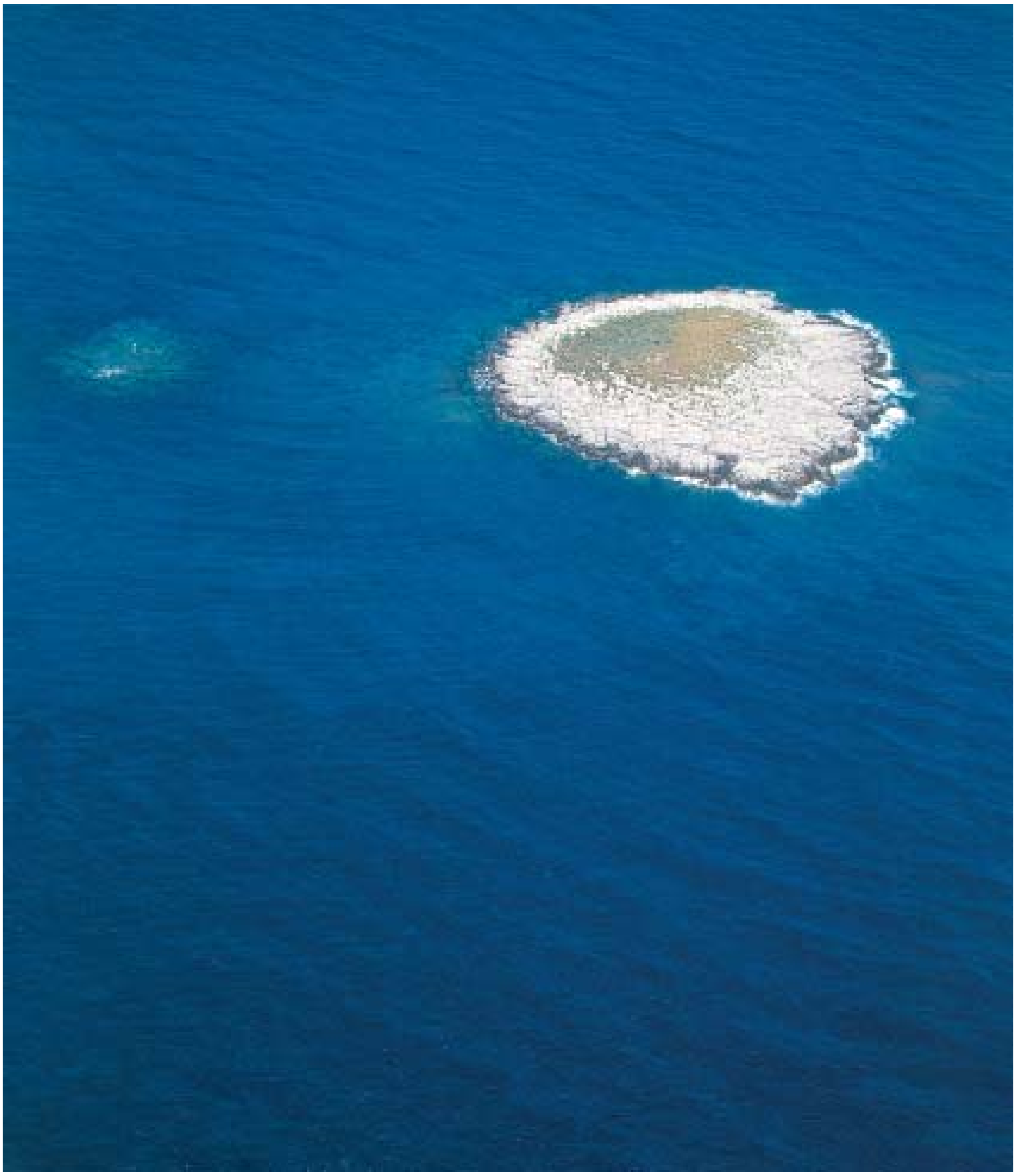
Republic of Croatia

Ministry of Environmental Protection and Physical Planning

The First National Communication of the Republic of Croatia to the United Nations Framework Convention on Climate Change (UNFCCC)



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Republic of Croatia - Ministry of Environmental Protection and Physical Planning

THE FIRST NATIONAL COMMUNICATION OF THE REPUBLIC OF CROATIA

TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

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Zagreb, December 2001

The Republic of Croatia
Ministry of Environmental Protection and Physical Planning

The First National Communication of the Republic of Croatia to the United Nations Framework Convention on Climate Change (UNFCCC)

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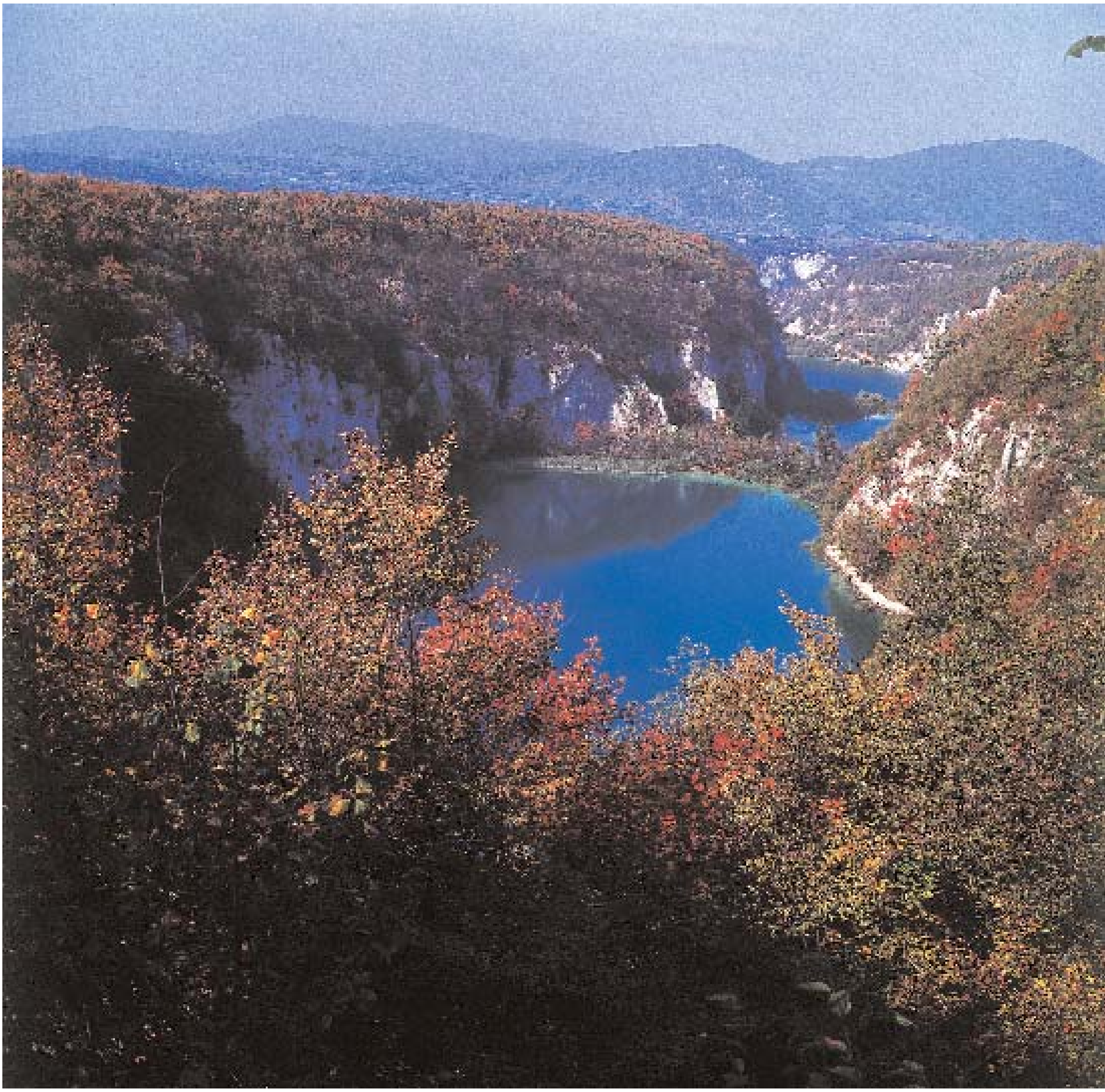
Content



Plitvice Lakes (National Park)

1. Executive Summary

1.

Executive Summary

1.1 Introduction

Commitments of the Republic of Croatia

The Republic of Croatia became a party to the United Nations Framework Convention on Climate Change (UNFCCC) in 1996, by parliamentary Decree on Ratification (Official Gazette # 55/1996). Pursuant to that Decree, the Republic of Croatia has under Article 22 of the Convention undertaken the commitments outlined in Annex I as a country undergoing the transition process to a market economy. Croatia has thus committed itself to maintain greenhouse gas emissions at their 1990 levels.

The Republic of Croatia is also a signatory of the Kyoto Protocol. Upon its entering into force and its ratification by Parliament, Croatia will commit to reduce its emissions of greenhouse gases by 5 percent in relation to the base year, over the commitment period from 2008 to 2012.

Croatia is a country that is particularly vulnerable to the impact of climate change due to its 5,800 km long coastline with 1185 islands, and its fragile agriculture and forestry with their social and economic significance. There is also the potential influence on hydrology, water resources, mainland and coastal ecosystems. Therefore, Croatia has cause for concern and is motivated to take an active part in international efforts aimed at finding practical solutions to climate change.

The Convention allows a certain degree of flexibility for countries with economies in transition meeting their commitments, including the choice of the reference year for greenhouse gas emission levels (Article 4.6 of the Convention). With regard to this, the Republic of Croatia cites some specific circumstances and proposals, which are elaborated in more detail in Chapter 1.2 hereunder.

Development of the First National Communication

This National Communication has been developed thanks to the Global Environmental Facility's (GEF) grant under the auspices of the project of the Croatian Government and the UNDP/GEF "*Enabling Croatia to develop its first National Communication pursuant to the UNFCCC commitment*". The Communication presents greenhouse gas emissions in the period from 1990 to 1995, in line with commitments outlined in the Guidelines for the Preparation of the First National Communication. Other data and information relate to the mentioned period too, while a part of the information is more recent - mainly that which was already available and required no further investigation.

1.2 National Circumstances

Social and Political Structure

Croatia, as an independent state, joined the United Nations on 22 May 1992. In terms of its territorial and administrative structure, the Republic of Croatia consists of 20 counties and the City of Zagreb. The highest legislative authority is the

Parliament of the Republic of Croatia, established as a unicameral parliament, with representatives elected to serve 4-year terms. The executive powers are divided between the President and the Government. Croatia has 19 government ministries. The Ministry of Environmental Protection and Physical Planning manages climate issues, and more specifically, its Atmosphere Protection Department and Climate and Ozone Layer Protection Section.

Population

According to the 1991 census, Croatia had 4,784,265 inhabitants. The average annual demographic growth rate in the past 20 years has been 0.39 percent, while in the past several years the number of inhabitants has decreased, accounting for the country's negative demographic trend. The population density is diverse, with an average of 84.6 inhabitants per km^2, making Croatia an averagely populated European country.

Geography

The Republic of Croatia is a Central-European, Adriatic and Mediterranean, Pannonian and Danube Basin country. It covers an area of 87,677 km^2, 56,610 km^2 of which is landmass. The Croatian territory is divided into large natural and geographic entities: Pannonian and Peri-Panonnian areas (54.4 percent), hilly and mountainous areas (14 percent) and the Adriatic areas (31.6 percent).

Climate

Under the Köppen classification, Croatia, for the most part, has a moderately warm and rainy climate with mean monthly temperatures in the coldest month of the year above -3 °C and below 18 °C. Only the highest mountain regions (>1200 m asl) have a snowy, forest climate, with the mean temperature in the coldest month below -3 °C. On the continental mainland, the hottest month of the year has a mean temperature lower, and in the coastal area higher, than 22 °C. Mean annual air temperature in the coastal area ranges between 12 °C and 17 °C. The lowland area of northern Croatia has a mean annual temperature between 10 °C and 12 °C, and in areas above 400 m the temperature is below 10 °C.

The mean annual precipitation in Croatia ranges from 600 to 3500 mm. The outlying islands have the lowest precipitation values of the Adriatic Sea (<700), while mean annual precipitation reaches its peak values of some 3500 mm at the summits of Gorski Kotar (Risnjak and Snježnik).

Croatia's sunniest areas include the outlying islands of the central Adriatic (Vis, Lastovo, Biševo and Svetac) and the western coastline of the islands of Hvar and Korèula, with over 2700 hours of sunshine. Annual insolation in the central mountainous area is 1700-1900 hours. The lowest levels of insolation (1700 hours per year) and the most overcast (6-7 tenths) conditions can be found in Gorski Kotar.

The observed climate changes are presented in Chapter 1.4 of this Summary.

Economy

The structure of the economy is such that services account for about 60 percent of income. Industry holds a 30 percent share, while agriculture makes up the remaining 10 percent. Due to its geographical location and natural resource base, tourism plays an important role in the Croatian economy.

In the first half of 2000, some economic indicators were showing an upward trend. However, what remains acute are a high unemployment rate (20.6 percent in July 2000), a budgetary deficit, a high balance of payments deficit and an absence of any major foreign investment. In June 2000, inflation reached 7 percent and the cost of living rose by 5.6 percent. Over the first seven months of 2000, GDP reached US$ 4254 per capita.

Energy Structure

Energy consumption in the Republic of Croatia in 1998 totalled 354 PJ, that is approximately 1.8 t of the oil equivalent per capita. This low energy consumption puts Croatia at the very bottom of the list of European countries and even those countries undergoing the process of transition, with regard to their respective energy consumption. The structure of the total primary energy consumption in the period from 1990 to 1998 has not changed significantly: liquid fuels retain a prevailing share at 45 percent, followed by natural gas and hydropower. It is noteworthy that coal consumption decreased from 8.5 percent in the 1990s, to 2.6 percent in 1998.

Concerning electricity generation, hydro-electric power plants accounted for 40 to 60 percent, and nuclear power for 15 to 20 percent of total generation (in the period from 1990 to 1995). **In 1996, only 21 percent of energy was generated by fossil fuel fired thermal power plants, half of which were powered by natural gas.** Combined heat and power plants contribute some 15 to 18 percent to electricity generation.

Agriculture

The total area of agricultural land in Croatia is 3,181,000 ha and accounts for 56.5 percent of Croatia's surface area (± 2 percent). Out of the total 4,784,265 inhabitants surveyed by the 1991 census, 409,647 (8.5 percent) belong to the agrarian population. Every third household in Croatia owns agricultural property. However, property is fragmented to the degree that it presents one of the key barriers to the rational use of production potentials. This point is illustrated by the fact that there are roughly 18 million land plots, leaving an average property area of about 3 ha divided into 7 to 8 plots. In the period between 1991 and 1998, the acreage covered by important field crops shrank and the production of main plough-field crops in Croatia declined.

Forestry

Forests cover approximately 36.4 percent of the national land area and, along with forestland, come under a unified forest management area that stretches across 2,457,648 ha (43.5 percent of total land area). 81 percent of forests are owned by the state and 19 percent are in private ownership. The forests in the Republic of Croatia that are located in coastal areas are among its most significant natural resources. Approximately 95 percent of Croatian forests are products of natural renewal. The remainder is cultivated woodland-cultures and plantations. The basic principle directing Croatian forestry is sustainable forest management, along with the preservation of natural structures, the diversity of forests, permanent increases in stability and the quality of economic and overall-benefit functions served by forests. It should be emphasised that clear-cutting is prohibited by the Forest Act and the natural regeneration of forests is the fundamental approach.

The total timber stock (volume) of Croatian forests amounts to 324 million m^3. It consists of approximately 84 percent deciduous and 16 percent coniferous trees. The most common types of trees found therein are common European beech, penduculate oak, fir, sessile flowered oak and other standard types of deciduous and coniferous trees.

Specific Croatian Circumstances under Article 4.6 of Convention

According to Article 4.6 of Convention, countries with economies in transition have a certain degree of flexibility in meeting their commitments to the Convention, including the selection of base year emission.

The emission of greenhouse gases (GHG) from Croatian territory is very low, one of the lowest among the Annex I parties to the Convention. Croatia is facing some problems in determining the emissions of greenhouse gases, since no reliable data existed until 1992, when Croatia gained its independence. Up to the year 1992, the area of former Yugoslavia functioned as an integral economic and energy market and the territorial allocation of activities couldn't be properly carried out. Due to the problems with determining emissions, especially in the energy sector that generates the majority of greenhouse gas emissions, the emission in Croatia until the year 1992 has partly been determined on the basis of data available for former Yugoslavia. In the reference year 1990, the Republic of Croatia had an emission of 39.4 Mt $eqCO_2$, i.e. 8.24 t $eqCO_2$/capita.

The implementation of the Convention's and the Kyoto Protocol's commitments will be an extremely difficult task for Croatia, perhaps even beyond its capacities. Considering the very low initial level of emissions, the consequences of war and an economy in transition, the introduction of additional measures will undoubtedly have great socio-economic implications. Practically any expense, that exceeds its delivered benefits, breaches the national scenario of sustainable development. At the COP6 (Hague, November 2000) and COP7 (Marakech, November 2001) Croatia made a statement announcing the problems it is facing in undertaking the Convention and the Kyoto commitments.

1.3 Calculation of Greenhouse Gas Emissions

Emissions in the Period from 1990-1995

In the period from 1990 to 1995, emissions fell by roughly 45 percent, and a particularly drastic reduction (by 26 percent) was recorded between 1991 and 1992. In the years following 1992, the quantity of emissions continued to fall, though at a slower pace, reaching its lowest level in 1994. In the last year observed, there was a slight increase in the quantity of greenhouse gas emissions. This situation stems from the specific circumstances that typified the Republic of Croatia in the period from 1991 to 1995, when it was faced with the defensive Homeland War after the disintegration of the former Yugoslavia. As a result of the upheaval, overall economic activity slumped, as did energy consumption within the country. Furthermore, due to adjustments dictated by the transition of the economy, some energy-intensive industries decreased or discontinued their production, significantly impacting the volume of greenhouse gas emissions.

The contribution share of individual greenhouse gases to the total emissions has not varied significantly over the years in question. In 1990, CO_2 contributed 78.0 percent to the aggregate greenhouse gases emissions, N_2O with 9.9 percent, CH_4 with 9.7 percent and synthetic gases with 2.4 percent. Synthetic gases are emitted mainly in the production of primary aluminium, a process that was discontinued in 1991. In the total 1990 emission, the energy sector contributed with 75.9 percent, industrial processes with 10.7 percent, agriculture with 11.0 percent and waste management with 2.4 percent.

Available data on emissions after the year 1995 shows a trend towards increase with a rate of 5 percent annually (emission calculation after year 1995 are not based on IPCC methodology).

Comparison with Emissions in other Countries

Croatia has a relatively low level of per capita emissions of greenhouse gases, practically the lowest amongst developed countries and countries in transition (Figures 1-2, 1-3). In 1990, the emissions in Croatia were in the order of 1.61 kg $eqCO_2$/US$ (GDP), and this emission level, despite the negative economic trends, fell by a further 24 percent up to the year 1995.

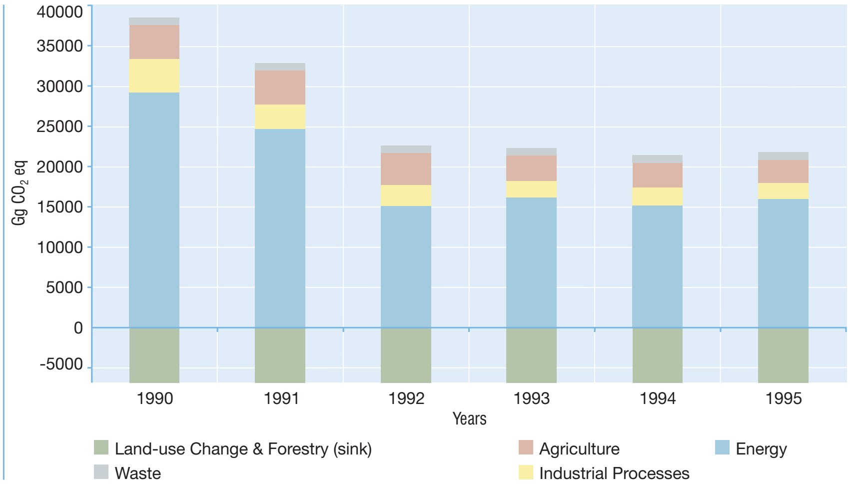


Figure 1-1: Aggregated emissions and sinks of greenhouse gases per sector in 1990 to 1995

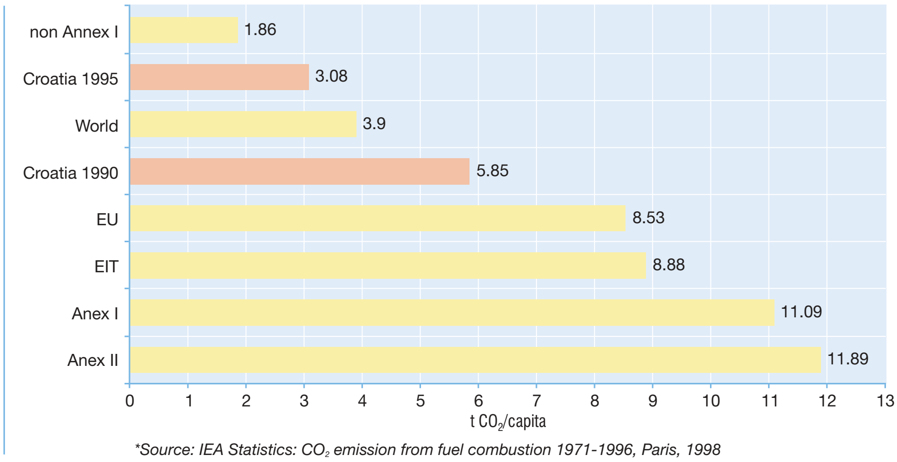


Figure 1-2: CO_2 emission from fuel combustion in Croatia and some groups of countries

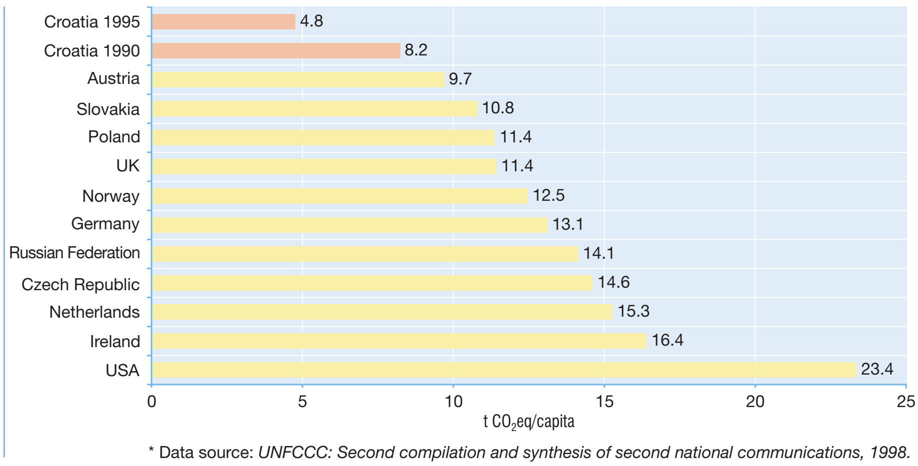


Figure 1-3: Total per capita emissions of greenhouse gases (without sinks) in some Annex I countries

1.4 Policies and Measures

1.4.1 Overall Context - Current Policy and Measures

Climate concerns became an issue of global significance at the time when Croatia was undergoing the most difficult years of its history - war, destruction and political isolation. The well-known problems of countries with economies in transition should also be taken into account. Under such conditions, it is understandable that there was insufficient political incentive to address global environmental issues, since the population was preoccupied with key problems such as reducing unemployment, improving the living standard, reconstructing destroyed areas and establishing democratic institutions and political stability. After the political changes of 2000, Croatia's international position has improved considerably, resulting in achievements such as the admission of the Republic of Croatia to the WTO, the Partnership for Peace and the beginning of negotiations for Croatia's accession to the EU.

Nevertheless, it can generally be said that past policy and measures and a number of *ad hoc* decisions resulted in low GHG emissions, significantly lower than the those recorded in developed countries and countries in transition. Some decisions, such as the suspension of the construction of a coal fired thermal power plant and the orientation of the energy sector toward natural gas, were almost exclusively guided by climate change and environmental protection issues.

1.4.1.1 General and Economic Policy

Croatian economic policy supports the transition to a market economy, the reconstruction of areas destroyed during the war, privatisation, greater integration into the international economy, the restructuring and orientation of the economy towards secondary and tertiary industries, as well as increases in production and a rise in employment. The high unemployment rate, at over 21 percent, is the reason why the current policy is directed at finding a solution to this particular problem. Political instability in the region remains a threat and represents a principal barrier to trade, having negative effects on Croatia's vital tourist industry.

The first integral document reflecting Croatia's vision for the future is to be adopted by the end of 2002 (*Economic Strategy - Croatia in the 21st Century*). This document outlines the basic framework for future socio-economic development, and includes environmental protection issues. The section therein relating to the energy development strategy, elaborated earlier in the *Draft Energy Strategy of Croatia* (1998), was used to prepare this National Communication.

1.4.1.2 Energy Policy

In accordance with the objectives set by the Government of the Republic of Croatia, the basic strategic task of the energy sector is to provide a high quality and reliable supply of energy to customers. This includes giving the customer the opportunity to choose a cheaper and more efficient energy source. To this end, a fuller inclusion in the international energy market needs to occur. The Government's program pursues: increases in energy efficiency; the diversification of power sources and fuels; the provision of incentives for the use of renewables; the establishment of fair (market) electricity prices; the development of an energy market and corresponding entrepreneurialism; and taking care to protect the environment. The reorganisation of the energy sector shall be implemented pursuant to five basic acts adopted in July 2001: the Energy Act, the Electricity Market Act, the Gas Market Act, the Oil Market Act and the Act on the Regulation of Energy Activities (Official Gazette # 68/2001). The legislation encourages the use of renewable resources and energy efficiency by providing different incentives. The establishment of a fund for the continuous financing of national energy programs is being prescribed, as well as the establishment of a regulatory agency.

National Energy Programs

In 1997, the Government of the Republic of Croatia reached a decision to initiate a National Energy Program (NEP) project within the PROHES program (Program of Development and Organisation of Croatian Energy Sector). The program was launched to develop an energy management framework that will principally promote clean technologies, gas networking, energy efficiency, and the use of renewable resources and environmental protection. Eleven programs have thus far been established in the fields of energy efficiency, renewable resources, transport and gas networking in Croatia.

Electricity Policy

The policies of the electricity generation sector have undoubtedly contributed to Croatia's relatively low GHG emissions as compared to other countries. The national utility company, *Hrvatska Elektroprivreda*, that covers 90 percent of the country's electricity demand, is currently facing corporate reorganisation and privatisation. During the first stage, the utility's activities, namely the generation, transmission and distribution of electricity, will be separated and in the second, a process of gradual privatisation will occur. The development of new generating capacities, *in mitigation scenario*, should be based on gas fired co-generation plants in towns with heat consumption, high-efficiency combined cycle gas turbines and the remaining hydro potential. Projects encouraging renewable energy sources are being prepared, and the establishment of energy service companies is imminent, both to be co-financed by the GEF.

1.4.1.3 Environmental Protection Policy

In the Republic of Croatia, environmental protection policy falls within the competence of the Ministry of Environmental Protection and Physical Planning. The State Directorate for Water is in charge of water conservation. The current body of legislation on environmental protection consists of acts, by-laws and regulations. Acts are to be passed by the Parliament of the Republic of Croatia based upon proposals of the government and the Ministry, subject to debate by the Parliamentary Committee for Environmental Protection and Physical Planning. Regarding climate change specifically, the most important legislation is the following: *The Environmental Protection Act, The Air Quality Protection Act, The Ordinance on Emissions Limits for Stationary Combustion Sources, The Waste Act, The By-law on Handling Hazardous Waste and the By-law on Environmental Impact Assessment.* An overall assessment of the realisation of environmental protection policies can be found in the "*Environmental Performance Review*", a report prepared by the UNECE in 2000. The *Environmental Protection Strategy*, with a *National Environmental Action Plan (NEAP)*, is currently at the stage of adoption. This document includes the climate-related concerns consistent with this Communication.

1.4.1.4 Approbatory Decisions, Activities and Positive Practices

A number of important decisions and positive practices, influenced by economic necessities and environmental concerns, had a direct impact on the reduction of Croatia's greenhouse gas emissions. They included: shutting down the large energy consumers, such as the coke plant in Bakar, the ferrous metals factory in Šibenik, and the high blast furnaces in Sisak; the orientation towards joint ventures, with regards to energy sources in the other republics of the former Yugoslavia, including those targeting renewables; the maximisation of hydroelectric power potential utilisation; the large share of cogeneration plants contributing to electricity generation; economic development directed towards services and energy non-intensive industries; the gas networking of Croatian households; closing down the sole domestic coal mine due to environmental reasons; postponing the construction of a new coal fired thermal power plant; sustainable forest management; a conventionally high share of biomass use for heating purposes (5 to 7 percent of total energy consumption); and the construction of a nuclear power plant pursuant to western PWR technology. Additionally, in a number of towns municipal authorities banned the utilisation of coal (the share of coal in general consumption is below 1 percent).

1.4.1.5 Available Technologies and Know-How

Croatia has good technical proficiency to support the introduction of climate-friendly technologies. Besides available personnel and large capacities within machine manufacturing and energy sector companies, there are also numerous small businesses that can reorganise their production in such a way as to adopt the new technologies. Croatia has producers of solar collectors, the entire equipment required for hydro-electric power plants and boilers. Experts in planning, study development, project preparation and project engineering are capable of implementing the overall program independently, with minimum technical assistance from international experts.

1.4.2 Planned Policies and Measures

1.4.2.1 Underlying Assumptions and Objectives

So far, Croatia has met its commitments under the Convention, since emissions of greenhouse gases are below the 1990 level.

The principal long-term objective of Croatia set under this National Communication in terms of climate issues is the following:

To mitigate climate change in accordance with the general principles of the Convention and undertaken commitments in such a way as to enable sustainable economic development.

Croatia has not, for the time being, set a quantitative target for the reduction of greenhouse gas emissions. The possibilities and implications of meeting the Convention and the Kyoto Protocol commitments have been analysed for the first time during the development of this National Communication. To this aim, actions described in the subsequent text represent the first framework action plan for the mitigation of climate change.

The Kyoto Protocol sets the reduction of greenhouse gas emission by 5 percent in relation to the reference year for Croatia. In respect of the general principles of the Convention, the set objective is unfair to Croatia. Unfortunately, at the time of the Kyoto negotiations Croatia had no available data on emissions and did not consider possibilities for their reduction. Consequently, Croatia was in no position to negotiate an objective consistent with its specific circumstances and capabilities.

Organisational and Institutional Framework for the Implementation of Measures

This National Communication has set a goal to establish a national program to mitigate climate changes. The program will build on the existing system developed within the project of preparation of national communication. The system will be composed of the following entities:

- **The Ministry of Environmental Protection and Physical Planning** will be in charge of the overall program realisation. It will set the strategic policy, co-ordinate and supervise the program, carry out administrative work and provide technical assistance. The responsibility for program realisation will lie within the competence of the **Climate and Ozone Layer Protection Section** and the **Atmosphere Protection Department.**

- **The National Commission for Climate Change** is the advisory body that will supervise and assess program results, evaluate and make decisions on key issues of strategic importance and support information exchange. Furthermore, it will network institutions and stakeholders.
- **The Executive Co-ordination Committee** is the body that will implement the program. It will be composed of top experts and representatives of relevant national and local government institutions.
- **The Scientific and Technical Advisory Body** of the program will give its assistance in resolving the technical and methodological problems experienced by the Program.
- **Working Groups** will be composed of stakeholders' representatives from specific fields. The working groups in the capacity building program will come within the competence of the Ministry of Environmental Protection, while the other program groups will come within the competence of their respective ministries.
- **Projects** and subprograms for specific work tasks relating to climate change issue assignments, with a fixed time limit and scope. They can come within the competence of individual ministries, public companies, local governments, scientific organisations, private companies, non-governmental organisations and others. The projects represent links between institutions and other programs of which they are constituent parts. Project leaders, or their agents, are members of the working groups.
- **Links with other programs and projects** are realised at all hierarchical levels of the programs: the project level, the work group level or the level of the Executive Committee and the National Commission for Climate Change.

The proposed model networks a number of existing institutions. The need for permanently employed staff in state institutions is minimal and the model can easily be adjusted if required. It enables the quick transfer of knowledge and activities from the public sector to the private sector and civil society, which is the ultimate requirement of every program that strives towards efficient implementation and strong partnerships.

After the establishment of the **Environmental Protection Agency** (a NEAP priority), specific areas that require permanent personnel and involve routine works, as well as the operative management of the program, will be assigned to the Agency.

The program will be organised into two parts: a) The Capacity Building Program and b) The Implementation Program.

Capacity Building Program (KLIMAkap) The objective of this program is to establish institutional, legislative, organisational and scientific capacities, build up human resources and promote public awareness regarding climate and development issues. The program will generate and transfer experience and knowledge, and promote the development, transfer and application of technologies.

Implementation Program (KLIMApro) KLIMApro will encompass the preparation and implementation of projects and the accompanying support at the implementation level in the form of regulations, technical manuals, support services, incentive measures, supervision, monitoring and project implementation.

Risks Attributable to Project Implementation

The risks associated with the implementation of the program are numerous since there are many obstacles to be overcome. These barriers are largely connected with financing, the mentality and knowledge of participants and, to a lesser degree, with technical precursors. From the outset, special attention should be paid to education and the promotion of public awareness.

Since the largest part of the proposed program is based on the use of resources outside governmental institutions, the rights and liabilities of individual participants should be carefully regulated. Care should also be taken to safeguard the institutional capacities, values and knowledge.

Financing

The costs associated with the climate program development (KLIMAkap) over the next three years are estimated at US$1.5 - 3 million. A system that will enable the full implementation of the proposed measures should be thoroughly developed during this period. These costs do not include the price of engaging experts from the government administration or external experts.

Cost estimates show that emission reduction by 20 percent in relation to the base scenario, which assumes implementation of nearly all currently analysed measures, could reach to US$ 120 million per year in the year 2010.

There are four envisaged basic sources for program funding: the national budget, the taxation of greenhouse gas emissions, commercial bank loans, and international financial and technical aid. The initial phases of the implementation of the program will require substantial international support. Hopefully, the GEF program financing mechanisms will continue to be a valuable source of support.

Priority Steps

The priority steps that will have to be urgently executed are the following:

- The establishment of a firm financing mechanism via emission taxes (within the establishment of an environmental protection and energy efficiency fund)
- Establishing the program through adequate political decisions

In order to build capacities for the implementation of the program, a number of activities should be executed in the next ten years like the development of operative and sector plans, background studies for legislation and projects, emission monitoring systems, knowledge on policy planning and measures, the implementation of a public awareness campaign program and so on. Capacity building should not slow down the implementation process. Therefore, the activities that have already started should be supported to the maximum degree and the parallel work of identifying and developing new projects should continue.

Demonstration and pilot projects should be launched in order to encourage the operations of the program. For that purpose, incentives to support national energy programs and other measures within industry, forestry and agriculture, should be developed. A detailed method for positive execution shall be defined in the Operative Action Plan.

International Co-operation - The Kyoto Protocol Mechanisms

The Kyoto Protocol enables the participating countries to fulfil their commitments through domestic measures, supplemented by the joint implementation mechanism (JI), the Clean Development Mechanism (CDM) or Emission Trading (ET). Joint Implementation and Emission Trading are the mechanisms operative among the Annex I countries, and the Clean Development Mechanism is operative between any Annex I country and the non-Annex I countries that are parties to the Convention.

The strategy for the application of the Kyoto mechanisms depends on how Croatia's base year issues will be solved under the Convention.

Possible Joint Implementation projects should be connected with those measures that deliver other benefits, which are currently priorities, such as waste management, forestry measures, industrial initiatives that increase production and promote the introduction of new technologies, agricultural measures and biomass utilisation projects.

Implementation Instruments
Croatia will apply the best practice principle, combining a number of different instruments for policy implementation: economic, fiscal, legal, voluntary, all based on information, education and research work. It is a priority in Croatia to reorganise the energy sector and introduce a CO_2 emission tax. The means collected via this tax should be used for capacity building, the implementation of incentive measures, the demonstration of best practices and providing for soft loans and project co-financing. The prerequisite for overall program success lies in setting targets for individual sectors and including these targets and implementation mechanisms in particular sectorial strategies, plans and regulations. The mode of assigning commitments to individual industrial branches and specific emission sources should be developed. Education, information dissemination and the promotion of public awareness should be continuous and performed with the active participation of non-governmental organisations.

In the establishment of a stimulating environment for the implementation of measures, it is crucial to increase the interest of the banking sector to stimulate investment in the projects aimed at mitigating climate change. For this to occur, the long-term objectives and state incentives provided for the successful implementation of measures should be transparent and the stability in the energy market should be assured.

Some of the measures that represent immediate barriers to the realisation of the project pipeline should be eliminated as soon as possible. Opportunities exist in *ad hoc* solutions for demonstration and pilot projects.

Inclusion of Local Communities in Program Implementation - Local Agenda 21
Since numerous problems and solutions are rooted in local activities, the participation and co-operation of local communities represents one of the key factors in meeting the program's objectives. The stimulation of Local Agenda 21 projects is planned as well as the start of a shared national program.

1.4.2.2 Measures to Reduce Emissions

A total of 39 measures have been identified for reductions in all emission sectors. The potentials identified for reductions represent target values; in some cases, these are maximum feasible values, while in some others these are realistic capabilities. If the quantitative targets are disregarded for a moment, each sector and subject that contributes to the emissions of greenhouse gasses should demonstrate progress, that is start to develop and implement projects.

The basic criterion for the selection of priority activities, measures and the appropriate implementation instruments, was the cost-effectiveness of a particular measure. In principle, priority will be given to those measures that have a lower cost per unit of avoided emission. Aside from the cost-effectiveness criteria, a number of other factors should be taken into account; they are of particular social importance that surpass purely economic considerations. The preferences expressed during the development of this Communication and accompanying public debates reveal that the most significant criteria at present is an increase in production and in the employment rate.

Energy Sector
The measures in the energy sector relate to the increase in efficiency in the generation, transmission and distribution of electricity, the use of renewable energy

sources, demand side management (DSM, energy savings), measures in transportation and a shift to fuels with lower carbon contents (natural gas). Figure 1-4 shows an overall presentation of the contribution made by the energy related measures per sector and Figure 1-5 per group of measures. The highest reduction can be achieved in the household and electricity sectors, by the application of efficiency measures and the use of renewable energy sources. The least costly, and most economically profitable measures, include enhanced energy efficiency and further use of solar energy in households and the "gas scenario" of electricity sector development, which has a large potential for emission reduction. The utilisation of biomass has the greatest potential among renewable energy sources - in the electricity generation sector, in households and services, and in the industrial sector.

Industrial Processes

In industrial processes, the production of nitric acid, ammonia and cement account for 90 percent of the total emissions from this sector. The production of nitric acid generates CO_2 emissions and there are no available technologies that could reduce emission in an economically acceptable way. A significant reduction could be achieved in the production of ammonia, with the installation of catalytic devices for the reduction of N_2O emission. In the cement industry, emissions can be reduced by increasing the energy efficiency of the process, using waste, instead of fossil fuels, using fuels with lower carbon content and altering the mixture of raw materials in the production of clinker. The highest reduction could be achieved by the fuel shift. However, this represents a problem in that cement works in Croatia, due to international competition, have shifted from liquid and gaseous fuel to petrol coke, threatening the implementation of this measure.

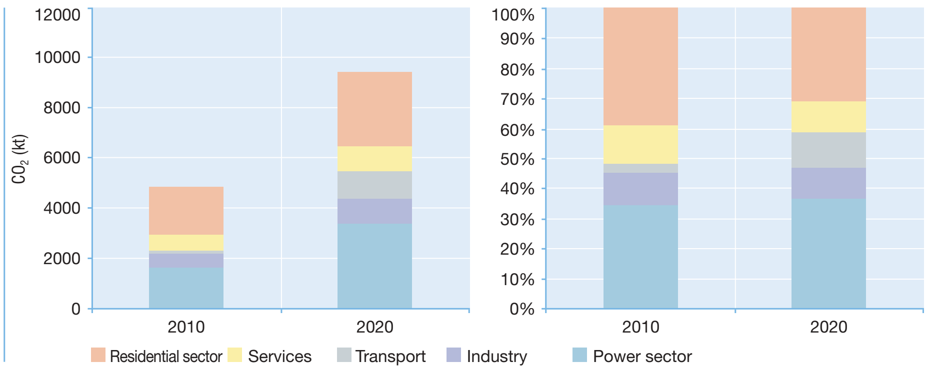


Figure 1-4: CO_2 Emission reduction potentials in energy sector by different sub - sectors

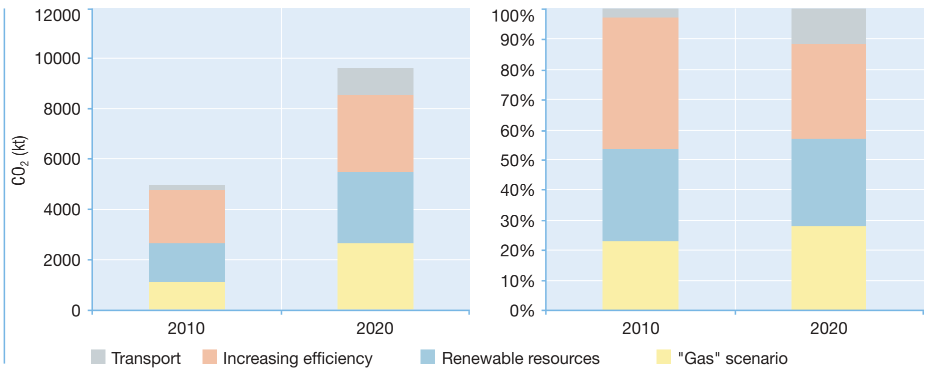


Figure 1-5: CO_2 emission reduction potentials in energy sector by different group of measures

Waste Management

A significant reduction in emissions could be realised through improved waste management, with relatively minor additional expenses and with additional benefits to environmental protection. The first measure is to avoid the unnecessary production of waste and intensify the classification and recycling of waste. The second measure covers the thermal processing of waste with energy utilisation. In this way, fossil fuels are being replaced, either by the thermal processing of solid waste or through the use of methane deposits for energy purposes. This could also be one of the possible solutions, if there are no opportunities for energy utilisation. Presuming that 70 percent of waste will be utilised for energy purposes, the emissions here can be reduced by 1 million tons eqCO_2.

Agriculture

Although there are numerous mitigation measures available in the agricultural sector, due to the difficulties and uncertainties related to the future development of this sector, total potential for emission reduction cannot be utilised. The estimates show that, even under the most optimistic scenario of agricultural development, the emission levels will increase. At the moment, the most significant viable and potent measure is the increased utilisation of bio-waste for energy purposes, and the production of bio-diesel.

Forestry

There are two types of positive measures associated with forestry: the increase in carbon stock of biomass - removal by sinks; and the use of biomass for energy purposes as a fossil fuel substitute. Out of the several potentially workable measures, planting new forests on the available existing forestland has the best prospects (330,000 ha of new forest land). The emissions can be reduced by approx. 2.2 million t CO_2. This measure has explicit environmental and social benefits, but can unfortunately generate little positive effects in the first commitment period from 2008 to 2012. A significant measure is the increased use of wood biomass as fuel, *i.e.* the utilisation of existing quantities of wood waste. This measure has by far the highest potential of all renewable energy sources.

Total potential for the reduction of greenhouse gases emissions per sector is shown in Figure 1-6.

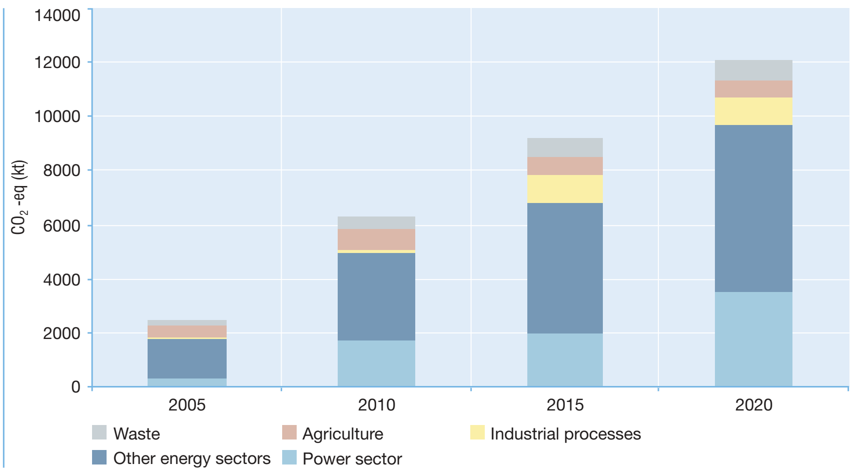


Figure 1-6: Total potential of emission reduction measures

1.5 Effects of Measures and Projections of Greenhouse Gas Emissions

The projections of emissions were made for the following two scenarios:

- **Scenario 01 –** *business-as-usual (synonyms: reference scenario and base-line scenario)* - is based on the assumption that new technologies will be slowly introduced into the economy and that the state will not be active enough in implementing reform, and restructuring the energy sector and all other relevant sectors. Here, the state will not adequately support institutional and organisational reform, will not support energy efficiency and renewable energy sources, changes in industry, agriculture, forestry and environmental protection in general. Scenario 01 does not represent a "frozen" state, and it includes certain technological improvements that would take place irrespective of climate program requirements. Scenario 01 originated from Scenario S-421 of the Draft Energy Strategy of the Republic of Croatia (Granić et. al., 1998).
- **Scenario M1 –** *mitigation* - starts with the assumption that the climate change issue and the sustainable development concept will in Croatia have, a significant impact on the reorientation of industry and the economy as a whole. The effects of changes will be manifested in the period after the year 2010. This scenario represents a combination of measures described in Chapter 1.4., in cases where one measure has two or more mitigation options, the option offering the largest potential for emission reduction will be chosen.

The analysis of the long-term social and economic development of the Republic of Croatia starts with the assumption that a balanced political solution for the region will be found, while at the same time the strategic goal underpinning Croatian policy is to join the European Union.

The result of the analysis is the assessment that the domestic product will grow at an average rate of approximatly 5 percent in the period from 1994 to 2025. The foreseen growth for Croatia would mean that in the year 2020, the GDP would be 3.2 times higher than in 1995. Expressed in US$/capita, this means an increase from 3,873 to 12,464 US$/capita. Consequently, in the year 2020, Croatian GDP will be at the level Greece and Portugal currently enjoy, but still significantly below the European Union average. In the structure of the domestic product, the share of services will grow from 61 percent to 66 percent, the secondary sector will keep its current share of 25 percent and the share of agriculture will fall from 14 to 9 percent. It is expected that Croatia will have 4.86 million inhabitants in 2020, roughly 0.2 million inhabitants more than in 1995, that is about 2 percent more than the number of inhabitants registered in the last census of 1991.

Total emissions under the *reference* and *mitigation* scenarios are shown in Figure 1-7. It should be mentioned here that **the nuclear option has not been considered**; potential measures in the energy sector should be investigated further, especially regarding wind power and biomass. The positive measures registered in forestry, relating to the increase in timber stock presently estimated at 2,2 million t of CO_2 (emission sinks) have not been taken into account. In fact, for Croatia, according to Kyoto documents, it is still not defined to what extent this measure could be accounted as sink. The scenarios are based on macroeconomic projections of economic development originating from the year 1995, ones that proved to be rather too optimistic. However, the total difference is not as great as to change the present conclusions.

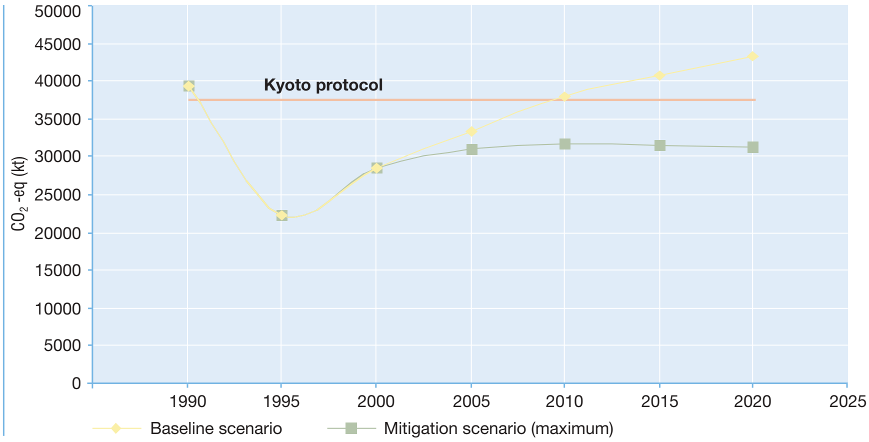


Figure 1-7: Projections of greenhouse gas emissions in Croatia

Figure 1-7 shows that with implementation of the additional measures in respect to reference scenario Croatia is able to achieve the GHG emission stabilisation, on the level of the base year emission and the Kyoto target.

It should be emphasised that the mitigation scenario presented in Figure 1-7 hardly could be reached in reality, or even that it would be nearly impossible to realise in the short term till the year 2012, which was the reason it was marked as the maximum achievable one. It assumes full utilisation of reduction potentials, presently estimated on aggregated analysis and data, with an approach which usually gives more optimistic figures than the collection of individual project potentials, by a bottom up approach.

All of the above statements should be taken with some reservations, since there are a number of uncertainties related to technological development, the political situation in the region, the status of Croatia in the EU, international assistance and a number of other concerns. The uncertainties surrounding the identification and estimate of potentials and costs of measures also exist and should be dealt with continuously.

1.6 Climate Change Impact and Adaptation

The state of existing knowledge about the climate change process does not allow us to predict with accuracy how the process will develop under the altered climate conditions forecast for the future. Estimates have focused on the historical trends displayed by climate factors and conclusions drawn about the sensitivity and vulnerability of individual parts of the ecosystem to forecast future conditions. These were mainly qualitative judgements, though in specific areas quantitative models were used in the analysis and, thus, should be elaborated in greater detail. Prior to the development of this Communication, significant investigation into the impact of climate change had been carried out in 1992 for the first time within the study *Climate Change and the Mediterranean (UNEP, 1992)*. Studies in the field of agriculture and forestry have been collectively published for the first time in *Adaptation of Agriculture and Forestry to Climate Change (HAZU, 1988)*.

Climate Scenarios

Regional models of air temperature variations were designed in accordance with the *business as usual* global scenario, which postulates a doubling of CO_2 emission into the atmosphere. These models show a temperature increase over the territory of Croatia ranging from 2.0 °C to 2.8 °C in the coastal and mountainous area, and from 2.4 °C to 3.2 °C in the lowland areas of the country. The greatest changes are likely to be seen during the summer months, with an anticipated temperature increase ranging from 2.8 °C to 3.2 °C, in coastal areas, and from 3.2 °C to 3.6 °C in the lowland part and Istria. Annual precipitation could increase between 4 and 10 percent in the coastal and mountainous area and between 8 to 10 percent in the lowland area and in Istria.

Observed Climate Change in Croatia

The main conclusions were drawn from an analysis of long-term meteorological measurements taken across Croatia:

- The territory of Croatia is located in a broad transitional zone, which will generate different changes in temperature trends; those for inland Croatia and coastal area differ in their respective characteristics.
- The annual mean daily temperature trend shows a slight rise of 0.3-0.4°C. However, this cannot currently be statistically substantiated as significant.
- The annual maximum daily temperature trend exhibits a slight, statistically insignificant, decline and differs with the particular season. In the spring and summer maximum temperatures fall slightly, while during autumn and winter they rise marginally.
- The annual minimum daily temperature trend shows a significant rise in inland Croatia, while in Crikvenica, a slight temperature drop was recorded during the spring.
- The daily temperature range (MAX-MIN) is decreasing (statistically significant change).

Weather Stations

1. At weather stations (Zavižan and Puntijarka) maximum temperatures have risen more rapidly than the minimum ones. The daily temperature range is increasing, significantly on Zavižan.
2. There has been a significant rise in air pressure at both weather stations, due to the increasing incidence of high-pressure weather patterns with a larger daily temperature range - indications of the changes in the overall circulatory patterns over Croatian territory.

Cloud Formation and Precipitation

1. There is a pattern of significant decreases in the median annual cloud formation over the territory of Croatia.
2. Annual precipitation displays a decreasing trend, which is more pronounced at the Adriatic weather station by virtue of more significant evaporation in the Mediterranean area (19 percent - northern Adriatic, 13 percent - eastern Croatia, 4 percent north-western Croatia).

Water Balance Components

1. The temperature rise causes significant overall increases in potential evapo-transpiration: Osijek - 15 percent in a 100-year period, Crikvenica - 7 percent.
2. Evapotranspiration in Osijek is substantial - 8 percent over 100 years, while no changes were recorded in Crikvenica.
3. Decreases in precipitation (due to a decreasing trend) cannot meet the water needs of plants (due to increased evapotranspiration), the result of which is a significant decline in runoffs and soil moisture in Slavonia and Primorje.
4. Significant decreases in runoffs can have a negative effect on water management, while the decline in soil moisture can have an adverse impact on vegetation.

Hydrology and Water Resources

Analyses of the historical water levels in Croatia's inland watersheds (the Sava and the Drava), and Lake Vrana in the coastal area over the period of 75 to 100 years, show that water levels have varied considerably between 1926 and 1975. Their amplitude has declined in the last few decades. Furthermore, in the past two decades there is a decreasing trend in median and minimum annual water levels. The analysis of meteorological and hydrology data shows that the fall in water levels is commensurate with the increase in temperature. A similar relationship can be seen between precipitation and flow rates. It can subsequently be argued that hydrology reflects the changes of climate patterns and that climate change will have a significant impact on water resources and their availability in the future.

Based on the existing climate change forecasts for Croatia, runoffs in the typical catchment areas of western Croatia and in the region of Dinaric karst could be reduced by 10 to 20 percent in relation to the present situation. In the eastern part of Croatia, these changes are expected to be below 10 percent. The possible decrease in runoffs and its redistribution during the year will result in water shortages during the summer months. The coastal area is especially sensitive to this state of affairs because temporary shortages of water occur in this area today during the tourist season and at times of high water demand. The risk of fire will also be heightened.

Possible changes in groundwater regimes and surface water regimes by virtue of possible decreases in groundwater inflows should be taken into account when planning water management works, such as the construction of multipurpose channels, irrigation systems or hydro-electric power plants in the Croatian interior.

Agriculture

The water balance of lowland Croatia supports the claim that soil moisture during summer months will decrease by 30 to 60 percent. At the same time, the annual number of days with temperatures exceeding 10ºC can be extended by 25 to 40 days in relation to the current situation. In mountainous areas, where today's average values of water balance reveal no shortage, an average water shortage during the month of August can be expected. Taking into account the duration of individual cardinal temperatures, one can assume that the vegetation period will be extended by 25 to 45 days. The estimates for the coastal region of Croatia show that a decrease in soil moisture, by 25 - 56 percent, can be expected. The period where the temperature period of 10ºC will be met could be prolonged by 55 to 90 days.

On the basis of these estimates, it can be assumed that spring crops can be sown earlier and, depending on water quantities available for irrigation, the growing season will be prolonged. In addition to irrigation, it is possible to abate the adverse impacts of water shortage by other means: tillage systems employed on a particular territory, tactical sowing schedules and the selection of correct seeds, and so on. are of key significance here. For sound, effective and sustainable adaptation of agriculture to the impact of climate change, innovative agricultural research should be devised and continuously carried out.

Impact and Adaptation in Forestry

Research into paleo-climates and more recent climate patterns in the Republic of Croatia has revealed that secular or long-term climate change generates no discernible negative impact on the vegetation mixture in individual climate zones neither resulting in warming nor chilling. These changes have caused vegetation zones to shift from lower altitudes to higher altitudes (in instances of warming) or vice versa (chilling). On the basis of such data, it can be assumed that future naturally occurring climate change, or that climate change directly or indirectly attributable to human activities, will cause further shifting of vegetation species across individual climate zones in the direction of climate change

The investigations carried out have shown that the expected climate change will have a significant impact on the types of trees belonging to narrow ecological valences, such as the fir-tree and penduculate oak. Their adaptation can already be observed, for example, with fir-trees growing at the edge of their natural habitat, moving towards the Mediterranean climate zone; here adjustments have been made to the warmer conditions in the forests of fir-tree and hop hornbeam on the slopes of Biokovo. The result of these changes will likely be an increased share of trees belonging to the broader ecological valences that did not play a dominant role, nor have a larger share in the structure of dry matter, historically. In this way the economic value of forests has somewhat declined, but the overall beneficial functions they serve have not been reduced (ecological and social), nor have their chances for survival.

Research into the dying of forests clearly points out that the changes occur in areas where a change of climate and hydrology has been recorded. However, it is still very difficult to differentiate between the impact of individual stress factors, amongst which air pollution plays an important role.

The data available on the number of fires and surface areas burnt show a strong relation to temperatures. In 2000, when air temperatures were extremely high, there was a total of 706 fires and the total forest and woodland area burnt was 68.171 ha, which is a level two to three times higher than any other seen over the past ten years.

Coast and Coastal Area

The estimated impact on the coastal areas of Croatia was based on expected changes in sea level ranging from 20 to 86 cm. The principal negative impacts include the flooding of seaside areas, salt-water intrusion into groundwater and coastal erosion.

An expected sea level rise of 20 cm. In general, the expected sea level rise of 20 cm will have no significant impact on the coastal area. However, there are certain areas where the impact will be particularly acute. These are the areas with a flood history, such as the coastal areas of the towns of Rovinj, Pula and Split. A sea level rise could possibly affect the only two freshwater reservoirs located in the coastal area - Vransko Lake on the island of Cres and Vransko Lake near the town of Biograd, as well as the alluvial plain at the mouth of the Neretva and Cetina rivers and thereby the town of Omiš. Certain adverse effects will be observed at the salt works in Pag, Nin and Ston and on the coastal sewage water outlets of these towns. It is difficult to estimate the impact on groundwater tables and the increased intrusion due to insufficient data, but it is realistic to expect that it will not be significant. It is also likely that the sea level rise will not cause substantial coastal erosion nor have a considerable impact on the existing beaches.

An expected sea level rise of 86 cm. This expected sea level rise will have a major impact on the aforementioned areas. It will also seriously influence a great many facilities in a number of settlements that are located at lower altitudes, sewage systems in the majority of coastal settlements and all marinas, boat jetties and harbours for larger ships. The study for the islands Cres/Lošinj has shown that a sea level rise of 1 m will flood an area inhabited by about 13 percent of the current population.

Biodiversity and Land Natural Ecosystems

It is expected that the following main groups of climate change impacts will register on the biodiversity of the territory of Croatia: a shift of vegetation zones (belts) in a horizontal and vertical direction; displacement and changes in the habitats of individual species of flora and fauna; extinction of individual species; changes in the qualitative and quantitative mixture of biocenosis; the fragmentation of habitats; and changes to ecosystem functioning. For now, we can assess which species and biocenosis are more sensitive, but are unable to estimate the magnitude of imminent changes.

Marine Ecosystems and Fish Stock

The estimated impact on the marine ecosystem is premised on the observation of changes in habitat parameters and appropriate biological and fishery data. There are numerous statistics on changes in Adriatic ichthyofauna. The most frequent indicators of marine resource impairment and potential problems have been identified. The connection between climate change and the fluctuations in fish stock, as the ultimate link in the food chain, has been confirmed with the example of a small pelagic fish.

Impact on Health

Individual research results regarding the impact of weather patterns on vascular diseases, psychological disorders, respiratory diseases and enquiries into the sensations of comfort can reveal the impacts of expected climate change on human health. It has been observed that high summer temperatures can have an adverse effect on health - medical problems increase due to rising temperatures. On the other hand, higher possible winter temperatures can reduce the number of heart attacks, cerebrovascular insults and asthmatic attacks.

Researches world-wide have shown that the anticipated warming could increase the risk from some vector-borne (insects) diseases. In some coastal areas of Croatia, a risk from malaria could occur and an increased risk from dengue and lismaniasis outbreak is also present. Warmer and more humid climate conditions could initiate the outbreak of food related diseases such as diarrhoea and dysentery.

1.7 Research Work and the Systematic Observation of Climate Change

The first National Communication, in the section related to the estimates of impacts, has been prepared on the basis of existing data and knowledge, with minimal additional analysis or numerical calculations. Further research is especially necessary regarding the flooding of coast, the impact on hydrology systems and water resources, and impact on cultivation of plants and forestry. The underlying bases for these analyses are historical climate data and climate scenarios. The existing observation and measurements made in Croatia that are connected with the climate should be organised and the methods of inclusion into the Global Climate Observation System (GCOS) investigated to a greater degree.

1.8 International Co-operation

Until the year 2000, due to political instability and open issues across the region, Croatia was politically and economically isolated. The possibilities for establishing bilateral and multilateral relations were subsequently limited. Bilateral aid was sporadic and limited primarily to technical assistance in the form of expertise and modest grants. Croatia has had limited access to EU funds, the only available funds being those within the scope of UN mechanisms (GEF and others) and the World Bank.

Considering the primary political goal to join the European Union, as well as climate, geographical and economic similitude, Croatia will, in its international relations, direct its co-operative practices towards the EU member states, neighbouring countries and those countries undergoing the process of transition to a market economy.

In order to fulfil its commitments under the Convention, Croatia needs a significant amount of international aid. Financial assistance is of the highest order of priority, and technical assistance is required in the form of the know-how and skills associated with specialised technology. However, external reliance is not applicable to the execution of the overall program. It has been proven through practice that international aid is often conditioned by the participation of international experts in a proportion exceeding actual needs.

1.9 Education and Promoting Public Awareness

The issue of education and public awareness has been identified as one of the key elements in the action plan to mitigate climate change. With this in mind, a comprehensive program of minimal actions to be carried out over next two years has been developed. The purpose of the planned educational activities and initial practical training (know-how) is to "generate significance" for this problem in the realm of social perception, to make young generations and citizens more sensible to these issues. The program has an additional purpose, of the same, or even greater importance, that is to provide initial information to social participants in the activities "generating" greenhouse gases about the necessity of, and possibilities for, implementing the technological, social and organisational changes that would pave the way for the process of reducing the generation of greenhouse gas emissions.

Successful promotional activities and a number of public appearances have been conducted during the development of this National Communication. Representatives from non-governmental organisations have participated in the development process within national workshops. The Communication was open to public debate for a period of three months, and was available on the Web site of the Ministry of Environmental Protection and Physical Planning.

Island of Žirje

2. Introduction

2. Introduction

2.1 Croatia's Commitments and Specific Circumstances

Croatia's Commitments

The Republic of Croatia became a party to the United Nations Framework Convention on Climate Change (UNFCCC) in 1996, by parliamentary Decree on Ratification (Official Gazette # 55/1996). Pursuant to that Decree, the Republic of Croatia has under Article 22 of the Convention undertaken the commitments outlined in Annex I as a country undergoing the transitional process to a market economy. Croatia has thus committed itself to maintain emissions of greenhouse gases at their 1990 levels.

The Republic of Croatia is also a signatory to the Kyoto Protocol. Upon its entering into force and its ratification by Parliament, Croatia shall commit to reduce its emissions of greenhouse gases by 5 percent in relation to the reference year, over the commitment period from 2008 to 2012.

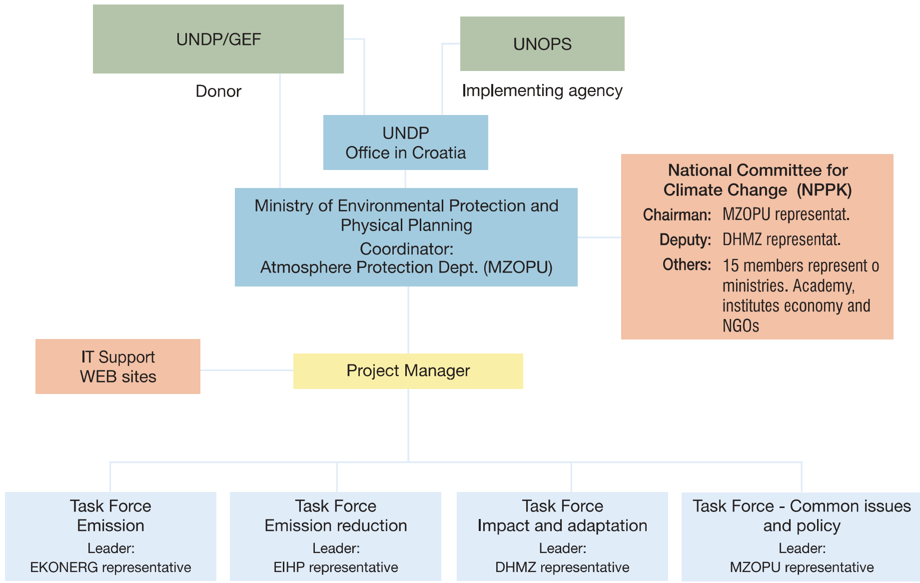
Croatia is a country that is vulnerable to climate change due to its 5800 km long coastline with 1185 islands, and its fragile agriculture and forestry that are socially and economically significant. There is also a potential influence on hydrology, water resources, mainland and coastal ecosystems. Therefore, Croatia has cause for concern and takes an active part in international efforts aimed at finding practical solutions to climate change.

The Convention does not only bear commitments but also offers some benefits connected with the orientation towards sustainable development, including environment-friendly clean technologies, transfer of knowledge, experience and technologies and financing possibilities via various mechanisms such as the Global Environment Facility (GEF) and other international and bilateral funds.

Development of the First National Communication

This National Communication has been developed thanks to the Global Environment Facility's (GEF) grant under the auspices of the project of the Croatian Government and the UNDP/GEF "*Enabling Croatia to Prepare its First National Communication to the UNFCCC*" (Figure 2-1).

The project took three years and involved over one hundred experts from 20 institutions that contributed to the project either by preparing the Communication itself or through workshops. The cooperation and the exchange of information were enabled through eight national workshops. Government institutions, public utilities, private sector, universities, scientific institutions, non-governmental institutions and media took an active part in the workshops. The experts from neighboring countries participated in national workshops, too. The information about all the activities related to the development of this Communication and the results thereof are available to broad public on the Web site . In 1998, the Government of the Republic of Croatia has established a National Climate Change Committee. The task of the Committee was to assist in the preparation of the Communication



Legend:
MZOPU - Ministry of Environmental Protection and Physical Planning
DHMZ - Meteorological and Hydrological Service
EKONERG - Energy and Environment Institute
EIHP - Energy Institute "Hrvoje Požar"
NPPK - National Committee for Climate Change
GEF - Global Environment Facility
UNDP - United Nations Development
UNOPS - United Nations Office for Project Services

Figure 2.1: Organization scheme of the project: Enabling Croatia to prepare its First National Communication to the UNFCCC

as an advisory and supervisory body of the Project. The UNDP/GEF National Communications Support Program helped in the development of this Communication, too, by holding national workshops, giving technical advises, providing information and literature and reviewing specific parts of this Communication.

The Communication outlines greenhouse gas emissions in the period from 1990 to 1995, in line with the commitments stated in the guidelines for the development of the **first** national communication. Other data and information relate to the mentioned period too, while a part of the information is more recent Ð mainly that which was already available and required no further investigation. The guidelines for the development of the **second** national communication were also used to the extent possible in view of available information.

Independent domestic experts reviewed the Communication in its entirety as well as its constituent parts, while international UNDP/GEF experts reviewed the calculation of emissions. The Communication was open to public debate for a period of three months, available on the Web site of the Ministry of Environmental Protection and Physical Planning. The Communication was finally reviewed and accepted by the National Physical Planning Committee, an expert advisory body of the Ministry and the Government. The results were also presented to the Environmental Protection and Physical Planning Council of the Parliament of the Republic of Croatia.

This Communication enabled the start of targeted and systematic treatment of climate change issues in Croatia by building up policy and measures, building common and specific knowledge, networking institutions and experts and providing general public with continual information. This document gives underlying basis for a climate change policy. For that reason, in the part relating to policy and measures (planned), the Communication is written as recommendation rather than mere description.

Specific Croatian Circumstances under Article 4.6 of the Convention

Being a country undergoing the process of transition to a market economy, under Article 4.6 of the Convention Croatia has the freedom to choose its reference year in the period up to the year 1990.

The emission of greenhouse gases from Croatian territory is very low, one of the lowest among the Annex I parties to the Convention. In its proposal, Croatia indicated some specific circumstances since it has been an integral part of the former Yugoslavia until 1991, when Croatia became an independent state. Croatia is facing some problems in determining the emissions of greenhouse gases, since there are no reliable data until 1992, when Croatia gained its independence. Up to the year 1992, the area of former Yugoslavia functioned as an integral economic and energy market and the territorial allocation of activities couldn't be properly carried out. Due to the problems with determining emissions, especially in the energy sector that generates the majority of greenhouse gas emissions, the emission in Croatia until the year 1992 has partly been determined on the basis of aggregate data available for former Yugoslavia.

