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Zagreb, 30 September 2003

UNFCCC Secretariat
P.O. Box 260 124
D-53153 Bonn

SUBJECT: Submission by Croatia related to the matter of the special circumstances of Croatia under Article 4, paragraph 6 of the UNFCCC Convention

Enclosed, please, find Croatia's inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, by year, including data from 1990 to 2001, as well as projections of its greenhouse gas emissions, consistent with inventory data in accordance with Decision FCCC/SBI/2003/L.7 related to the matter of the special circumstances of Croatia under Article 4, paragraph 6 of the UNFCCC Convention.

The provided data and information are based on the requirements of Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories as well as the ?UNFCCC guidelines for the preparation of national communication by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories? contained in the annex to decision 3/CP.5 and presented in formats as those specified in document FCCC/CP/1999/7.

The submitted documents do not include Croatian special circumstances related to gaining of independence after the dissolution of the former Yugoslavia, as already described in the First National Communication of the Republic of Croatia to the UNFCCC as well as in the Croatian request for base year determination referring to Article 4, para 6 of the Convention, submitted on COP 7 in Marrakech.

Sincerely yours,

Minister
Ivo Banac

Enclosures:

Croatian inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol for the period 1990-2001

Projections of greenhouse gases emissions

EKONERG – Energy Research and Environmental Protection Institute
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CROATIAN INVENTORY OF ANTHROPOGENIC EMISSIONS BY SOURCES AND REMOVALS BY SINKS OF ALL GREENHOUSE GASES NOT CONTROLLED BY THE MONTREAL PROTOCOL

FOR THE PERIOD 1990 - 2001

Ordered by:
Ministry of Environmental Protection and Physical Planning
Ulica grada Vukovara 78, Zagreb, Republic of Croatia

Prepared by:
EKONERG – Energy Research and Environmental Protection Institute
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Zagreb, September 2003

CONTENT:

LIST OF ABBREVIATIONS

CDM	*- Clean Development Mechanism (CDM)*
CFC	*- Chlorofluorocarbons*
COPERT	*- Computer Programme to Calculate Emissions from Road Transport*
CORINAIR	*- Core Inventory of Air Emissions in Europe*
CPS Molve	*- Central Gas Station Molve*
CRF	*- Common Reporting Format*
EMEP	*- Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe*
ET	*- Emissions Trading*
FAO	*- Food and Agriculture Organization of the United Nations*
GHG	*- Greenhouse gas*
GWP	*- Global Warming Potential*
HEP	*- Croatian Electricity Utility Company*
IEA	*- International Energy Agency*
IPCC	*- Intergovernmental Panel on Climate Change*
ISWA	*- International Solid Waste Association*
JI	*- Joint Implementation*
NGGIP	*- National Greenhouse Gas Inventories Programme*
NMVOC	*- Non-methane Volatile organic Compounds*
OECD	*- Organisation for Economic Co-operation and Development*
UNEP	*- United Nations Environment Programme*
UNFCCC	*- United Nations Framework Convention on Climate Change*
CBS	*- Central Bureau of Statistics*
EIHP	*- Energy Institute "Hrvoje Požar"*
CEE	*- Cadastre of Emission in Environment*
MZOPU	*- Ministry of Environmental Protection and Physical Planning*
INA	*- Croatian Oil and Gas Company*
ZGO	*- Zagreb's Environmental Protection and Waste Management Company*
APO	*- Hazardous Waste Management Agency*

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EXECUTIVE SUMMARY

ES.1. BACKGROUND INFORMATION ON GHG INVENTORIES AND CLIMATE CHANGE

In 1996 the Republic of Croatia became a party to the United Nations Framework Convention on Climate Change (UNFCCC) pursuant to the Parliament's decision on its ratification (Gazette 55/1966). By this decision and the Article 22 of the Convention and as a country undergoing the process of transformation to the market economy, the Republic of Croatia has assumed the scope of its commitments under the Annex I to the Convention. Among other obligations, Croatia undertook to maintain the emission of greenhouse gases to the 1990 level.

The Republic of Croatia has signed the Kyoto Protocol according to which, when it becomes operative and is ratified by the Parliament, it will have to reduce the greenhouse gas emission by 5 per cent in the 2008-2012 period as compared to the base year. The Kyoto Protocol provides the possibility for the countries to meet their commitments by “domestic” measures and, additionally, by applying the joint implementation (JI) mechanism, clean development mechanism (CDM), or emission trading (ET).

One of the essential steps in a systematic consideration of the climate change issues and their solving is the development of a greenhouse gas emission inventory. Even before the First National Communication made in compliance with the United Nation Framework Convention on Climate Change (hereinafter referred to as the Convention), the inventories of the pollutant emissions to air had been systematically made in Croatia for the most important greenhouse gases (CO_2, CH_4 and N_2O) and other pollutants (SO_2, NO_x, CO, NMVOC, NH_3, heavy metals and persistent organic compounds). Since 1995, the Ministry of Environmental Protection and Physical Planning has been regularly preparing its annual reports of the pollutant emissions. The experience and the know-how in GHG inventory preparation of EKONERG’s experts gained during the development of the First National Communication has played an important role in making the inventory and this report.

This inventory report comprises greenhouse gas emissions in the Republic of Croatia for the period 1990-2001. The structure of inventory report is in line with Annex I of the *Guidelines for the preparation of national communication by parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories* (FCCC/CP/2002/8). The methodology used for emissions calculation is in line with the *Revised 1996 IPCC Guidelines for National GHG Inventories (IPCC/UNEP/OECD/IEA)* and *Good Practice Guidance and Uncertainty Management in National GHG Inventories, 2000 (IPCC/NGGIP),* recommended by the UNFCCC. The available methodology and a systematic approach insure that the principles of transparency, consistency, comparability, completeness and accuracy of calculations could be achieved. The methodology additionally requires uncertainty assessments of input data and the results of calculations and verification in order to improve the quality and reliability of the inventory.

ES.2. SUMMARY OF NATIONAL EMISSION AND REMOVAL RELATED TRENDS

The emissions of individual greenhouse gases can be expressed in an aggregated form taking into consideration their different radiation properties. The global warming potential (GWP) values were used for comparison. The reference gas CO_2 (GWP=1) and 100 year time horizon is used.

Overall decline of economic activities and energy consumption in the period 1991-1995, which was mainly the consequence of the war in Croatia had directly caused the decline in total emissions of greenhouse gases in that period. With the entire national economy in transition process, some energy intensive industries reduced their activities or phased out certain productions, which was considerably reflected in GHG emissions. Emissions have started to increase in the period 1996-2001 in average of 3.2 per cent per year, because of revitalisation of economy.

The shares of emission by greenhouse gases have not significantly changed during entire period. The CO_2 is the largest anthropogenic contributor to total national GHG emissions. In 2001 the shares of GHG emissions were as follows: 75.9 per cent CO_2, 12.4 per cent CH_4, 11.5 per cent N_2O and 0.2 per cent HFCs. The trend of aggregated emissions/removals, for the period 1990-2001, is shown in tables ES.2-1 and ES.2-2 and the figure ES.2-1.

Table ES.2-1: *Aggregated emissions and removals of GHG by sectors (1990-2001)*

Source	Emissions and removals of GHG (eq-CO_2)											
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Energy	22463	16568	15467	16526	15499	16353	17076	18037	18872	19256	18817	19875
Industrial Processes	3892	2976	2653	2066	2317	2021	2095	2365	2002	2454	2815	2785
Agriculture	4321	4344	4060	3277	3109	2891	3192	3479	3186	3282	3303	3036
Waste	933	917	901	913	937	995	983	1034	1082	1160	1162	1163
Total	**31609**	**24804**	**23082**	**22783**	**21862**	**22259**	**23347**	**24915**	**25142**	**26151**	**26097**	**26859**
Removals (LUCF)	-6505	-6505	-6505	-6505	-6505	-6505	-8069	-8069	-8069	-8069	-8069	-8069
NET EMISSION	**25104**	**18299**	**16577**	**16278**	**15357**	**15754**	**15278**	**16845**	**17073**	**18082**	**18028**	**18790**

Table ES.2-2: *Aggregated emissions and removals of GHG by gases (1990-2001)*

Gas	Emissions and removals of GHG (eq-CO_2)											
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Carbon dioxide (CO_2)	22970	16702	15764	16399	15674	16251	16976	18057	18956	19678	19379	20390
Methane (CH_4)	3815	3611	3419	3291	3099	3104	3146	3243	3099	3179	3210	3332
Nitrous oxide (N_2O)	3886	3843	3898	3093	3089	2896	3165	3523	3070	3285	3484	3088
HFCs, PFCs and SF_6	939	648	0	0	0	8	60	91	18	9	23	49
Total	**31609**	**24804**	**23082**	**22783**	**21862**	**22259**	**23347**	**24915**	**25142**	**26151**	**26097**	**26859**
Removals (CO_2)	-6505	-6505	-6505	-6505	-6505	-6505	-8069	-8069	-8069	-8069	-8069	-8069
NET EMISSION	**25104**	**18299**	**16577**	**16278**	**15357**	**15754**	**15278**	**16845**	**17073**	**18082**	**18028**	**18790**

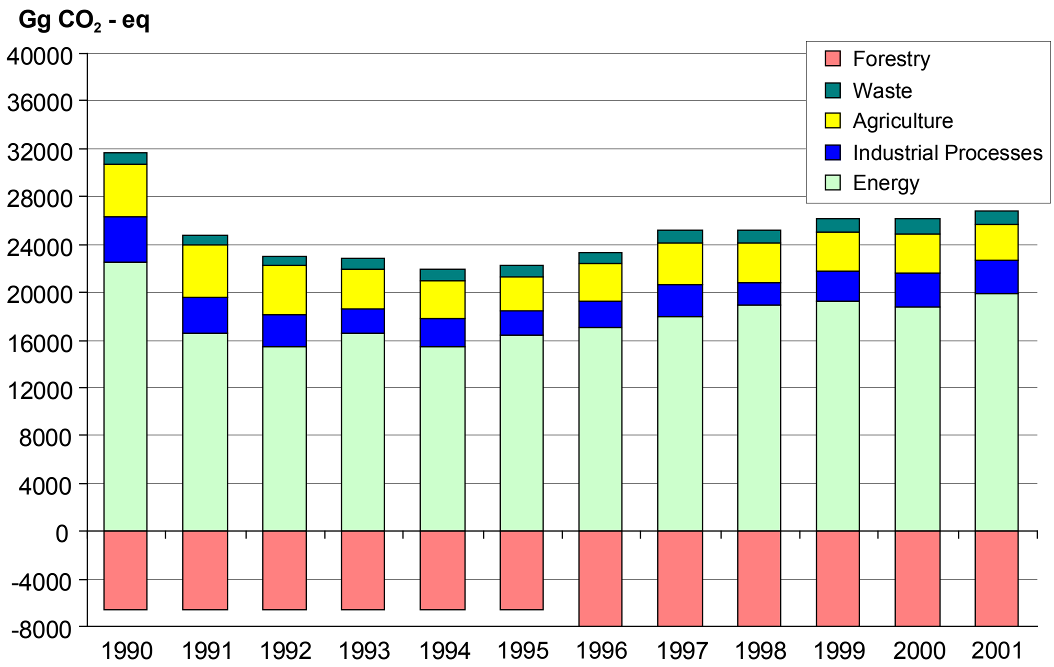

Figure ES.2-1: Trend of total emissions/removals of GHGs from 1990 to 2001

ES.3. OVERVIEW OF SOURCES AND SINK CATEGORY EMISSION ESTIMATES AND TRENDS

ES.3.1. CARBON DIOXIDE EMISSIONS

The most significant anthropogenic source of CO_2 is the energy sector (mainly fossil fuel combustion) and some industrial processes (e.g. cement production). The results of CO_2 emission estimates in the period 1990-2001 are shown in table ES.3-1. More detailed information on CO_2 emissions from various sectors (according to IPCC methodology) are given in the text below.

Table ES.3-1: Total CO_2 emissions and removals in the period 1990-2001

Source	CO_2 emissions and removals (Gg)											
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Energy	20959	15201	14187	15146	14235	15082	15727	16607	17594	17966	17448	18379
Industrial Processes	2011	1501	1578	1253	1439	1170	1250	1450	1362	1713	1932	2011
Forest (sink)	-6505	-6505	-6505	-6505	-6505	-6505	-8069	-8069	-8069	-8069	-8069	-8069
Total	22970	16702	15765	16399	15674	16251	16976	18057	18956	19679	19379	20390
NET EMISSION	16465	10197	9259	9894	9169	9746	8907	9988	10887	11610	11310	12321

Energy

This sector covers all activities that involve fuel consumption (fuel combustion and non–energy use of fuel) and fugitive emissions from fuels. The fuel fugitive emissions are generated during production, transport, processing, storing, and distribution of fossil fuels. Emissions from fossil fuel combustion comprise the majority (more then 90 per cent) of energy-related emissions. The results of CO_2 emission estimates for energy subsectors in the period 1990-2001 are shown in table ES.3-2.

Table ES.3-2: CO_2 emission estimates for energy subsectors in the period 1990-2001

Energy	CO_2 emissions (Gg)											
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Energy Industries	5897	3847	4514	5185	3925	4460	4310	4875	5531	5699	5156	5650
Manufacturing Industries and Construction	6546	4732	3730	3658	3815	3617	3763	3714	4008	3729	3805	3903
Transport (Road & Off-Road)	4046	2917	2781	2949	3124	3337	3668	4013	4163	4394	4396	4459
Other sectors (Comm./Inst., Residential…)	3616	3003	2495	2484	2568	2778	3136	3180	3107	3513	3359	3576
Other (non-energy fuel consumption)	439	246	189	194	199	193	206	225	196	105	99	102
Total	**20543**	**14745**	**13709**	**14470**	**13630**	**14385**	**15083**	**16007**	**17005**	**17441**	**16814**	**17691**

The methodology used for estimating CO_2 emissions follows the *Revised 1996 IPCC Guidelines.* Emission estimates are based on fuel consumption data given in National Energy Balance (Energy Institute "Hrvoje Požar"), where energy demand and supply is given at sufficiently detailed level, what allows emissions estimation by sectors and subsectors (IPCC Methodology, Sectoral approach). Also, the CO_2 emission is estimated by Reference approach, which considered only total energy balance, without subsectors analyses. Comparison between these approaches was made, and the difference is not greater than 5.2 per cent (Table ES.3-3 and table A2-6 in Annex 2).

Table ES.3-3: CO_2 emission comparison due to fuel combustion

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Reference Approach (Tg)	19.94	14.19	13.23	13.72	13.59	14.06	14.83	15.37	16.59	17.28	16.62	17.51
Sectoral Approach (Tg)	20.54	14.74	13.71	14.47	13.63	14.38	15.08	16.01	17.00	17.44	16.81	17.69
Relative Difference (per cent)	2.92	3.78	3.46	5.18	0.33	2.29	1.66	3.97	2.35	0.87	1.17	1.03

According to calculation results there are two emission intensive subsectors in Energy sector i.e. Energy Industries and Manufacturing Industries and Construction.

Energy Industries comprise emissions from fuel combustion in thermal power and district heating plants, petroleum refining plants, solid transformation plants, oil and gas extraction and coal mining. It should be point out that a large part of the electrical energy is generated without CO_2 emission (hydroelectric power plants, nuclear power plant Krško and import), therefore the emission from this sector is relatively small, 23-32 per cent of emission from Energy sector. The largest part (60 to 80 per cent) of the emissions is a consequence of fuel combustion in thermal power plants, following by the combustion in oil refineries 16-28 per cent.

Manufacturing industries and construction include the emissions from fuel combustion in different industries, such as industry of building materials (22-37 per cent), iron and steel industries, industries of non-ferrous metals, chemicals, pulp and paper, food processing, beverages, tobacco and others. This sector also includes the emissions from fuel used for the generation of electricity and heat in industry (industrial cogeneration and heating plants) with sectoral contribution of 43-57 per cent

Transport is also one of the important emission sources of CO_2. The most of emission comes from road transport (86-94 per cent, depending on the year), then from rail transport and domestic air and marine transport. The emission of international aircraft or marine transport is excluded from the national total but is reported separately (Table A2-8 in Annex 2).

The emissions due to non-energy fuel consumption (fuels used as feedstock) where one part or even the whole carbon is stored in product for a longer time and the other part oxidizes and goes to atmosphere. The feedstock use of energy carriers occurs in chemical industry (natural gas consumption for ammonia production, production of naphtha, ethane, paraffin, and wax), construction industry (bitumen production), and other products such as motor oil, industrial oil, grease etc. As a result of non-energy use of bitumen in construction industry there is no CO_2 emission because all carbon is bound to the product. In order to avoid double counting, CO_2 emission in non-energy consumption of natural gases in ammonia production was estimated in sector Industrial processes. Detailed information about non-energy fuel consumption is presented in the table A2-11 in Annex 2.

CO_2 emissions from biomass combustion are not included in total national GHG emission because emitted CO_2 has been previously absorbed from the atmosphere for growth and development of biomass, as proposed by *Revised 1996 IPCC Guidelines*. Removal or emission of CO_2 due to the changes in the forest biomass is estimated in the sector Land Use Change and Forestry.

Fugitive emission of greenhouse gases from coal, oil and natural gas, due to mining, production, processing, transportation and use of fossil fuels is also part of Energy sector. Although these emission sources are not characteristic in respect of CO_2 emission (more for methane), specifically in Croatia emission of CO_2 from natural gas scrubbing is assigned here. Natural gas produced in Croatian gas fields has a large amount of CO_2, more than 15 per cent, and before coming to commercial pipeline (max. 3 per cent of CO_2) has to be cleaned (scrubbed). Emission estimation from natural gas scrubbing is done by material balance method and it is up to 5 per cent of CO_2 emission in Energy sector (tables 2.5-2 and 2.6-1).

