion; working out measuring methods for total amount of precipitation at certain river basins in real time; warning and informing the population for extraordinary meteorological phenomena that cause enormous economic damages such as: floods, lightning, and storms.

Ministry of Environment and Physical Planning, within its Environmental information center, monitors the air quality on the territory of Skopje, through four automatic air quality monitoring stations, measuring the following parameters: carbon monoxide (CO), sulphur dioxide ($SO_2$), nitrogen monoxide (NO), nitrogen dioxide ($NO_2$), Suspended Particular Matters (SPM), Ozone ($O_3$), solar radiation, wind speed, wind direction, temperature and humidity. The monitoring system was set up in 1998. In addition to the automatic stations, the monitoring system also includes a mobile monitoring car to measure the emissions of pollutants in the air. Data from the stations are collected via radio telemetric system into the central station in the Environmental Information Center. Various databases from other institutions involved in air monitoring are also located there. The results are public and values of the particular polluters in $mg/m^3$ (except for CO, which is presented in $mg/m^3$) are shown on display in City Trade Center every hour. Through its web site and various kinds of reports, the Ministry of Environment and Physical Planning is completely transparent and all results are available to the public.

The Republic health institute, which monitors the pollutants in aspect of their impact on human health, covers several cities by its network. The most advanced measurements are carried out in Skopje, including measurement of concentrations of $SO_2$, CO, black smoke, aerosediment and lead; in some other towns aerosediment is measured in general.

## RECOMMENDATIONS FOR FURTHER RESEARCH

In order to improve the available databases, the number of measure points for hydro-meteorological parameters needs to be increased, especially on higher altitudes and certain urban locations, in order of fulfills researches on mezo-scale and micro-scale climate systems. Modernization of the hydro-meteorological network for information exchange, archives and publication are necessary, as well as establishment and restitution of observations that are not yet in function. Modernization of current networks is necessary. Furthermore, other water resources should be identified, especially on altitudes of about 1000 meters above sea level, where most quality surface waters and springs exist. Certain urban locations need, besides measurements of weather and climate components, measurements of air quality. That indicates the need of information exchange and close cooperation among all relevant parties between HMS, Republic public health institute, Ministry of Environment and Physical Planning and other related institutions in the country, in order to establish unique database and data bank for climate system research.

Capacity building activities related to collection, archiving, utilization exchange data in order to meet local, and international needs, as well as active participation and cooperation in global and regional climate observation related networks and systems in order to promote and cooperate in systematic observation, are part of the activities that need to be undertaken in order to enhance and strengthen national capacities regarding systematic observation.

The First National Communication of Climate Change consists of: inventory of GHGs, abatement analysis to GHGs reduction and vulnerability assessment and adaptation measures.

It is necessary to carry out permanent activities for systematic observation as well as monitoring of GHG emissions and their reductions. For this purpose a capacity building is necessary within the Ministry of Environment and Physical Planning, establishing a firm office within the Ministry in order to coordinate and initiate activities at national level for enhancing of the national capacities in the relevant institutions related to:

**1. GHGs Inventory**

- Building the national emission inventory system, including register of sources and technologies
- Improvement of methods and procedures for improving quality of emission inventory