2.2 Problem Background

Earth's climate is continuously changing due to various astronomical, physical and chemical factors. During the past hundred years human activities intensified and they now have direct impact on climate. The emission into the atmosphere due to combustion has caused changes in radiation patterns. Air temperature, precipitation and other climatic elements can be changed by a complex sequence of interactions resulting from the modification of radiation equilibrium.

Air temperature measurements taken during last fifty years, and at some stations even during more than a hundred years, have shown an increase in global mean air temperature of 0.3 to 0.6 °C over the past 80 to 100 years. The warmest years have also occurred during the past decade. And still, temperature increase cannot be, in a statistically significant manner, related to the hypothesis that the climate change is induced by human activities. The paleoclimate research has shown that warmer and colder periods have occurred on the Earth in more distant past, too. Due to natural climate variability it is hard to determine the exact contribution of human activities to climate change. Today's scientifically accepted thesis has a rather "loose" wording: "the balance of evidence suggests a discernible human influence on global climate" (IPCC, 1996).

Natural greenhouse gases in the atmosphere make the life on Earth possible. Natural greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and tropospheric ozone (O_3) and water vapor (H_2O). Greenhouse gases let short-wave radiation through and filter long-wave radiation out, thus preventing more intensive cooling of Earth's surface. Since the beginning of the Industrial Revolution late in the eighteenth century, the concentration of greenhouse gases in the atmosphere started to grow due to human activities. In addition to an increased concentration of gases that already existed in the atmosphere, the chlorofluorohydrogens appeared. Furthermore, it has been established that the production of secondary pollutants (photochemical oxidants) in urban environment is being increased by higher air temperatures, which can additionally burden the already polluted atmosphere.

2.3 International Response to Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992, at the Rio de Janeiro summit. Since that time, 186 countries have ratified the Convention, and so did Croatia in 1996.

The ultimate objective of the Convention is to *"achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous antrophogenic interference with the climate system"!* Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner".

Under the Convention, the Annex I countries i.e. mainly the developed countries of the world and countries with economies in transition such as Croatia, have committed to keep their greenhouse gas emission levels at their 1990 levels (reference year). A certain degree of flexibility was allowed to the countries with economies in transition in the choice of their reference years. They can select a year from the period 1985 to 1990 or choose an average of several years from the same period.

The experts believe that climate change is an irrevocable process. Therefore, in the moment of action there are already cumulative effects, meaning that the later the measures are introduced the more drastic measures have to be applied. The basic principle accepted internationally in response to climate change is to take preventive actions, i.e. the existing uncertainties regarding risk assessment should not be the reason for delaying actions.

It soon became obvious that the commitments under the Convention will not be sufficient as to stabilize the concentration of greenhouse gases. The most recent estimates show that the emissions have to be reduced by 50 to 70 percent, which is unlikely to be achieved without major socio-economic impacts. The first step in future efforts to reduce greenhouse gas emissions was the Kyoto Protocol of 1997, that commits the parties to reduce their greenhouse gas emissions by 5 percent in the period 2008-2012 in reference to the base (reference) year. The targeted reduction for Croatia under the Kyoto Protocol is 5 percent with reference to the base year. European Union has accepted the reduction in the order of 8 percent as a common goal, thus enabling an increase in emissions for some EU member states.

The Kyoto Protocol enters into force 90 days upon its ratification by 55 parties to the Convention accounting for at least 55 percent of 1990 emissions from the countries listed in the Annex B of the Protocol (developed countries). Thus far, 84 countries have signed the Kyoto Protocol, and 33 countries have ratified it.

Many parties to the Convention, including EU countries, have an objective and strive to put the Kyoto Protocol into effect 10 years upon the Rio de Janeiro summit, in 2002. A number of documents which elaborate the Kyoto implementation rules in more detail have to be agreed upon till that time. The last Conference of the Parties held in Hague Ð COP6 (2000) has shown that a number of crucial issues exist on which a consensus has to be reached. Basic differences arise from the differences in viewpoints of developed countries and developing countries.

Islands of Kornati (National Park)

3. National Circumstances

3.

National Circumstances

3.1 Social and Political Structure

Pursuant to the Constitution of the Republic of Croatia adopted on 22 December 1990, Croatia was established and defined as a unitary and indivisible democratic and social state. Power in the Republic of Croatia derives from the people and belongs to the people as a community of free and equal citizens. Freedom, equal rights, national equality, love of peace, social justice, respect for human rights, inviolability of ownership, the rule of law, conservation of nature and the human environment, and a democratic multiparty system are the highest values of the constitutional order of the Republic of Croatia.

As an independent state, Croatia became the United Nations member state on 22 May 1992.

As regards territorial and administrative structure, the Republic of Croatia consists of 20 counties (županije) and the City of Zagreb.

Figure 3-1: Territorial and administrative structure of Croatia - counties and county centers

The Croatian Parliament (Sabor) is a body of the elected representatives of Croatian citizens and is vested with the legislative power in the Republic of Croatia. The Croatian Parliament is established as a unicameral parliament. The representatives serve a 4-year term. The Parliament comprises several Committees that manage specific sectorial issues. One of the committees is the Parliamentary Committee for Environmental Protection and Physical Planning.

The state authority in the Republic of Croatia is divided into legislative, executive and judicial authority, and is limited by constitutional rights to local and regional self-management.

The President of the Republic of Croatia represents and acts on behalf of the Republic of Croatia in Croatia and abroad, attends to regular and coordinated operation and the stability of state authority.

The Government of the Republic of Croatia exercises executive power in accordance with the Constitution and the law. The Law and Government's Rules of Procedure define its structure, work and decision making. The Prime Minister designate, appointed by the President, selects Government members.

The Government of the Republic of Croatia proposes laws and other regulations to the Croatian Parliament, proposes state budget and annual financial report, enforces laws and other decisions of the Croatian Parliament, manages country's foreign and interior politics, directs and supervises the work of the state administration bodies, attends to the country's economic development, directs the operation and development of public services and conducts other affairs as specified by the Constitution and the law. The Government acts through governmental bodies, the most important ones being the ministries and state administration bodies. Croatia has 19 ministries.

The Ministry of Environmental Protection and Physical Planning performs administrative work and other activities associated with general environmental protection policy and sustainable development; air quality protection, soil, water and marine protection, vegetation and animal life protection in overall interaction; drafting the strategy for environmental protection and the enhancement of the state of environment; drafting, promulgation and monitoring of environmental protection measures; implementation of the inventory of pollutants (monitoring); environmental IT system management; environmental protection measures, environmental conditions and permits; care, adjustment and control over environmental protection program financing; waste treatment; drafting environmental protection standards; assessment of working conditions for legal and natural persons in the field of environmental protection; international cooperation in the field of environmental protection; environmental inspection; stimulating education and environmental research work.

The Directorate for Environmental Protection within the Ministry of Environmental Protection and Physical Planning is in charge for climate issues. This Directorate includes the Atmosphere Protection Department with two sections: Air Quality Protection Section and Climate and Ozone Layer Protection Section.

3.2 Population

According to the 1999 census, Croatia has 4,784,265 inhabitants. The average annual population growth rate over the past 20 years has been 0.39 percent; while in the past several years the number of inhabitants has decreased, accounting for the country's negative demographic trend.

The birth rate in Croatia was continuously declining during the past decade. The birth rate decreased from 14.66 per thousand in 1981 to 10.83 per thousand in 1991. The general fertility rate permanently decreased, too: in 1981 it was 18.9

births/1.000 live births, and in 1991 it fell to 11.1. The average life expectancy at birth in Croatia is 68.6 years (men) and 76.0 years (women).

Out of total number of inhabitants, 54 percent live in 204 urban settlements. The largest city is Zagreb with over 700,000 inhabitants. More than 400,000 inhabitants reside in three other major cities: Split, Rijeka and Osijek.

As regards the population density, Croatia has, on average, 84.6 inhabitants per square kilometer, which makes her a commonly populated European country. The population density differs significantly per different altitude and region. The most populated areas are the areas of northwestern Croatia with over 140 inhabitants/km^2, and the least populated ones are the regions of Lika, Gorski Kotar and the Velebit coastline, parts of inland Istria and some islands where the density falls below 20 inhabitants/km^2.

3.3 Geography

The Republic of Croatia is a Central-European, Adriatic and Mediterranean, Pannonian and Danube basin country. It covers an area of 87,677 km^2, 56,610 km^2 of which is landmass and 31,067 km^2 is territorial sea. It stretches in the form of an arc from the Danube in the northeast to Istria in the west and Boka Kotorska in the south.

Total land boundary of the Republic of Croatia with neighbouring countries is 2,028 km long, and the marine boundary, located at the outskirts of territorial sea towards Italy, is approximately 980 km long. The distance between northernmost and southernmost points of Croatian territory is approximately 433 km, and between westernmost and easternmost points about 448 km.

Croatia is situated close to densely populated and economically developed European countries. Many internationally important transport routes cross Croatia. The Adriatic Sea, the northernmost gulf of the Mediterranean, which is the closest to the central part of the European continent, enhances the importance of the geographical position of the Republic of Croatia. The most important transport routes are situated along the Sava River and the Adriatic Sea, followed by the routes along the Drava River and several important transversal routes from the Austrian and Hungarian border to the Adriatic coast (to Rijeka and Split).

The area of Croatia can be divided into three major natural and geographic parts:

- **The Pannonian and Peri-Pannonian area** (accounting for 54.4 percent of total surface area) comprises the continental lowland and hilly parts of eastern and northwestern Croatia, bordered by the rivers Sava, Drava and Donube. The mountains higher than 500 m are rare and have an “insular” character. Most of this area is being used for farming and livestock breeding. Slavonija and Baranja in the east are the most suitable for growing cereals; the humid plains and the hills are richly afforested while the northwestern part, which gravitates to Zagreb, is industrially the most developed.
- **The mountainous area** (accounting for 14.0 percent of total surface area), which separates Pannonian Croatia from its coastal part, consists of a high karst belt with sink plains and river valleys and belongs to Dinaric mountain area. This is a less developed area and its future development will be based on its transit importance, the development of already existing timber and wood industry and the still underexploited potential for the production of healthy food and development of winter and rural tourism.

- **The Adriatic area** (accounting for 31.6 percent of total surface area) includes the narrow coastal belt separated from the hinterland by high mountains. This is (predominantly) a karst area with very dry summers. The few water streams mainly follow narrow gorges in breaking their way through to the sea. The Croatian coastal area may further be divided into the northern (Istria and Kvarner) and southern part (Dalmatia) with a pronounced longitudinal division into the islands, the coast proper and the immediate hinterland. The Croatian Adriatic coast is one of the most indented in the world: it has 1.185 islands and islets with riffs, with total coastline length of 4,012.4 km and that of landmass 1,777.7 km. The largest island is Krk (410 km^2), and other major islands include Cres (404 km^2), Braè (395 km^2), Hvar (300 km^2), Pag (285 km^2), Korèula (276 km^2). The largest peninsulas are Istria and Pelješac and the largest bay is the Kvarner archipelago.

3.4 Climate

Climate Conditions

Under the Köppen classification (Figure 3-2), the largest part of Croatia has a moderately warm rainy climate, with mean monthly temperature in the coldest month of the year above -3 °C and below 18 °C. The highest mountain regions (> 1,200 m of altitude) alone have a snowy, forest climate, with the mean temperature in the coldest month below -3 °C. In the continental mainland, the hottest month of the year has mean temperature lower, and in the coastal area higher than 22 °C.

Mean annual air temperature in the coastal area ranges between 12 °C and 17 °C. The northern part of the coast has somewhat lower temperature than the southern part, and the highest temperatures are recorded at the seashore and on the islands of the central and southern Adriatic. The lowland area of northern Croatia has mean annual temperature between 10 °C and 12 °C, and in the areas above 400 m the temperature is below 10 °C. The coldest areas of Croatia are the regions of Lika and Gorski Kotar, with temperatures ranging from 8 to 10 °C at lower altitudes and from 2 to 4 °C at the summits of the Dinara Mountain. Due to the impact of the sea, air temperature amplitudes and anomalies have for years been less pronounced in the coastal area than in the inland area, and the autumn has been warmer than spring. The difference between mean maximum air temperatures in the continental and coastal part of Croatia is less significant than the difference between mean minimum air temperatures in those parts. The absolute air temperature extremes have been measured in the continental part of Croatia (-35.5 °C in 1929 and 42.4 °C in 1950).

Mean annual precipitation in Croatia ranges between 600 and 3,500 mm. The outlying islands have the lowest precipitation values of the Adriatic Sea (<700). As we approach the Dinaric massive, mean annual precipitation increases and reaches peak values of up to 3,500 mm at the summits of Gorski Kotar (Risnjak and Snježnik). In the western part of northern hinterland annual precipitation ranges between 900 and 1000 mm and in the eastern part of Slavonia and in Baranja it is somewhat below 700 mm. Although this area is the driest in Croatia, the distribution of precipitation during the year is such that the largest precipitation occurs during the growing season. Northern inland has no dry periods, and annual precipitation cycle is of continental type with the primary maximum in the warm part of the year and the secondary maximum in late autumn. The northern Adriatic, Lika and Gorski Kotar do not have dry periods, have two maximums, but the primary precipitation maximum occurs in the cold part of the year and the secondary maximum at the turn of spring into summer. At the central and southern

Adriatic, annual precipitation cycle is of maritime type with dry summers and the precipitation maximum occurs in the cold part of the year.

The prevailing wind direction in inland Croatia is from the northeast followed by that from the southwest. As regards wind intensity, it is weak to moderate. In the cold part of the year predominate winds in the Adriatic area are bora (from the NE quadrant) and jugo - sirocco (from the S quadrant), and during summer months maestral - landward breeze (mainly from the W quadrant). Wind speeds are higher than in the inland. Maximum bora squalls can exceed 50 m/s, while sirocco rarely reaches this speed.

Figure 3-2: Köppen's classification of climate

Croatia's most sunlit areas include the outlying islands of the central Adriatic (Vis, Lastovo, Biševo and Svetac) and the western coastline of islands Hvar and Korèula with over 2,700 hours of insolation. The central and southern Adriatic has more sunshine (2,300-2,700 hours) and less cloudiness (4.0-4.5 tenths) conditions than the northern Adriatic (2,000-2,400 hours of sunshine and 4.5-5.0 tenths of cloudiness condition). The duration of sunshine decreases from the sea towards the mainland and at higher altitudes. Annual duration of sunshine in the central mountainous area is 1,700-1,900 hours, with the lowest insolation (1,700 hours per year) and most cloudiness (6-7 tenths) conditions in Gorski Kotar. Due to frequent fogs during the cold part of the year, the insolation in the mainland is lower than the insolation at the same altitudes in the coastal area. In northern Croatia there are 1,800-2,000 hours of sunshine, more in the eastern than in the western part. Cloudiness declines from the west (6 tenths) to the east (< 6 hours).

Observed Climate Changes in Croatia

The change of climate elements in Central Europe is regionally homogenous and graduate. In the outskirt areas there is an increasing influence of the Mediterranean in the south, and of the Atlantic in the west. In Eastern Europe maritime influence decreases and the continental one gets stronger. Thus, changes in intensity or even direction of temperature and precipitation patterns occur. Under the Schönwiese (1997), the region of Croatia is situated in a broad zone of changes in temperature patterns. The continental part of Croatia has annual and seasonal changes that resemble the changes observed at the eastern brink of Alps and in the southern part of the Pannonian plain. The changes in the northern part of the Adriatic coast resemble that taking place at lowland locations of western Alps and in southern Europe. At the same time, at the Zagreb location, where an influence of the city with its heat island, changed regime of humidity and precipitation and industrial emissions can be assumed, no changes have been observed that can exclusively be attributed to possible local anthropogenic impact, if one compares the direction and intensity of such changes with the concurrent changes taking place in Central Europe.

Annual precipitation exhibits a decreasing trend. This trend is also characteristic for the southeastern Europe and central part of Central Europe. This tendency is more pronounced at the Adriatic weather station. Hence, this region is exposed to more significant drying up of the Mediterranean than other parts of Europe.

The results of researches into climate change carried out so far in Croatia are based on secular temperature series measured at the Zagreb-Grič observatory (northwestern part of continental Croatia), Osijek (eastern part of lowland Croatia) and Crikvenica (northern part of the east Adriatic Coast) stations, and historic climatic data gathered over the past 40 years in the northern lowland Croatia and at two highland weather stations.

Air Temperature

In the course of the XX century, a decade of warm years occurred round 1947, along with a very cold 1940 and 1956 (Zaninović and Gajić-Čapka, 1995). A warm period in the forties and in the first half of the fifties does not represent a temperature anomaly only at lowlands stations of Central Europe (Weber ET al., 1997), but worldwide. Round 1960, this anomaly was observed in mean temperatures recorded in the Northern Hemisphere (IPCC, 1992) and, to a lesser degree, in the Southern Hemisphere. Following the cold years immediately before 1980, a significant rise in maximum and minimum temperatures occurred. This trend continued in the 1990s, too. In 1994, the highest mean annual temperature was recorded at Zagreb-Grič observatory, not only in this century but also since the mid-last century when the measurements on that location started. The intensity of temperature rise is reduced on the coastal location by the activity of water. The stations in Central Europe that have a long tradition of measurements recorded the same warm and cold periods as the lowlands stations. General compatibility in the time series of maximum and minimum temperatures, even with different instruments and measurement and calculation methods applied, indicate that these temperature data are a distinctive feature of the lower troposphere over the Central Europe.

During the period from 1901 to 1992, stations Zagreb-Grič, Osijek and Crikvenica recorded a positive trend in minimum daily air temperature (Figure 3-3). This trend is statistically significant at continental stations and at locations in Central Europe (Table 3-1). Maximum daily temperatures on the territory of Croatia show a very weak negative trend, as opposed to the lowlands and highlands locations in Central Europe. Such a pattern of temperature extremes in Croatia resulted in a decrease of diurnal temperature range, which is significant at continental stations. As per season, the most pronounced fall of maximum and rise in minimum daily temperatures occurs during summer period, causing a significant decrease in diurnal temperature range (Table 3-2). A significant rise in mean minimum air temperature has been present since 1919 in Osijek and since 1946 in Zagreb, contributing to a significant decrease in diurnal temperature range in Osijek since 1914 and in Zagreb since 1962.

Table 3-1: Secular linear trends of mean annual air temperature values as compared to the period 1901 to 1990 (Weber et al., 1997 and Brázdil et al., 1996). The trends of the significance level 0.05 are in bold print. Asterisks denote stations with 1911 to 1990 time series, while the letters in Italics denote weather stations.

Station	T	T_{MAKS}	T_{MIN}	DTR
Trier (south Germany)	0.9	-0.1	1.7	-1.9
Zürich (Switzerland)	1.1	0.8	1.8	-1.1
Säntis (Switzerland)	1.1	1.4	1.1	0.3
Hohenpeissenberg (Germany)	0.8	1.0	1.4	-0.4
Potsdam* (east Germany)		0.1	0.4	-0.3
Prag Klementinum* (Czech)		1.4	1.0	0.4
Hurbanovo* (Slovakia)		1.0	0.3	0.7
Vienna (Austria)	1.1	1.3	1.1	0.2
Sonnblick (Austria)	1.2	1.4	1.2	0.2
Klagenfurt (Austria)	1.1	1.0	1.1	-0.1
Zagreb Grič (Croatia)	0.3	-0.2	0.6	-1.0
Crikvenica (Croatia)	0.4	-0.1	0.4	-0.4
Sadovo* (Bulgaria)		**-1.4**	**-1.1**	-0.3

Table 3-2: Seasonal and annual trends (in °C/100 years) of mean maximum (TMAKS) and mean minimum (TMIN) air temperatures; mean daily temperature range (DTR) and overcast (N). The trends of the significance level 0.05 are in bold print.

OSIJEK (1901-1992)					
	T	T_{MAKS}	T_{MIN}	DTR	N
Spr.	0.2	0.0	**0.7**	-0.7	
Sum.	0.1	**-1.0**	**0.9**	**-1.9**	
Aut.	0.2	0.3	0. 8	-0.1	
W.	0.3	0.3	0.8	-0.1	
Ann.	0.1	-0.1	**0.9**	**-0.9**	

ZAGREB-GRIČ (1901-1992)					
	T	T_{MAKS}	T_{MIN}	DTR	N
Spr.	0.5	-0.1	**0.7**	**-0.8**	**0.6**
Sum.	0.3	**-0.9**	**0.9**	**-1.8**	**0.8**
Aut.	0.4	0.4	0.8	-0.4	-0.1
W.	0.7	0.3	0.8	**-0.6**	0.1
Ann.	0.5	-0.0	**0.9**	**-0.9**	0.4

CRIKVENICA (1901-1992)					
	T	T_{MAKS}	T_{MIN}	DTR	N
Spr.	-0.3	-0.2	-0.2	-0.0	0.1
Sum.	0.4	-0.8	**0.9**	**-1.7**	0.3
Aut.	0.5	0.5	0.3	0.2	-0.4
W.	0.5	0.3	-0.0	0.3	0.2
Ann.	0.3	-0.0	0.3	-0.3	0.1

During the last four decades (1951 to 1990), the continental area of lowland Croatia shows the same pattern of changes in temperature extremes (rise) as observed in Central Europe, but with lower intensity (Table 3-3). At the same time, there is a decline in mean annual cloudiness over the entire Central Europe. In Croatia, this decline has the same degree of significance as in Slovakia.

Table 3-3: Ten-year linear trends of mean annual values as compared to the period 1951 to 1990 (Brázdil ET al., 1996). Trends of the significance level 0.05 are in bold print.

Country, region	T	T_{MAKS}	T_{MIN}	DTR	N
GERMANY	0.15	0.09	0.16	-0.07	-0.05
SWITZERLAND-centr.	**0.17**	0.06	**0.30**	-0.24	0.04
POLAND	0.10	0.23	0.17	0.06	
CZECH REP.	0.11	0.08	**0.19**	-0.11	-0.03
SLOVAKIA	0.04	0.04	0.13	-0.09	**-0.14**
AUSTRIA	**0.18**	**0.20**	**0.18**	0.02	
HUNGARY	0.03	0.07	0.07	0.00	-0.03
SLOVENIA	0.05	0.09	0.06	0.03	-0.03
CROATIA-lowlands	0.05	0.02	0.08	-0.06	**-0.09**
BULGARIA	-0.09	-0.02	-0.10	0.08	-0.02
CENTRAL EUROPE	0.10	0.13	0.15	-0.02	

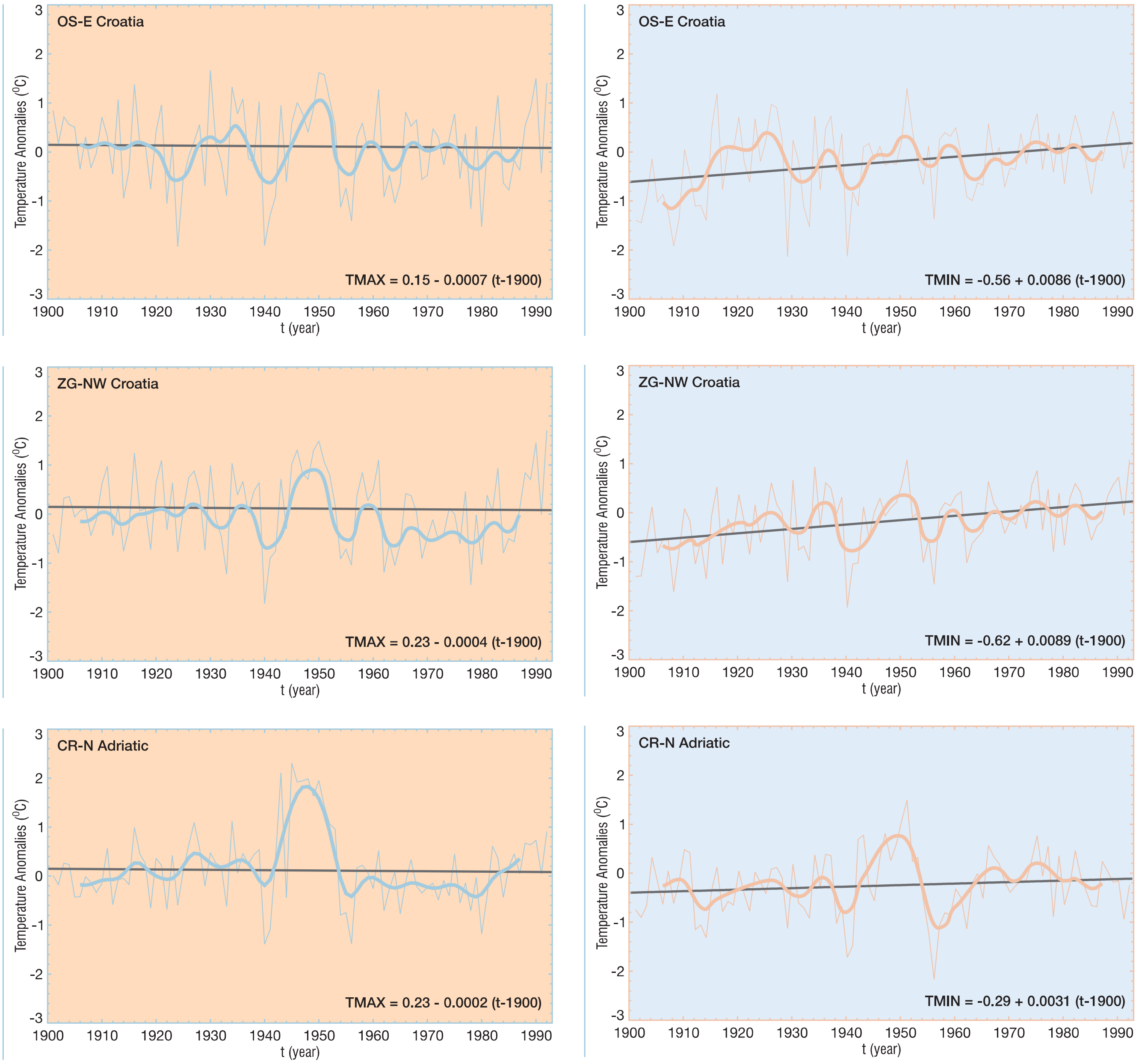


Figure 3-3: Anomalies and trends of mean, maximum (left) and minimum (right) air temperature in the period 1901 to 1992. (Osijek - OS, Zagreb - ZG, Crikvenica - CR)

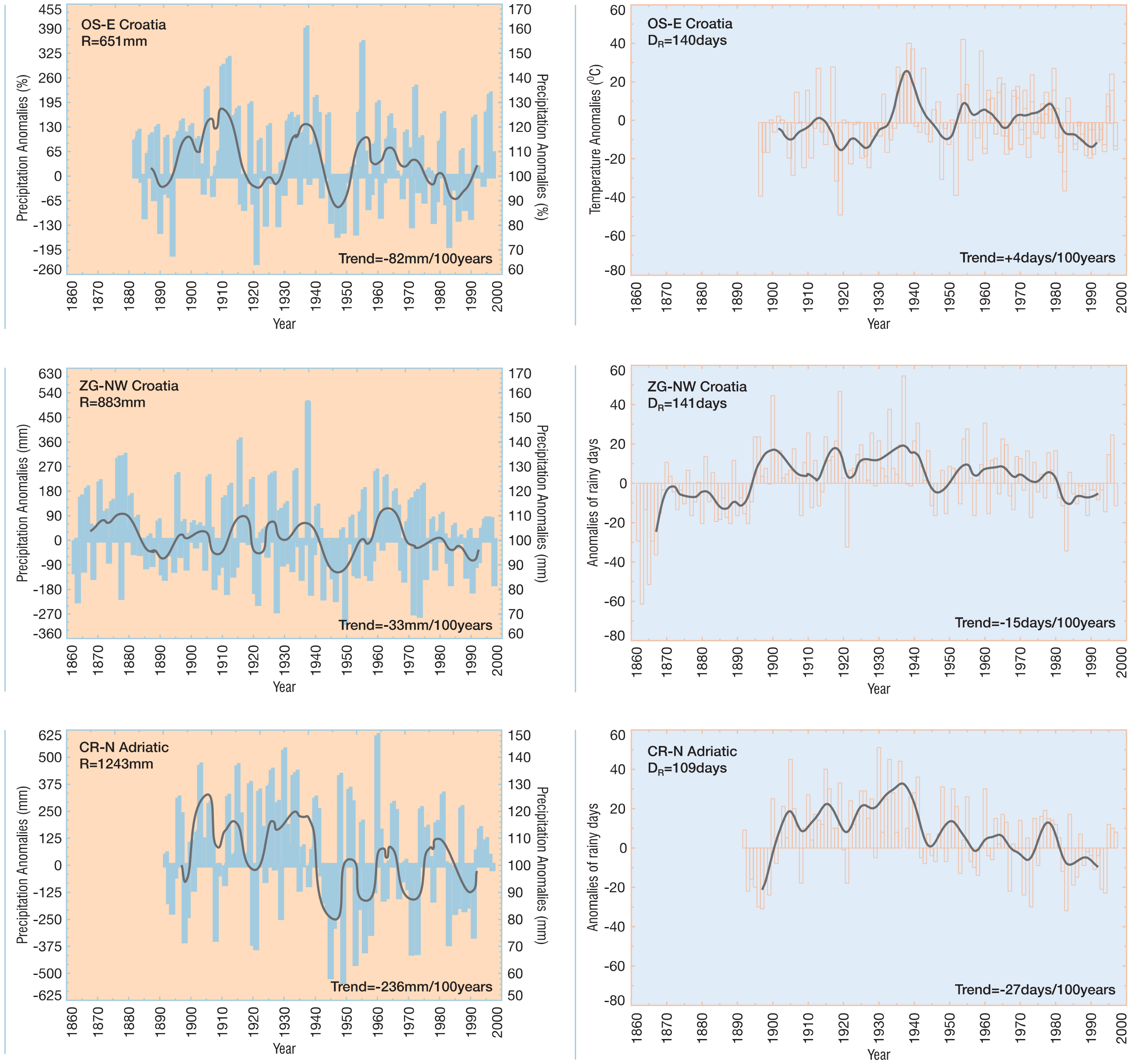


Figure 3-4: Precipitation anomalies and trends (left) and number of precipitation days (right) in the period 1901 to 1997

Table 3-4: Seasonal and annual precipitation trends (in mm/100 years) and precipitation days (number of days/100 years) (right), 1901 to 1997. Trends of the significance level 0.05 are in bold print.

	Osijek	Zagreb	Crikvenica
W.	+8.5	-0.8	-43.1
Spr.	**-62.4**	-23.6	-67.6
Sum.	+15.5	+35.4	-48.8
Aut.	-44.7	-44.5	-74.8
Ann.	-82.3	-33.1	**-236.0**

	Osijek	Zagreb	Crikvenica
W.	+3.2	-2.7	-5.5
Spr.	+1.0	-3.2	-8.7
Sum.	+4.1	-0.8	-4.8
Aut.	-4.1	-8.7	-7.3
Ann.	+3.8	-15.0	-26.6

Air Pressure and Weather Types

In order to find an explanation to air temperature changes, the changes of temperature parameters in the second half of the 20th century (1954 to 1995) have been analysed at the highlands station Puntijarka (988 m of altitude) in the northwestern Croatia and at Zavižan (1594 m of altitude) on the Velebit Mountain by the Adriatic Coast. Simultaneous changes in air pressure and weather types were also observed since they can indicate reasons for such changes (Gajić-Čapka and Zaninovіž, 1997). Since maximum air temperatures rise more rapidly than the minimum ones, diurnal temperature range rises, too, but this rise is significant only at Zavižan on the Velebit. At the same time, there is a significant air pressure increase at both stations. This is consistent with the trend of greater incidence of weather types with higher air pressure and larger diurnal temperature range. Weather types with lower air pressure exhibit a trend of an insignificant rise, or even fall, as regards incidence. Similar temperature tendencies are observed at Sonnblick, Säntis and Zugspitze, highland locations in the Alps (Böhm and Auer, 1994; Stefanicki et al. 1994). Statistically significant air pressure increase started at the end of the analysed period, and it still remains to be seen whether this trend shall be continued in the future or not.

Precipitation

A general decreasing trend in annual precipitation has been present at the territory of Croatia since the beginning of the XX century. Statistically, this trend is significant in the northern Adriatic region (by 19 percent with relation to average annual quantity). In eastern Croatia this decrease is in the order of 13 percent, and in northwestern Croatia 4 percent (Figure 3-4, table 3-4). Main contribution to annual decrease in precipitation can be attributed to the decrease in autumn and spring precipitation amounts, where only the spring decrease in precipitation in eastern Croatia is significant. A significant tendency of decrease in annual number of precipitation days is observed in the northern Adriatic region and in northwestern Croatia, while a slight increase in the number of precipitation days was recorded in eastern Croatia.

The decreasing trend in annual precipitation that is present in Croatia (Gajić-Čapka, 1993) is also characteristic for the eastern part of Central Europe (Hungary, Slovakia, Check Republic and Moravia) (Brázdil, 1985,1986, 1990, 1992; Šamaj et al. 1986.) and for southeastern Europe and the Mediterranean region. At the same time, northwestern and eastern parts of Europe show a positive trend in precipitation amount (Birrong and Schönwiese, 1988; Schönwiese, 1990; Ullrich et al. 1991).

Water Balance Components

The temperature increase reflects in a general significant increase in potential evapotranspiration, namely in Osijek by 15 percent/100 years (annual values) and by 14 percent/100 years (warm part of the year), and in Crikvenica by 7 percent/100 years (annual and semiannual values) (Gajić-Čapka and Zaninović, 1998; Zaninović and Gajić-Čapka, 1998; Zaninović and Gajić-Čapka, 2000). The increase in evapotranspiration in Osijek is a significant one (8 percent/100 years - annual values, 6 percent - warm part of the year), but in Crikvenica this parameter barely changed during the analysed period. Since lower amounts of precipitation (due to a decreasing trend) cannot meet increased needs of plants for water (due to increased evapotranspiration), this results in a significant decrease in runoffs and water content in soil in Slavonia and Primorje. A significant decline in runoffs can have adverse impact on water management, and reduced water quantity in soil can impair vegetation.

3.5 Economy

The economic situation in the Republic of Croatia in the year 2000 shows a certain degree of continuity in terms of stability, which is a good prerequisite for further economic growth and foreign investments. Political developments (admission of Croatia to the Partnership for Peace) along with Croatia's gradual economic integration into the international community (admission of Croatia to the World Trade Organization, start of negotiations with EU on the Stabilization and

Association Agreement) represent good prerequisites for the inflow of foreign capital and the arrival of foreign partners.

In the first half of 2000, some economic indicators have grown. This positive economic trend can be observed in increased exports, industrial output, retail trade, salaries, and tourist overnights. The industrial output in the first half-year of 2000 increased by 2.9 percent as compared to the same period in the year before, productivity grew by 5.4 percent and goods on stocks fell by 4 percent. Total exports in the first half-year of 2000 grew by 10.9 percent, and total imports remained at the 1999 level, which brought down the foreign trade deficit by 12 percent. However, the problems of high unemployment rate (in July 2000 it was 20.6 percent), national budget deficit, a high current account deficit and balance of payment deficit and lack of significant foreign investments remain acute. In June 2000, the inflation rate reached 7 percent, the costs of living rose by 5.6 percent. Over the first seven months of 2000, the per capita gross domestic product reached US$ 4,254. Foreign currency reserves of the Croatian National Bank amount to US $ 3.3 billion.

The Republic of Croatia has defined its relations with the Paris and London Clubs and agreements were signed on the obligations arisen from the debts incurred by former Yugoslavia. These relations are based on the succession of States. In early 1996, Croatia received credit ratings by the leading world agencies.

In the structure of Croatian economy the agriculture accounts for 10 percent, industry 30 percent, and services 60 percent of total economy. Owing to her geography and natural resources, tourism plays an important role in Croatia. The tourist season 2000 has been one of the most successful since 1990 in terms of the number of tourists and tourist overnights as well as financial results. **It is expected** that the foreign currency earnings from tourist trade in 2000 will reach US$ 3.5 billion, about 40 percent more than in 1999 (in the first seven months of 2000 the number of foreign tourists increased by 62.4 percent as compared to 1999).

The privatisation process has been largely completed. The privatisation of public companies is now under way as well as the second privatisation stage of the Croatian Telecommunications. The bulk of legislation has been adjusted to the Western legislation standards. Foreign and domestic entrepreneurs have equal rights and liabilities. The Company Act was followed by the Investment Promotion Act passed in July 2000.

The Croatian economic policy aims to build on the achieved stabilization results and to create conditions for sustainable development. The sound economic policy implemented by the Croatian Government promises to solve structural problems on a long-term basis. The admission of Croatia to the WTO and trade preferential with EU should result in more favourable trends. Croatia starts and continues negotiations with the CEFTA member states on a free-trade zone in order to join the CEFTA. The negotiation with EU on the Stabilization and Association Agreement is pending; this will completely liberalize the trade between Croatia and EU member states.

Table 3-5 shows some macroeconomic indicators for Croatia in the period 1995 to 2000. (Source: Ministry of Economy of the Republic of Croatia: Country Report), table 3-6 shows the share of industries in total GNP for the year 1995.

Table 3-5: Selected macroeconomic indicators for the period 1995 to 2000

	1995	1996	1997	1998	1999	2000*
GDP, bn USD	18.81	19.87	20.11	21.75	20.18	
GDP growth rate. percent	6.8	5.9	6.8	2.5	-0.3	2.8
GDP per capita, USD	4 029	4 422	4 398	4 833	4 483	4254
Industrial production rate, percent	0.3	3.1	6.8	3.7	-1.4	2.7
Inflation rate, percent (end of period)	2.0	3.5	3.6	5.7	4.2	5.7
Unemployment rate, percent (average)	14.5	16.4	17.5	17.2	19.1	21.4
Exports, bn USD	4.63	4.51	4.17	4.54	4.28	3.28
Imports, bn USD	7.51	7.79	9.10	8.38	7.78	5.70
Total foreign debt, bn USD (end of period)	3.81	5.31	7.45	9.59	9.85	9.69
Total foreign currency reserves of CNB, bn USD (end of period)	1.90	2.31	2.54	2.82	3.03	3.38
Exchange rate HRK:USD (end of period)	5.32	5.54	6.30	6.25	7.65	8.52

* *First 9 months*

Table 3-6: GDP structure per industry (percent), current prices

	1997	1998	1999
Agriculture, hunting and forestry	7.65	6.99	6.88
Fishing industry	0.17	0.12	0.11
Mining industry and extraction	0.52	0.45	0.41
Manufacturing/processing industry	18.41	16.61	16.74
Electricity, gas and water supply	2.97	3.21	3.18
Construction industry	6.01	5.64	5.61
Wholesale and retail; repair of motor vehicles and motorcycles, appliances for personal use and household appliances	10.54	9.57	9.51
Hotels and restaurants	2.64	2.47	2.28
Transport, storage and communications	7.34	7.67	8.09
Financial brokerage	3.27	3.92	4.11
Real estate business, rentals and business services	8.60	8.82	9.19
Public administration and defence; compulsory social insurance	7.71	8.58	8.87
Education	3.12	3.52	3.77
Health care and social welfare	3.59	3.90	4.04
Other public, social and personal services	2.01	2.02	2.08
Private households with employed personnel	0.02	0.03	0.03
Extra-territorial organizations and bodies	-	-	-
Financial transaction services	*-3.06*	*-3.65*	*-3.74*
Gross value added (basic prices)	**81.51**	**79.87**	**81.16**
Taxes on products minus product subsidies	*18.49*	*20.13*	*18.84*
GDP (market prices)	**100.00**	**100.00**	**100.00**

3.6 Energy Structure

Croatian energy sector is predominantly in state ownership. Two largest companies in the Croatian energy sector - INA - Oil Industry and Hrvatska Elektroprivreda (HEP) are joint stock companies, with 100 percent state owned shares.

The internal organization of the INA embodies research, production, transport and storage of natural gas and research, production and processing of crude oil and bulk of oil derivative trade and liquefied petrol gas trade. Own production of crude oil meets about 40 percent of total demand, while the production of natural gas covers 60 percent of domestic market.

Electricity generation, transmission and distribution, heat generation and distribution, and electric power system operation and control are organized within HEP. The production in HEP's hydro power plants, thermal power plants and combined heat and power plants meets about 95 percent of total electricity demand, and the remainder is being produced in industrial boiler plants and privately owned mini- hydro power plants.

The processes of energy sector restructuring started, aiming at vertical unbundling of state owned companies and market de-monopolization. Thus, organizational, economic and legal prerequisites will be created for further reform and privatization of the sector.

In 1998, total energy demand in the Republic of Croatia was 354 PJ, or about 1,849 kg of oil equivalent per capita. Such a low specific energy demand puts Croatia at the very bottom of the list of European countries and even the countries with economies in transition as regards energy demand (Figure 3-5).

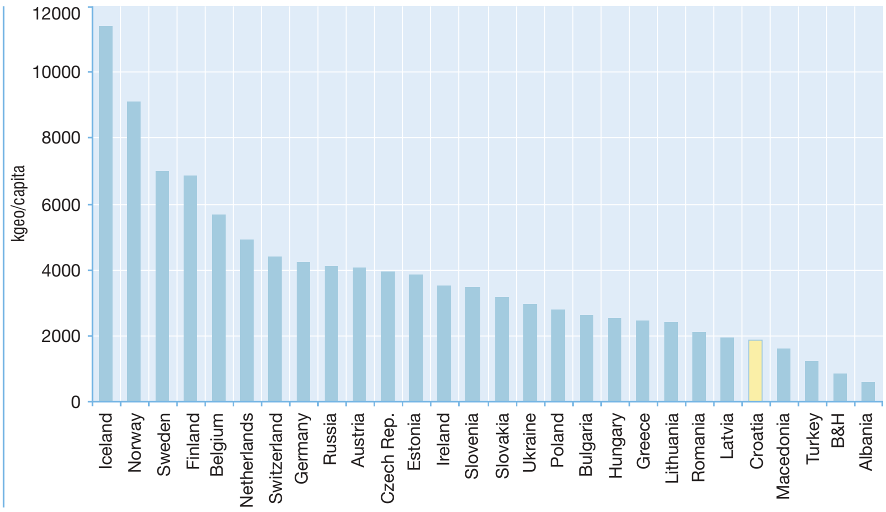


Figure 3-5: Total energy demand per capita in some European countries

In the period 1990 to 1992, total primary energy supply in Croatia fell by 27 percent and final energy demand by 34 percent. Since 1993, a slight increase in demand has been recorded, and in 1998 total demand accounted for 86 percent of the 1990 demand, final demand accounted for 83 percent of the 1990 demand.

Total primary energy supply and production in Croatia in the period 1990 to 1998 are shown in Figure 3-6. Over that particular period, the highest energy self-sufficiency was recorded in 1991 (65.7 percent) and the lowest in 1998 (51.9 percent).

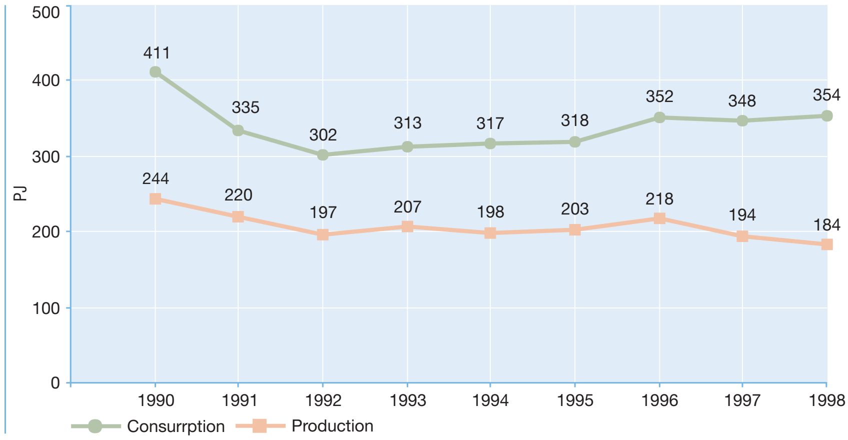


Figure 3-6: Total primary energy production and supply in the period 1990 to 1998

The structure of primary energy supply has not changed significantly over the period 1990 to 1998: liquid fuels have predominant share of about 45 percent, followed by natural gas and water resources. Coal consumption decreased from 8.5 percent at the beginning of the period to 2.6 percent in 1998 (Figure 3-7).

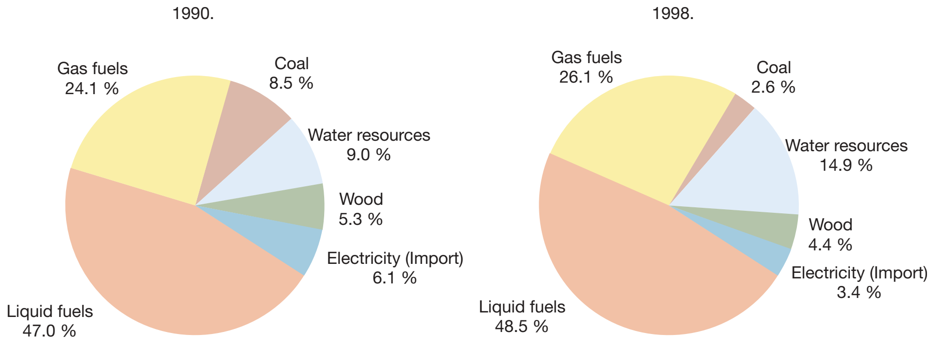


Figure 3-7: Structure of total primary energy supply in the period 1990 to 1998

Total fuel wood consumption and total hydropower demand are met from the territory of Croatia, and the consumption of other energy forms by the production in Croatia and by imports.

The structure of total energy consumed per sector in the period 1990 to 1998 is shown in Table 3-7. Table 3-8 shows the structure of final demand (general consumption, transport and industry).

Figure 3-8: shows the consumption of fossil fuels for combustion (energy transformations, transport, and industry).

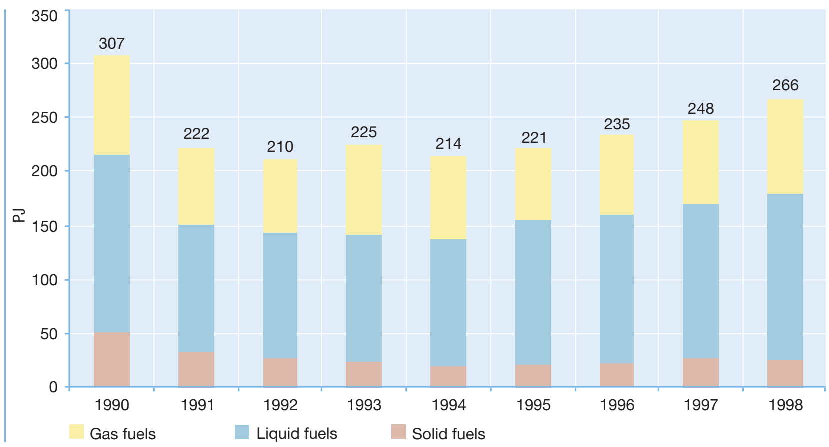


Figure 3-8: Consumption of fossil fuels for combustion in the period 1990 to 1998

Table 3-7: Total energy consumption per sector in the period 1990 to 1998. PJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998
General consum.	107.6	88.6	76.3	78.1	81.0	88.1	98.2	100.5	100.2
• *building constr.*	*5.9*	*4.6*	*2.9*	*3.3*	*3.4*	*3.0*	*4.0*	*4.7*	*4.7*
• *agriculture*	*14.5*	*10.5*	*9.3*	*9.2*	*9.2*	*8.3*	*8.4*	*8.5*	*9.3*
• *services*	*18.1*	*14.5*	*12.6*	*14.6*	*16.2*	*18.1*	*19.2*	*19.1*	*19.2*
• *households*	*66.8*	*59.0*	*51.5*	*51.1*	*52.2*	*58.6*	*66.7*	*68.2*	*67.0*
• *other consumers*	*2.3*								
Transport	61.2	43.1	40.9	44.4	48.2	50.6	56.2	59.3	62.0
Industry	88.9	65.4	54.2	50.0	49.6	47.3	46.9	50.6	51.1
Non-energy consumption	32.8	29.2	32.6	29.8	31.8	25.2	27.3	29.9	24.5
Transport & distribution losses	7.7	10.6	7.4	8.2	8.4	9.0	12.4	11.0	12.3
Own consumption	54.3	37.2	30.8	36.8	37.5	38.7	39.7	31.4	29.1
Transformation losses	59.0	61.0	60.4	65.4	60.5	59.5	71.9	65.3	74.8
TOTAL	**411**	**335**	**303**	**313**	**317**	**318**	**352**	**348**	**354**

Table 3-8: Structure of final demand in the period 1990 to 1998, PJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Electricity	47.8	40.9	34.0	33.7	34.5	35.7	37.1	39.7	40.0
Gas fuels	30.8	28.7	26.3	26.5	25.5	28.8	32.9	34.7	35.4
Liquid fuels	111.5	80.9	73.4	74.5	82.0	83.8	91.6	96.5	99.9
Coal	16.7	9.5	5.4	4.5	3.9	3.0	3.3	3.3	3.7
Steam and hot water	31.9	24.7	21.6	23.3	22.1	23.6	22.8	22.6	21.7
Fuel wood	19.1	12.2	10.7	10.0	10.8	11.1	13.7	13.6	12.6
TOTAL	**258**	**197**	**171**	**173**	**179**	**186**	**201**	**210**	**213**

The structure of electricity sources at the end of 1998 is shown in Table 3-9, and electricity generation in the period 1990 to 1998 in Figure 3-9.

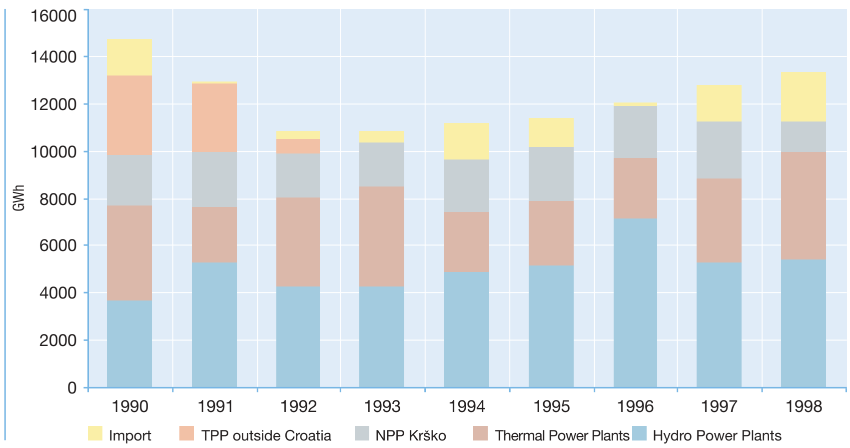


Figure 3-9: Electricity generation in the period 1990 to 1998

Table 3-9: Installed capacities in the electricity sector

	Installed capacities MW	Share Percent
Hydro power plants	2 076	47
Thermal power plants	1 339	30
Nuclear power plant Krško	332	8
TPPs outside Croatian borders	650	15
TOTAL	**4 397**	**100**

Figure 3-9 shows a significant share of hydropower production that ranges from 40 to 60 percent, while the share of nuclear power ranges from 15 to 20 percent. In 1996, only 21 percent of energy was generated by fossil fuel fired thermal power plants, a half of which powered by natural gas. Cogeneration power plants contribute to electricity generation with 15 percent. The emissions per kWh of electricity supplied range from 280 to 350 kg/kWh, and belong to the lowest values recorded in Europe.

Total energy flow in 1998 is shown in Figure 3-10.

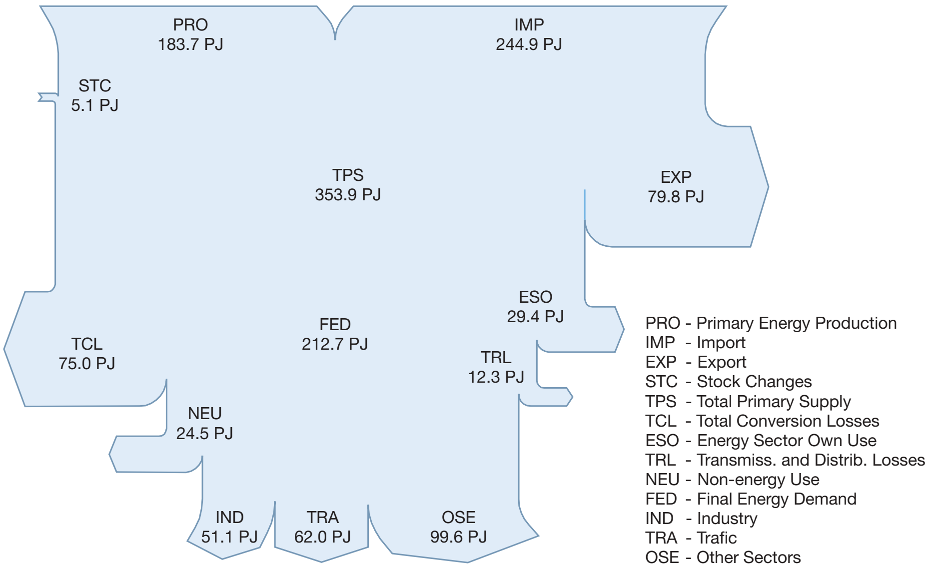


Figure 3-10: Energy flow in 1998

3.7 Transport and Housing

Owing to its specific shape and geopolitical position, the Republic of Croatia, as a coastal state with the access to the Adriatic Sea, has significant natural advantages that enable good connections with other countries.

According to the 1997 data, the Republic of Croatia has a total of 2,726 km in railways, out of which 36 percent electrified. Total length of roads is 27,840 km, out of which 330 km are highways. The number of registered road vehicles is shown in Table 3-10.

Until the early nineties, Croatia was a country with a pronounced traffic transit. However, during the nineties, due to the disruption in important road routes, the intensity of passenger and goods transport significantly decreased. The highest decrease in total transport volume was recorded in rail transport (by 29 percent in 1997 as compared to 1990) and inland waterways transport (by 4 percent), while an increase was recorded only in air transport (**by 867 percent**). Table 3-11 shows basic data on passenger and goods transport in Croatia, and the Figure 3-11 shows the shares of transport types.

Table 3-10: Registered road motor vehicles

	1994	1995	1996	1997
Passenger vehicles	698 391	710 910	835 714	932 278
Combined vehicles	5 226	6 215	7 893	8 683
Freight vehicles	59 212	67 282	87 028	101 051
Buses	4 026	3 897	4 596	4 771
Motorcycles	9 304	9 933	14 128	17 401
TOTAL	825 852	841 167	1 008 878	1 142 201

Table 3-11: Passenger and freight transport

	1991	1993	1995	1997
Passengers transported, million	123	104	107	109
Efficiency, bn. passenger km	6.16	4.87	5.72	6.30
Goods transported, bn tons	59.1	40.6	57.3	56.2
Efficiency, bn tons km	189	176	198	203

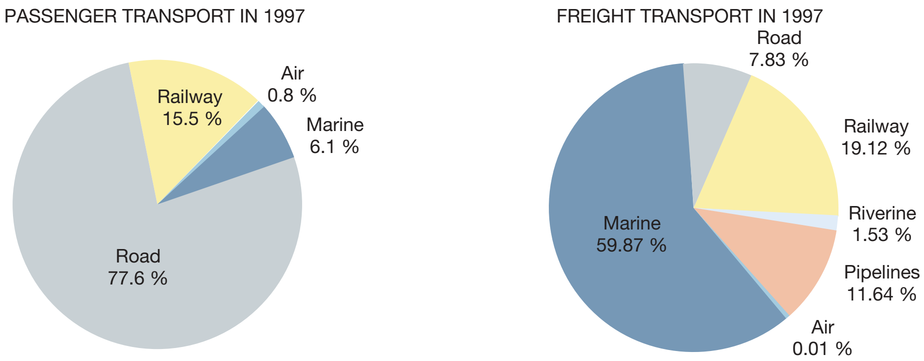


Figure 3-11: Shares of transport types in passenger and goods transport

The development of seaborn transport is very important for Croatia as a maritime state with a long and indented coast and numerous inhabited islands. There are about 90 ports that can harbour larger coastal navigation ships. Large ocean ships can dock in seven main Croatian harbours located at the seacoast. The number of merchant marine ships at the end of 1995 was 267. On average, they are 13.9 years old.

Navigable inland waterways of the rivers Sava up to Sisak, Drava up to Osijek and Donau, have the status of international navigable waterways. River harbours Sisak, Slavonski Brod, Osijek and Vukovar have the status of international harbours.

According to the 1991 census, average surface area of a flat in the Republic of Croatia was 71.1 m^2, i.e. 22 m^2 per resident. The housing fund in 1996 amounted to 1.6 million of flats with an average of 3 residents per flat. A long-term plan envisages an increase in the number of flats in order to reach the number of 2 million flats, and the level of developed West-European countries with less than 2.5 residents per flat.

3.8 Agriculture

Total area of agricultural land in Croatia is 3,181,000 ha and accounts for 56,5 percent of Croatia's surface area. Out of the total 4,784,265 inhabitants surveyed by the 1991 census, 409,647 belong to agricultural population (219.010 women and 190.637 men).

Every third household in Croatia owns an agricultural economy. The property is extremely fragmented, even “splintered”, to the degree that it presents one of key barriers to the rational use of production potentials. This point is illustrated by the fact that there are roughly 18,000,000 land plots, leaving the average property area of about 3 ha divided into 7 to 8 plots.

The agricultural land-use is shown in Table 3-12. Due to high fragmentation of property, the consolidation issue is being raised, especially as regards crop farming. Croatia became a WTO member, and the domestic agriculture will not be competitive if all the possibilities for cheaper production are not fully utilized. In the majority of cases, the size of agricultural economy is insufficient for modern production technologies to be used and, consequently, production costs lowered.

Table 3-12: Surface area of Croatia, population and agricultural land-use

Agricultural land in 1998			
Land use (ha)	**Total**	**Private**	**Legal entities**
Ploughland and gardens	1 458 000	1 155 000	303 000
Orchards	69 000	66 000	3 000
Vineyards	60 000	54 000	6 000
Meadows	434 000	350 000	84 000
Total cultivable land	2 021 000	1 625 000	396 000
Pastures	1130 000	461 000	669 000
Total agricultural land	3 181 000	2 089 000	1 092 000

(Source: Croatian Bureau of Statistics, 1998)

Production in the Period 1989 to 1998

In the period 1989 to 1998, the acreage covered by important field crops in Croatia lessened and the production of main ploughfield crops declined. This decrease in production caused greenhouse gas emissions to fall. Such a state of affairs cannot be attributed to neither grown environmental awareness nor new production technologies, but to the consequences of war, subsequent privatization and transition problems and, in some cases, imports of particular products.

Table 3-13 shows data on the number of livestock over the mentioned period. A significant decrease in livestock number has been recorded in all groups. Conse-

Table 3-13: Number of livestock in the Republic of Croatia

Year	Cattle, 000	Pigs, 000	Horses, 000	Sheep, 000	Poultry, 000
1989	830	1573	39	751	17102
1990	757	1621	36	753	16512
1991	757	1621	36	753	16512
1992	590	1182	26	539	13142
1993	589	1262	22	525	12697
1994	519	1347	21	444	12503
1995	494	1175	21	453	12024
1996	461	1197	21	427	10993
1997	451	1176	19	453	10945
1998	443	1166	16	427	9959

quently, greenhouse gas emissions caused by inner fermentation and piling, handling and use of manure were reduced.

Agricultural Regions in Croatia

The geographical position of Croatia is such that influences of several types of climate meet and mingle, and therefore natural vegetation is highly diverse. Similarly, Croatia is a natural compendium of all important soil types encountered in Europe and the Mediterranean.

All the diversities and wealth of Croatian natural conditions are reflected in the regionalization of Croatian agriculture. As to agricultural development, the management and investment policy is based on regional distribution of agricultural land. There are three different agricultural regions: Pannonian, Mountain and Mediterranean region, with minor sub-regions (Figure 3-12).

Figure 3-12: Agricultural regions in Croatia

I. PANNONIAN REGION
P_1 - EASTERN PANNONIAN SUBREGION - TCHERNOZEM, EUTRIC BROWN SOIL, Regosol, Marshy black earth-soil, Gleyic-calcareous soil, Alluvial calcareous soil
P2 - CENTRAL PANNONIAN SUBREGION - TYPIC ILLIMERIZED SOIL, PSEUDOGLEY, EUTRIC AND DYSTRIC, Eutric Eugley soil, Marshy black earth-soil
P3 - WESTERN PANNONAIN SUBREGION - PSEUDOGLEY, EUTRIC AND DYSTRIC, ILLIMERIZED SOIL, PSEUDOGLEY, Typical illimerized soil, Acid brown soil, Eutric Eugley soil, calcareous and vertic soil
P4 - NORTHWESTERN PANNONAIN SUBREGION - REGOSOL, ANTHROPOGENIC SOILS, RENDZINE, Typical illimerized and pseudogley soil, Pseudogley, Eutric and dystric brown soil, Eugley soil, eutric, dystric, vertic

II. MOUNTAIN REGION
G1 - PERYMOUNTAIN SUBREGION - ACRIC ILLIMERIZED SOIL, RELICT TERRA ROSSA, Pseudogley, Dystric brown soil, Typical illimerized soil, Brown soil on limestone
G2 - MOUNTAIN SUBREGION - BROWN SOIL ON LIMESTONE, LIMESTONE-DOLOMITE BLACK EARTH-SOIL, ACID BROWN SOIL, Typical illimerized soil, Relict terra rossa, Brown podzole, Rocky grounds and bare rocks

III. MEDITERRANEAN REGION
M1 - NORTHERN MEDITERRANEAN SUBREGION - TERRA ROSSA, BROWN SOIL ON LIMESTONE, REGOSOL, Limestone-dolomite black earth-soil, Anthropogenic soils, Rendzine, Vertic soils
M2 - CENTRAL MEDITERRANEAN SUBREGION - BROWN SOIL ON LIMESTONE, LIMESTONE--DOLOMITE BLACK EARTH-SOIL, ROCKY GROUNDS, Rendzine, Terra rossa, Regosol
M3 - SOUTHERN MEDITERRANEAN SUBREGION - BROWN SOIL ON LIMESTONE, ROCKY GROUNDS, Limestone-dolomite black earth-soil, Terra rossa, Alluvial soil, Antropogenic soils

Pannonian Region The Pannonian Croatia is located in the southern part of the Carpathian hinterland on a broad Pannonian plain. It accounts for 48 percent of national territory and 62 percent of population. This is the most populated area and has the highest potentials for agricultural production. Therefore, this is the most valuable part of Croatia.

This region has all the characteristics of continental climate with clearly marked seasons. Climate characteristics change in the direction from the east to the west; the precipitation increases and the mean annual temperature decreases. The water balance shows that Osijek, on average, has a water surplus of 100 mm and water shortage of 116 mm. Daruvar and Zagreb experience no water shortages, but have a rather significant surplus: 213 mm in Daruvar, 193 mm in Zagreb and 200 mm in Varaždin.

The lowland part of this region has the most fertile soils and represents Croatia's granary, having high and stable yields of all significant field and industrial crops. On the hilly part there are mixed family economies, orchards and vineyards.

To ensure high and firm production of all crops, and especially more sensitive ones, the basic investment orientation in the Pannonian Croatia will be the investment into hydro and agro-technical land reclamation, irrigation and drainage.

Mountain Region This geographical region consists of fairly heterogeneous area, starting from, so-called, shallow or covered karst in the hinterland of Karlovac, and stretching towards mountain massifs of Mala Kapela and Velika Kapela, Gorski Kotar and Velebit. This region has a typical mountainous climate with large precipitation amounts reaching 2,500-3,500 mm per year, which are very high values. A significant quantity of precipitation occurs in the form of snow. A fairly short growing season and the occurrence of late spring and early autumn frosts characterize this region. The soils are very heterogeneous. They were developed on acid silicate rocks or on limestone and dolomites. The agriculture in this region is adapted to mountain conditions and is characterized by fragmented private property. Livestock breeding is the primary production branch. Farming is oriented towards the production of forage crops. The choice of cultures the growth of which can be sustained in this region is a modest one. The prevailing crop is maize - hybrid maize from early harvest group, followed by potatoes, rye and vegetables. The conditions for potato growing, mainly seed potato, are very favourable since there are no diseases. The production is traditionally extensive, with minimum use of mineral fertilizers and pesticides, and the soils are among the cleanest soils in Europe. A general characteristic of this mountainous agricultural region is low utilization of region's production potentials. Besides war destruction during the Homeland War, this region suffers also from depopulation.

Mediterranean Region This region encompasses the Mediterranean part of Croatia, from Istria in the northwest up to the hinterland of Dubrovnik and Konavle in the southwest. The geomorphology and all natural properties show karst-specific features. The area was built of Mesozoic limestone and dolomites. These rocks are chemically rather clean, i.e. they contain only 1-2 percent of insoluble residuum out of which the soil is being formed very slowly. Besides these substrates, more soft Tertiary limestone also occurs sporadically, especially in the hinterland of Zadar. Specific features of its climate mark the agro-ecological conditions and the agriculture in this region. In the direction from the northwest to the southeast, mean annual temperature rises regularly, and the precipitation amounts grow, too. The climate is warm, with a lot of sunshine; the temperature rarely falls below zero, which enables the growth of Mediterranean cultures - olives and figs.

There are two opposite water balance conditions - a pronounced surplus in the winter period and a significant shortage during summer. Due to these characteristics, water management is very delicate. In the winter period soil protection measures against erosion should be taken. In the summer period irrigation is essential for production, especially for growing vegetables - a branch that has a long tradition in this region. The differences are less pronounced as regards water shortage. A very important climate factor in this region is wind. Winds blow regularly throughout the year and have large potential and frequency. Among other factors, they cause Aeolian erosion. Agricultural areas of the Mediterranean region are mainly located on flat relief forms and in depressions, i.e. by river valleys, on plateaus and on karst fields. The following larger karst fields are worth mentioning here: the Imotsko (4,500 ha in Croatia), the Sinjsko (6,400 ha) and the Vrgoračko Polje (3,700 ha). Special agro-ecological and economic entities are the Čepić Polje, the valley of the river Mirna in Istria and the valley of the river Neretva in central Dalmatia. Private tenure is prevailing, with small production lots, but with intensive production e.g. vegetable growing. The products are of supreme quality.

3.9 Forestry

The surface area of the Republic of Croatia is 5.7 million ha. Forests cover approximately 36.4 percent (± 2 percent) of the national mainland and, along with forestland, represent an integral forest management area that stretches across 2.5 million ha. 81 percent of forests are owned by the state and 19 percent are in private ownership. The forests in the Republic of Croatia that are located in coastal areas are among its most significant natural resources.

The public utility Hrvatske Šume (Croatian Forests) manages state-owned forests and forestland in the Republic of Croatia.

Classification of Forests and Forestland

Types of Forestland Forestland is every land stocked with forest trees or the land that is, due to its natural features and management conditions, considered most appropriate for growing forest trees. Thus, the forestland is classified into stocked and non-stocked with forest trees.

The non-stocked forestland can be a productive forestland (ponds, meadows, rocky grounds, heather, brackens, etc,) and an unproductive forestland (forest lanes, repositories, highland pastures, turfs, etc.).

Unproductive forestland are transport routes, waterways, channels, wetlands, bare karst, areas under forest buildings, gravel pits, quarries and similar.

Forested land	2,061,509 ha	(84 %)
Non-stocked productive forestland	315,166 ha	(13 %)
Unproductive and barren forestland	80,973 ha	(3 %)
Total	2,457,648 ha	(100 %)

Establishment of Forests Approximately 95 percent of Croatian forests came to existence by natural regeneration, and the remaining percentage represent artificially grown forests and plantations. The rejuvenation (restoration, regeneration) of forests is the process of replacing old, parent stands by new ones. Natural regeneration takes place when the seeds of parent trees fall onto ground, while artificial reforestation presumes seeding or planting seedlings under the canopy of old parent trees.

According to tree species (mixture ratio), forests can be pure forests and mixed forests. Pure forests are those forests in which 90 percent of the trees present are of the same species.

Mixed forests include other tree species besides the predominant species, and these other tree species account for over 10 percent of total stand. Mixed forests prevail in the Republic of Croatia.

Considering the way in which the forest has been established, forests can be classified into high forests established by tree-seeds or seedlings and coppice forests, grown mainly from tree stumps. There are also different degraded forest types such as maquis and gariques. They differ in their respective characteristics depending on ecological features of their habitats. In the Mediterranean area, namely in the central and southern coastal and island belt, we can find maquis, garique and rocky grounds; while at the northern coastline in Istria and in the southern hinterland we can find thicket, osier-beds and rocky grounds.

The forestland in Croatia is overgrown with 53 percent of valuable regular high forests (spermatophyte forests), 31 percent low forests (coppice forests), 11.5 percent different degraded forest types and the remaining forests are newly planted forest cultures and plantations.

Plant Species in Forest Habitats The geographical position and diverse ecological conditions are the reasons why the flora in the Republic of Croatia, and consequently in Croatian forests, is very diverse. Approximately 4,500 plant species and sub-species grow on a relatively small area. Almost one half of these species grows in forests and on forestland. Out of total number of forest species, there are about 260 endemic timber species, sixty of which are interesting from different economic points of view.