Industrial processes

Greenhouse gas emissions are produced as by-products of non-energy industrial processes in which raw materials are chemically transformed to final products. Industrial processes whose contribution to CO_2 emissions is identified as significant are production of cement, lime, ammonia, ferroalloy, as well as use of limestone and soda ash in different industrial activities.

The general methodology applied to estimate emissions associated with each industrial process, recommended by *Revised 1996 IPCC Guidelines*, involves the product of amount of material produced or consumed, and an associated emission factor per unit of consumption/production. The activity data on consumption/production for particular industrial processes were, in most cases, extracted from Monthly Industrial Reports, published by Central Bureau of Statistics, Department of Manufacturing and Mining. Certain activity data were collected from voluntary survey of manufacturers and cross-checked with statistical data. The results of CO_2 emission estimates for industrial processes in the period 1990-2001 are shown in table ES.3-4.

Table ES.3-4: CO_2 emission estimates for industrial processes in the period 1990-2001

Industrial Processes	CO_2 emissions (Gg)											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Cement production	1022.9	647.5	774.7	648.5	793.8	584.9	634.0	753.5	811.4	1072.6	1242.3	1419.6
Lime production	145.1	86.9	54.5	60.3	59.7	62.3	79.3	101.8	105.9	102.7	124.5	143.7
Limestone and dol. use	18.9	15.7	10.5	9.6	15.5	11.2	8.5	7.3	8.6	8.0	8.4	9.2
Soda ash prod. and use	25.7	21.8	14.7	12.5	15.2	14.4	11.4	9.7	11.5	10.6	11.0	12.4
Ammonia production	491.6	471.5	606.8	471.3	474.7	462.9	502.7	546.2	409.7	519.1	525.3	425.9
Ferroalloys production	194.9	181.4	116.7	50.9	79.9	33.9	13.7	31.5	15.4	0.0	20.5	0.5
Aluminium production	111.4	76.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**2011**	**1501**	**1578**	**1253**	**1439**	**1170**	**1250**	**1450**	**1362**	**1713**	**1932**	**2011**

Most significant CO_2 industrial processes emission source is cement production (with 40 to 70 per cent of total CO_2 emissions in sector) and ammonia production (with 20 to 40 per cent of total CO_2 emissions in sector). 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, while in the period 1996-2001 emissions were approached to emission in 1990. Some productions, such as iron, steel and aluminium were halted in 1992.

The quantity of the CO_2 emitted during cement production is directly proportional to the lime content of the clinker. Therefore, estimation of CO_2 emissions is accomplished by applying an emission factor, in tonnes of CO_2 released per tonne of clinker produced, to the annual clinker output corrected with the fraction of clinker that is lost from the kiln in the form of Cement Kiln Dust (CKD). The emission factor and correction factor for CKD is determined according to *Revised 1996 IPCC Guidelines* and *Good Practice Guidance.* The activity data for clinker production were collected from voluntary survey of cement manufacturers and cross-checked with cement production data from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Emissions of CO_2 from ammonia production were calculated by multiplying annual consumption of natural gas used as a feedstock in process by carbon content of natural gas. Data on consumption and composition of natural gas used as a feedstock in a process were collected from voluntary survey of ammonia manufacturer and cross-checked with statistical data. CO_2 which was produced as a by-product during the production of ammonia was used as a feedstock in the production of urea. Emissions of intermediately bound CO_2 occurred during the use of urea as a fertilizer in agriculture and should be reported perhaps under agriculture sector. According to *Revised 1996 IPCC Guidelines* no account should consequently be taken for intermediate binding of CO_2 in production of urea, dry ice and fertilizer. Therefore, total CO_2 emissions of natural gas used as a feedstock in ammonia production were reported here.

Removals

According to General Forest Management Plan of the Republic of Croatia forests and forest land in Croatia cover 43.5 per cent of the whole area. In Croatia forests were formed by natural regeneration over 95 per cent of the area and 5 per cent of the forests are grown artificially. Of all forested area and forest land, 2,061,609 ha (84 per cent) is under forests, 315,166 ha (13 per cent) is non – forest productive land, and 80,973 ha (3 per cent) is bare unproductive and infertile soil.

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

Annual increment in Croatian forests is 9,643,000 m^3 of wood. Increment is an increase in forest wood stock over a certain time period. It is calculated as annual, periodical and average increment. Different methods have been developed in forest management to identify the forest increment. The methods mostly 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. A described cut is a part of the forest wood stock planned for commercial cutting over a time period (1 year, 10 years, 20 years) expressed in wood stock (m^3, m^3/ha) or in an area (ha). In order to satisfy the basic principal of forest management and a principle of sustainability the described cut shall not be larger than the increment value.

The methodology used for estimating net uptake of CO_2 follows the *Revised 1996 IPCC Guidelines*, based on annual increment of biomass in forests and wood harvest. The net carbon uptake due to these two sources was then calculated and expressed as CO_2. Due to long term nature of changes in forestry same annual emission estimate was given for the period 1990-1995 (6505 Gg CO_2) and for the period 1996-2001 (8069 Gg CO_2).

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

ES.3.2. METHANE EMISSIONS

In Croatia, the major sources of methane are agriculture, municipal solid waste disposal on land and fugitive emission from fuel production, processing, transportation and using activities. The results of CH_4 emission estimates in the period 1990-2001 are shown in table ES.3-5.

Livestock farming in agriculture is the major anthropogenic source of methane emissions in Croatia. CH_4 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 methods presented in *Revised 1996 IPCC Guidelines* were used and form the basis of the methane emissions estimates for each animal type. General decrease of economic activities during the period from 1990 to 1995 influenced decreasing of animal's number and thus CH_4 emissions decreased considerably as well.

Table ES.3-5: CH_4 emission estimates in the period 1990-2001

Source	**CH_4 emissions (Gg)**											
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Energy	67.8	62.5	58.7	63.4	57.9	58.2	61.2	64.3	56.4	56.1	58.7	63.9
Industrial processes	0.8	0.5	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3
Agriculture	75.3	71.9	67.1	55.6	50.8	48.1	45.3	44.5	43.1	43.9	42.6	43.1
Waste	37.8	37.0	36.6	37.2	38.4	41.2	42.9	45.3	47.8	51.1	51.3	51.3
Total	**182**	**172**	**163**	**157**	**148**	**148**	**150**	**154**	**148**	**151**	**153**	**159**

Methane (CH_4) emissions from solid waste disposal sites (SWDSs) result from anaerobic decomposition of organic wastes by methanogenic bacteria. The default methodology was used for estimating CH_4 emissions according to *Revised 1996 IPCC* Guidelines. The quantity of the CH_4 emitted during decomposition process is directly proportional to the fraction of degradable organic carbon (DOC), which is defined as the carbon content of different types of organic biodegradable wastes such as paper and textiles, garden and park waste, food waste, wood and straw waste. DOC was estimated by using country-specific data and according to that data fraction of DOC in municipal solid waste (MSW) was estimated to be 0.17. In wastewater treatment aerobic biological processes are used mostly. According to national wastewater experts anaerobic treatment is applied in some wastewater treatment. Total amount of gas is flared in these treatments, and therefore all methane from gas is oxidized to carbon dioxide and water vapour.

The fugitive emission estimates were calculated by proposed IPCC methodology. The fugitive emission of methane is mainly (about 97 per cent) the consequence of production, transmission and distribution of natural gas. The fugitive emission from oil accounts for about 1 per cent and venting and flaring of gas/oil production accounts for approximately 2 per cent (table A2-19 in Annex 2). The fugitive CH_4 emissions based on mining and processing of coal are reduced significantly after closing the underground coal mines in Istria in 1999.

ES.3.3. NITROUS OXIDE EMISSIONS

The most important sources of N_2O emission in Croatia are agriculture and nitric acid production. The results of N_2O emission estimates in the period 1990-2001 are shown in table ES.3-6.

Table ES.3-6: N_2O *emission estimates in the period 1990-2001*

Source	N_2O emissions (Gg)											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5
Industrial processes	3.0	2.6	3.4	2.6	2.8	2.7	2.5	2.6	2.0	2.3	2.8	2.3
Agriculture	8.8	9.1	8.6	6.8	6.6	6.1	7.2	8.2	7.4	7.6	7.8	6.9
Waste	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Total	**12.5**	**12.4**	**12.6**	**10.0**	**10.0**	**9.3**	**10.2**	**11.4**	**9.9**	**10.6**	**11.2**	**10.0**

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 are distinguished in the methodology we used: direct emissions from agricultural soils, direct soil emissions from animal production and N_2O emissions indirectly induced by agricultural activities. Direct emissions N_2O from agricultural soils, with largest emission between mentioned sources, includes total amount of nitrogen to soils through cropping practices. These practices includes application of synthetic fertilizer, nitrogen from animal waste, production of nitrogen – fixing crops, nitrogen from crop residue mineralisation and soil nitrogen mineralisation due to cultivation of histosols. Annual synthetic fertilizer consumption data were taken from Croatian Statistical Reports and appropriate methodology and emission factor (default values) to give direct soil emission from synthetic fertilizer, are taken from *Revised 1996 IPCC Guidelines*.

In Industrial processes N_2O is only generated as a by-product in nitric acid production. Emissions were calculated by proposed IPCC methodology (by multiplying annual nitric acid production with emission factor which reflects the process type, i.e. dual pressure type, according to *Good Practice Guidance*).

Concerning Waste sector indirect N_2O emissions from human sewage, using the *Revised 1996 IPCC Guidelines*, are calculated based on population data and annual per capita protein consumption.

Emissions in energy sector were calculated on the basis of the fossil fuel consumption balance, applying emission factors from the *Revised 1996 IPCC Guidelines*.

ES.3.4. HALOGENATED CARBONS (HFCs, PFCs) AND SF_6 EMISSIONS

Synthetic greenhouse gases include halogenated carbons (HFCs and PFCs) and sulphur 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 aluminium. The Croatian aluminium industry was still operational in 1990/1991, but production was stopped in 1992. Activity data (production of primary aluminium) and adequate emission factors (proposed by *Revised 1996 IPCC Guidelines*) were used to calculate emissions.

A certain amount of SF_6 is contained in electrical equipment used in the facilities of Croatian National Electricity (Hrvatska elektroprivreda). Equipment manufacturers guarantee annual leakage of less than 1 per cent, 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.

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 and information related to import and export of HFCs in the period 1995-2001, provided by Ministry of Environmental Protection and Physical Planning, was used to calculate emissions. According to this information potential HFCs emissions (proposed by *Revised 1996 IPCC Guidelines*) were calculated by difference of import and export of these gases.

ES.4. OTHER RELEVANT INFORMATION

ES.4.1. EMISSIONS OF INDIRECT GREENHOUSE GASES

Although they are not considered as greenhouse gases, photochemical 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. Sulphur dioxide (SO_2), as a precursor of sulphate and aerosols, is believed to contribute negatively to the greenhouse effect. The calculation aggregate results for the emissions of indirect gases in the period 1990-2001 are given in table ES.4-1.

Table ES.4-1: Emissions of indirect GHG by different sectors in the period 1990-2001

Gas	Emissions (Gg)											
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
NO_x Emission	**91.8**	**67.9**	**64.5**	**67.5**	**66.1**	**68.1**	**74.8**	**77.9**	**81.7**	**85.6**	**86.2**	**87.9**
Energy Industries	16.4	10.9	12.7	14.5	10.8	12.1	11.6	13.4	15.1	15.5	14.6	16.0
Manuf. Ind. & Constr.	18.0	13.3	10.6	10.4	10.8	10.1	10.5	10.5	11.2	10.3	10.6	10.8
Transport	38.8	29.2	28.7	29.8	31.0	33.1	37.4	40.4	41.3	43.5	43.5	44.5
Other Energy	17.9	14.1	12.2	12.6	13.2	12.5	15.0	13.3	13.9	16.0	17.2	16.3
Industrial Processes	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3
Agriculture*	0.2											
CO Emission	**486.7**	**348.7**	**298.7**	**298.5**	**317.5**	**331.8**	**332.0**	**352.8**	**364.5**	**380.2**	**391.4**	**365.7**
Energy Industries	1.4	1.0	1.1	1.3	1.0	1.0	1.1	1.2	1.3	1.3	1.3	1.4
Manuf. Ind. & Constr.	11.1	9.5	7.7	7.6	6.4	6.6	6.5	7.9	7.6	5.9	6.0	5.5
Transport	290.5	219.3	193.2	191.0	208.6	219.6	240.8	262.3	283.1	298.3	300.1	292.0
Other Energy	166.2	109.1	93.2	95.7	98.5	101.3	80.4	78.0	69.9	71.4	80.7	64.0
Industrial Processes	13.1	9.8	3.5	2.9	3.0	3.3	3.2	3.4	2.6	3.2	3.3	2.7
Agriculture*	4.3											
NMVOC Emission	**561.2**	**508.0**	**428.4**	**416.8**	**320.3**	**323.0**	**205.4**	**260.0**	**257.6**	**271.5**	**258.5**	**219.1**
Energy Industries	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Manuf. Ind. & Constr.	0.9	0.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4
Transport	54.8	41.3	36.4	36.1	39.4	41.5	45.6	49.6	53.5	56.4	56.7	55.2
Other Energy	55.3	36.7	31.7	37.3	38.4	40.4	10.4	9.9	9.0	9.3	10.5	8.5
Industrial Processes	419.4	396.8	335.6	317.3	214.3	212.9	118.4	172.4	168.8	183.2	165.3	130.6
Solvent Use	30.4	32.3	23.9	25.2	27.5	27.4	30.3	25.2	25.3	21.8	25.2	23.9
SO_2 Emission	**185.9**	**112.1**	**111.6**	**117.2**	**93.8**	**76.4**	**69.9**	**83.4**	**91.9**	**93.4**	**61.0**	**64.3**
Energy Industries	86.9	48.8	61.3	59.0	35.9	36.1	31.8	45.9	59.8	61.5	29.6	23.3
Manuf. Ind. & Constr.	62.7	34.3	30.5	37.5	40.3	26.0	17.9	18.1	15.2	14.5	12.5	26.6
Transport	5.8	9.5	5.6	6.3	4.6	3.6	9.4	8.2	7.1	7.1	8.7	4.9
Other Energy	24.1	14.9	8.7	10.7	8.7	6.0	6.4	7.0	6.2	6.1	5.8	6.2
Industrial Processes	6.3	4.6	5.5	3.7	4.3	4.7	4.5	4.2	3.6	4.2	4.4	3.3

* - Field burning of agricultural residues (data existed only for 1990)

ES.4.2. UNCERTAINTY EVALUATION AND VERIFICATION

<u>Uncertainty evaluation</u>

The uncertainty assessment of the calculation is one of the key elements of the national emission inventory. The information about the uncertainty does not dispute the calculation validity but helps with the identification of the priority measures for higher accuracy of the calculation and for selection of the methodological options. There are several reasons why the actual emissions and sinks are different in comparison with the figures obtained by the calculation. Totally quantified uncertainty of the emission from certain sources is a combination of some uncertainties of the emission estimate elements:

- uncertainty related to the emission factors
- uncertainty related to the activity data

The experts involved in making this GHG emissions/removals inventory have assessed for the first time the total uncertainty of the entire inventory for 2001 and the uncertainty of emission trend for the period from 1990 to 2001 following the guidelines given in the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. The approach used was the simpler Tier 1 Level approach.

The quantitative assessment of uncertainty is presented in the Annex 3 (Table A3-1). The total uncertainty of GHG emission estimate for 2001 has been assessed at 37 per cent whereas the trend uncertainty at 8 per cent. The higher reliability of trend is easy to understand and results from the calculation consistency, one of the basic principles of the IPCC methodology.

The uncertainty of the calculation of certain emissions from some sectors/sub-sectors is quantified and presented in Table ES.4-2 and categorized at three levels: to ±10 per cent high reliability level, from ±10 to ±50 per cent medium reliability level, and above ±50 per cent low reliability level.

Table ES.4-2: Qualitative analysis of uncertainty

High reliability level • CO_2 Emissions from Fuel Combustion • CO_2 Emissions from Natural Gas Scrubbing • CO_2 Emissions from Industrial Processes (Cement and Ammonia Production)
Medium reliability level • CH_4 Emissions from Fuel Combustion • CO_2 Emissions from Industrial Processes (Lime Production, Limestone and Dolomite Use, Soda Ash Production and Use, Iron and Steal Production, Ferroalloys Production, Aluminium Production) • CH_4 Emissions from Industrial Processes (Other Chemical Production) • N_2O Emissions from Industrial Processes (Nitric Acid Production) • N_2O Emissions from Human Sewage
Low reliability level • N_2O Emissions from Fuel Combustion • CH_4 Fugitive Emissions from Coal Mining and Handling • CH_4 Fugitive Emissions from Oil and Natural Gas • HFC Emissions from HFC Consumption • CH_4 Emissions from Enteric Fermentation in Domestic Livestock • CH_4 and N_2O Emissions from Manure Management • N_2O Emissions from Agricultural Soils • CH_4 Emissions from Solid Waste Disposal Sites

Verification

The verification process of calculation is aimed at the improvement of the input quality and identification of the calculation reliability. The IPCC Guidelines recommends that inventories should 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.
- The 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 5.2 per cent (Tables ES.3-3 and A2-6 in Annex 2).
- The CO_2 emissions from road transport were estimated by the IPCC Tier 1 approach. Also, the rough estimate was done by using COPERT package methodology. The difference between estimated emissions is less than 2.5 per cent.