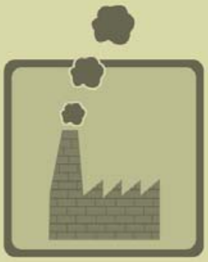
**2. GHGs Reduction measures**

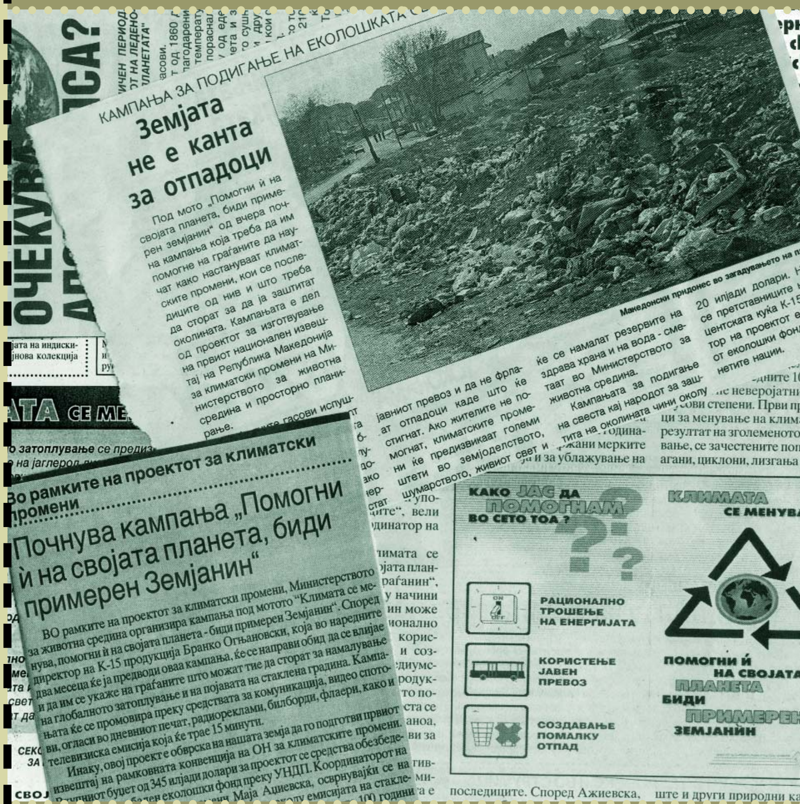
- Development and implementation of methods for emission abatement analyses, emission projections and scenarios development
- Development of strategies, programs and plans on different levels
- Supporting projects preparation

**3. Impacts and adaptation measures**

- Development and implementation of methods for assessment of impact, sensitivity and vulnerability to climate change
- Development of methods and measures for adaptation to climate changes

Scientific research and exchange of information will be developed with world leading research institutions. Existing scientific potential and research should be systematized.




КАМПАЊА ЗА ПОДИГАЊЕ НА ЕКОЛОШКАТА
Земјата не е канта за отпадоци
Во рамките на проектот за климатски промени
Почнува кампања „Помогни ѝ на својата планета, биди примерен Земјанин“
КАКО ЈАС ДА ПОМОГНАМ ВО СЕТО ТОА ?
РАЦИОНАЛНО ТРОШЕЊЕ НА ЕНЕРГИЈАТА
КОРИСТЕЊЕ ЈАВЕН ПРЕВОЗ
СОЗДАВАЊЕ ПОМАЛКУ ОТПАД
ПОМОГНИ Ѝ НА СВОЈАТА ПЛАНЕТА БИДИ ПРИМЕРЕН ЗЕМЈАНИН

chapter

# 9

CHAPTER 9

# PUBLIC AWARENESS, EDUCATION AND TRAINING

Despite the fact that global climate change represents one of the most serious environmental issues today, the Macedonian public is not fully aware of the consequences of climate change. The important task of all relevant institutions is to improve general public awareness and to support education, concerning these issues.

## 9.1. PUBLIC AWARENESS

Raising public awareness is one of the most important approaches to support the climate change strategy and policy. The measures, which will have to be taken, require coordinated effort and assume co-operation of policy makers, NGOs, professional organizations, industry stakeholders, even individuals. The public has to be aware of the implications of expected climate change, potential benefits of the response measures for mitigation and adaptation to climate change, and the importance of meeting the commitments under the UNFCCC.

The preparation of the First National Communication on Climate Change has positively contributed to awareness rising among all relevant stakeholders, contributing to information exchange, cooperation and building national capacities.

During the preparation of the National Communication a public awareness campaign was carried out. Eight week long campaign, with the logo “Climate is changing... Help your planet, be a well-mannered Earthling” was carried out by implementation of the following activities:

- Broadcasting radio and TV spots on the national and local channels. Three types of video spots, with duration of 30, 15 and 7 seconds, were broadcasted on one national and five local TV stations. Prepared in a form of an animation, with the voice explanations in the background, the video clip addresses the climate change phenomenon, its origin, sources of pollution, negative effects as a result of climate change and simple actions the population can undertake in order to help reducing the GHG emission. The radio commercial which is in-line with the voice over the TV clip, was broadcasted on one of the national radio stations.
- Daily print and leaflets distribution within newspapers. Printed visual image used in the newspaper ads follows the TV clip. Some of the images from the clip served as background supported by textual explanation on climate change related issues.
- Billboards and posters with the overall visual identity of the campaign were printed; billboards were located on six places in the city of Skopje, posters were distributed on the territory of the country.