According to the phytogeographical distribution, the forest vegetation in the Republic of Croatia is divided into two Mediterranean and five continental vertical vegetation belts.

In the Mediterranean region the most distinctive belts are the Mediterranean-littoral belt and the Mediterranean-montane vegetation belt. Main tree species growing in these belts are: holm oak (Quercus ilex), Pubescent oak (*Quercus pubescens*), Croatian oak (*Quercus virgiliana*), flowering ash (*Fraxinus ornus*), white hornbeam (*Carpinus orientalis*), black hornbeam (*Ostrya carpinifolia*), Aleppo pine (*Pinus halepensis*) and black pine (*Pinus nigra*).

In the continental region we can distinguish planar (lowlands), colline (hilly), montane (lower mountain), altimontane (upper mountain) and subalpine (perymountain) belts. The **Planar belt** encompasses lowland areas between the rivers Sava and Drava at approximate elevation of 80 to 150 m. Main tree species growing in this belt are penduculate oak (*Quercus robur*), narrow-leafed ash (*Fraxinus angustifolia*), hornbeam (*Carpinus betulus*), black alder (*Alnus glutinosa*), willow (*Salix sp.*) and poplar (*Populus sp.*) The **Colline belt** stretches above the planar belt and spreads at the elevation between 150 and 500 m. This belt comprises hills and lower parts of the Slavonian mountains, Medvednica and Ivanšćica; it stretches south from Karlovac towards Severin na Kupi and Josipdol, and can be discerned at the edge of the Lika fields and in Istria. The main timber species growing in this area is sessile flowered oak (*Quercus petraea*). Other timber species found in this area include hornbeam (*Carpinus betulus*), beech (*Fagus sylvatica*), chestnut (*Castaea sativa*), silver birch (*Betula pendula*), bitter oak (*Quercus cerris*), wild cherry (*Prunus avium*) and common maple (*Acer campestre*). The **Montane belt** stretches above the colline belt up to approximate elevation of 700 to 900 m. This belt is dominated by the most frequent timber species in the Republic of Croatia - beech (*Fagus sylvatica*). It is located in the Dinaric region and the Pannonian region. The **Altimontane** belt is prominent on the Dinarides and in the Pannonian region at the average elevation of 800 to 1100 m. Main timber species are common fir (*Abies alba*), beech (*Fagus sylvatica*), spruce (*Picea abies*), European ash (*Fraxinus excelsior*) and sycamore maple (*Acer pseudoplatanus*). The **Subalpine belt** includes the forests of inner Dinarides at the elevation of approximately 1100 to 1700 m. In the lower sub-belt of this belt we can find the forests of beech, common fir and spruce, and in higher sub-belt we find mugo pine (*Pinus mugo*) and juniper trees. This is the uppermost limit of forest vegetation in Croatia.

Silvicultural Approaches Regarding the structure, silvicultural approaches and forest management practices, forests can be classified into even-aged forests (regular forests) with forest stands composed of trees of approximately equal height, thickness and age and with stand management, and uneven aged forests (selection forests) with trees of different heights, thickness and age per unit of area, that are naturally regenerated and the management system applied is tree selection or group selection.

The management of regular forests is based on silvicultural operations of care and rejuvenation that are applied in the forest stand during one rotation (lifetime of forest determined by management objective, ecological and biological factors). Silvicultural operations are performed separately as regards area and time.

In the management of uneven-aged forests, silvicultural operations of care and rejuvenation are integrated in space and time in one activity that is being repeated each 10 years (short rotation). In the Republic of Croatia, the management of uneven-aged forests is performed only in the stands in which the main tree species is common fir (*Abies alba*).

The Republic of Croatia has a long and rich legislative tradition in the field of forest management and natural regeneration. The basic principle directing Croatian forestry is **sustainable forest management**, along with the preservation of natural structures, the diversity of forests, permanent increases in stability and quality of economic and overall-benefit functions served by forests. It should be emphasized that **clear-cutting is prohibited by the Law on Forests and natural regeneration of forests is the fundamental approach**. The first regulations relating to sustainable development, and thus the preservation of biodiversity in Croatia, emerged already in the 16th century. The principles of sustainability and preservation of biodiversity were incorporated in all legal acts in forestry, and the guidelines for the preservation of biodiversity in environmental protection regulations.

Forest Management Practices

The stewardship and management of forests and forestland in the Republic of Croatia is prescribed by the Law on Forests and by secondary legislation (e.g. Ordinance on Silviculture) and other laws and regulations significant for environmental protection (e.g. Environmental Protection Act, Vegetation Protection Act, Act on Forest Seeds and Seedlings, etc.). The mentioned regulations are based on the experience gained during 236-year old expert and scientific practice in forest management and stewardship.

The Law on Forests establishes that the forests and forestland and the management thereof is of general social interest. In order to guarantee an integrated and sustainable forest management in Croatia, one forest management area has been established.

The management of forests and forestland on a forest management area is carried out pursuant to the Forest Management Area Plan approved by the Ministry of Agriculture and Forestry, which will be effective until the year 2005. It also leans on management projections until the year 2025, which represent a constituent part of the Plan.

The Forest Management Plan is a strategic stronghold of Croatian forestry and is subject to renewal every ten years. It prescribes long term spatial and time management of forests and forestland on the territory of the Republic of Croatia. The program outlines the condition of forests and defines management objectives, as well as types and scope of work and measures and methods to be implemented in order to meet management targets.

According to the Forest Management Area Plan, the objectives of forest management in Croatia are the following:

1) provision of ecosystem stability
2) maintenance and improvement of overall-benefit functions served by forests
3) advanced and sustainable management
4) use of forests and forest land in a way and at a rate that maintains their biodiversity, productivity, regeneration capacity, vitality and potential,
5) to fulfil, now and in the future, relevant economic, ecological and social functions at local and global level, in a way not causing damage to other ecosystems

The last two items are identical to the term *sustainable management* as defined at the Ministerial Conference on the Protection of Forests in Europe held in Helsinki.

Forest Management Area Plan classifies forests and forestland on the territory of the Republic of Croatia into 657 forest management units, and management units are further divided into permanent units and temporary units. Each management unit has its own Forest Management Plan developed in accordance with the Forest Management Area Plan. More significant parts of every management plan of individual management units are: detailed description of forest stands divided into permanent and temporary units, presentation of areas, tables showing age and thickness classes, presentation of growing stock and annual cut, plan of silvicultural operations, plan of harvest cut and intermediate cut, analysis of management in the preceding period.

Growing Stock, Increment and Annual Cut

Total growing stock (synonyms: timber mass, timber volume, volume) in Croatian forests amounts to 324,257,000 m^3. It consists of approximately 84 percent of deciduous trees and 16 percent of conifers. The most represented tree species are penduculate oak, common fir, sessile flowered oak, and other types of broadleaf and evergreen trees. The average growing stock in state-owned forests is 202 m^3/ha, and in private forests 82 m^3/ha.

The forests in the Republic of Croatia have an annual increment about 9,643,000 m^3 of timber. The increment is an increase in timber stock in a particular forest within a specified time period. It is calculated as annual, periodical or average. Different methods have been developed in forest management practice, which are used for determining the increment. In Croatia, control method and the Pressler increment borer method are the most frequently applied. Different silvicultural operations can contribute to improved forest increment in terms of quality and quantity.

Annual cut represents a part of growing stock anticipated for harvesting in the management plan over a particular period (annual, 10-years, 20-years) and is expressed in timber volume (m^3, m^3/ha) or surface area (ha). In regular forests, we distinguish harvest cuts and intermediate cuts. Harvest cut is the timber volume realized in mature stands envisaged for harvesting. Intermediate cut is the timber volume realized in young and immature stands by clearing and thinning (Sever & Horvat, 1996).

In order to meet the basic principle of forest management, the principle of sustained yield, annual cut must be lower than annual volume increment. Average annual cut in Croatia is 5,354,000 m^3 or 56 percent of increment volume.

3.10 Coast and Coastal Area

General Properties of the Coast and Coastal Area

Main natural characteristics of Croatian coast and coastal area are the following: the coast is predominantly rocky, with several alluvial areas; it is very indented; in its major part the coastal belt is very narrow and separated from the hinterland by mountain ranges; numerous islands, islets and riffs are located in front of the coastline in several rows parallel with the mainland. Total length of coastline is 5,835.3 km, out of which 4,058 km pertains to islands. The indentedness coefficient of coastal mainland is 3.4. Croatia has 1,185 islands and islets, out of which 67 inhabited.

The coast is mainly made of stone, and is relatively steep. Minor part of the coast is low and has alluvial deposits. In the western part of Istria and in the area to the south of Zadar the coast is lower and gently sloping. The majority of beaches are of "pocket" type. The problems of soil erosion are not pronounced at the coast, except at several location as for example in the area of the town Nin. At river estuaries there are mainly small alluvial valleys. Only the rivers Raša and Neretva have rather large valleys. Two fresh water lakes are located in the coastal area: the Vransko lake on the island Cres and the Vransko lake near the town of Biograd. The first of the two is an important source of potable water for the islands Cres and Lošinj. Minor water quantities from the lake near Biograd are used to irrigate the surrounding agricultural land.

The results of sea level measurements performed so far on the Croatian coast show different trends at individual locations. In Rovinj and Split data show an average annual fall in sea water level of 0.050 mm/year and 0.082 mm/year, respectively. In Bakar there is an average gradual sea level rise of 0.053 mm/year. This can be the result of coast rising due to tectonic movements.

The coastal area of Croatia (surface area is 1,245 km^2) has 1,119,113 inhabitants. The population density in the coastal zone is 89.9 inhabitants/km^2, while the density in the mainland is 84.5 inhabitants/km^2. On numerous locations at lower altitudes along the seashore there are historic centres of particular towns, residential and vacation houses, tourist facilities and infrastructural facilities such as traffic routes, sewage outlets, docks and marines. Main economic branches in the coastal area are marine-based and oriented towards the exploitation of marine potential and to Mediterranean agriculture. The registered number of beds in coastal area is 586,000, there are 47 marines with 12,600 berths and 7 harbours open for international freight traffic. There are 5 shipyards that build large vessels. The number of registered fishing-ships and fishing-boats in the fishing industry is 302 and 10,600, respectfully. In 1996, total production of grapes amounted 155,615 tons and that of olives 16,000 tons.

3.11 Specific Croatian Circumstances under Article 4.6 of the Convention

Special Circumstances with Regard to Basic Principles of the Convention

We hereby highlight some general principles outlined in Article 3 of the Convention that are of relevance for Croatia:

- *the Parties should protect the climate system … on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities*
- *the special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change … should be given full consideration in meeting the commitments under the Convention*

- *the parties shall promote sustainable development, policies and measures, taking into account that economic development is essential for adopting measures to address climate change*

In view of its relatively low emission of greenhouse gases per capita, it can be considered that Croatia's historic contribution to global warming was not significant. Due to relatively low base emission, which under the reference ("business as usual") scenario of development will remain below emission levels recorded in developed countries and countries in transition, the possibilities of further reduction are limited and the implementation of such measures will be more expensive than in other countries.

Croatia is vulnerable to climate change, especially as regards its coast and agriculture. Significant adverse effects can be expected in hydrology, water resources and forestry. The Croatian coastline is 5,800 km long and has a total of 1,100 islands. The coastal cities even now experience problems with periodic high seas and weather extremes.

The socio-economic implications of the application of measures and problems associated with meeting commitments under the Convention are discussed in more detail below.

Specific Circumstances under Article 4.6 of the Convention

Croatia gained its independence in 1991. During its self-reliant development as a sovereign state, Croatia was faced with numerous difficulties. Besides the problems associated with an economy in transition, the Croatian problems include negative consequences of the war for independence, the political instability that defined the region as a whole and ten years of marked political and economic isolation. All the relevant indicators confirm that the ongoing process of reconstruction and development will not advance further without an increase in energy demand. In the past several years, from 1995 to 1999, energy demand has been growing at a rate of 3.3 percent and electricity demand at a rate of 3.4 percent, while gross national product grew at a rate of 4 percent. Due to increased energy demand and loss of energy sources constructed on the territory of former Yugoslavia, Croatia has to construct 1000 to 1500 MW of new electricity sources in the next ten years, which is an increase of 23 to 34 percent as compared to current capacities.

The implementation of the Convention's and the Kyoto Protocol's commitments will be an extremely difficult task for Croatia, perhaps even beyond its capacities. Considering the very low initial level of emissions, the consequences of war and an economy in transition, the introduction of additional measures will undoubtedly have great socio-economic implications. Practically any expense, that exceeds its delivered benefits, breaches the national scenario of sustainable development. It should be mentioned that the application of additional measures to reduce emissions of greenhouse gases would have relatively small impact on the improvement of the existing state of the environment at local level, since Croatia has no major problems with air pollution. Croatia made a statements at the COP6 (Hague, November 2000) and COP7 (November 2001.) announcing the problems it is facing in undertaking the Convention and the Kyoto Protocol commitments.

In this Communication we are therefore seeking consideration of Croatia's specific circumstances, referring to Paragraph 6, Article 4 of the Convention *that allows a certain degree of flexibility to the countries undergoing the process of transition to a market economy in the implementation of their commitments, including the choice of reference year for the emissions of greenhouse gases.*

In our appeal to consider the special Croatian circumstances, we would like to emphasize the following:

- The emissions of greenhouse gases on the territory of Croatia account for less than 0.2 percent of the Annex I countries' total emissions, i.e. the per capita emission approaches the lowest emission levels amongst these countries
- The renewable energy sources are being rather extensively used in Croatia even now. Hydro power plants contribute with 40 - 60 percent to electricity generation. Energy utilization of biomass meets about 5 percent of total energy demand, and biomass is the main fuel in the majority of settlements that do not have a gas supply network.
- A large part of electricity is generated in high efficiency gas fired combined heat and power plants; cogeneration accounts for 15 percent of total electricity generation
- The nuclear power plant met 15 to 20 percent of electricity demand (until 1995)
- The share of coal in total energy demand is only 2 percent
- 36 percent of Croatian territory is covered by forests

During the period offered for the selection of the reference year under Article 4.6 of the Convention (until 1990), Croatia was a part of former Yugoslavia (Croatia was recognized as an independent state by the UN in May 1992). Former Yugoslavia was composed of six Republics, totalling 23.7 million of inhabitants. At that time, Croatia had 4.8 million of inhabitants.

Croatia is facing some problems in determining the emissions of greenhouse gases, since there are no reliable data until 1992, when Croatia gained its independence. Croatia's statistical energy balance is developed by gathering information from a number of different sources and not by a bottom-up approach. Bulk of information is provided directly by emission sources on voluntary basis. Legal obligation on emission reporting was imposed in 1996 by the Ordinance on Environmental Emission Inventory. Regretfully, this system is insufficiently reliable to serve as the basis for national emission calculation and expert assessments are still extensively used. The Republic of Croatia is aware of this fact and it applied for technical and financial assistance in building a high quality emission inventory system. The UNPD/GEF and EC support are imminent, and will build up the system for GHG emission calculation in the next three years.

Due to the problems connected with identifying emissions, especially in the energy sector that generates the majority of greenhouse gas emissions, the emission in Croatia until the year 1992 has partly been identified on the basis of data available for former Yugoslavia. The methodology for establishing this emission is given in continuation and is based on the calculation data of the International Energy Agency.

In accordance with the relevant international *literature (IEA Statistics (1998): CO_2 Emissions from Fuel Combustion, 1971-1996*), the per capita CO_2 emissions in the former Yugoslavia are shown in Table 3-14.

Table 3-14: CO_2 emission per capita in former Yugoslavia from fuel combustion

	1985 t/cap	1986 t/cap	1987 t/cap	1988 t/cap	1989 t/cap	1990 t/cap	1991 t/cap
Former Yugoslavia	5.53	5.71	5.69	5.73	5.62	5.85	5.18

Total quantity of greenhouse gases that includes non-energy sources, too, shown in Table 3-15 was calculated for Croatia by adding the emissions from other sources located on the territory of Croatia to the CO_2 emission from fuel combustion (former Yugoslavia's average). The values shown in table 3-15 relate to total

Table 3-15: Emissions of greenhouse gases (Mt eq-CO_2)

	1990	1991
Emission per capita, t eq-CO_2/capita	8.24	7.44
Total emission, Mt eq-CO_2	39.40	33.60

anthropogenic emission; emission sinks that are to be deducted haven't been taken into account in this presentation (binding carbon in woodland biomass).

In view of the above, the Republic of Croatia proposes the year 1990 as its reference year under the Convention. Total emission of greenhouse gases in 1990 was 39.4 Mt eq-CO_2.

Waterfalls of the River Krka (National Park)

4. 1990-1995 Emissions Inventory

4.

1990-1995 Emissions Inventory

4.1 Introduction

The inventory of greenhouse gas emissions is one of basic steps in the systematic consideration of and solution climatic change issues. Systematic estimates of emissions of specific greenhouse gases and other pollutants has been practiced in the Republic of Croatia long before the preparation of this Communication commenced. Although periodical estimates had been conducted earlier, annual reporting on the calculation of atmospheric emissions for specific pollutants, which is a responsibility assigned to the Ministry of Environmental Protection and Physical Planning, only became a regular practice in 1995. The inventory methodology used was the European CORINAIR method. EKONERG Holding, an institute charged with the implementation of calculations, i.e. emission balances, has gained extensive experience both in implementation of the methodology and generally in the emission estimate process. This knowledge, its application in practice and the data collected have served as a sound basis for the estimation of greenhouse gas emissions used in this Communication. In 1996, the establishment of the Croatian Environmental Emissions inventory (EEI) was initiated. The inventory was meant to become the primary background and database for the development of environmental emission balances. Since this Communication covers the 1990-1995 period, the EEI was not used as the direct source of data but rather for checking of individual emission sources. It should be noted that the greenhouse gas emission data for Croatia cover the period up to 1999. However, calculation pursuant to IPCC methodology was not conducted for the period 1996-1999, so these data are not included in this Communication. Still, the 1996-1999 data were used in projections and the development of scenarios.

The IPCC (Intergovernmental Panel on Climate Change) methodology stipulated by the UN Framework Convention on Climate Change and detailed in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC/UNEP/OECD/IEA)* was used for emission calculations in this Communication, along with *Good Practice Guidance and Uncertainty Management in National GHG Inventories, 2000 (IPCC/NGGIP)*. The available methodology and a systematic approach insure that the principles of transparency, consistency, comparability, completeness and accuracy of calculations are respected. The methodology additionally requires the reliable evaluation of margins for error in the input data and the results of calculations and verification in order to improve the quality, accuracy and reliability of the calculations. One of the steps undertaken to verify the completeness and consistent implementation of the methodology has been to submit to the UNDP National Communications Support Program (NCSP) the preliminary and final calculation for review and technical assessment. The assessment was generally positive, and certain technical recommendations pertaining to the further improvement of calculation procedures have been taken into consideration. Also, one of the internal checks for calculations used as a part of the methodology was the calculation of CO_2 emissions from fuel combustion carried out in two ways: the first, more detailed Sectoral Approach, and the second, more simple Reference Approach. The difference in results (year-dependant) was 3 percent on average, which is a highly acceptable outcome.

4.2 Data Collection and Management System

For the purposes of compiling an inventory and in order to assure transparency, consistency, comparability, completeness and accuracy, a Data Collection and Management System has been set up. Although at this moment the data management system has been set up within a range that primarily provides for the fulfillment of obligations to prepare the GHG emission communication for the First National Communication, the possibility of developing and improving the system for UNFCCC and other purposes has been incorporated as well. The basis of the system is to identify and define the data sources (national balance of energy supply and demand, national environmental emissions inventory, statistical data, direct questionnaires, etc.), data collection, storage and processing for specific reporting purposes. Figure 4-1 shows the basic concept and components of the Data Collection and Management System used in the calculations for this Communication. The objective of the Data Collection and Management System is to achieve the maximum possible level of the electronic data cross-referencing and processing in order to achieve the highest possible level of process "automation."

According to IPCC methodology, greenhouse gas emission sources and sinks are arranged in six sectoral categories. Depending on the sector, data on different activities are provided such as: fuel consumption (balance of energy supply and demand), data on petroleum and natural gas extraction (INA), individual industrial processes (statistical data or questionnaires), the number of head of cattle and land being cultivated for various crops (statistical data and data from the Faculty of Agriculture), data on forests (the national forest management company, Hrvatske šume and the Faculty of Forestry), municipal waste quantities (data and estimates from professional institutions), etc.

The data collection method is such that some data are acquired from the existing databases or directly from the polluters, while some are obtained from professional groups and individual experts for specific areas.

Most of the data needed for the emission estimate is taken from the existing data collection systems, such as statistical data (DZZS[1]), balance of energy supply and demand (EIHP[2]), and data from EEI[3] (MZOPU[4]). The remaining data are obtained by means of direct contact with individual sources of pollution or expert/professional groups (for agriculture, forestry and waste). If necessary, the data available from different companies and institutions such as EKONERG, MUP[5], HEP[6], INA[7], ZGO[8], APO[9], counties, customs authorities, Hrvatske šume, Hrvatske vode (the national water management company), some faculties, etc. are used as well. For example, Hrvatske vode has its own Data Collection and Management System so they are capable of providing their own data (e.g. water rates for individual water management facilities, quantity of industrial wastewater and so forth) or data collected from other participants in water use (e.g. data on water demand from the municipal utilities, etc.).

For the purposes of conducting emission calculations in compliance with the aforementioned principles of transparency, consistency, comparability, completeness and accuracy, a Data Form for every sector has been developed. This Data Form

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[1] DZZS - National Statistics Bureau
[2] EIHP - Hrvoje Požar Energy Institute
[3] EEI - Environmental Emissions inventory
[4] MZOPU - Ministry of Environmental Protection and Physical Planning
[5] MUP - Ministry of the Interior
[6] HEP - Hrvatska elektroprivreda, the national electricity utility
[7] INA - INA, the national petroleum company
[8] ZGO - Zbrinjavanje gradskog otpada, Zagreb's publicly owned environmental protection and waste management company
[9] APO - Hazardous Waste Management Agency

contains all relevant information on sources and quality of used data and suggestions for emissions inventory improvements. Currently, all the Data Forms are maintained as text files/hardcopies which may be converted into a computer database in the future.

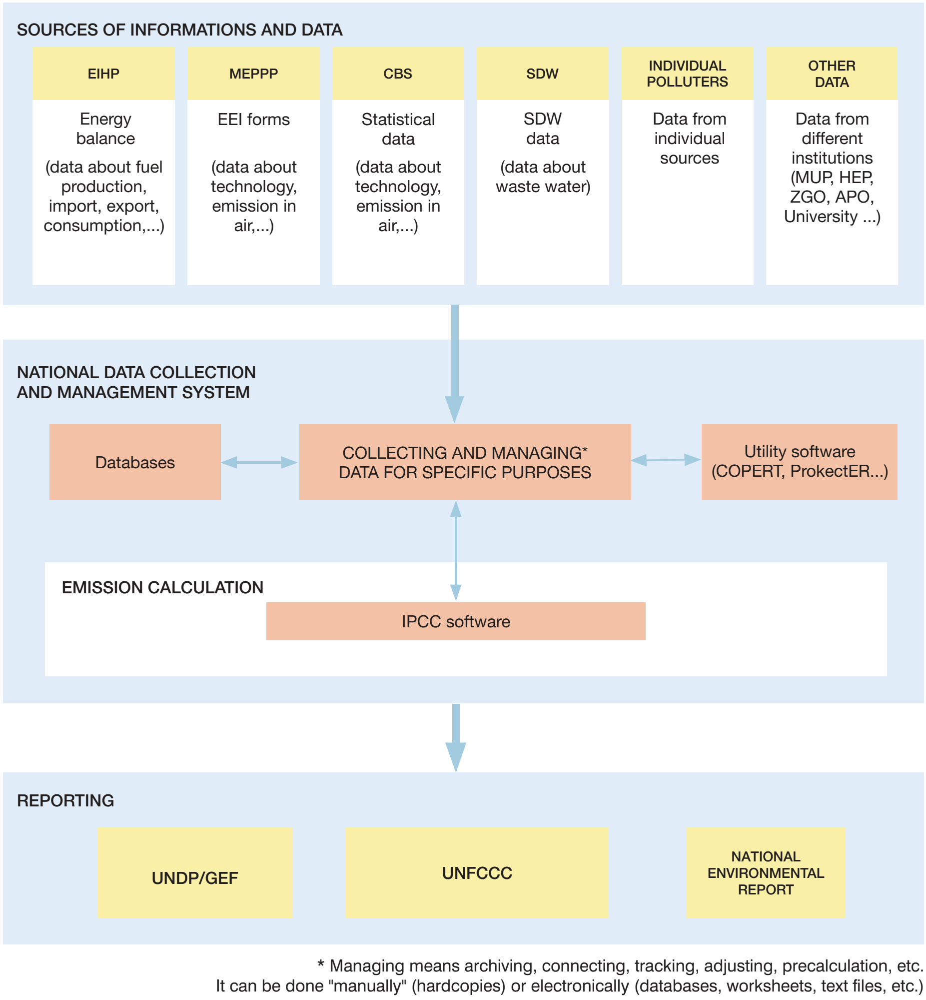


Figure 4-1: National emission data collection and management system

4.3 Methodology

The IPCC Methodology (Intergovernmental Panel on Climate Change) recommended by the Convention, and based on *Revised 1996 IPCC Guidelines for National GHG Inventories (IPCC/UNEP/OECD/IEA)* has been used to calculate greenhouse gas emissions for the National Communication together with good practical experience from *Good Practice Guidance and Uncertainty Management in National GHG Inventories, 2000 (IPCC/NGGIP).*

The methodology covers only an estimate of emissions as a consequence of anthropogenic activity for the following gases: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, CO, NO_x, NMVOCs, and SO_2. Greenhouse gases such as CFCs, which are covered under the Montreal Protocol on Substances that Deplete Ozone Layer, are not included. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are greenhouse gases and though they occur naturally in the atmosphere, their recent atmospheric build-up appears to be largely the result of human activities. Halogenated hydrocarbons (PFCs, HFCs) and sulfur hexafluoride (SF_6), artificial compounds, are also greenhouse gases called synthetic gases and the result of human activities. In addition, there are other photochemically active gases such as carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane volatile organic compounds (NMVOCs) that, although not greenhouse gases, contribute indirectly to the greenhouse effect in the atmosphere. These are generally referred to as ozone precursors, because they participate in the creation and destruction of tropospheric and stratospheric ozone (which is also GHG). Sulfur dioxide (SO_2), as a precursor of sulfate and aerosols, is believed to exacerbate the greenhouse effect because the creation of aerosols removes heat from the environment.

The emission estimate is divided into six sectors: Energy, Industrial Processes, Solvent Use, Agriculture, Land Use and Forestry, and Waste Management. Basically, the emissions from any sector are the product of a specific activity (e.g. annual production of aluminum, fuel consumption, head of livestock, wood stock increment and so forth) multiplied by adequate emission factors. It is recommended to use local "national" emission factors wherever justified and possible, otherwise methodology's results will produce typical emission factors for all sectors and geographical areas.

4.4 Calculation Results

Emissions in 1990 and 1991 were determined as described in Section 3.11. Since 1992, when the Republic of Croatia become a member of the UN, calculations have been conducted in standard fashion.

Below, the results of greenhouse gas emission calculations are shown for Croatia for the period from 1990 to 1995. The results are first presented as total (aggregate) emissions of all greenhouse gases by individual sectors, and then as emissions of individual greenhouse gases, also by sectors. Since individual greenhouse gases have different radiation characteristics, and therefore their contribution to the greenhouse effect is different, in order to enable consolidation and aggregate presentation of emissions, the emissions of each gas needs to be multiplied by its global warming potential (GWP). The GWP is a measure of the contribution of a gas to the greenhouse effect compared to the CO_2 impact, and the greenhouse gas emission is expressed as kg eqCO_2 (equivalent CO_2 weight).

Table 4-1 shows the global warming potential (GWP) for particular gases. The GWPs cover a 100-year period.

In cases when, as opposed to emissions, greenhouse removal occurs (e.g. CO_2 removal resulting from the forest wood stock increment), it is referred to as greenhouse gas removal (sink) and the sink value is expressed with negative sign.

Table 4-1: Global warming potential of particular gases

GHG	GWP
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
CF_4	6500
C_2F_6	9200
SF_6	23900

4.4.1 Aggregate Results

Total greenhouse gas emissions and removal by years, and their trends by sectors are shown in table 4-2 and figure 4-2, and an overview of greenhouse gases is shown in table 4-3 and figure 4-3.

Table 4-2: Aggregate emissions and removals of GHG by sectors ($eqCO_2$) for the 1990-1995 period

EMISSIONS	1990*		1991*		1992		1993		1994		1995	
	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%
Energy	29910	75.9	25251	75.2	15467	67.0	16526	72.5	15499	70.9	16353	73.5
Industrial Processes	4227	10.7	3086	9.2	2653	11.5	2066	9.1	2317	10.6	2021	9.1
Agriculture	4321	11.0	4344	12.9	4060	17.6	3277	14.4	3109	14.2	2891	13.0
Waste	933	2.4	917	2.7	901	3.9	913	4.0	937	4.3	995	4.5
Total	**39391**	**100**	**33598**	**100**	**23082**	**100**	**22783**	**100**	**21862**	**100**	**22259**	**100**
Trend	100		85		59		58		56		57	
REMOVALS												
Land Use & Forestry	**-6505**		**-6505**		**-6505**		**-6505**		**-6505**		**-6505**	
NET EMISSIONS	**32886**		**27093**		**16576**		**16278**		**15357**		**15754**	

*Energy emissions are calculated for 1990 and 1991 as described in section 3.11

Table 4-3: Aggregate emissions and removals of GHG ($eqCO_2$) by gases for the 1990-1995 period

EMISSIONS	1990*		1991*		1992		1993		1994		1995	
	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%
Carbon dioxide (CO_2)	30713	78.0	25450	75.7	15764	68.3	16399	72.0	15674	71.7	16251	73.0
Methane (CH_4) as $eqCO_2$	3835	9.7	3635	10.8	3419	14.8	3291	14.4	3099	14.2	3104	13.9
Nitrous oxide (N_2O) as $eqCO_2$	3904	9.9	3864	11.5	3898	16.9	3093	13.6	3089	14.1	2896	13.0
HFCs, PFCs and SF_6 as $eqCO_2$	939	2.4	648	1.9	0	0.0	0	0.0	0	0.0	8	0.0
Total	**39391**	**100**	**33598**	**100**	**23082**	**100**	**22783**	**100**	**21862**	**100**	**22259**	**100**
REMOVALS												
Carbon dioxide (CO_2)	**-6505**		**-6505**		**-6505**		**-6505**		**-6505**		**-6505**	
NET EMISSIONS	**32886**		**27093**		**16576**		**16278**		**15357**		**15754**	

*Energy emissions are calculated for 1990 and 1991 as described in section 3.11

During the entire 1990-1995 period, emissions declined by approximately 45 percent, and the most dramatic reduction has been noted between 1991 and 1992 (26 percent). The decrease continues after 1992 at a somewhat slower pace, to reach its minimum in 1994, while the mild increase in emissions was recorded during the last year analyzed. Such emission trends are a direct consequence of the specific situation in the Republic of Croatia during the 1991-1995 period, when wartime events and separation from the former Yugoslavia influenced the overall situation. The general decrease in business activities and energy demand was felt throughout the country. Further, with the entire economy in transition, some energy-intensive industries experienced a downturn in production or phased out certain programs, which was considerably reflected in greenhouse gas emissions.

The share in emission by greenhouse gases did not markedly change during these years. In 1990, it was 78.0 percent for CO_2, 9.7 percent for N_2O, 9.9 percent for CH_4 and 2.4 percent for synthetic gases. The source of synthetic gas emissions was primarily aluminum production, which was phased out after 1991.

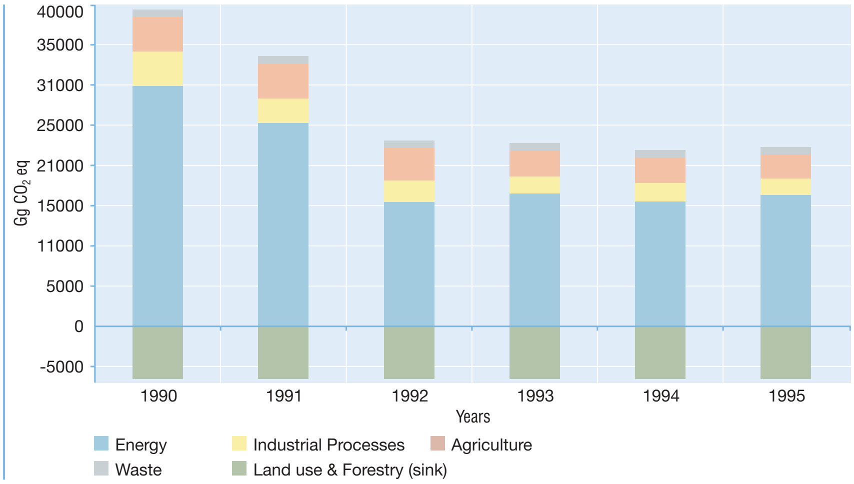


Figure 4-2: Aggregate emissions and removals of greenhouse gases by sector for period 1990-1995

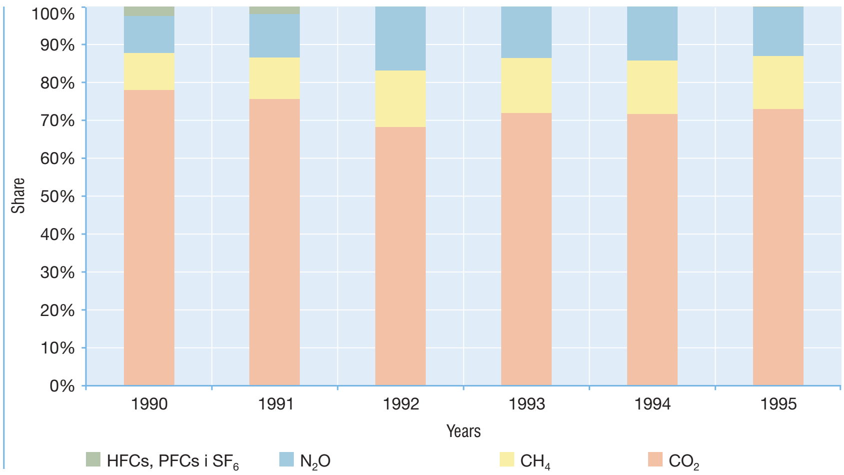


Figure 4-3: Share of greenhouse gases in emissions for the 1990-1995 period

There are a number of methods to estimate the “intensity” of national greenhouse gas emissions. Commonly used measures of intensity are the emission/population ratio and the emission/GDP ratio. Croatian per capita emissions (1991 Census) were 8.2 t $eqCO_2$ for 1990, which places Croatia at the bottom of the European scale of greenhouse gas emissions per capita. Net per capita emissions (i.e. including removals) was approximately 6.9 t $eqCO_2$. For the 1991-1995 period, per capita greenhouse gas emissions were considerably lower. Figure 4-4 shows the emission/GDP ratio compared to 1990 as the base year. A specific decrease of emissions to gross domestic product (GDP) is notable after 1991; in Croatia this

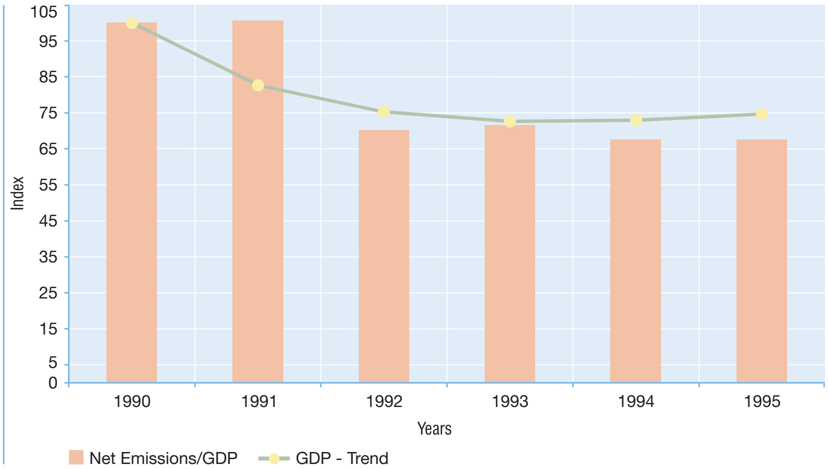


Figure 4-4: Greenhouse gas emission and gross domestic product ratio

was primarily the consequence of phasing out or reduced production in certain energy-intensive industries.

4.4.2 Comparison with Emissions in Other Countries

By way of illustration, this section provides a comparison of emissions with groups of countries or individual countries. Figure 4-5 shows a comparison of per capita CO_2 emissions from fuel combustion for Croatia (1990 and 1995) and groups of countries (for 1997) such as: the entire world, countries from Annex I of the Convention on Climate Change (Annex I), countries from Annex II of the Convention (Annex II), European Union member states (EU), countries undergoing economic transition (EIT), and countries not included in Annex I of the Convention (non-Annex I).

Figure 4-6 shows total per capita emissions (without removals) of greenhouse gases (as $eqCO_2$) for Croatia and certain Annex I countries in 1995. For Croatia, per capita emissions for 1990 and 1995 are shown.

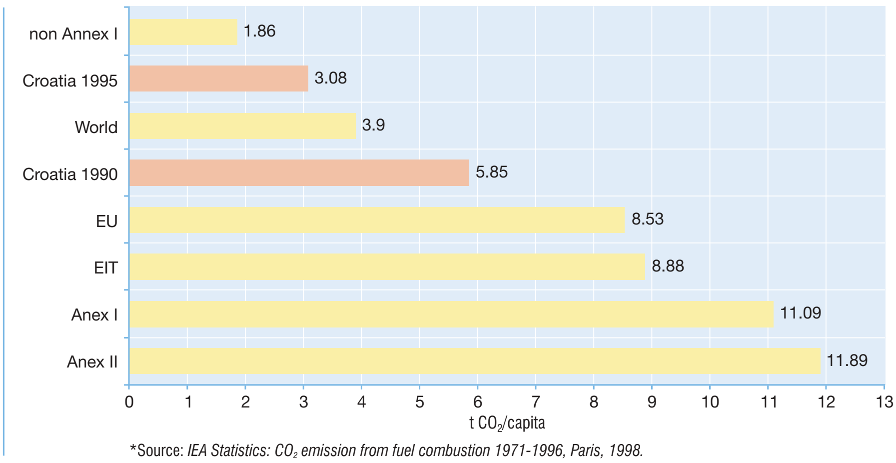
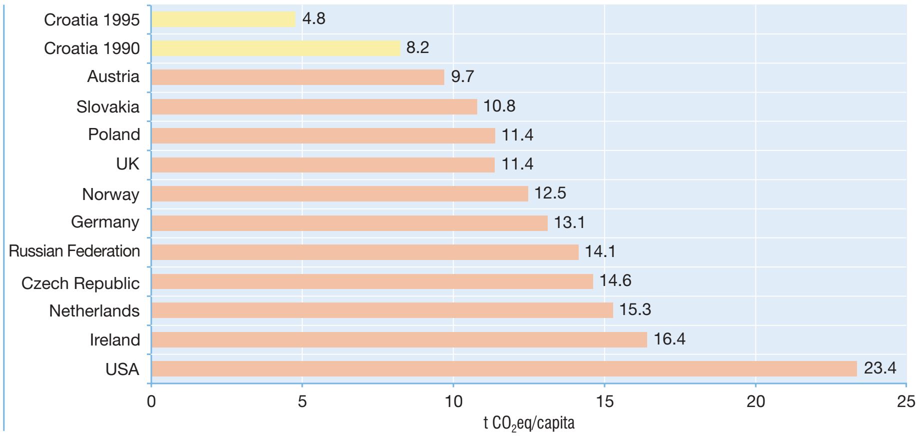


Figure 4-5: CO_2 emissions from fuel combustion in Croatia and specific groups of countries

Both figures clearly indicate that the Croatia's per capita greenhouse gas emissions are very low, actually among the lowest compared to developed countries and other countries in transition. This is important data that illustrates the Croatia's current position in light of fulfilling Kyoto Protocol requirements.



* Source: *UNFCCC: Second compilation and synthesis of second national Communications, 1998*

Figure 4-6: Total per capita emissions of greenhouse gases (without removals) in specific Annex I countries

4.4.3 Carbon Dioxide Emissions

Carbon dioxide is one of the most important greenhouse gases, particularly when the consequences of human activities are concerned. According to IPCC, it accounts for approximately 50 percent of global warming. Like almost everywhere in the world, anthropogenic sources of CO_2 in Croatia are fossil fuel combustion (in power generation, industry, traffic, heating, etc.), industrial activities (cement production), and changes in land-use and forestry practices (in Croatia, timber biomass stock increment causes negative emissions Ð removal).

The results of CO_2 emission calculations for Croatia are shown in figure 4-7. In the years after 1990 the decline in emissions is noticeable because of the aforementioned decline in economic activities caused mainly by the war and the significant reduction of certain sectors of industrial production. The most significant source of CO_2 is definitely the energy sector, which accounts for 90 to 94 percent of total emissions, depending on the year analyzed. More detailed information on CO_2 emissions from various sectors are shown below.

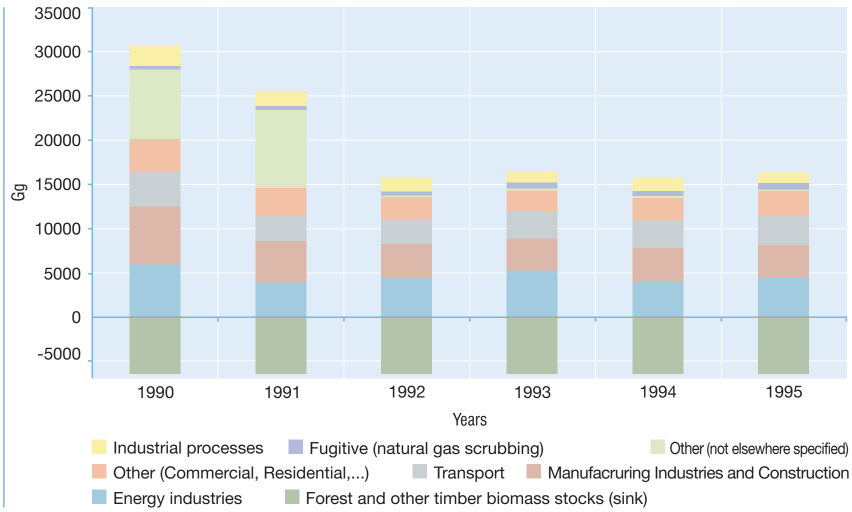


Figure 4-7: Total CO_2 emissions and removals for the 1990-1995 period

Energy Sector

This sector covers all activities that involve fossil fuel consumption (fuel combustion and non-energy use of fuel) and fugitive emissions from fuels. Fuel fugitive emissions are generated during the production, transmission, processing, storage, and distribution of fossil fuels. The energy sector is the main anthropogenic source of greenhouse gas emissions. Depending on the year, these emissions account for over 70 percent. CO2 emissions from fuel combustion account for the majority (more then 92 percent of energy-related emissions). Emission by energy subsectors is presented in figure 4-8.

Emission estimates are based on fuel consumption data given in the National Energy Balance (Hrvoje Požar Energy Institute), where energy supply and demand are presented in sufficient detail, which allows emission estimates by sectors and subsectors (IPCC Methodology, Tier 2 Ð Sectoral Approach). Also a more simple approach is taken into account (Reference Approach), which considers only the total energy balance, without subsector analysis. Comparison of the results of these two methods, a sort of internal control, provided average 3 percent variations on the Sectoral Approach side. The two most emission-intensive subsectors in the energy sector are energy transformation (thermal power plants, district heating, refineries) and fuel combustion in industry. Fuel combustion in industry is the highest in iron and steel industries, industries of non-ferrous metals, chemicals, pulp and paper, food processing, beverages and tobacco and so forth. This subsector also includes emissions from fuel used to generate electricity and heat in industry (industrial co-generation plants and industrial heating plants).

Most of the CO_2 emissions in energy transformation comes from fuel combustion in thermal power plants. The structure of fuel used in thermal power plants is: 50 percent fuel oil, 35-45 percent natural gas, and 5-15 percent coal (figure 4-8). A characteristic of Croatian energy sector is that more than 60 percent of power demand is covered from sources without CO_2 emissions (hydroelectric power plants, Krško Nuclear Power Plant, and imports). The supply of electricity for the period from 1990 to 1995 is shown in figure 4-9.

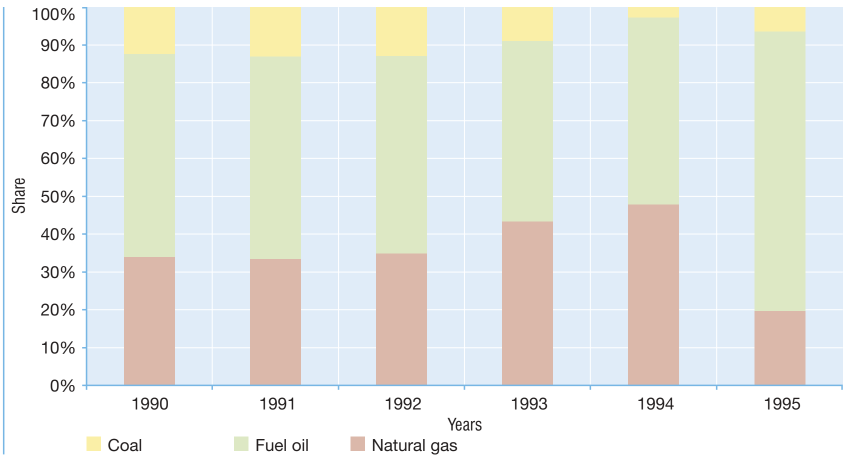


Figure 4-8: The share (%) of fossil fuels used in thermal power plants in Croatia

Transportation is also a major source of CO_2 emissions. The majority of emissions comes from overland (road) transportation (86-92 percent, depending on year), followed by railroad transportation and domestic air and marine transport. Emissions from fuel sold to any aircraft or marine vessel engaged in international transport is excluded from the national total, but reported separately.

Furthermore, in this sector a certain quantity of carbon from fuel is stored in non-energy products (lubricants, bitumen, etc.), while a portion of this carbon oxidizes and is emitted during product use.

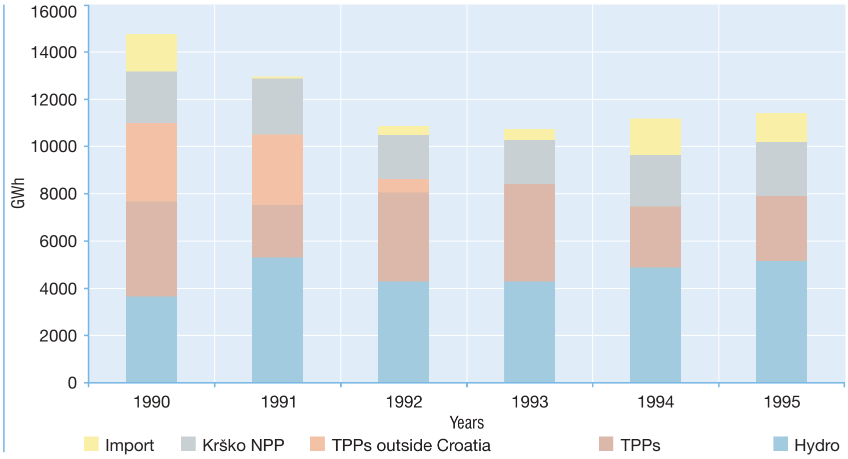


Figure 4-9: Structure of electricity supply in Croatia for 1990-1995 period

Fugitive emissions of greenhouse gases from coal, fuel oil and natural gas, mining, production, processing, transportation and usage activities also belongs to this energy sector. Although that emission source is not characteristic with respect to CO_2 emissions (more methane), in Croatia emissions of CO_2 from natural gas scrubbing is assigned here. Natural gas produced in Croatian gas fields has a high content of CO_2, more than 15 percent, and before it enters the commercial pipeline it has to be cleaned (scrubbed). Estimates of emissions from natural gas scrubbing is done by the material balance method and it is up to 5 percent of total CO_2 emissions in the energy sector.

Industrial Processes

Greenhouse gas emissions are generated as a by-product in various non-energy industrial processes in which raw materials are chemically transformed into final products. Industrial processes whose contribution to CO_2 emissions are identified as significant are the production of cement, lime, ammonia, iron and steel, ferrous alloys, aluminum, as well as use of limestone and soda ash in different industrial activities. The results of CO_2 emission estimates for industrial processes are shown in figure 4-10. Figure 4-11 shows share of individual industrial processes in total CO_2 emissions between 1990 and 1995.

Figure 4-10: CO_2 emissions from Industrial Processes

The most significant CO_2 emission source among industrial processes is cement production, with over 40 percent, or 50 percent (depending on year), of total subsector emissions. Generally, CO_2 emissions from industrial processes declined from 1990 to 1995, due to the decline in industrial activities caused by the war in Croatia. Some production, such as iron, steel and aluminum were halted in 1992.

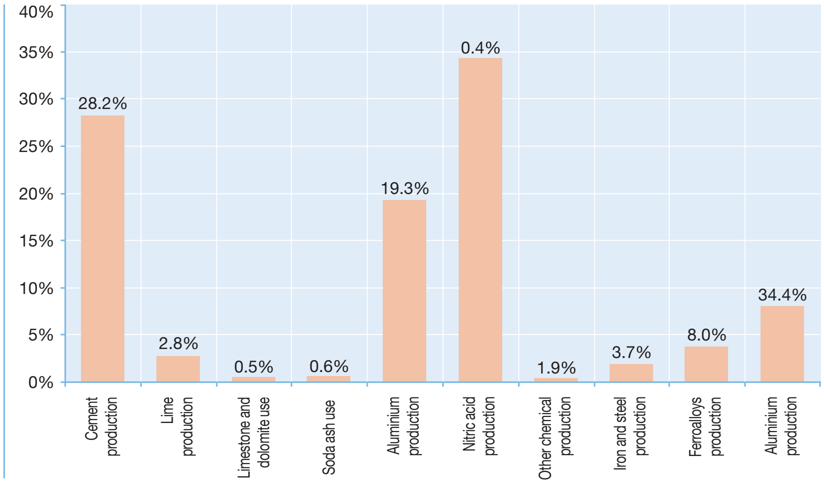


Figure 4-11: Average share of different industrial processes in total emissions (1990-1995)

The general methodology applied to estimate emissions associated with each industrial process, as recommended by the Convention (IPCC methodology), involves the product of an amount of material produced/consumed and an associated emission factor per unit of production/consumption. The data on annual business activity, namely on consumption/production for particular industrial processes were, in most cases, those published by the National Statistics Bureau. Some data were obtained through direct surveys of individual emission producers.

Emissions of CO_2 from ammonia production were calculated by multiplying annual consumption of natural gas used as a feedstock in processes by the corresponding carbon content of natural gas. But it should be noted that 47 percent of CO_2 generated a by-product during the production of ammonia was used as a feedstock in the production of urea (mineral fertilizer). Emissions of intermediately bound CO_2 are released during the use of urea as a fertilizer in agriculture (not during the production of ammonia). However, since the IPCC methodology does not envisage such an approach, total CO_2 emission (nearly 500 Gg) from natural gas used as raw material in ammonia production, is presented here.

In cement production, which makes the most significant contribution in total CO_2 emissions from the Industrial Processes sector, CO_2 emissions are directly proportional to the lime content of clinker. Therefore, CO_2 emissions are estimated as a product of an emission factor (in tons of CO_2 released per ton of clinker produced) and annual clinker output corrected for the clinker amount that is lost from the rotation kiln in the form of Cement Kiln Dust (CKD). Emission factors and correction factors for CKD loss were estimated according to the *Revised 1996 IPCC Guidelines* and *Good Practice Guidance*. The data on clinker production were collected through a survey of cement manufactures and cross-checked with cement production data from Monthly Industrial Communications published by the National Statistics Bureau.

Removals

As mentioned previously, the intake of greenhouse gases (e.g. CO_2 uptake caused by the forest wood stock increment) is actually greenhouse gas removal and the amounts are presented with negative sign.

According to the Forest Management Plan of the Republic of Croatia, forests and forest land in Croatia cover 43.5 percent of the entire surface area. In Croatia, forests were formed by natural regeneration on over 95 percent of this area and 5 percent of the forests are grown artificially. Of all forested zones and forest land, 2,061,609 ha (84 percent) is under forests, 315,166 ha (13 percent) is non-forest productive land, and 80,973 ha (3 percent) is barren unproductive and infertile soil. The basic data on the forest increment and management are given in section 3.9.

Only changes in forest and other timber biomass stocks are included in estimates of CO_2 emissions here, because insufficient data were available to estimate emissions from forest and grassland conversion, abandonment of croplands, pastures, tree plantations and changes in soil carbon.

The IPCC methodology was used to estimate net CO_2 intake. First, the annual increment of biomass in forests was estimated and the carbon removal calculated. Then, wood harvested for fuel, commercial lumber and other uses was estimated, keeping in mind that subsequent oxidation of the carbon content becomes a CO_2 emission source. The sum of these two figures is net carbon intake (the timber biomass increment is higher than the amount of harvested wood), and recalculation to CO_2 produces the removal (sink).

The annual increment in Croatian forests is 9,643,000 m^3 of wood. The increment is an increase in the forest timber stock over a specific period. It is calculated as an annual, periodical and average increment. Different methods have been developed in forest management to identify the forest increment. The methods primarily used in Croatia are a check method and a method of bore-spills. Different methods of forest cultivation can make the increment larger both in terms of their quantity and quality. The described cut is a part of the forest timber stock planned for commercial harvesting over a given period (1 year, 10 years, 20 years) expressed in timber stock (m^3, m^3/ha) or area (ha). In order to satisfy the basic principles of sustainable forest management, the described cut should not be larger than the increment value. The average annual described cut in Croatia is 5,354,000 m^3 or 56 percent of the increment value.

Based on the above data, the annual CO_2 net removal in Croatia is about 6,505 Gg CO_2. Due to the long-term nature of changes in forestry, the same annual emission estimate is given for each year in the period from 1990 to 1995.

The most important human activity that affects forest carbon fluxes is deforestation. In Croatia, the problem of deforestation does not exist. According to current data, the total forest area has not been reduced in the last 100 years.

4.4.4 Emissions of Methane (CH_4)

Figure 4-12 shows emissions of methane (CH_4) by sectors. In Croatia, the major sources of methane are agriculture, waste disposal and fugitive emissions from fuel production, processing, transportation and use.

In Croatia, livestock farming is a major anthropogenic source of methane emissions in agriculture. Methane is formed as a direct product of the metabolism of herbivorous animals (enteric fermentation) and as the product of organic degradation of animal waste (manure management). The IPCC methodology was used to determine methane emissions for each animal type (dairy cattle, non-diary cattle, sheep, horses, hogs and poultry). Between 1990 and 1995, the number of cattle decreased by approximately 40 percent, which resulted in a decrease in methane emissions.

Methane emissions from solid waste disposal sites (SWDS) are the result of the anaerobic degradation of organic waste by methanogenic bacteria. The quantity of the methane emitted during the degradation process is directly proportional to the share of degradable organic carbon (DOC), which is defined as the carbon content of different types of organic biodegradable wastes. The annual generation of municipal solid waste is about one million tons, and the average content of its biodegradable fraction includes paper and textiles (24 percent), green waste (17 percent), food waste (22 percent) and wood waste (including straw) (4 percent).

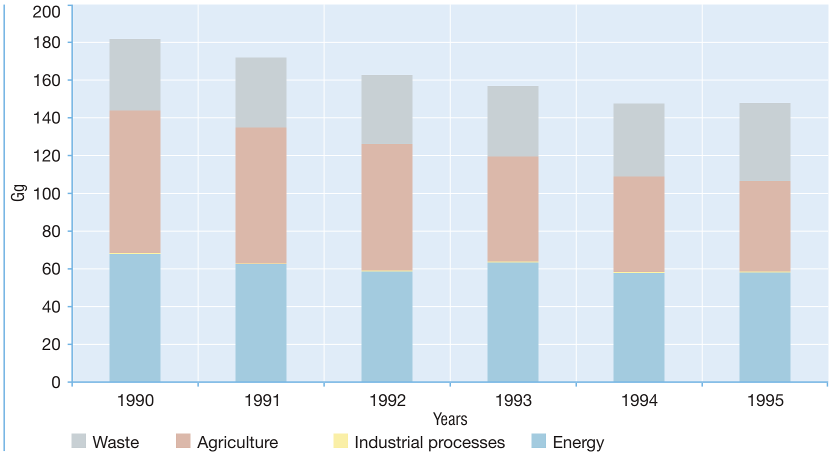


Figure 4-12: Total CH_4 emissions for the 1990-1995 period

Anaerobic wastewater treatment is not used in Croatia; the proper implementation of aerobic processes prevents methane emissions.

4.4.5 Nitrous Oxide (N_2O) Emissions

Figure 4-13 shows N_2O emissions by sectors. The most important source of nitrous oxide in Croatia is agriculture. A number of agricultural activities add nitrogen to soils, thereby increasing the amount of nitrogen available for nitrification and denitrification, and ultimately the amount of N_2O emitted. Three sources of N_2O emissions are distinguished in this methodology: direct emissions from agricultural soils, direct soil emissions from animal production, and N_2O emissions indirectly induced by agricultural activities. The highest direct N_2O emissions are those from agricultural soils, caused by tillage and crop growing practices. These practices includes the application of fertilizer, nitrogen from manure, production of nitrogen-fixing crops (legumes and soy), nitrogen from crop residue mineralization and soil nitrogen mineralization due to the cultivation of histosols.

Indirect nitrous oxide (N_2O) emissions in the waste management sector are predominantly those from human sewage. The calculation is based on total popula-

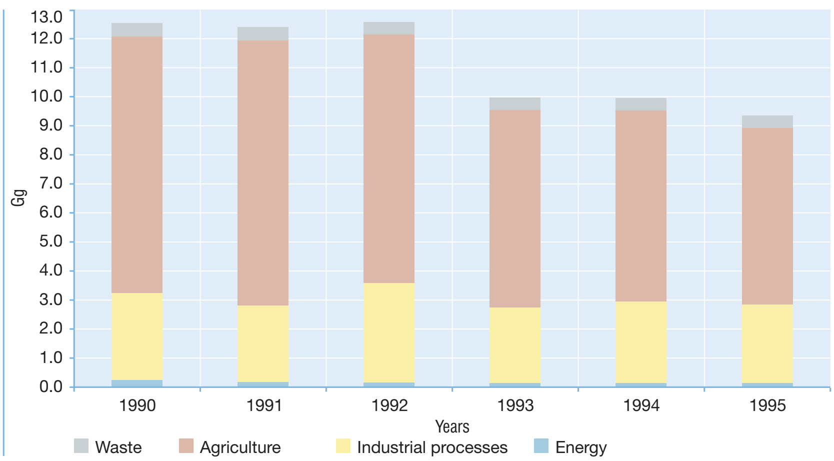


Figure 4-13: Total N_2O emissions for the 1990-1995 period

tion data and data on annual per capita protein intake. Because data on protein intake were not available for Croatia, it has been assumed that it equals the average protein intake in other European countries.

Emissions in the energy sector were calculated on the basis of fossil fuel consumption and corresponding emission factors (IPCC), while in industrial processes N_2O is only generated as a by-product in nitric acid production.

4.4.6 Hydrocarbon (HFCs, PFCs) and Sulfur Hexafluoride (SF_6) Emissions

Synthetic greenhouse gases include halogenated carbons (HFCs and PFCs) and sulfur hexafluoride (SF_6). Although on an absolute scale their emissions are not great, due to their high global warming potential (GWP) their contribution to global warming is considerable. PFC (CF_4 and C_2F_6) emissions are generated in the production of primary aluminum. The Croatian aluminum industry was still operational in 1990/1991, so production data and adequate emission factors (IPCC) were used to calculate emissions in the amount of 983.6 Gg eqCO_2 for 1990, and 648.3 Gg eqCO_2 for 1991.

Also, some emissions are released by the handling and consumption of synthetic greenhouse gases. HFCs and PFCs are used as substitutes for cooling gases in refrigerating and air-conditioning systems that deplete the ozone layer. The survey carried out among the major agents, users and consumers of these gases was used to calculate only emissions for 1995, which was 7.8 Gg eqCO_2.

A certain amount of SF_6 is contained in various electrical equipment used in the facilities of Hrvatska elektroprivreda. Equipment manufacturers guarantee annual leakage of less than 1 percent, so this information could be used to determine the SF_6 emissions. However, it is still not included in the inventory because the input data are not reliable.

4.4.7 Emissions of Indirect Greenhouse Gases

Although they are not among greenhouse gases, photochemically active gases such as carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane volatile organic compounds (NMVOCs) indirectly contribute to the greenhouse effect. These are generally referred to as indirect greenhouse gases or ozone precursors, because they effect the creation and degradation of O_3 as one of the GHGs. Sulfur dioxide (SO_2), as a precursor of sulfate and aerosols, is believed to contribute negatively to the greenhouse effect. The calculation results for the emission of indirect gases are given in table 4-4.

Table 4-4: Emissions of indirect GHGs for the 1990-1995 period

Gas/sector	1990	1991	1992	1993	1994	1995
	Gg	Gg	Gg	Gg	Gg	Gg
NO_x	**91.8**	**67.9**	**64.5**	**67.5**	**66.1**	**68.1**
Energy	91.0	67.5	64.1	67.2	65.7	67.8
Industrial Processes	0.5	0.4	0.3	0.2	0.3	0.3
Agriculture	0.1					
CO	**486.7**	**348.7**	**298.7**	**298.5**	**317.5**	**331.8**
Energy	469.1	338.8	295.2	295.5	314.4	328.5
Industrial Processes	13.1	9.8	3.4	2.8	2.9	3.2
Agriculture	4.3					
NMVOC	**561**	**508**	**428**	**417**	**320**	**323**
Energy	111.4	78.9	68.9	74.2	78.5	82.6
Industrial Processes	419.4	396.7	335.5	317.3	214.3	212.9
Solvent use	30.3	32.2	23.8	25.2	27.4	27.4
SO_2	**185.9**	**112.1**	**111.6**	**117.2**	**93.8**	**76.4**
Energy	179.5	107.5	106.1	113.5	89.5	71.7
Industrial Processes	6.3	4.5	5.4	3.6	4.2	4.6

4.4.8 Calculation Uncertainty and Verification

Uncertainties

Uncertainty estimates are an essential element of a complete emissions inventory. Uncertainty information is not intended to dispute the validity of inventory estimates but to help prioritize efforts to improve the accuracy of calculations in the future and guide decisions on methodological choices.

There are many reasons why actual emissions and removals differ from the figures from the national inventory. Total estimated uncertainty of emissions from individual sources (e.g. thermal power plants, motor vehicles, dairy cattle) is a combination of particular uncertainties of emission estimation elements, such as:

- uncertainties associated with continuous monitoring of emissions,
- uncertainties associated with direct determination of emission factors
- (by periodic emission measurements),
- uncertainties associated with emission factors from published references,
- uncertainties associated with activity data.

Some sources of uncertainty may generate well-defined, easily characterized estimates of the range of potential errors. Also, some other sources of uncertainty may be much more difficult to characterize. The estimated uncertainty depends either on instrument characteristics, calibration and sampling frequency of direct measurements, or (more often) on a combination of uncertainties in emission factors for typical sources and the corresponding activity data.

The pragmatic approach to quantitative estimates of uncertainty is to use the best available estimates by a combination of the available measured data and expert data. But, in situations where it is impractical to obtain reliable data or where existing inventory data lack sufficient statistical information, it may be necessary to elicit expert judgements about the nature and properties of the input data. Experts may be reluctant to provide quantitative information regarding data quality and uncertainty, preferring instead to provide relative levels of uncertainty or other qualitative inputs.

Elicitation protocols (*IPCC-Good Practice Guidance and Uncertainty Management in National GHG Inventories, 2000*) may be helpful in overcoming these concerns and minimizing the risk of biases that can be introduced by rules of thumb (sometimes called "heuristics") that experts might use when formulating judgements about uncertainty. If necessary, the experts should be made aware of the existence of IPCC default uncertainty ranges which would be used in the absence of their judgements.

At this moment, Croatian inventory, with exception of activity data, is mostly based on emission factor data published in the *Revised 1966 Revised Guidelines.* Except for the uncertainty ranges known from IPCC Guidelines, other uncertainties are exclusively determined by the assessments of experts for specific fields. Since the estimate was not based on a single method, the aggregate quantitative calculation uncertainty is not expressed. Rather, the relatively subjective qualitative estimates were collected for individual segments and sectors. However, the intention to formalize and quantify the estimate methodology to the maximum possible extent in the future. Some data (energy balance, industrial activity data) are very reliable and some data are not. For the purpose of this Communication uncertainties for some sectors are concisely and preliminarily categorized at several levels: high (data reliability ±5 percent), medium (10 percent) and low reliability level, and the categorization is given in table 4-5.

Table 4-5: Qualitative analysis of uncertainty:

QUALITATIVE ANALYSIS OF UNCERTAINTY IN CROATIAN INVENTORY
High reliability level
Data from Croatia's energy balance
Energy sector data (emission factors) from the Revised 1996 IPCC Guidelines
Emission from industrial processes
Medium reliability level
CO_2 emission from natural gas scrubbing
Consumption of HFCs, PFCs and SF_6
Emission from enteric fermentation and manure management
Emissions from agricultural soils
Changes in forest carbon stocks
Emission from solid waste in landfills
Emissions from human sewage
Low reliability level
Data for non-CO_2 emissions from fuel combustion
Fugitive emissions of methane from coal mining and handling
Fugitive emissions from oil and natural gas activities
NMVOC emissions - solvent use
Field burning of agricultural residues
Land-use and management

Verification

Verification processes are intended to help improve the quality of input data and to establish an inventory calculation reliability. The IPCC Guidelines recommend that inventories be verified through the use of a set of simple checks for completeness and accuracy, such as checks for arithmetic errors, checks of country estimates against independently published estimates, checks of national activity data against international statistics and checks of CO_2 emissions from fuel combustion calculated using national methods with the IPCC Reference Approach. Further verification checks may be done through an international co-operation and comparison with other national inventory calculation data.

In the development of the Croatian inventory certain steps and some of these checks were performed:

- Two National Workshops on Emissions were organized with the participation of numerous experts and representatives from the relevant institutions and industry, where discussion and cross-checking on data from different sectors were performed and recommendations for improving of the quality of data and emissions inventory were given.
- Comparison with the national inventory data of other countries was conducted by comparing communications or through a direct Communication with Hungarian and Slovenian colleagues.
- CO_2 emissions from fossil fuel combustion, within the framework of IPCC methodology, are estimated using two approaches: (1) Reference Approach and (2) Sectoral Approach (tier 1). The difference between them is not greater than 3 percent.
- Comparison of calculations of CO_2 emissions from fuel combustion was conducted with the calculation of the International Energy Agency (IEA) published in *CO_2 Emissions from Fuel Combustion 1971-1996, OECD 1998.* The IEA based its calculation on IEA statistical and energy balance data for non-OECD countries and the mentioned Reference Approach from the IPCC methodology. The comparison has shown that the average difference is 4 percent.
- CO_2 emissions from road transport was estimated by the IPCC Tier 1 approach. Also, the rough estimate for 1990 was done by using COPERT II package methodology. The difference between estimated emissions is about 2 percent.

Also, Croatian interim and final communications on inventory calculations were submitted for a technical review organized by UNDP-National Communications Support Program (NCSP). The overall communication assessment was positive, and the detail technical comments have been accepted and appropriate corrections were made in this final inventory communication.

Lake Lokve in Gorski Kotar

5. Policy and Measures

5.

Policy and Measures

5.1 Background - Existing Policy and Measures

The climate had become a global issue when Croatia was experiencing the most difficult years in its history, the brutal war, followed by the period of political isolation, and all this accompanied by the well known problems of the countries in transition. It is only understandable that under such circumstances the global environmental issues had relatively smaller importance while the politics was facing existential problems, increased unemployment, falling standard of living, reconstruction of the war-stricken areas, and establishment of a democratic and politically stable system. The last political changes of 2000 contributed to a significant improvement in the Croatian international position and resulted in memberships in WTO, Partnership for Peace, and the beginning of the EU accession negotiations.

However, generally speaking, the policy and measures that have been implemented and a number of *ad hoc* decisions resulted in very low greenhouse gases emission, which has been considerably lower than that in developed countries and countries in transition. Some decisions, such as abandoning of the coal-fired thermal power plant projects and orientation towards natural gas based development of the energy sector, have almost exclusively been guided by the climate change and environmental issues.

Below, the basic policy and the measures having direct or indirect effect on the climate issues are described.

5.1.1 General and Economic Policy

The basic orientation of the Croatian economic policy is its transformation towards the market economy, reconstruction of the territory destroyed in war, privatization, integration with the international economic trends, structural adjustment in specific economic sectors and tertiary industry, increase in production and employment.