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.

In March 2002, Croatia organized an In-depth review of the First National Communication, which also included the review of greenhouse gas inventory for the period 1990-1995. Generally, review team's opinion of the inventory quality was good. A comments and recommendations for the inventory improvement have been taken into account when making the inventory and this report.

ES.4.3. KEY SOURCES

The Annex I Parties to the Convention should identify their key emission sources for the base year, for the last year of inventory and for the emission trend. The key emission sources are the sources that substantially contribute to the total GHG emissions (95 per cent) with all the emissions presented as equivalent emission of CO_2. The emissions from each source are summed up starting with the most significant to the less significant sources thus excluding from the emission key sources the least significant sources whose emissions cover the remaining 5 per cent.

Table ES.4-3 shows the emissions of key sources in Croatia obtained by analysing the total emission of the last year inventory (Level Assessment) and the trend analysis (Trend Assessment) according to the methodology given in the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. A detailed outline of the emission key sources analysis is given in the Annex 3.

Table ES.4-3: Key sources of GHG emission in Croatia

IPCC Category Source	GHG	Level/Trend
ENERGY		
Stationary Sources - Coal	CO_2	Level, Trend
Stationary Sources – Liquid Fuel	CO_2	Level, Trend
Stationary Sources – Natural Gas	CO_2	Level, Trend
Stationary Sources – All Fuel	CH_4	Trend
Mobile Sources – Road Transport	CO_2	Level, Trend
Mobile Sources – Domestic Aviation Transport	CO_2	Trend
Mobile Sources – Agriculture/Forestry/Fishing	CO_2	Level, Trend
Mobile Sources – Road Transport	N_2O	Trend
Fugitive Sources – Natural Gas and Oil	CH_4	Level, Trend
Natural Gas Scrubbing* - CPS Molve	CO_2	Level, Trend
INDUSTRIAL PROCESSES		
Cement Production	CO_2	Level, Trend
Ammonia Production	CO_2	Level
Ferroalloys Production	CO_2	Trend
Nitric Acid Production	N_2O	Level, Trend
AGRICULTURE		
Enteric Fermentation	CH_4	Level, Trend
Manure Management	N_2O	Level
Direct N_2O Emission from Agricultural Soils	N_2O	Level, Trend
Indirect N_2O Emission from Nitrogen Used in Agriculture	N_2O	Level
WASTE		
Managed Waste Disposal on Land	CH_4	Level, Trend

*** CO_2 Emission from Natural Gas Scrubbing** – IPCC doesn't offer methodology for estimating emission of CO_2 scrubbed from natural gas and subsequently emitted into atmosphere. Natural gas produced in Croatian gas fields has a large amount of CO_2, more than 15 per cent. The maximum volume content CO_2 in commercial natural gas is 3 per cent and gas must be cleaned before coming to pipeline and transport to users. Because of that, the Scrubbing Units exist at largest Croatian gas field. The CO_2, scrubbed from natural gas, is emitted into atmosphere. The emission is estimated by material balance method.

1. INTRODUCTION

1.1. BACKGROUND INFORMATION ON GHG INVENTORIES AND CLIMATE CHANGE

In 1996 the Republic of Croatia became a party to the United Nations Framework Convention on Climate Change (UNFCCC) pursuant to the Parliament's decision on its ratification (Gazette 55/1966). By this decision and the Article 22 of the Convention and as a country undergoing the process of transformation to the market economy, the Republic of Croatia has assumed the scope of its commitments under the Annex I to the Convention. Among other obligations, Croatia undertook to maintain the emission of greenhouse gases to the 1990 level.

The Republic of Croatia has signed the Kyoto Protocol according to which, when it becomes operative and is ratified by the Parliament, it will have to reduce the greenhouse gas emission by 5 per cent in the 2008-2012 period as compared to the base year. The Kyoto Protocol provides the possibility for the countries to meet their commitments by “domestic” measures and, additionally, by applying the joint implementation (JI) mechanism, clean development mechanism (CDM), or emission trading (ET).

One of the essential steps in a systematic consideration of the climate change issues and their solving is the development of a greenhouse gas emission inventory. Even before the First National Communication made in compliance with the United Nation Framework Convention on Climate Change (hereinafter referred to as the Convention), the inventories of the pollutant emissions to air had been systematically made in Croatia for the most important greenhouse gases (CO_2, CH_4 and N_2O) and other pollutants (SO_2, NO_x, CO, NMVOC, NH_3, heavy metals and persistent organic compounds). Since 1995, the Ministry of Environmental Protection and Physical Planning has been regularly preparing its annual reports of the pollutant emissions. The experience and the know-how in GHG inventory preparation of EKONERG’s experts gained during the development of the First National Communication has played an important role in making the inventory and this report.

This inventory comprises greenhouse gas emissions in the Republic of Croatia for the period 1990-2001. The methodology used for emissions calculation is in line with the *Revised 1996 IPCC Guidelines for National GHG Inventories (IPCC/UNEP/OECD/IEA)* and *Good Practice Guidance and Uncertainty Management in National GHG Inventories, 2000 (IPCC/NGGIP),* recommended by the UNFCCC. The available methodology and a systematic approach insure that the principles of transparency, consistency, comparability, completeness and accuracy of calculations could be achieved. The methodology additionally requires uncertainty assessments of input data and the results of calculations and verification in order to improve the quality and reliability of the inventory.

1.2. INVENTORY PREPARATION PROCESS

For the purposes of preparation of inventory that can be readily assessed in terms of quality and completeness data collection and management system scheme has been set up. The objectives of this system are to identify and determine data sources, data collection frequency, data storage and processing for specific reporting purposes. The objective of the system is also to achieve the maximum possible level of the data transfer in electronic format, 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 divided in 6 sectors. Depending on the sector, different activity data are required, such as fuel consumption, data on petroleum and natural gas extraction, individual industrial products/raw materials, the number of head of cattle and land being cultivated for various crops, data on forests, amounts of municipal solid waste, etc.

The data collection system includes different methods and approaches in collecting the data. Most of the data needed for the emissions estimation are taken directly from the existing databases managed by public or governmental institutions, such as statistical database (CBS[1]), balance of energy supply and demand (EIHP[2]), CEE[3] (MZOPU[4]) and the motor vehicles database from Ministry of Interior Affairs. Some of the activity data are obtained by questionnaires which were directly send to companies which represent individual emission sources, or from different studies and documents prepared by institutions/companies with expertise in particular areas such as agriculture, forestry and waste. (EKONERG, HEP[5], INA[6], ZGO[7], APO[8], counties, customs authorities, Hrvatske šume, Hrvatske vode, some faculties, etc.).

For the purposes of good archiving of activity data and emission factors, a special form called Inventory Data Record Sheets has been developed for every IPCC sector. These forms contain all relevant information on data sources, their quality and recommendations for improvements.

1.3. METHODOLOGY

The IPCC methodology from *Revised 1996 IPCC Guidelines for National GHG Inventories*, and *Good Practice Guidance and Uncertainty Management in National GHG Inventories*, recommended by the UNFCCC was used to calculate greenhouse gas emissions. This methodology covers following gases which are result of anthropogenic activities: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, CO, NO_x, NMVOCs, and SO_2. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are principal greenhouse gases and though they occur naturally in the atmosphere, their recent atmospheric build-up appears to be largely the result of human activities. Synthetic gases such as halogenated hydrocarbons (PFCs, HFCs) and sulphur hexafluoride (SF_6) are also considered as greenhouse gases and they are solely the result of human activities. The methodology does not include the CFCs which are the subject of the Montreal Protocol. 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 considered as 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). Sulphur 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 estimates are divided into following IPCC sectors: Energy, Industrial processes, Solvent Use, Agriculture, Land Use Change and Forestry and Waste. Generally, methodology applied to estimate emissions involves the product of activity data (e.g. fuel consumption,

[1] CBS - Central Bureau of Statistics
[2] EIHP - Energy Institute “Hrvoje Požar”
[3] CEE - Cadastre of Emission in Environment
[4] MZOPU - Ministry of Environmental Protection and Physical Planning
[5] HEP - Croatian Electricity Utility Company
[6] INA - Croatian Oil and Gas Company
[7] ZGO - Zagreb’s Environmental Protection and Waste Management Company
[9] APO - Hazardous Waste Management Agency

cement production, wood stock increment and so forth) and an associated emission factor. The use of county-specific emission factors, if available, is recommended but these cases should be based on well-documented research. Otherwise, the *Revised 1996 IPCC Guidelines* provides a default values for emission factors.

1.4. KEY SOURCE CATEGORIES

The Annex I Parties to the Convention should identify their key emission sources for the base year, for the last year of inventory and for the emission trend. The key emission sources are the sources that substantially contribute to the total GHG emissions (95 per cent) with all the emissions presented as equivalent emission of CO_2. The emissions from each source are summed up starting with the most significant to the less significant sources thus excluding from the emission key sources the least significant sources whose emissions cover the remaining 5 per cent.

Table 1-1 shows the emissions of key sources in Croatia obtained by analysing the total emission of the last year inventory (Level Assessment) and the trend analysis (Trend Assessment) according to the methodology given in the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. A detailed outline of the emission key sources analysis is given in the Annex 3.

Table 1-1: Key sources of GHG emission in Croatia

IPCC Category Source	GHG	Level/Trend
ENERGY		
Stationary Sources – Coal	CO_2	Level, Trend
Stationary Sources – Liquid Fuel	CO_2	Level, Trend
Stationary Sources – Natural Gas	CO_2	Level, Trend
Stationary Sources – All Fuel	CH_4	Trend
Mobile Sources – Road Transport	CO_2	Level, Trend
Mobile Sources – Domestic Aviation Transport	CO_2	Trend
Mobile Sources – Agriculture/Forestry/Fishing	CO_2	Level, Trend
Mobile Sources – Road Transport	N_2O	Trend
Fugitive Sources – Natural Gas and Oil	CH_4	Level, Trend
Natural Gas Scrubbing* - CPS Molve	CO_2	Level, Trend
INDUSTRIAL PROCESSES		
Cement Production	CO_2	Level, Trend
Ammonia Production	CO_2	Level
Ferroalloys Production	CO_2	Trend
Nitric Acid Production	N_2O	Level, Trend
AGRICULTURE		
Enteric Fermentation	CH_4	Level, Trend
Manure Management	N_2O	Level
Direct N_2O Emission from Agricultural Soils	N_2O	Level, Trend
Indirect N_2O Emission from Nitrogen Used in Agriculture	N_2O	Level
WASTE		
Managed Waste Disposal on Land	CH_4	Level, Trend

*** CO_2 Emission from Natural Gas Scrubbing** – IPCC doesn't offer methodology for estimating emission of CO_2 scrubbed from natural gas and subsequently emitted into atmosphere. Natural gas produced in Croatian gas fields has a large amount of CO_2, more than 15 per cent. The maximum volume content CO_2 in commercial natural gas is 3 per cent and gas must be cleaned before coming to pipeline and transport to users. Because of that, the Scrubbing Units exist at largest Croatian gas field. The CO_2, scrubbed from natural gas, is emitted into atmosphere. The emission is estimated by material balance method.

1.5. VERIFICATION

The verification process of calculation is aimed at the improvement of the input quality and identification of the calculation reliability. The IPCC Guidelines recommends that inventories should 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.
- The 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 5.2 per cent (table A2-6 in Annex 2).
- The CO_2 emissions from road transport were estimated by the IPCC Tier 1 approach. Also, the rough estimate was done by using COPERT package methodology. The difference between estimated emissions is less than 2.5 per cent.

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.

In March 2002, Croatia organized an In-depth review of the First National Communication, which also included the review of greenhouse gas inventory for the period 1990-1995. Generally, review team's opinion of the inventory quality was good. A comments and recommendations for the inventory improvement have been taken into account when making the inventory and this report.

1.6. UNCERTAINTY EVALUATION

The uncertainty assessment of the calculation is one of the key elements of the national emission inventory. The information about the uncertainty does not dispute the calculation validity but helps with the identification of the priority measures for higher accuracy of the calculation and for selection of the methodological options. There are several reasons why the actual emissions and sinks are different in comparison with the figures obtained by the calculation. Totally quantified uncertainty of the emission from certain sources is a combination of some uncertainties of the emission estimate elements:

- uncertainty related to the emission factors
- uncertainty related to the activity data

The experts involved in making this GHG emissions/removals inventory have assessed for the first time the total uncertainty of the entire inventory for 2001 and the uncertainty of emission trend for the period from 1990 to 2001 following the guidelines given in the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. The approach used was the simpler Tier 1 Level approach.

The quantitative assessment of uncertainty is presented in the Annex 3 (table A3-1). The total uncertainty of GHG emission estimate for 2001 has been assessed at 37 per cent whereas the trend uncertainty at 8 per cent. The higher reliability of trend is easy to understand and results from the calculation consistency, one of the basic principles of the IPCC methodology.

The uncertainty of the calculation of certain emissions from some sectors/sub-sectors is quantified and presented in table 1-2 and categorized at three levels: to ±10 per cent high reliability level, from ±10 to ±50 per cent medium reliability level, and above ±50 per cent low reliability level.

Table 1-2: Qualitative analysis of uncertainty

High reliability level • CO_2 Emissions from Fuel Combustion • CO_2 Emissions from Natural Gas Scrubbing • CO_2 Emissions from Industrial Processes (Cement and Ammonia Production)
Medium reliability level • CH_4 Emissions from Fuel Combustion • CO_2 Emissions from Industrial Processes (Lime Production, Limestone and Dolomite Use, Soda Ash Production and Use, Iron and Steal Production, Ferroalloys Production, Aluminium Production) • CH_4 Emissions from Industrial Processes (Other Chemical Production) • N_2O Emissions from Industrial Processes (Nitric Acid Production) • N_2O Emissions from Human Sewage
Low reliability level • N_2O Emissions from Fuel Combustion • CH_4 Fugitive Emissions from Coal Mining and Handling • CH_4 Fugitive Emissions from Oil and Natural Gas • HFC Emissions from HFC Consumption • CH_4 Emissions from Enteric Fermentation in Domestic Livestock • CH_4 and N_2O Emissions from Manure Management • N_2O Emissions from Agricultural Soils • CH_4 Emissions from Solid Waste Disposal Sites

2. ENERGY

2.1. INTRODUCTION

This sector covers all activities that involve fuel combustion from stationary and mobile sources and fugitive emission from fuels.

The energy sector was the main cause for anthropogenic emission of greenhouse gases. It accounted for some 72 to 75 percent of the total emission of all greenhouse gases presented as equivalent emission of CO_2. Looking at its contribution to total emission of carbon dioxide (CO_2), the energy sector accounts for about 90 percent. The contribution of energy in methane (CH_4) emission is substantially smaller (about 40 percent) while the contribution of nitrous oxide (N_2O) is quite small (2 to 5 percent).

The emission of CO_2, which is the most important greenhouse gas, is generally a consequence of fuel combustion. This was the reason for making a detailed estimate by IPCC methodology. There are some other gases generated from fuel combustion such as methane (CH_4) and nitrous oxide (N_2O), and indirect greenhouse gases such as nitrogen oxides (NO_x), carbon monoxide (CO) and non-methane volatile organic compounds (NMVOC). The indirect greenhouse gases participate in the process of ozone creating and destroying, which is one of the GHGs. In the framework of the IPCC methodology, the calculation of sulphur dioxide (SO_2) emission is also recommended. The sulphur dioxide, as a precursor of sulphate and aerosols, is believed to have a negative impact on the greenhouse effect because the creation of aerosols removes heat from the environment.

The fuel fugitive emission is also estimated, which is generated during production, transport, processing, storing, and distribution of fossil fuels. These activities produce mainly the emission of CH_4, and smaller quantities of NMVOC, CO and NO_x.

Emissions from fossil fuel combustion comprise the majority (more then 90 percent) of energy-related emissions. Contribution of individual subsectors to emission of greenhouse gases, for the last estimated year (2001), is presented in the Figure 2-1-1.

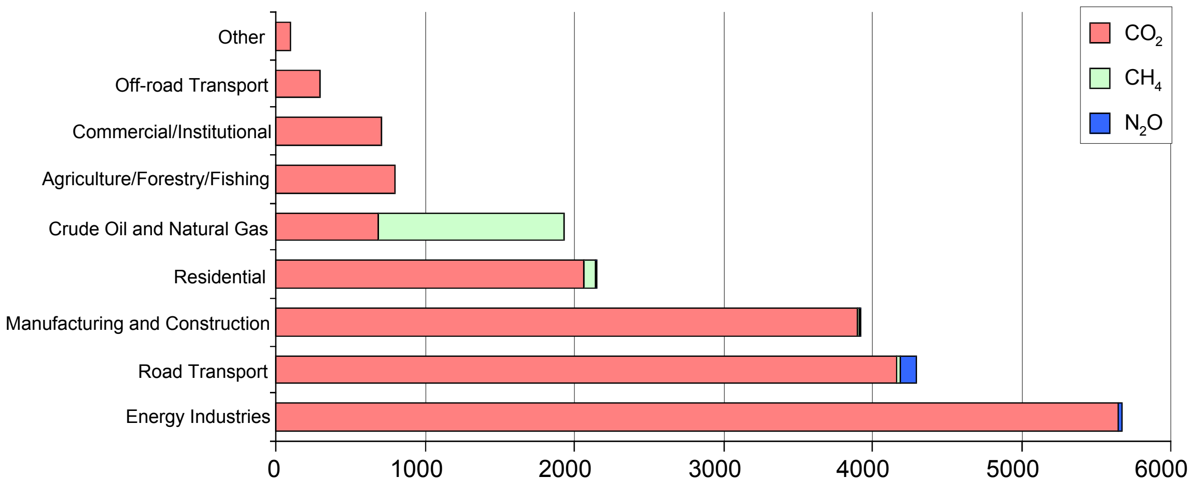

Figure 2.1-1: The contribution of different subsectors to GHG emission, year 2001

Greenhouse gases are also generated during combustion of biomass and biomass-based fuels. The CO_2 emission from biomass, in line with IPCC recommendations, is not included into the national emission totals because emitted CO_2 had been previously absorbed from the atmosphere for growth and development of biomass. Removal or emission of CO_2 due to the changes in the forest biomass is estimated in the sector of Land-use Change and Forestry.