- Broadcasting short documentary TV film. A simple, 13-minute low-budget production, using images, graphics and popular-science articles for the narrative part of the program was produced and broadcasted on local TV stations, in order to bring up the importance of the climate change issues among population.
- Organizing public events for the young population and distribution of T-shirts, desk and pocket calendars with the logo of the campaign, climate change brochures. The public events – Good Climate Parties, aimed to transfer the message to municipal level and make the climate change issues closer to the young population, were organized in five cities. Representatives from local environmental NGOs took active part on the events.

Many people have heard some information on climate change for the first time thanks to the public campaign throughout the country, coordinated by the Climate Change Project Office. Besides this, there was a significant number of articles printed in the daily newspapers in the last two years about the climate change issues, especially giving attention to major global events, such as the COPs, or reporting on extreme climate incidents.

Obviously, this is only a beginning and it is not enough; the arising of the public awareness has to be a permanent process.

The national television and major TV broadcasting companies should show an interest to produce a programme addressing climate change in the future.

A substantial number of articles have to be written by government negotiators, university professors and specialist journalists for the newspapers in order to explain the various aspect of climate change to the public.

In the year 2002, the Ministry of the Environment and Physical Planning published the brochure "Inventory of GHG Emissions and Removal by Sinks in the Republic of Macedonia" prepared by MANU (Macedonian Academy of Science and Arts). Besides this, translation, printing and distribution of other climate change related documents, such as: "Understanding Climate Change: A Beginner's Guide to the UN Framework Convention and its Kyoto Protocol", "Climate Change 2001 synthesis report", GEF Medium-Sized Projects", "The Kyoto Protocol to the Convention on Climate Change" contributed to raising public awareness and knowledge on climate change related issues.

The Climate Change Project Office web site www.unfccc.org.mk has a very useful role to widen information on this issue. Along with other services, the web site lists government departments involved with the climate change programme, policy documents, basic climate change information and resources, key contacts and links to other relevant websites. The web site is regularly updated with new information, especially about activities related to preparation of the First National Communication. Draft versions of experts' reports could be easily downloaded. Information on existing projects related to climate change and donors for possible funding are also identified.

## 9.2. EDUCATION

In the curriculums of primary and secondary schools, environmental education in several subjects is partially presented. Unfortunately, it is not introduced at a level to know the complex of environment. Preparing a special programme for the environmental education in schools in a proper manner is recommended to begin as soon as possible. Probably it is suitable to introduce experiences from the schools of the European countries.

In several faculties of the universities in the country the environmental education trough various forms (subjects, seminar works, workshops etc.) is presented. Within the Faculty of Mechanical Engineering there are inter-discipline studies on environmental engineering. However, it is necessary environmental education to be introduced as a separate discipline in the regular university programs, where climate change issues will be included, especially in the subjects connected with energy and its rational use.

At this moment, maybe it is interesting the idea for some experts to visit schools and universities in order to give short lectures about climate change and topics connected with it. The lectures should be adapted to the corresponding level.

Publishing books and booklets with the topics related to climate change will be a good contribution to the education of students, engineers, technicians and others. The publications will be supported by the government, related companies and international funds.

## 9.3. TRAINING AND CAPACITY BUILDING

The preparation of the First National Communication on Climate Change has contributed to building of national capacities. Many working groups and individual experts from various sectors, including Governmental institutions, academic sector, private sector and NGOs were involved.

The establishment of the Climate Change Project Unit within the Ministry of Environment and Physical Planning is a step forward in the process of building the institutional capacity for climate change issues. The mission of this Unit is to implement the climate change enabling activities, as well as to assist the Ministry of Environment in the implementation of commitments under the UNFCCC.

The Government established the National Climate Change Committee (NCCC), in order to supervise and co-ordinate the implementation of the project and climate change related issues, and to initiate related programs and projects on a national level.

During the preparation of the First National Communications several national workshops were organized on the thematic areas. The workshops were divided into two phases: in the first phase of each thematic area methodologies, tools, experiences and approaches of the countries from the region were presented. In the second phase, results from analysis and related response measures for each thematic area were presented and discussed. The workshops and training sessions contributed to strengthening the technical capacity, enhancing knowledge and exchange experience about climate change issues among academic sector, civil servant in relevant state institutions, private sector and NGOs.