The Government's 2000-2004 Program (February 2000) sets up *"growth and development of economy, particularly increase in production and export, and accelerated opening of new jobs"* as its priority.

As regards the environmental protection, the arrangements underlying sustainable economic development focus on harmonization of the Croatian legislation with the EU criteria, and enhancing of all sorts of mechanisms for nature conservation and environmental protection. The principles of partnership and equality of all the participants in the decision-making process will be fostered when it comes to the investments crucial for the economy and environment. The prospective is that the environmental protection measures will be paid from the charges for pollution. The objective is an increase in funds earmarked for the environmental protection, and setting up a separate fund primarily intended for granting of soft loans and encouraging the environmentally sound facilities, projects and plants within the shortest possible period of time.

Late in 2000, the Draft Economic Strategy for the Republic of Croatia was finished, which is currently under adaptation. Since this document determines the economic development orientation it is of particular importance for planning of policy and measures for the greenhouse gases emission reduction.

It should be noted that the analyses and scenarios from this National Communication are based on the macroeconomic projections from 1995. The development has been slower than planned, so the 1995 projections can be shifted a couple of years into the future. Once the above mentioned economic strategy is adopted, the sector strategies development will start. The reevaluated projections will be presented in the Second National Climate Change Report.

5.1.2 Energy Policy

Energy and Industry Sector of the Ministry of Economy is in charge of the energy policy. According to the objectives of the Government of the Republic of Croatia, the basic strategic task in the energy sector is to ensure quality and reliable energy supply of consumers, and provisions for consumers to choose a higher quality and cheaper energy source. The only condition precedent to achieve this is a more intensive presence in the international energy market. The Government's Program objective is achieving higher energy efficiency, diversification of energy resources, encouraging the use of renewable energy, realistic (market-based) pricing of electricity and development of energy market and entrepreneurship, and the environmental protection.

Reorganization of the energy sector will be based on five recently promulgated laws: Energy Act, Electricity Market Act, Gas Market Act, Oil and Oil Derivatives Market Act and Act on Regulation of Energy Sector Activities (Official Gazette 68/2001).

Draft Energy Development Strategy

The basic long-term planning document is the Draft Energy Development Strategy (EIHP et al, 1998). Although this comprehensive document has not yet passed thought the discussion and adoption stages, it has been used in the previous years as the basis for all planning analyses, and in this National Communication. The Draft baselines have been incorporated in the Economic Development Strategy for the Republic of Croatia, which is expected to be adopted in 2002.

The Draft Energy Development Strategy considers two possible scenarios of the energy sector development. The ultimate options include the baseline ("business-as-usual") scenario with moderate initiatives of the state, and the strongly "environmental scenario" with high involvement of the state in encouraging achievement of the set up objectives. These scenarios are described in more detail in Section 6.

National Energy Action Programs

In 1997, the Croatian Government has brought a Decision on Initiation of the National Energy Action Plan within the PROHES (*Croatian Energy Sector Development and Organization*) Program. This project has been initiated in order to build the energy management system that would specifically promote cleaner technologies, gas introduction, energy efficiency, renewable energy resources and environmental protection.

Realization of these projects is based on the programs, each of which covers a specific energy management field. These programs are planned to underlie organized and systematic care of energy efficiency and exploitation of the renewable energy resources.

The National Energy Action Plans include:

- **Gas Introduction Program for the Republic of Croatia:** PLINCRO

- **Energy Efficiency Programs:**
  - $KUEN_{zgrada}$ - building energy efficiency
  - MIEE - industrial energy efficiency networks
  - KOGEN - cogeneration
  - $KUEN_{cts}$ - district heating systems energy efficiency
  - TRANCRO - transport energy efficiency

- **Renewable Energy Resources Programs:**
  - BIOEN - energy from biomass and waste
  - SUNEN - use of solar energy
  - ENWIND - use of wind energy
  - GEOEN - use of geothermal energy
  - MAHE - small hydro projects

Energy-related issues of the Croatian islands shall be resolved through a separate islands energy program - CROTOK.

The objectives and strategy for implementation of the renewable energy resources programs depends on specific characteristics of each renewable resource and the program of its use, and their common characteristic is considerable increase in share of renewable resources by the year 2030, which corresponds with the general trends in EU countries.

PLINCRO program has been initiated in order to increase gas share in the energy consumption, provide for expansion of the gas network in the areas where it has already existed, and for its introduction into the uncovered areas. In addition to the development of the new gas supply import routes, construction of the gas transmission mains and distribution networks would enable more pro-active participation of Croatia in the European and world gas network and consequently make use of the advantages offered by the global trade system.

The primary objective of the introduction of the building energy-efficiency program **$KUEN_{zgrada}$** is reduction of energy demand through design, construction and use of new buildings and housing estates, and through retrofitting of the existing buildings, providing for favorable microclimate parameters for the premises in the building, and reduction of the environmental impacts.

The energy-efficiency improvement strategy for consumers in industrial, services and public sector is encouraged by setting up of an organized structure within the **MIEE** program. As regards energy efficiency, the primary interest of industrial sector, and the strategic objectives of the community are reduction of operating costs, avoiding of high investment into the energy sector and lesser dependence on energy supply, optimization of technological processes and environmental impacts mitigation.

The primary objective of the **KOGEN** program is to encourage construction and exploitation of cogeneration plants in all the facilities that have realistic process and economic prerequisites for implementation of the program. The program is primarily based on establishing of a favorable legal, financial, technical/technological framework for construction of the cogeneration facilities.

As regards **KUEN**$_{cts}$ program for district heating systems, it is imperative to encourage development and advancement of the district heating systems and improve efficiency of the existing systems in the Croatian cities an towns, particularly there where the heat consumption density or concurrent demand for heat and power are high.

The **TRANCRO** program is aimed at permanent care for energy efficiency and environmental protection in transportation sector. The program encompasses long-term forecast of energy consumption increase in the transportation sector in the Republic of Croatia and determination of its environmental impact, along with the model analysis of economically viable measures that could result in energy efficient and environmentally sound development of the transportation system.

The **BIOEN** program is focused on energy generation from biomass and waste and it indicates that such production could cover minimum 15 percent of total primary energy demand by the year 2020. The objective is to be realized by initiation of the demonstration projects, creation of market and conditions for increased use of biomass energy, by attracting industry and businesses, education, and stimulation of research and international collaboration.

The **SUNEN** program has shown that combination of solar energy and LPG and/or natural gas is technically and environmentally acceptable concept for the Croatian Adriatic coast. Also, hybrids including solar energy, wind energy and LPG could contribute to both setting up of the energy infrastructure on the islands and initiation of development of the traditional island activities through harnessing of local resources in compliance with the strategic baselines for development of the Croatian islands.

The **ENWIND** program will ensure a number of conditions necessary for cost-efficient harnessing of wind in power generation, by using the wind turbines of new generation. The wind energy, an environmentally sound and accessible local resource, is a completely undeveloped energy resource that might contribute to satisfying the energy demand in Croatia..

Exploitation of geothermal energy demands that certain conditions for its increased use in the existing facilities be fulfilled. An organized approach, such as envisaged by the **GEOEN** program, asks for adequate and comprehensive marketing campaign that would attract interest of private businesses and local community in the use of geothermal energy and result in increased energy efficiency of the overall energy sector.

The basic objective of the **MAHE** program is construction of small hydro power plants and removal of any hurdles to the program implementation, along with providing all necessary for increased construction of such facilities in the Republic of Croatia. These power plants are planned as IPP projects, so it is necessary to ensure transparent and simple legislation for the private investors, particularly when it comes to their design and construction, and to provide soft loans for such investments.

Power Generation Sector Policy

Hrvatska Elektroprivreda - HEP (the Croatian Power Company) is a public limited company for power generation, transmission and distribution. It covers about 90 percent of power demand from its own generation and from import.

HEP's development policy has had the best positive effect on reduction of greenhouse gases emission in Croatia during the past period. The HEP's development policy has traditionally been oriented towards electricity generation in hydroelectric power plants and use of natural gas in cogeneration facilities. Presently, the cogeneration share in Croatia is 15 percent, and further development of new capacities in the cities is based on gas-fired cogeneration plants. This is the reason why specific emission from the power generation sector is about 250-380 kg CO_2/kWh of supplied power, and HEP's contribution to the total emission in Croatia is 12 to 18 percent, which is significantly lower than the usual contribution of power industry in other countries. It is interesting that the power generation sector emission is lower than that of the agricultural sector.

HEP's development planning by employing the method of strategic environmental impact studies has been used for a number of years. Full attention is paid to any commitments under the Convention and Kyoto Protocol. Concurrently with development of this National Communication, HEP has been working on a comprehensive study that analyzes possibilities for reduction of greenhouse gas emission. The teams, information and know-how engaged in the HEP's study have been used in this Communication (EKONERG, 2001).

An important concrete step was made by Hrvatska Elektroprivreda already in 1994, when the conditions have been provided for the power purchase from small independent power producers, IPPs (power plant capacity less than 5 MW). Electricity from the small hydroelectric power plants and cogeneration plants is purchased at 70 percent and from the wind power plants is at 90 percent of the average power system price. The power purchase and correction to grid of these power plants is based on the Power Purchase Agreements. The guidelines are available for potential small IPPs and partners interested in small hydroelectric power plants, cogeneration plants and wind plants projects. Hrvatska Elektroprivreda is currently preparing to introduce the demand-side management (DSM) system by setting up a network of Energy Service Companies (ESCO), along with the Renewable Resources Project to be financed by the GEF and the World Bank.

The power sector structural adjustment will be conducted so that all EU market development processes are taken into consideration and the Croatian processes harmonized with them, and that all the requirements ensuing from political, economic and energy-related objectives of the Republic of Croatia are met.

The first step in HEP's structural adjustment is unbundling of its core business (power generation, transmission and distribution) from the non-core activities (heat and gas distribution, various supporting services). The core business will be organized within the HEP Group (private and state ownership), and it will provide for reliable and stable functioning of the power system. The non-core activities shall be carried out through newly incorporated companies, fully or partly owned by HEP. Organization of the market and partial privatization of the HEP Group (in power generation segment) would further enable opening of the market for the demand-side, in compliance with the EU standards, and more intensive participation on the energy markets in the region.

5.1.3 Environmental Policy

The Ministry of Environmental Protection and Physical Planning is in charge of the environmental policy with the exception of the water resources issues that are the authority of the State Water Directorate. The environmental legislation includes laws, decrees and rules. The laws proposed by the Government and the Ministry are passed by the Croatian Parliament and subject to prior discussion at the Committee for Environmental Protection and Physical Planning of the Croatian Parliament. The Government brings the decrees on technical standards, and the Ministry brings the rules.

Within the Ministry, the climate issues come under the responsibility of Climate and Ozone Layer Protection Section within the Atmosphere Protection Department.

The *Environmental Act* elaborates general environmental issues and it is an umbrella document for a number of other sector bylaws. The Act stipulates development of strategy and regular reporting on the environmental protection performance. The First Environmental Status Report was prepared in 1998. Currently, the *Environmental Strategy with the National Environmental Action Plan (NEAP)* is under adoption. The analyses and goals from this National Communication have also been incorporated in the Environmental Strategy and in NEAP.

As far as air is concerned, the most important legislation includes the Low on Air Protection, Decree on air pollutants emission limits for Stationary Sources, Decree on Substances that Deplete the Ozone Layer, Waste Management Act, Rules on Waste Management Requirements, Rules on Environmental Impact Assessment, Law on Air Protection., The Decree on emission stipulates limit values for emission pursuant to the BAT technologies from the Protocol on Long-Range Transboundary Air Pollution (UNECE) and the measures, ranging from primary to secondary, depending on the type and capacity of a facility. For small furnaces, maximum heat losses are stipulated, and all furnaces must measure emission, that provides indirect determination of their energy efficiency. The same Decree recommends recovery of heat from thermal waste treatment facilities.

An important instrument for implementation of the environmental policy in Croatia is the mandatory Environmental Impact Assessment for different projects. The regulation that governs development of the Environmental Impact Study reflects the USA regulations. It has been in effect since 1986, when only a few countries in Europe had such a regulation. The impact assessment procedure applies to all industrial facilities, power generation facilities over 50 MW, power plants with unconventional energy sources, hydroelectric power plants, landfills and thermal waste treatment facilities. The assessment procedure includes public consultations, while the decision on project acceptability is brought on the basis of the conclusions of an independent expert committee appointed by the Government based on the proposal of the Ministry of Environmental Protection and Physical Planning. The large projects, such as thermal power plants or industrial facilities are commonly considered for CO_2 emissions, having in mind the present and potential international commitments. The last version of the Rules from 1999 explicitly demands a cost-benefit analysis and consideration of the environmental issues in the line with the Croatian international commitments.

The state of the environment in Croatia is rather favourable, and the major problems are those related to the waste disposal, water and sea pollution, and air quality in the vicinity of some industrial sources[1]. A comprehensive overview of the environmental policy implementation is given in the *Environmental Performance Review* prepared by the UNECE experts (UNECE, 2000).

The environmental protection priorities are currently under discussion within the process of the NEAP adoption (). Here some infrastructure investments could be highlighted, e.g. rehabilitation of refineries aimed for fuel quality improvement, construction of municipal wastewater treatment plants in inland and coastal region, implementation of the BAT technologies for emission abatement, enhancement of domestic industry participation in energy efficiency equipment production, use of renewable resources and cleaner production.

5.1.4 Forest Management Policy

The forests cover 36.4 percent of Croatia and have significant environmental, social and economic value. The Ministry of Agriculture and Forestry is in charge of the forest management policy which is impemented by the public company Hrvatske Šume (*Croatian Forests*) pursuant to the Forests Act and appurtenant bylaws. The Forest Management Scheme is brought every ten years to determine forest management implementation orientation. The basic principle is the *sustainable management* that ensures continuous reforestation and permanent increase in timber-growing stock and conservation of the biodiversity. The forest management policy baselines are described in Section 3.

5.1.5 Some Environmentally Favorable Decisions

Here, should be highlight some important individual decisions that directly affected greenhouse gases emission, such as, phasing out of some major energy consumers e.g. Bakar Coke Mill, ferrous alloys factory in Šibenik, blast furnaces in Sisak Steel Mill, orientation towards maximum use of the hydro potentials, large share of cogeneration plants in power generation, orientation to energy non-intensive industries, natural gas network expansion (27 percent of households is supplied with gas), shutting down of the only domestic coal mine for environmental reasons, suspension of construction of new coal-fired thermal power plant, sustainable forest management, construction of a PWR nuclear power plant of western type. Burning of coal in new heating plants has been banned in the City of Zagreb for over fifteen years and this policy, aimed at air pollution control, has also been enforced in some other cities and towns by individual decisions or within the Environmental Impact Studies (coal share is less than 1 percent of consumption in household and services sector).

[1] A significant portion of the Croatian economic revenue is earned in tourism and agriculture, which partly affects general public awareness of environmental issues for economic reasons. Further, natural, geographic and clearly environmental diversity is recognized as a national capital, thus a synonymous cluster used for Croatia - "Our Beautiful". Such a genuine attitude could be considered as one of the reasons that industrialization in the period of communism did not rendermajor environmental pollution issues in Croatia.

5.1.6 Available Technologies and Tradition of Energy Sector Planning

Croatia has relatively good technical conditions for introduction of "climate-friendly" technologies. In addition to the available human resources and large capacities within the renown mechanical and energy engineering companies, there are a number of small businesses that could convert their production programs and adopt new technologies.

Development of solar technologies in Croatia started twenty years ago, so fifteen years ago Croatia had about 40,000 m^2 of solar collectors. Complete technology for the hydroelectric power plants is available from the Croatian internationally recognized manufacturer of this equipment. Croatia has its own technology for gas and oil exploration, it conducts research in this field in other countries, and uses technologies for CO_2 capture from natural gas. The period of war and economic recession during the last ten years has caused decrease of solar collectors manufacturing capacities and, and threatened manufacture of equipment for hydroelectric power plants because of market lose. Metal industry and boiler manufacturers are able to re-oriented to production of equipment for using renewable resources. There is significant experience with design and building of "solar houses" with passive and active systems.

Energy planing tools in Croatia have been developing for several decades. Models national energy planning, urban energy supply and power sector has been developed based on principle of strategic environmental impact studies. These models have been used for national planning, and some of them have been used as an integral methodology in other republics of the former Yugoslavia. Already over twenty years ago, the Croatian Ministry of Science developed the national energy conservation programs. Emission monitoring and energy performance in combustion plants over 1 MW was conducted in some cities on regular basis already twenty years ago. The Ministry of Economy encouraged energy efficiency in public institutions through specialized non-governmental organizations.

5.2 Planned Climate Change Mitigation Policy

5.2.1 Background and Objectives

Croatia has so far been meeting its commitments under the Convention since its greenhouse gases emission is below the 1990 level.

The basic long-term Croatian objective regarding the climate issue set up within the framework of this National Communication is:

Climate change mitigation pursuant to the general principles of the Convention and assumed commitments, along the course that enables sustainable economic development of the country

When speaking about mitigation it relates to the measures for reducing GHG emission by sources and increasing removals by sinks, and the measures for adaptation to the climate changes because of their possible detrimental impact on the human health, ecosystems, material and cultural goods and economy. The general principles from the above objective are orignated from the Article 3 of the Convention, and they are commented in Section 3-11.

The objective is set up as a long-term objective that cannot be fulfilled in a couple of years. Therefore the socio-economic effects of the commitments might on a short run exceed the long-term benefits.

At the moment, Croatia has no quantitatively defined objective for the greenhouse gases emission reduction. During the preparation of this National Communication the possibilities and consequences of fulfilling the commitments under the Convention and Kyoto Protocol have been analyzed for the first time. Therefore, the actions presented here below are the first framework of the climate change mitigation action plan or rather a background for preparation of such a plan. For that reason part of the text was written in form or instructions rather than as description of the current status.

The Kyoto protocol defines the emission reduction of 5 percent in relation to base year for Croatia. In the light of general principles of Convention (Article 3 of Convention), established Kyoto target is not justifiable in the case of Croatia. Unfortunately, during the Kyoto negotiations Croatia didn't have available data on emissions and GHG reduction potentials, consequently not being in position to negotiate on targets appropriate to its circumstances and capabilities.

5.2.2 National Climate Change Mitigation Action Plan

The National Action Plan will set up a framework for systematic addressing of climate change issue, pursuant to the defined objectives. The Plan will be an institutional and organizational framework for partnership of all the stakeholders, governmental institutions, public institutions, local authorities and services, scientific community, private businesses, non-governmental organizations and the general population, which will contribute to the climate change mitigation. The climate issue needs to be resolved on a global level and through the international collaboration, it is specifically inter-sectorial in nature, and one that asks for a framework that will stimulate synergetic effects of all the participants.

The Croatian National Climate Action Plan will consists of two parts: (a) Capacity Building Program and (a) Implementation Program.

Capacity Building Program (KLIMAkap) This Program will establish institutional, legal, organizational and scientific capacities, enhance human resources and arise general public awareness on the issues related to the climate change mitigation. This program needs to be dynamic and maximally tailored to the requirements of the Implementation Program by creation of different legal, incentive and economic tools. The objective is building of a system that will be permanently sustainable and self-supporting, in addition to its being economically effective.

The main features of the Capacity Building Program include:

Emission inventory

- building the national emission inventory system, including register of sources and technologies
- improvement of methods and procedures for enhancing quality of emission inventory

Support to building, maintenance and evaluation of policy and measures

- designing and building a system for collecting information necessary for planning of the policy and measures
- setting up the systems for projects/programs planning, reporting, monitoring and evaluation

- development and implementation of methods for emission abatement analyses, emission projections and scenarios development,
- development of strategies, programs and plans on different levels
- drafting of legislation, and economic and other incentives
- assessment of capacity building needs (technology, experience and knowledge)
- removal of barriers to efficient program implementation
- studies supporting project preparation
- building of project financing mechanisms and their monitoring
- collaboration with similar programs on the national and local levels
- development and promoting of approaches, methods and knowledge for sustainable development planning
- building of incentive and other measures for implementation of demonstration and pilot projects and programs
- development of and support to the demonstration and pilot projects and programs
- setting up the system for implementation of the mechanisms for joint implementation (JI), clean development mechanism (CDM) and emission trading (ET)
- international collaboration on climate issues
- networking of institutions and programs

Support for impact and adaptation analysis

- 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

Observation, systematic monitoring and research

- joining the Global Climate Observing System (GCOS)
- research on climate change, new technologies and solutions

Education and public awareness arising

- access to information
- education and public awareness arising
- other activities supporting the setting up of the system for implementation of policy and measures and reporting pursuant to the Convention.

Implementation Program (KLIMApro) The Implementation Program (KLIMApro) will encompass preparation and implementation of projects, and all necessary implementation support such as regulations, manuals, facilitative services, incentives, and supervision and control of the project implementation. The Implementation Program should simplify preparation, organization of the project implementation and accelerate transfer of activities from the state and public institutions onto the private sector, businesses and civil sector.

The Program will encompass the following measures:

- use of renewable energy resources
- energy efficiency measures
- technical and other measures in the transportation sector
- fuel conversion into low-carbon energy forms
- increase removals by sink
- measures for emission reduction and sink increase in agriculture
- measures for waste management emission reduction
- measures in industry and cleaner production
- international projects based on joint implementation (JI) and clean development mechanisms (CDM) pursuant to Kyoto provisions
- integrated sustainable development projects
- other projects contributing to the climate change mitigation

Some of the KLIMApro activities overlap with the KLIMAkap program since it was not possible and there is no need to define strict boundaries. Preparation of the demonstration projects, regulations, manuals, public promotional campaigns are those areas where the boundaries need to be flexible. The KLIMApro program uses these activities directly for implementation, while all other activities on the level of the overall system or interaction with other sectors need to be incorporated in the KLIMAkap program.

5.2.2.1 Institutional Framework

The planned Program organizational chart is given in Figure 5-1.

- **Ministry of Environmental Protection and Physical Planning** is responsible for the overall program implementation. The Ministry creates strategy, coordinates and supervises the program implementation, provides administrative and technical support. Operatively, the Program is the responsibility of the **Ozone Layer Protection Section, Atmosphere Protection Department**. After the Environmental Protection Agency has been established, some of operational and technical activities will be taken over by the Agency.
- **National Climate Change Commission** is an advisory body for supervision and evaluation of the program implementation results, assessment and decision-making on crucial strategic issues and support to exchange of information, cross-connecting of institutions and stakeholders. The Commission has 17 members, representatives of the Ministry, Croatian Power Board, INA Oil Industry, Croatian Chamber of Economy, academy of sciences, State Hydrometeorological Bureau and two representatives of the NGOs. The National Committee chairman is the representative of the Ministry of Environmental Protection and Physical Planning (minimum Assistant Minister).
- **The Ministry maintains the Program Website** on its web domain.

- The **Executive Coordinating Committee** is the body running the Program implementation, consisting of the leading experts in the field and a representative of the Ministry of Environmental Protection and Physical Planning, Ministry of Economy, Ministry of Transportation, Marine Affairs and Communications, Ministry of Agriculture and Forestry and Ministry of Finances each. The Executive Coordinating Committee is accountable to the Ministry of Environmental Protection and Physical Planning and through it to the National Climate Change Commission.
- **Scientific and Technical Advising Committee** for the Program assists in resolving technical and methodological issues related to the Program. Upon request of the Ministry of Environmental Protection and Physical Planning, the National Climate Change Commission or the Executive Coordinating Committee, the Council renders its opinions on individual issues arising during the project preparation, implementation and control. The Council gathers prominent experts, some of which may be members of other Program bodies.
- **Task Groups** consist of representatives of stakeholders in individual sectors. The coordinators and members of these Task Groups under the KLIMAkap Program are appointed by the Ministry of Environmental Protection and Physical Planning in agreement with the Executive Committee. The coordinators and members of the KLIMApro Program are appointed by a ministry in charge of coordination with the Ministry of Environmental Protection and Physical Planning. The Ministry of Economy is in charge of energy efficiency, renewable energy sources and industry, the Ministry of Transportation, Maritime Affairs and Communications is in charge of transport, agriculture and forestry fall under the Ministry of Agriculture and Forestry, while waste management and joint projects come within the competence of the Ministry of Environmental Protection and Physical Planning. Coordinators of specific Task Groups are also members of the **Program Task Groups**.
- **Projects** and subprograms are individual terms of reference of defined duration, the scopes of which cover the climate change issues. They may be within the authority of individual ministries, public companies, local administrations, science, private companies, NGOs and others. The Project managers or their representatives are the members of the Task Groups. Each project or program financed, or formally supported by the state, public companies, local self-government and international grants and loans is considered a part of the climate program and should be collaborative as stipulated by the Operational Instructions.
- **Links to other programs and projects** are made on all hierarchical levels of the program, which means on the levels of projects, Task Groups or Executive Committee or the National Climate Change Commission. So, the national energy programs, scientific programs and educational programs will have their representatives in corresponding bodies of the KLIMA.

The structure set up in this way enables maximum exploitation of the human and technical resources, it networks the existing institutions with minimum demand for full-time staff in state institutions, and therefore makes it adaptable to the necessary changes.

Furthermore, the structure provides for short paths for transfer of know-how and activities from the public into the private sector and on the civil sector, which is an imperative if any program wants to achieve efficient implementation and partnership.

The structure of the planned program is easily tailored to changes, and therefore sustainable since it connects and integrates synergistically the capacities of different sectors and actors. Once the Environmental Protection Agency (NEAP priority) is established, some sectors that express their need for permanent human resources and carry out the routine jobs will be transferred into the Agency. The Agency shall also take over the operational coordination of the Program. Since the complete activity is interdisciplinary and involves numerous actors, most of the tasks will be rendered by different institutions, experts and representatives outside the state administration bodies.

Such Program structure is tailored to different funding sources and implementation actors. The Capacity Building Programs are mostly financed from the national funds, grants and international funds, or through technical assistance. Only a minor part of the KLIMApro projects would be financed from national and international funds, the major part funded from the so-called incentive and commercial loans. The major KLIMAkap implementation actors will be the administrative bodies supported by the scientific and technical institutions, while the KLIMApro is carried out by design engineering companies, businesses and NGOs. On some projects, where the capacity building components emerge on the level of the project, they need to be coordinated with the overall climate program, and those parts that are within the general capacity building should be connected with the KLIMAkap.

It should be noted that the proposed institutional and organizational framework is modern and original to a certain degree. It corresponds with the new strategic objectives and criteria for building of national capacities within the Convention and GEF capacity building funding mechanisms that are in preparation (*UNDP/GEF Building Capacities Assessment Report*). In this form, the Program has a number of desirable characteristics that need to be underscored once again - flexibility to changes, institutional networking, outsourcing, leaving initiative to the sectors in their domain, vertical and horizontal integration of activities, building on existing resources, openness to different financing modes, stimulation of synergy of all the involved actors. The Program does not establish formal links among the actors. It engages the actors on resolving the climate issues, which is the basic condition for its successful implementation. This is a framework oriented towards those who should implement it self-sufficiently to their best capacities, while strategically guided and assisted by the state administration.

The Fig. 5-1 is chart of activities/actors, which is already mostly functional, and the tasks are being successfully carried out. Boxes 2, 4, 7, 8, 9 and 10 are operational, and they have been developed within this National Communication. Boxes 12, 13 and 15 need to be established by grouping from the already existing energy programs. Boxes 3, 5, 6, 11, 14, 16 and 18 need to be set up since they still do not exist.

5.2.2.2 Program Implementation Risk Areas

The Program implementation risks are numerous, since there are numerous barriers to be removed. The risks are mainly related to the funds, attitudes and knowledge, and to a smaller degree to the technical conditions. Croatia will face difficulties in realization of objectives set up., particularly in defining the programs, without international financial support. In the initial stage, special attention should be paid to the education and arising of public awareness.

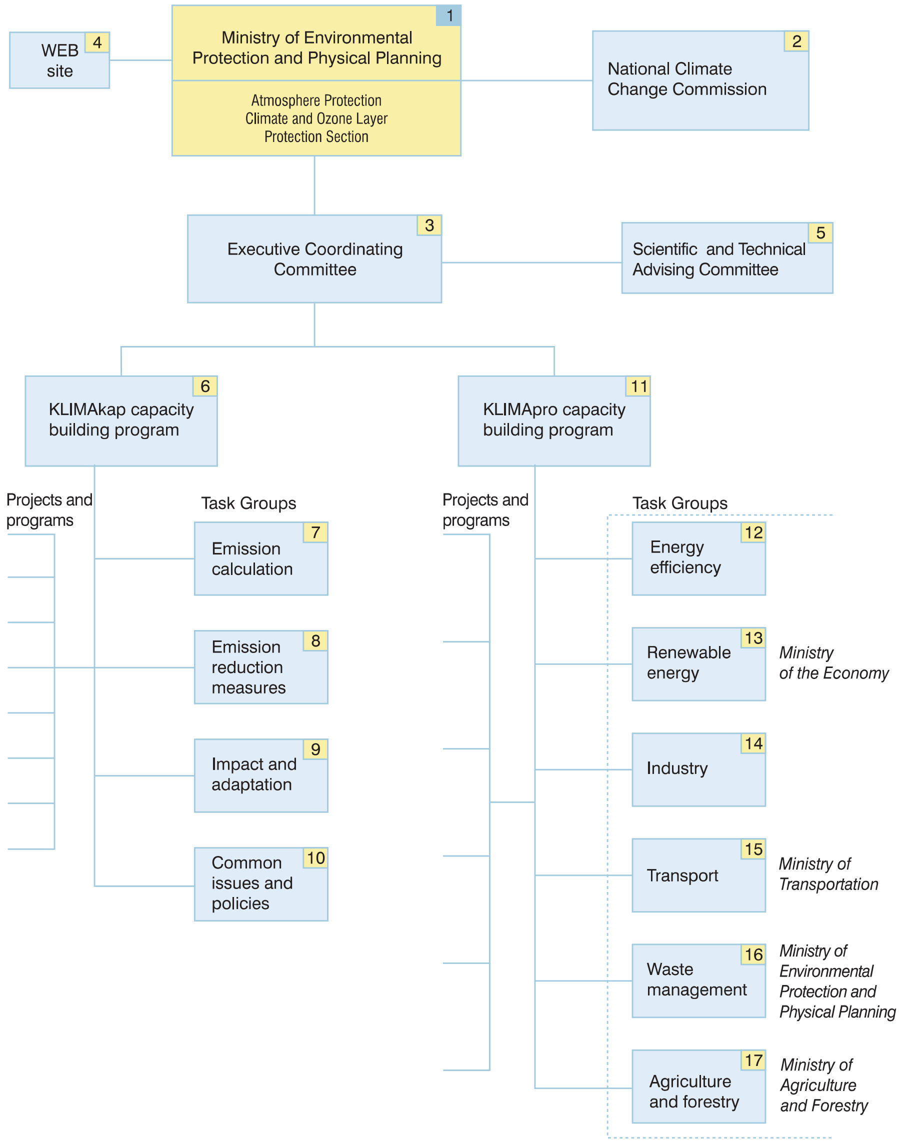


Figure 5-1: Proposal of KLIMA – National Climate Change Mitigation Program

Since the proposed Program is mostly based on outsourcing from the state administration bodies, the rights and duties of individual actors need to be carefully regulated, and care should be taken of maintaining the generated capacities, values and knowledge.

For the Program to be permanently sustainable, its financial aspect must be based on the market principles to the maximum degree, with minimum use of incentive financing. General environment, including the pace at which the Croatian economy and energy sector will adopt market principles, and willingness of the Croatian commercial banks to share risks, shall determine the level of success of the climate Program.

Here below some of existing barriers are listed, which are identified and systematically analyzed in preparations of the national project for *Removing Barriers for Implementation of Energy Efficiency in Households and Services Sectors* (UNDP-GEF). These include lack of regulations for fostering of measures and self-initiative, low prices of energy sources, lack of knowledge and accessibility of technology, insufficient information on costs, lack of knowledge about market and financing mechanisms and implementation of measures, lack of interest of the banking sector, poor information accessibility and low interest at the local level, insufficient knowledge about the potentials (e.g. wind and biomass), nontransparent ownership relations in services sector (hotels), lack of technical standardization and verification for new technologies lack of trust between the public sector and NGOs.

The modes of structural adjustment, liberalization and privatization of the energy sector will largely affect the use of renewable energy resources and energy efficiency. Thus, it will be necessary to permanently develop new stimulation mechanisms adjustable to the changes leading to decentralization of systems and of the free energy market.

5.2.2.3 Performance Indicators

The Program implementation indicators need to be defined from the onset. The basic performance indicators include:

- quantity of GHG emission reduction and removal by sinks
- investments into climate change mitigation projects
- number of projects
- number of new jobs created through the measures implementation
- local/foreign financial component ratio in the projects
- transfered and newly developed technologies
- conservation of energy and other resources achieved by the measures implementation
- positive side effects of implementation measures (reduction of local pollution, improvement in international cooperation, and the like)
- interest of media and professional community on climate issues
- public awareness of the climate issues
- other measure-specific indicators.

The performance monitoring and evaluation asks for databases, while some indicators such as the media interest and public awareness ask for determination of the initial status. The first systematic step should be determination of the national sustainability indicators in compliance with the global and regional approach to this issue.

5.2.2.4 Funding

The costs of planned establishment of the capacity building program (KLIMAkap) are estimated to USD 1.5-3 million in the next three years. During that period, it will be necessary to complete a system that will provide for the implementation of measures. The costs mainly include engagement of experts, either in the state administration bodies or outside them.

In planning the measures, the evaluation has been made of additional marginal costs and the so-called national emission reduction curve was constructed. The determined costs are the difference between the costs of the technical solutions with the measures and those without the measures (base line). The technical solutions without undertaking the measures are based on implementation of the "business-as-usual" scenario.

The emission reduction costs indicate that the most profitable is the energy efficiency measure applied to household and services sectors and the option that includes selection of the "gas scenario" for expansion of power capacities. Cost estimates shows that for 20 percent emission reduction in relation to reference scenario, which assumes implementation of nearly all adopted measures, needs 120 mil. $ in the year 2010. Presently, there is no cost estimate for energy from biomass, the cost of which might range from highly cost-effective solutions to the comparatively expensive options. For these costs to be determined, additional detailed analyses need to be made in which all other environmental and socio-economic effects will be accounted for.

A four basic funding sources are planned for use: national budget, fund based on greenhouse gases emission charges, commercial bank loans and international bilateral financial and technical assistance.

The KLIMAkap implementation program should be funded from the national budget, emission charges and international grants, particularly from the financing programs under the Convention (GEF). The major part of this Program could be implemented through bilateral technical assistance. The GEF support within a new program, the Capacity Building Initiative, is expected for the initial stage of the capacity building.

The KLIMApro Program is planned to be financed from the greenhouse gases emission charges. The incentives should cover the difference in costs between the "climate-friendly" and base line technology. The implementation projects should be a combination of funding from the incentives and different forms of soft commercial loans, although it is possible to use only commercial loans only. In the initial stage of the measure implementation, the assistance from GEF and other international funds could be expected for the demonstration projects and programs aimed at creating a positive environment. A good example of the latter are the projects: Removing Barriers to Energy Efficiency which has been approved for co-financing (UNDP-GEF), the Energy Efficiency Program based on implementation of the ESCO program at the HEP (WB-GEF), and the Croatian Project for Renewable Energy Resources (WB-GEF).

5.2.2.5 Priority Steps

The policy priority steps include:

- **setting up a stable funding mechanism based on emission charges (within the Environmental Protection Fund)**
- **setting up the Program based on an adequate political decision.**

The capacity building for implementation of the climate program asks for the following actions to be undertaken during the next 1-2 years:

- assessment of capacity building needs
- implementation strategy with operative plan
- standards and technical legislation, regulations
- development of a national emission inventory system and register of emission
- project cycle database
- defining base lines and guidelines for joint implementation (JI) and emission trading (ET)

- support to development of sector plans and programs pursuant to National Climate Action Program objectives
- detailed evaluation of potentials and mapping of biomass, wind and small hydro capacities
- development of the background studies necessary for preparation of design documentation and programs (feasibility studies, socio-economic analyses, generic environmental impact studies, preliminary studies)
- identification of projects, their prioritization and preparation for implementation alternatives
- realization of international collaboration
- public promotion program implementation (2 years)
- preparation of the Local Agenda 21 for Croatia
- building capacities for policy and measures planning (professional education, technical excursions, planning models, climate impact models, climate scenarios, observation system)
- sea level rise impact effect analysis
- support to the design documentation development
- starting to work on Second National Communication

The applications is planned to be submitted for the funds from GEF and other potential donors for setting up of the climate Program. The capacity building must not cause lagging behind the implementation, thus the maximum support is necessary for already started activities while concurrently searching for new projects. The study research should specifically focus on the biomass projects on which the available information is insufficient.

To encourage implementation, the demonstration projects and programs and pilot projects should be used, which asks for creation of incentives to support the National Energy Action Plans and other measures in industry, forestry and agriculture. The operational plan for implementation of the Climate Program shall detail the implementation method. The support is given to urgent realization of the projects in preparation or those nearing realization, such as the projects planned to be co-financed by GEF, Project for Removing Barriers for Implementation of Energy Efficiency in Households and Services Sectors, Renewable Energy Resources Project and Energy Efficiency Project.

The priority in implementation is given to the measures with the lowest costs, while respecting the criteria specified in Section 5.2.1.

5.2.2.6 Kyoto Protocol Mechanisms of International Collaboration

The Kyoto Protocol provides the possibility for the countries to meet their commitments by implementing "domestic" measures and, additionally, by applying the joint implementation (JI) mechanism, clean development mechanism (CDM) or emission trading (ET). The JI and ET are mechanisms applicable between the countries, which are the parties to Annex I, while CDM is the mechanism applicable to countries to parties not included to the Annex I to the Convention. The parties may use JI and ET only if they set up an internationally verified national emission inventory system as defined under the Kyoto Protocol.

The Croatia's Kyoto mechanism implementation strategy depends on how the base year issue will be resolved for Croatia.

At this moment, when the baseline year for Croatia has still not been determined, Croatia should be very careful with possible JI arrangements. The emission reduction costs need to be taken into consideration, and they indicate that the cost of the most of the measures is more than 10 USD/tCO_2eq. Possible JI projects should be connected with the measures that have other positive and currently favoured effects, such as waste management, forestry measures, industrial measures that contribute to the production increase and introduction of new technologies, agricultural measures, and the bioenergy projects.

So far, the JI projects should be used to encourage implementation of the measures, to cover different types of measures and demonstration projects on which valuable experience could be gained. However, no significant exchange of the ERUs has been permitted. Thus, it is necessary to adopt new knowledge shortly and prepare technical documentation to support the decision-making process. It is of particular importance to determine the baselines for determination of the ERUs is reccomended. The project preparation, verification and implementation procedure needs to involve domestic professional capacities to the maximum extent. It should be born in mind that a wrongly determined ERU credit will "become due" in 2008, since that is the year in which the assigned (sold) emission is added to the Croatian quota, so the "blown up" ERU today might damage the integrity of the planned "domestic" measures.

Considering the implementation of the CDM, Croatia might be interested in investment in the countries, which are not parties to the Annex I.

Croatia's position is that the major portion of the emission reduction could be achieved with the domestic measures, and the ratio between the domestic and Kyoto mechanism measures is still the matter of negotiations under the Kyoto process.

One of the priorities is determination of the baselines and stipulation of rules for approval, evaluation, verification and monitoring of JI projects.

The emission trading marcet should be monitored for strategic reasons, particularly regarding creation of the common EU electricity market. So, it is useful that HEP has already got involved in international pilot programs, such as EWP program of EURELECTRIC and Climate Program of REC/WRI.

5.2.2.7 Implementation Instruments

There is no such an approach that could be considered best for implementation of the measures, since it mostly depends on the national situation. Thus, the international community now refers to the "good practice" instead of the "best policy", since the good practice integrates a number of different instruments for the policy implementation. The instruments can be economic, fiscal, legislative, voluntary and based on information, education and research.

The Croatian priority is reorganization of the energy sector that asks for removal of the market imperfection in prices of individual energy sources, both on the primary energy and on the demand side.

When selecting measures, special care should be paid not to disturb the market relations and competitive capacity. Therefore, the general principle should be that of the "polluter pays", based on the emission and external costs.

Table 5-1: Major instruments for implementation of the greenhouse gases emission reduction measures

	Instrument	Sector	Implementation
I1	Setting up actual energy market	energy	energy sector reform
I2	CO_2 emission charges	energy	payment for carbon content in fossil fuel
I3	Charges on greenhouse gases emission, products and raw material causing greenhouse gases emission	industry	charges on emission, quantity of goods and raw material
I4	Incentives for renewable energy	energy	soft loans, competitive capacity incentives, import and tax relieves
I5	Incentives for energy efficiency measures	industry	soft loans, import and tax relieves
I6	Eco-labeling and sales of "green" energy from renewable sources	energy	"green energy" certification
I7	Clean production initiatives and Environmental Management System introduction	energy, industry	soft loans, import and tax relieves, product price incentives
I8	Setting up target limit values per sectors and sources	energy, industry, waste management, agriculture, forestry	burden sharing based on measures economic efficiency and cost-benefit analysis, considering initial status regulating share of renewable energy in power generation
I9	Setting up local greenhouse gases market	all	defining basic concepts, trading regulations and emission inventories
I10	Defining conditions for JI projects and international trade	energy, industry, waste management, agriculture, forestry	defining basic concepts, trading regulations and emission inventories
I11	Voluntary agreements	power generation industry, agriculture	building partnership in setting up objectives and implementation measures
I12	Promotion of sustainable integrated planning on all levels–Agenda 21 principles implementation	all sectors, local administration	Introducing Strategic Environmental Impact Study development obligation, national and local Agenda 21 program
I13	Education, information, promotion	all sectors	Education and public promotion program, Access to information on technologies, measures, possibilities of banking sector involvement
I14	Encouraging demonstration and pilot projects and programs	all sectors	Removing barriers, grants, co-financing
I15	Encouraging research and development of new technologies	all sectors	Grants, co-financing, support to technology transfer
I16	Encouraging domestic production of "climate-friendly" technologies	all sectors	Grants, loans, information, cross-linking of actors
I17	Regulating conditions for waste thermal treatment and landfilling	waste management	Regulation and instructions on waste-to-energy projects
I18	Defining sustainable development of agriculture	agriculture	Strategy and Implementation Program development
I19	Control over organic and mineral fertilizers application	agriculture	regulations
I20	Encouraging reforestation and sustainable projects in energy and forestry sectors	forestry	projects co-financing, demonstration projects and programs

In building the policy for implementation of the measures in Croatia, priority should be given to the instruments shown in Table 5-1, which is an open list in which the activities are not presented in order of their valuation.

The first measure is introduction of realistic pricing and competitiveness in the energy market. The energy sector reform is in progress, and it will be implemented on the basis of six recently passed laws (Section 6.1.2). The Croatian Power Company is concurrently undertaking its structural adjustment towards unbundling of production, transmission and distribution of electricity.

The mechanism that needs to be urgently introduced is the CO_2 emission charge. The most practical approach is taxation of fossil fuel in proportion with its carbon content. At the same time, development of CO_2 emission-trading system should be initiated along with defining the rules for JI arranged between the local and international partners. The funds raised through the charges should be used for capacity building, incentives, and encouragement of the demonstration "good practice" projects and programs, granting of soft loans and co-financing of the projects.

A condition underlying successful implementation of the climate program is stipulation of objectives as per sectors and incorporation of those objectives and implementation mechanisms into the sector strategies, plans and legislation. It is necessary to develop a method for transfer of commitments to individual industries and emission sources.

Education, informing and public awareness arising need to be continuous, with maximum participation of NGOs, and the priorities are given in Section 10.

To establish a favourable environment for implementation of the measures, it is important to increase the interest of the banking sector to invest into the climate change mitigation projects. This will only be possible if the long-term objectives and state incentives are transparent and the energy market stability ensured.

Some measures which might be direct barriers to the project implementation should be removed urgently in the preparation stage, even if *ad hoc* solutions are to be used for of demonstration and pilot projects and programs, in order to gain valuable experience for the full implementation projects.

5.2.2.8 Involvement of Local Communities into the Program Implementation - Local Agenda 21

The Framework Convention on Climate Change is related to the general sustainability principles as defined in the Agenda 21, the document on development and environment adopted in 1992 in Rio de Janeiro. Since many problems and solutions originate from local activities, participation and collaboration of the local communities is one of the crucial factors in fulfilling the objectives. Local bodies of a city administration build and maintain the economic and social infrastructure, along with the environmental protection infrastructure. This being the administrative level closest to the population, local communities have the vital role in education, mobilization and solution finding when it comes to fostering of the sustainable development.

Since the basic objective of Climate Change mitigation program is to achieve specific objectives of emission reduction, pursuant to the sustainable development principle, a logical priority step is setting up of an directed program for implementation of the Local Agenda 21 principles as defined under the Section 28 of the Agenda 21. The Local Agenda 21 program should offer a vision of sustainable development of the local communities and aim at achieving understanding and application of the global context on individual decisions. The objectives may be achieved only if there is a coordinated partnership on local, regional, national and international level.

Some cities and actors in Croatia have already got involved in Local Agenda 21 initiatives on the European or global level. An establishment is proposed of the Croatian Local Agenda 21 program that would be a focal point integrating interests of numerous cities and local communities. There are numerous successful examples worldwide that confirm benefits, the support may be sought form the relevant United Nations programs, the United Nations Development Program (UNDP) and the United Nations Environmental Program (UNEP), and other international programs and associations.

5.2.3 Measures as per Sectors

General on Available Measures

Below, the objectives and measures for emission reduction as per sectors are described. This objectives need to be included the sector strategies and programs, therefore each sector or entity the program encompasses, should develop its own strategy and program for operational implementation. It should be noted that the indicated emission reductions are the target values, sometimes even the maximum achievable values, while in some cases the realistic potentials are presented. Without focusing on target figures at the moment, each sector or entity contributing to the greenhouse gases emission should show it is making a progress, which means they should initiate preparation and implementation of the projects.

The measures described below have been prepared on the basis of aggregate analysis of individual sectors, and further analyses should be based on “bottom up” approach.

The basic criterion used in selecting priority actions and measures and adequate instruments for their implementation is economic efficiency of a measure. This means that generally the priority is given to a measure that incurs lower cost per avoided emission unit. In addition to the cost efficiency criterion, a number of other factors, equally or even more important than the economic, may need to be taken into consideration. The Table 5-2 is an overview of the valuated significance of individual criterions, according to the results obtained during the workshop for Program preparation and confirmed in public consultations.

Table 5-2 indicates that the criterion under 1, the accompanying economic benefit, has been attributed more importance than the cost of avoided emissions. The employment issue is particularly prominent at the moment. It should be fully incorporated in planning of policy and implementation of measures.

The next sections will give a more detailed elaboration of measures as per sectors, their potentials will be expressed same as the potentials, costs and instruments available for their implementation.

Table 5-2. Valuation of measure selection criteria, grades 1-5 (1- negligible, 5-very important)

	Criterion	Average
1	Cost-benefit ratio for national economy - GDP increase - employment rate increase - import/export balance - increase in technical capacities of domestic production	4.8
2	Greenhouse gases reduction efficiency compared to investment	4.2
3	Compliance with national development plans	4.2
4	Information availability - on technologies - on program implementation costs	4.2
5	Implementation potential under Croatian conditions	4.0
6	Co-ordination with other environmental objectives - reduction of other detrimental matter emission - reduction of other environmental impacts	3.5
7	Arises public awareness of respect for quality of life and environmental benefits	3.3
8	Socio-economic impacts	3.3
9	Permanent sustainability of option	3.3

5.2.3.1 Energy Sector - CO_2 Emission Reduction

5.2.3.1.1 Power Generation Sector

The measures in the power generation sector have been taken from the Analysis of Possible Greenhouse Gases Emission Reduction at Hrvatska Elektroprivreda (EKONERG, 2001). Since this study has been developed concurrently with preparation of the National Communication, and is not completely finished, its results need to be taken as preliminary. The total analysed potential in power generation is shown in Fig. 5-2.

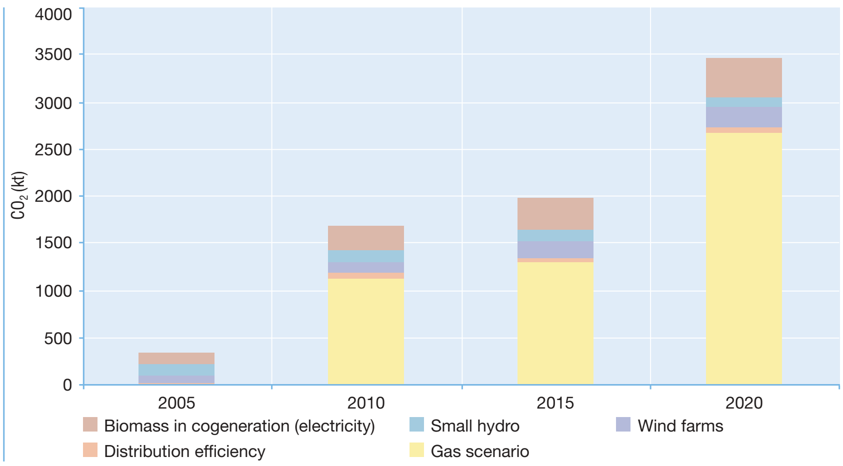


Fig. 5-2.: Potential greenhouse gases emission reduction in power generation sector

Gas Scenario for the Power System Development For the purpose of the analysis of reduction of greenhouse gases emission from the power generation sector, two scenarios are observed. In the first, the baseline scenario, the development of power system is based on the need to diversify the analysed energy forms used in power generation, which involves a significant share of coal along with already high share of liquid fuels and natural gas. The presumption for the second scenario was a construction of the natural gas-fired instead of the coal-fired thermal power plants (TPPs). The hydro-electric power plants construction rate would remain the same for both scenarios. It should be noted that the shown construction rate for the hydroelectric power plants (HPPs) is to be regarded as optimistic.

Baseline Scenario - S1 This scenario examines the development of the power system by the lowest-cost method, taking into account the reliability of energy sources supply. It presumes the inclusion of various criteria, not always simple to quantify, such as: world gas and coal reserves, price stability, transport facilities for providing adequate quantities of energy sources, storage facilities for energy sources, how realistic is the gas introduction scheme implementation, etc. Those criteria could at certain rate give coal an edge over the gas, all in the period 2005-2010. These are only some of the problems, which together with conventional namely technical and economic ones must be taken into account in power system development planning.

Hence, this scenario envisages putting into operation the two coal-fired thermal power plants with capacity of 500 MW in years 2010 and 2020. Other plants, which should meet the power demand, would be the combined-cycle gas-turbine thermal power plants (1,700 MW) and the hydroelectric power plants (378 MW).

Total installed capacities under the baseline scenario-S1, expressed in MW_e, for the years 2000, 2010, and 2020 are shown in Table 5-3.

Table 5-3: Total installed capacities (MW_e) under baseline scenario

	2001	2005	2010	2015	2020
HPPs	2061	2101	2184	2376	2439
TPPs – liquid fuel	952	952	927	355	0
TPPs – natural gas	377	677	977	1442	1942
TPPs – coal	315	315	815	815	1210
Nuclear power plants	332	332	332	332	332
Total	4052	4392	5250	5335	5938

"Gas" Scenario - S2 This scenario presumes construction of natural gas-fired instead of coal-fired thermal power plants. By the year 2020, a total of 2,300 MW in new combined-cycle gas-turbine thermal power plants is expected to be available. Same as in the baseline scenario, this scenario envisages intensified construction of the hydroelectric power plants.

A possible problem in implementation of this scenario is supply of sufficient gas quantities. About 1,345 million m^3 of natural gas will be necessary already in 2010, and 2,660 million m^3 in 2020.

The emission avoided by implementation of the gas scenario is the result of changes in the fossil fuel structure (Table 5-4).

The emission reduction calculation has considered only the direct emission of greenhouse gases, i.e. the emission from burning of the fuel in power generation rather than entire cycle (emission from the fuel production, transportation and storage, emission from the manufacture of materials used in power plant construction and the like).

Table 5-4: Change in fossil fuel consumption structure under gas scenario, PJ

	2010	2015	2020
Natural gas	18.9	21.1	42.7
Liquid fuel	1.7	0.5	0.0
Coal	-23.9	-25.8	-51.9

Power Generation, Transmission and Distribution Efficiency Increase
Increase in efficiency of fuel energy conversion into useful electrical energy can be achieved by a series of technical measures implemented in thermal power plants, on boilers, turbines and auxiliaries. Increase in efficiency is usually connected with upgrading of the existing facilities, extension of operating life and refurbishment of the complete facility. Since the efficiency of the existing thermal power plants is rather satisfactory, and considering their age and planned phasing-out by the year 2015, along with the comparatively high costs of additional activities, this measure has not been evaluated as attractive for the CO_2 emission reduction.

The losses from the power transmission network have been maintained during the last ten years at 3 to 3.7 percent of the total power output. Considering the configuration, spatial distribution of the generation facilities, the war-inflicted damages and outdated equipment, the losses could be taken as satisfactory. Reduction of the losses is a continuous task of the HEP, and it will be fostered regardless of the climate plan requirements. Additionally, it would have no economic justification compared to another measures.

The technical losses from the distribution network are evaluated at 5 to 5.5 percent. Hence, by exercising good practice, the loses could be reduced to approximately 1 percent. These measures demand high additional investment, for reduction of losses from the existing network, which is usually not cost-effective.

Energy Conservation by the Demand-Side Management (DSM) These measures are described in the sections on energy consumption in services and household sectors.

Low-Carbon Fuel Use The most important of all the measures is the earlier described "gas" scenario. Other measures include substitution of the liquid and solid fuel with natural gas in the existing thermal power plants. Technically highly feasible measure is use of gas in thermal power plants using dual fuel (gas/fuel oil). Switching (from coal to gas) of other power plants, namely Rijeka and Plomin TPPs, demands construction of the gas mains. The major problem in implementation of these measures is supply of sufficient gas quantities, since not even the very optimistic projections of the domestic production and import envisage quantities sufficient for implementation of these measures. Considering the available quantities, it would be economically viable to use the gas in modern combined-cycle facilities with 50 percent higher efficiency. Thus, these measures that result in about 1,250 kt CO_2 in 2010, are not shown in the table of measures (Table 5-4).

Wind Energy Use The research conducted so far has singled out 29 sites for the wind energy harnessing at the Adriatic. The feasibility of the potential use depends on the size of the wind plants and their consolidation (wind farms). The unit capacities of 250, 500 and 750 MW enable the output ranging from 380 to 800 GWh/year, with total installed capacity of 195 to 380 MW. If the complete capacities were used, 1.5 to 3.2 percent of the power demand in 2020 could be covered.

The potential for use of the seaborne wind is estimated to another 170 to 250 GWh/year, which is 0.7 to 1.0 percent of the power demand in 2020.

In the emission reduction estimate, it is optimistically assumed that 50 percent of the coastal zone potential will be harnessed in 2010. It must be noted that the potentials are based on very limited data, since no detailed mapping of the Adriatic was made for harnessing of the wind potential, which is one of the research priorities. Further, the environmental impact studies point to the impact on birds and aesthetic pollution for which some of the technically feasible sites are questionable for use.

The cost estimates show that the emission reduction by implementation of this measure is relatively more expensive than implementation of most other measures, so its launching would demand considerable incentives.

Intensified Construction of Hydroelectric Power Plant Total potential of the waterpower in Croatia is estimated to approximately 20 TWh a year. Technically feasible is approximately 12 TWh, and 6.2 TWh is already used. Opening of possibilities for harnessing of the unused water potential of the border rivers will depend on coordination of the Croatian interests with those of the neighboring countries. Part of the available potential may remain unused because of the environmental and other problems, so the realistic long-term estimate is that about 3.0 TWh a year may be harnessed in new hydroelectric power plants.

The baseline scenario envisages construction of the hydroelectric power plants with total capacity of 378 MW, i.e. startup of one facility every third year. It should be born in mind that this reduces the emission compared to the scenario combining the "coal/gas" thermal power plants (1:1, for new plants) by 1,100 kt CO_2 in 2010, and as much as 2,200 kt CO_2 in 2020.

Additionally, the construction of small hydro-electric plants was considered. There are records of 699 possible stretches for waterpower harnessing in small hydro plants on 63 streams in Croatia. Approximate total potential installed capacity could be 177 MW, and the power generation potential is about 570 GWh. If the stretches at small gradients are excluded, it is realistically assumed that about 350 technically feasible stretches are available. This number will further reduce because of the local town-planning and environmental requirements. If only 200 stretches were used, and about 160 GWh of power generated, the CO_2 emission would be reduced by 117 kt in 2010.

Waste- and Biomass-Derived Power Biomasa je obnovljiv izvor energije, jer korištenjem biomase za gorivo ne dolazi do emisije stakleničkog plina ako se promatra ukupni ciklus: prirast drvne zaBiomass 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. lihe, spaljivanje biomase i upijanja CO_2 asimilacijom. Naime, drvo sadrži oko 50 posto ugljika koji se emitira pri izgaranju u obliku CO_2, ali se ta količina opet veže u biomasu.

The biomass can be of wooden, non-wooden or animal origin. The biomass needs to be pretreated for its use in power generation, which includes the biomass collecting, preparation for transport and utilization.

Here, the estimate is given of possible utilization of the biomass generated as a byproduct and waste in forestry and agriculture. The presented figures do not encompass the energy farms (farms of the fast-growing trees, energy grass, algae and sugar-beet).

It should be underscored that the biomass use evaluation in determination of the theoretical potential, is technically feasible, but its economically justified use is highly uncertain. The biomass use has significant socio-economic and environmental consequences, which should be accounted for in the potential assessment. High uncertainties are already encountered in determining the existing quantities of fuelwood, since the official data do not correspond with the “field” data. The information on energy supply in particular Croatian regions point to a much higher use of fuelwood than the official records from the forestry management show. Today, the agricultural waste use is not practiced. This should be born in mind when considering the data given below, and it indicates the need for urgent research into this issue and its clarification.

Here, only the summary values are given from the HEP’s study (EKONERG, 2001), which assessed the biomass on the basis of the results obtained by the national energy program BIOEN and other studies.

During the period 1990-1995, 12 to 16 PJ of fuelwood was used, which is about 6 to 7 percent of the total primary energy in Croatia (14 PJ in 1999). It is assumed that the 17 PJ value could be reached by the year 2020, and 20 PJ by 2020. This is the fire biomass in the form of stacked wood for energy, faggot wood and cutting and wood processing waste.

The usable potential in agriculture, in the form of **animal husbandry biogas**, could be 2 to 4 PJ, and **corn remains** could amount to 12 to 22 PJ. The differences arise from different agriculture development scenarios, where the higher figures correspond with the scenario of the “economically efficient” agriculture and gradual increase in plant production and animal breeding.

Total usable biomass potential from **forestry and agriculture** is 35 PJ for the baseline scenario, 41 PJ assuming the most probable scenario of the agriculture development, and 46 PJ for the efficient agriculture scenario.

This potential may be used in households, small boiler houses, industrial boiler plants or cogeneration plants. The optimum proportion of harnessing and probable implementation schedule need to be determined. Here, it is assumed that 50 percent of possible additional potential in forestry and 30 percent in agriculture will be in use by the year 2010, and 100 percent in forestry and 70 percent in agriculture by the year 2020. It is also assumed that 40 percent of additional potential will be used for cogeneration. The biomass-fired cogeneration plants should contribute to reduction of the CO_2 emission from power generation in the amount of equal to the generated power, and the reduction in the energy consumption sectors (mainly households) equal to the generated heat quantity.

Nuclear Power Plants Construction The nuclear option, namely construction of two 660 MW power plants by the year 2020 was considered within the analyses carried out for the Draft Energy Strategy for the Republic of Croatia in 1998. In the light of the European policy, short deadlines for implementation of this option, and negative public attitude, confirmed through the public consultations on this Communication, the nuclear option is for the time being considered unattractive for the first commitment period from 2008 to 2012. Considering the fact that currently construction of 1000 MW units is considered optimum, the issue is arising of incorporating of such a large unit into the power system so small as the Croatian is. At a certain point, Croatia was very serious about continuation of nuclear power plants constriction after completion of the 730 MW Krško Nuclear Power Plant owned jointly by the Republic of Croatia and the Republic of Slovenia.

5.2.3.1.2 Industry

The total potential of the analyzed measures related to the fuel consumption in industry is shown in Figure 5-3.

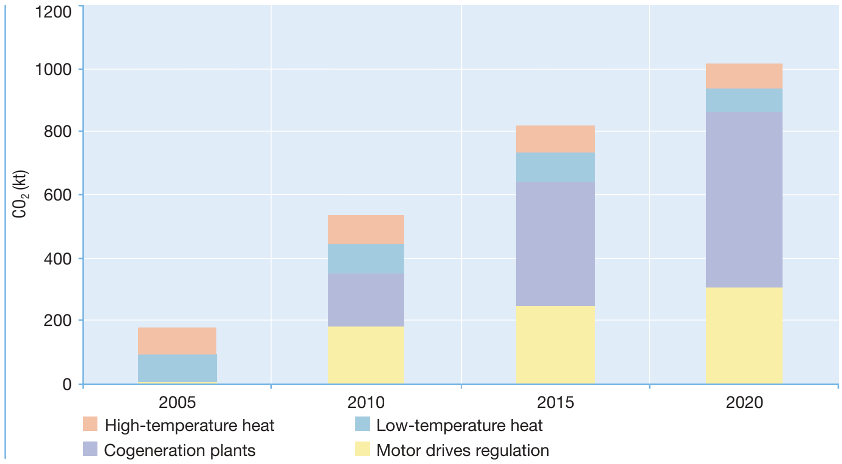


Figure 5-3: Potential for greenhouse gases emission reduction in industry

High-Temperature Heat Generation Efficiency Increase High-temperature heat is mostly used in building material industry, paper industry, non-metal and chemical industry. This measure assumes introduction of new and more efficient technologies, and it is best visible as the improvement of conversion of fossil fuels to useful heat. The baseline scenario envisages a gradual replacement of the old with new and/or newer technologies, while the *mitigation scenario* sees the technology replacement rate as more intensive. In that way, the overall degree of conversion of fossil energy forms into the high-temperature heat in the *mitigation scenario* is about fifteen years ahead of the conversion degree in the baseline scenario.

The difference between presumed efficiencies causes different consumption of final fossil fuels, whether the measure is implemented or not. The potential for fossil fuels consumption reduction is not very significant and ranges from 1.4 percent of total electricity consumption in industry in 2010 to 0.4 percent in 2030.

Low-Temperature Heat Generation Efficiency Increase Almost equal share of low-temperature and high-temperature heat is characteristic for the Croatian industry. The low-temperature heat is mostly used in non-metal, chemical and food processing industry, which, therefore offers more room for introduction and intensive use of process efficient plants, like in case of the high-temperature heat. Unlike the rate at which new technologies for direct fossil fuels combustion are introduced, introduction of the low-temperature technology will be somewhat slower. So, the *mitigation scenario* envisages five to ten years of intensified introduction of new and high efficiency technologies. The expected savings might be from around 2.1 percent in 2005 up to 0.4 percent in 2030. This is because at the end of the observed period and in the *baseline scenario*, the conversion efficiency gets closer to the desirable level set in the *mitigation scenario*.

Industrial Cogeneration Plants Given the fact that cogeneration capacities are more efficient because of the combined generation of heat and power, the industries, particularly those that use more low-temperature heat, have noteworthy potential for construction of small cogeneration facilities and saving of a certain amount of fossil fuels because of increase in efficiency.

In order to estimate the contribution of a cogeneration plant, it should be compared with other thermal power plants under the condition that the heat and power generation is the same. The use of the industrial cogeneration plants will be instrumental in reducing heat and power generation in separate processes, i.e. generation of heat in boiler plants and of electricity in thermal power plants. The calculation presumes that the cogeneration plants and the boiler plants use natural gas as fuel, and that the thermal power plants use mixed fossil fuels with the mix structure that changes for different years. In that way, this measure includes the fuel substitution effects, i.e. the natural gas fired in cogeneration substituted the fuel oil and coal burned in the boiler plants and thermal power plants.

Industrial Electric Motors Efficiency Improvement One of the most-well known measures which can be instrumental in boosting the electricity efficiency is regulating of the motor drives in industry because in Croatian industry, similarly to the industries all over the world, about 90 percent of electricity for non-heat purposes is used for motor drives. The estimate is that possible savings are up to 7.5 percent of electricity, so that figure is set up as an objective in the *mitigation scenario*. In that way it would be possible to conserve energy and save from 254 GWh in 2010 up to 487 GWh in 2020.

Biomass Use in Industry Use of biomass in industrial facilities, both in cogenerations and the heat generating facilities, carries a large potential for emission reduction. This Communication analyzes the total biomass potential that is further simplified by its division into the power generation sector potential when the cogeneration plants are considered, and the household sector for the facilities generation only heat. Thus, the reduction potential of the industrial facilities is not presented separately.

5.2.3.1.3 Transport

Total potential of the analyzed measures for the transport sector is shown in Figure 5-4.

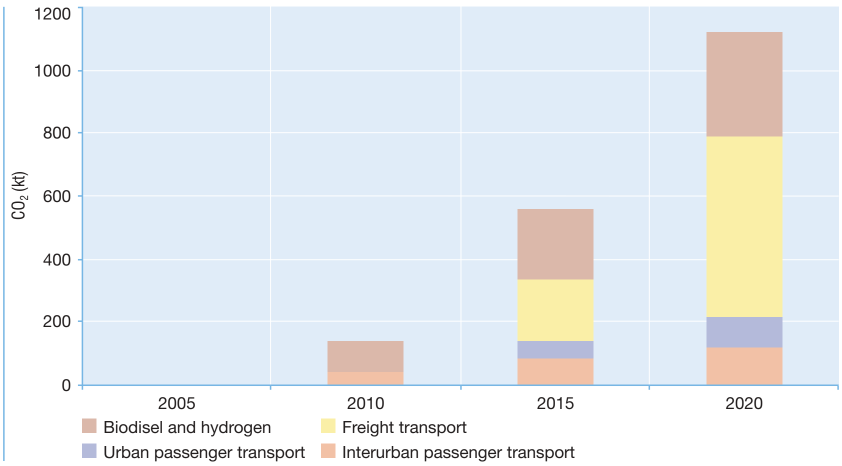


Figure 5-4: Potential for greenhouse gases emission reduction in transport

Interurban Passenger Transport The greenhouse gases emission reduction potential in the inter-city traffic is considerable, as will be shown, and it is the result of the changes in passenger-kilometer structure. It should first be noted that the population mobility is equal in both scenarios. So, in this planning period the passenger-kilometer structure changes in a way that the share of the passenger cars is decreasing while the buses and trains, i.e. mass public transport would increase its share. By 2010, these changes would not be so visible, while up to 2030 the share of passenger cars in interurban passenger-kilometers would drop from 85 to 65.8 percent, and the buses share would rise from 7.8 to 15.4 percent. Equally, the participation of railway traffic would increase from 4.6 to 13 percent by 2030.

Urban Public Transport The structure of the urban public transport would experience a change similar to the interurban passenger traffic structure. It means that the passenger cars share would decrease and urban public transport share increase. More significant changes are expected only after the year 2010, and until 2030 we can expect the fall in the passenger cars share from 46 to 30 percent. At the same time, it means equal growth of the urban public transport.

Freight Transport Similar to the passenger transport, we expect to see more substantial changes in freight transport beyond the year 2010. The share of lorry traffic is relatively falling and the share of railway traffic is rising. The structure of railway traffic will be subject to some changes. After 2010, the electric-driven railway traffic will increase its share while the diesel-driven traffic will decline. Hence, until 2030, we should expect the decreasing of lorries share from 36.3 percent in the baseline scenario, down to 26 percent in the *mitigation scenario*, and the proportional increase of the railway traffic share. Further, until 2030 we should expect the rise in electric-drive portion from 80 to 85 percent, and the diesel-engine portion decline.

Biodiesel and Hydrogen Introduction of biodiesel and hydrogen is covered by the BIOEN and TRANSCRO national energy program. Gradual supplementation of motor fuels with biodiesel and hydrogen is expected beyond 2005 according to both the mitigation and baseline scenario. The mitigation scenario envisages faster rate for introduction of these fuels in the motor fuels market, so the increase in use of 0.8 PJ and 0.6 PJ for biodiesel and hydrogen, respectively, is expected in the year 2010 in comparison with the baseline scenario, and total increase by 4.6 PJ is expected by the year 2020. Increased use of these fuels decreases the demand for motor oil and diesel fuel, and results in CO_2 emission reduction (about 330 kt in 2020).

5.2.3.1.4 Services Sector

Total potential of the analyzed measures for the services sector is shown in Figure 5-5.