The emission from fuel combustion in international air and waterborne transport is reported separately and it has not been included in the national emission totals.

2.2. ENERGY STRUCTURE

2.2.1. POWER SECTOR

During the observed period between 1990 and 2001 in Croatia only 20 to 35 percent of energy demand was produced in power plants (Figure 2.2-1). The largest contribution to electricity production had hydroelectric power plants 40 to 60 percent. Nuclear power plant Krško delivered 50 percent of electricity produced to Croatian energy system until 1998. The past few years the electricity demand was compensated with import. Therefore, in 2000 the energy import was larger than production in all Croatian thermal power plants (TPPs).

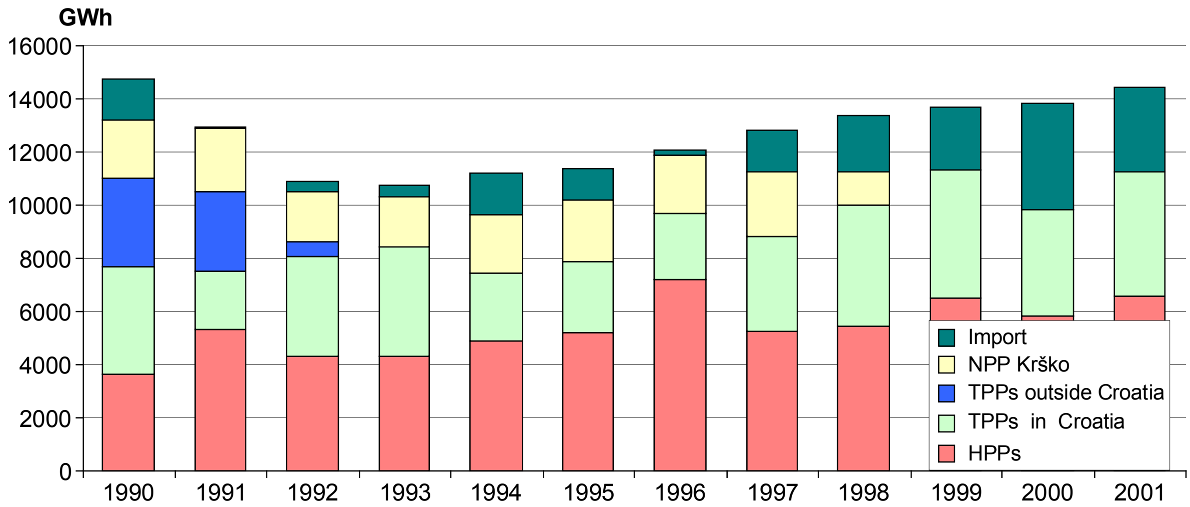

Figure 2.2-1: The electricity generation in Croatia, Import and Export

The dominate fuel in energy production until 1999 was fuel oil. After putting into operation the TPP Plomin 2 the consumption coal (bituminous coal) increased considerably. The share of natural gas was about 30 percent (table 2.2-1) during the period from 1990 to 2001.

Table 2.2-1: The share (%) of fossil fuel used in thermal power plants in Croatia

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Natural Gas	34.0	33.4	34.9	43.3	47.9	19,7	37.3	30.3	26.1	25.0	36.4	35.6
Fuel Oil	53.6	53.4	52.3	47.8	49.4	73.8	58.7	57.2	63.3	66.1	33.2	36.4
Coal	12.4	13.1	12.8	8.9	2.7	6.4	3.9	12.5	10.6	8.9	30.3	28.0

2.2.2. ENERGY BALANCE

The basis for an estimate of the GHGs emission from Energy sector is the national energy balance. Production, imports, exports, stock change and consumption of fuels are shown in the national energy balance report in natural units (kg or m^3) or energy units (J).

For easier data comparison in energy balance the natural units are transformed to energy units using proper national net calorific values for different fuels. The structure of energy consumption of fossil fuels from 1996 to 2001 is shown in Figure 2.2-2.

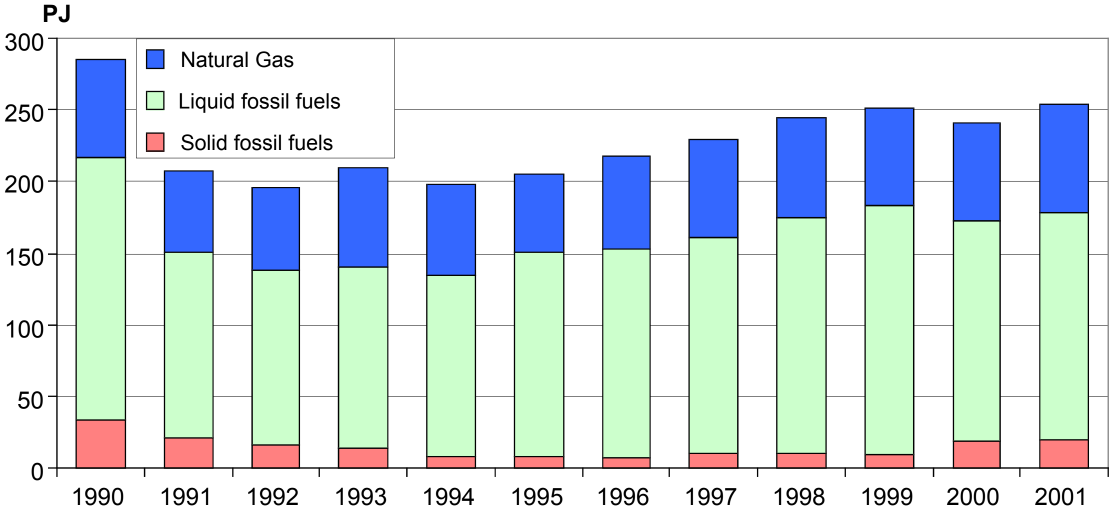

Figure 2.2-2: Structure of energy consumption

Liquid fossil fuels are mainly used with share between 62 to 67 percent, after that is natural gas with approximately 30 percent, while share of solid fossil fuels is 6-8 percent. Fuel woods and biomass-based fuels are neutral with regard to CO_2 emission, therefore they are shown separately. The sectoral consumption of fuels is shown in Annex 2 (Table A2-1 to A2-4). Net calorific values taken from the national energy balance are used for the calculation of GHG emission (Annex 2, Table A2-5).

2.3. CARBON DIOXIDE EMISSIONS (CO_2) FROM FOSSIL FUEL COMBUSTION

During full combustion, the carbon contained in fuel oxidizes and transforms into CO_2, while through the incomplete combustion the small amounts of CH_4, CO and NMVOC emissions also appears. For the time being, there is no technology for successful mitigation of CO_2 emission. The emission of CO_2 depends on the quantity and type of the fuel used. The specific emission is the largest during combustion of coal, then oil and natural gas. A rough ratio of specific emission during combustion of the stated fossil fuels is 1 : 0.75 : 0.55 (coal : oil : gas).

The emission of CO_2 is calculated using 2 different approaches: Reference approach and Sectoral approach. In Reference approach the input data are production, import, export, international bunkers and stock change for primary and secondary fuel; while more detailed Sectoral approach calculates emissions using fuel consumption in different energy subsectors. The difference in results between Reference and Sectoral Approach is relatively small (about 2 percent) and it is shown in Table A2-6, Annex 2. The total CO_2 emission from Energy sector (Sectoral approach) for Croatia from 1996 to 2001 is shown in Table 2.3-1.

Table 2.3-1: The CO_2 emission (Gg) from fuel combustion activities from 1996 to 2001

CO_2 (Gg)			1990	1991	1992	1993	1994	1995
Energy Industries			5897	3847	4514	5185	3925	4460
Manufacturing Industries & Construction			6546	4732	6546	4732	3730	3658
Transport	Domestic Aviation		296	81	32	64	64	89
	Road		3480	2581	2486	2662	2878	3044
	Railways		138	147	97	101	94	106
	National Navigation		133	108	167	121	87	98
Other Sectors	Commercial/Institutional		782	540	394	489	552	601
	Residential		1995	1736	1463	1357	1372	1596
	Agriculture/ Forestry/Fishing	Stationary	98	125	111	78	55	58
		Mobile	741	603	527	560	588	522
Other* (not elsewhere specified)			439	246	189	194	199	193
Total			**20543**	**14745**	**13709**	**14470**	**13630**	**14385**
International Marine Bunkers			109	71	81	115	138	102
International Aviation Bunkers			202	17	46	131	199	175

* - Non-energy fuel consumption (for entire period) and statistical differences (for 1990)

Table 2.3-1: The CO_2 emission (Gg) from fuel combustion activities from 1996 to 2001 (cont.)

CO_2 (Gg)			1996	1997	1998	1999	2000	2001
Energy Industries			4310	4875	5531	5699	5145	5650
Manufacturing Industries & Construction			3763	3714	4008	3729	3805	3880
Transport	Domestic Aviation		107	110	127	131	110	111
	Road		3313	3689	3847	4084	4114	4169
	Railways		100	96	90	92	85	88
	National Navigation		243	118	90	88	86	92
Other Sectors	Commercial/Institutional		608	647	615	640	605	700
	Residential		1779	1939	1841	2033	1896	2068
	Agriculture/ Forestry/Fishing	Stationary	91	55	52	134	76	67
		Mobile	658	539	599	707	781	731
Other* (not elsewhere specified)			206	225	196	105	99	102
Total			**15083**	**16007**	**17005**	**17441**	**16814**	**17691**
International Marine Bunkers			115	74	81	66	57	89
International Aviation Bunkers			174	145	148	137	115	115

* - Non-energy fuel consumption (for entire period) and statistical differences (for 1990)

Furthermore, in Energy sector the non-energy fuel consumption (fuels used as feedstocks) is calculated. Primarily, the non-energy consumption features in chemical and construction industries, but also in transport, agriculture etc. For example, some oil products can be used for manufacturing plastics, asphalt, or lubricants. The CO_2 emission of non-energy fuels consumption is also presented in Table 2.3-1 (sector Other not elsewhere specified) and Table A2-11 (Annex 2).

The CO_2 emissions from the consumption of fossil fuels for aviation and marine international transport activities, as required by the IPCC methodology, are reported separately, and not included in national emission totals (Table 2.3-1). The fuel consumption for International Aviation and Marine Bunkers is shown in Annex 2 (Table A2-8). Fuels consumption (activity data) and emissions for observed period are shown in Annex 2 (Table A2-7).

2.3.1. ENERGY INDUSTRIES

This subsector comprises emission from fuel combustion in thermal power and district heating plants, petroleum refining plants, solid transformation plants, oil and gas extraction and coal mining.

It should be stressed out that a large part of the electrical energy is generated without CO_2 emission (Figure 2.2-1); therefore the emission from this sector is relatively small, 23-32 percent of emission from total fuel consumption in Energy sector. The largest part (60 to 80 %) of the emission is a consequence of fuel combustion in thermal power plants, than the combustion in oil refineries 16-28 percent. The remaining combustion in oil and gas fields, coal mines and the coke plant accounts for some 4-14 percent. The contribution to the CO_2 emission of thermal power plants, refineries and other is shown in the Figure 2.3-1.

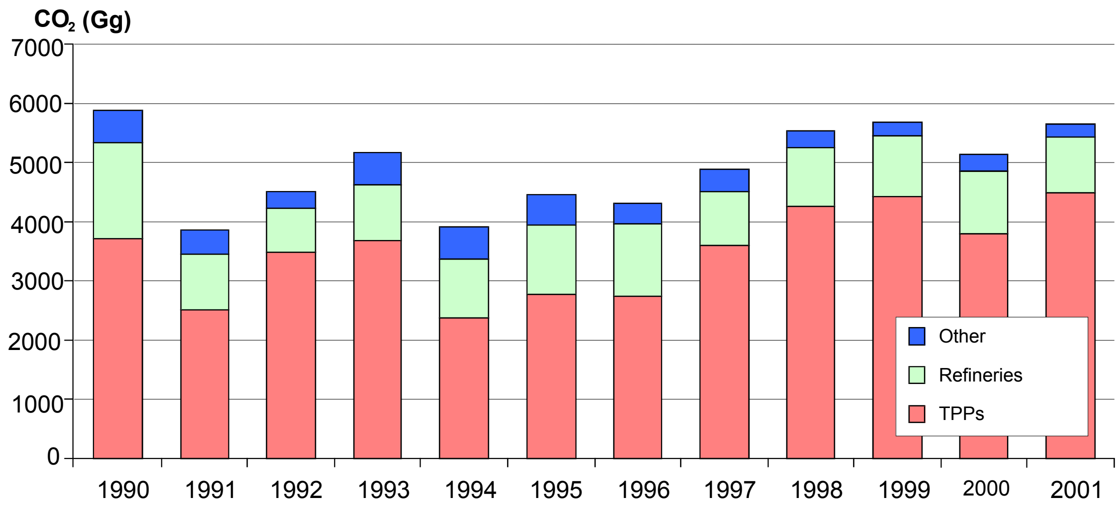

Figure 2.3-1: The CO_2 emission of Energy Industries

2.3.2. MANUFACTURING INDUSTRIES AND CONSTRUCTION

Manufacturing Industries and Construction include the emission from fuel combustion in different industries, such as iron and steel industries, industries of non-ferrous metals, chemicals, pulp and paper, food processing, beverages and tobacco, construction and building material industries. This sector also includes the emission from fuel used for the generation of electricity and heat in industry (industrial cogeneration plants and industrial heating plants).

The emission from this sector contributes 20-29 percent of the emission from fuel combustion. In national energy balance the fuel combustion in industrial cogeneration and heating plants is not divided on appropriate industrial branches, for which electricity and/or thermal energy is produced. The fuel consumed in industrial cogeneration and heating plants is divided first time for the year 2001 and it is shown in CRF tables.

The largest contribution to emissions have the industrial cogeneration and heating plants (43-57 percent), than comes the fuel combustion in industry of building material (23-37 percent). The chemical industry contributes with 5-14 percent. The significant contribution have also the iron and steel industry, food processing industry, industry of glass and non-metal, non-ferrous metal and paper industry. The CO_2 emission from Manufacturing Industries and Construction is presented in Figure 2.3-2.

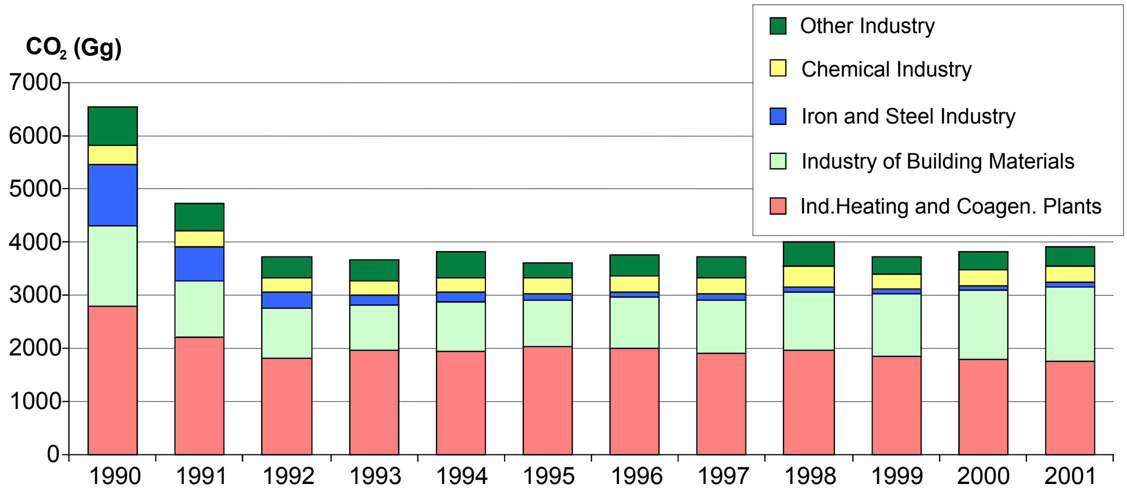

Figure 2.3-2: The CO_2 emission of Manufacturing Industries and Construction

2.3.3. TRANSPORT

The emission from combustion and evaporation of fuel for all transport activities is included in this sector. In addition to road transport this sector includes the emission from air, rail and marine transport as well.

The emission from fuel sold to any aircraft or marine vessel engaged in international transport is excluded from the national total. This emission is reported separately.

The contribution from Transport to total emissions from Energy sector was 20-25 percent. The most of the emission comes from road transport (86-94 percent), than from domestic air, rail and marine transport (Figure 2.3-3). The increase of emissions from this sector is a consequence of growth of mobility and number of road motor vehicles.