National representatives participated in thematic regional workshops, aimed to support the process of preparation of the National Communications, organized by the National Communications Support Programme (NCSP).

Additional funds are requested from UNDP-GEF under the Operational Guidelines for Expedited Financing of Climate Change Enabling Activities (EA) - Phase II, to maintain and enhance national capacities to prepare National Communications, to ensure a continuity and improvement of this process. Raising public awareness regarding climate change issues is another objective of the phase II. Additional activities will be undertaken to meet the country's needs to build capacities for identification and assessment of technology needs.

Macedonia is going to participate in the GEF funded project “Capacity Building for Improving the Quality of Greenhouse Gas Inventories (Europe/CIS region)”. The project will initiate a regional programmatic approach to build capacity for improving the quality of data inputs to national greenhouse gas inventories, using the good practice guidance of the IPCC for cost effectiveness.

The project will be built upon the expertise gained during the preparation of the initial National Communication. By strengthening the institutional capacity to prepare inventories and establish a trained, sustainable inventory team, the project will help the participating countries to reduce uncertainties and improve the quality of inventories for Second National Communication. This, on the other hand, will allow the participating countries to improve their national strategies for reducing greenhouse gas emissions.

## 9.4. NON-GOVERNMENTAL ORGANISATIONS (NGOs)

In Macedonia, until now, the NGOs had not a much active role in any activities on the climate change programme. Their actions are mainly directed to the air and water pollutions, and emissions of gases in the industry.

An important share of training and education in the area of climate change has been contributed by NGOs in the form of lectures, advisory services, and campaigns. NGOs also play an important role in popularizing the use of renewable sources of energy, the efficient use of energy, environment-friendly traffic, the use of bicycles instead of cars in urban areas.

In the period between 2000 - 2001, three NGOs from Veles and Bitola, conducted educational activities promoting energy saving at local level. These activities included specific topics aiming at informing and training the local population for energy saving in the households, schools and working places. There is a high demand for educational projects in the future that will use the methodology for training representatives from the local communities (NGOs, teachers, local self government personnel, energy sector companies). Local trainers should further implement programs for public education and their active contribution for reducing the problems of climate change at local level.

## GENERAL CONCLUSIONS

By the analysis and assessment published in the IPCC reports for the climate change, i.e. global warming, it is evident that it will have a harmful influence on the Earth, but not with the equal intensity everywhere. By this report, Southern Europe (where Macedonia belongs) will be vulnerable with more intensity.

Available observational evidence indicates that regional changes in climate, particularly in increasing temperature, have already affected a diversity of physical and biological systems in many parts of the world. Examples of observed changes include shrinkage of glaciers, thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of mid- to high-latitude growing seasons, poleward and altitudinal shifts of plants and animal ranges, declines of some plant and animal populations, and earlier flowering of trees, emergence of insects, etc.

There is emerging evidence that some social and economic systems have been affected by the recent floods and droughts in some areas. These systems are affected by demographic shifts and land-use changes.

According to the analyses developed by the experts who have taken part in the preparation of this National Communication, climate change will affect almost all domains in the Republic of Macedonia. They certainly foresee harmful influences on the agriculture, such as soil, yield and livestock production. The forest areas will decline because of droughts and some specific tree diseases, as well as from forest fires. The exceptionally rich biological diversity in many mountainous and river regions will be affected, so movements of some species can be expected, even their disappearances. The water resources will continue to be reduced because of the predicting of more often and longer drought periods. All above mentioned will have consequences on the human health concerning infectious diseases, circulatory system (cardiovascular) diseases.

The energy sector and industry will have to adapt to new conditions and rules in order to reduce the energy consumption and GHG emission, which will require additional investments.

At the same time, Macedonia and its economy will face great pressure from the future commitments specified in UNFCCC. It is therefore important that people, including decision-makers and the population as a whole, are acquainted with the problem of climate change and with the measures necessary for preventing or mitigating this change. The fact is that Macedonia is now just at the beginning of the activities about the climate change. A lot of efforts need to be done in the next period with short and long-term measures which will contribute to respond to the climate change related issues.

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**ANNEX I**

# DOCUMENTS IN RELATION WITH ENVIRONMENT

## LAWS

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