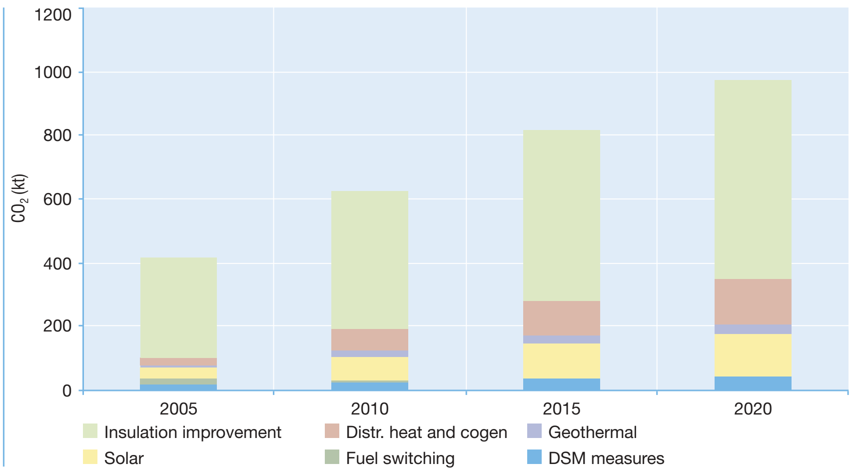


Figure 5-5: Potential for greenhouse gases emission reduction in services

Fuel Switching Greenhouse gases emissions can be considerably reduced by a simply performed fuel switching from liquid fuel to natural gas. In the baseline scenario the services use 5.026 PJ of liquid fuels and this amount is slowly falling towards the end of the analyzed period. The liquid fuel share in meeting the energy demand in the services sector is 20 percent. The declining rate of fuel consumption towards the end of the planning period is almost negligible and primarily depends on available quantities of some other energy forms, which could be used as substitutes. At the moment, a very intensive gas introduction campaign is ongoing in those Croatian regions where natural gas was not available before. Meanwhile there is also an intensive upgrading of the existing gas networks. The liquid fuel burners replacement is an additional costs and there is no possibility for return on investment into the existing burners *(sunk cost)*. Nevertheless, this measure is foreseen only in that section of services sector where major works are not required and where the investments in new devices will not be necessary. Also, this measure is envisaged for those parts of the sector where it will not be possible to build in cogeneration systems either centralized or de-centralized ones, or another devices using the renewable energy (sun, geothermal energy, etc). It means that this measure is envisaged only for the exiting service sector coverage where the connection to natural gas system is feasible.

Higher Share of District Heating and Small Cogeneration Energy conservation is best achieved in the cogeneration plants, generating both heat and power. The district heating systems participate in meeting the total useful heat demand in the services sector with around 12.4 percent. In the baseline scenario the quantity of thermal energy from the district heating systems remains constant throughout the planning period. Small cogeneration systems envisaged in the baseline scenario grow by an average annual rate of 8.9 percent to reach 2 PJ in 2030. In the *mitigation scenario*, the heat generated in the district heating systems grows at the same pace as the small cogeneration output. The potential for higher use of cogeneration plants is envisaged mostly in hospitals, state and other administration buildings, hotels and commercial molls.

Solar Energy The solar energy use potential is the most significant in the coastal counties, and especially favorable conditions for its use are in the services sector of this Croatian region.

The *baseline* scenario envisages that about 3 PJ of thermal energy will be obtained from solar energy in 2030, while the *mitigation scenario* plans about 5.5 PJ of solar energy in the same year.

Geothermal Energy Croatia has a centuries-long tradition of using geothermal energy from natural sources for medical purposes. The thermal gradient of the Croatian geothermal sources is much higher than the European average and the overall geothermal energy potential of discovered sources is 812 MW_{th}. Besides many spas where the geothermal energy is manly used for baths, there are two locations where geothermal energy surfacing from deeper wells has its energy-related use. In future we should expect the use of geothermal potentials mostly in hospitals and some hotels located in the vicinity of wells. The potential of wells gives total of 0.7 PJ of heat energy in the *mitigation scenario* in 2030, which indicates that the overall geothermal potential is not relevant.

Thermal Insulation Improvement The total floor area of premises in the services sector is estimated to around 25 million m^2. Until 2030, it is estimated that the floor area will be doubled. Here, it should be kept in mind that the specific heat consumption by m^2 in newly built floor area is much lower than in the existing premises. It means that the improvements of thermal insulation in the services sector relate to the already existing floor areas. The *baseline* scenario envisages the thermal insulation improvement in the existing premises by about 15 percent in relation to the initial status by the end of the planning period. The mitigation scenario foresees an additional improvement of about 10 percent until the end of the planning period.

Comparatively high marginal costs of this measure are the result of high investment costs compared to the achieved energy savings.

DSM Measures in Non-Heat Electricity Use In addition to being heat-intensive, the services sector is equally highly intensive user of non-heat electricity. Given the sector's intensive development we can count on potential reduction in non-heat electricity use, primarily with introduction of low-energy bulbs, substitution of the existing freezers and refrigerators with more efficient ones, introduction of better motor drive regulation and air-conditioning and finally, introduction of the information technology for demand-side management in complex buildings (hospitals, hotels, banks). The overall savings potential is estimated to around 24 GWh in the beginning and to around 50 GWh at the end of the planning period.

5.2.3.1.5 Residential Sector

Total potential of the analyzed measures for the residential sector is shown in Figure 5-6.

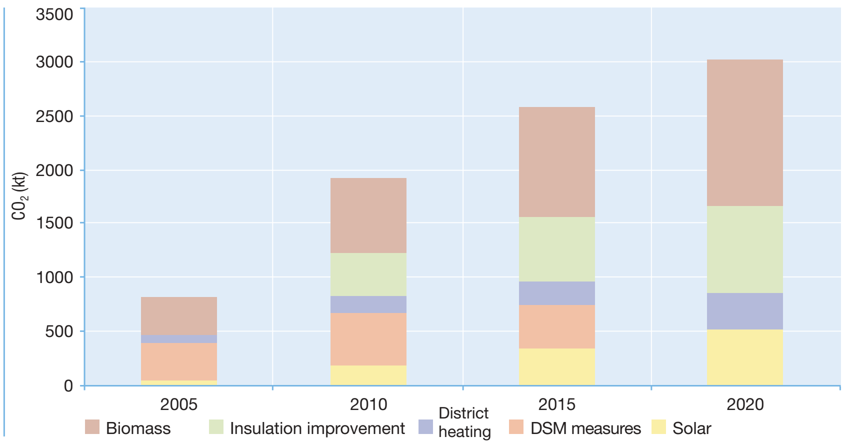


Figure 5-6: Potential for greenhouse gases emission reduction in residential sector

Thermal Insulation Improvement In order to assess the potential of reducing greenhouse gases emission by improved insulation in households in Croatia, we should start from the fact that the housing stock of Croatia is rather old. Out of 1.6 million apartments 26 percent is over 50 years old, while almost 30 percent is 30 to 50 years old. On the other hand, it should be kept in mind that less than half of floor area in these apartments has quality heating. In the future, it can be expected that floor area in old apartments with quality heating will increase so, knowing that about 60 percent of useful heat used by households is consumed for space heating, it can be estimated how much useful heat will be consumed in the next thirty years. Based on various studies, the potential for insulation improvements in old apartments is estimated, given the assumption that new apartments will be built using the latest technologies with modern and efficient insulation, so the insulation improvement refers only to old housing stock.

The analysis of thermal energy demand has shown that by 2030 the heat required for apartment heating will grow almost twofold compared to 2000. Having in mind the possibility of 30 percent insulation improvement, total useful heat would by 2030 decrease by about 15 PJ in comparison with the scenario that does not include insulation improvement. However, the *baseline* scenario envisages the insulation improvement of 10 percent. So, the additional improvement in the *mitigation scenario* refers to the additional 20 percent of insulation improvement, which makes the total useful thermal energy for space heating lower by about 10 PJ in relation to the baseline scenario.

Total reduction of final energy forms use by this measure is about 8.6 percent of the total consumption of final energy forms by households. The potential reduction of greenhouse gases emission is rather good and amounts to 400 to 800 kt, pending on the year observed.

District Heating Share Increase Similar to services, the household sector has good conditions for connecting to the district heating systems to meet the apartment space heating and hot water preparation demand. Due to a better efficiency compared to the conventional combustion systems, a more intensive development of the district heating systems will improve the overall efficiency of the energy system enabling savings of the final energy forms, especially the fossil fuels. A more intensive use of the district heating systems enables saving of about 6.3 percent of the overall final energy from the baseline scenario

Solar Energy Use The solar energy potential in the seven coastal counties is very high. The biggest potential of solar energy application lays in water and space heating. This *mitigation scenario* gives estimates, based on the so far carried studies, of savings in final fossil energy forms as well as of electricity, achieved primarily by the solar energy use for water and space heating.

DSM Measures in Households (Low-Energy Bulbs and Refrigerators)
As in the services, a significant portion of total electricity consumption in households goes to the no-heat purposes. In order to encourage and calculate the potential of electricity savings by DSM measures, the model of introducing low-energy bulbs and refrigerators in the households has been worked out. The potential of electricity consumption trimming ranges from 93 GWh at the beginning of the observed period to almost 600 GWh at its end. In case of low-energy bulbs introduction the marginal costs proved to be exceptionally favorable, as is the case in the services sector, while the marginal cost of energy saving refrigerators is also favorable but is not negative.

Energy Efficient Buildings Croatia has long experience in design and construction of buildings in which the passive and active energy conservation measures are implemented. Such construction integrates numerous measures and it is, as a rule, cheaper than when individual measures are separately introduced (insulation of buildings, solar energy, heat pumps and the like). Additional possibilities and costs of such building practice need to be determined.

5.2.3.1.6 Energy Sector Measures Summary

A summary of measures in energy sector is presented in Table 5-5, and in Figs. 5-7 and 5-8. Among the presented possibilities, the highest insecurity is related with the biomass utilization. Since this is a considerable potential, it is a priority to determine actual possibilities for biomass exploitation in the power generation and all other sectors with direct energy consumption. The biomass projects should be linked with the forestry and agricultural projects and implementation of sustainable energy solutions where use of biomass from forestry and agriculture is possible.

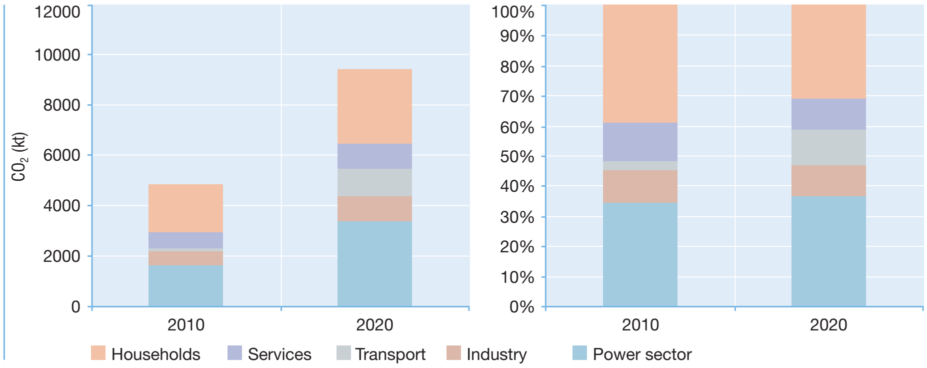


Figure 5-7: Share of energy sectors in CO_2 emission reduction potential in energy sector

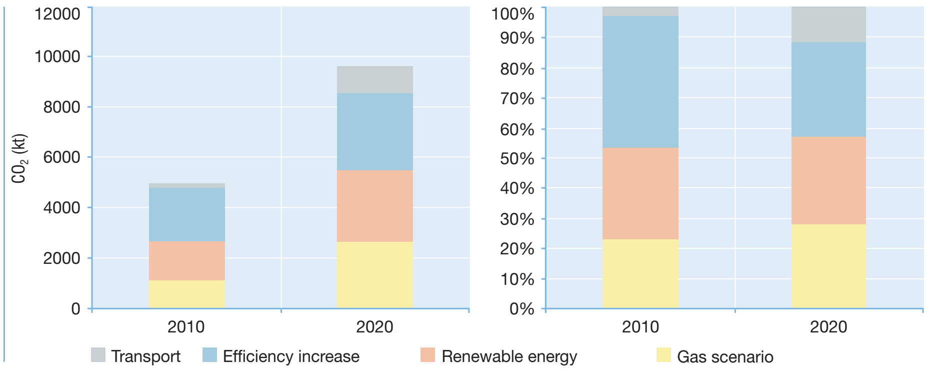


Figure 5-8: Share of individual groups of measures in potential for reduction of CO_2 emission from energy sector

The curve of marginal costs of the emission reduction in energy sector is shown in Figure 5-9. The marginal costs are calculated as the difference between the equivalent annual costs of the reference solution (or scenario) and the mitigation scenario. Thus, for example, the wind power plants pricing considers the difference between the power generation cost and the average power generation cost from the

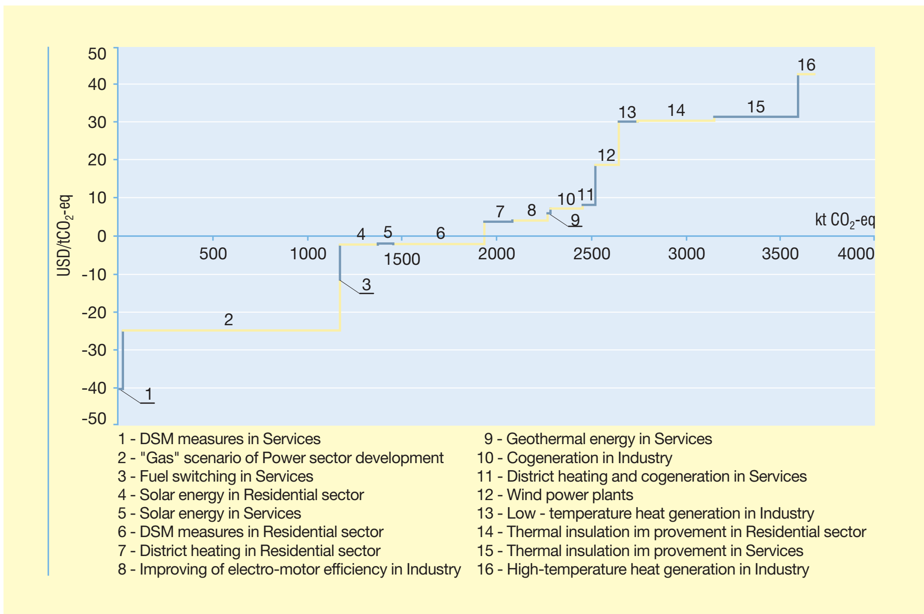


Figure 5-9: Curve of marginal costs of emission reduction in energy sector

Table 5-5: Overview of CO_2 (kt) emission reduction in power sector for 2010 and 2020

Energy sector measures	Possible policy instruments	Mitigation potentional CO_2 (kt)	
		2010	2020
Power generation			
Gas scenario	- CO_2 emission charge - emission quotas regulation - technical guidelines and standards - renewable energy incentives - eco-labeling - voluntary agreements - construction-related administrative procedure simplification - public promotion	1135.5	2666.9
Savings in power transmission and distribution		47.4	56.3
Wind power plants		126.6	219.0
Small HPPs		117.4	101.6
Biomass use in cogeneration (for power generation)		251.8	431.4
Industry			
Motor drive regulation	- CO_2 emission charge - realistic fuel prices parity - measures introduction incentives - voluntary agreements - regulating emission quotas per sectors	186.3	309.1
Cogeneration contribution		163.4	549.7
Low-temp heat generation efficiency increase		97.7	81.4
High-temp heat generation efficiency increase		87.3	75.9
Transport			
Interurban passenger transport measures	- CO_2 emission charge - traffic planning and regulation - incentives for public traffic improvements - biodiesel production subsidies - Local Agenda 21 - public promotion	39.4	117.4
Urban passenger transport measures		0.0	96.5
Freight transport measures		0.0	569.6
Increase in biodiesel and hydrogen use		99.2	326.0
Services			
Electricity savings for non-heat purposes (DSM)	- ESCO companies incorporation incentives - realistic power prices - public promotion	25.1	42.9
Fuel switching (natural gas – liquid fuel)	- emission charge CO_2 - gas introduction incentives	2.3	0.0
Solar energy use increase	- technology introduction incentives - information accessibility and public promotion - domestic industry capacity building	79.1	137.7
Geothermal energy use increase		17.1	28.2
District heating and cogeneration use increase	- fuel prices parity - emission charge CO_2 - grid interconnecting regulations - investment encouragement	70.3	147.5
Thermal insulation improvement	- financial incentives - regulations and standards	441.6	637.2
Residential			
Solar energy use increase	- technology introduction incentives - information accessibility and public promotion - domestic industry capacity building	196.4	527.6
Electricity savings for non-heat purposes (DSM)	- ESCO companies incorporation incentives - realistic power prices - public promotion	482.2	0.0
District heating use increase	- energy planning - realistic price parity	146.6	332.8
Thermal insulation improvement	- financial incentives - regulations and standards	401.9	803.2
Heat-from-biomass (cogeneration + boiler plants)	- emission charge CO_2 - renewable energy subsidies	698.6	1353.6
Total potential		**4913.2**	**9611.5**

thermal power plants park in the baseline scenario. The calculations used the discount rate of 8 percent, and the methodology from the Economics of Greenhouse Gas Limitations - Methodological Guidelines (UNEP, 1998).

The expenses should be taken as given for orientation only, since the calculations have not been based on actual data of the projects implemented in Croatia.

5.2.3.2 Industrial Processes

During the period 1990-1995, the share of industrial processes in total greenhouse emission in the Republic of Croatia was 11 percent. On average, 82 percent of the total emission from this sector is from manufacture of the nitric acid, ammonium and cement. Until 1991, when the Sisak Steel Mill and Šibenik Aluminum Industry were closed down, share of these processes in the emission has been more than 92 percent.

Possible Emission Reduction Measures

Ammonia Production For development of the baseline scenario for ammonia production, it was assumed that the production would recover its full capacity of 1,350,000 tonnes by the year 2010. This means that the consumption of mineral fertilisers in Croatia in the observed future period shall recover to the average level from the period 1986-1988, i.e. 650,000-700,000 tonnes, and the rest will be placed on foreign markets. It has been assumed that the structure of the final product will be 23 percent of urea, 25 percent of KAN and 52 percent of NPK fertiliser.

According to the present level of the technology development, there are no measures that would enable reduction of the CO_2 emission from ammonia production.

Nitric Acid (HNO_3) Production The nitric acid production directly depends on production of individual types of mineral fertilizers. It is estimated that the production could reach 305,000 to 345,000 tonnes by the year 2010.

The N_2O emission reduction measure undertaken in the nitric acid production consists of use of non-selective catalytic reduction (NSCR) which uses N_2 to reduce N_2O. The marginal cost of implementation of this measure can be evaluated to 1 USD/t CO_2eq, which makes this measure very attractive. First, the detailed emission measurements need to be carried out in the plant, since the standard IPCC factors are used in calculation.

Cement Production Generally, there are two types of measures for CO_2 emission reduction in cement industry:

1. Energy-related mitigation measures, encompassing:

- changes in the production process type (switching from "wet" and "semi-wet" to "dry" and "semi-dry")
- increase in the process energy efficiency (reduction in heat and power consumption per the produced unit)
- switching to fuel with lower carbon content (switching from coal and petrol coke to natural gas or fuel oil)
- use of fossil waste as alternative fuel (car tires, plastics, waste oil and solvents and the like)

2. Process-related measures (non-energy related mitigation measures), encompassing:

- reduction of the clinker content in cement (increase of other ingredients/additives)
- removal of CO_2 from the process flue gases

The feasibility analysis for individual emission reduction measures demands familiarity with the current conditions prevailing in the cement industry. There are four cement plants in Croatia - three producing clinker in "dry" process, and one using purchased (imported) clinker. The heat consumption rate in clinker production, as the process energy efficiency indicator, was between 3.26 and 4.48 GJ/t during the period 1990-1999. In clinker production, all types of fuel are used, however the fuel oil and natural gas predominate. It should be noted that all cement producers want to switch to coal and petrol coke as the basic fuel in clinker production, primarily because of their lower price. Waste as alternative fuel is used on a smaller scale in one of the cement plants. The clinker percentage in cement ranged from 68 to 88 percent during the period 1990-1999.

All the cement producers in Croatia use the "dry" procedure for clinker production, which is the most fuel effective. However, the heat consumption rate in clinker production does not compare with the best available practice results, which range between 2.9 and 3.2 GJ/t. The planned switching to coal and petrol coke as fuels with higher carbon content is not favourable from the greenhouse gases emission aspect, although it should be underscored that coal and petrol coke currently make about 81 percent of the total fuel consumption in the European cement industry.

Thus, the applicable greenhouse gases emission measures could include:

a) Increase in energy efficiency of the clinker production process

b) Switching to fuel with lower carbon content

c) Decrease of the clinker percentage in cement

d) Use of fossil waste as alternative fuel

The increase in energy efficiency of the clinker production process by decrease of energy consumption per ton of product is a measure incorporated in the baseline scenario because the increased process efficiency is primarily aimed at increase of the product competitive capacity in the market, rather than exclusively at the greenhouse gases emission. Removal of CO_2 from the flue gases, as the emission reduction measure, is still in the research stage, and it is not certain whether it will prove feasible for the cement industry.

Currently, Croatia has no instruments that would regulate the greenhouse gases emission either specifically from the cement production or from industry in general. Switching to fuels with lower carbon content is exclusively related to the fuel prices in the market. This measure envisages gradual switching to the fuel with lower carbon content, i.e. substitution of the current consumption of coal, petrol coke and fuel oil with natural gas in all the cement plants. It should be noted that this switching reduces only the emission from the energy-related segment of the clinker production, while the non-energy-related emission remains the same. This measure could result in emission reduction of up to 265 kt CO_2. The price of switching depends mainly on the fuel price difference and less on the investment into new equipment.

At the moment, the only process-related measure that can be applied to the CO_2 reduction is production of cement with lower clinker percentage, which reduces total production of clinker. The projections, which would take this measure into consideration, are unsafe since the cement industry products range primarily depends on the market demand. The percentage of clinker in the cement differs for different cement plants, and it ranges from 68 to 88 percent. Approximate data can be given that reduction of clinker by 1 percent results in reduction of CO_2 emission from the process by 5.2 kg CO_2 per ton of cement.

The measure (d), which is very attractive from the environmental standpoint, has not been considered for the time being since there is no sufficient data on the quantity of waste that could be cost-effectively turned into power in the cement industry.

5.2.3.3 Waste Management

Possible Methane Emission Reduction Measures and Scenarios In addition to the measures from the baseline scenarios (waste avoiding and recycling), other possible measures for reduction of methane (CH_4) emission from the waste management sector correspond with the current technology development level in the developed countries and include various thermal treatment procedures based on the waste-to-energy processes, which bring double benefit as regards the greenhouses gases emission reduction:

- The greenhouse gases, carbon dioxide and vapor are the products of the thermal waste treatment. Their global heating potential is considerably lower than that of methane.
- The energy derived from waste reduces the quantity of fossil fuel necessary for generation of that energy, and consequently the carbon dioxide emission from combustion.

The main thermal treatment procedures used for municipal and similar waste include:

- **Incineration** of waste in waste-to-energy plants in which both heat and power are generated (cogeneration). Considering the number of constructed and planned facilities, this is the most widespread thermal municipal waste treatment technology. The waste-to-energy plants are often called the "waste incinerators" which thermally treat waste without energy generation; they are today generally not used for the municipal waste treatment.
- **Co-firing** of the waste-derived fuel and fossil fuels in large industrial furnaces, such as rotary kilns for production of clinker or the boiler furnaces of the coal-fired thermal power plants. This is an attractive solution because of relatively low costs but the conflict of interest and process-related problems have prevented its wider implementation so far. In Croatia, this process is mainly used for thermal treatment of the process waste. An example is the Koromačno Cement Plant, which co-fires the used car tires and waste oil.
- **Pyrolysis** of the municipal waste is a procedure under development, with only a few demonstration plants in developed countries, and it should find no application in the developing countries in due time.

As can be concluded from the above, the best option for Croatia in the near future is the use of the waste-to-energy plants as tested technology for thermal treatment of municipal and similar waste for larger cities and regions.

The described methane reduction measures have been used as the basis for development of three reduction scenarios for the methane emission from the waste management sector, as shown in Table 5-6.

Table 5-6: Methane emission reduction scenarios

Scenario	Thermal treatment share (%)	
	2010	2020
S4 - “mini-thermal”	20	40
S5 - “midi-thermal”	35	70
S6 - “maxi-thermal”	50	100

All three scenarios for the methane emission reduction in the waste management sector include, in addition to the thermal treatment, intensive implementation of measures of waste avoiding and recycling of separately collected waste, including the aerobic and anaerobic composting of separately collected biowaste. For the described scenarios of the methane emission reduction, with the presumed share of the waste thermal treatment from Table 5-6, the quantities of landfilled untreated and thermally treated waste are calculated, and the methane emission reduction expressed in equivalent quantities of carbon dioxide (eqCO_2), as shown in Table 5-7.

Table 5-7: Methane emission reduction by thermal waste treatment

Scenario /Year	*S4*		*S5*		*S6*	
	2010	2020	2010	2020	2010	2020
Disposed untreated waste (1000 t) and flaring	1,200	1,000	1,000	500	750	0
Thermally treated waste (1000 t)	310	670	510	1,170	760	1,670
Total (1000 t)	1,510	1,670	1,510	1,670	1,510	1,670
Methane emission reduction (1000 t eqCO_2)	280	441	490	772	700	1,103

Table 5-7 shows the methane emission reduction in comparison to the baseline scenario. Each of the solutions assumes that the methane released from waste is flared, while the portion that is intended for power generation is used in a cogeneration plant, which reduces the fossil fuel consumption (fuel mixture for the power generation sector in the baseline scenario).

The major emission reduction is achieved under the “maxi-thermal” scenario S6, under which all generated waste would be thermally treated by the year 2020. Theoretically, this means that the landfill gas (methane) emission would be completely eliminated by 2020, which is less realistic than other emission reduction scenarios. The cost estimate for these measures shows that the costs of the emission reduction scenarios S4, S5 and S6 range from 11 to 18 USD/t CO_2, considering only reduction of the methane emission from the landfills. If the resulting reduction of the fossil fuel emission caused by use of waste is also considered, the cost of 7 to 11 USD/t CO_2 puts this solution among very attractive measures since it also resolves other environmental problems.

5.2.3.4 Agriculture

In agriculture, the following measures have been considered:

a) Energy-from-agricultural biomass

b) Improvement in application of organic and mineral fertilizers aimed at nitrous oxide (N_2O) emission reduction

c) Reduction in methane (CH_4) emission by decreased fermentation

d) Anaerobic fermentation related to decomposition of organic manure and biogas generation

e) Carbon storage in agricultural soil.

These measures are briefly described below, and the effects of the measures are summarized in Section 6. The measure under (e), carbon storage in agricultural soil is very efficient but it is still not considered in the international analyses, so it will not be presented here although the preliminary assessments have already been made.

a) Energy-from-agricultural biomass

Use of biomass from agriculture in energy generation is described in the section covering the energy sector.

b) Improvement in application of the organic and mineral fertilizers aimed at nitrous oxide (N_2O) emission reduction

Organic Agriculture Za održavanje plodnosti tla neophodno je voditi računa o prometu organske tvari u tlu. Organska gnojidba je nezamjenjiva u održavanju plodnosti tla, i to ne samo zbog sadržaja hranjiva. Plodnost tla u intenzivnoj biljnoj proizvodnji uvjetovana je, između ostalog, i s pravilnom primjenom organskih i mineralnih gnojiva. Istovremeno, usmjerenost na biološku poljoprivredu, koja traži samo organsku gnojidbu podrazumijeva i odgovarajuću stočarsku proizvodnju.

Application of the organic fertilizers may have positive economic effects (reduced production costs) although the yield will be somewhat lower. However, it is true that the application of organic fertilizers must ensure sufficient quantity of biogenic elements if the yield of the grown cultures is to be achieved.

The organic agriculture usually understands lower energy consumption and lower emission of carbon dioxide and nitrous oxide compared to the conventional agriculture. This is a consequence of reduced or completely phased out application of agrochemicals, storing of the organic matter in soil, wider crop rotation, and sometimes even smaller tillage depth. According to IPCC, the organic agriculture uses by 10-15 percent less energy than the conventional agriculture.

The organic agriculture promotion in Croatia should be scientifically based. Today, the organic agriculture is often based exclusively on ruling out the application of agrochemicals, while problems remain with use of organic fertilizers, inadequate tillage, crop rotation, and doubtful plant growing practices.

Emission from Mineral Fertilizers Application The mineral fertilization in Croatia is on average lagging far behind that in the developed European countries. It has further decreased during the last decade for well-known reasons. The approach based on the demand for sustainable agriculture is certainly good, however the sustainable soil management indicators have still not been determined in Croatia. Reduction of nitrogen fertilization is not a way to reduce nitrous oxide emission from application of the mineral fertilizers in Croatia. A Good Agricultural Practice Code must be prepared and the farmers educated on adequate use of the fertilizers.

The Good Agricultural Practice Code understands high efficiency and rational use of mineral fertilizers. The Code defines the methods for preparation of the nitrogen fertilization plans. Knowledge of specific needs of individual crops, estimate of the soil nitrogen content, and the methods of application might contribute to considerable decrease in losses, and therefore reduction in nitric oxide emission.

c) Reduction in methane (CH_4) emission from animal production

The simplest method of reducing methane emission from the animal production (fermentation during digestion and manure fermentation) is reduction in total cattle stock, particularly the ruminants. However, this solution is unacceptable for Croatia since the self-sufficiency of all the animal products, with exception of the poultry meat, is significantly less than 100 percent (e.g. 72 percent for beef, 85 percent for pork, 37 percent for mutton, 70 percent for milk and diary products). Since Croatia is considerably lagging behind the developed countries considering its (per capita) consumption of the animal products, the increase in the standard of living will certainly result in increased consumption. Furthermore, increase in demand during the tourist season (about 150,00 temporary inhabitant's) results in increase in demand for food production by 10 percent over the self-sufficiency. Thus, in addition to increase in production intensity per production unit (genetic and management improvements), the number of domestic animals will grow in the future (Section 6).

Feed Improvement through Mechanical and Chemical Treatment of Cattle Feed

These treatments primarily include feedstuff with high lignin content (straw, corn stalks), that is generally not used as the domestic animal feed in Croatia. Straw and corn stalks are used as feed for low-productivity animals (ruminants and horses) or only in some phases of the production process (offspring, dry period). The straw can be chemically treated or mechanically shredded, which increases its digestibility and reduces the methane emission during the digestion. These practices are less significant for Croatia since the straw is used as bedding material rather than for the domestic animal feed. Croatia has ample natural resources (about 1.5 million ha of pastures) that are not used, although they are suitable for grazing of cows, sheep and goats. Thus, the agricultural development strategy envisages use of these resources for the milk and meat production.

Feed Improvement through Organic and Inorganic Feed Additives

The feed additives that increase the growth and activity of rumen bacteria shall increase the bacteria digestion and reduce emission of methane per production unit. The microbial growth in the rumen is limited primarily by the concentration of the ammonia, available energy, phosphor, sulfur and other minerals. To increase the microbial growth in rumen and digestivity of feed, and to ensure better supply of the ruminants with proteins, urea and molasses can be added to the feed. They increase production and reduce methane emission. Use of feed with high percentage of bypass proteins (cotton, flax, soya, and sunflower) is the practice. In Croatia, sunflower and soya grits are added in the amount of 20-40 percent.

- a) **Use of hormones** The growth hormone (bST), anabolic steroids and other preparations, such as clenbutherol and cimaterol, are used worldwide to increase production efficiency of the domestic animals. Use of these preparations is forbidden in Croatia.
- b) **Reproduction efficiency increase** Improvement in reproduction efficiency of the domestic animals can result in reduction of methane emis-

sion since the number of animals necessary for offspring production is reduced s. The techniques used in Croatia to that end include artificial insemination, estrus synchronization and embryo transfer.

c) **Rumen flora modification** Research into the rumen flora modification for more efficient decomposition of the cellulose and reduction in methane generation are topical in the world (McAllister et al., 1996). No research of this type has so far been conducted in Croatia.

d) **Manure management and procedures** Over 80 percent of all domestic animals in Croatia are kept on small family farms. The animals are mainly fed on feed produced on those farms, and the manure is used for improvement in farm soil fertility. Therefore, most of the manure remains in the cycle, but for the part lost during storage, transportation and disposal in the form of animal product. These small farms do not attract interest of the public when the environmental issues are discussed. Although the family farms generate over 80 percent of manure, they do not cause significant pollution since the manure is, as a rule, used on the farmland. On the other hand, these farms are characterized for low production, so if the pollution index is expressed as quantity of waste per production unit, than these farms can also be referred to as the environmental polluters.

Most of the large farms have built lagoons, with capacities sufficient for 6-7 months of storage. Only two farms separate the solid from liquid phase. These lagoons are mainly located on the large diary farms, and on beeflings and hog breeding farms. The diary farms have sufficient land so the produced manure is used for fertilization. Croatia has only 20 such large diary farms and their waste management procedures are rather good closed-cycle, so they do not pose any environmental issue. The situation is similar at the large beefling farms. Since Croatia has about 1,500,000 ha of pastures which are not used, the agricultural development strategy proposes that they be primarily used in meat production (beef and mutton). Thus, we should expect more intensive introduction of meat animal sorts in Croatia (today, only several hundred cows are of meet sort). The management of the future meat animal farms envisages sustainable use of pastures and organic production in some locations (Lika, Gorski Kotar). Although manure has a comparatively small share in the methane emission, good management can considerably reduce emission of the detrimental gases. This particularly applies to the manure from large hog breeding and poultry farms, that have good manure handling and storage practices but insufficient land for its optimum use. These farms could be fitted, with small investment, with the anaerobic fermentation facilities for production of biogas.

5.2.3.5 Forestry

Measures for Increase of Carbon Sequestration with Forest Biomass

Under the conditions prevailing in the Croatian forestry, regarding the habitat and structural conditions in the forests, the forest management and forestry policy, the increase in carbon stock in the existing forests could be achieved by undertaking the following measures:

a) **Reforestation of productive bare forestland**

b) **Increase in forestland surface to be cared by thinning**

c) **Including of complete second age class forests (all the forests 20-40 years of age) into the thinning**

d) **Planting pioneer wood species (Aleppo pine, Austrian pine) on the degraded forests (garique and osier-beds)**

e) **Improvement in wood utilization efficiency and increase in harvesting**

The Croatian forestry sector attitude towards the forest protection and conservation is highly developed. The forests protected under the law cover 544,197 ha or 26 percent of the total forest surface area (Matić, 1999). Private forests in Croatia that cover 19 percent of the total forest surface area, are in poor condition, primarily because of the fragmented properties (0.7 ha per owner) and low timber-growing stock per hectare (82 m^3/ha). Improvement and increase in quality of these forests is not feasible under the present economic conditions and ownership conditions. This means that any increase in carbon, stocked in these forests, is not realistic at the moment.

Reforestation of Productive Bare Forestland To increase the surface under forests, reforestation needs to be undertaken as a measure for expansion of the forests biological production-capacity. Croatia disposes of 331,000 ha of bare fertile forestland. About 30 percent of that land surface could be used for establishment of energy forests with 5-year rotation and expected increment of 12-15 m^3/ha, which gives an annual increment of 1.3 million m^3 on the surface of 100,000 ha. The remaining 231,000 ha of free surface would be used to plant the pioneer coniferous and deciduous wood species (pine, birch-tree, black alder, poplar-tree, willow, European ash, and the like). The expected increment of the cultures grown in this way is on average 8-10 m^3/ha, or 2.1million m^3 of annual increment on the entire surface. The reforestation could be carried out by 2020.

Increase in Forestland Surface to be Cared by Thinning Increase in forestland surface to be cared by thinning assumes that the present 1.7million m^3 of the timber-growing stock obtained from the previous yield or by thinning in the next period should give 2.2million m^3, which is currently the main yield. In this way, the quality would be improved, same as the biodiversity, stability and productivity of the thinned woods, and that would considerably increase the carbon stocked in the existing forests.

Including of Complete Second Age Class into the Thinning Including of the complete second age class into the thinning would result in care by thinning on the surface of approximately 225,000 ha in the forest stand with the timber-growing stock of 20 million m^3 and increment of 1.8 million m^3. The thinning would include about 0.4 million m^3 a year. This would result in increase of carbon stocked in the forests, in the trees, underbrush and in forest soil.

Planting Pioneer Wood Species on the Degraded Forest Surfaces Planting of pioneer wood species (Aleppo pine, Austrian pine) on the degraded forest surfaces (garique and osier-beds) would result in increase of surfaces under high wood by 20,000 ha. Until 2020, this would result in growing stock increase by 1.5 million m^3 and corresponding increase in carbon stocked in these woods.

Improvement in Wood Utilization Efficiency and Increase in Harvesting
When speaking about the increase in wood utilization efficiency and harvesting, it should be noted that presently 60 to 70 percent of the forest stand mature for cutting and 50 percent of the biomass from the young forests is utilized. Further, the present stacked fuelwood production is 0.85 million m^3. It is forecasted that until 2020, the stacked wood production will increase to 1.2 million m^3. The demand for fuelwood is on increase, and it may be grown in short-rotation forests. Further, utilization of brushwood (under 7 cm in diameter on the thinner end) from the regular felling must be increased. Out of the total wood biomass, 20 to 25 percent remains in wood as brushwood with leaves or needles and tips (Sever et al., 1996). The quantity changes in dependence on the wood species, age and height. In mature beech stand about 14 percent of brushwood is expected as compared to the trunkwood, in oak stand 7 percent and in firtree 18 percent. In younger forest stands and smaller size trees, share of the brushwood is considerably higher. Taking that the average brushwood share is 20 percent compared to the trunkwood

about 0.88 million m^3 of brushwood should be expected to remain on felling area during the period until 2020, and it might be included in production (Sever et al., 1996).

Another possibility for increase in share of fuelwood is utilization of the felling and primary wood processing waste. On average, felling, working and skidding waste could be accounted for with somewhat more than 20 percent of each timber stand and wood species. The expected wood waste from primary wood processing (sawmills) is 30 percent of waste from wood worked and transported from the forest to the wood working sites. The waste from the wood utilization is 1.1 million m^3 and further 0.6million m^3 of fuelwood comes from the mechanical woodworking.

Increased efficiency of the wood utilization and more intensive harvesting practices could render 1.2 million m^3 of stacked fuelwood, 0.88 million m^3 of brushwood in forests, 1,100,000 m^3 of felling and working waste, and 0.6 million m^3 of primary wood processing waste (sawmills) by the year 2020. Total calculated quantity of the biomass as fuel is 3.78 million m^3.

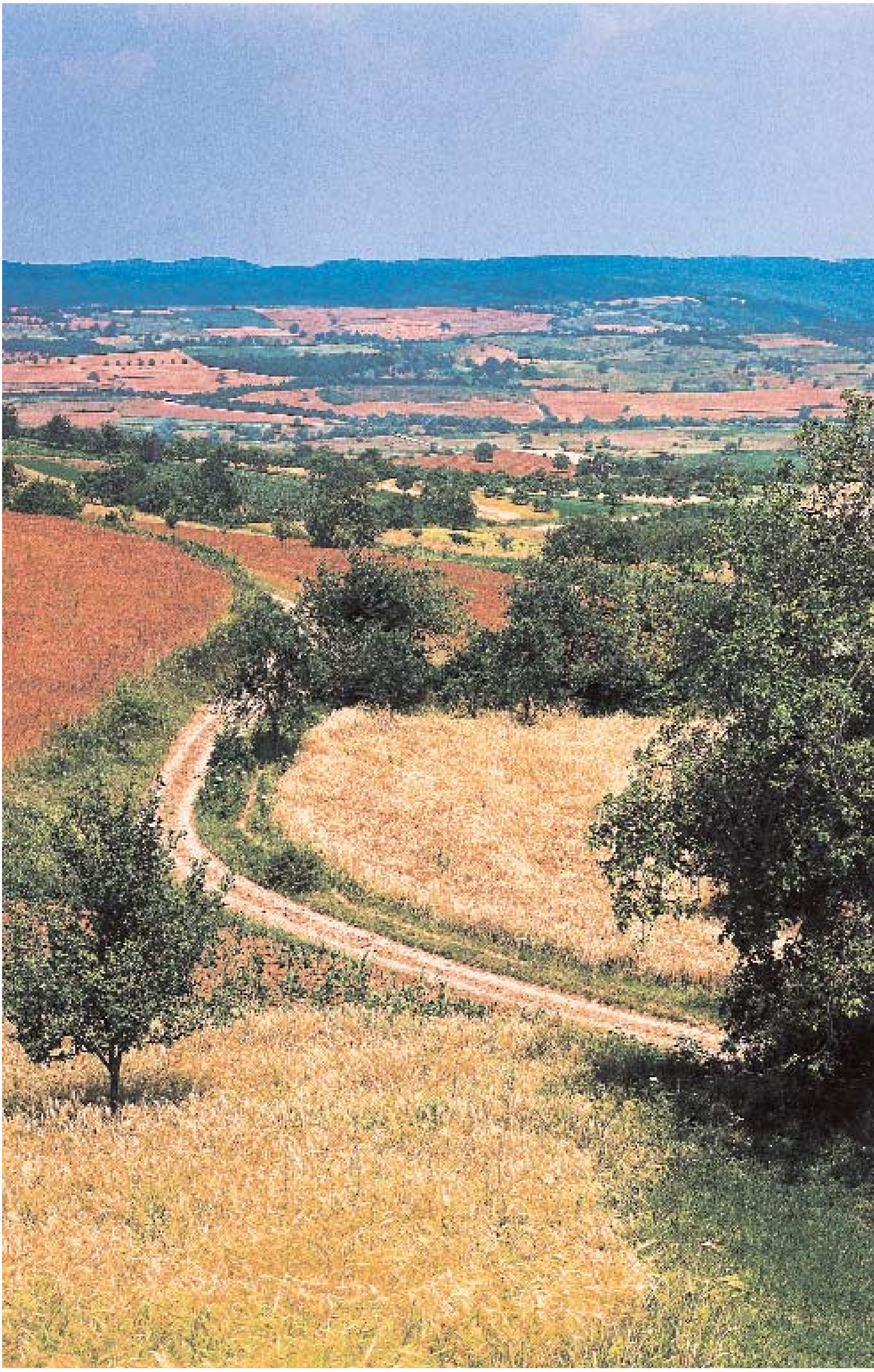
Switching from fossil fuel to wood depends on the fuelwood production in the forests. According to the current data, 25 percent of annual felling in the state forests in Croatia is stacked fuelwood, 12 percent is stacked industry wood. The average consumption of fuelwood in Croatia is 0.18 m^3 per capita.

According to the FAO estimates, the average fuelwood consumption in undeveloped countries is 0.45 m^3 per capita, and in developed countries only 0.13 m^3 (Sever et al., 1996). According to the estimates, the Croatian consumption is 0.30 to 0.35 m^3 of fuelwood per capita, thus the actual production of fuelwood would be 1.45 to 1.67 million m^3. The differences are covered from the private forests, which render wood of poorer quality and have higher percentage of the fuelwood than of the timber.

It is assumed that by the year 2020 the realized annual felling would be 4.4 million m^3 of trunkwood. Out of this quantity, 60 percent will be round timber, and about 40 percent stacked wood. It is expected that 1.2 million m^3 will be fuelwood and 0.5 million m^3 industry wood.

The produced fuelwood, along with the biomass from different wood felling and working stages, will be a significant substitute for the fossil fuels.

The emission reduction resulting from the wood biomass use for energy generation is shown in Table 5-5, Power Sector section.



Slavonia

6. Effects of Measures and Greenhouse Gases Emission Projection

6. Effects of Measures and Greenhouse Gases Emission Projections

6.1 Introduction

An overview of individual measures and their relation with the reference solutions is given in Section 5, where the alternative baseline scenarios are described. This section offers a joint summary and overview of total emission for the "baseline" and "mitigation" scenarios as a combination of different measures and sector scenarios. The presented results are summaries of studies prepared for the energy, agriculture and waste management sectors, and industrial sources.

Basic characteristics of the two analyzed basic scenarios are:

- **Scenario 01** - *baseline scenario* is based on the presumption of delayed introduction of new technologies into the business sector and insufficient support of the state to the reforms and restructuring in energy and other sectors. It implies lesser government involvement in institutional and organizational reform, lack of support for energy efficiency, renewable resources, changes in industry, agriculture and forestry, and environmental protection. The Scenario 01 does not represent a completely "frozen" status and an intention to continue the business-as-usual. It also includes the improvements that are to happen regardless of the climate change program requirements. Thus, reduction in fuel consumption is forecasted due to the technological advancement, same as the increase in share of geothermal energy and all other sorts of renewable energy. The Scenario 01 is the Scenario S-421 taken over from the Draft Croatian Energy Strategy (Granić *et al.*, 1998).
- **Scenario M1** - *mitigation scenario* assumes that the climate change and sustainable development concept shall cause significant change in orientation of the overall Croatian industry and economy. Considerable changes are expected beyond the year 2010. This scenario is a combination of measures described in Section 5, only that in cases where two or more options of a particular mitigation measure are available, those with the highest potential for emission mitigation are selected. The measures included in the Scenario M1 are described below. It should be stressed that the Scenario M1 differs from the baseline scenario not only with regard to the greenhouse gases emission but also with regard to the energy demand.

An analysis of the long-term social and economic development of the Republic of Croatia is based on the assumptions that:

- stable political solution will be found for the region,
- strategic objective of Croatia is its membership in the European Union.

According to the analysis results, it is evaluated that the GDP is to grow by approximately 5 percent in the period from 1994 to 2025. The forecasted increase would mean that in 2020 the Croatian GDP would be 3.2 times higher than in 1995, which is an increase from USD 3,873 to USD 12,464 per capita. Therefore, in 2020 Croatia would have GDP equal to the present Greek and Portuguese GDP, but still considerably lower than the European Union average. In the domestic product structure, share of services would increase from 61 to 66 percent, the secondary industry would remain at 25 percent, and the participation of agriculture would fall from 14 to 9 percent.

During the four consecutive years, from 1991 to 1994, negative population growth trends were recorded in the Republic of Croatia. Decrease in population is partly caused by the aggression on Croatia, but it is primarily a result of the long-term unfavorable demographic trends. Slow increase in population is expected after the political situation has been resolved and the society democratized. In 2020, Croatia is expected to have a population of 4.86 million, which is about 200,000 more than in 1995 and about 2 percent more than during the 1991 census (Table 6-1).

Table 6-1: Croatian GDP and population change trends

	1990	1995	2005	2010	2015	2020
GDP (USD/capita)	5,106	3,873	6,250	7,971	10,056	12,664
Population (million)	4,778	4,669	4,820	4,833	4,846	4,860

6.2 Energy Sector

The progress and all structural features of energy sector development depend on a number of influential factors. The most important are:

- Economic development
- Energy sector reform and government measures
- Development of international energy market and international influence
- Technology development
- Global environmental constraints.

Each of these factors has its extent of influence and the effects will be read as different levels of energy consumption and different structures of power generation. For comprehensive presentation of the consequences each of the factors could have, a number of the energy sector development scenarios has been analyzed. This study gives a detailed description of the baseline scenario of the energy sector development, the *baseline scenario*, amended with the greenhouse gases emission mitigation measures (*mitigation scenario*).

The historical data and energy sector development projection under the *baseline* scenario are presented using the following indicators:

- Direct energy consumption of end-users as per energy sources,
- Direct energy consumption as per typical consumption groups,

- Structure of energy sources used in electric power generation,
- Share of domestic power generation and energy import,
- where these energy indicators refer to the territory of the Republic of Croatia.

The analysis has been conducted for the expected increase in direct energy consumption of 3 percent on average. The consumption of all the energy sources shall increase, but the increase rate shall differ for individual sources, which shall cause certain changes in structure of the energy sources (Table 6-2).

Table 6-2: Structure of energy sources in direct consumption for the baseline scenario on the Croatian territory, PJ

	Historic		Projected				
	1990	1995	2000	2005	2010	2015	2020
Steam and hot water	31.9	23.5	27.5	34.3	41.1	47.4	53.6
Electricity	47.8	35.7	47.3	60.3	73.3	85.3	97.2
Gaseous fuels	30.8	28.8	41.8	56.4	70.9	79.9	88.9
Liquid fuels	111.5	83.8	102.6	118.0	133.2	150.1	166.9
Renewable resources	19.1	11.1	18.6	21.8	25.0	28.7	32.4
Coal	16.7	3.0	4	4.1	4.2	4.2	4.2
Total	**257.8**	**185.9**	**241.7**	**294.8**	**347.7**	**395.5**	**443.2**

The steam and hot water consumption should remain at almost the same level of 12 percent of total direct energy consumption. The share of electricity will gradually increase because of its consumption for non-heating purposes. The consumption of gaseous fuels will increase only to stabilize at approximately 20 percent. The share of liquid fuels and coal of low presence shall decrease. The renewable resources will slightly grow, to remain at some 7 percent.

The energy consumption in individual sectors should not undergo considerable changes, because the major structural changes have already been finished. The energy-intensive industry has significantly reduced its economic activity, so technological improvements should be expected for the future without increase in consumption of the energy-intensive consumers. The share of the energy consumption in transport shall grow to 28 percent in 2020, while the household consumption shall drop below 30 percent beyond 2010. A slight increase in participation of the building industry, agriculture and services in energy consumption is expected (Table 6-3).

Table 6-3: Structure of direct consumption per sectors for the baseline scenario, PJ

	Historic		Projected				
	1990	1995	2000	2005	2010	2015	2020
Building industry	5.9	3.0	4.7	6.6	8.4	11.0	13.5
Agriculture	14.5	8.3	9.7	11.6	13.4	14.7	16
Services	18.1	18.1	24.8	31.4	38	43.6	49.1
Residential	66.8	58.6	78.4	92.4	106.4	116.2	125.9
Others	2.3						
Transport	61.2	50.6	65.7	79.5	93.3	109.4	125.5
Industry	88.9	47.2	58.4	73.3	88.2	100.7	113.2
Total	**257.8**	**185.9**	**241.7**	**294.8**	**347.7**	**395.5**	**443.2**

The power generation should mainly remain within the public grid system which is presently under the Croatian Power Board (*Hrvatska Elektroprivreda, HEP*), while a minor share will be generated in decentralized facilities, i.e. the cogeneration plants, renewable energy and small consumers.

The power generation within the public grid system should undergo significant changes. Although construction of six new hydroelectric power plants is planned, participation of these facilities in power generation will decrease from 65 percent in 1995 to 31 percent in 2020. After the fuel oil-fired thermal power plants are out of operation (beyond 2015), the fuel oil will be phased out from the power generation. New demand and replacement of the fuel oil under the *baseline* scenario would be satisfied from the gas- and coal-fired thermal power plants (Table 6-4).

Table 6-4: Structure of fossil fuels consumption in energy sector for the baseline scenario at the Croatian territory, PJ

	Historic		Projected				
	1990	1995	2000	2005	2010	2015	2020
Fuel oil	27.7	27.7	32.9	31.1	19.8	5.8	0.0
Natural gas	17.6	7.4	10.3	23.6	26.9	47.6	47.8
Coal	6.4	2.4	21.0	20.7	41.0	41.1	60.9
Total	**51.7**	**37.5**	**64.2**	**75.4**	**87.7**	**94.5**	**108.7**

Such scenario of the electric energy sector development primarily takes into account the diversification and safety of the power system. During the period until 2010, the priority in the power generation is given to gas since it is more cost effective, and certainly more environmentally and site-wise acceptable than coal. A coal-fired thermal power plant option would become viable only around 2010, when phasing out of some existing fuel oil-fired thermal power plants would result in demand for an approximately 500 MW coal-fired thermal power plant.

So far, the energy sector development was predominantly based on the local energy resources. In 1995, the share of local resources was over 60 percent. The *baseline* scenario assumes increase in share of the energy import; at the end of the analyzed period, about 75 percent of energy demand would be covered from import (Table 6-5).

Table 6-5: Relation between the imported and local energy resources for the baseline scenario, %

	Historic		Projected		
	1990	1995	2000	2010	2020
Imported energy	40.1	36.1	49.5	66.0	74.2
Local energy	59.9	63.9	50.5	34.0	25.8

According to the baseline scenario, it is expected that about 7 percent of the energy demand will be covered from the renewable resources. This primarily includes the two traditional resources that have been used so far - water power and biomass (fuelwood). In 2020, use of geothermal energy, wind energy, solar energy and biofuel is expected to join these two.

6.2.1 Power Generation Sector

The customary model used for the long-term electricity demand forecasts in Croatia for more than fifteen years has been the standard end-use mathematical model MEDEE. The model is based on scenarios for socio-economic aspects of demand trends, and it reflects total energy demand and electricity in particular.

The elaboration of this scenario on all key electricity consumption sectors gave as a result a **baseline demand scenario**. The expected electricity demand until 2020 is shown in Table 6-6.

Table 6-6: Electricity demand growth by 2020

Year	Electricity TWh	Max. loading MW	Year	Electricity TWh	Max. loading MW
1999	14.3	2623	2010	20.4	3553
2000	15.0	2743	2011	20.9	3622
2001	15.6	2841	2012	21.4	3691
2002	16.1	2923	2013	21.9	3759
2003	16.7	3006	2014	22.5	3828
2004	17.2	3088	2015	23.0	3897
2005	17.7	3171	2016	23.4	3942
2006	18.3	3247	2017	23.9	3987
2007	18.8	3324	2018	24.3	4032
2008	19.3	3400	2019	24.8	4077
2009	19.8	3477	2020	25.2	4122

According to the baseline scenario, the electricity demand will grow by 2.7 percent a year on average, thus the electricity demand per capita would grow from 3,000 kWh in 1999 up to 5,200 kWh in 2020. It is still below the level in the developed West European countries today.

In 2020, the deficit of about 11 TWh is expected in comparison to the current Croatian power potentials. With the expected pace of phasing out of the existing thermal power plants the actual shortage in generation would exceed 15 TWh.

The Croatian Power Board has 4583 MW_e of installed power generation capacities in the facilities in and out of Croatia, out of which 33 percent or 1525 MW_e are thermal power generation capacities in Croatia. Presently, Croatia has 30 hydroelectric power plants with the overall capacity of around 2076 MW_e (46 percent) and average potential generation of about 6200 GWh. It is estimated that all hydro power plants will be operational until the end of the analyzed period. The remaining capacities (21 percent) are installed out of Croatia, 650 MW in coal-fired thermal power plants in Bosnia and Herzegovina and Serbia and 332 MW in the Krsko Nuclear Power Plant, Slovenia.

Many of the thermal power plants are more than 20 years old. At present there is no specific revitalization plan and thus, we can assume based on what we know now, that almost all existing thermal power plants will be phased out within the planning period by 2020.

Candidate Power Plants Croatia does not dispose of sufficient quantities of primary energy forms and it covers most of its demand from import. Therefore, it is clear that any development option of the generation section of the power system, no matter whether we analyze the thermal or nuclear power plants, is necessarily related to the import of those energy sources. Although most of the electricity currently generated in the thermal power plants comes from the liquid fuel-fired power plants, the power system development policy is such that it does not envisage construction of new liquid fuel-fired thermal power plants. The candidate power plants are natural gas-fired thermal power plants with capacity of 200 and 300 MW, a 500 MW coal-fired thermal power plant and a nuclear power plant of 660 MW.

The candidate hydroelectric power plants are shown in Table 6-7.

Table 6-7: Candidate hydroelectric power plants

HE	Capacity MW	Output GWh
Novo Virje	140	650
Podsused	44	215
Drenje	39	185
Lešće	40	94
Ombla	63	172
Kosinj	52	265
Total	378	1581

6.2.2 Industrial Sector

Baseline Scenario The baseline scenario of industrial development envisages some structural changes in industrial gross domestic product, aimed at lowering the share of energy-intensive branches from the present 30 percent down to 25 percent in 2030. Structural changes would be accompanied with replacing the old technologies with new ones, but at a rather slow pace and not with the technologies that represent the cutting edge of energy efficiency.

Despite the expected intensive gas introduction in the Republic of Croatia this scenario presumes relatively high electricity coverage of the heat demand, more than 10 percent in a long run. Total electricity consumption would grow faster than that of other energy sources, whereas the share of energy for high-temperature heat generation would decrease from today's 40 percent to around 30 percent, and the share of low-temperature heat would remain at the level of 35 percent. The share of coke would continue to decline.

High-temperature heat generation will be based on natural gas, oil products and coal combustion. One of the presumed results of gas introduction is faster growth of natural gas share while the liquid fuels share will slightly decline towards the end of the analyzed period. A certain decline in coal consumption for high-temperature heat generation is also expected.

Mitigation Scenario The *mitigation* scenario expects faster replacement of production machinery in the Croatian industry with more efficient technologies so that, in a long run, the heat consumption rate would be twice as low as today and the electricity consumption intensity would fall by 20 percent. Enhanced introduction of renewable resources and cogeneration in the energy market is also expected, which would enable that, in the long term, the share of electricity in heat demand falls below 8 percent.

The difference between final energy forms used to cover the industrial energy demand as shown in the reference and *mitigation* scenario shall disappear due to implementation of the measures.

6.2.3 Transport

Baseline Scenario Certain technical improvements but also different or altered structure of energy sources are expected to support fulfilling the overall transport efficiency. The customer-side demand will, in this scenario, be primarily met with motor fuels, which should reach the share of somewhat less than 94 percent in 2030. The basic fuels are gasoline with a share of almost 48 percent, diesel fuel with 37 percent, and jet fuel with slightly less than 8 percent. The electricity share should be 2.2 percent. In the period following 2020 a gradual introduction of biofuels and hydrogen is foreseen in the energy supply of customers in the transportation sector. Introduction of these fuels in this scenario is moderate, so the expected hydrogen and biofuel shares in 2030 are 1 percent and 3 percent, respectively.

Mitigation Scenario In this scenario the transport undergoes significant changes. It is presumed that an adequate transport policy would essentially change the freight transport structure. Namely, the so-called integral goods transport would allow the increase of railway traffic against the road traffic. In the passenger traffic, public transport would have bigger share in the cities, and in the interurban traffic. The structure of used energy sources would also be changed. In that way the share of electricity in this scenario would be the highest, and would amount to 4.7 percent. The shares of motor gasoline and diesel fuels would notably decline and in 2030 would be 41.6 and 31.7 respectively. The jet fuel consumption is presumed to be at the same level as in the previous scenario.

The greenhouse gases emission reduction measures analyzed in the transport sector are different from those analyzed in other energy consumption sectors. The differences primarily refer to the ways of implementing the measures. Hence, the structural changes in interurban and urban transport can occur through some administrative measures since the same effect is not possible to achieve with technical and technological improvements only. The described measures in freight transport, and partly in passenger interurban transport are the result of major infrastructural projects that, given their magnitude, represent capital investments in the country. Having this in mind it was not possible to determine marginal greenhouse gases emission costs in the way as it was estimated for other measures in other energy consumption sectors. However, what is most important is that the estimated potential of reducing energy consumption in transport sector, with the equal efficiency and equal level of passenger and freight transport effects.

6.2.4 Service Sector

Baseline Scenario The baseline scenario represents a very slow introduction of the new renewable resources technologies so that by the end of the analyzed period the solar energy share is expected to be 5.4 percent and of geothermal energy only 0.7 percent. It is also expected that share of heat generated in small cogeneration plants will grow and reach 3.6 percent in 2030.

Mitigation Scenario Unlike the baseline scenario, the *mitigation* scenario expects the improving of thermal insulation of sector's premises and the long-term reduction of thermal energy demand. The share of renewable resources and cogeneration would increase. So, the solar energy will participate with 13 percent and geothermal energy with 1.6 percent in 2030, which is much higher than in the baseline scenario. An even faster introduction of heat generated in small cogeneration plants (8 percent share in 2030) and of district heating (3.8 percent in 2030) is expected. Due to lower absolute level of energy consumption in relation to the baseline scenario, the electricity share in services will be bigger and will amount to 62.5 percent in 2030. The share of natural gas will decrease and after 2010 its decline in absolute terms is expected. A sharper decrease in the use of liquid fuels and coal, in relation to the baseline scenario, is estimated. Thus, the share of liquid fuels at the end of the planning period would be about 3 percent and the share of coal would be negligible.

6.2.5 Residential Sector

Baseline Scenario Due to increase in the standard of living, increase is expected in heat consumption for space heating, hot water preparation and some decrease in heat use for food preparation. It is also expected to see the increase in electricity use for non-heating purposes (freezers, refrigerators, washing machines, dishwashing machines, entertainment equipment, etc.).

To meet the heat demand this scenario forecasts a modest decline in coal use, stagnation in liquid fuels use, very slow increase of district heating i.e., the thermal energy from a centralized heating system, fuel wood and the most rapid rise in natural gas consumption. Foreseen is also a delayed penetration of new technologies for exploitation of renewable resources. Thus, at the end of this period, the solar energy share would be 3.6 per cent, equally to the share of heat produced in small cogeneration plants, while the share of thermal energy obtained from biomass-firing district heating plants would be 0.6 per cent.

Mitigation Scenario An organized and focused national action enables the improvements of thermal insulation of existing apartments by 30 percent on average. The solar energy and biomass shares are very high, which gives way to reduction in fossil fuels use, i.e. to stagnation in natural gas use by the end of the period.

In relation to the baseline scenario, faster decline in coal and oil derivatives use is expected, slower growth of natural gas use, and a more intensive application of new technologies (solar collectors, biomass-fired boiler plants, solar boiler plants and heat produced in small cogeneration plants). However, lower level of biomass use in individual stoves is expected compared to the baseline scenario.

6.2.6 Projection of Greenhouse Gases Emission in Energy Sector - Summary

Scenario 01 - Baseline According to the *baseline* scenario of the energy sector development, the direct energy consumption is estimated along with the energy sources consumption in the power generation sector, as shown in the above Tables 6-2 to 6-5. The fossil fuels consumption projections, obtained by application of adequate emission factors recommended in IPCC method, enabled that the greenhouse gases emission be determined. A considerable increase is expected in CO_2 emission. The highest increase is expected in the power generation sector as result of construction of two coal-fired thermal power plants, and in transport due to increase in vehicle number and mobility.

The greenhouse gases emission for the *baseline* scenario of the energy sector development, reduced to the equivalent CO_2 emission, is shown in 6-1. According to the *baseline* scenario, a dramatic increase in CO_2 emission will happen, i.e. in 2010 it will be 89 times that from 1995.

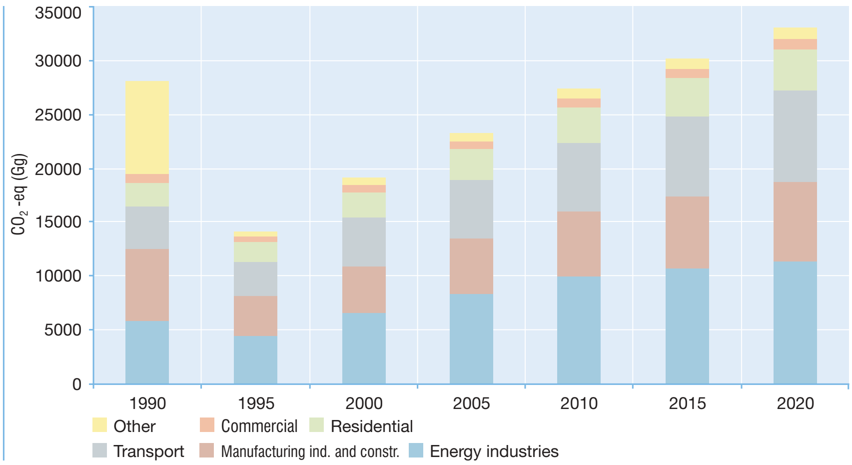


Figure 6-1: Projection of greenhouse gases emission for baseline scenario in power sector

Scenario M1 - Mitigation The projections of greenhouse gases emission for the energy sector development *baseline* scenario and *mitigation* scenario M1 are shown in Figure 6-2.

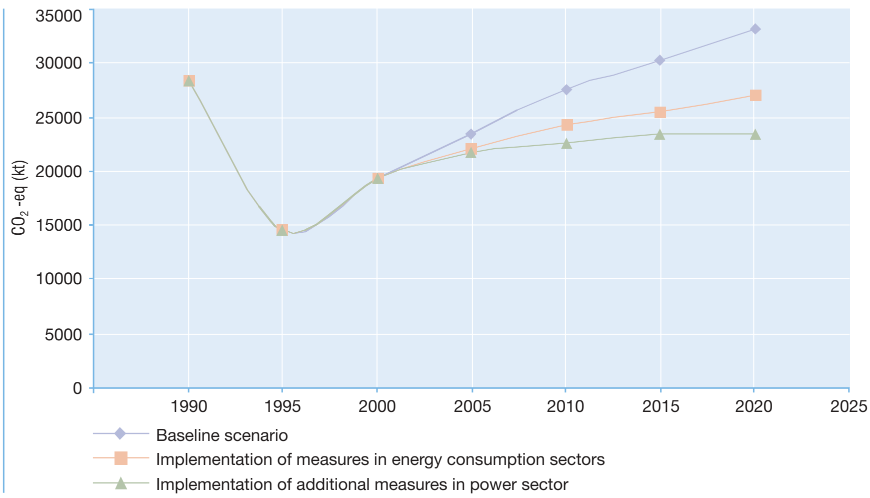


Figure 6-2: Projection of greenhouse gases emission from energy sector

The m*itigation* scenario in the figure includes all the energy sector measures shown in Table 5-5, Section 5. It should be reiterated that estimated mitigation possibility is rather optimistic and feasible only in an ideal situation in presence of incentive factors and expected social and economic development of Croatia and in considerable international support.

6.3 Industrial Processes

The projection of emission from industrial processes assumes that Croatia is not going to develop additional capacities of the energy-intensive industry and that development will be based on orientation towards secondary and tertiary sectors. Thus, it is presumed that there will be no revival of manufacture of aluminum in Šibenik and iron in Sisak Iron Mill. The industrial processes analyzed here have the major share in the emission (around 92 percent). These are production of nitric acid (CO_2), ammonium (N_2O) and cement (CO_2). The analysis does not encompass the closed down processes and the ones for which there are no realistic plans for production revival, as well as those that have negligible contribution to the greenhouse gases emission.

Several production capacity alternatives were considered for the production of nitric acid, ammonium and cement, and summary presentation is based on the baseline scenarios with the maximum production assuming return to the prewar production level. The available capacities in the industry ask for considerable import, and it depends on stabilization of the political situation in the region.

The baseline scenario used here assumes that in the near future all the cement mills in Croatia shall fire coal and petrol coke for economic reasons and increasing of their competitive capacity, which should position them on the equal footing with the majority of other cement producers worldwide. The baseline scenario for cement industry also assumes that the strive for competitive capacity shall bring about energy efficiency, so it is expected to reach the level of the Best Available Technologies (BAT) with consumption of 3.2 GJ/t by the year 2010. The baseline scenarios assume that the average weight share of clinker in cement is 0.75.

Figure 6-3 shows the structure of the greenhouse gases emission as per the baseline scenario.

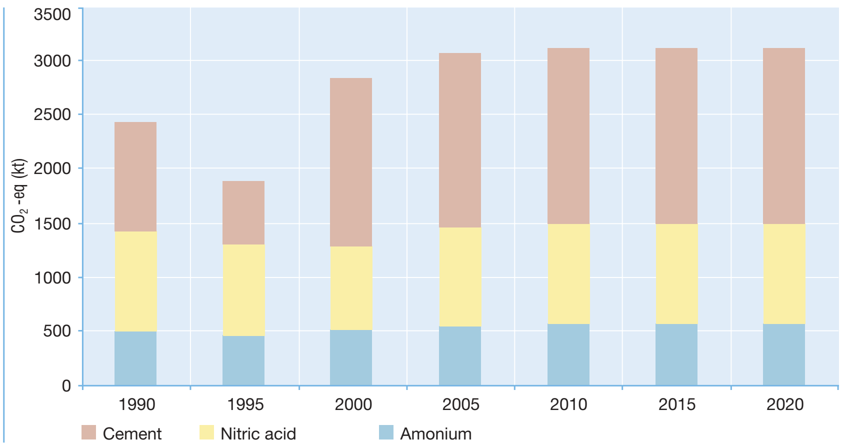


Figure 6-3: Projection and structure of the emission in the baseline scenario of nitric acid, ammonium and cement production

Presentation of the emission projection according to the *mitigation* scenario, which includes total emission from the production of nitric acid, ammonium and cement, is given in Fig. 6-3. There is no economically viable technology for mitigation of CO_2 emission from the nitric acid production; while installation of a NSCR (Non-Selective Catalytic Reduction) facility is available for mitigation of N_2O production emission. In cement production, the shown contribution to the emission mitigation is the result of switching from coal and petrol coke to natural gas and burning of waste as an alternative fuel. The emission reduction due to the modifications in the production process have not been taken into consideration at this point.