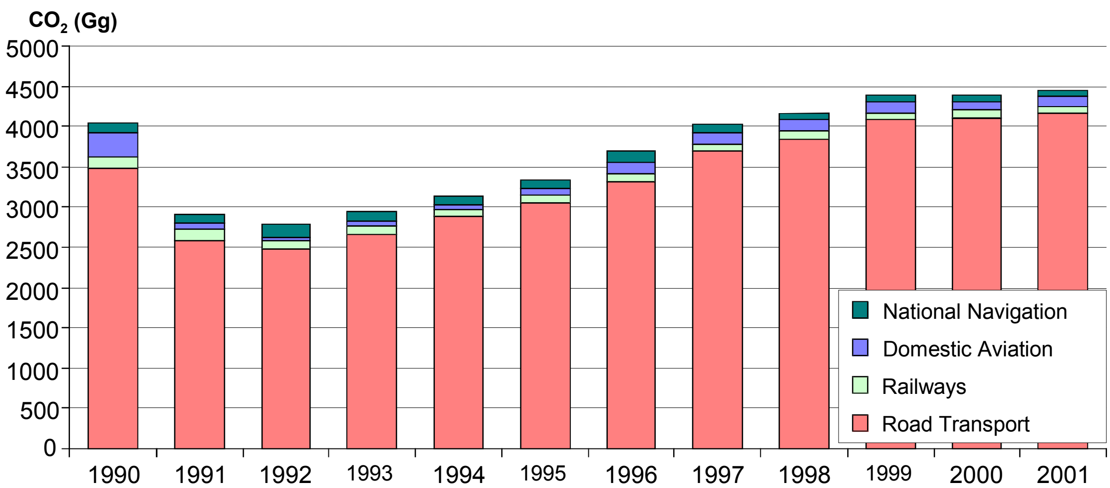

Figure 2.3-3: The CO_2 emission of Transport

The emission of CO_2 is estimated by Tier 1 approach, on the basis of fuel consumption and appropriate emission factors. For determination of road transport emission, the COPERT III package (Tier 2/3 method) was also used. The CO_2 emissions calculated with COPERT were almost identical to those calculated with Tier 1 method (the maximum declination is 2.5 percent) and this was a good calculation control. Some additional data, which are necessary for COPERT estimation, like number of different type of vehicles (source: Statistical Yearbook) and consumption of fuels in road transport (source: National energy balance) are presented in Annex 2 (Tables A2-9 and A2-10).

2.3.4. SMALL STATIONARY SOURCES

This sector includes emission from fuel combustion in commercial and institutional buildings, emission from fuel combustion in residential sector and the emission from fuel combustion in agriculture, forestry and fishing.

The CO_2 emission from these subsectors was about 20 percent of the total emission from fuel combustion. The most of the emission comes from small household furnaces and boiler rooms (55-60 percent), then from service sector (16-22 percent), while the combustion of fuel in agriculture, forestry and fishing accounts for 18 to 26 percent. (Figure 2.3-4).

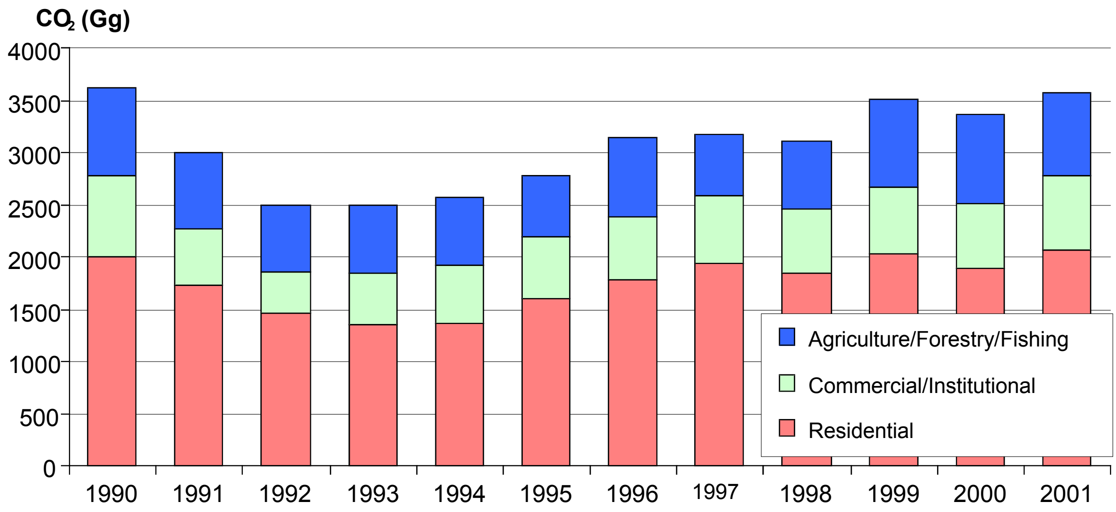

Figure 2.3-4: The CO_2 emission from small stationary sources

2.3.5. OTHER

This sector includes the remaining CO_2 emission originating from fuel and emissions not included in other sectors.

A statistical difference occurred in the energy balance only for the year 1990 in consumption of gas and other kerosene. This fuel is also burned but the sub-sector is not identified, so the CO_2 emission is reported here.

The emission due to non-energy fuel consumption (fuels used as feedstock) one part or even the whole carbon is stored in product for a longer time and the other part oxidizes and goes to atmosphere. The feedstock use of energy carriers occurs in chemical industry (natural gas consumption for ammonia production, production of naphtha, ethane, paraffin, and wax), construction industry (bitumen production), and other products such as motor oil, industrial oil, grease… As a result of non-energy use of bitumen in construction industry there is no CO_2 emission because all carbon is bound to the product. Non-energy consumption occurs in various areas, such as chemical industries, traffic, construction, agriculture, etc. These are the main reasons to set non-energy fuel consumption in energy subsector Other. The contribution of non-energy fossil consumption is presented in the Figure 2.3-5. Detailed information about non-energy fuel consumption is presented in the Table A2-11 (Annex 2).

The CO_2 emission from non-energy consumption of natural gas in chemical industry is calculated under Industrial Processes to avoid double counting.

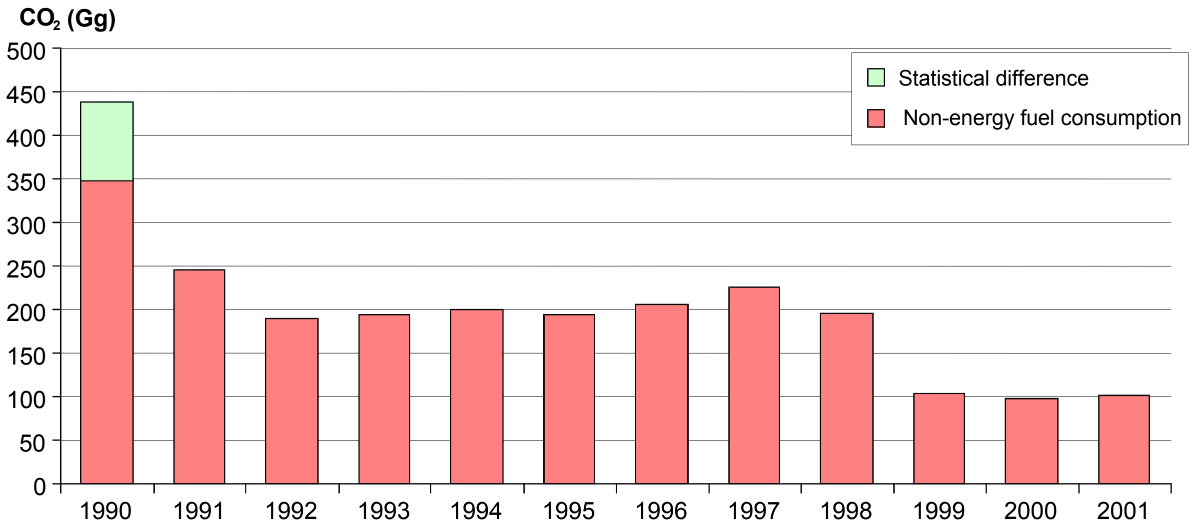

Figure 2.3-5: The CO_2 emissions of non-energy fossil fuel consumption

2.3.6. METHODOLOGY AND DATA SOURCES

The CO_2 accounts for the most emission from the energy sector. That is the reason why it is analysed in greater detail by IPCC methodology given in the Revised 1996 IPCC Guidelines for National GHG Inventories.

The CO_2 emission is estimated by two approaches: (1) Reference approach and (2) Sectoral approach. Inputs in the Reference approach are production, import, export, international bunkers, and stock change for primary and secondary fuel. The Sectoral approach is used to identify the emission by means of fuel consumption for each group of sources (sectors). The energy data from the national energy balance are recalculated from natural units into energy units by means of own net calorific values for each fuel. Calorific values are also taken from the energy balance. The emission factors used for calculation are taken from IPCC Guidelines (Revised 1996 IPCC Guidelines for National GHG Inventories, Workbook, Page 1.6).

Since the combustion processes are not 100% efficient, the part of carbon stored is not emitted to the atmosphere so it occurs as soot, ash and other by-products of inefficient combustion. Therefore, it is necessary to know the fraction of carbon which oxidizes. This value was taken from IPCC Guidelines as recommended (Workbook, Page 1.8).

Non-energy uses of fossil fuels can result in storage (in products) of some or all of the carbon contained in the fuel for a certain period of time, depending on the end-use. The fraction of carbon stored in products is suggested in IPCC Guidelines (Workbook, auxiliary worksheet 1-1, page 1.37).

According to the IPCC guidelines the emission from international transport activities should not be included in national totals. The amount of fuel consumption for International Marine Bunkers is taken from national balance (till 1994 – expert estimation), while the fuel consumption for International Aviation Bunkers is calculated together with Domestic Aviation Transport. National experts estimated the share of fuel consumed in domestic and international aviation transport for the purpose of this report.

2.3.7. UNCERTAINTY

The CO_2 emission, from the fossil fuel combustion, depends of the amount of fuel consumed (energy balance), net calorific values (energy balance), carbon emission factors (IPCC recommendation), the fraction of carbon stored (IPCC recommendation) and the fraction of carbon oxidised (IPCC recommendation).

The national energy balance is based on data from all available sources. The data from Central Bureau of Statistics about production, usage of raw material and consumption of fuels in all industrial facilities in Croatia are used. The data from questionnaires about monthly use of natural gas in certain sectors from all distributive company in Croatia, about annual consumption of coal in certain sectors and the data from Customs Administration about export and import of fossil fuels are also used. The data from these sources and other necessary data are organised in related database. The estimated uncertainty of data from energy balance is below 5 percent.

The accuracy of data on net calorific values, which are also taken from national energy balance, is high.

There are more uncertainties in data on international marine and aviation bunkers. Nevertheless, possible errors in estimated values do not affect the accuracy of data of national emission, as marine and aviation transport have relatively small influence. The estimated CO_2 emissions for International Marine and Aviation Transport are not included in nationals totals.

The other data needed for calculation, such as, carbon emission factors, the fraction of carbon stored for non-energy uses of fuel and the fraction of carbon oxidised, are taken from Revised 1996 IPCC Guidelines for National GHG Inventories. Experts believe that CO_2 emission factors for fuels are generally well determined within $\pm$5 percent, as they are primarily dependent on the carbon content of the fuel.

For example, for the same primary fuel type (e.g., coal), the amount of carbon contained in the fuel per unit of useful energy can vary. Non-energy uses of the fuel can also create situations where the carbon is not emitted to the atmosphere (e.g., plastics, asphalt, etc.) or is emitted at a much-delayed rate. Additionally, inefficiencies in the combustion process, which can result in ash or soot remaining unoxidized for long periods, were also assumed. These factors all contribute to the uncertainty in the CO_2 estimates. However, these uncertainties are believed to be relatively small. Overall uncertainty for CO_2 emission estimates from the fossil fuel combustion are considered accurate within 7 percent.

2.4. NON-CO_2 EMISSIONS FROM FUEL COMBUSTION

This chapter gives overview of the emission of other greenhouse gases such as CH_4 and N_2O, indirect greenhouse gases (NO_x, CO and NMVOC), and SO_2. The emission of these gases depends on fuel characteristics, technology applied, size of the facility, and application of the emission mitigation technique.

Emissions of N_2O and NO_x depend on fuel-air ratio, combustion temperature and installed equipment for emission mitigation. The installation of three-way catalytic converters in road vehicles efficiently reduces the emission of NO_x, CO, NMVOC and CH_4, but it increases N_2O emission. The emission of CO occurs under conditions of incomplete combustion and it is almost insignificant from large, well-managed stationary furnaces. Higher emission occurs in case of sudden load changes, boiler ignition, or change of fuel. The SO_2 emission depends on sulphur content in the fuel and the used technique for emission reduction (desulphurization).

2.4.1. METHANE (CH_4) AND NITROUS OKSIDE (N_2O) EMISSIONS

Emissions of CH_4 and N_2O are identified by Tier 1 method of IPCC methodology and estimated results are given in the Figure 2.4-1 and the Figure 2.4-2.

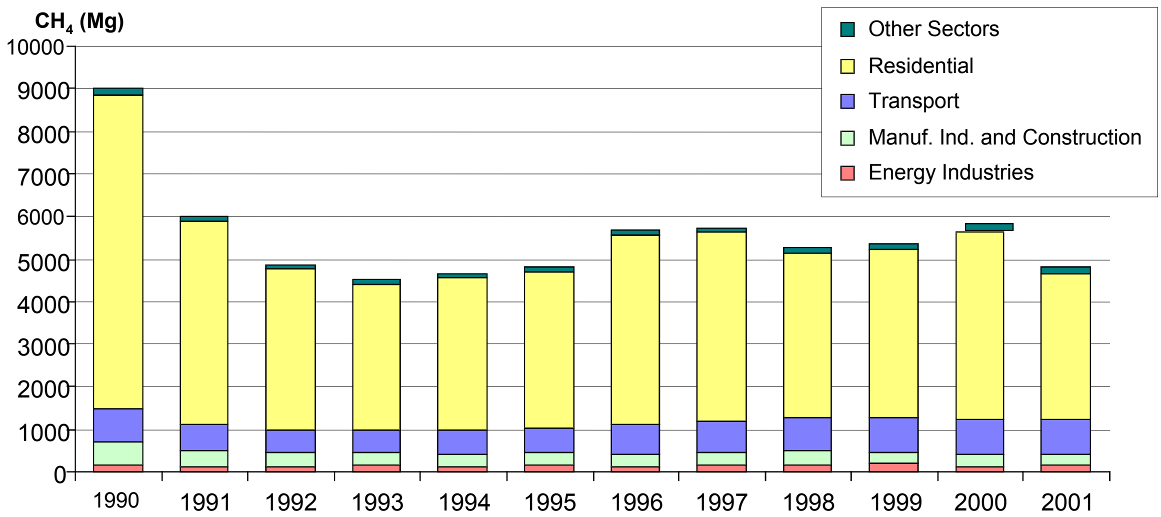

Figure 2.4-1: The methane (CH_4) emission from fuel combustion activities

The most of CH_4 emission is a consequence of fuel combustion in residential sector (70-82 percent), then from transport (8-17 percent), and combustion in industry (5-7 percent). The detail methane emission for every sub-sector is presented in Annex 2 (Table A2-12). The table in Appendix also shows the emission from international air and marine transport that is not included in national emission totals.

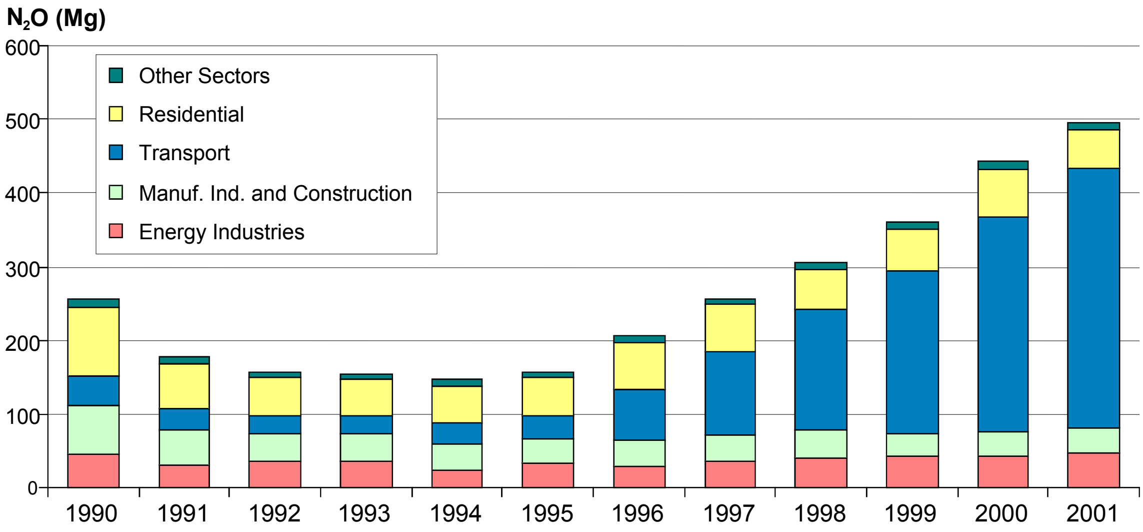

Figure 2.4-2: The N_2O emission from fuel combustion activities

The situation is different with N_2O emission. The most of the N_2O emission is a consequence of fuel combustion in traffic. Since there is more three-way catalyst in road motor vehicles the N_2O emission increases (15-72 percent). The N_2O emission from residential is 10-36 percent, and from energy industries 9-23. Road motor vehicles with catalyst have 30 times larger N_2O emission than vehicles without the catalyst. Detailed data on N_2O emission is given in Annex 2 (Table A2-13).