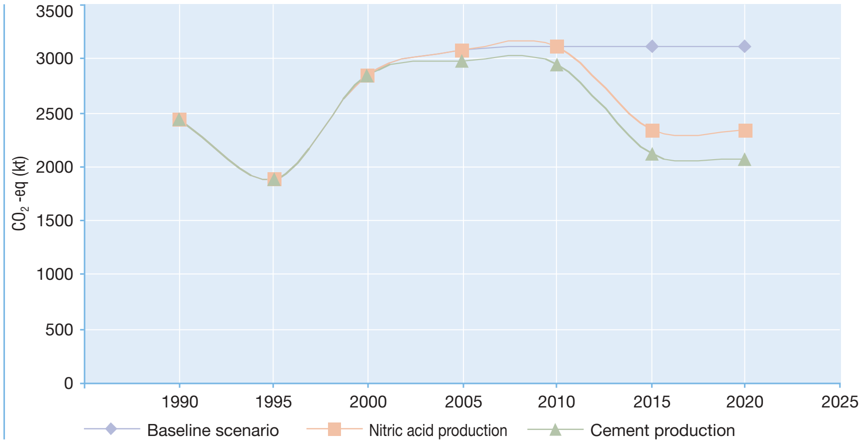


Figure 6-4: Projection of emission from the industrial processes(nitric acid, ammonium, cement)

6.4 Waste Management

Baseline Scenario

The baseline scenario for the waste management development is the projection of the situation based on the currently applicable documentation and plans, mostly ensuing from the 1992 Strategy of the Croatian Government. The baseline of the waste management is the waste tipping on engineered sanitary landfills following the economically viable and environmentally sound measures for waste avoidance, separate collecting, and recycling.

The baseline scenarios assume continuous increase in the solid municipal and similar waste caused by increase in the standard of living and size of the population, and subsequent decrease with time due to the waste avoidance and recycling measures. During the last decade, from 1990 to 2000, the estimated annual waste quantity increase was 2.7 percent. The estimated increase for the period 2001-2010 is 1.5 to 2.5 percent, and for the period 2011-2020 from 1.0 to 2.0 percent. At such increase rates, the annual waste production shall grow from 1 million tonnes in 1990 to approximately 1.6 million tonnes in 2010 and 2.0 million tonnes in 2020. This is a "pessimistic" scenario with minimum avoidance and recycling of waste; the "optimistic" scenario envisages by 20 percent lower quantities.

In 1990, the landfill gas was neither collected nor flared on the dumpsites and landfills in the Republic of Croatia. Complete elimination of the dump sites is planned by the year 2020, and all the engineered landfills shall comply with the EC Directive 1999/31/EC on landfilling, which demands, among other requirements, that the landfill gas emissions be controlled, namely mitigated. Share of the landfill, gas that could be flared or used in power generation, is estimated based on this presumption. It is assumed that 80 percent of waste will be disposed on the landfills fitted with the landfill gas collecting and flaring systems by the year 2020. It is also assumed that the gas extraction systems on the landfills could collect on average 60 percent of generated landfill gas (methane).

Mitigation Scenario

The *mitigation* scenarios analyzed three methane (landfill gas) emission mitigation alternatives (mini-thermal, midi-thermal and maxi-thermal), differentiated by the share of waste to be thermally treated in the solid waste-to-energy plants (Section 5, Table 6.2-6). It is assumed that the methane generated from landfilling of the residual waste will be flared. All three *mitigation* scenarios include intensive waste avoidance and recycling measures. The emission projection according to the "optimistic" baseline scenario and three *mitigation* scenarios is given in Fig. 6-5.

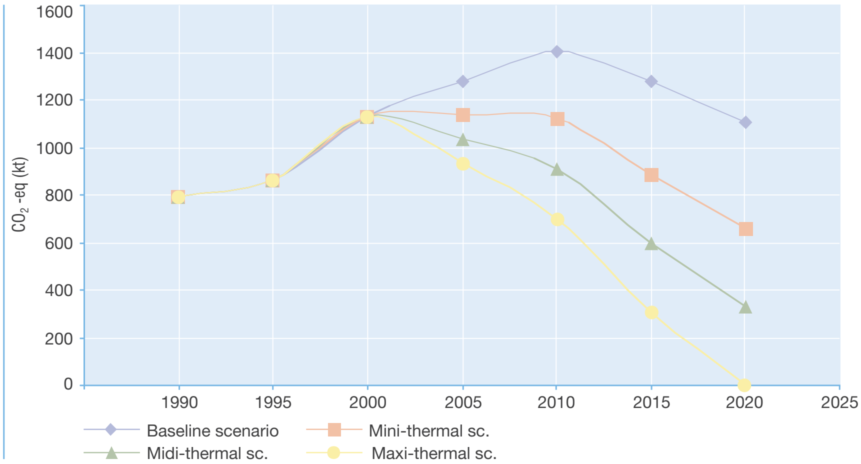


Figure 6-5: Scenarios for greenhouse gases emission mitigation in the waste management sector

6.5 Projection of Greenhouse Gases Emission in Agriculture

The projection is made on the basis of the current situation in agricultural production, and pre- and post-war trends. It is assumed that the present population increase trend (1 percent a year) will be sustained, that the GDP increase rate will be lower (2 percent beyond 2001), and that the consumption of agricultural products will increase according to the results of the research conducted by the Agricultural Economics Department (1986-1990).

For consumption forecast, the econometric model was used based on the consumer people income projection (€ 6,000 per capita), increase in present population/consumers (4,400,000) at an average annual rate of 2 percent, and coefficients of income-based elasticity of consumption known from the earlier research of the Agricultural Economics Department of the Agricultural College of the University of Zagreb. The forecast does not account for unexpected events that might cause significant disturbances in offer and demand of the agricultural products. It is assumed that in 2005 the tourist consumption will reach 150,000 conditional inhabitants or an occupancy level of about 55 million of foreign tourists, and this trend is seemly to be maintained until the end of the analyzed period.

As regards production of forage, and partly corn and cereals intended for animal feed, the animal feed demand has been calculated as per the feed units. The yield increment in the plant production by the year 2020 is accounted for as a 30 percent increase of the present standards for cattle, pig and poultry gain.

The calculation is made on the basis of an estimate that 56 to 85 percent of arable land shall be included in high-input agriculture by the year 2020.

It is assumed that the domestic agricultural production will, in the best case, remain at the present level of the self-sufficiency, which is measured as the ratio of domestic production and quantity available for overall consumption. According to the present trends and expected conditions in the future international economic integration Croatia will take part in, no significant increase in export is envisaged. It is certain that the import/export balance for the agricultural product will be relatively uniform beyond 2010, and no significant deviations are expected. The strategic objective of the domestic production in the period until 2010 is increase in self-sufficiency until the said values are achieved, followed by stabilization or small increase in the reached level.

Baseline Scenario

The production is oriented towards meeting of the lower demand level, which will be reached under the conditions of the slower increase in purchasing power and a particularly slow development of agriculture. A 25-38 percent lower technical advancement is planned measured by the plant production yield. The animal husbandry production rates, measured by the live weight gain, is about 30 percent lower. The milk production per head is relatively high, since considerable increase is assumed in larger farms share without any additional incentives (2,672 kg/year in 2020 on average). The expected cattle stock trend is shown in Table 6-8.

Table 6-8: Expected cattle heads according to the baseline scenario

	1997	2005	2010	2020
Cows and heifers	299,904	373,520	455,159	446,502
Cattle, total	442,911	593,074	674,378	644,750
Sows and in-pigs	174,828	212,435	237,132	244,176
Hogs, total	1,165,521	1,417,736	1,583,381	1,629,838
Poultry, total	9,958,673	12,370,651	12,852,142	13,339,548

Economic Efficiency

At the very best, a significant consolidation of farm land is planned, application of modern technology on 70-85 percent of arable land and over 50 percent participation of large farms in animal husbandry. As said, the increase in plant production yield is also anticipated. In animal husbandry, an expected average increase in milkiness to about 3,360 kg milk a year from about 55 percent of milking cows on larger farms. An average increase in animal breeding productivity measured by the live weight gain is about 30 percent (pork, beef and eggs production). With such structure, a well-organized production could meet a maximum domestic demand (increased by tourist demand).

All major agricultural projects (plantations, farms, processing facilities) will be highly environmentally oriented, with considerable use of sound practices for removal of the potentially harmful substances.

Most Probable Scenario (Mitigation Scenario)

The most probable agricultural production development is based on realization of 60-70 percent of presumptions from the economically efficient case. The production is focused on meeting a moderate demand to be achieved under the conditions of the slower increase in purchasing power and medium agricultural development efficiency. A 12-23 percent lower technical advancement is planned, measured by the plant production yield, animal husbandry productivity measured by the live weight gain and milk production per head (2,704 kg/year in 2020 on average).

The projection of the greenhouse gases emission for the baseline scenario, the most probable scenario and the economically efficient scenario are shown in Fig. 6-6.

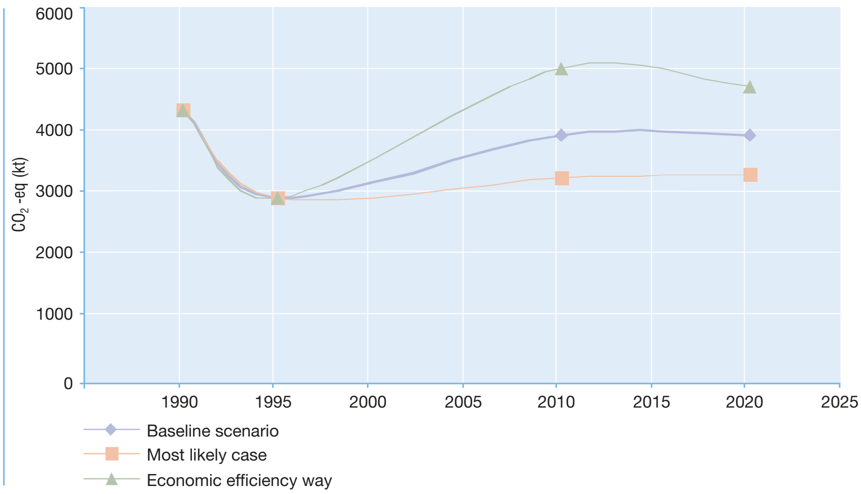


Figure 6-6: Projection of greenhouse gases emission from agriculture

6.6 Projection of Greenhouse Gases Emission in Forestry - Carbon Sequestration

The *baseline* scenario for forestry does not envisage any changes in surfaces under the forests and their structure, so the carbon sequestration remains at the present level of 6.5 million ton CO_2 per year. A number of measures described in Section 5 could result in considerable increase of carbon stock in the forest biomass, with the highest contribution being that of reforestation and better use of biomass in power generation, or use of waste wood.

Reforestation has significant environmental, economic and social value so the greenhouse gases issue is just another reason to undertake this measure. This measure does not bring short-term results and the procedure for determination of the greenhouse gases emission and sinks is very complex if the entire cycle is to be covered. That is the reason that within the Convention this issue is still undergoing the methodological analyses and discussion. For better understanding of the problem, Croatia has for a number of years participated in the international IEA program Bioenergy - Task 38 "GHG Emission Balances of Bioenergy Systems".

No significant effects of the measures are expected in the sector on Land Use Change and Forestry until the year 2010. So far, allowed level for sinks are limited by Kyoto rules and for Croatia the limitations have not yet been established. It is only highlighted that the reforestation of the free forestland on the surface area of 331,000 ha could result in an increase in the annual increment of 2.2 million m^3, which means the emission sink increase by 49 percent or 2 million tons.

6.7 Summary of Scenarios

Total greenhouses emission in the baseline scenario, and contribution of individual sectors, are shown in Fig. 6-7.

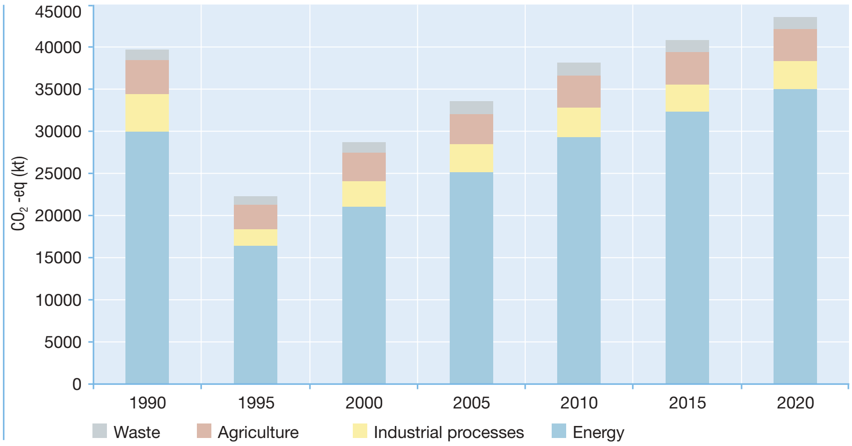


Figure 6-7: Total greenhouse gases emission according to the baseline scenario

It must be noted that the projection has not been detailed for individual sub-sectors, such as: fugitive emission from fuels, some less important industries, and emission from human secretion. Their contribution to the total emission was about 9 percent in 1995, and the baseline scenario projection assumes that the emission from these sub-sectors is at the 1995 level.

Total greenhouse gases emission mitigation potential is shown by sectors in Fig. 6-8.

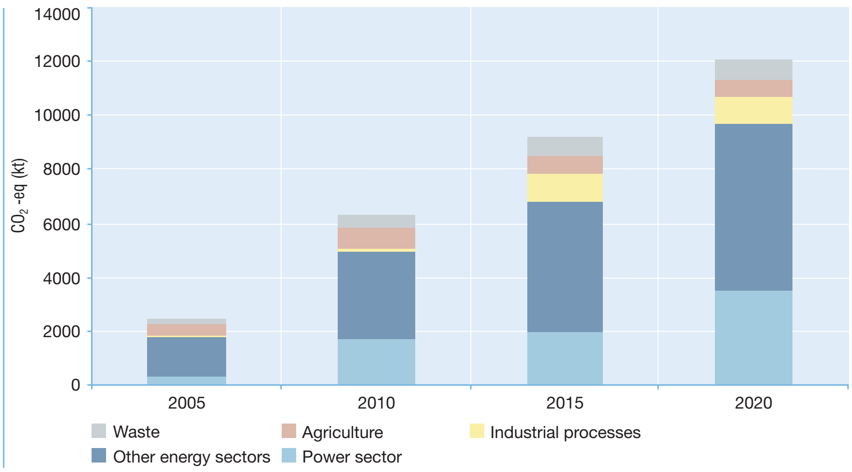


Figure 6-8: Total potential of emission mitigation measures

Total emission in *baseline* and aggregate *mitigation* scenarios are shown in Fig. 6-9. The aggregate *mitigation* scenario includes the emission mitigation measures for individual sectors, described in the previous sections. These are some remarks related to them:

- in energy sector, aggregate effect of all the measures from the Section 5 are analyzed (nuclear option not included),
- the potential of the measures to be undertaken in energy sector need to be additionally researched, particularly regarding the wind and biomass energy,
- the mitigation scenario for agriculture is taken as the most probable scenario,

- the significant forestry measures have not been taken into consideration since no major effects are expected until the first commitment period (2008-2012),
- the scenarios are based on macroeconomic projections of the economic development from 1995, which have proven overoptimistic; however, total difference is not of such an extent that it would ask for change in conclusions at the moment,
- the Fig. 6-8 shows potential measures identified and evaluated so far as the most important; those measures that have still not been analyzed certainly have certain potential.

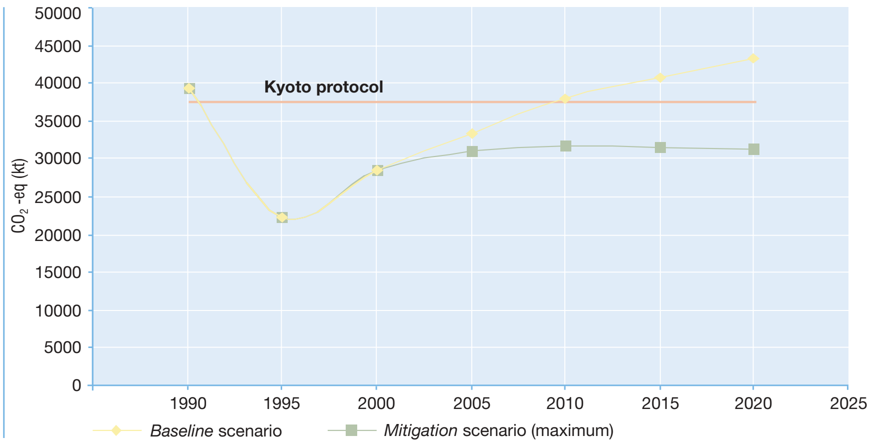


Figure 6-9: Greenhouse gases emission projection for Croatia

Figs. 6-7 to 6-9 show that with implementation of the additional measures in respect to reference scenario Croatia is able to achieve the GHG emission stabilization, on the level of the base year emission and Kyoto target.

It should be emphasised that mitigation scenarios presented in figs. 6-7 to 6-9 hardly could be reached in reality, or even that it would be nearly impossible to realise in the short term till the year 2012, which was the reason it was marked as the maximum achievable one. It assumes full utilisation of reduction potentials, presently estimated on aggregated analysis and data, with an approach which usually gives more optimistic figures than the collection of individual project potentials, by a bottom up approach.

There are certain reservations in all the above statements because of numerous uncertainties regarding the technological progress, economic development, political situation in the region, Croatia's relation with EU, international support and numerous other issues, in addition to the uncertainties regarding identification and evaluation of the potential and cost of the measures, that ask for permanent engagement.

Slavonia

7. Impact Assessment and Adaptation to Climate Change

7. Impact Assessment and Adaptation to Climate Change

7.1 Global Climate Change

Over 5000 scientists around the world have joined the research on human influence on global warming, as a part of the international scientific forum *Intergovernmental Panel on Climate Change* (IPCC). The intensity of the phenomenon and the structure of the observed changes indicate that the human activity is the most significant cause. The climate system is determined by the numerous interactions between the sun, the ocean, the atmosphere, the land and the living organisms. The composition of the atmosphere within this system is relevant, since certain gases and particles absorb the heat, which the Earth radiates into the atmosphere, thus contributing to its additional warming. By interrupting the chemical structure of the air, the balance of the climate system is also interrupted, producing climatically measurable consequences. The observations confirm that the climate changes beyond the frameworks that can be attributed to natural variability. The climate statistics that have been derived from the climate data of the recent past are no longer reliable enough and cannot ensure the relevant description of the climate we can expect in the future. Therefore, today, the question whether the greenhouse gases cause the global warming is not posed any more, but rather what consequences of the changes of the thermal balance can be expected within the atmosphere-hydrosphere-lytosphere system.

One of the most effective ways of answering the numerous questions is the application of the Global Circulation Models (GCM). The circulation models simulate the behaviour of the climate system by means of integrating physical, chemical and biological processes and their numerous interactions. Using the circulation modelling, a research of the relations of the quantitative indicators among the climate variables is conducted. The reliability of GCMs is tested by the data resulting from the long series of measurements. Today, there are about twenty circulation models of different characteristics, which are used worldwide. Most of these models simulate certain aspects of the future climate changes exemplary well. For example, all circulation models simulate the phenomenon of warming, and the precipitation cycle in the regime of extreme occurrences. Climates differ significantly in certain aspects, which demands not only a continuous development and improvement of the models, but also the appropriate scenarios of the possible changes. Therefore, the methodology of the climate change evaluation includes not only physical and chemical description of the climate system and the corresponding interactions within the system, but also the scenarios of our behaviour within this system in regards to the dynamics of fossil fuel exploitation, the greenhouse gas emission, the planned economic development and growth, the population growth, etc.

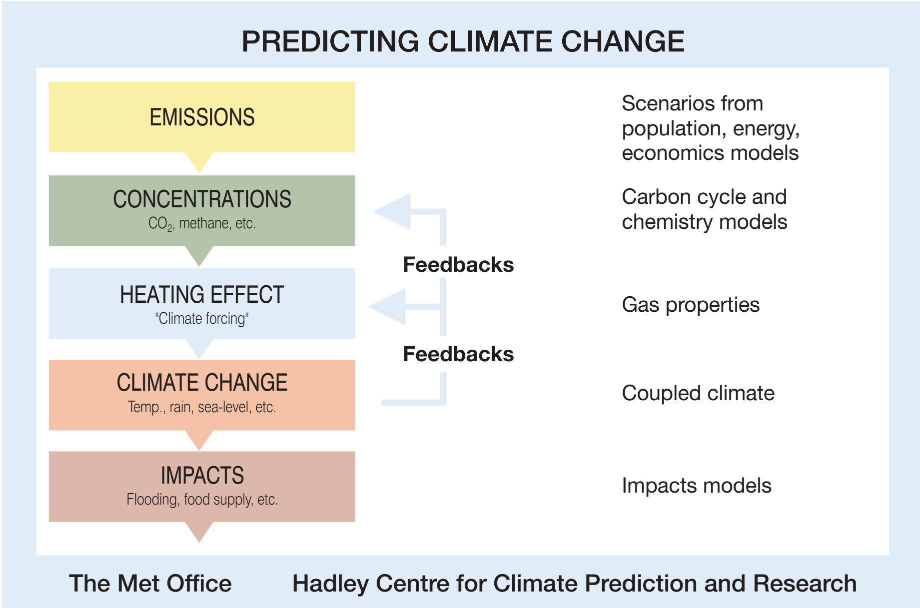


Figure 7-1: Elements of climate change system prediction

7.2 Scenario Construction

The scenarios represent a coherent, systematic and consistent description of possible climate changes. Climate scenarios should be taken as probable future alternative climate realisations, while every scenario represents one example of what could be expected from the given hypothesis. Therefore, the scenarios are not anticipation or forecast of future events. They are a starting point and a means of investigating the development of alternative future, and of the analysis of the sensibility and adaptability of all activities and systems dependant on climate and its variables.

Climate scenarios and reliability of climate estimates are based on:

1. Quality of global circulation models in regards to their ability to enable the simulation of climate conditions on regional scale with sufficient reliability. Connecting the global estimates with climate realisations on regional scale still represents a proportionally great problem. The global models have spatial resolution of several hundred kilometres (300-400 km), which is insufficient for climate analysis as well as the differences that can be expected on a smaller area scale. This is especially emphasised in regions with developed orthography and/or coastal regions with very dynamic atmospheric processes and climate differences at small distances.
2. Our ability to anticipate the most probable scenario of global social, economic, technological and energy development that will influence the rate at which the concentration of greenhouse gases will stabilise in the atmosphere in the next hundred years. At the moment it is still difficult to evaluate which model of the greenhouse gas control emission will be accepted. Therefore, the circulation models are applied along with several different scenarios in regards to the anticipated increase of CO_2 concentration.

In 1990 the Intergovernmental Panel on Climate Change (IPCC) published its first report - *Climate Change-The IPCC Scientific Assessment* - that gave four hypothetical scenarios for greenhouse gas emission based on the different assumptions of economy, technology and population growth. In 1992 the second report was published, with partial corrections and improvements in regards to emission scenarios. Considering that the model results depend on emission scenario, the usual procedure is to choose and analyse at least two different scenarios. The principal emission scenario is known as "business as usual" in which future greenhouse gas emissions are assumed to evolve in the absence of climate policies beyond those already adopted.

Other scenarios are based on the different hypothesis of industrial growth, but also on the adequate restrictive policy in regards to the greenhouse gas emission.

The climate change modelling results shown by the IPCC in the 1990 report and in the 1992 update are mainly based on two working hypotheses:

1) Instantaneous doubling of the CO_2 amounts in the atmosphere;
2) Gradual increase of the CO_2 amount in the atmosphere at an annual rate of 1%.

Average global estimates for temperature increase under the first hypothesis are between 1.5 °C and 4.5 °C with the best estimate of 2.5 °C. According to the "business as usual" scenario, the doubling of CO_2 would occur in about 2020, and it is therefore realistic to hypothesise that the estimated increase under these conditions could represent the conditions which would occur at least a decade after this date.

7.2.1 Climate Change Scenarios for Croatia

The climate change scenarios for Croatia are made on the basis of IPCC alternative scenarios (1992a-1992f), assuming the present CO_2 concentration increase policy ("business as usual"). Two projections of global social and economic growth have been chosen: 1992a and 1992e. Scenario 1992a is a scenario on the lower limit of the expected changes, while scenario 1992e is on the upper limit. In both cases, the parameters of these projections were derived applying the hypothesis of cooling effect of aerosols; the values are given in table 7-1.

Table 7-1: Summary of scenario and projection of climate estimate range up to year 2100

Scenario characteristics	Present values	Scenarios for 2100	
	1990	1992a	1992e
Population (in billions)	5.252	11.3	11.3
Economic growth (annual GNP; %)	-	2.3	3.0
Concentration of CO_2 (ppmv)[1]	354	708	954
Global mean annual temperature change (°C)[2]	-	2.18	2.64
Range (°C)[3]	-	1.5 - 3.14	1.83 - 3.73
Global mean sea level rise (cm)[2]	-	51	57
Range (cm)[3]	-	20-90	24-98

1 the best estimate for carbon cycling;
2 with estimated climate sensitivity of 2.5 °C;
3 with estimated climate sensitivity range from 1.5 °C to 4.5 °C

Regional climate scenarios are developed based on the global circulation models' results (GCM). One problem with the application of GCMs to the study of climate impacts is the coarse resolution of the model grid. The grid scale of the global models ranges from 4° latitude x 5° longitude (OSU) to 7.83° latitude x 10° longitude (GISS). GCMs, therefore, have a spatial resolution of several hundreds of kilometres, which is inadequate for many regional climate changes studies, especially in the areas with higher relief. The scenario for the Mediterranean is based on the analysis of long data series, statistical relationship between grid-point GCM data and observations from surface meteorological stations. For this study, basic global circulation scenarios 1992a and 1992e have been used as well as regional circulation scenario for the Mediterranean developed at East Anglia University, one of the UK's most prominent centres for the analysis of climate change in the next 100-200 years.

Basic Conclusions Derived from Global Circulation Models and Regional Climate Scenarios

Basic conclusions resulting from global models for Europe as a region and Croatia as a part of that region can be summarised:

- higher warming of land compared to the sea and ocean is expected in the cold season,
- maximum warming in the northern latitudes is expected in late autumn and winter, in connection to the reduction of ice-sheet areas and snow cover,
- slight warming of the Arctic is expected during summer,
- slight variations of seasonal warming are expected in middle and smaller latitudes as well as above the south seas,
- decrease of diurnal temperature range is expected over the continent in most of the regions and almost at all seasons,
- increase of high temperature anomalies and decrease of low temperature anomalies is expected,
- enhanced hydrological cycle is expected,
- greater precipitation in Northern latitudes is expected over winter season,
- increase in the frequency of intense precipitation occurrence is expected in many regions.

Global and regional projections have been examined and compared with long-term data series for Croatia. Three 100-years-data series (Osijek, Zagreb-Grič and Crikvenica) have been analysed, being the representatives of Croatia's three different climate regions. All available measurement data series of Croatian meteorological stations in the period 1961-1990 have been used for the elaboration of the Mediterranean climate scenario.

The estimates have been made for temperature, precipitation amounts and sea level rise (Table 7-2). Table 7-3 shows a total range of expected changes for scenarios 1992a and 1992e for all three-time horizons.

Regional characteristics of the scenarios for seasonal and annual values are given in figures 7-1 and 7-2.

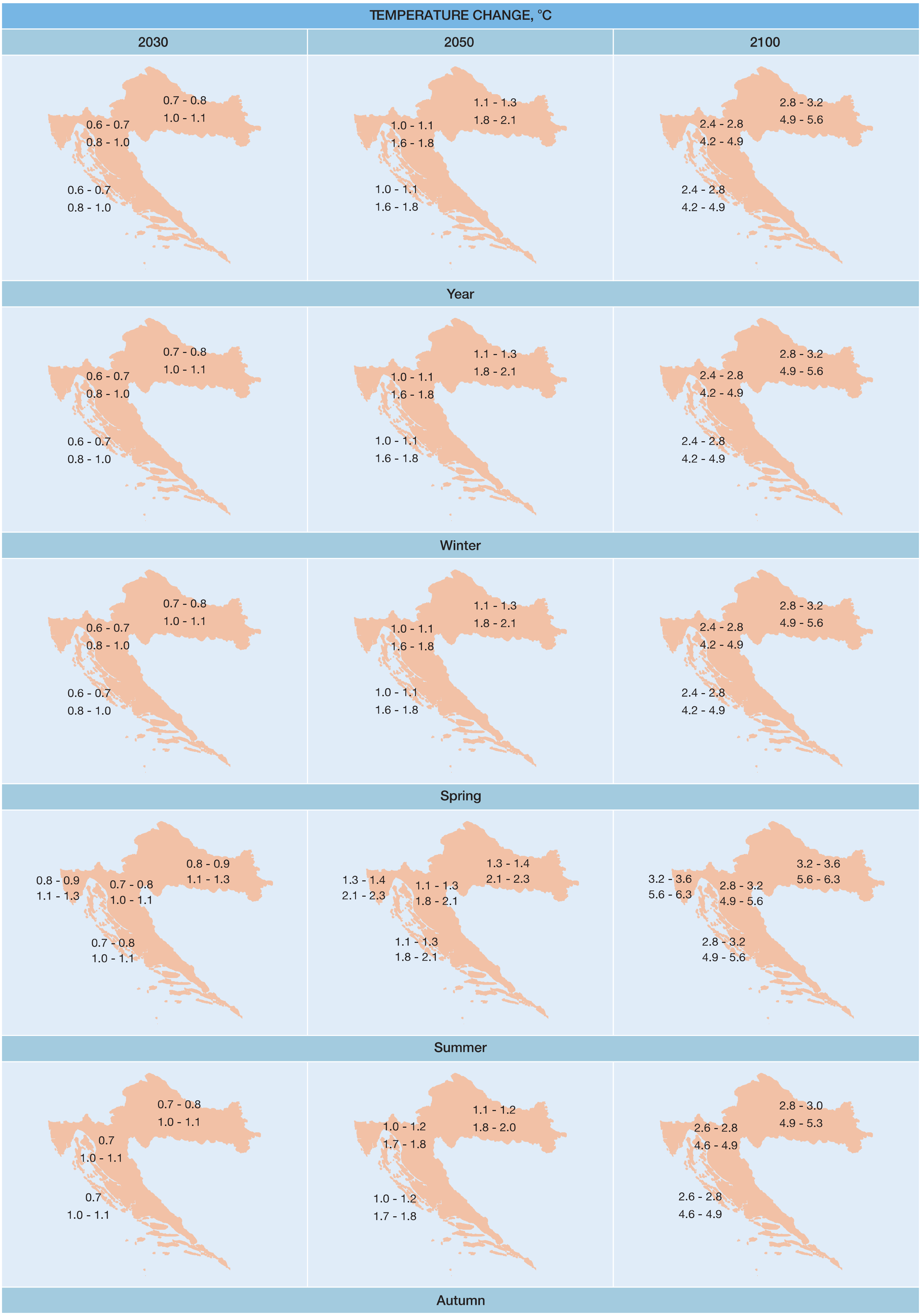


Figure 7-2: Temperature change scenario for Croatia along with global temperature change according to scenario IPCC 1992a (above) and IPCC 1992e (below)

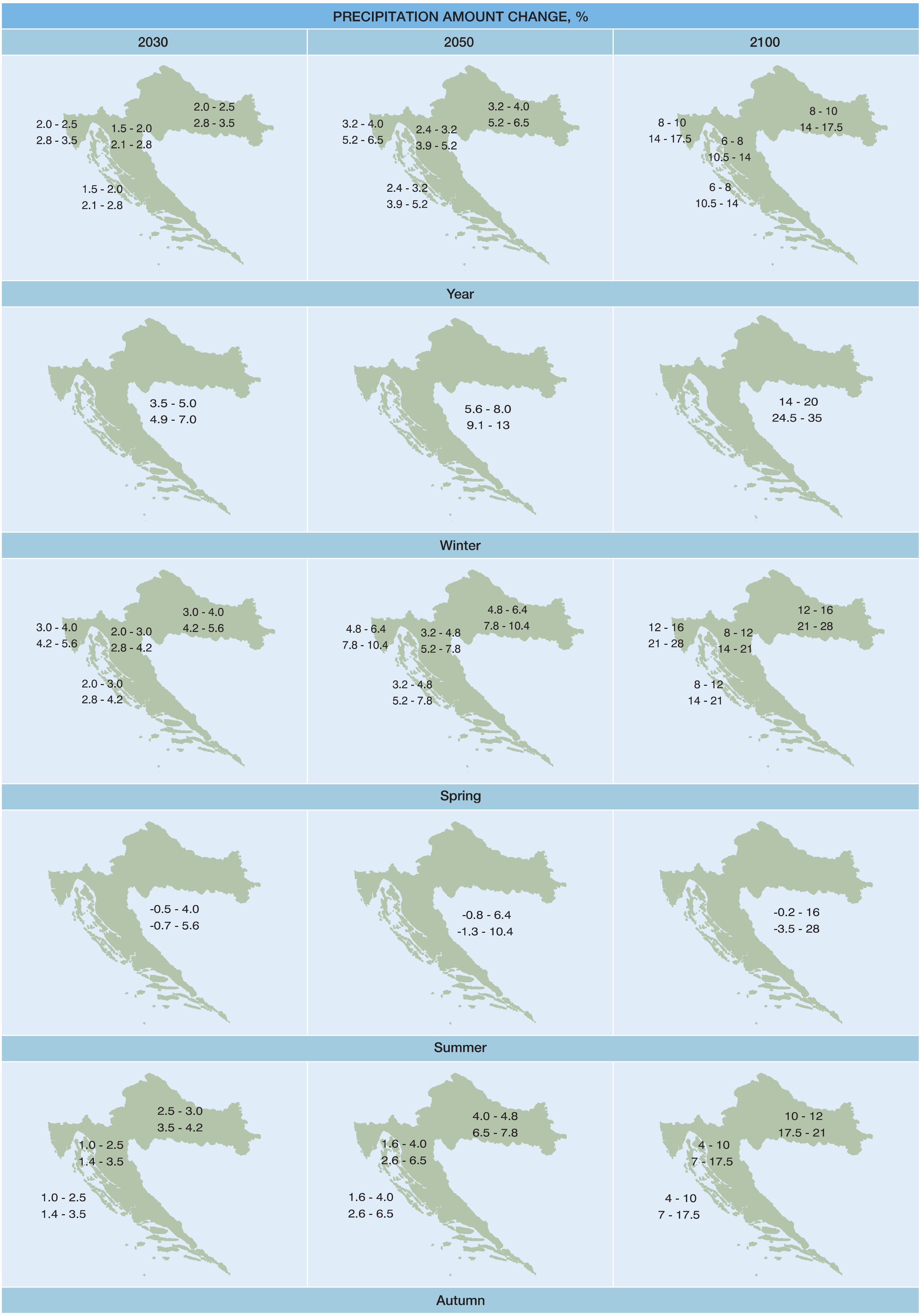


Figure 7-3: Precipitation amount change scenario for Croatia along with global precipitation amount change according to scenarios IPCC 1992a (above) and IPCC 1992e (below).

trast to model-average change. The expected annual temperature changes are between 2.4 and 2.8 °C for the coastal and mountainous area and between 2.8 and 3.2 °C in the lowland area of Croatia. The same changes are expected for the winter and spring seasons. The expected temperature increase for the autumn season is less expressed in the coastal and mountainous area (2.6 to 2.8 °C) than in the lowland area (2.8 to 3.0 °C). The most expressed changes are expected for the summer season, with an increase between 2.8 and 3.0°C for the coastal and mountainous area, and from 3.2 to 3.6 °C for the lowland areas and the Istrian Peninsula. The annual changes of precipitation would increase between 6 and 8% in the coastal and mountainous area and 8 to 10% in the lowland area and Istra Peninsula. An increase from 4 to 10% is expected for the autumn season all over Croatia (except eastern part, where the expected increase is 10 to 12%). Also, a greater increase during the spring season is expected in lowland area (12 to 16%), and the winter increase would be uniformly all over the country within the ranges from 14 to 20%. The greatest precipitation variations are expected for summer, with the changes between -0.2 and 16%.

The temperature and precipitation changes for Croatia can be expressed by taking into consideration the global changes according to the IS92e scenario (which gives the greatest temperature changes with the climate sensitivity of 4.5 °C). The changes, as mentioned above, were calculated including the effects of changing aerosol concentrations after 1990, which, according to IPPC of 1995, is the latest trend. The results thus obtained are of greater absolute values, but they are applied to specific Croatian regions following the pattern of the first case (according to the IS92a). See tables 7-2 and 7-3.

7.2.2 Observed Climate Changes in Croatia

The basic conclusions derived from the results of the long series of meteorological measurement in Croatia:

- The Croatian region is situated in the broad transitional zone of the changes of temperature trends. The trends for continental Croatia and coastal Croatia differ in certain features.
- Annual trends of mean diurnal temperature show a slight increase of 0.3-0.4°C, which, for now, is statistically insignificant.
- Annual trends of maximum diurnal temperature show a slight decrease (statistically insignificant), which changes seasonally. In spring and summer, the temperatures show a slight decrease, and in autumn and winter they show a slight increase.
- Annual trends of minimum diurnal temperature show a significant increase in continental Croatia, while a slight decrease is observed in Crikvenica in spring season.
- Daily range of temperature (MAX-MIN) decreases at the significance level.

Elevated Stations

1. Elevated stations of Zavižan and Puntjarka record a faster increase of maximum temperature than of minimum temperature. Diurnal temperature range increases (significantly at Zavižan).
2. There is a significant air pressure increase at both elevated stations, which is related to the increase of the occurrences of weather types with higher air pressure and wider diurnal temperature range - it is an indication of the changes of general circulation above our region.

Cloudiness and Precipitation

1. There is a tendency of a significant decrease of mean annual cloudiness in the Croatian region.
2. Annual precipitation amounts show a decreasing trend, which is more prominent at Adriatic station - a significant desiccation of the Mediterranean region (19% the northern Adriatic, 13 % the eastern Croatian region, 4% the northwestern Croatian region).

Components of Water Balance

1. Increase of temperature influences the general significant increase of potential evapotranspiration: Osijek by 15% in 100 years, Crikvenica by 7%.
2. Evapotranspiration in Osijek is significant, + 8% in 100 years, while no changes are recorded in Crikvenica.
3. Reduced precipitation amounts (due to the decreasing trend) do not meet vegetation water amount requirements (due to increased evapotranspiration). This results in significant drainage and in soil water content decrease in the regions of Slavonija and Primorje.
4. Significant drainage decrease can have negative consequences on water management, while reduced soil water amounts can damage the vegetation.

7.3 Hydrology and Water Resources

7.3.1 Introduction

Climate change impact on intensification of the hydrological regime, disturbance of the water cycle in nature and water resources potentially falls among the most intensive impacts considering its possible consequences, natural adaptation capacity of the systems, its capability and carrying out of autonomous, purposeful and targeted adaptations.

The components of the water balance and streamflow generation in a watercourse and basin are affected by numerous factors that could broadly be classified as climate-related, physiographic, geomorphologic, and hydrogeologic. The climate factors include intensity, duration, type and spatial distribution of precipitation and evapotranspiration component. The physiographic, geomorphologic and hydrogeologic factors include basin geometry, land use, vegetation cover, soil properties and physical characteristics of geological formations.

Construction of large hydraulic engineering projects in Croatia started in mid-20th century. During the last 50 years, a number of regional water supply systems, hydroelectric power plants, reservoirs, water tunnels and other large structures have been built. Their construction and functioning have considerably affected the surface and groundwater regimes. All these structures were built in order to improve the water regime and consequently the living conditions. However, the experience has confirmed that many of them have proven suboptimal in exploitation.

The climate changes are indicated through local variations of the hydrological parameters. Human activity, which has direct impact on the local water balance, has been causing (and will undoubtedly continue to do so) climate change at a regional and global scale. There is therefore no significant difference between the influence of human activities and the influence of climate change on the hydrology and water resources. However, the existing interaction of man-climate-hydrological cycle-water resources is the basis for consideration of impacts of possible climate projections.

Croatia as a small country with diverse climate zones and consequently extremely diverse and variable waters resources. Climate variability could be illustrated with annual precipitation, which ranges from less than 600 mm on the east to more than 2000 mm in the mountain region and in the far southern part of the country (Fig. 7-4). The hydrologic variability is more pronounced than the climate diversity. For example, mean multi-annual runoff coefficient in the western karstic region in about 0.6 and in the eastern parts it falls below 0.2. It should be stressed that during last decades Croatia has not suffered from floods that could be classified as natural disasters. There have been some flush floods, generally in urban areas, as consequence of poor training of smaller watercourses. The decade 1981-1991 could be considered a long period of drought that affected almost the entire Croatian territory.

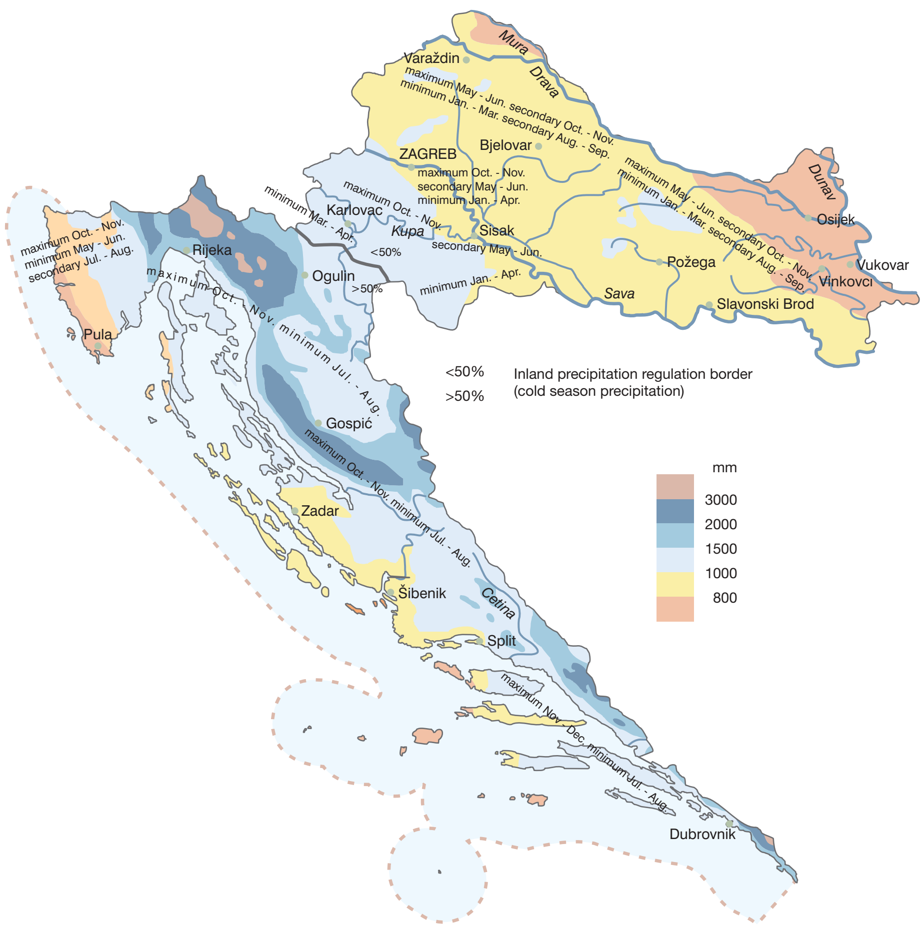


Figure 7-4: Spatial distribution of annual precipitation, 1931-1960

Reliability of estimates on climate change impact on water resources depends on the precision of the climate scenario and on the knowledge of processes governing water balance in the basin. The quantitative knowledge of the hydrological cycles is generally poor, due to:

1. Climate change and/or variability;
2. Dilemmas caused by temporal and spatial scales governing the hydrological cycle;
3. Man induced influence on the water regime;
4. Operational difficulties in maintaining hydrological, hydrogeological and meteorological observing networks.

All the above mentioned, and many others reasons make it difficult to assess the climate change impacts on global as well as on the Croatian hydrology and water resources

This communication will present results of some studies that analysed the climate change and anthropogenic impacts on the Croatian water resources. The analysis and conclusions from this communication will be used as a baseline for assessment of possible future changes in hydrological regime of Croatia within specific climate scenarios.

7.3.2 Water Resources in Croatia

The surface area of Croatian land territory is 56,538 km^2, and the territorial sea area is 31,067 km^2 (Fig. 7-5). The Croatian rivers belong to either the Adriatic (about 40 percent of national land territory) or the Black Sea (about 60 percent of n.l.t.) watersheds. Due to the intensive karstification of the ground, the precise boundaries among the two basins have not been determined up to day. Share of the river courses and their valleys in the total land border length is large (2,028 km). The presence of karst causes that the parts of the border between Slovenia and Croatia, and that between Bosnia-Herzegovina and Croatia have numerous underground connections and streamflows which are hard to determine. This makes the management of the border and transboundary water resources shared with the neighbouring countries very difficult.

About 53 percent of land area lays between 0-200 m above sea level, 26 percent between 200-500 m, and the remaining 21 percent at altitudes over 500 m. Approximately 40 percent of the Croatian territory id covered with limestone-dolomite rocks, in which deep karstic underground forms prevail. These forms are causing specific complex hydrological and hydrogeological runoff conditions. Due to the karstic terrain in the western coastal region of Croatia, the average annual runoff coefficient is about 0.60. In the eastern flatland nonkarstic region it is about 0.20. Water resources in Croatia are very unevenly distributed notwithstanding the fact that its territory is small. Causes to this phenomenon are precipitation regimes induced by terrain orography and extremely different runoff conditions.

Wet air masses that bring precipitation to Croatia originate mostly in the Northwest and Southwest. In the continental region of the country, the amount of precipitation decreases from west towards east. The average annual precipitation ranges from 2,000 mm in coastal-Dinaric region to 600 mm in the Far Eastern region. The Croatian inland territory receives on average $61.6 \cdot 10^9$ m3 of precipitation, so that the average annual precipitation is about 1,100 mm. The average potential annual evapotranspiration has been estimated to 800 mm, but it should be kept in mind that it varies from 1,100 mm in the south to 700 mm in the east.

Figure 7-5: Water resources in Croatia

From neighbouring countries, Croatia annually receives 127,279 m3 of water on average. About 41,804 m3 of open streamflow water is annually formed within the Croatian territory. It should be pointed out that these are only rough estimates which will have to be confirmed through new measurements and analyses, having in mind that in some regions a decreasing trend has been observed for both surface and underground water reserves.

In spite of extensive research activity, the knowledge on the amount and the condition of underground water is inconclusive. Alluvial, karstic, artesian and other aquifers are not sufficiently explored. The karst aquifers represent a special problem. Estimates of permanently stored underground water reserves range from $6 \cdot 10^9 m^3$ m^3 to $30 \cdot 10^9 m^3$ annually.

On the basis of the data presented above it can be concluded that Croatia is a country rich in water, especially considering the low population density and modest demand for industrial and agricultural water, which is well below average of developed countries. Relatively high quality of both surface and ground water can certainly be considered a positive element, with most problems occurring during warm summer periods when the natural discharge is small, the groundwater level low and water demand increased due to the tourism and irrigation demands.

During the past decade, the Republic of Croatia was subject to complex and specific circumstances: the war, independence and transition of the national economy. Therefore it is not easy to predict either the demographic changes or the economic development strategy. The water use is a significant economic factor. The water resources are used for water supply of the cities, industry, agriculture, power generation, sports, leisure industry and other needs, and the water is tapped from the rivers, lakes and the underground. The priority in water supply is given to the supply of the population and manufacturing and process industries.

In potable water supply 86 percent is groundwater and 14 percent surface water, with renewable groundwater resources predominantly used for the purpose. The power generation and mining use 97 percent of surface water and only 3 percent groundwater. Table 7-4 shows the water consumption data for Croatia. The data for the war period are incomplete.

Table 7-4: Water consumption in Croatia ($10^6 m^3$)

Consumer	YEAR				
	1985	1990	1991	1995	1999
Public consumption (households and part of industry)	497	449	390	358	352
Industry (in-plant water intakes)	301	251	127	215	210
Fish ponds	600	560	240	320	400
Other consumers (individual supply, irrigation etc.)	80	79	75	78	77
Power generation and mining	29,980	32,846	24,000	26,000	29,500
TOTAL	**31,467**	**34,185**	**24,832**[1)]	**26,971**[1)]	**30,539**

Remark: [1)] insufficient data for the war period

Table 7-5 gives a water demand estimate for Croatia. An exact forecast of the water demand would ask for long-term planning focused on rational and efficient use of water resources, and respect of the sustainable development principles. The water supply of the general population and industry should support optimum development of the country.

Table 7-5: Planed water demand in Croatia ($10^6 m^3$)

Consumer	1999 Status	Planned by	
		2015	2050
Public consumption	352	1,000	1,525
Fish ponds	400	480	700
Irrigation	24	517	1,663
Power generation, mining, etc.	29,764	35,000	36,000
TOTAL	**30,540**	**36,997**	**39,888**

7.3.3 Croatian Water Resources Management System

The Waters Act, which defines the water resources management system, was passed in 1995. The system includes a number of activities, decisions and measures focused on maintenance, improvement and realisation of an integrated water regime for particular basins. Pursuant to the Waters Act, Hrvatske Vode (*Croatian Waters*), a public company was established to perform the activities and regulate the relations between the states and the local water management authorities. The administrative control over the enforcement of the Waters Act and of Hrvatske Vode is carried out by the State Directorate for Water. The Croatian Waters are divided in five regional water management departments for: (1) the Sava River basin; (2) the Drava and Danube Rivers basins; (3) the Primorje-Istria basins; (4) the Dalmatian basins and (5) the City of Zagreb basin.

The basic planning document regulating water management, water balance and water resources system development in Croatia is the Water Management Master Plan of the Republic of Croatia. The active water resources management is subdivided into (1) flood control, (2) water use (3) water protection.

The State Directorate for Water is specifically responsible for the inspection of the condition of water courses, proper operation of water structures and facilities, use of water and water resources in accordance with the Waters Act, water contamination and pollution protection, implementation of water protection measures, preparation and implementation of flood control measures.

The cities and counties are the owners and have the right to establish water management enterprises for the minor catchment areas. These enterprises are organised as companies with minimum 51 percent of private capital, pursuant to the Privatisation Act.

The Ministry of Environmental Protection and Physical Planning is in charge of protection of ecological systems and biodiversity in Croatia. The institutions, the Ministry and the State Directorate, closely co-operate in the field of water resources management and protection.

The State Meteorological and Hydrological Service is in charge of measurement, collecting and interpretation of meteorological and hydrological data.

About 74 percent of population are supplied with potable water from public water supply systems, mostly (90 percent) with groundwater. The population uses 45 percent, and industry 55 percent of tapped groundwater.

Central sewer systems are constructed only in large urban and industrial centres. Less then 35 percent of wastewater in Croatia is discharged into the sewer systems and less than 10 percent is treated in wastewater treatment plants.

7.3.4 Impact on Hydrology and Water Resources

The hydrological system is potentially very sensitive to changes in climate. Changes in precipitation regime affect the magnitude and timing of precipitation and the frequency and intensity of floods and droughts. Even if no significant changes are suffered of average annual precipitation, the seasonal rainfall-runoff cycle will be disturbed, which might cause insufficient precipitation during the vegetation period or excessive precipitation during harvest season.

Changes in temperature result in changes in evapotranspiration, soil moisture, and infiltration. The resulting changes in surface condition, wetness, reflectivity, and vegetation cover also affect evapotranspiration and the formation of clouds, as well as surface net radiation and precipitation.

Further, the hydrological system is affected by direct human activities, such as deforestation, urbanisation and water resource exploitation. Since the rainfall-runoff regime highly depends on numerous climate related and unrelated factors, which need not necessarily be connected with exploitation of the water resources, the scenarios of a hundred-year changes are very insecure.

Estimates of regional hydrologic and water resources changes for this communication will be made using two different methods. The methods are based on the analysis of the dependence of monthly flow regimes on the summer water balance and on basin geological conditions. The regional differences and features of the water cycle can be determined by studying water discharge and water level data series, with an open issue of separating the direct anthropogenic effects from the natural climate fluctuations, since their effects start almost simultaneously.

Still, the water resources issue has been recognised local, regional and global scale as one of the key issues of the 21st century. Possible climate changes and unexpected climate fluctuations additionally increase the pressure.

Based on numerous measurements of water levels and discharges at the Sava River near Zagreb and the Drava River near Donji Miholjac, it is intended to:

1. Assess variability in water balance by using historical time series;
2. Investigate the factors controlling river basins sensitivity to climate change;
3. Describe characteristics of the water cycle in different regimes and estimate impacts of possible climate change on its development.

Variability of the Sava and Drava Rivers, and the Vrana Lake is shown in Fig. 7-6. The time series are 75 (the Sava, Vrana Lake) and 100 (the Drava) years long. All three cases show:

- high variability of maximum water levels during the period 1926-1975, with decreasing amplitude during the last two decades,
- decreasing tendency of the medium and minimum annual water level during the last two decades.

In addition to the water level time series, the Fig. 7-6 also shows the RAPS (Rescaled Adjusted Partial Sums) parameter indicating accumulated departure of the water level from its mean value, so it is used in water management systems design and management. In addition to visual presentation of the fluctuation trends, RAPS points to the periods with different statistical characteristics.

Fig. 7-6 also shows a series of annual water levels for the Vrana Lake at the Island of Cres. The long-term decreasing trend is noticed, which could be connected with the climate changes. However, this already intensified during the period 1985-1990 (3 meters in 6 years), which might be caused by more intensive water pumping due to the increased demand of tourism and periods of drought.

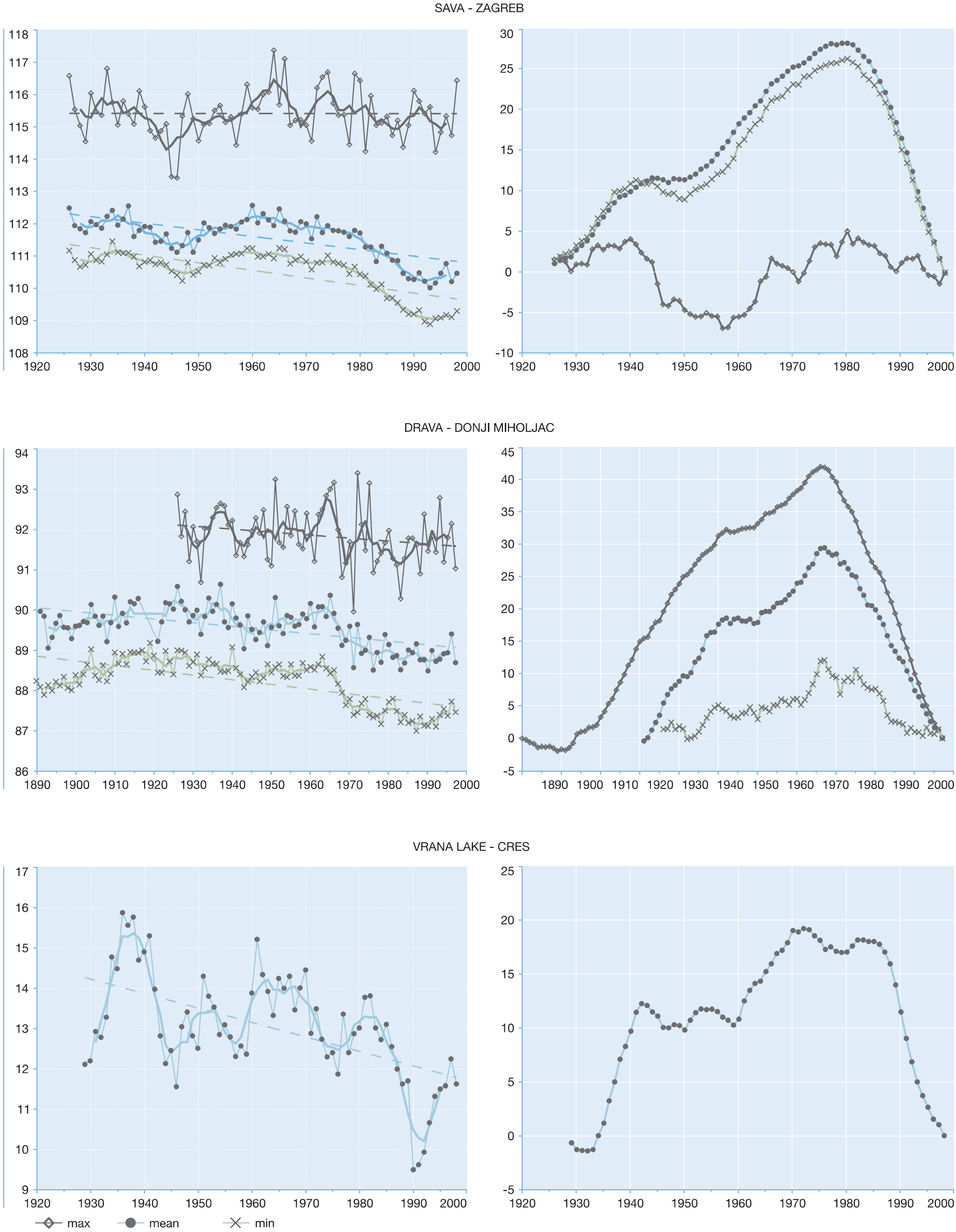


Figure 7-6: Maximum, mean and minimum water levels expressed in meters (left) and RAPS parameter for maximum, mean and minimum water level (right) for the periods 1926-1997 (Sava-Zagreb), 1980-1997 (Drava-Donji Miholjac) and 1926-1997 (Vrana Lake - Island of Cres)

Fig. 7-7 shows time series of the Sava and Drava profile discharges and the RAPS parameter calculated for those discharges. The analysis indicates water level and discharge negative trends caused by anthropogenic factors and climate variability.

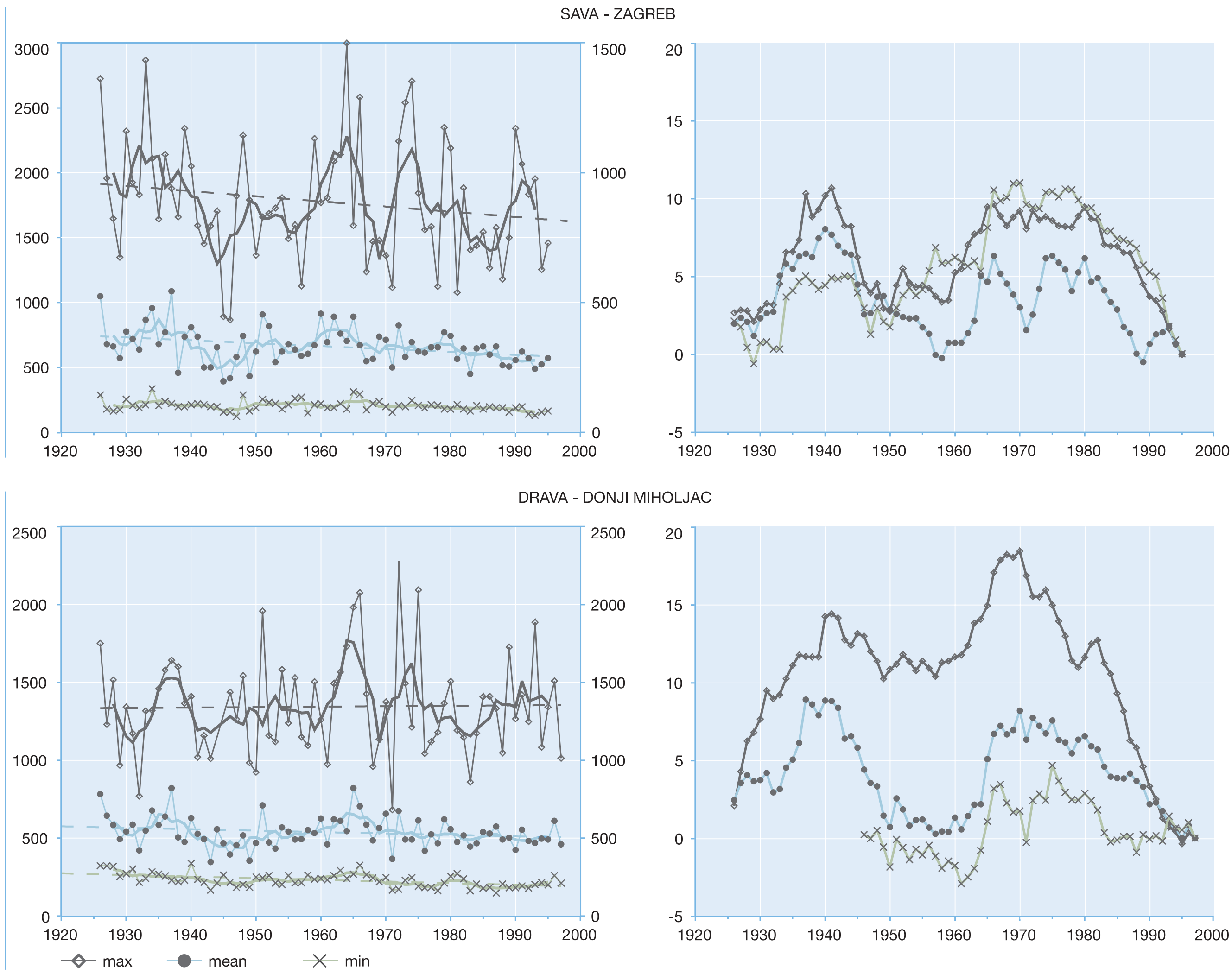


Figure 7-7: Maximum, mean and minimum discharges, m^3/s (left) and RAPS parameter for maximum, mean and minimum discharges (right) for the period 1926-1997 (Sava-Zagreb and Drava-Donji Miholjac)

Fig. 7-8 shows comparative data series on the mean annual temperature and water level deviations from the average for the period 1961-1990, and deviation of the mean annual precipitation and discharge compared to the period 1961-1990 for the Zagreb-Grič Weather Station and for the Sava River near Zagreb. Both these series have almost identical characteristics. The negative water level deviations follow almost completely the positive sign of the temperature deviation, and similar relation is determined in the precipitation and discharge analysis. Thus, there is no doubt that the hydrological regime follows the changes in climate characteristics and that the future climate changes will considerably reflect on the water resources and their availability.

In estimating climate change effects, the general model of circulation in the atmosphere, GMC, is used. Assuming that the carbon dioxide (CO_2) content in atmosphere doubles, the air temperature increase in the next 40-60 years is estimated at 1.8 °C. The impact of climate changes caused by the greenhouse effect on the demand for irrigation water is one of the issues to be resolved by planning and management of water resources systems. Determining of possible impact of climate changes involves the use of mathematical models. The input data are long-time

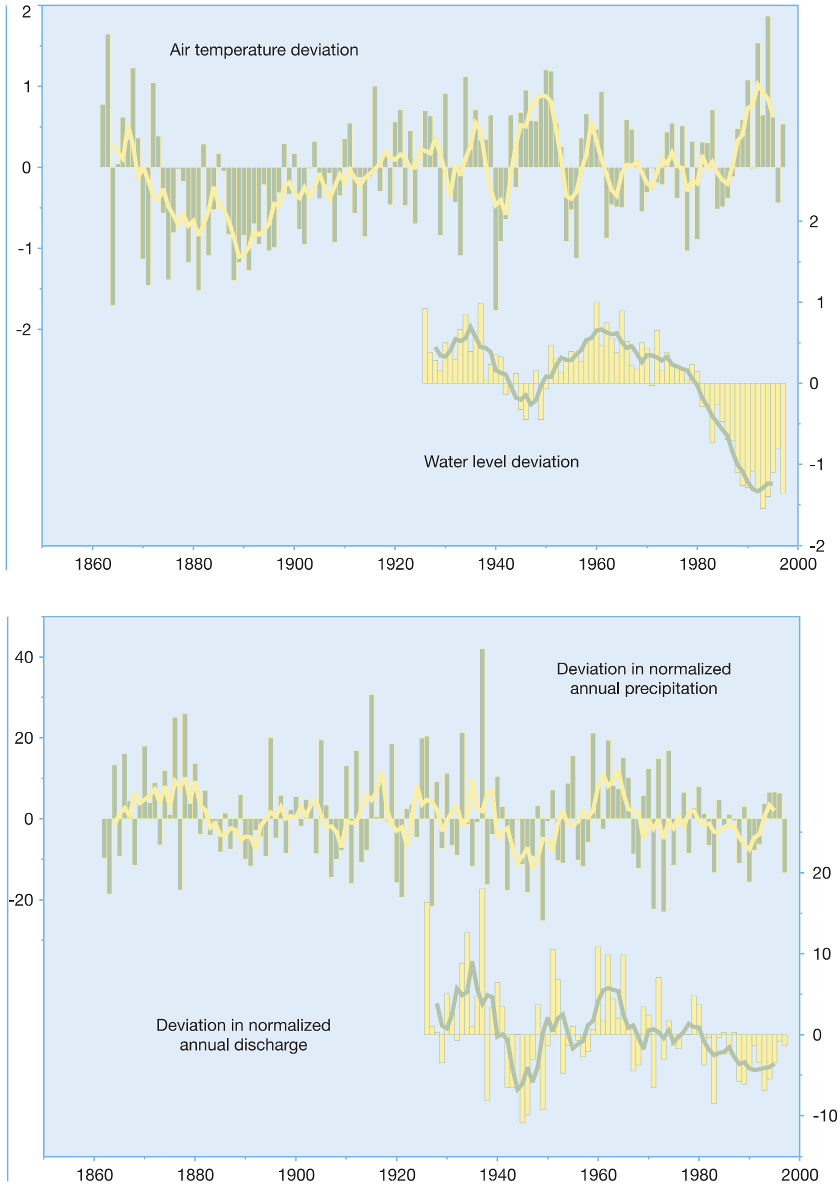


Figure 7-8: Deviations of mean annual temperature (Zagreb-Grič) and water level (the Sava near Zagreb) from the mean for the period 1961-1990 (top) and deviation of normalised mean annual precipitation (Zagreb-Grič) and discharge (the Sava near Zagreb) from the mean for the period 1961-1990

series of climate parameters. Data on soil moisture, effective precipitation, potential evapotranspiration and the Morton formula for wet-environmental area evapotranspiration are used. The region of eastern Croatia was selected for analysis, with the Osijek Weather Station, which has good quality meteorological and hydrological data. To assess the impact of changes on water resources, two scenarios are considered. In the first scenario, real evapotranspiration is determined on the basis of 1961-1990 period data. The second scenario involves simulation of values of changes in air temperature, precipitation and real evapotranspiration under the assumption the carbon dioxide content in the atmosphere doubles. The increase in air temperature will affect the form of precipitation, causing a decrease of average annual precipitation by 10 percent, wherefore 17 percent in April-September period; the real evapotranspiration will increase by 9 percent of the mean annual value. The Table 7-6 gives average monthly and annual air temperature T, precipitation P and real evapotranspiration ET at the Osijek Weather Station and the evaluated values of their climate change induced changes.

The next step is to estimate the changes in the annual runoff D and effective runoff R deficit expressed in mm caused by possible climate change effects. The total annual runoff deficit D, is calculated using the Turc formula, which describes the runoff deficit as ratio between the mean annual precipitation in a basin and non-linear change of an average annual air temperature within that basin area.

This method is illustrated on an example of the Gradole karst spring catchment, with an area of 114 km^2. Its average annual precipitation is 986 mm, average air temperature 11.4 °C, and average annual runoff deficit D 556 mm. It means that the average annual effective runoff R is 430 mm. The temperature change range from 1 to 4 °C was monitored, which was accompanied by 1 to 10 percent decrease in precipitation. The calculation shows that such climate changes would cause a decrease in effective runoff R from 25 mm to 179 mm a year, which is a decrease from 5.8 to as much as 42 percent.

Table 7-6: Average air temperature T, precipitation P and real evapotranspiration ET for the Osijek Weather Station with estimated changes for specific climate change scenarios

Scenario	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	YEAR
1	-0.2	0.9	6.5	10.8	16.5	19.5	20.8	20.1	17.3	11.5	5.4	1.2	10.9
2	1.5	2.4	7.4	11.3	17.7	21.3	23.1	21.8	18.2	11.5	6.0	2.5	12.1
ΔT	1.7	1.5	0.9	0.5	1.2	1.8	2.3	1.7	0.9	0.0	0.6	1.3	1.2
1	48.9	41.0	37.9	52.0	53.0	93.4	69.5	61.9	49.2	45.4	55.0	52.8	660.0
2	50.9	42.0	36.9	49.0	44.0	78.4	51.5	49.9	43.2	42.4	53.0	52.8	594.0
ΔP	2	1	-1	-3	-9	-15	-18	-12	-6	-3	-2	0	-66
1	0.0	2.9	16.6	34.3	65.3	80.8	88.8	78.6	53.1	30.8	10.0	1.2	462.4
2	1.5	4.9	18.5	36.0	71.3	89.5	100.4	83.2	53.8	31.0	11.2	2.7	504.0
ET	1.5	2.0	1.9	1.7	6.0	8.7	11.6	4.6	0.7	0.2	1.2	1.5	41.6

7.3.5 Impact on Water Resources Management System

Climate variability is important for the planning, design and operation of all water resource systems, because social benefits derived from these systems are direct functions of the reliability of system operation. The water resource systems in Croatia have been designed and operated on the assumption that future climate variations might be expected to be similar to those observed within the past 30 to 50 years.

The predictions of water uses and demands are essential elements of the information used in planning of water resources management development. The water demands are not well known as yet so it is difficult to estimate the future water resources management.

Further problems of water demand prediction are connected to legal and institutional aspects and problems of regional planning. The water demand and the decisions on the ways to meet them may involve mass transfers of water for multipurpose use in regions that have the potential for economic growth. In such cases economic and legal studies are necessary for resolving of individual problems encountered in the way.

Predictions of water demand in the international or interstate planning is considerably more complicated than the national planning. The river basins rarely coincide with the political boundaries and different administrative regions mean also different approaches to resolving of water demand. Water should be considered a scarce strategic resource, thus decisions on its exploitation and harnessing must take into account all the conflicting interests.

In water resources management planning, the time period of 20 years is probably the minimum time required to recognise water problems and then plan and implement water management projects. Projections under steady-state conditions are uncertain. Additional uncertainty is brought in by the socio-economic and environmental circumstances.

The climate changes initiated by global warming have the potential to cause major changes in hydrological processes and hence water availability. The present state of knowledge however does not enable that the actual impacts on climate change be estimated with certainty. The hydrological impact in small but climate-wise and geologically extremely diverse country, such as Croatia, depends upon estimated changes in rainfall and evapotranspiration. Such changes are difficult to estimate with precision from the available climate simulation models.

In the previous section of this communication the existence of changes (general decrease in water levels and discharges) in Croatia during the last century was shown. According to the existing climate change estimates for Croatia, the runoff in a typical basin in western Croatia (Dinaric karst region) by the middle of the 21^{st} century could be expected to decrease by 10 to 20 percent compared to the present. In the eastern flatland part of Croatia the expected change will be less than 10 percent.

Although these indications of possible future climate changes might already be of value to the water resources managers, no certain decision could be made unless the climate change scenarios themselves are more reliable. It is particularly important to have more reliable estimates of possible rainfall and evapotranspiration changes during the year, i.e. their redistribution compared to the present situation.

Under the above-mentioned uncertainties, it is very likely that both the seasonal and regional distribution of water resources will change, with an increasing concentration of available water in winter and central western basins. Supplies during the warmer and, possibly, drier summers would need to be maintained by larger storing or inter-basin transfer.

The transfer of water from one Croatian basin to another is realistic because three rivers with abundant quantity of water are running through the Croatian territory: the Danube, Drava and Sava rivers.

A possible decrease of runoff and its probable redistribution during the year will cause shortages in water supply in summer season. It should be stressed that such shortages are already being experienced, since Croatia is a tourist country with large agricultural production. Tourism in Croatia has an international dimension, which is sensitive to any change in climate, and water resources availability that alters the competitive balance of summer holiday destinations worldwide. Would any change towards warmer and drier summer conditions occur, there might be a need to restrict public access to large coastal areas because of the enhanced risk of fire?

Demand for water will increase in Croatia during the summer and vegetation season (from April to September). Domestic demand will increase during the dry summer tourist season. The increased evapotranspiration can be expected to lead to large increase in demand for water for irrigation.

Changes in water quality may have important implications for water resources availability, as chemical and biological processes may change to worse in warmer lake and river waters. Changes in agricultural and forestry practices may result in increased intake of fertilisers and pesticides into ground and surface waters.

It should be stressed that water resources managers will face an evolving, not a static climate. Planners should check carefully the long-term variations of present and planned schemes. Special attention should be given to groundwater recharge and depletion in the Croatian flatlands, namely the area between the Sava, Drava and Danube rivers (eastern part of Croatia). In this region the surface runoff is significantly lower in comparison with evapotranspiration and infiltration. It means that the vertical hydrological component dominates over the horizontal one. During the last 50 years the water regime of this area has dramatically changed. The groundwater level decrease has been noticed, which influences the water supply reliability. The process of surface and groundwater availability decrease in this region is enduring and hard to be stopped. Possible climate change will affect it negatively. Because of all this, and also due to increase in groundwater pumping in the area and building of a dense drainage system for agricultural purposes, the situation might in the future be critical. The planned large regional water supply system, construction of hydroelectric power plants in the downstream sections of the Drava and Danube rivers, and especially a multi-purpose canal Danube - Sava (navigation and irrigation), in combination with the climate change will probably cause very dangerous consequences.

The decrease in the groundwater level at the right Sava bank, in City of Zagreb area, has been noticed during the last fifteen years. The phenomenon can be explained by a multitude of erosion control works, construction of various dams, regulation works on the Sava river and its tributaries, including embankment construction, and possibly due to the climate change. The changes are particularly significant in the Sava profile in the very city, where the minimum annual water levels dropped by about 200 cm in the last thirty years. This causes great problems in water supply during the low water level period, mostly during the summers.

7.3.6 Adaptation

Another major problem is that there is an enormous time lag between the moment of recognition of the climate change impact and the moment any measures undertaken become effective. This time period is 30 to 50 years.

Technically, it is possible to protect threatened regions by adaptation of water management systems in such a way that the major functions of these areas be maintained. However, the economic and environmental impacts will often make such a protection strategy unfeasible or unacceptable. Consequently, different strategies will need to be developed and the best one chosen for implementation. In order to be able to select the impact of climate change as a factor, it should be described in a consistent set of categories. An evaluation of the effects described shows that the impacts fall into four main categories as follow:

(1) Economic effects (property and production losses, cost of undertaken measures);
(2) Public health (safety, diseases, availability of food supplies);
(3) Social aspects (unemployment, resettlement, loss of public benefit);
(4) Administrative aspect (legal problems, competence and jurisdiction, administrative boundaries).

The water resources related problems caused by the climate change should be resolved gradually, with a great patience and without compromising the principles of the following basic concepts:

(5) Each and every river and region is unique;

(6) River basin management should be to the benefit of the people, enhance quality of their life and reinforce their interaction with the environment;

(7) The demands and priorities of different uses in each river and /or system, and suitability of the system for those particular uses, vary for different places and times;

(8) The location of a river and /or regional system, together with factors such as climate, human population, food and agricultural engineering demands, degree of industrialisation and availability of natural resources, dictate the most suitable policy for an integrated water resources management.

In order to apply these principles in practice, it is necessary to fulfil numerous prerequisites. It is of paramount importance to establish legal and administrative framework for national and international co-operation, and to organise, reconstruct, and modernise the existing water quality and quantity monitoring systems that are insufficient for some rivers and/or in some regions.

It is equally important to ensure a stable exchange of information and to create institutions and focal points in which public and open discussion among all partners in the process will be conducted. It is the only way to crate a long-term strategy for a more efficient water resources management in the changing environment, while respecting the principles of sustainable development.

There is a need to increase awareness and understanding of the importance of droughts and floods in Croatia which may be caused by possible climate change. The knowledge of assessment, mitigation and response strategies and means of improving drought and flood preparedness in Croatia should be increased. Research capacities at national and sub-regional levels should be reinforced. An inventory of technology and traditional international and local knowledge and know-how for mitigating the effect of drought and flood should be prepared.

Study of expected climate change impacts could be used for long-term and large-scale plans. Inventories of endangered areas and impact studies need to be prepared by national authorities in co-operation with the local authorities. The main elements are:

(1) planning and management;

(2) investigation and a study of the natural systems to be affected;

(3) identification and assessment of impact and mitigation options.

The possible solutions include on-site adjustment or solutions far in time and space. The response to expected impacts can be technical, natural (to replace lost or damaged resources) or non-structural (modification of the human use of area or resources). No major project should be approved without taking into account the results of the relevant climate impact studies.

The future water supply-demand relations are a central problem in the climate change impact assessment. Particularly, the climate change could considerably affect the agricultural engineering and economic development at the regional and state level. The development of water resources systems and their adaptive management strategies have to be considered. The new policy should be oriented towards a more resilient and robust water resources and agricultural engineering systems in order to achieve sustainable development.

The basic principles which are the baseline for the of the action plan for adjustment to the climate changes are:

1. Strategy of water resources management development in Croatia;
2. Water Resources Management Master Plan for Croatia (in development);

3. Analysis of existing state and the climate change impact through various scenarios.

National action plan for adaptation to climate changes is based on above principles and consists of many targets. For realisation of those targets, guidelines need to be prepared.

7.4 Climate Change Impact and Adaptation in Forestry

7.4.1 Introduction

Climate change that results in an increase or decrease of climate indicators and occurrence of climate extremes can change forest habitats. The degradation of habitat conditions is followed by a phenotype adaptation and selection by which ecotypes with better adaptive capacities occur, species that were subordinate in the past become dominant species, the migration of species takes place as well as degradation and drying up of species that cannot adapt themselves to new conditions in their habitats.

The climate system is complex and can be broken down into a number of parameters. Temperature, precipitation, insolation, cloudiness and winds are the most significant climate parameters.

Factors most relevant for the development, composition and distribution of forest vegetation are soil and climate. If the development of forest vegetation is predominantly influenced by climate we talk about climatogene vegetation and if it is predominantly influenced by soil we talk about edaphic vegetation. The climatogene vegetation that develops under the prevailing impact of general zonal climate is called climazonal vegetation. Croatia is a country with a very diversified relief and the forest vegetation is divided into vertical vegetation belts. These belts are further divided into horizontal vegetation zones. The conditions prevailing in Croatia in these geographic latitudes are such that the average temperature drops by 1°C each 100 m of relative height, and vary between two adjacent belts by 3°C (Trinajstić, 1998).

The forestry, as well as agriculture, adapts to average climate conditions and anomalies. In comparison with regular meteorological conditions, long-term anomalies can have significant impact on forest condition.

7.4.2 Climate Change Impact on the Structure and Development of Forest Ecosystems in Croatia

Forest soils are the soils that are sufficiently stocked with trees, bushes and underwood. They continuously produce wood mass and maintain overall benefits expressed in ecological (protection) and social functions of forests. The equilibrium and interaction of biota (plants, animals, microorganisms) and habitats (soil, climate) is fully evident here. The forest is a complex ecosystem with a dynamic equilibrium established among its members, forest soil and the surrounding climate.

Biodiversity should be maintained in forests to enable good functioning and the stability of forests. The cultivation of forests should be oriented to the achievement of economic and overall benefits. At the same time, the cultivation of forests increases the bonding of carbon dioxide, thus contributing to the reduction of greenhouse effects.

Under today's very difficult ecological conditions many of forest ecosystems have lost stability and are deteriorating. The reasons for such a condition are the disturbances in the humidity regime caused by the drop in groundwater level and lack of floodwater and the years of extreme drought with increased average annual and multiannual temperatures. Air pollution, water and soil pollution also contribute to the conditions that have adverse impact on the growth and development of forests. Under such unfavorable conditions the species that form climatogene communities most frequently suffer from drying up. These are usually the most valuable species that belong to narrow ecological valency relative to humidity and temperature.

Almost all the forests in Croatia have natural structure and entail high biodiversity characterized by several types of trees and underwood. When the most threatened species dry up they are being succeeded in the forest structure by the species that belong to broader ecological valency and have better adjustment capacities.

The research into the impact of climate change on the structure and development of forest ecosystems in Croatia have been carried out on three ecologically and floristically very diverse and distant regions with different forest stands in which the change in habitats has been observed. The forests in the researched areas suffer from drying up and dieback. Structural changes have also been recorded. The first researches were carried out in northern Croatia, in the lowland area by the river Drava characterized by the forests of poplar, willow and black alder. The researches were carried out also in the wider area of the city of Zagreb, in the penduculate oak forests, and in the central mountainous area of Croatia , Gorski Kotar, the area characterized by fir and beech forests. The studied areas are predominantly influenced by continental climate.

Podravina (northern Croatia): Research into wetland poplar and willow forests has been carried out in the Upper Podravina, in the economic unit "Varaždinske Podravske Šume". In 1970, this economic unit stretched across an area of 2350 ha. Over the period of 12 years the unit lost 560 ha of its surface area overgrown with forests. The main reason for drying up was the lowering of groundwater level. The water in these stands represents a dominant ecological factor significant for the survival of white willow, white and black poplar, white alder, black alder and penduculate oak stands and other tree species. The distribution of species in this area follows the pattern of ecological requirements of each of the species regarding soil quality and humidity.

Wider area of the City of Zagreb: Research into lowland penduculate oak forests has been carried out in the economic unit "Kalje", where a disastrous drying up of penduculate oak took place. In the period 1982 to 1986, 176,451 m^3 of wood mass dried up, out of which penduculate oak accounted for 98.5 percent. Nine locations were studied with the stands of different drying and regeneration intensities.

Gorski Kotar: Research into selected beech and fir-tree forests has been carried out in the region of Gorski Kotar, in the economic unit Brloško belonging to the Fužine forestry office. This region was affected by a catastrophic drying up of fir trees, especially intensive in the past twenty years.

Meteorological Indicators for the Croatian Forest Ecosystems Suffering from Drying Up

The analysis of climate data was carried out for the three mentioned areas. For this purpose, data from the Hydrological and Meteorological Institute were used. In the period 1961 to 1994, average annual temperatures have risen by 0.8 °C, and average temperatures in the growing season by 0.7 °C in the area of northern Croatia (Podravina) and in the central part of Croatia (Gorski Kotar). As regards precipitation amounts, average annual precipitation fell by 149.5 mm or by 17.1 percent. In the same areas the average precipitation during growing season fell by 138.7 mm or by 27 percent. The temperatures measured at the same time in the wider area of Zagreb show a decrease in average annual temperatures. The average temperature in the growing season fell by 0.4 °C at one station and rose by 0.8 °C at another. While at the first station precipitation decreased by 84.1 mm, at the second it increased by 84.5 mm.

In addition to the increase in average annual temperatures and decrease in precipitation amounts, the constructed reservoirs had significant influence on the drying up of poplar and willow forests. In the vicinity of the reservoirs the groundwater level has risen, while in more distant areas the drying up of poplar and willow forests has been observed. In distant areas groundwater level fell and had influence on the drying up of penduculate oak forests.

The recorded drying of fir-tree forests is due to long lasting dry climatological periods and air pollution caused by transboundary pollutant transport.

Changes in the Forest Structure in the Areas of Drying Up

Podravina (northern Croatia): Pursuant to the data on the structure of stands in the poplar and willow forests that were affected by drying up and in view of an increasing appearance of "subordinate" tree species, a connection can be made between the change in temperature, precipitation and water regime and the accidence of drying up. The forests of willows, black and white poplars, locust-trees, penduculate oaks and black alders are the most affected by drying up. In the case of groundwater level lowering, white willow dries most extensively and we can observe a downward shift, meaning that it is being succeeded by white alder in forest stands, and white alder is in turn being succeeded by poplars, etc. In case of groundwater and floodwater rise, there is an upward shift since the species inhabiting micro-hills and beams increasingly dry up and willows appear in the areas previously overgrown with white alders and poplars which in turn move to higher altitudes.

In this dynamic process of disappearance and emergence of individual tree species and communities, the appearance of some species that played a minor role in the structure of these stands can be observed. This includes, first of all, the appearance of white alder, *prunus padus* and elm. These species play an important role in the stands, especially as in their horizontal and vertical structure and microclimate and make pioneering vegetation in creating conditions for the regeneration of main tree species.

In view of the above, it can be concluded that the stands in the area of wetland forests adapt to climate and other ecological changes. Main tree species belonging to narrow ecological valency are being succeeded by tree species belonging to broader ecological valency that played a minor economic role in the past. Thus, the economic value of the stands has declined , but the overall beneficial functions they serve have not been significantly reduced (ecological and social).

Wider area of the City of Zagreb: In the area of changed climatological conditions there are discernible and proven changes related to the groundwater level lowering and occurrence of swamps. An increase in toxic carbon dioxide (CO_2) contents in the soil has also been detected. The inflow of floodwater into neighboring rivers and their long subsistence in forests contributed to the change in forest habitats. These changes have caused physiological weakening of the penduculate oak, which, along with the mentioned climate changes, led to more rapid drying up and dieback of oak forests.

Research into the structure of penduculate oak forests has shown that after the penduculate oak dries up, the dried areas are naturally regenerated to a lesser degree by penduculate oak and to a very significant degree by narrow-leafed ash and black alder. This fact can be explained by better adaptation of hydrophilic species, narrow-leafed ash and black alder, to increased humidity. Penduculate oak, a climatogenous dominant tree species belonging to narrow ecological valency relative to soil humidity is being succeeded by tree species such as narrow-leafed ash and black alder that belong to broader ecological valency relative to soil humidity. In this case, the composition of forests changes since instead of penduculate forests of narrow-leafed ash and black alder are predominantly being established. Thus, the economic value of these forests has somewhat declined and so did overall beneficial functions they serve, but to a lesser degree.

Gorski Kotar: The average annual and growth season temperature in the area of fir-tree forests has increased by 1.3 °C and 1.8 °C, respectively, while the average annual and growth season precipitation fell by 592.6 mm and 265 mm, respectively. Since fir-tree is very sensitive to temperature and humidity (it belongs to narrow ecological valency), and in view of other factors caused by air pollution that are present in that area, a disastrous drying up of fir-trees occurred.

The temperature increase and precipitation decrease favor common beech which more and more replaces fir-tree stands. The mixed fir-tree and beech selection stands with a regular composition ratio being 70 percent fir and 30 percent beech; have changed into almost pure beech stands. Such habitats are being increasingly naturally regenerated by beech.

The investigations carried out have shown that the expected climate change will have a significant impact on the types of trees belonging to narrow ecological valences, such as the fir-tree and penduculate oak. Their adaptation can already be observed, for example, with fir-trees growing at the edge of their natural habitat, moving towards the Mediterranean climate zone; here adjustments have been made to the warmer conditions in the fir-tree and hop hornbeam forests on the slopes of Biokovo.

The changes taking place in forests will have an effect on biodiversity, and can additionally endanger the species of overall ecological significance.

7.4.3 Climate Change Impact on Forest Fires

The largest part of the territory of the Republic of Croatia belongs to the Mediterranean region. One of the most significant potential impacts of climate change in the sense of global warming is the occurrence of forest fires in the coastal area. Deciduous and coniferous high forests account for 26 percent of total area burnt in 2000. about 1,059,110 ha of forest surface area and forest land belong to the area of karst, out of which 870,010 ha are state owned forests and forest land, and 189,100 ha privately owned forests and forest land.

In the past ten years there were 330 fires and 19.164 ha of forests and woodland area was burnt down on average. Fires in the Mediterranean karst area outnumbered all other fires.

Pursuant to the data on fires it can be concluded that the year 2000 takes precedence as regards the number of fires and the area burnt. There were a total of 706 fires and

Table 7-7: Number of fires in the period 1992 to 2000

YEAR	TOTAL (ha)	NO.	STATE OWNED (ha)	NO.	TOTAL (ha)	NO.
1992	11 130	325				
1993	20 156	372	9 673	248	10 483	124
1994	7 937	181	3 479	92	4 458	89
1995	4 650	109	535	69	4 115	40
1996	11 210	305	6 790	196	4 420	109
1997	11 122	305	5 543	169	5 579	136
1998	32 055	441	11 320	213	20 735	228
1999	6 053	223	2 367	93	3 686	130
2000	68 171	706	39 875	441	28 296	295

68.171 ha of forest and woodland was burnt down. The greatest number of fires occurred in the karst area, namely 590. The year 2000 also recorded the highest daily air temperatures that had a significant impact on the occurrence of fires.

Table 7-8: Number of fires per month

	Total	Karst
January	6	6
February	46	28
March	72	35
April	12	1
May	13	12
June	93	82
July	143	135
August	299	271
September	20	19
October	1	0
November	0	0
December	1	1
Total	706	590

Table 7-8 shows that the greatest number of fires occurred during summer months, namely July and August - totaling 406 fires in the Mediterranean area. In the same months the highest daily temperatures were recorded on those days when fire outbreaks occurred. In July, on the days of fire outbreaks, an average air temperature of 28.5 °C was recorded, and in August it was 31.6 °C. In addition to high temperatures, winds contributed to fire spreading significantly.

7.4.4 Measures to Mitigate Climate Change Impact on Forests

Expert forestry institutions of Croatia undertake all measures to mitigate damages caused by forest degradation and drying up, first of all by natural regeneration or, where this cannot be done, by introducing indigenous tree species, especially those that are missing in the structure of forest community and belong to that habitat. (Matić, 1989)

Research into paleo-climates and more recent climate patterns in Croatia has revealed that secular or long-term climate change generates no discernable negative impact on the vegetation mixture in individual climate zones. While resulting in either warming or cooling tendencies, these changes have caused vegetation zones to shift from lower altitudes to higher altitudes (in instances of warming) or vice versa (chilling). On the basis of such data, it can be assumed that future naturally occurring climate change, or that climate change directly or indirectly attributable to human activities, will cause further shifting of vegetation species across individual climate zones. (Matić et al., 1998a, 1998b; Trinajstić, 1998) In that case the lower edge of beech and fir-tree forest will move from 650 m of altitude to 700 or 750 m of altitude if the mean annual temperature increases by 1 or 2 degrees. Similar behavior will be observed in the forests of penduculate and sessile flowered oak. In the Mediterranean area, coniferous vegetation will shift towards north or towards continental areas, depending on whether the minimum temperature, now being below -2 °C, will increase to 2 °C or more, or not.

It is being assumed that the increased concentration of CO_2 in the atmosphere would not have a significant impact on forest ecosystems since its assimilation would be increased as well as economic and overall benefit functions served by forests. This fact is being confirmed by researches carried out by Spieker et al. (1996) and Bachman (1997) which revealed that in the past 40 years forest increment grew all over Europe, except in Scandinavia and the Alpine countries. Increased contents of carbon dioxide in the atmosphere contributed to these developments.

While estimating potential impact of global climate on forest soil it should be emphasized that the soil is considered a stable part of the forest ecosystem. Forest soil has two types of properties, the ones that can easily be changed and those that cannot. The properties that can easily be changed include reservoirs and organic matter decomposition processes, soil humidity and composition of soil solution. The changes in soil processes, and thus soil properties, occur mainly indirectly by the change of vegetation cover. A significant indicator of soil change is higher concentration of carbon dioxide in the soil, which can have impact on the physiological processes of plants and their survival.

The climate change characterized by average air temperature increase and precipitation decrease will have a significant impact on the drying up and degradation of main types of trees belonging to narrow ecological valency. Increased carbon dioxide concentrations in the atmosphere along with other climate, climate-edaphic and edaphic changes will have additional adverse effects on the forest ecosystems in Croatia. The result of these changes will be an increased share of trees belonging to the broader ecological valency that neither played a dominant role, nor have historically a larger share in the structure of dried substances. In this way the economic value of forests has declined somewhat, but the overall beneficial functions they serve have not been reduced (ecological and social), nor have their chances for their survival.

7.5 Effects of and Adaptations to Climate Changes in Agriculture

7.5.1 Introduction

Forecast climate changes constitute a new challenge, with so far unknown demands upon agricultural science and practice. Food production should be tripled to feed the entire population of the Earth in the coming fifty years, that is, as much food has to be produced in that period as in the last 8000 years. It is obvious that this cannot be achieved by developing new agricultural areas since there are simply not available. Thus, increased production per unit area seems to be the only remaining solution to this problem.

On the other hand, the soil is already under great pressure and, according to all estimates, if practising modern intensive agriculture should attain production increase, its adverse effects on the environment, notably soil and water, would become an almost insolvable problem. Besides, scenarios pointing to climate changes, involving the foreseen changes in temperature and precipitation, would additionally affect agriculture, as an activity governed by its own rules and regularities. Along with the forecast increase of the world population, a global reduction in agricultural production would have a strong impact on all the Planet Earth inhabitants. For these reasons, the forecast change of climate should be recognised as a factor that will influence creation of a new approach to food production.

7.5.2 Effects on Soil

Land suitability for agriculture is restrained by the soil quality, climate and relief. The global strategy of future development of agriculture primarily relies on optimal land use, which implies application of high technology on the best agricultural land, and protection of less suitable areas as well as of natural vegetation and animal species. However, also such, more or less intensive, technology must be adopted to the requirements of sustainable agriculture and sustainable land use, taking into consideration the potential trends of climate changes in particular agroecological entities of Croatia.

According to the existing scenarios of climate changes in Croatia, of special importance are the warming processes in the lowest layer of the atmosphere, which will also result in higher soil temperatures. Another important factor that will affect the indicators of sustainable land management is increased precipitation. Higher temperatures and increased precipitation will have a strong impact on the biological, chemical, and thereby also physical properties of soils. Trends of these changes can be only tentatively indicated, while a more detailed analysis would require in-depth research targeted at the effect of increased temperatures and precipitation upon all the relevant pedogenic processes.

Table 7-9 presents the potential effects on soil erosion in the conditions of precipitation increase/decrease per crops and months. It is a known fact that erosion risks for particular crops change with their development stages. Standard soil tillage practices for a crop are applied within the soil tillage system, in which it is possible to foresee when the soil will be especially exposed to erosion.

7.5.3 Effects on Plant Production

Effects of climate changes on different agricultural crops cannot be foreseen with certainty. Still, according to the existing scenarios, estimates were made of the potential change in the soil water balance, and the dates of air temperature increase/decrease of 5, 10, 15 and 20 °C for one meteorological station each in of the lowland, mountainous and littoral parts of Croatia. Based on the analysis of these data, it is possible to point to the diversity of problems that will appear in particular agroecological parts of Croatia.

When considering the factors affecting plant production in a region, which are likely to be changed under the influence of changed climate, those included in the existing scenarios can be discussed.

Besides temperature and precipitation changes, a substantial change is expected of the CO_2 concentration in the atmosphere, which will also have a direct influence on plant production.

If a doubled CO_2 concentration in the atmosphere is assumed, a certain increase of the total plant mass of different agricultural crops, due to fertiliser effects, may be expected. Along with increased biomass production, a corresponding increase of root organic matter is expected as well. Because of slower decomposition of the root biomass, due to increased CO_2 concentration, permanent enrichment of soil with organic matter might be assumed, whereby the humus content would increase as well. Still, effects of the increased CO_2 concentration on

Table 7-9: Effect of water erosion on field crops on sloping terrains under potential climate changes

CROP	MONTH											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
MAIZE - Current precipitation		+ + +	+ + -	- - -	- - -	- - -	- - +					
Increased quantity and intensity of precipitation		+ + +	+ + +	+ - -	- - -	- - -	- + +					
Decreased quantity and intensity of precipitation		+ + +	+ - -	- - -	- - -	- - -	- - -					
SOYBEANS - Current precipitation		- + +	+ + +	+ + -	- - -	- - -	- - +	- - +				
Increased quantity and intensity of precipitation		+ + +	+ + +	+ + +	+ - -	- - -	- - +	- + +				
Decreased quantity and intensity of precipitation		- - +	+ + +	+ - -	- - -	- - -	- - -	- - +				
SUGAR BEET - Current precipitation		- - +	+ + -	+ + +	+ - -	- - -	- - -	- - -	- - -			
Increased quantity and intensity of precipitation		- - +	+ + +	+ + +	+ + -	- - -	- - -	- - -	- - +			
Decreased quantity and intensity of precipitation		- - -	- + +	+ + -	+ - -	- - -	- - -	- - -	- - -			
SUNFLOWER - Current precipitation		- + +	+ + -	+ - -	- - -	- - -	- - +					
Increased quantity and intensity of precipitation		+ + +	+ + +	+ + -	- - -	- - -	- + +					
Decreased quantity and intensity of precipitation		- + +	+ + -	- - +	- - -	- - -	- - -					
TOBACCO - Current precipitation		+ - -	+ + +	+ + -	- - +	- - -	- - -					
Increased quantity and intensity of precipitation		+ + -	+ + +	+ + -	- - -	- - -	- - +					
Decreased quantity and intensity of precipitation		- - +	+ + -	+ - -	- - -	- - -	- - -					
POTATO - Current precipitation		- + +	+ + -	+ + -	+ - -	- - -	- - -	- - -				
Increased quantity and intensity of precipitation		+ + -	+ + +	+ + +	+ + -	+ - -	- - -	- - +				
Decreased quantity and intensity of precipitation		- - +	+ - -	+ - -	- - -	- - -	- - -	- - -				
OIL RAPE - Current precipitation	- - +	- - +	- - -	- - -	- - -		+ + -	+ - -	- - +	- - +	- - +	
Increased quantity and intensity of precipitation	- - +	- - +	- - +	- - -	- - -		+ + +	+ + -	- - +	- - +	- - +	
Decreased quantity and intensity of precipitation	- - +	- - +	- - -	- - -	- - -		+ - -	- - -	- - -	- - +	- - +	
WINTER WHEAT & other stubble winter crops - Current precipitation	- - +	- - +	- - +	- - -	- - -	- - -		+ + -	+ - -	- - +		
Increased quantity and intensity of precipitation	- - +	- - +	- - +	- - +	- - -	- - -		+ + +	+ + -	- - +		
Decreased quantity and intensity of precipitation	- - +	- - +	- - -	- - -	- - -	- - -		+ - -	- - -	- - +		
SPRING WHEAT & other stubble spring crops - Current precipitation		+ - -	+ - -	+ - -	- - +	- - -						
Increased quantity and intensity of precipitation		+ - -	+ + -	+ + -	+ - -	- - -						
Decreased quantity and intensity of precipitation		+ - -	- - +	- - +	- - -	- - -						
GRASSLANDS AND PASTURES - Current precipitation	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Increased quantity and intensity of precipitation	- - -	- - -	- - -	- - -	- - +	- - +	- - -	- - -	- - -	- - +	- - +	- - -
Decreased quantity and intensity of precipitation	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -

+ + + marked erosion - critical erosion periods; + + - great risk of erosion; - - + slight erosion; - - - negligible erosion plant production will largely depend on changes in the temperature and precipitation regime.

Based on the temperature and precipitation changes predicted by the scenario of climate changes for Croatia, using the regional model of mean global temperature in a 90% confidence interval (Scenario I) and taking account of global changes (Scenario II), the soil moisture balance was calculated for Osijek according to Thornthwait's method.

Although Thornthwait's method for calculation of evapotranspiration is indirect, and includes the assumption that a maximum of 100 mm of water can be stored in soil, the advantage of estimating the water balance by this method is the fact that the required input parameters are temperature and precipitation. Anyway, calculation based on the changes of the mean monthly temperature and the overall monthly precipitation for different scenarios of climate changes enables a more detailed recognition of the trends of changes that will, if the scenarios are at least partially realised, undoubtedly have a strong influence on plant production. Analyses of soil water balance for lowland Croatia indicate that the temperature increase foreseen by the models will cause higher evapotranspiration. Although increased precipitation is foreseen as well, it will not suffice to compensate for water evaporation by combined processes of evaporation and transpiration. For this reason, the probability of dry periods in summer months will be increased, which will have an essential influence on yield decrease unless enough water is provided for spring crops. As regards other water balance components, a reduction of soil water as well as a certain decrease in the total annual water surplus are notable in both scenarios.

The example of water balance for lowland Croatia allows the assumption that the summer water deficiency will increase by 30 to 60% (33.6% according to Scenario I, and 59.9% according to Scenario II) by the year 2100.

Despite a number of drawbacks of estimates based on the presented scenarios, it was deemed useful to determine the number of days with cardinal temperatures above 5, 10, 15 and 20 °C, in order to analyse the expected changes in plant production influenced by climate changes.

Results of calculations are certainly interesting. The yearly number of days with a temperature above 5 °C would be larger in 2100 than it is today, by 35 to 84 days in lowland Croatia. Cardinal temperature of 10 °C would last 25 to 41 days longer than today and that of 15 °C 26 to 46 days longer. The period with temperatures above 20 °C would be also prolonged, depending on the scenario, by 45 to 73 days.

According to these estimates, it may be assumed that seeding of spring crops will commence at an earlier date and, depending on the possibility of providing sufficient irrigation water, the growing period will last longer. Yields would be constrained by the length of the growing period, provision of sufficient water for intensified evapotranspiration, and possible crop damage due to early spring frosts as well as excessively high temperatures in summer months. Winter crops would have more favourable conditions for growth and development, so some yield increases may be expected. In such conditions, however, considerable problems may occur in terms of weed, disease and pest control.

Spring crops will suffer from water deficiency in summer months (Fig. 7-9) and, unless sufficient water is provided for irrigation, in some years yields may be substantially reduced due to droughts. Besides irrigation, adverse effects of water defi-

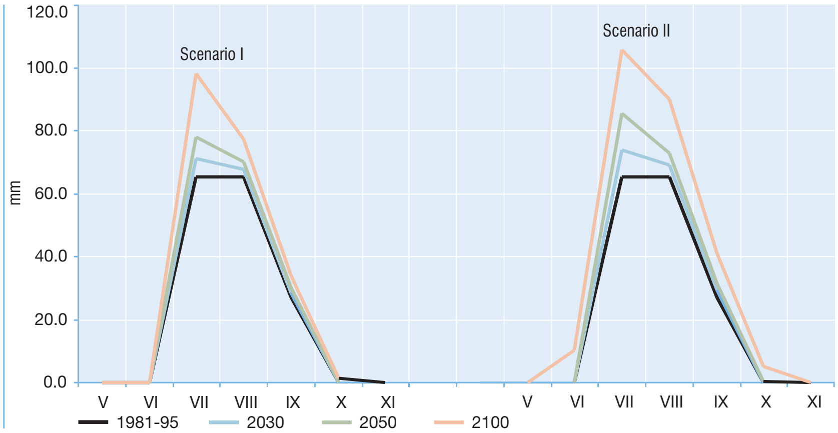


Figure 7-9: Water deficiency in soil according to different scenarios on the example of Osijek

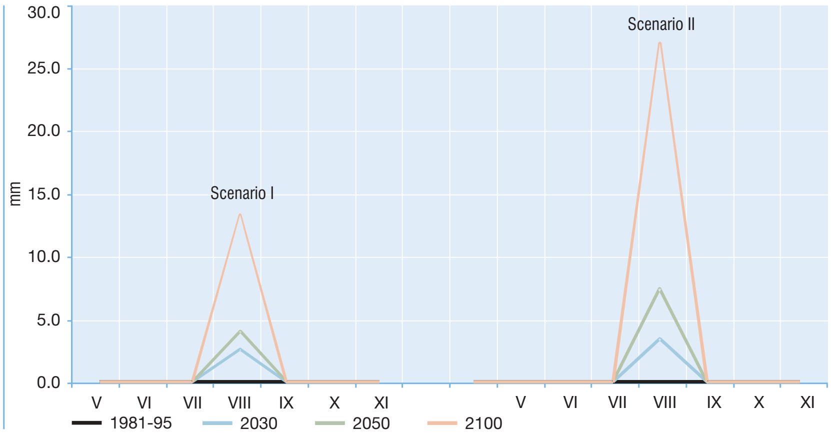


Figure 7-10: Water deficiency in soil according to different scenarios on the example of Gospić

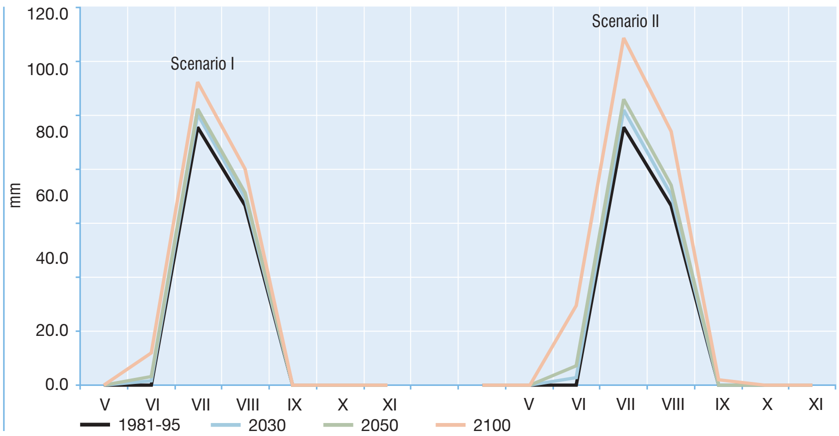


Figure 7-11: Water deficiency in soil according to different scenarios on the example of Zadar

ciency may be also avoided by the application of adequate tillage systems for a given region, seeding dates, choice of appropriate seed, etc.

In mountain regions, where there is enough water according to the current average water balance values, an average water deficiency may be expected in August. Depending on the scenario, it will range between 13.6 and 27.6 mm in the example given (Fig. 7-10). Based on the duration of particular cardinal temperatures, prolongation of the growing period by 25 to 45 days may be assumed, which might have a good effect on yields of field crops. Higher air temperatures influence earlier emergence and faster going through particular phenophases. Compared to the current situation, ripening and harvests of most annual crops would be precipitated by at least 15 - 25 days. On the other hand, faster initial growth in spring increases the risk of crop impairment by frost. The expected temperature increase should provide enough warmth for thermophilic crops.

Evapotranspiration foreseen for Zadar according to the presented scenarios may serve to estimate the changes in the coastal region, and on the islands, where substantial water deficiency is expected during the summer months. According to the calculation for Zadar, an increase of water deficiency in soil by 25.5% is foreseen by Scenario I, and by 56.5% by Scenario II (Fig. 7-11).

Duration of cardinal temperature of 10 °C would be prolonged from 55 (Scenario I) to 90 days (Scenario II) by the year 2100. According to the second scenario, temperatures above 10 °C would practically last throughout the year. If not enough water can be provided, part of the drought associated problems could be solved by shifting seeding times to periods with sufficient precipitation.

Effects of extremely high temperatures on heat stress in some plants must not be disregarded. According to agroclimate indicators estimated on the basis of temperature increase assumed by the two scenarios, without significantly higher precipitation and with the expected increase in evapotranspiration, the largest part of the lowland and coastal parts of Croatia will be exposed to drought hazards. This also holds for summer months in mountain regions, particularly with respect to the water-holding potential of Karst soils. The foreseen increase in precipitation may only partially compensate for the effects of intensified evapotranspiration due to higher temperatures. Provision of sufficient water or a favorable precipitation distribution may have a positive effect upon the yields of agricultural crops in the conditions of raised temperatures.

7.5.4 Effects on Animal Production

Since farm animals are much more susceptible to high temperatures than man, they should be adequately protected in order to ensure normal production. Hence, in the future, more attention should be paid to animal protection from high temperatures (and THI) to avoid heat stresses. For this reason, a short survey will be given of the management of the protection of farm animals against heat stress, the incidence of which is increasing in Croatia.

Farm animals have certain requirements regarding the climate (and microclimate), the most important of which are: temperature, air humidity, light and concentrations of harmful gases. Optimal temperatures for most farm animals are in the range of 0-20 °C, and optimal relative humidity is 60-80% (Koller et al., 1981). Farm animals are much more sensitive to high than to low temperatures because, due to lower perspiration (e.g., cattle perspire 90% less than man, pigs do not perspire) compared to man, they have a significantly smaller capacity of thermoregulation. Thus, the comfort zone for most animals ends at air temperatures above 25 °C. If temperature of 26 °C is accompanied with high relative humidity (95%), it is very difficult for animals to maintain their normal body temperature. Combination of temperature and relative air humidity is called the temperature humidity index (THI), “discomfort index” or “heat index” and is the measure of comfort for farm animals.

Since the microclimate in buildings where farm animals are kept strongly depends on the external climate, a brief description is given of the major meteorological indicators for continental Croatia. The temperate continental climate of Croatia is characterised by rather high temperature ranges. Winter temperatures often drop below -20 ^oC, while summer temperatures surpass 35 ^oC. The warmest months in continental Croatia are July (mean temperature 26 ^oC and relative humidity 71%) and August (mean temperature 25 ^oC and relative humidity 76%). Temperatures above 25 ^oC have been recorded on 64 days (average for the last 20 years), and temperatures above 30 ^oC on 11 days in a year. As these temperatures are accompanied with rather high relative humidity (above 70%), it can be taken that the period in which animals in Croatia are exposed to a slight heat stress is relatively long (40-84 days a year). Exposure to very strong heat stress (highly impaired thermoregulation endangers animal health and life) lasts about 3-20 days a year.

As can be seen from the given data, the climate of continental Croatia is relatively favourable for all kinds of farm animals. Owing to the relatively short period with expressly low temperatures (below -15 ^oC), the climate allows keeping of farm animals in cheap semi-open or "external climate" structures.

7.5.5 Socioeconomic Effects

The primary objectives of agriculture include provision of enough food for the population, production of natural fibres, and recently also production of energy, along with enabling farmers to make their living and earn sufficient profit. However, agriculture and agricultural land use have a complex influence upon the overall life of a community, through non-productive effects - landscape planning, keeping of tradition and cultural heritage, environmental protection, creating conditions for tourist industry, etc. Achieving a high degree of self-sufficiency in providing sufficient quantities of agricultural products is of great importance for the independence - integrity as well as social, cultural, political and economic stability of each country. According to the MFCAL concept (Multifunctional Character of Agriculture and Land), agriculture and land use involve three overlapping and closely connected roles: 1) an economic role, 2) a social role, and 3) an ecological role.

Change of Climate and the Concept of "Multifunctional Character of Agriculture and Land" in Croatia

With respect to agroecological conditions, three agricultural regions are distinguished in Croatia: Pannonian, mountainous and Mediterranean. Each of these regions, due to the specific features of its soil and climate, has different ratios of rural, mixed and urban population. Recognising the natural conditions and the structure of agricultural production in these three regions, as well as the number of their active agricultural population, pursuant to the concept of "multifunctional character of agriculture and land", advantages, disadvantages and specific features of each region should be defined. The geographic position of farms raises the issue of evaluating the fact that somebody is living in a region distant from any larger town, far away from the market, works on less fertile land, or that the farm is on a higher altitude above sea level, on a remote island, etc. One of the future objectives of agrarian policy should be a more precise definition of the regions in which agriculture should be especially stimulated. Considering Croatia's aspiration to join the European Union, we propose that also in Croatia zones of mountain farms and zones of less favourable areas (LFA) should be defined according to the regulations applicable in the EU.

If the scenarios of climate changes described in the preceding chapters are recognised, relatively large shifting of the boundaries of mountain farm regions can be expected, as well as the need of redefining the zones of less favourable areas. The current descending trends in the number of rural population are likely to

be further prompted by climate changes, both due to higher production risks and to more difficult conditions for agricultural activities.

7.5.6 Adaptations in Land Management

According to Hakansson (1994), the short-term goal of soil tillage research is to raise the efficiency of production systems, while the long-term goals involve maintenance or improvement of soil fertility and reduction of the plant production impact on the environment. Methods of soil tillage complementary with sustainable land management imply development leading to the following goals:

- reduced application of agrochemicals,
- reduced leaching of nutrients and ecologically risky chemicals,
- reduced emission of greenhouse gases from soil.

Considering separately the problem of fertilisation, two systems of sustainable agriculture are distinguished: ecological and integral. The ecological system comprises input of nutrients without application of mineral fertilisers, and as such it is not uninteresting, particularly for farms committed to such farming.

The integral system is based on taking advantage of the interactions between the conditions for plant growth (soil, climate), biological abilities of crops and production conditions, including fertiliser and pesticide application.

Sustainable land management is imperative for the development of Croatian agriculture in order to enable future generations to make use of its advantages, viz. production of sufficient quantities of organic food on soils of preserved fertility.

Awareness of the need of sustainable development is already present, and all the scientific and professional potentials should be engaged in designing adequate research programs and then applying their results in practice. As the first step in this direction, the available data on soils as well as on the results of the so far soil research done in this country should be electronically saved.

Use of modern procedures and models will enable computer modelling of soil changes, allowing precise definition of sustainable land management for each region of Croatia, and also, in case of signs of soil fertility degradation, its timely modification.

Application of research results may bring about desirable effects in terms of cost reduction, along with maintaining a satisfactory level of soil fertility. Attainment of this goal requires a multidisciplinary approach to solving land management problems.

7.5.7 Adaptations in Plant Production

For a good and efficient adaptation of agriculture to climate changes, naturally to the extent that it is possible, the following should be undertaken:

- Make preparations for own production or procurement of agricultural machinery and equipment that will enable application of new practices and new soil tillage methods, adapted to the changed climate conditions, such as no-tillage, direct drilling, minimal tillage, ridge-tillage, and other forms of conservation tillage, adapted to water surplus/deficiency, stronger winds, rains of higher intensity, higher temperatures, etc.

- The time and depth of application of particular plant-growing practices, such as ploughing, seeding, fertilisation, top-dressing, pest protection, etc., will have to be adapted to the changed climate conditions.
- Plant breeding - creation of varieties and hybrids resistant to more severe droughts or higher humidity should ensure stable production.
- Choice and adequate,rotation of winter and spring crops, high-density crops and row crops, as well as crops with longer and/or shorter growing periods, in compliance with the new changed climate conditions.
- Development of new agricultural areas. Croatia, however, does not have great potentials in this respect because of mainly marshy areas, which in turn have an ecological role and importance of their own.
- Reintroduction of old, domestic cultivars that used to be grown in these parts.
- The role of wind in our conditions should be specially emphasised. In our opinion, wind will have and even more important role and influence than now in case of climate changes. Soil erosion by wind which, though neglected, has been causing great damage, will become an even more serious problem, notably on sandy soils in the Sava valley and on light soils in eastern Slavonija, Baranja and Srijem.
- Besides its effect on soil erosion, wind will have a stronger influence on the distribution of pollutants, emitted from industrial and urban areas, as well as roads, into the environment. Thus, excessive pollution will occur on the sites where solid particles from air are deposited. These reasons justify our assumption of windbreaker belts gaining on importance.
- Wind will also have a major role in salinization/alkalisation of soils in the coastal region, as well as in damage incurred to agricultural crops by increasing occurrence of rime frost.
- For the said reasons, slope exposition will gain on importance. Northern sides will be subjected to more intensive water erosion, so crop rotation and tilling practices will have to be adapted to the new conditions.

7.5.8 Adaptation in Animal Production

Maximum attention should be paid to the housing of farm animals; they should be protected from direct sunshine in summer and provided with dry warm litter (straw) in winter. Built structures should have an adequately large volume and efficient ventilation. Since most farm animals perspire only slightly (or do not perspire at all), they maintain their normal body temperature in warm weather by exhaling water vapour. For this reason, the relative air humidity in buildings where animals are kept is always higher than that of the external air. As high relative air humidity impairs animal health, good ventilation is necessary both in winter and in summer. To ensure optimal relative humidity in structures where animals are kept, about 500 m^3 of water exchange per hour should be provided per conditional head. Such ventilation can be achieved only in “external climate” structures.

Adequate management can substantially reduce the adverse effect of high temperature on animal production. Farmers must be ready and conversant with all the measures that should be undertaken before high temperatures start. In doing so, they must keep in mind that heat stress appears in animals at considerably lower temperatures than in man.

Good management that is suggested to Croatian farmers includes:

1. Animal protection from direct sunshine by providing shady places or roofed shelters.
2. If necessary, in warm regions (Dalmatia), buildings for animals should be additionally cooled (additional ventilation - ventilators installed in the “wind tunnel” system, roof showers, etc.).
3. Rations should supply animals with adequate quantities of proteins, energy, vitamins and minerals.
4. Animals should be fed bulky feed (roughage) of high quality.
5. Animals should be fed rather small rations several times a day in order to increase feed consumption.
6. Feeding animals during cooler parts of the day.
7. If possible, animals should be kept outside on pasture at night.
8. Feed leftovers should be removed every day.
9. Animals should b provided with unlimited quantities of clean, cool drinking water.

7.5.9 Adaptation and Socioeconomic Effects

The concept of “multifunctional role of agriculture and land” can be applied to planning agricultural development in different agricultural regions of Croatia. Recognising the specific features relating to the soil, climate, and tradition in plant and animal production, a projection of agricultural development should be designed for each region of Croatia in compliance with the production, social and economic roles of agriculture, as well as its role in the development of tourism. Our agricultural science is confronted with the task of a detailed analysis of all the numerous aspects of the “multifunctional role of agriculture and land” under different agroecological and economic conditions, that is, in different agricultural regions.

According to these conditions, socially, economically and ecologically acceptable and sustainable practices in agriculture and land management have to be designed, aimed at achieving the principal goal of Croatian agriculture also under changed climate conditions - provision of enough food for the population, along with enabling farmers to earn their living and make sufficient profit from agriculture.

7.6 Biological Diversity

7.6.1 Introduction

Latest surveys of the effect of climate change on biological diversity and continental ecosystems have pointed to several main trends:

- species will react differently on climate change, due to the mutual differences in their competitive abilities, migration capabilities, reaction to disturbances, etc. Therefore, new combinations of species will originate. The effects that this "reorganisation" of the species system has on ecosystem as a whole are still unknown
- many taxa will be capable of spreading and changing their areals fast enough following the expected changes, therefore preserving relatively unbroken and continuous areals through natural ecosystems
- depending on the magnitude of climate changes, other ecological factors affecting the characteristics of ecological niches do not have to change the same way the climate does, which will result in new habitats, not encountered by the species before
- changes in the lasting of seasonal events during the annual natural cycles may have strong negative effects on many species, especially the migratory ones
- problem of invasion of alien species into natural ecosystems, already strongly manifested, appears to become even more dramatic with the climate change. Dying rate will increase in the long-living taxa (i.e. trees) parallel with moving of their living optimum away from centres of their areals. Also, expected land use changes may endanger these taxa even more. Increase in degree of disturbances of natural ecosystems will probably cause origin of ecosystems of early successive phases, decrease in diversity and simplification of the biosphere structure
- effects that the climate change will have on taxa structure will be very different within certain systems, depending on local differences, i.e. soil influence, land use, topographic diversity and such
- reduction of sizes of ecosystems adapted to lower temperatures (Arctic, Alps) are expected, with negative effect on Arctic and Alpian species

7.6.2 Limitations in Estimations

The Estimation is limited to the period until the year of 2100, with interval projections for 2030 and 2050. In principle, areal limitation relates to the whole country or a region ("province", river valley, ecological zone, and such). The whole territory may be the subject of a study in smaller countries, so the question of a range is not critical. In this case, territorial limitation relates to the state borders and the whole territory of Croatia (56.830,00 km^2) denotes it as one of the smaller European countries, although ecological heterogeneity (for instance, big difference between its continental and Mediterranean parts) may generate the need for individual approach to its smaller parts. In case of making of this estimation, climate scenario IS92a (climatological sensibility 2.5 °C) was considered with data for three periods of time (until 2030, 2050 and 2100), as well as scenario IS92e (climatological sensitivity to 4,5 °C) considering the changes in concentration of aerosols and applying the "business as usual" approach.

7.6.3 Methodological Limitation

Incapability of carrying out long-term experiments in controlled conditions generally led to the development of other techniques of conducting the Estimation. Out of five approaches (research techniques) given the circumstances four of them can be applied in Croatia.

1. paleoecological, archeological or historic studies on the effect of climate change on man and natural systems in the past
2. studies on short-term climate changes more or less analogue to the expected events in a longer period of time(for instance, droughts, floods, and such). A formal method including this approach is called *forecasting by analogy*
3. studies on the impact of today climate and its variability
4. expert judgement and projection of the results given in other (similar, related) areas (groups)

The approach not applicable in Croatia given the conditions and deadlines is making of quantitative models based on the relationships between climate variables, i.e. the chosen influencing factors and the variables surveyed, in this case variables of biological diversity. Each model's need for a specific type of data is the basic test for choosing an approach to the modelling. Often are the model's demands for data very high and hardly accessible, in best case leading to its simplification (interpretation errors) or complete inapplicability in given conditions. Out of several groups of models (biophysical-empirical, biophysical-processual, economical, integral). In this case:

1. there is no database infrastructure to implement some of the quantitative models of analysis of the effect climate change has on biological diversity
2. there is no cadre in this moment fully capable of handling the adequate methodology
3. there are no adequate tools, in the first place program support. Some programs are in the shareware domain, but covering them and getting accustomed will take time
4. even with the difficulties cited at 1 to 3 resolved, deadlines for implementation are too short.

7.6.4 Global Effect on Continental Ecosystems and Biological Diversity

In the territory of Croatia, the following main groups of effects of climate change on biological diversity may be expected (in accord with Kapelle 1999):

1. moving of vegetation zones in horizontal and vertical direction

2. moving and changes in areals of individual taxa of flora and fauna
3. disappearance of some species
4. changes in qualitative and quantitative structure of biocenoses
5. fragmentation of habitats
6. changes in the ecosystem functioning.

7.6.5 Effect on Plant Taxa

The most drastic changes may be expected in taxa found in the highest mountain areas of Croatia. The expected rise of temperature ranges from 2.2-2.4 °C (IS92a sign. 90%) to 4.2-4.9 °C (IS92e sign. 95%). According to the Hopkins Bioclimate Law (Brown et Gibson 1983, Beniston et Fox 1995), temperature rise of 3°C corresponds to the change of height of 500 m above sea level.

Plant taxa of narrower ecological valence will tend to adapt their areal to the newly created conditions. The critical element is the speed of adaptation. Pollen charting and measuring its age (by radioactive isotope ^{14}C) pointed to the migration speed of plant species during the Holocene climate changes. Woody plant species of European territory (including Croatia) show that the rate that edges of areals change is 50-2000 m/year (Davis 1983). This fact might insure the migration of at least some woody species in the direction the Dinarics stretch towards northwest with possible local impoverishment of flora.

Decrease in the number of herbaceous taxa of narrow ecological valence of highest mountain areas not able to adapt their areal fast enough (for instance *Arabis alpina* L., *Arctostaphylos alpinus* (L.) Spreng., *Arctostaphylos uva-ursi* (L.) Spreng., *Veronica alpina* L., *Pinguicula alpina* L., *Hieracium alpinum* L., et al) might be expected. This group includes the taxa of Croatian circumpolar, pre-Alpian and Alpian diffusion flora types. According to ecological indexes (Ellenberg 1983, Korneck et Sukopp 1988) available for 29,93 % of Croatian flora (Nikolić 2000), the most endangered will be 40 taxa of circumpolar, 266 taxa of pre-Alpian and 607 taxa of Alpian diffusion.

Flora of small southern and middle Adriatic islands will probably bear the brunt. Rich and endemic flora and a great number of already endangered species have, within island ecosystems, little possibility of migration given the available dispersion mechanisms. With moving of climate zones, disappearance of a part of hardly adaptable species might be expected (for instance *Asperula staliana* Vis. ssp. *arenaria* Korica, *Asperula staliana* Vis. ssp. *issaea* Korica, *Asperula visianii* Korica, *Campanula poscharskyana* Degen, *Centaurea crithmifolia* Vis. et al).

Dynamics of a breakthrough of alochtonous species might increase, with more aggressive ones pushing the autochthonous taxa out of their natural habitats. These are the processes that have already been documented. That is how, for example, for the first time, but somewhat recently, *Salvia peloponnesiaca* Boiss. et Heldr. (Regula-Bevilacqua 1969), *Sporobolus neglectus* Nash (Marković 1972), *Avellinia michelli* (Savi) Parl. (Pavletić 1972), *Bidens bipinnata* L. (Trinajstić 1975), *Ballota acetabulosa* (L.) Bentham (Trinajstić 1983), *Diplotaxis erucoides* (L.) DC. (Pavletić 1987), *Guizotia abyssinica* (L. F.) Cass. (Trinajstić et Pavletić 1989), *Lingularia sibirica* (L.) Cass. (Šagulja et Krga 1990), *Damasonium polyspermum* Cosson (Trinajstić et al. 1995) and others were recorded although one cannot say with certainty which mechanisms of input of these species were present.

Changes in size and shape of areals, mostly decreasing, of some taxa were documented for the Mediterranean type of area too (GLM, GAM model, for instance Austin 1998). Although the modelling of changes of areals caused by climate changes is sometimes criticised (for instance Davis et al. 1998), the very changes were never denied.

7.6.6 Effect on Plant Communities

Plant communities are extremely complex ecological systems. Because climate models, the global climate predictions, still lack regional resolution, it is hard to predict local changes with great certainty, especially in mountain regions (Beniston et al. 1997).

Vegetation model of impact, carried out with IMAGE (Leemaans 1999) pointed to the alarming changes in vegetation of European territory (including the Croatian state territory), which is in accordance with the results of IPCC (Watson et al. 1996). Natural adaptation takes place only in a small percentage of vegetation under impact. The model carried out with IMAGE 2 pointed that successful adaptation was possible only with a very small climate change, smaller than 0.1°C/10 years, and an absolute climate change smaller than 1°C total (Leemaans 1999).

Regional model of average yearly change of air temperature gives the average increase of temperature over the whole Croatian territory ranging from 2.2 to 2.4 °C (IS92a, sig. 90%) until the end of the next century, or from 4.2 to 5.6 °C (IS92e. sign. > 95%). Both these extreme scenarios, with reference to the rate of change and the final absolute value of change, exceed multiply the limitations resulted from the model carried out with IMAGE 2 (Leemaans 1999). Effective adaptation of natural vegetation will not be possible in some types of communities. In accordance with the Hopkins' Bioclimate law (Brown et Gibson 1983, Beniston et Fox 1995), vegetation of higher mountain regions with boreal characteristics will partly be replaced by temperate communities. In higher regions, the eliminating ecological index will probably be the temperature, in lowland continental regions the rainfall. Slowness in migration abilities, absence of migration ways, and lack of alternative habitats will cause fragmentation or disappearance of some stands.

The rates of a change of vegetation's structure (response time) will vary depending on various local ecological factors. Border areas between vegetation types might demonstrate changes already within one decade with rise in the temperature of 1-2 °C (Woodward 1992). This makes the transitional belt between the adriatic province (submediterranean zone and Mediterranean mountain belt) and the Illyrian province (the belt of mountain and submountain deciduous and coniferous forest) especially sensitive (regions according to Horvatić 1967).

Research on the Mediterranean type of vegetation of California (Westman et Malanson 1992), in most ecological factors comparable with eumediterranean and submediterranean zone of the Adriatic coast (according to Horvatić 1967), and coincident rise of temperature show several outcomes in these zones can be expected. Increase in the evaporational-transpirational stress is expected, as well as certain changes in successive lines of vegetation communities and increase in the number of species of annual plants (terophita and geophita) from current 21%, i.e. 12% (Nikolić 2000) to higher values.

Globally, forest communities of temperate regions, mostly forests of lowland and mountain regions of Croatia, compared with other forest belts, will be the last to be exposed to changes (Kirschbaum et Fischlin 1995). However, in spite of physiognomic stability, certain communities may undergo changes in floristic composition and impoverishment of low strata of herbaceous vegetation. One can expect the spreading of Mediterranean ecotypes into the zones of submountain floristic elements (Beniston et Fox 1995), for instance thermophitic and terophitic species of *Quercus ilex, Q. pubescens,* etc.

7.6.7 Effect on Soil Biocenoses

It is little probable that the predicted climate changes will influence the decrease in the number of species in the soil directly, except in the case of obligate symbionts whose plant partner is affected by the changes (Whitford 1992). Most components of soil biocenoses have high tolerance to changes of temperature and moisture. Mostly short life cycles will also make genetic adaptation possible. Climate changes may still affect the abundance of species, which secondarily may have qualitative and quantitative effects on ecosystem as a whole, first of all, the trofic relations between the members of biocenosis. The heating of soil will cause the increase in the number of microorganisms and processes of mineralization of nitrogen and phosphorus, making these nutritional elements for plants more accessible. Also, the fauna of the narrow coastal area interstice (depending on local topographic features) may be directly exposed to salinization as a result of the rising of sea level. As a result of participation of certain microorganisms and organisms in complex ecological chains, the total effect on biological diversity will be negative (Ruess 1999b).

7.6.8 Effect on the Fresh Water Biocenoses

The heating of air near the ground level will cause the heating of the ground itself, and the water in it. The moving of zones in the mountain regions will reduce the size of areas under snow and the amount of water bonded in snow, and have effect on the amount of water which, from these sources, reaches rivers and other courses in spring. Changes in yearly water level rhythms and the quality of water might be expected. This will probably effect the quality of underground and overground waters, and, directly or indirectly, composition of the constituent biocenoses.

7.6.9 Physiological and Ecological Effect on Fauna

Adult animals, especially those of higher taxonomic groups, have the ability to lessen the effect of global heating by physiological mechanisms (behavior, thermoregulation, hypothermia, temperature compensation, etc.) (Dawson 1992). Although these mechanisms increase the resistance substantially, they cannot eliminate the secondary effects on animal biology, particularly the mechanisms connected with breeding. In ecological sense, global heating may as a result have decrease in the number of fauna species in natural habitats, and the effect on their spatial and temporal distribution (Tracy 1992). It has been noticed for instance that certain butterfly species change areal also with a change of environment's temperature $<1°C$. One can expect the effect on daily, seasonal and annual rhythms, activity, and migrations, of insects in particular (Kapelle 1999, Rubenstein 1992), and on sensitive insect-plant interaction (Fleming et Candau 1998). In the nematode group, it has been noted that different taxa react variously on the soil heating, and that both decrease and increase in the number of species might be expected, depending on the group (Ruess et al. 1999). To understand the connection between population biology of Vertebrata and climatology, the data is still insufficient. It seems that the birds of the sea coastal habitats will experience more negative effects (Myers et Lester 1992) than the rest of ornithofauna.

Especially affected will probably be the endemic fauna of small southern- and middle-adriatic islands. Great number of already endangered species has, within the limits of island ecosystems, little possibility of migration given the absence of migration ways. With moving of climate zones one can expect the disturbance of unknown physiological and ecological conditions necessary for surviving of individual stenoendemic taxa of karst and coastal small lizards.

7.6.10 Effect on Coastal Ecosystems

With the impact of changes in regime of temperatures and rainfalls, biological diversity of coastal systems of the Adriatic coast will be affected by a change in sea level. For the Mediterranean area, a rise of 34-52 cm of sea level has been predicted. Low coastal areas, like coastal sands, salt areas and estuaries are the habitats and biocenoses, which will be directly exposed to this effect. Changes in physical, hydrodinamic, biological and chemical parameters with associated qualitative and quantitative changes in biocenoses' structure might be expected. The heating of the surface water layer and deeper penetration of mixed water into estuaries might have serious effects on the fresh water biocenoses. Deterioration or disappearance of certain valuable coastal habitats through erosion processes might be expected. It is hard to predict the direction of changes and the impact on certain taxonomic groups. Rivers of the Dinaric watershed, Krka and Neretva in particular will bear the brunt. Since these areas are, because of their biological characteristics, protected in the category of National parks, and included in the list of valuable swamp habitats according to the RAMSAR convention (Kutle 1999), possible negative trends are especially unfavorable.

7.6.11 Effect on Protected Regions

The changes in area of some species and communities may have an effect on the areas under protection. This can result with a need to modify the borders of National parks situated in the mountain regions (Davis et Zabinski 1992), namely NP Risnjak, NP North Velebit, NP Plitvice ~~a~~ Lakes and NP Paklenica. "An extenuating circumstance" is that borders of these parks are not precisely fixed even today, and sometimes not even created based on biological criteria. But since this is a long-term processes and there is a possibility of correcting these faults, even the potential need for consideration of the effect the climate change has on the borders, may be expressed fully.

7.6.12 Most Sensitive Ecosystems and Regions

According to the available data and their analysis, all of the three macroregions of Croatia, lowland, mountain and Mediterranean will be effected by climate changes. Most endangered, in the context of possible negative trends on biological diversity, that is decrease in the number of species per surface unit, are:

1. Mountain Croatia, especially the Dinaric area. This mountain chain and associated areas, were recognised before for their extraordinary biological and geomorphologic value, and some parts protected in various categories (UNESCO MAB - Velebit Biosphere Reserve, NP North Velebit, NP Paklenica, NP Risnjak, NP Velebit, NP Plitvica Lakes et al). At least two European centres of endemism are registered in the region: Velebit and Biokovo.
2. Mediterranean Croatia, especially estuaries of the karst rivers basins, and south Adriatic islands with great accumulation of endemic flora and fauna

7.7 Coast and Coastal Area

7.7.1 Areas Endangered by Sea Level Increase

The process of identification of coastal areas, both on the mainland and on the islands that will be imperilled by the sea level increase was conducted so that the sea level increase by 20 and 86 cm was considered. The evaluation was made considering the assumed increase in sea level and corresponding mainland-sea border determination. Further, the saline water ingress into the underground was accounted for, and an increased risk of the flooding of the coastal zone due to the storm waves, extreme precipitations, and increase in the groundwater table.

Expected Sea Level Increase by 20 cm As a rule, the expected increase in the sea level by 20 cm will not significantly affect the coastal area. However, there are some areas where its impact might be severe. These areas have already been occasionally flooded, such as the coastal areas of the cities of Rovinj, Pula and Split. The increase in the sea level could significantly affect the only two fresh water lakes located in the region, i.e. the Vransko Lake on the Island of Cres and the Vransko Lake near the town of Biograd. It could also affect the alluvial plane at the mouth of the Neretva and Cetina rivers, and consequently the City of Omiš. Also, the negative impact will be felt by the salt works at the Island of Pag and in towns of Nin and Ston, and the municipal waste water outfalls. The impact on groundwater and increase in intrusion are difficult to evaluate because of insufficient data, but it is realistic to expect that they will not be high. It is also expected that the increase in the sea level will not cause littoral erosion nor significantly affect the existing beaches.

Expected Sea Level Increase by 86 cm The expected increase in sea level will considerably affects the above mentioned areas. It will also significantly affect a large number of structures/buildings located at the low above-sea level in numerous settlements, the sewage systems in most of the coastal settlements and all the marinas, small marinas and harbors. So the study for the islands of Cres and Lošinj has shown that the sea level increase of 1 m would flood the area inhabited by approximately 13 percent of the current population.

7.7.2 Impacts and Their Socio-Economic Effects

Biogeophysical Impact

Possible impact of the given scenarios on the coast and coastal zones are summarised in tables 7-10 and 7-11. The impact of the sea level increase (by 20 cm and 86 cm) envisaged in the given scenarios on settlements, coastal structures, infrastructure and industry has been assessed in descriptive terms as significant, moderate, insignificant, none, favourable and unfavourable.

It is obvious that increase in sea level by 20 cm will have insignificant or modest impact on the said aspects, while the increase by 86 cm will have moderate impact which will become significant when infrastructure, harbors, marinas and beach structures are considered.

Probability of Increase in Frequency of Floods

Sea Level Increase by 20 cm The floods, as result of coastal storms or river flooding would at this sea level increase be of small significance for the entire coastal area for two main reasons. The low-lying coast that might be exposed to stormy weather is protected by islands, with an exception of the western Istria coast. As a

Table 7-10: Possible impact of the sea level increase on settlements, beach structures, infrastructure and industry

	20 cm	86 cm
SETTLEMENTS	Insignificant	moderate
TOURIST (HOSPITALITY) STRUCTURES	Insignificant	moderate
WATER RESOURCES	Insignificant	moderate
INFRASTRUCTURE	moderate	significant
INDUSTRY	Insignificant	moderate
HARBORS AND MARINAS	moderate	significant
ARCHITECTURAL HERITAGE	Insignificant	moderate
ARCHEOLOGICAL SITES	Insignificant	moderate
BEACH STRUCTURES	moderate	significant

Table 7-11: Explanations with the table 7-10, Possible impact

	20 cm	86 cm
SETTLEMENTS	small number of houses in coastal and island areas	larger number of houses in settlements located in coastal and island areas on el. up to 2 m a.s.l.
TOURIST (HOSPITALITY) STRUCTURES	camps, tourist compounds located immediately by the coast	hotels, annexes, camps, tourist compounds on el. up to 2 m a.s.l.
WATER RESOURCES	river mouths (11), groundwater, lakes	river mouths, groundwater, lakes
INFRASTRUCTURE	roads, bridges, water supply and sewage networks, in the vicinity of the sea	roads, water supply and sewage networks, water treatment plants, outfalls
INDUSTRY	shipyards, cement industry, oil refineries	shipyards, cement industry, oil refineries
HARBORS AND MARINAS	quays in harbors, marinas and small marinas	oil terminals, quays in harbors, marinas and small marinas
ARCHITECTURAL HERITAGE	churches, fortresses, remains of ancient settlements in the coastal and island areas	churches, fortresses, remains of ancient settlements in the coastal and island areas
ARCHEOLOGICAL SITES	archaeological sites in coastal area	Archaeological sites in coastal area on el. up to 2 m a.s.l.
BEACH STRUCTURES	diminishing of sandy beaches	individual sandy beaches will almost disappear

rule, related to the mainland coast areas the islands are laid in the direction of storms, and the island settlements are mostly located on the north-eastern sides of the islands. The river mouths are also generally protected from storms, so the waterstream levels will also not increase. The main socio-economic effect of the expected sea level increase, would be the direct consequence of flooding rather than those caused by storms or river floods.

Sea Level Increase by 86 cm Flooding of coastal area caused by coastal storms would significantly affect the western Istrian coast and the low-lying coast in the northern and central Dalmatia. The sea level increase could significantly increase the flooding risk of the Mirna, Zrmanja, Cetina and Neretva rivers. The expected impact will not significantly affect the main business sectors in the coastal area.

Coast Erosion, Flooding and Significant Socio-Economic Effects

Sea Level Increase by 20 cm As already said, the Croatian coast is not exposed to the erosion processes. The erosion is pronounced in specific limited localities, the most important being the city of Nin territory. It is realistic to expect that the increase in the sea level will accelerate the process of erosion. In the predominant part of the coast, the coast flooding due to the sea level increase will be experienced only in the low-lying areas, which includes the majority of small beaches. These changes will as a whole have a relatively small impact on the economic activities such as agriculture, fishery, tourist industry and the residential sector.

Sea Level Increase by 86 cm Regarding erosion, the increase in the sea level will have the strongest effect on the territory of the city of Nin. There is a high probability that such sea level increase will cause erosion in some other zones as well. The coast flooding, as a consequence of the sea level increase will significantly impact a large part of the coast. The impact of the said consequences on the economic activities, such as agriculture and fishery, will be negligible. However, some impact will be suffered by the tourist industry and human settlement, and high negative impact on the coastal infrastructure (harbors, marinas and small marinas, outfalls).