2.4.2. OZONE PRECURSORS AND SO_2 EMISSIONS

The emission of indirect greenhouse gases (NO_x, CO and NMVOC) and SO_2 is given in the Table 2.4-1. Ozone precursors are cause of greenhouse gas - tropospheric ozone, whereas SO_2 was added to a list of pollutants first time in Revised 1996 IPCC Guidelines for National GHG Inventories due to the importance of this gas from the position of acidification and eutrophication.

Table 2.4-1: Emissions of indirect GHG and SO_2 from fuel combustion in the period 1990-2001

Gas	Emissions (Gg)											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
NO_x Emission	90.9	67.4	64.0	67.1	65.6	67.7	74.6	77.6	81.5	85.3	85.9	87.5
CO Emission	421.3	307.8	266.9	261.7	280.7	292.4	330.1	349.4	361.9	377.0	388.1	362.7
NMVOC Emission	71.0	52.2	45.6	44.9	48.5	50.6	57.0	60.4	63.4	66.5	68.0	64.5
SO_2 Emission	177.1	105.9	104.7	111.8	87.8	69.9	65.4	79.1	88.3	89.2	56.6	61.1

The emission of NO_x is the largest from road transport (about 50 percent), then from energy industries and manufacturing industries and construction. Emissions of CO and NMVOC are mainly from road transport and small household furnaces using firewood or coal. The emission of SO_2 mainly originates from stationary energy sources, such as thermal power plants and refineries, and depends on the quantity of fuel used and the sulphur content of fuel.

Emissions of the ozone precursors and SO_2, for every subsector, are shown in Annex 2, (Table A2-14 to A2-17).

2.4.3. METHODOLOGY AND DATA SOURCES

Emissions of CH_4, N_2O and indirect greenhouse gases (NO_x, CO and NMVOC) have been identified by Tier 1 method in such a way that the fuel used in each sector is multiplied by the emission factor suggested in Revised 1996 IPCC Guidelines for National GHG Inventories (Reference Manual, page 1.33-1.42). The basis for the estimate is the fuel used in different energy sectors. The used fuel is grouped into basic fossil fuels categories according to its aggregate condition: coal, natural gas and oil, and biomass-based fuel. Data about quantities of the fuel used are taken from the national energy balance.

In order to identify the SO_2 emission, besides the data on the type and the quantity of fuel consumed it is necessary to know the sulphur content in fuel. The available data on the sulphur content were from fuel burned in thermal power facilities (provided by HEP – Croatian Electric Utility Company) and sulphur content in petroleum derivatives (gasoline, residual oil, diesel oil, jet fuel) produced in refineries (INA – Croatian Oil and Gas Industry Company).

2.4.4. UNCERTAINTY

Estimates of CH_4, N_2O and ozone precursor emissions are based on fuel (coal, natural gas, oil and bio-fuels) and aggregate emission factors for different sectors. Uncertainties in estimates are due to the fact that emissions are estimated on the base of emission factors representing only a limited subset of combustion conditions.

Using the aggregate emission factors for each sector the differences between various types of coal and especially liquid fuel are not included nor are the differences in the technology and the contribution of equipment for emission reduction. Therefore, the uncertainties associated with emission estimates of these gases are greater than estimates of CO_2 emissions from the fossil fuel combustion.

The uncertainty of CH_4 emission is estimated to ±50 percent; while the uncertainty of N_2O emission is estimated to factor 2 (the emission could be twice larger or smaller than the estimated one). The largest part of uncertainty refers to the emission factor applied while the fuel consumption data (national energy balance) are rather good.

2.5. FUGITIVE EMISSIONS FROM FOSSIL FUELS

This section describes fugitive emission of greenhouse gases from coal, oil and natural gas activities. This category includes all emissions from mining, production, processing, transportation, and use of fossil fuels. During all stages from the extraction of fossil fuels to their final use, the escape or release of gaseous fuels or volatile components may occur.

2.5.1. FUGITIVE EMISSIONS FROM COAL MINING AND HANDLING

All underground and opencast coal mines release methane during their regular operation. The amount of methane generated during mining is primarily a function of the coal rank and mining depth, as well as other factors such as moisture. After coal has been mined, small amounts of methane retained in coal are released during post-mining activities such as coal processing, transportation and utilization.

In Croatia the coal production is rather low. Until 1999 only underground coal mines in Istria were in operation (Tupljak, Ripenda and Koromačno) and they produced some 0.015 to 0.365 tons of coal. Global Average Method (Tier1) was used for the methane emission estimation and the estimated emission was 0.2 to 4.88 Gg. The emission of methane from mining and post-mining activities is showed in the Figure 2.5-11 and Table A2-18 (Annex 2).

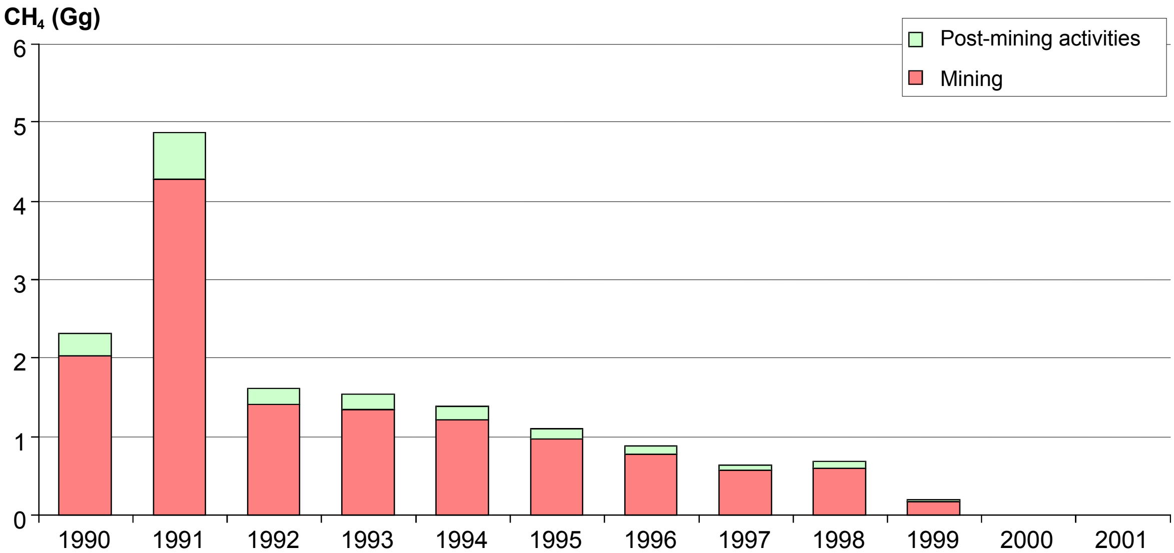

Figure 2.5-1: The fugitive emission of methane from coal mines

2.5.2. FUGITIVE EMISSIONS FROM OIL AND NATURAL GAS ACTIVITIES

The fugitive emission of methane is inevitable during all the activities involving oil and natural gas. This category includes the fugitive emission from production, refining, transportation, processing, and distribution of crude oil or oil products and gas. The fugitive emission also includes the emission of methane, which is the result of incomplete combustion of gas during flaring, and the emission from venting during oil and gas production.

The most significant fugitive emissions after methane among the activities relating to oil and gas are the emissions of non-methane volatile organic compounds (NMVOCs). They are produced by evaporation when fuel oil gets in contact with air during refining, transportation, and distribution of oil products. In addition to NMVOCs there are fugitive emissions of NO_x, CO and SO_2 during various processes in oil refineries.

2.5.2.1. Fugitive emission of methane

For estimating the fugitive emission of methane the simplest procedure has been used (Tier 1), which is based on production, unloading, processing, and consumption of oil and gas.

According to IPCC, all countries are divided into regions with relatively homogenous characteristics of oil and gas systems. Croatia is included in the region that covers the countries of Central & East Europe and former Soviet Union. For this region higher emission factors are provided, especially for the gas system. In the absence of better data, average emission factors provided for the region are used for estimating the fugitive emission of methane. Estimated results are given in Figure 2.5-2.

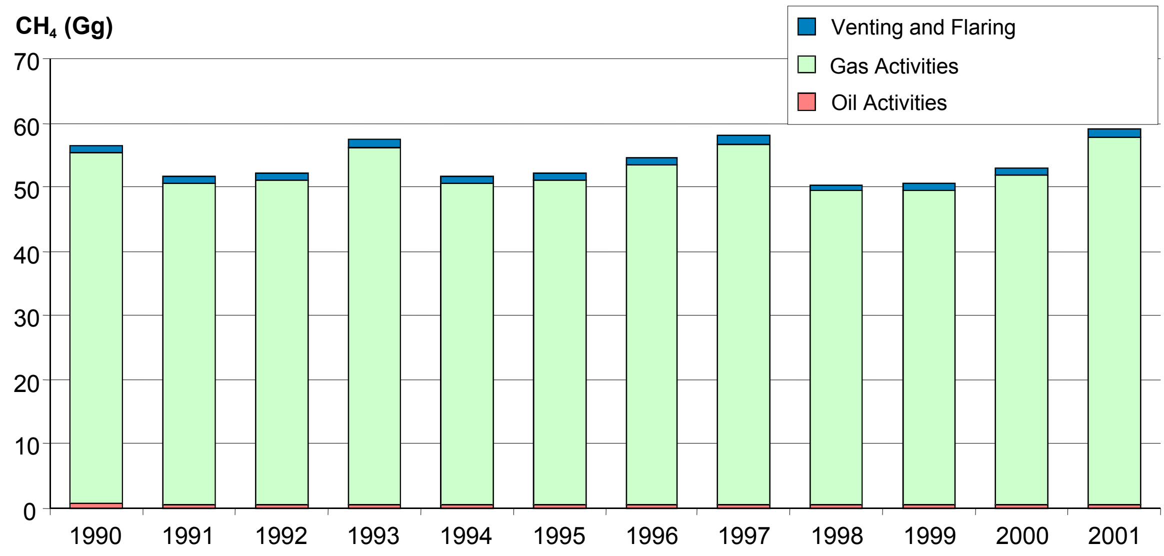

Figure 2.5-2: The fugitive emission of methane from oil and gas activities

The fugitive emission of methane is mainly (about 97 percent) the consequence of production, transmission, and distribution of natural gas. The fugitive emission from oil accounts for about 1 percent and venting and flaring of gas/oil production accounts for approximately 2 percent.

Additional information about activity data, CH_4 emission and used emission factors is presented in Annex 2 (Table A2-19).

2.5.2.2. Fugitive emission of ozone precursors and SO_2

A simplified Tier 1 procedure was used to make a fugitive emission estimate of ozone precursors and SO_2 from oil refineries for the period from 1996 to 2001. The simplified procedure is based on the quantity of crude oil processed in oil refineries while the detailed procedure (Tier 2) was used to identify the fugitive emission from individual sub-processes in oil refineries for the period from 1990 to 1995. Default emission factors were used for the estimation. A summary of estimated results of the fugitive emissions of CO, NO_x and NMVOC and SO_2 are illustrated in the table 2.5-1. The reason of high deviation between emissions for the period from 1990 to 1995 and the period from 1996 to 2001 (especially for CO and SO_2 emissions) is a different approach used for emission calculation (Tier 1 and Tier 2). In the next report, the fugitive emission of ozone precursors and SO_2 from oil refining will be recalculated.

Table 2.5-1: The fugitive emission of ozone precursors and SO_2 from oil refining

Gas	Emission (Gg)											
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
CO emission	47.93	31.06	28.33	33.91	33.78	36.08	0.47	0.46	0.46	0.50	0.47	0.44
NO_x emission	0.23	0.15	0.13	0.16	0.16	0.17	0.31	0.31	0.31	0.34	0.32	0.29
NMVOC emission	40.47	26.76	23.38	29.33	29.98	32.04	3.24	3.17	3.17	3.47	3.26	3.04
SO_2 emission	2.43	1.57	1.44	1.72	1.71	1.83	4.85	4.75	4.76	5.20	4.90	4.57

2.5.2.3. CO_2 emission from natural gas scrubbing

In this chapter the CO_2 emission from gas scrubbing in Central Gas Station Molve is described. IPCC doesn't offer methodology for estimating CO_2 emission scrubbed from natural gas and subsequently emitted into atmosphere.

Natural gas produced in Croatian gas fields (Molve, Kalinovac and Stari Gradac) contains a large amount of CO_2, more than 15 percent. Since the maximum volume content of CO_2 in commercial natural gas is 3 percent, it is necessary to clean the natural gas before transporting through pipeline to end-users. Because of that, the Scrubbing Units exist at largest Croatian gas field. The estimated CO_2 emissions, by the material balance method, are presented in Table 2.5-2.

Table 2.5-2: The CO_2 emission (Gg) from natural gas scrubbing in CPS Molve

Gas	Emission (Gg)											
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
CO_2 Emission	416	456	477	676	605	697	644	600	589	525	633	688

2.5.3. METHODOLOGY AND DATA SOURCES

The fugitive emission of methane from coal, oil, and gas has been identified by Tier 1 method with average emission factors given in Revised 1996 IPCC Guidelines for National GHG Inventories (Workbook, page 1.26 and 1.30). Data about quantities of the mined coal and production, unloading, transportation, processing, storing, and consumption of oil and gas are taken from the national balance energy supply and demand.

Inputs on processed crude oil in refineries are taken from national energy balance while emission factors are taken from IPCC Guidelines (Reference Manual, page 1.133 and 1.134).

The methodology for estimating CO_2 emission from natural gas scrubbing is not given in IPCC Guidelines. The CO_2 emission is determined on the base of differences in CO_2 content before and after scrubbing units and quantity of scrubbed natural gas.

2.5.4. UNCERTAINTY

The fugitive emission of methane from coal mining and handling is determined by use of Global Average Method (Tier 1), which is based on multiplication of coal produced and emission factor. The amount of coal produced is taken from energy balance and that value is very accurate. The main uncertainty of calculation depends on accuracy of used emission factor. The arithmetic average value of emission factor has been chosen from IPCC for the region to which Croatia belongs. The estimated uncertainty of methane emissions, for underground mining may be as a high as a factor of 2 and for post-mining activities a factor of 3.

The Production-Based Average Emission Factors Approach is used to determine fugitive emission from oil and natural gas activities. This approach is based on activity data (production, transport, refining and storage of fossil fuels) and average emission factors. Due to the complexity of the oil and gas industry, it is difficult to quantify the net uncertainties. The uncertainty of calculation is linked mostly to the emission factor, just like the determination of fugitive emission of methane from coal mining and handling. The expert estimated that accuracy of calculation of fugitive emission from oil is better than from fugitive emission from gas, but the uncertainty of both estimations is pretty high. Similarly, the uncertainty of calculation of emission of ozone precursors and SO_2 is also very high.

The CO_2 emission from scrubbing of natural gas is also shown here. The calculation is based on material balance which gives much better accuracy ($\pm$10 percent).

2.6. GHG EMISSIONS FROM ENERGY SECTOR

The contribution of individual energy subsectors to the total emission of greenhouse gases for the observed period is given in the Table 2.6-1.