Groundwater Table Increase

Sea Level Increase by 20 cm It is highly probable that the increase in the sea level and the resulting increase in groundwater table will not affect the agricultural activity in the low-lying coastal areas. It is actually difficult to forecast the significance of the impact because of insufficient data on the groundwater tables and permeability of the underground strata. Any increase in the groundwater level could slightly affect the permeable black holes encountered in the low-lying coastal area.

Sea Level Increase by 86 cm It is highly probable that the increase in the sea level and the resulting increase in groundwater table will have a significant positive effect on agricultural activities in the low-lying coastal areas. However, it is practically impossible to assess the effect because the available data is insufficient. The groundwater table in the coastal area could in some areas have major effect on the black holes, and on underground installations, such as sewer pipes, power and telephone cables, and the like. However, the insufficient data make it impossible to assess the groundwater table increase effect.

Sea Waster Ingress into the Underground

Sea Level Increase by 20 cm The sea level increase could cause the saline water ingress into the ground and surface waters in the coastal belt. Ingress of the saline water into the fresh water could negatively affect the potable water supply and agriculture. The saline water ingress into the underground is not possible to assess because the data on the local soil permeability data is insufficient, so only the areas for which the data is sufficient are referred to, primarily both Vransko lakes and the Neretva River valley.

The Vransko Lake is the only potable water source for the islands of Cres and Lošinj and the saline water ingress could have a significant impact on the island population. The impact on the other lake, which is already exposed to the saline water ingress, would be even more pronounced and it could affect agriculture in the vicinity of the lake. The saline water ingress into the Neretva River valley could negatively affect the agricultural sector.

Sea Level Increase by 86 cm At this sea level increase, the saline water ingress into the areas, referred to above, would be more pronounced, and the negative impacts would probably be suffered by agricultural and some other sectors.

7.7.3 Elements of an Action Plan for Prevention, Reduction and Mitigation of the Socio-Economic Impacts

Climate change and its consequences, such as the sea level increase, are poorly indicated and they do not ask for immediate response. This is particularly characteristic for Croatia, where there are no problems related to the coast flooding or erosion. For this reason, it is difficult to initiate the activities related to adoption of an action plan for prevention, reduction and mitigation of the socio-economic impacts of the sea level increase. However, this attitude needs to be changed since the climate change and the related consequences will certainly occur in a long-term. The problem lies in the fact that preventing impacts once they occurred is impossible, thus timely planning is almost only available adjustment measure.

Coastal Zone Management

The initial (imperative) activities related to the coastal zone management with regard to the climate change and increase in the sea level include development of detailed studies on identified sites and assessment of possible impacts. It is necessary to acquire the following data: maximum coastal surface to be exposed to temporary or permanent flooding; population affected by the floods; saline water ingress into the fresh water recipients. The obtained results should be used to prepare national strategy and action plan for prevention, reduction and mitigation of negative socio-economic impacts, which should be adopted and approved by the state authorities. The strategy and action plan should include two major areas - protection of existing natural resources and man-made structures and facilities, and the criteria and guidelines for construction of new structures and facilities in the coastal zone.

7.8 Marine Ecosystem and Fisheries

Based on climate change scenarios and influences of climate changes on oceanographic properties in the Adriatic Sea, it could be possible to identify the responses of marine ecosystem and fish resources on climate changes. All these effects and linkages are shown schematically in the next figure and in tables.

In the previous table (Table 7-14) linear trends of sea temperature and salinity are estimated based on the real data, e.g. based on calculated trend of air temperature and precipitation using a linear regression model. For the primary production and for the other parameters in the food chain, in this moment only a qualitative approach can be used Historical series of small pelagic fish landing data along the Eastern Adriatic coast, which show strong year-to-year fluctuations, were compared to climate fluctuations over the Northern Hemisphere, and with regional salinity fluctuations. In order to establish the connection between the hydro-climate variables and pelagic species on a secular scale, basic climate oscillation were determined for both, hydro-climate and biological data, showing the main climate oscillation period of approximately 80 years, and interrelation between climate fluctuations over the Northern Hemisphere and small pelagic fish landing data was found. The advection of LIW (Levantine Intermediate Water), controlled by the MOI (Mediterranean Oscillation Index), whose inflow causes higher productivity of the Adriatic, influences also fish abundance. Since the MO index is linked

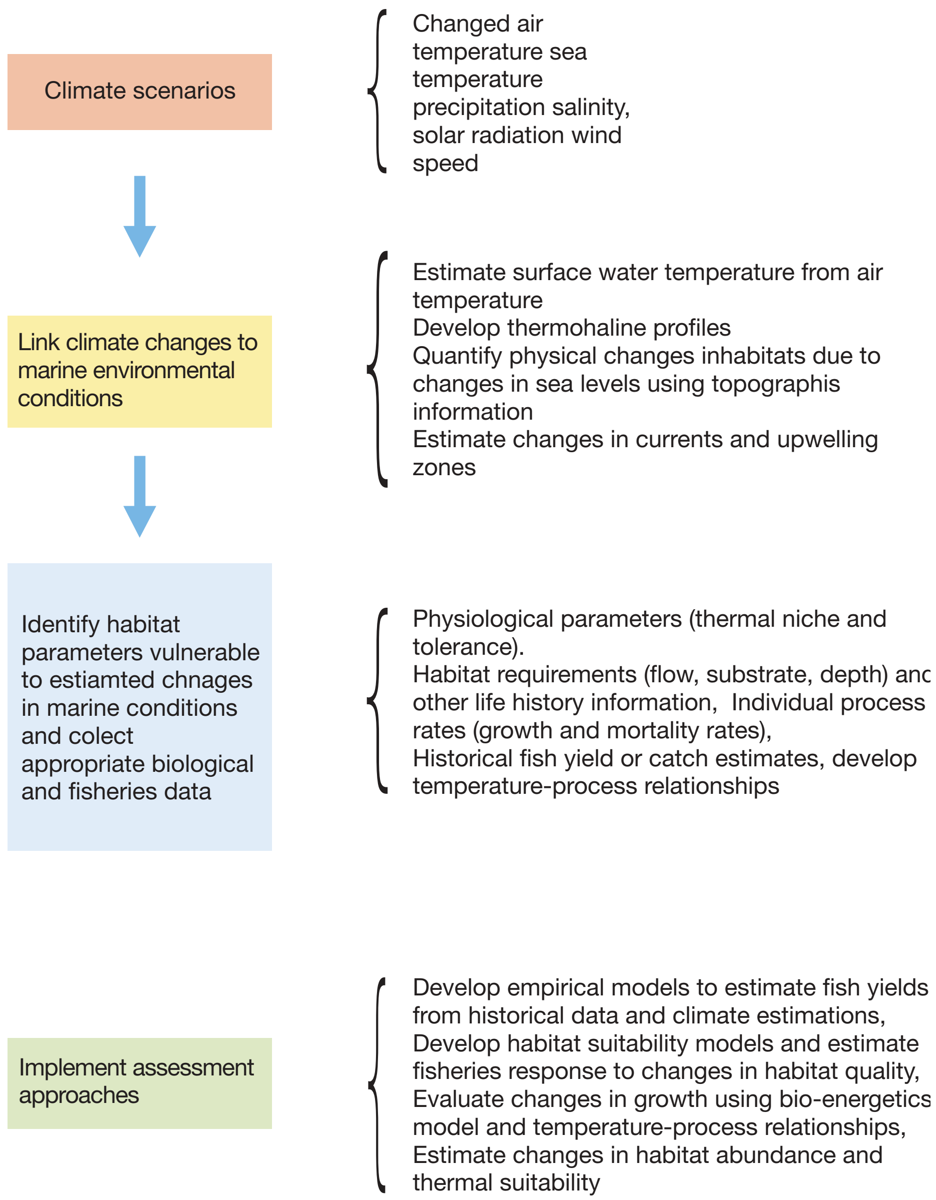


Figure 7-12: Conceptual framework for linking estimated climate changes to environmental conditions in marine habitats and estimating biological

Table 7-12: Most common signs of deteriorating fishery resources status and potential problems in the Adriatic Sea.

Symptoms and indicators	Considerations	Interpretation
1. Abundance decrease	Environmental influence Changes in availability and vulnerability	Warning, establish reference level
Catch rate (CPUE) decrease	Environmental influence	Warning
Stock range decrease	Environmental influence	Warning
Change in species composition	Environmental influence Change in other species Changes in market, regulations, fishing patterns	Warning
Change in predator indices	Environmental influence Availability to predators	Warning
2. Recruitment decrease	Environmental influence Availability, vulnerability	Warning, establish reference level, try stock/ /recruit relationship, compare replacement level
Increase in mean age	Market, regulation, fishing patterns	Danger, recruitment failure
Anomalous fat	Environmental influence	Danger
3. Fishing mortality approaches natural mortality	Environmental influence Changes in availability, vulnerability	Danger, try yield per recruit, production model
Mean age/length approaches age/length at first maturity	Environmental influence Availability, vulnerability Changes inmarket, regulations, fishing patterns	Danger
4. Variable catch (after catch increase)	Environmental influence market, regulations	Warning
5. Deviations from normal patterns		Warning
Changes in spawning or recruitment pattern	Environmental influence Availability	Warning
Changes in age/length at maturity	Environmental influence	Warning
Changes in fecundity	Environmental influence	Warning
Changes is size composition of catch	Environmental influence Changes in availability, vulnerability Changes in market, regulations, fishing patterns	Warning

to climate fluctuations over the Northern Hemisphere, historical fluctuation of small pelagic fish landing data may be controlled not only by some usually considered factors, but by climate variations.

Table 7-13: Changes in Adriatic ichthyofauna. The codes used for the observation are: 1 - First occurrence for the Adriatic Sea; 2 - Second occurrence for the Adriatic Sea; 3 - First occurrence for the Northern Adriatic; 4 - First occurrence for the Middle Adriatic; 5 - First occurrence in Slovenian coastal waters; 6 - Northernmost occurrence of species; 7 - Increased frequency of occurrence; 8 - First occurrence of larval stage; 9 - First occurrence of juvenile specimen; 10 - Northernmost occurrence in the Adriatic Sea, 11 - Reduced yearly migration; 12 - Stock collapsed from 1985; 13 - Disappearance. The asteriks against the species name indicate relatively rare (one asterisk), fairly rare (two asteriks), very rare (three asteriks) based on criteria of Pallaoro and Jardas (1996).

Species	Year	Area	Observation
Zu cristatus**	1973	Island Brač-Eastern Middle Adriatic	2
Sardinella aurita	1974, 1977, 1995-1996	Middle Adriatic, Gulf of Trieste, western coast of Istra	3, 6 (B group)
Schedophilus medusophagus***	1982	Pelješac channel - Korčula Island	2
Schedophilus ovalis***	1982	Pelješac channel - Korčula Island	1
Xyrichtys novacula***	1983	Pelješac channel - Korčula Island	1
Trachinotus ovatus*	1984, 1994	Gulf of Trieste, Brač Island	4, 9 (B group)
Brama brama*	1984, 1998	Kaštela Bay, River Neretva Estuary	4, 8
A Group (1985-1987) (see Fig. 3)			
Hemiramphus far***	1985	Albanian coast	1
Paraexocoetus mento***	1985	Albanian coast	1
Apterichthus anguiformis***	1985-1987	Along the coast of Puglia-Southern Adriatic	1
Opichthus rufus***	1985-1987	Along the coast of Puglia-Southern Adriatic	1
Notacanthus bonapartei***	1985-1987	Along the coast of Puglia-Southern Adriatic	1
Lepidotrigla dieuzeidi***	1985-1987	Along the coast of Puglia-Southern Adriatic	1
Benthocometes robustus***	1985-1987	Along the coast of Puglia-Southern Adriatic	1
Centracanthus cirrus*	1987, 1995	Vis Island, Omiš area	2 (A i B grupa)
Pseudocharanx dentex***	1986	Trpanjarea-Pelješac peninsula, Lastovo Is.	1
Centrolophus niger*	1984, 1985, 1986-1987, 1990-1991	Gulf of Trieste, Blitvenica, Trpanj area, Lastovo Island, Split Harbour	7 (A i B group)
Sphyraena sphyraena	1986-1987, 1994, 1997	Middle and Northern Adriatic	5 (A i B group)
Aulopus filamentosus***	1987	Jabuka Pit	1
Balistes capriscus	1986, 1992-1994	Along the Eastern Adriatic coast	7, 9 (A i B group)
Lepidopus caudatus*	1987	Novigrad Sea-Middle Adriatic	10
B Group (1990-1995) (see Fig. 3)			
Trachipterus trachypterus*	1989, 1992, 1994	Middle and Northern Adriatic	7, 8 (A i B group)
Coryphaena hippurus*	1986, 1993	Middle and Northern Adriatic	5, 7 (A i B group)
Pomatomus saltatrix**	1991	Tar cove-Northern Adriatic	10
Naucrates ductor	1992	Southern and Middle Adriatic	7
Sphoeroides pachygaster***	1992	Blitvenica, Sušac and Mljet Island	1
Plectorhinchus mediterraneus***	1993	Gulf of Trieste, Piran Bay	1, 6
Tylosurus acus imperialis***	1994-1995	South-western Adriatic-Bari	1
Epinephelus marginatus	1994	Piran Bay	3
Synodus saurus*	1993-1994, 1998	Eastern Adriatic coast, Piran Bay	5, 7
Luvarus imperialis**	1994	Split Harbour	2
Stromateus fiatola**	1994, 1996	Neretva river channel, Trpanj	7
Epinephelus aeneus***	1992, 1996	Kornati Archipelago, Southern Adriatic	1 (B group)
Ruvettus pretiosus***	1998	Trieste Harbour	6
Sprattus sprattus phalericus		Eastern Adriatic	11
Engraulis encrasicolus		Eastern Adriatic	12
Scomber scombrus		Eastern Adriatic	13

Table 7-14: Adriatic Sea example for some fish species

CLIMATE SCENARIOS/ TIME HORIZONT	IPCC - IS92a (90 %) YEAR 2100	IPCC - IS92e (95 %) YEAR 2100
Air temperature Precipitation	+2.2° C - 2.4° C +3.5 - 7 %	+4.20 °C - 4.9 °C 10.5 - 14 %
SECULAR TREND ESTIMATED FROM MEASURED DATA		
Air temperature Precipitation ↓	0.3 °C -19 % ↓	
Sea temperature Salinity Primary production landing data sardine mackerel anchovy sprat	+ 0.1 °C /100 YEAR + 2 PSU /100 YEAR positive trend in open and coastal water	

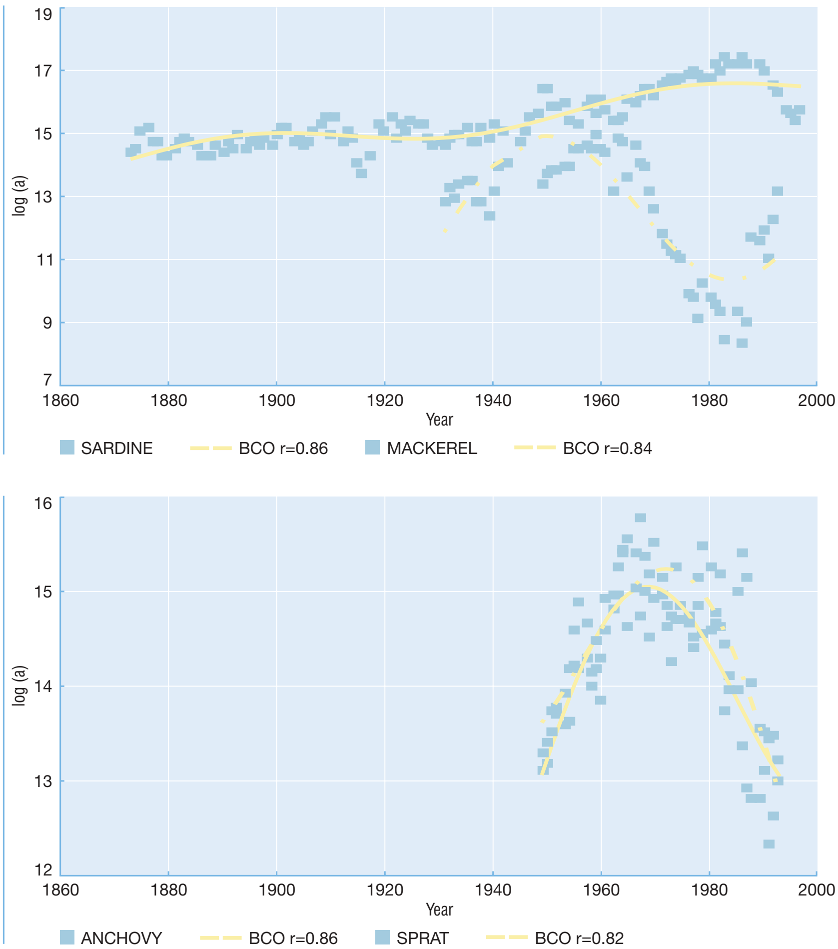


Figure 7-13: Basic climate oscillations of the sardine, mackerel, anchovy and sprat landing data.

7.9 Health Impacts

7.9.1 Influence of Weather on Health in Croatia

Vascular Diseases Influence of weather on the incidence of cerebrovascular insult, myocardial infarct and pulmonary emboli were investigated. The greatest number of myocardial infarction occurs during winter in weather situations with the low atmospheric pressure, in the weather types with southern air-flow and during frequent front passages (Pleško et al., 1983). In those situations the atmosphere is unstable, and cloudy, often windy, snowy or rainy and very cold weather prevails. During summer the infarctions are the most frequent in situations with unstable weather, characteristic for the weather types with small air pressure gradient, especially if followed by the cold front passages and thunderstorms. Before these situations it is often very hot and sultry. Correlation between meteorological parameters and myocardial infarctions showed a significant negative correlation with temperature only (Pleško et. al, 1983). The investigations of weather and cerebrovascular insults gave the similar results. The cold periods with great changes in air pressure and unstable atmosphere, characteristic for the cold front passages, are dangerous for the cerebrovascular insults (Pleško et al, 1987; Zaninović, Pleško, 1987). The correlation between cerebrovascular insults and meteorological parameters confirmed that the cerebrovascular insults are more frequent in cold situations (Pleško, Zaninović, 1986). After the cold front passages and during the cold weather situations the changes in coagulograms and tromboelastogram indicate at the possible aggravation of cerebrovascular disease (Pleško et al, 1991, Zaninović, Pleško, 1992).

A Psychical Disease A great number of suicide attempts are connected with the front passage. The warm sector of the cyclone is especially inconvenient. Suicides are more frequent than usually in weather situations with relatively high temperatures with irregular daily course, low and changeable air pressure, clouds or fog, often with slight rain and during summer with thunderstorms (Pleško et al, 1985). The number of suicide attempts and psychoses rises a day or two before as well as a day or two after the cold front passage. The psychoses and suicide attempts are as greater as the cloudy period is longer (Pleško et al, 1991).

Respiration Diseases The frequency of asthmatic attacks in children allergic at home dust and pollen is greater in situations with low air pressure. The incidence of asthmatic attacks in children with no allergy is greater in weather situations with high pressure during winter and with low pressure during summer. The greater number of asthmatic attacks occurs in situations with cold front passage as well. The incidence of asthmatic attacks is greater as the temperatures are lower during winter for all the categories of asthmatic patients. These are anticyclonic situations (Pleško, Zaninović, 1988; Zaninović, 1999). The relation between asthmatic attacks and the biometeorological index, as an indicator of the cooling of the organism under combined influence of temperature, wind speed and humidity is especially strong. The patients with chronic sinobronchial syndrome are more sensible on weather that those with the acute one. In the warm part of the year, the chronic patients react at the cooling, and in the cold part of the year at the warming. The acute patients react to the weather situations with high humidity, to the warm periods in the cold part of the year and to the cold periods in the warm part of the year (Pleško et al, 1994, Pleško et al, 1994).

Climate Changes of Thermal Comfort

In the framework of investigation of climate change the fluctuations and trends of thermal comfort at the island Hvar in the middle Adriatic are analysed. There is a positive trend in all seasons, i.e. a tendency toward warmer classes of thermal comfort. The trends for winter and autumn are significant. These trends are the result of trends of meteorological parameters influencing the thermal comfort - temperature, wind speed and humidity. The temperature trends are positive, and the air flow trends negative during all seasons. The relative humidity trends for winter and spring are positive, and negative for summer and autumn. Although all these trends are not significant, the combination of all these meteorological parameters results in significant positive trends of thermal comfort (Figure 7-14).

7.9.2 Influence of Expected Climate Changes on Health

The results of investigation of influence of weather on different diseases could indicate at possible consequences of expected climate changes on human health. Future increase in average temperatures entail an increase in the number of heatwaves in summer and a decrease in the number of cold spells in winter. It can lead to the increase of mortality caused by heatwaves. At the other hand, a future benefit of climate change may be a reduction in excess winter mortality, particularly that from the cardiovascular disease and asthma.

Some investigations in the world indicate at the temperature thresholds, above, which the number of deaths increases rapidly. The temperature thresholds differ for various climate conditions, and it would be useful to determine such temperature limits for Croatia. It can be assumed that the results could clarify the possible influence of climate change at the frequency of mortality.

According to some investigations in the world, the expected warming could lead to an increase of some vector borne diseases. These investigations indicated at the

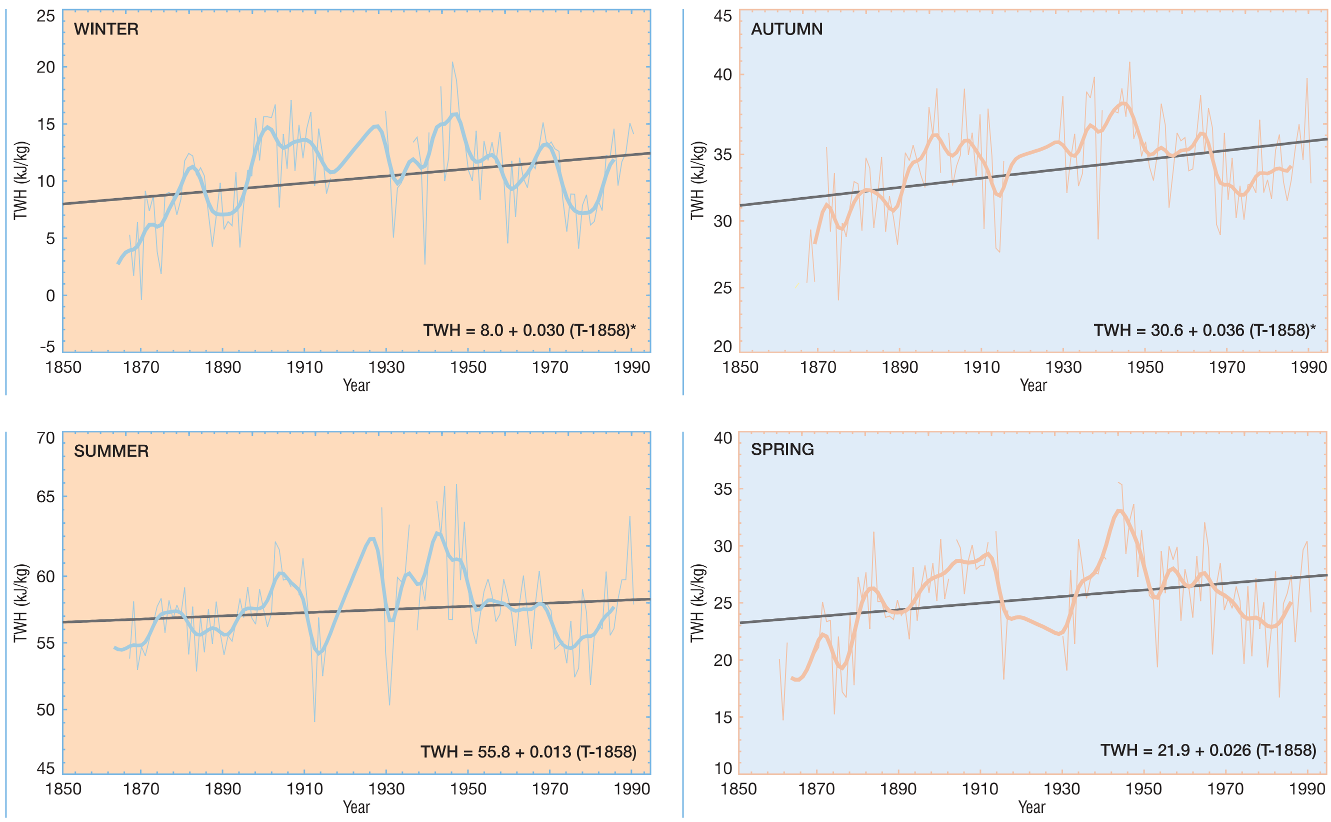
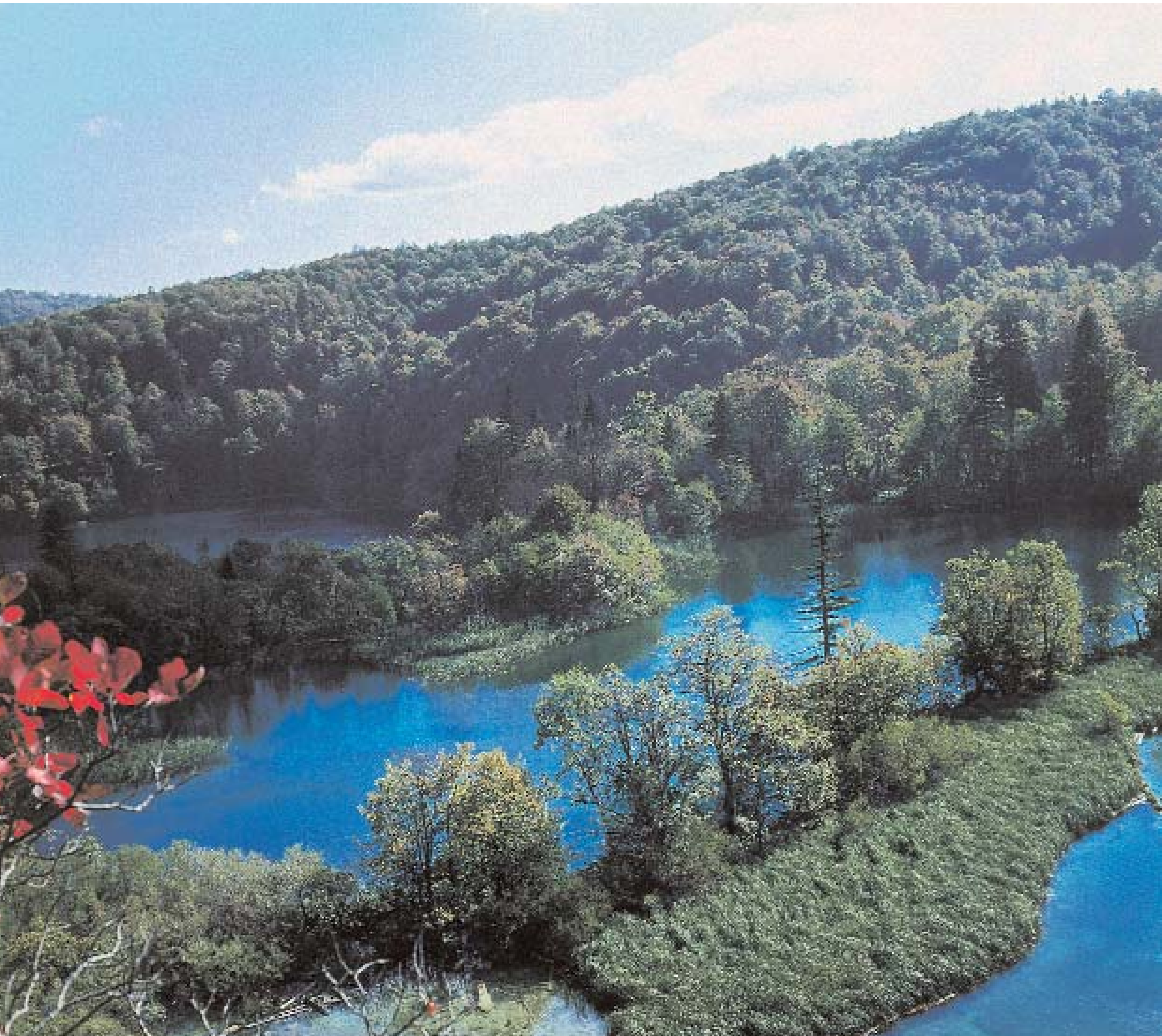


Figure 7-14: Fluctuations and trend of biometeorological index, Hvar, 1867-1995

increased danger from the malaria in the coastal area of Croatia. The greater risk from dengue and lishmaniasis can be expected also. Warmer and wetter conditions, predicted according to climate scenarios in Croatia can be favourable for some food or water borne diseases, like diarrhoea or dysentery.

The influence of climate change on health can be also indirect. Namely, the climate change can influence at the disposal of drinking water or food production.



Plitvice Lakes (National Park)

8. Research, Systematic Observations and Monitoring

8.

Research, Systematic Observations and Monitoring

8.1 Research Related to Climate and Climate Scenario Development

The scientific and development research into climate has been carried out by the Meteorological and Hydrological Service of Croatia (MHSC) within the framework of the National Climate Programme and scientific research projects supported by the (MHSC) and the Ministry of Science and Technology. The next phase of research in the field of climate change and variability on the local and regional scale will deal with the meteorological extremes.

Up to now, the research into the air temperature changes in Croatia has been based on changes in mean daily and mean minimum and maximum temperatures. The impact of extreme temperatures is essential in various aspects of life such as food production, design and building of structures, water resources management, health, tourism, etc. It is important to establish how the observed global warming can increase the frequency of warm waves or decrease of appearance or intensity of frost. The temperature parameters, which should be analysed for this purpose, are number of days with different extreme temperature characteristics (ice, frost, cold, warm and hot days, as well as days with warm nights).

During the twentieth century, the precipitation at the Croatian territory showed a decreasing tendency. Such changes have been indicated in the total amounts of the long-term precipitation (annual, seasonal or monthly). Although such results are useful in many applications, they do not present time variability or change in relations between frequency and intensity of precipitation. That is the reason for further analyses of precipitation days with different amounts.

8.2 Systematic Monitoring within Global Climate Observation System (GCOS)

Introduction

Due to variety of geographic and climate conditions in Croatia, need for systematic climate observation is unambiguous and indisputable.

The major demand for climate system data is in agriculture, particularly in the lowland continental region of Croatia, with predominating continental climate. In the central mountain region with snow/forest climate, the data is demanded for forest protection and use, and in the Adriatic coast and sea region with Mediterranean climate there is a demand for climate data for tourism and fishing. Generally, the available data is widely used for different purposes by many users.

Topographic features and diversity of climate conditions lays emphasis on operational performance of all systematic observations, which characterise climate system: meteorological and atmospheric observations, marine observations, terrestrial observations, space-based observations.

The ultimate benefit of the comprehensive observational and data processing system rests in the congregation of reliable and homogenous data sets.

The initial collection of climate data in Croatia dates back in early Middle Ages, and it was done sporadically by individual researchers and people interested in weather and climate.

Systematic meteorological observations started in the middle of the 19th century. Different institutions performed measurements independently, without co-ordination and methodological guidance so that many observed data was incompatible or lost.

From this experience, it became obvious that supplemental information is needed for the review and assessment of data quality: length of data records, the homogeneity of series, continuity of observations, changes in methods, replacement of instruments used, possibility of electronic access to the data, data rescue and recovery tools, in other words-meta data.

Current Data Collection and Systematic Observations in Croatia

The systematic observations and data collection in Croatia are carried out by different uncoordinated organisations and institutes. Therefore many data in the system are not cross-linked, which indicates that more efforts and co-ordination is needed.

Presently, atmospheric observations are organised to encompass:

a) Atmospheric observation system for land surface measurements (meteorological land surface observations) that include: surface synoptic stations (38[1]), aeronautical stations (5), climatological stations (109), precipitation stations (326), agrometeorological stations (40), special meteorological stations - radiation, atmospheric electricity, road traffic safety, (20);

b) Atmospheric observation system above the surface (meteorological upper air observations) that include: radiosounding stations (1), pilot balloon stations (1), radar stations (8);

c) Atmospheric constituents observing systems for measurements that include ozone stations (2), SO2 stations (3), NO2 stations (12), smoke stations (3), daily precipitation sampling stations (19). Air pollution measurements for the assessment of health impact and impact on materials, ecosystem and cultural monuments are carried out in many cities;

d) Marine observational systems include meteorological observations (messages) from ships (4500), sea surface temperature (15), sea level (3), sea state (21). Ship measurements across the Adriatic Sea are done periodically including measurements of mixed layer depth, sea currents, salinity, wave heights/period/ direction and other chemical and biological parameters;

e) Terrestrial observation systems include measurements of: evaporation (30), groundwater level (1000), precipitation rate liquid/solid (80), river height (500), discharge (450), runoff (450), snow cover (483), snow depth (483), snow water equivalent (30), soil moisture (3), soil temperature (50), soil type (30), streamflow (450);

[1] number of stations

f) Ecological observation systems include: phenological measurements (57), biomass change (3), vegetation type (3), fire distribution (30), land use change (3), paleoclimate (2);

g) Space based observation programmes. Croatia is participating in EUMETSAT programme. The main space-based observation programmes are in operational use for meteorological forecasts.

Responsibility and institutional authority for maintenance of observation systems is with:

1. Meteorological and Hydrological Service, (a, b, c, d, e, f, g),
2. Institute for Oceanography and Fisheries (d, f),
3. Hydographic Institute, (d),
4. Department of Geophysics of the Faculty of Science, University of Zagreb (d, e),
5. Centre for marine research of the Rudjer Boskovic Institute (d, f),
6. Ministry of Environmental Protection and Physical Planning (f),
7. Other organisations with responsibilities at regional and local levels.

Ongoing Plans for Systematic Observation

To meet GCOS requirements, the Croatian national plan for capacity building, scrutinising and strengthening of the observational systems and programs comprises of:

- Active and continuous participation in the Global Climate Observation System and its Observing System Partners (Global Observation System and Global Terrestrial System), with the goal to promote and co-operate in systematic observations and development of data archives related to climate systems,
- Making plans to establish and forward co-ordination between different observation networks at national level,
- Planing activities related to capacity building for collection, exchange and utilisation of data to encourage and enhance their use, to meet local, regional and international needs,
- Strengthening maintenance and quality assurance within existing climate related networks,
- Modernisation of networks in operation and establishment or restitution of observations that are not yet in function,
- Modernisation of existing climate data banks and development of a pertinent system that will enable better access to the data and facilitate data use and exchange,
- Continuation of efforts to recover past climate data records, processing and entry for electronic use,
- Development of strategy for space based observing programs improvement,
- Development and implementation of methods for homogeneity inspection in data series for all climate data types and development of the system for meta data collection.

8.3 Research in Different Impact Sectors

8.3.1 Hydrology

For preparation of the adaptation policy and measures regarding hydrology and water resources, a number of study researches need to be conducted. The priority activities are enlisted below:

(1) Mapping of changes in air temperature, precipitation and other hydrometeorological data;
(2) Assessment of climate change impact on evapotranspiration and runoff;
(3) Assessment of climate change impact on water balance;
(4) Assessment of climate change impact on water resources management activities.

A study should be developed on impact of the expected climate change for individual Croatian catchment areas based on these and other input data. .

8.3.2 Agriculture

The agricultural research program primarily includes:

- Agricultural land management and climate change
- Possible introduction of soil conservation and no-tillage approaches
- Possible carbon sequestration in the Croatian soils achieved through introduction of different soil tillage methods in different crop rotations
- Possible adjustments in plant growing
- Possible adjustments in animal husbandry.

8.3.3 Forestry

It is necessary to investigate into the extent to which the observed changes and forest damage are attributable to the climate change, and to what extent to the other factors such as the pollution of air, soil and water and anthropogenic causes. The development should be continued of the model for assessment of changes in the forest vegetation spatial distribution which has already proven useful for simulation of the future conditions. There is a need to investigate the influence of selected silviculture activities on the structure properties of forest stands.

8.3.4 Biodiversity and Natural Terrestrial Ecosystems

The level of knowledge on global impact of climate change on terrestrial ecosystems and biodiversity in Croatia is very low, the professional staff is insufficient and the education inadequate. Further, the methods globally applied in this sector have not been in use in Croatia, thus the methodology and technology transfer is imperative.

As regards accessibility of the basic spatial data, the already noticed chronic unavailability of some essential biological documents is encountered (atlases of flora and fauna, the biodiversity maps, vegetation maps, biotope maps and the like

(Kutle, 1999). Some of these materials will need to be prepared for the purpose of impact assessment and the adjustment planning.

Therefore, the General Action Plans 1-3 could be taken over as the research proposals, namely as special research proposals or as individual projects with their main features including:

1. Building of scientific infrastructure necessary for assessment of the climate change impact on terrestrial ecosystems and biodiversity.
2. Collecting data necessary for assessment of the climate change impact on terrestrial ecosystems and biodiversity.
3. Assessment of the global climate change impact on terrestrial ecosystems and biodiversity in Croatia.

Integration of data and impacts The assessment of the global climate change impact on terrestrial ecosystems and biodiversity must be adequately integrated into all other assessment aspects outside the framework of this document. The data integrated in this way might point to the cross-links between individual assessed sectors (e.g. forestry, agriculture, water, sea and the like) which are presently not foreseeable or are hardly foreseeable, and will therefore affect the final statements of the document.

8.3.5 Coastal Area

It is necessary to improve the existing sea level monitoring system on the Croatian coast. It is also necessary to organise observation of the sea level impact on erosion, groundwater and fresh surface water in selected locations, primarily in the areas of both Vransko lakes (Cres and at Zadar), in the Neretva River valley and at the town of Nin area.

It is necessary to investigate into the behaviour of the Croatian coast (uplift/subsidence) in order to assess the possible impact of an absolute increase in the sea level and create the model of the coast flooding and economic valuation of possible damage. It is particularly important that the research be focused on an integrated observation approach.

8.3.6 Marine Ecosystems and Fish Fund

The impact of the possible climate change on changes in ecosystems of open and coastal waters is insufficiently researched. The knowledge exists of the effect the relations between the physical and chemical parameters have on the living organism., and of the response of individual units to changes in ecosystem is satisfactory. The present knowledge does not enable forecasting of future trends in the marine ecosystem, primarily because of numerous cause/effect relationships and unavailability of scenarios related to another causes of change such as the anthropogenic ones. Increase in the ground air temperature and decrease in precipitation result in increase of temperature and salinity in the sea surface due to vertical flows of heat and humidity at the atmosphere/sea boundary. In deeper layers, temperature and salinity change because of horizontal processes, which could also be a consequence of climate change. In the late seventies, an unexpectedly fast increase was noticed of primary production accompanied by increased frequency of phytoplankton blooming (monospecific blooming, coloured sea, "mare sporco", toxic blooming, "mucillagine"), both in coastal and open Adriatic waters. Although increased frequency of occurrence of these phenomena is generally attributed to anthropogenic impact, there is no doubt that it was in part related to climate change, first noticed by response of the primary producers. These phenomena could negatively reflect on the tourist industry and the economy because of the environmental degradation and damage caused to the fisheries and mariculture. In case of the toxic blooming, human health could be significantly threatened because of the toxicity of shellfish. Continuous targeted monitoring and research into these phenomena could possibly offer mitigate their unwanted consequences. Undertaking of specific measures based on the monitoring results could fully prevent risks to the human health. Development of the ecological model, presently not available for the Adriatic sea ecosystem, would give answers to some of the key questions. The model could be developed by the use of available input data and individual targeted investigations. The results obtained from such a model could be used as the baseline for determination of future changes in the ecosystem, primarily those regarding the fish resources population and composition.

8.3.7 Public Health Effects

The results of investigation of influence of weather on various diseases could indicate possible consequences of expected climate changes on human health. Future increase in average temperatures entail an increase in the number of heatwaves in summer and a decrease in the number of cold spells in winter. It could lead to the increase of mortality caused by heatwaves. At the other hand, a future benefit of climate change may be a reduction in excess winter mortality, particularly that from the cardiovascular disease and asthma.

Some investigations in the world indicate the temperature thresholds, above, which the number of deaths increases rapidly. The temperature thresholds differ for various climatic conditions, and it would be useful to determine such temperature limits for Croatia. It can be assumed that the results could clarify the possible influence of climate change on the frequency of mortality.

According to some investigations in the world the expected warming could lead to an increase of some vector borne diseases. These investigations indicated that there is an increased danger from malaria in the coastal area of Croatia. A greater risk from dengue and lishmaniasis can also be expected. Warmer and wetter conditions, predicted according to climate scenarios for Croatia can be favourable for some food or water borne diseases, like diarrhoea or dysentery.

The influence of climate change on health can also be indirect. Namely, the climate change can influence the disposal of drinking water or food production.

Mt. Svilaja

9. International Co-operation

9. International Cooperation

Until the year 2000, due to the political instability and open issues across the region, Croatia was politically and economically isolated. The possibilities for establishing bilateral and multilateral relations were subsequently limited. Bilateral aid was sporadic and limited primarily to technical assistance in the form of expertise and modest grants. Croatia has had limited access to EU funds, the only available funds being those within the scope of UN mechanisms (GEF and others) and the World Bank. In the past two years, within the USAID and ECO-links programs, it was made possible for Croatia to apply for the preparation of small-scale projects to reduce greenhouse gas emissions. However, only a few projects of that type are under development at the moment.

This National Communication has been developed thanks to the Global Environment Facility's (GEF) grant under the auspices of the project of the Croatian Government and the UNDP/GEF *Enabling Croatia to Prepare its First National Communication to the UNFCCC*. The cooperation with task forces from neighboring countries Slovenia and Hungary was established during the development of this Communication by holding working sessions on particular thematic issues. Experiences were extensively exchanged with former Yugoslav republic of Macedonia. The UNDP National Communications Support Program contributed significantly to the preparation of this Communication. Domestic experts developed the Communication and the consultation with international experts was limited only to critical sections such as the cost estimate of emission reduction measures. Thus, the national communication project has proven that, with appropriate and reliable technical support at global and/or regional level, national teams are capable of elaborating very complex and completely innovative tasks.

Despite the fact that Croatia's international standing is continuously improving, up to the publication of this Communication no noticeable concrete support was provided by the international community.

Considering the primary political goal to join the European Union, as well as climatic, geographical and economic similitude, Croatia will, in its international relations, direct its cooperative practices towards the EU member states and states in the process of accession and especially towards neighboring countries that share the same problems of impacts.

Croatia is participating in several international research programs relating to climate change and energy field. We can mention here the IEA/OECD Bioenergy program within which Croatia leads Task 29 - Socio-Economic Aspects of Bioenergy Systems; Croatia is a member of Task 38 - Greenhouse Gas Balances of Biomass and Bioenergy Systems; it is a member of the IAEA program - Role of Nuclear Power in the Reduction of Greenhouse Gas Emissions. A significant international cooperation is under way within the program Removing Barriers to Implementation of Energy Efficiency Measures in Services and Residential Sector financed by the UNPD/GEF, the implementation of which shall start in 2002. Croatia has applied for financing of the project of national system for emission calculation within the program LIFE-Third Country and is awaiting the decision on this very important project.

Croatia has signed a Letter of Understanding with the Kingdom of Netherlands on potential implementation of JI projects. Other countries have also expressed their interest in this form of cooperation, as well as some international organizations. The Kingdom of Netherlands is presently financing the project of renewable energy sources on the island Hvar in Croatia.

In order to fulfil its commitments under the Convention, Croatia needs a considerable amount of international aid. Financial assistance is of the highest order and technical assistance is required in the form of the know-how and skills associated with specialized technology. However, external reliance is not applicable to the execution of the overall program. It should be emphasized that international aid is often conditioned by the participation of international experts in a proportion exceeding actual needs.

Sljeme forest

10. Education and Public Awarennes

10. Education and Public Awarennes

This issue is recognized as one of the crucial elements for addresing of global climate change. Included in the First National Report there is a complete program of the minimum of activities desired. There is a hope that this program could be financed and supported by international community. The program was designed in collaboration of sociologists, journalists and NGO activists. It covers a two years period. The realisation of this program could be feasible if all actors, from various institutions would participate in it.

After the preparation of the First National Report on Climate Change, outlining the basic parameters of existing conditions and by drafting the recommendations for future activities, in the next two years the educational and public awareness program should be realised. The aims of these educational activities and initial practical (know-how) trainings is to attract public attention to these problems: to sensitize the young and general public for these issues. It is even more important to persuade the producers of greenhouse gases in Croatia that it is possible and necessary to make technological and social changes in order to reduce the emissions.

The information and education on global climate change activities in Croatia are very poor. During the nineties, i.e. during the war destructions, transitions and property reform caused a drastic reduction of quality of life, and it was almost impossible to engage in large-scale environmental education.. The conditions for such activities were quite unfavourable. Today there is much more opportunity for directing public attention to environmental and development problems, and especially global climate changes. There are fair chances for promotion of these issues through the systematic (methodical) education and training.

Nevertheless, some NGO activities were very successful. For example in the campaign against the construction of coal-power-plant at the Adriatic various ecological associations collected 73 000 signatures and that had serious (significant) influence upon the decision to postpone it.

The media are giving attention to climate changes only at major global events, such as COP-s or on occasions of extreme climatic incidents, i.e. when "something is happening with climate".

Recently, the Zelena akcija (Green Action - NGO) campaigns receive prominent attention, because it is the only organisation that constantly direct attention to climate changes, sometimes in a very provocative and very attractive way ("banana-tree" in Zagreb). During the year 2000 in daily newspaper 103 articles concerning climate changes were published. There is a journalist association promoting the general ecological knowledge among newspapermen. This organisation is giving the yearly reward for the most successful environmental journalist. The NGO (environmental) network "Zeleni forum"(Green Forum) coordinates the activity of 40 member associations.

The global warming is a very complex problem, and to be successful in mitigation many actors should be included. The main aim is to change the usual custom of ignoring (as insignificant) the Croatian participation in global warming.

There are two urgent tasks. The first one is the initiation of widespread basic informations and rising of general public awareness concerning the general causes and consequences of global climate change, with special emphasis on the Croatian participation. The task is up to mass media and occasional activities of professional and environmental organisations should do it.

The second task is to inform and educate the primary and secondary school students and the general public during the next two years, by means of public lectures, booklets and promotion materials.

It is also necessary to educate and train the administrative staff in relevant government departments and local authorities as well as professionals and management in industries (energy, agriculture, forestry etc) producing greenhouse gases.

The realisation of this program will begin with presentation/promotion of the First National Report on climate change in four macroregional centres in Croatia. The next is production of initial informative and educational materials and methodical and multiplex mass media campaign explaining the causes and consequences of climate change, especially those concerning Croatia. This is the minimum program for promoting ecological awareness in Croatia.

Program includes the following activities:

- Preparation of educational materials: two sets of transparents with essential facts of climate change (general issues, Croatian circumstances); four video films, posters, booklets (made by professional associations and experts)
- The presentation of the First National Report with workshops for journalists
- Six street actions by ecological associations
- Seminar for teachers throughout Croatia; state administration staff seminars, professional and managers seminars
- Educational campaign in elementary and secondary schools

Figure 10-1 Numerous newspapers articles on climate change (Zelena akcija poster)

- Mass media campaign with 4 video plays materials and constant monitoring of global heating
- Posters and jumbo street posters in several cities.

The program is planned to last for two and half years. It could be intensified from teams of young in every school in Croatia, to activists carrying out presentations.

The other, more intensive and more expensive program would include the professionals and managers of main GHG industry emitters. That program would be essential for education on and enhancing the awareness of climate change in Croatia.

All previously mentioned is a minimum of necessary activities for enacting a positive change. It is hardly enough and should be complemented by spontaneous and creative actions of environmental NGO-s. Of extreme importance is the founding of an international information network. In rising awareness, initiatives of NGO-s and professional associations should be supported in their intentions for establishing educational and information focal centres, particulary international ones.

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11.

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Annex

Croatia 1990	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	share
	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**28367.267**	**68.782**	**1444.422**	**0.318**	**98.580**	**0.000**	**0.000**	**29910**	**75.93**
Energy Industries	5896.546	0.189	3.969	0.046	14.260			5915	15.02
Manufacturing Industries and Construction	6545.887	0.508	10.668	0.066	20.460			6577	16.70
Transport	4046.038	0.777	16.317	0.040	12.400			4075	10.34
Domestic Aviation	295.612	0.002	0.042	0.008	2.480			298	0.76
Road	3479.921	0.756	15.876	0.030	9.300			3505	8.90
Railways	137.525	0.010	0.210	0.001	0.310			138	0.35
National Navigation	132.980	0.009	0.189	0.001	0.310			133	0.34
Other Sectors	3616.102	7.519	157.899	0.106	32.860			3807	9.66
Commercial/Institutional	782.137	0.094	1.974	0.006	1.860			786	2.00
Residential	1994.779	7.363	154.623	0.093	28.830			2178	5.53
Agriculture/Forestry/Fishing	839.186	0.062	1.302	0.007	2.170			843	2.14
Other (not elsewhere specified)*	7846.694	0.979	20.559	0.060	18.600			7886	20.02
Fugitive	416.000	58.810	1235.010					1651	4.19
Coal		2.322	48.762					49	0.12
Oil & Natural gas	416.000	56.488	1186.248					1602	4.07
Industrial Processes	**2345.368**	**0.752**	**15.792**	**2.992**	**927.520**	**0.139**	**938.600**	**4227**	**10.73**
Cement production	1022.903	0.752	15.792	2.992	927.520	0.139	938.600	1023	2.60
Lime production	145.070							145	0.37
Limestone and dolomite use	18.906							19	0.05
Soda ash production and use	25.740							26	0.07
Ammonia production	491.551							492	1.25
Nitric acid production								928	2.35
Product. of other chemicals								16	0.04
Iron and steel production	334.893							335	0.85
Ferroalloys production	194.933							195	0.49
Aluminium production **	111.372							1050	2.67
Agriculture	**0.000**	**75.322**	**1581.762**	**8.835**	**2738.850**	**0.000**	**0.000**	**4321**	**10.97**
Enteric fermentation		64.064	1345.344	1.215	0.000			1345	3.42
Manure management		11.051	232.071	7.616	376.650			609	1.55
Agricultural soils management				0.004	2360.960			2361	5.99
Agricultural residue burning		0.207	4.347		1.240			6	0.01
Land-use Change & Forestry	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.130							-6505	-16.51
Changes in soil carbon								0	0.00
Waste	**0.000**	**37.774**	**793.254**	**0.450**	**139.500**	**0.000**	**0.000**	**933**	**2.37**
Land Disposal of Solid Waste		37.774	793.254					793	2.01
Human Sewage				0.450	139.500			140	0.35
Other	**0.000**		**0.000**		**0.000**	**0.000**	**0.000**	**0**	**0.00**
TOTAL EMISSIONS	**30712.6**	**182.6**	**3835.2**	**12.6**	**3904.5**	**0.139**	**938.600**	**39391**	**100.00**
NET EMISSIONS (Sources and Sinks)	**24207.5**	**182.6**	**3835.2**	**12.6**	**3904.5**	**0.139**	**938.600**	**32886**	
Share of Gases in Total Emissions (%)	**77.97**		**9.74**		**9.91**		**2.38**	**100.00**	
Share of Gases in Net Emissions (%)	**73.61**		**11.66**		**11.87**		**2.85**	**100.00**	

* - correction according to the article 4.6. of UNFCCC (94 % of emission), statistical difference and non-energy fuel consumption

** - for PFCs: 0.13 CF_4 + 0.013 C_2F_6

Croatia 1991	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	share
	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**23838.526**	**63.624**	**1336.104**	**0.247**	**76.570**	**0.000**	**0.000**	**25251**	**75.16**
Energy Industries	3846.946	0.120	2.520	0.030	9.300			3859	11.49
Manufacturing Industries and Construction	4732.072	0.393	8.253	0.049	15.190			4756	14.15
Transport	2916.561	0.586	12.306	0.026	8.060			2937	8.74
Domestic Aviation	80.904	0.001	0.021	0.002	0.620			82	0.24
Road	2581.142	0.568	11.928	0.022	6.820			2600	7.74
Railways	146.654	0.010	0.210	0.001	0.310			147	0.44
National Navigation	107.861	0.007	0.147	0.001	0.310			108	0.32
Other Sectors	3003.322	4.915	103.215	0.072	22.320			3129	9.31
Commercial/Institutional	539.795	0.065	1.365	0.004	1.240			542	1.61
Residential	1735.553	4.793	100.653	0.062	19.220			1855	5.52
Agriculture/Forestry/Fishing	727.974	0.057	1.197	0.006	1.860			731	2.18
Other (not elsewhere specified)*	8883.625	1.130	23.730	0.070	21.700			8929	26.58
Fugitive	456.000	56.480	1186.080					1642	4.89
Coal		4.876	102.396					102	0.30
Oil & Natural gas	456.000	51.604	1083.684					1540	4.58
Industrial Processes	**1611.767**	**0.547**	**11.487**	**2.628**	**814.680**	**0.096**	**648.300**	**3086**	**9.19**
Cement production	647.459							647	1.93
Lime production	86.932							87	0.26
Limestone and dolomite use	15.689							16	0.05
Soda ash production and use	21.752							22	0.06
Ammonia production	471.503							472	1.40
Nitric acid production				2.628	814.680			815	2.42
Product. of other chemicals		0.547	11.487					11	0.03
Iron and steel production	110.611							111	0.33
Ferroalloys production	181.424							181	0.54
Aluminium production **	76.397					0.096	648.300	725	2.16
Agriculture	**0.000**	**71.912**	**1510.152**	**9.141**	**2833.710**	**0.000**	**0.000**	**4344**	**12.93**
Enteric fermentation		61.062	1282.302		0.000			1282	3.82
Manure management		10.850	227.850	1.165	361.150			589	1.75
Agricultural soils management				7.976	2472.560			2473	7.36
Agricultural residue burning		0.000	0.000	0.000	0.000			0	0.00
Land-use Change & Forestry	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.130							-6505	-19.36
Changes in soil carbon								0	0.00
Waste	**0.000**	**37.019**	**777.399**	**0.450**	**139.500**	**0.000**	**0.000**	**917**	**2.73**
Land Disposal of Solid Waste		37.019	777.399					777	2.31
Human Sewage				0.450	139.500			140	0.42
Other	**0.000**		**0.000**		**0.000**			**0**	**0.00**
TOTAL EMISSIONS	**25450.3**	**173.1**	**3635.1**	**12.5**	**3864.5**	**0.096**	**648.300**	**33598**	**100.00**
NET EMISSIONS (Sources and Sinks)	**18945.2**	**173.1**	**3635.1**	**12.5**	**3864.5**	**0.096**	**648.300**	**27093**	
Share of Gases in Total Emissions (%)	**75.75**		**10.82**		**11.50**		**1.93**	**100.00**	
Share of Gases in Net Emissions (%)	**69.93**		**13.42**		**14.26**		**2.39**	**100.00**	

* - correction according to the article 4.6. of UNFCCC (97 % of emission) and non-energy fuel consumption

** - for PFCs: 0.087 CF_4 + 0.009 C_2F_6

Croatia 1992	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	share
	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**14186.306**	**58.691**	**1232.511**	**0.157**	**48.670**	**0.000**	**0.000**	**15467**	**67.01**
Energy Industries	4514.102	0.136	2.856	0.035	10.850			4528	19.62
Manufacturing Industries and Construction	3730.067	0.318	6.678	0.038	11.780			3749	16.24
Transport	2781.336	0.524	11.004	0.024	7.440			2800	12.13
Domestic Aviation	32.051	0.000	0.000	0.001	0.310			32	0.14
Road	2485.774	0.506	10.626	0.021	6.510			2503	10.84
Railways	96.718	0.007	0.147	0.001	0.310			97	0.42
National Navigation	166.793	0.011	0.231	0.001	0.310			167	0.72
Other Sectors	2494.699	3.882	81.522	0.060	18.600			2595	11.24
Commercial/Institutional	393.708	0.047	0.987	0.002	0.620			395	1.71
Residential	1463.012	3.787	79.527	0.053	16.430			1559	6.75
Agriculture/Forestry/Fishing	637.979	0.048	1.008	0.005	1.550			641	2.78
Other (not elsewhere specified)*	189.102	0.000	0.000	0.000	0.000			189	0.82
Fugitive	477.000	53.831	1130.451					1607	6.96
Coal		1.608	33.768					34	0.15
Oil & Natural gas	477.000	52.223	1096.683					1574	6.82
Industrial Processes	**1577.881**	**0.464**	**9.744**	**3.436**	**1065.160**	**0.000**	**0.000**	**2653**	**11.49**
Cement production	774.676							775	3.36
Lime production	54.491							54	0.24
Limestone and dolomite use	10.537							11	0.05
Soda ash production and use	14.681							15	0.06
Ammonia production	606.765							607	2.63
Nitric acid production				3.436	1065.160			1065	4.61
Product. of other chemicals		0.464	9.744					10	0.04
Iron and steel production	0.000							0	0.00
Ferroalloys production	116.731							117	0.51
Aluminium production	0.000							0	0.00
Consumption of HFCs, PFCs and SF_6						0.000	0.000	0	0.00
Agriculture	**0.000**	**67.081**	**1408.701**	**8.554**	**2651.740**	**0.000**	**0.000**	**4060**	**17.59**
Enteric fermentation		56.588	1188.348		0.000			1188	5.15
Manure management		10.493	220.353	1.090	337.900			558	2.42
Agricultural soils management				7.464	2313.840			2314	10.02
Agricultural residue burning								0	0.00
Land-use Change & Forestry	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.130							-6505	-28.18
Changes in soil carbon								0	0.00
Waste	**0.000**	**36.580**	**768.180**	**0.428**	**132.680**	**0.000**	**0.000**	**901**	**3.90**
Land Disposal of Solid Waste		36.580	768.180					768	3.33
Human Sewage				0.428	132.680			133	0.57
Other	**0.000**		**0.000**		**0.000**	**0.000**	**0.000**	**0**	**0.00**
TOTAL EMISSIONS	**15764.2**	**162.8**	**3419.1**	**12.6**	**3898.3**	**0.000**	**0.000**	**23082**	**100.00**
NET EMISSIONS (Sources and Sinks)	**9259.1**	**162.8**	**3419.1**	**12.6**	**3898.3**	**0.000**	**0.000**	**16576**	
Share of Gases in Total Emissions (%)	**68.30**		**14.81**		**16.89**		**0.00**	**100.00**	
Share of Gases in Net Emissions (%)	**55.86**		**20.63**		**23.52**		**0.00**	**100.00**	

* - non-energy fuel consumption

Croatia 1993	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	share
	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**15145.994**	**63.447**	**1332.387**	**0.155**	**48.050**	**0.000**	**0.000**	**16526**	**72.54**
Energy Industries	5184.890	0.155	3.255	0.036	11.160			5199	22.82
Manufacturing Industries and Construction	3657.877	0.310	6.510	0.037	11.470			3676	16.13
Transport	2948.633	0.524	11.004	0.026	8.060			2968	13.03
Domestic Aviation	64.412	0.000	0.000	0.002	0.620			65	0.29
Road	2661.908	0.509	10.689	0.022	6.820			2679	11.76
Railways	101.075	0.007	0.147	0.001	0.310			102	0.45
National Navigation	121.238	0.008	0.168	0.001	0.310			122	0.53
Other Sectors	2484.258	3.523	73.983	0.056	17.360			2576	11.30
Commercial/Institutional	489.318	0.055	1.155	0.003	0.930			491	2.16
Residential	1356.902	3.421	71.841	0.048	14.880			1444	6.34
Agriculture/Forestry/Fishing	638.038	0.047	0.987	0.005	1.550			641	2.81
Other (not elsewhere specified)*	194.336	0.000	0.000	0.000	0.000			194	0.85
Fugitive	676.000	58.935	1237.635					1914	8.40
Coal		1.538	32.298					32	0.14
Oil & Natural gas	676.000	57.397	1205.337					1881	8.26
Industrial Processes	**1253.102**	**0.499**	**10.479**	**2.590**	**802.900**	**0.000**	**0.000**	**2066**	**9.07**
Cement production	648.494							648	2.85
Lime production	60.253							60	0.26
Limestone and dolomite use	9.604							10	0.04
Soda ash production and use	12.534							13	0.06
Ammonia production	471.336							471	2.07
Nitric acid production				2.590	802.900			803	3.52
Product. of other chemicals		0.499	10.479					10	0.05
Iron and steel production	0.000							0	0.00
Ferroalloys production	50.881							51	0.22
Aluminium production	0.000							0	0.00
Consumption of HFCs, PFCs and SF_6						0.000	0.000	0	0.00
Agriculture	**0.000**	**55.570**	**1166.970**	**6.808**	**2110.480**	**0.000**	**0.000**	**3277**	**14.39**
Enteric fermentation		47.143	990.003		0.000			990	4.35
Manure management		8.427	176.967	0.907	281.170			458	2.01
Agricultural soils management				5.901	1829.310			1829	8.03
Agricultural residue burning								0	0.00
Land-use Change & Forestry	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.130							-6505	-28.55
Changes in soil carbon								0	0.00
Waste	**0.000**	**37.208**	**781.368**	**0.424**	**131.440**	**0.000**	**0.000**	**913**	**4.01**
Land Disposal of Solid Waste		37.208	781.368					781	3.43
Human Sewage				0.424	131.440			131	0.58
Other	**0.000**		**0.000**		**0.000**	**0.000**	**0.000**	**0**	**0.00**
TOTAL EMISSIONS	**16399.1**	**156.7**	**3291.2**	**10.0**	**3092.9**	**0.000**	**0.000**	**22783**	**100.00**
NET EMISSIONS (Sources and Sinks)	**9894.0**	**156.7**	**3291.2**	**10.0**	**3092.9**	**0.000**	**0.000**	**16278**	
Share of Gases in Total Emissions (%)	**71.98**		**14.45**		**13.58**		**0.00**	**100.00**	
Share of Gases in Net Emissions (%)	**60.78**		**20.22**		**19.00**		**0.00**	**100,00**	

* - non-energy fuel consumption

Croatia 1994	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	share
	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**14235.251**	**57.903**	**1215.963**	**0.153**	**47.430**	**0.000**	**0.000**	**15499**	**70.89**
Energy Industries	3924.562	0.124	2.604	0.025	7.750			3935	18.00
Manufacturing Industries and Construction	3814.872	0.301	6.321	0.035	10.850			3832	17.53
Transport	3124.039	0.568	11.928	0.028	8.680			3145	14.38
Domestic Aviation	64.412	0.000	0.000	0.002	0.620			65	0.30
Road	2878.225	0.556	11.676	0.024	7.440			2897	13.25
Railways	94.207	0.006	0.126	0.001	0.310			95	0.43
National Navigation	87.195	0.006	0.126	0.001	0.310			88	0.40
Other Sectors	2567.650	3.667	77.007	0.059	18.290			2663	12.18
Commercial/Institutional	552.401	0.065	1.365	0.003	0.930			555	2.54
Residential	1372.245	3.556	74.676	0.051	15.810			1463	6.69
Agriculture/Forestry/Fishing	643.004	0.046	0.966	0.005	1.550			646	2.95
Other (not elsewhere specified)*	199.128	0.108	2.268	0.006	1.860			203	0.93
Fugitive	605.000	53.135	1115.835					1721	7.87
Coal		1.379	28.959					29	0.13
Oil & Natural gas	605.000	51.756	1086.876					1692	7,74
Industrial Processes	**1438.784**	**0.479**	**10.059**	**2.801**	**868.310**	**0.000**	**0.000**	**2317**	**10.60**
Cement production	793.810							794	3.63
Lime production	59.654							60	0.27
Limestone and dolomite use	15.504							16	0.07
Soda ash production and use	15.213							15	0.07
Ammonia production	474.728							475	2.17
Nitric acid production				2.801	868.310			868	3.97
Product. of other chemicals		0.479	10.059					10	0.05
Iron and steel production	0.000							0	0.00
Ferroalloys production	79.875							80	0.37
Aluminium production	0.000							0	0.00
Consumption of HFCs, PFCs and SF_6						0.000	0.000	0	0.00
Agriculture	**0.000**	**50.780**	**1066.380**	**6.590**	**2042.900**	**0.000**	**0.000**	**3109**	**14.22**
Enteric fermentation		42.358	889.518		0.000			890	4.07
Manure management		8.422	176.862	0.836	259.160			436	1.99
Agricultural soils management				5.754	1783.740			1784	8.16
Agricultural residue burning								0	0.00
Land-use Change & Forestry	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.130							-6505	-29.76
Changes in soil carbon								0	0.00
Waste	**0.000**	**38.401**	**806.421**	**0.421**	**130.510**	**0.000**	**0.000**	**937**	**4.29**
Land Disposal of Solid Waste		38.401	806.421					806	3.69
Human Sewage				0.421	130.510			131	0.60
Other	**0.000**		**0.000**		**0.000**	**0.000**	**0.000**	**0**	**0.00**
TOTAL EMISSIONS	**15674.0**	**147.6**	**3098.8**	**10.0**	**3089.2**	**0.000**	**0.000**	**21862**	**100.00**
NET EMISSIONS (Sources and Sinks)	**9168.9**	**147.6**	**3098.8**	**10.0**	**3089.2**	**0.000**	**0.000**	**15357**	
Share of Gases in Total Emissions (%)	**71.70**		**14.17**		**14.13**		**0.00**	**100.00**	
Share of Gases in Net Emissions (%)	**59.71**		**20.18**		**20.12**		**0.00**	**100.00**	

* - non-energy fuel consumption

Croatia 1995	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	share
	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**15081.941**	**58.203**	**1222.263**	**0.157**	**48.670**	**0.000**	**0.000**	**16353**	**73.47**
Energy Industries	4459.922	0.155	3.255	0.032	9.920			4473	20.10
Manufacturing Industries and Construction	3617.023	0.284	5.964	0.034	10.540			3634	16.32
Transport	3337.203	0.601	12.621	0.030	9.300			3359	15.09
Domestic Aviation	88.684	0.001	0.021	0.003	0.930			90	0.40
Road	3044.158	0.586	12.306	0.025	7.750			3064	13.77
Railways	106.086	0.007	0.147	0.001	0.310			107	0.48
National Navigation	98.275	0.007	0.147	0.001	0.310			99	0.44
Other Sectors	2777.689	3.763	79.023	0.061	18.910			2876	12.92
Commercial/Institutional	601.402	0.070	1.470	0.003	0.930			604	2.71
Residential	1595.980	3.651	76.671	0.053	16.430			1689	7.59
Agriculture/Forestry/Fishing	580.307	0.042	0.882	0.005	1.550			583	2.62
Other (not elsewhere specified)*	193.104	0.009	0.189	0.000	0.000			193	0.87
Fugitive	697.000	53.391	1121.211					1818	8.17
Coal		1.099	23.079					23	0.10
Oil & Natural gas	697.000	52.292	1098.132					1795	8.06
Industrial Processes	**1169.490**	**0.400**	**8.400**	**2.694**	**835.140**	**0.006**	**7.800**	**2021**	**9.08**
Cement production	584.885							585	2.63
Lime production	62.268							62	0.28
Limestone and dolomite use	11.191							11	0.05
Soda ash production and use	14.387							14	0.06
Ammonia production	462.854							463	2.08
Nitric acid production				2.694	835.140			835	3.75
Product. of other chemicals		0.400	8.400					8	0.04
Iron and steel production	0.000							0	0.00
Ferroalloys production	33.905							34	0.15
Aluminium production	0.000							0	0.00
Consumption of HFCs, PFCs and SF_6 **						0.006	7.800	8	0.04
Agriculture	**0.000**	**48.061**	**1009.281**	**6.069**	**1881.390**	**0.000**	**0.000**	**2891**	**12.99**
Enteric fermentation		40.443	849.303		0.000			849	3.82
Manure management		7.618	159.978	0.796	246.760			407	1.83
Agricultural soils management				5.273	1634.630			1635	7.34
Agricultural residue burning								0	0.00
Land-use Change & Forestry	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.130							-6505	-29.22
Changes in soil carbon								0	0.00
Waste	**0.000**	**41.164**	**864.444**	**0.421**	**130.510**	**0.000**	**0.000**	**995**	**4.47**
Land Disposal of Solid Waste		41.164	864.444					864	3.88
Human Sewage				0.421	130.510			131	0.59
Other	**0.000**		**0.000**		**0.000**	**0.000**	**0.000**	**0**	**0.00**
TOTAL EMISSIONS	**16251.4**	**147.8**	**3104.4**	**9.3**	**2895.7**	**0.006**	**7.800**	**22259**	**100.00**
NET EMISSIONS (Sources and Sinks)	**9746.3**	**147.8**	**3104.4**	**9.3**	**2895.7**	**0.006**	**7.800**	**15754**	
Share of Gases in Total Emissions (%)	**73.01**		**13.95**		**13.01**		**0.04**	**100.00**	
Share of Gases in Net Emissions (%)	**61.86**		**19.71**		**18.38**		**0.05**	**100.00**	

* - non-energy fuel consumption
** - consumption of HFC

Republic of Croatia

Ministry of Environmental Protection and Physical Planning