Table 2.6-1: The GHG emission from Energy Sector

Source Categories	Year	CO_2 Gg	CH_4 Gg	N_2O Gg	GHG Gg eq-CO_2	Share in Energy %
Energy Industries	1990	5897	0.184	0.045	**5914**	**26.3**
	1991	3847	0.120	0.030	**3859**	**23.3**
	1992	4514	0.136	0.035	**4528**	**29.3**
	1993	5185	0.155	0.036	**5199**	**31.5**
	1994	3925	0.124	0.025	**3935**	**25.4**
	1995	4460	0.155	0.032	**4473**	**27.4**
	1996	4310	0.143	0.028	**4322**	**25.3**
	1997	4875	0.153	0.035	**4889**	**27.1**
	1998	5531	0.180	0.041	**5547**	**29.4**
	1999	5699	0.188	0.042	**5716**	**29.7**
	2000	5156	0.137	0.043	**5172**	**27.5**
	2001	5650	0.150	0.047	**5668**	**28.5**
Manufacturing Industries and Construction	1990	6546	0.508	0.066	**6577**	**29.3**
	1991	4732	0.393	0.049	**4756**	**28.7**
	1992	3730	0.318	0.038	**3748**	**24.2**
	1993	3658	0.310	0.037	**3676**	**22.2**
	1994	3815	0.301	0.035	**3832**	**24.7**
	1995	3617	0.284	0.034	**3634**	**22.2**
	1996	3763	0.288	0.035	**3780**	**22.1**
	1997	3714	0.312	0.036	**3732**	**20.7**
	1998	4008	0.316	0.037	**4026**	**21.3**
	1999	3729	0.271	0.032	**3745**	**19.4**
	2000	3805	0.277	0.033	**3821**	**20.3**
	2001	3903	0.275	0.033	**3919**	**19.7**
Road Transport	1990	3480	0.756	0.030	**3505**	**15.6**
	1991	2581	0.568	0.022	**2600**	**15.7**
	1992	2486	0.506	0.021	**2503**	**16.2**
	1993	2662	0.509	0.022	**2679**	**16.2**
	1994	2878	0.556	0.024	**2897**	**18.7**
	1995	3044	0.586	0.025	**3064**	**18.7**
	1996	3313	0.650	0.065	**3347**	**19.6**
	1997	3689	0.712	0.107	**3738**	**20.7**
	1998	3847	0.763	0.158	**3912**	**20.7**
	1999	4084	0.804	0.214	**4167**	**21.6**
	2000	4114	0.810	0.288	**4221**	**22.4**
	2001	4169	0.796	0.350	**4294**	**21.6**

Table 2.6-1: The GHG emission from Energy Sector (continue)

Source Categories	Year	CO_2 Gg	CH_4 Gg	N_2O Gg	GHG Gg eq-CO_2	Share in Energy %
Off-road Transport	1990	566	0.021	0.011	**570**	**2.5**
	1991	335	0.018	0.004	**337**	**2.0**
	1992	296	0.018	0.003	**297**	**1.9**
	1993	287	0.016	0.004	**288**	**1.7**
	1994	246	0.013	0.003	**247**	**1.6**
	1995	293	0.015	0.004	**295**	**1.8**
	1996	355	0.018	0.005	**357**	**2.1**
	1997	324	0.015	0.005	**326**	**1.8**
	1998	315	0.014	0.005	**317**	**1.7**
	1999	311	0.013	0.005	**312**	**1.6**
	2000	282	0.012	0.005	**283**	**1.5**
	2001	290	0.013	0.005	**292**	**1.5**
Commercial/ Institutional	1990	782	0.094	0.006	**786**	**3.5**
	1991	540	0.065	0.004	**542**	**3.3**
	1992	394	0.047	0.002	**395**	**2.6**
	1993	489	0.055	0.003	**491**	**3.0**
	1994	552	0.065	0.003	**555**	**3.6**
	1995	601	0.070	0.003	**604**	**3.7**
	1996	608	0.071	0.004	**611**	**3.6**
	1997	647	0.077	0.004	**649**	**3.6**
	1998	615	0.072	0.004	**617**	**3.3**
	1999	640	0.076	0.004	**642**	**3.3**
	2000	605	0.073	0.004	**608**	**3.2**
	2001	710	0.085	0.004	**713**	**3.6**
Residential	1990	1995	7.363	0.093	**2178**	**9.7**
	1991	1736	4.793	0.062	**1855**	**11.2**
	1992	1463	3.787	0.053	**1559**	**10.1**
	1993	1357	3.421	0.048	**1444**	**8.7**
	1994	1372	3.556	0.051	**1463**	**9.4**
	1995	1596	3.651	0.053	**1689**	**10.3**
	1996	1779	4.459	0.064	**1893**	**11.1**
	1997	1939	4.427	0.065	**2052**	**11.4**
	1998	1841	3.885	0.056	**1940**	**10.3**
	1999	2033	3.932	0.057	**2133**	**11.1**
	2000	1896	4.411	0.064	**2009**	**10.7**
	2001	2068	3.423	0.052	**2156**	**10.8**
Agriculture / Forestry / Fishing	1990	839	0.062	0.007	**842**	**3.7**
	1991	728	0.057	0.006	**731**	**4.4**
	1992	638	0.048	0.005	**640**	**4.1**
	1993	638	0.047	0.005	**641**	**3.9**
	1994	643	0.046	0.005	**646**	**4.2**
	1995	580	0.042	0.005	**583**	**3.6**
	1996	748	0.055	0.006	**751**	**4.4**
	1997	594	0.042	0.005	**596**	**3.3**
	1998	651	0.046	0.005	**654**	**3.5**
	1999	841	0.065	0.007	**844**	**4.4**
	2000	858	0.063	0.007	**861**	**4.6**
	2001	798	0.057	0.006	**801**	**4.0**

Table 2.6-1: The GHG emission from Energy Sector (continue)

Source Categories	Year	CO_2 Gg	CH_4 Gg	N_2O Gg	GHG Gg eq-CO_2	Share in Energy %
Other (not specified elsewhere)	1990	439	0.009	0.000	**439**	**2.0**
	1991	246	0.000	0.000	**246**	**1.5**
	1992	189	0.000	0.000	**189**	**1.2**
	1993	194	0.000	0.000	**194**	**1.2**
	1994	199	0.000	0.000	**199**	**1.3**
	1995	193	0.000	0.000	**193**	**1.2**
	1996	206	0.000	0.000	**206**	**1.2**
	1997	225	0.000	0.000	**225**	**1.2**
	1998	196	0.000	0.000	**196**	**1.0**
	1999	105	0.000	0.000	**105**	**0.5**
	2000	99	0.000	0.000	**99**	**0.5**
	2001	102	0.000	0.000	**102**	**0.5**
Fugitive- Coal	1990		2.322		**49**	**0.2**
	1991		4.876		**102**	**0.6**
	1992		1.608		**34**	**0.2**
	1993		1.538		**32**	**0.2**
	1994		1.379		**29**	**0.2**
	1995		1.099		**23**	**0.1**
	1996		0.886		**19**	**0.1**
	1997		0.648		**14**	**0.1**
	1998		0.679		**14**	**0.1**
	1999		0.205		**4**	**0.0**
	2000		0.000		**0**	**0.0**
	2001		0.000		**0**	**0.0**
Fugitive- Oil & Natural Gas	1990	416	56.488		**1602**	**7.1**
	1991	456	51.604		**1540**	**9.3**
	1992	477	52.223		**1574**	**10.2**
	1993	676	57.397		**1881**	**11.4**
	1994	605	51.756		**1692**	**10.9**
	1995	697	52.292		**1795**	**11.0**
	1996	644	54.650		**1792**	**10.5**
	1997	600	57.910		**1816**	**10.1**
	1998	589	50.411		**1648**	**8.7**
	1999	525	50.543		**1587**	**8.2**
	2000	633	52.910		**1744**	**9.3**
	2001	688	59.124		**1929**	**9.7**
Total	1990	20959	67.806	0.257	**22463**	**100.0**
	1991	15200	62.493	0.177	**16568**	**100.0**
	1992	14187	58.691	0.157	**15468**	**100.0**
	1993	15146	63.448	0.154	**16526**	**100.0**
	1994	14235	57.797	0.147	**15494**	**100.0**
	1995	15082	58.193	0.158	**16353**	**100.0**
	1996	15727	61.220	0.206	**17076**	**100.0**
	1997	16607	64.297	0.257	**18037**	**100.0**
	1998	17594	56.366	0.306	**18872**	**100.0**
	1999	17966	56.097	0.361	**19256**	**100.0**
	2000	17447	58.693	0.443	**18817**	**100.0**
	2001	18379	63.921	0.496	**19875**	**100.0**

2.7. REFERENCES

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3. INDUSTRIAL PROCESSES

3.1. INTRODUCTION

Greenhouse gas emissions are produced as by-products of non-energy industrial processes in which raw materials are chemically transformed to final products. During these processes different greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) or nitrous oxide (N_2O) are released in the atmosphere.

Industrial processes whose contribution to CO_2 emissions was identified as significant are production of cement, lime, ammonia, ferroalloy, as well as use of limestone and soda ash in different industrial activities. Nitric acid production is source of N_2O emissions. Emissions of CH_4 are appeared in production of other chemicals, as well as carbon black, ethylene and dichloroethylene.

Consumption of halocarbons (HFCs), which are used as substitution gases in refrigeration and air conditioning systems, is source of emissions of fluorinated compounds.

Some industrial process, particularly petrochemical, generate emissions of short-lived ozone and aerosol precursor gases such as carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2). These gases indirect contribute to greenhouse effect.

The general methodology applied to estimate emissions associated with each industrial process, as recommended by *Revised 1996 IPCC Guidelines* and *Good Practice Guidance and Uncertainty Management in National GHG Inventories* involves the product of amount of material produced or consumed, and an associated emission factor per unit of production/consumption.

The activity data on production/consumption for particular industrial process, in most cases, extracted from Monthly Industrial Reports, published by Central Bureau of Statistics, Department of Manufacturing and Mining. This report covers industrial activities according to prescribed national classification of activities and comprises data on production and consumption of raw materials on monthly basis. In cases when such data were insufficient or some production-specific data were required to calculate emissions individual manufacturers were contacted and voluntary surveys were carried out.

Emission factors used for calculation of emissions are default emission factors according to *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, and *Good Practice Guidance and Uncertainty Management in National GHG Inventories*, mainly due to a lack of plant-specific emission factors.

Uncertainty estimates associated with emission factors for some industrial processes are well reported in *Good Practice Guidance*, while those associated with activity data are based on expert judgements since statistics and manufacturers have not particularly assessed the uncertainties.

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, while in the period 1996-2001 emissions were approached to emission in 1990. Some productions, such as iron, steel and aluminium were halted in 1992.

The total annual emissions of greenhouse gases, expressed in Gg eq-CO_2, from industrial processes in the period 1990-2001 are presented in figure 3.1-1.

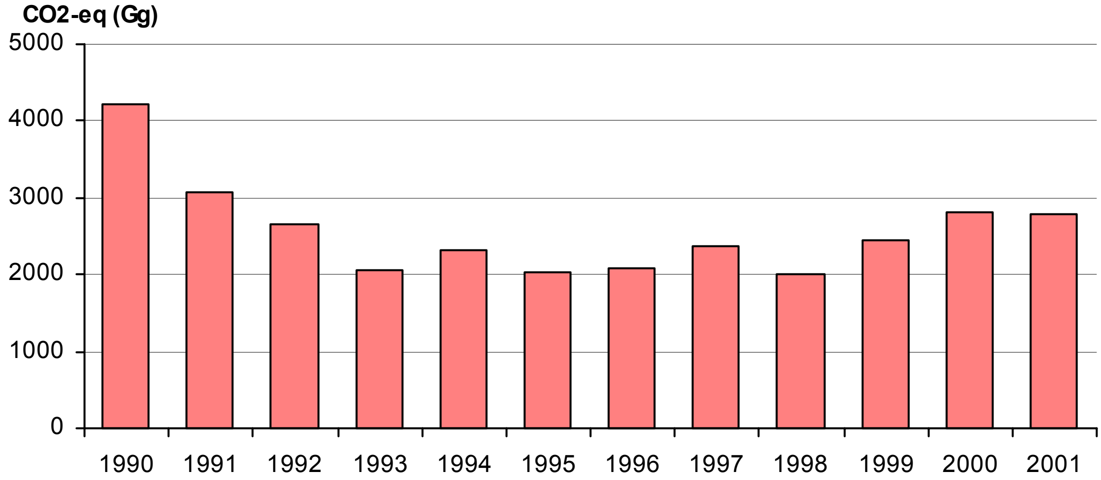

Figure 3.1-1: Emissions of greenhouse gases from industrial processes (1990-2001)

3.2. CEMENT PRODUCTION

The quantity of the CO_2 emitted during cement production is directly proportional to the lime content of the clinker. Therefore, estimation of CO_2 emissions is accomplished by applying an emission factor, in tonnes of CO_2 released per tonne of clinker produced, to the annual clinker output corrected with the fraction of clinker that is lost from the kiln in the form of Cement Kiln Dust (CKD), (Tier 2 method, *Good Practice Guidance*). The emission factor is the product of the average lime fraction in cement clinker which has been estimated to be 0.646 according to *Revised 1996 IPCC Guidelines*, and a molecular weight ratio which reflects the mass of CO_2 released per unit of CaO, which equals 0.507 tonnes of CO_2 per tonne of clinker produced. According to *Good Practice Guidance* there are few data available on total CKD production, and these are functions of plant technologies and can vary over time. Therefore, in the absence of country-specific data, provided default correction factor for CKD, which equals 1.02, was taken into account to calculate actual amount of clinker produced in the cement kiln.

The activity data for clinker production (see table 3.2-1) were collected by EKONERG from voluntary survey of cement manufacturers, cross-checked with cement production data from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining, and corrected with the fraction of clinker that is lost from the kiln during clinker production in the form of Cement Kiln Dust (CKD).

The resulting emissions of CO_2 from cement production in the period 1990-2001 are presented in figure 3.2-1.

Uncertainties contained in these estimates are primarily related to uncertainties in the fraction of lime in domestic cement clinker and the actual fraction of CKD. According to *Revised 1996 IPCC Guidelines* most of the cement currently produced in the world is of Portland cement type[9], which contains 60-67 per cent lime by weight.

[9] In the period 1990-2001 over 98 percent of cement produced in Croatia were of Portland cement type.

Table 3.2-1: Clinker production (1990-2001)

Year	Clinker production (tonnes)[1]	Actual clinker production (tonnes)[2]
1990	1978000	2017560
1991	1252000	1277040
1992	1498000	1527960
1993	1254000	1279080
1994	1535000	1565700
1995	1131000	1153620
1996	1226000	1250520
1997	1457000	1486140
1998	1569000	1600380
1999	2074000	2115480
2000	2402147	2450190
2001	2745112	2800014

[1] Clinker production according to voluntary survey of cement manufacturers

[2] Actual clinker production calculated as a product of clinker production and default CKD correction factor

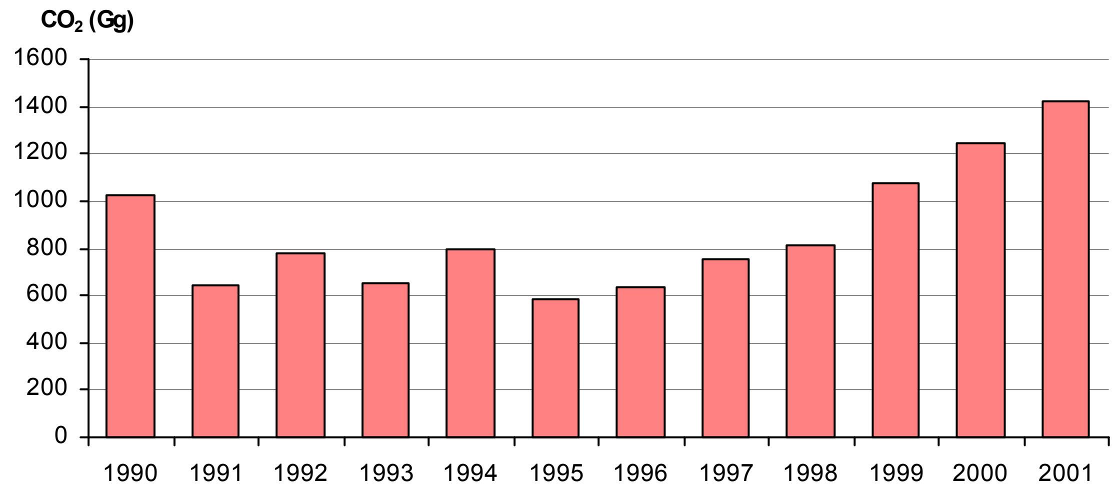

Figure 3.2-1: Emissions of CO_2 from cement production (1990-2001)

3.3. LIME PRODUCTION

Calculation of CO_2 emission from lime production is accomplished by applying an emission factor in tonnes of CO_2 released per tonne of quicklime or dolomitic lime produced, to the annual lime output. The emission factors were derived on the basis of calcination reaction depending on the type of raw material used in the process and assuming 100 per cent pure products. According to aforementioned, emission factors for production of quicklime and dolomitic lime equals 0.79 tonnes CO_2/tonnes quicklime produced and 0.91 tonnes CO_2/tonnes dolomitic lime produced, respectively (*Revised 1996 IPCC Guidelines*).

The activity data for total lime production (see table 3.3-1) were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining, and also were collected by EKONERG from voluntary survey of lime manufacturer since national classification of activities does not distinguish quicklime and dolomitic lime production.

Table 3.3-1: Lime production (1990-2001)

Year	Quicklime production (tonnes)	Dolomitic lime production (tonnes)[1]
1990	183633	0
1991	110040	0
1992	68976	0
1993	76269	0
1994	75511	0
1995	78820	0
1996	57522	37042
1997	65231	55047
1998	72419	53367
1999	68684	53088
2000	77804	68999
2001	102802	68427

[1]According to survey of dolomitic lime manufacturer there was no dolomitic lime production in the period 1990-1995 (production of dolomitic lime started in 1996).

The resulting emissions of CO_2 from lime production in the period 1990-2001 are presented in figure 3.3-1.

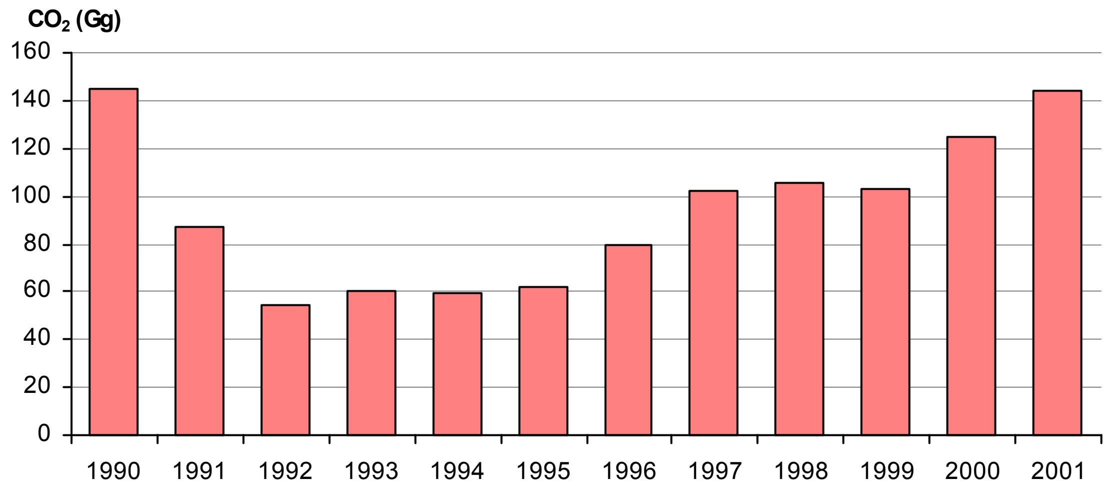

Figure 3.3-1: Emissions of CO_2 from lime production (1990-2001)

Uncertainties contained in these estimates are due to provided default emission factors which assume 100 per cent of CaO in lime (in some cases purity may range from 85 to 95 per cent depending on lime type). Emissions estimation using default emission factors lead to overestimation of CO_2 emission, but at the moment there are no adequate information concerning to purity of lime.

3.4. LIMESTONE AND DOLOMITE USE

Limestone ($CaCO_3$) and dolomite ($CaCO_3$*$MgCO_3$) are basic raw materials having commercial applications in a number of industries including metal production, glass and ceramic manufacture, refractory materials manufacture, chemical and agriculture products.

Emissions of CO_2 from use of limestone and dolomite were calculated by multiplying annual consumption of raw material in processes (limestone/dolomite) by emission factors, which are based on a stoichiometric ratio between CO_2 and limestone/dolomite used in a particular process. Emission of CO_2 from the use of dolomite was estimated by using emission factor which equals 477 kg CO_2/tonne dolomite, assuming 100 per cent purity of raw material (*Revised 1996 IPCC Guidelines*).

The activity data for dolomite use in glass, ceramic and refractory materials manufacture in the period 1990-1995 were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining. The activity data for dolomite use in glass manufacture in the period 1996-2001 were collected by EKONERG from voluntary survey of glass manufacturer since national classification of activities does not distinguish dolomite use in abovementioned process. According to statistical data and data from voluntary survey there was no limestone use in abovementioned processes (see table 3.4-1).

Table 3.4-1: Dolomite use (1990-2001)

Year	Dolomite use (tonnes)
1990	39635
1991	32891
1992	22091
1993	20134
1994	32504
1995	23461
1996	17827
1997	15191
1998	18028
1999	16666
2000	17634
2001	19364

The resulting emissions of CO_2 dolomite use in the period 1990-2001 are presented in figure 3.4-1.

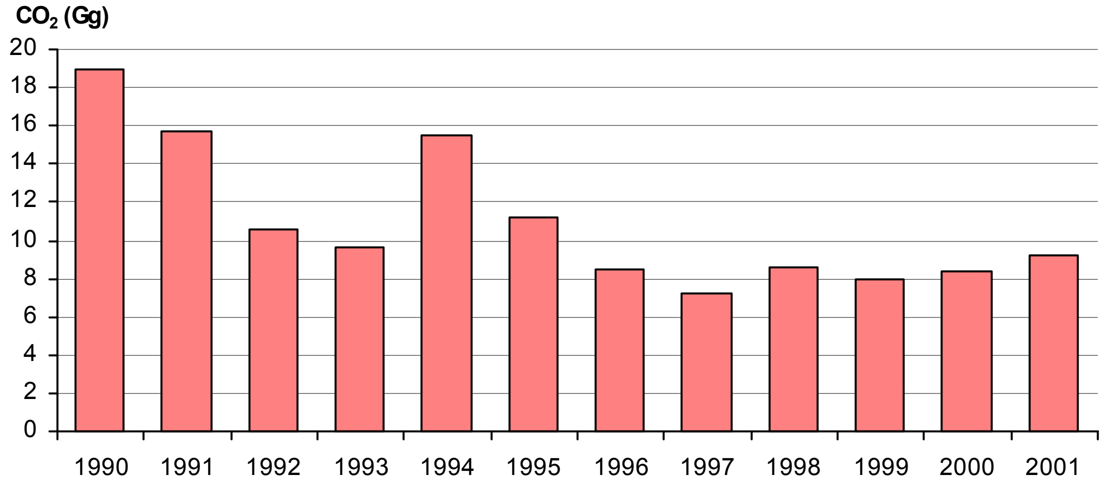

Figure 3.4-1: Emissions of CO_2 from dolomite use (1990-2001)

Uncertainties in this estimates are related to possible variations in the chemical composition of dolomite (dolomite may contain smaller amounts of impurities i.e. magnesia, silica, and sulphur). Also, uncertainties contained in these estimates are due to provided default emission factor which assume 100 per cent purity of dolomite.

3.5. SODA ASH PRODUCTION AND USE

Soda ash (sodium carbonate, Na_2CO_3) is commercially used as a raw material in different industrial processes including glass and ceramic manufacture, soap and detergents, pulp and paper production and water treatment. According to Department of Manufacturing and Mining (Central Bureau of Statistics) there was not any significant production, both natural and synthetic, of soda ash in Croatia in the period 1990-2001.

Emission of CO_2 from the soda ash use was calculated by multiplying annual consumption soda ash by emission factor, which is based on a stoichiometric ratio between CO_2 and soda ash used. Default emission factor equals 415 kg CO_2 per tonne of soda ash used (*Revised 1996 IPCC Guidelines*).

The activity data for soda ash use in glass and ceramic manufacture, and in the production of soap and detergents in the period 1990-1995 were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining. The activity data for soda ash use in glass manufacture in the period 1996-2001 were collected by EKONERG from voluntary survey of glass manufacturer since national classification of activities does not distinguish soda ash use in abovementioned process (see table 3.5-1).

Table 3.5-1: Soda ash use (1990-2001)

Year	Soda ash use (tonnes)
1990	62024
1991	52415
1992	35376
1993	30202
1994	36659
1995	34668
1996	27493
1997	23320
1998	27694
1999	25538
2000	26536
2001	29818

The resulting emissions of CO_2 from soda ash use in the period 1990-2001 are presented in figure 3.5-1.

Emissions of CO_2 from soda ash use are dependent upon a type of end-use processes involved. Specific information characterizing the emissions from particular end-use process is not available. Therefore, uncertainties are related primarily to the accuracy of the emission factor.

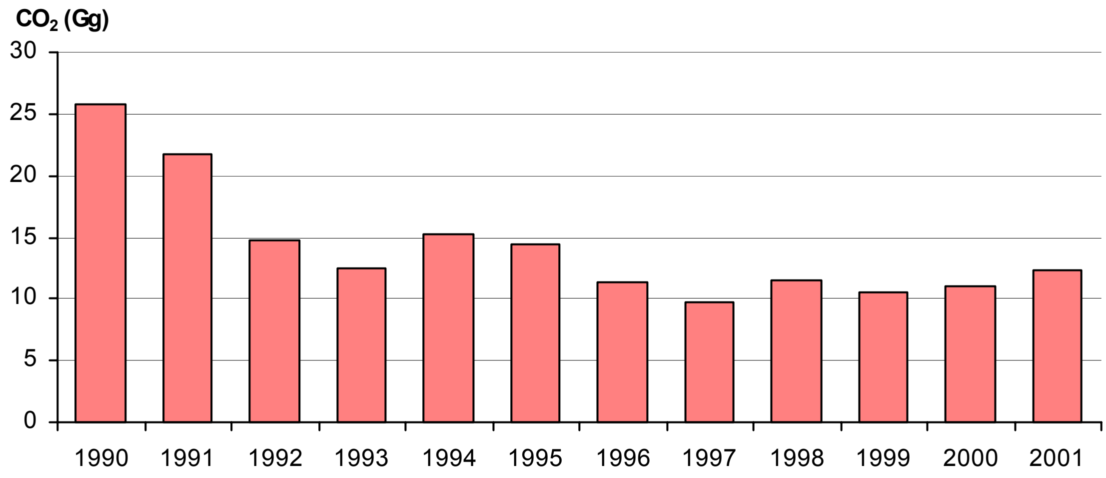

Figure 3.5-1: Emissions of CO_2 from soda ash use (1990-2001)

3.6. AMMONIA PRODUCTION

Emission of CO_2 from ammonia production was calculated by multiplying annual consumption of natural gas used as a feedstock in process by carbon content of natural gas and molecular weight ratio between CO_2 and carbon (Tier 1a method, *Revised 1996 IPCC Guidelines*).

Data on consumption and composition of natural gas (see table 3.6-1) used as a feedstock in a process were collected by EKONERG from voluntary survey of ammonia manufacturer and cross-checked with ammonia production data from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Table 3.6-1: Consumption and composition of gas in ammonia production (1990-2001)

Year	Gas consumption (m^3)	Carbon content of gas (kg C/m^3)
1990	242905233	0.5519
1991	230492226	0.5579
1992	299567927	0.5524
1993	238269046	0.5395
1994	239717137	0.5401
1995	232773.362	0.5423
1996	254116356	0.5395
1997	277311935	0.5372
1998	207973360	0.5373
1999	262772017	0.5388
2000	266433375	0.5377
2001	214441408	0.5416

The resulting emissions of CO_2 from ammonia production in the period 1990-2001 are presented in figure 3.6-1.

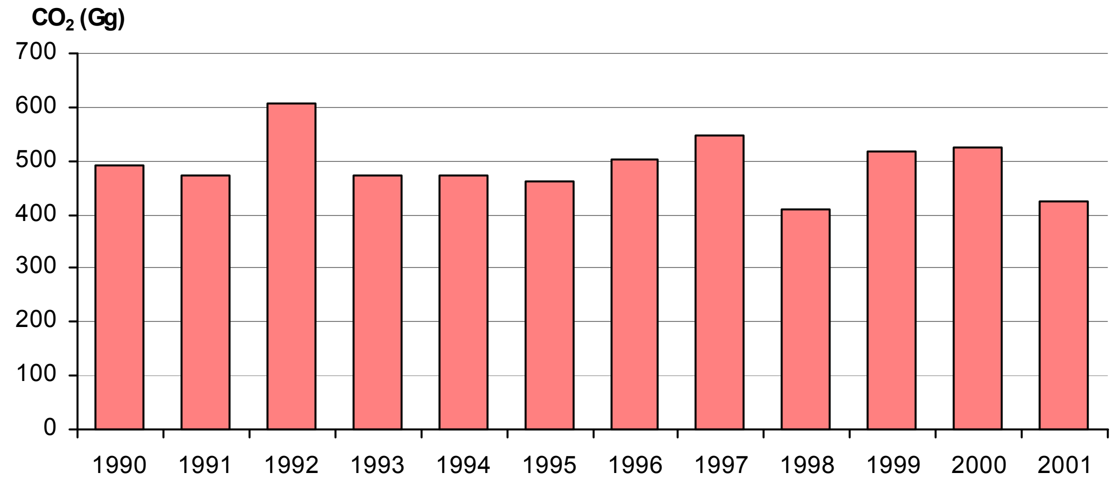

Figure 3.6-1: Emissions of CO_2 from ammonia production (1990-2001)

According to *Revised 1996 IPCC Guidelines* the most accurate method of emissions estimation is based on the consumption and composition of natural gas used as a feedstock in the process[10]. However, there are some uncertainties concerning to use of CO_2 as a feedstock in downstream manufacturing processes, in the production of urea, dry ice and fertilizer. According to *Revised 1996 IPCC Guidelines* no account should consequently be taken for intermediate binding of CO_2 in production of urea, dry ice and fertilizer.

3.7. NITRIC ACID PRODUCTION

Emission of N_2O from nitric acid production was calculated by multiplying annual nitric acid production by emission factor which reflects the process type, i.e. dual pressure type. According to *Good Practise Guidance* emission factor given for European designed dual pressure plants is in the range from 8 to 10 kg N_2O/tonne nitric acid. In consultations with plant experts emission factor was determined as mean value of estimated range, i.e. 9 kg N_2O/tonne nitric acid.

Data on nitric acid production (see table 3.7-1) were collected by EKONERG from voluntary survey of nitric acid manufacturer and cross-checked with nitric acid production data from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining.

The resulting emissions of N_2O from nitric acid production in the period 1990-2001 are presented in figure 3.7-1.

The main uncertainties concerning the emission of N_2O from nitric acid production are due to applied emission factor, since the activity data, i.e. annual production of nitric acid, were collected directly from manufacturer and cross-checked with statistical data. As mentioned before the process of nitric acid production in Croatia is European designed dual pressure type and because none of the emission factors proposed by *Revised 1996 IPCC Guidelines* correspond to plant type default emission factor was taken from *Good Practice Guidance*[11].

[10] In order to avoid double counting, the quantities and composition of gas used as a feedstock have been separately reported from the quantities used as fuel in the ammonia production process. The latter were reported in the Energy Chapter.
[11] *IPCC Guidelines* provide emission factor for medium pressure plants in the range of 6 to 7.5 kg N_2O/t nitric acid which could be considered as nearest which correspond to plant type. *Good Practise Guidance* provide emission factor for European designed, dual pressure, double absorption plant in the range of 8 to 10 kg N_2O/t nitric acid.

Table 3.7-1: Nitric acid production (1990-2001)

Year	Nitric acid production (tonnes)
1990	332459
1991	291997
1992	381797
1993	287805
1994	311236
1995	299297
1996	278683
1997	292892
1998	220509
1999	260198
2000	306201
2001	257534

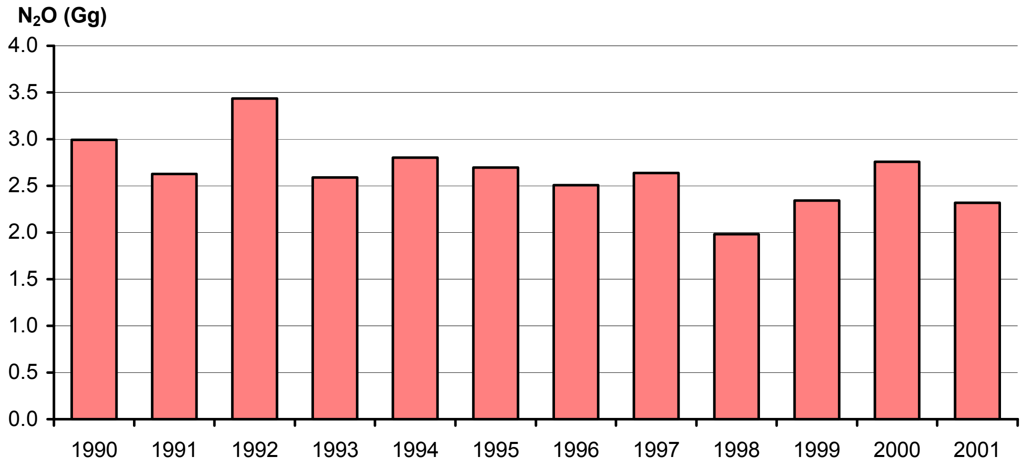

Figure 3.7-1: Emissions of N_2O from nitric acid production (1990-2001)

3.8. PRODUCTION OF OTHER CHEMICALS

The production of other chemicals such as carbon black, coke, and some petrochemicals (ethylene, dichlorethylene, and styrene) can be sources of methane emissions. Although most methane sources from industrial processes individually are small, collectively they may be significant.

Emission of CH_4 from the production of other chemicals was calculated by multiplying an annual production of each chemical with related emission factor provided by *Revised 1996 IPCC Guidelines*.

The annual production of chemicals (see table 3.8-1) was extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining.

The resulting emissions of CH_4 from production of other chemicals in the period 1990-2001 are reported in table 3.8-2.

Table 3.8-1: Production of other chemicals (1990-2001)

Year	Carbon black (tonnes)	Ethylene (tonnes)	Dichloro-ethylene (tonnes)	Styrene (tonnes)	Coke (tonnes)
1990	30624	72631	72653	8923	556084
1991	18783	66871	68325	6376	441584
1992	13479	68318	92089	1381	409371
1993	17123	68634	79608	0	420676
1994	21468	65285	97528	0	276854
1995	27185	67547	84374	0	0
1996	26735	64782	48630	0	0
1997	24214	63554	26264	0	0
1998	22165	60148	31308	0	0
1999	17589	60295	47686	0	0
2000	20029	38918	71364	0	0
2001	21180	46632	64442	0	0

Table 3.8-2: Emissions of CH_4 from production of other chemicals (1990-2001)

Year	Emissions of CH_4 from production of other chemicals *(Gg)*				
	Carbon black	Ethylene	Dichloro-ethylene	Styrene	Coke
1990	0.34	0.07	0.03	0.04	0.28
1991	0.21	0.07	0.03	0.03	0.22
1992	0.15	0.07	0.04	0.01	0.20
1993	0.19	0.07	0.03	0.00	0.21
1994	0.24	0.07	0.04	0.00	0.14
1995	0.30	0.07	0.03	0.00	0.00
1996	0.29	0.06	0.02	0.00	0.00
1997	0.27	0.06	0.01	0.00	0.00
1998	0.24	0.06	0.01	0.00	0.00
1999	0.19	0.06	0.02	0.00	0.00
2000	0.22	0.04	0.03	0.00	0.00
2001	0.23	0.05	0.03	0.00	0.00

3.9. METAL PRODUCTION

In some industrial processes of metal production (production of aluminium, iron and steal) production was stopped in 1992.

3.9.1. IRON AND STEEL

Emissions of CO_2 from iron and steel production were calculated by multiplying annual production of pig iron by the emission factor proposed by *Revised 1996 IPCC Guidelines* (1.6 tonnes CO_2/tonne pig iron produced). The activity data for iron and steel were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining and cross-checked with iron and steel manufacturer[12]. The emission factor applied was assumed to be applicable to both pig iron production and integrated pig iron and steel production. The use of plant-specific emission factors would minimize uncertainty, but

[12] It should be noticed that blast furnaces were closed at the end of 1991 mainly due to war activities near the location of iron and steel plant.

these factors were not available in adequate form. The most accurate method would be to calculate emissions using the amount of reducing agent; however these data were not available.

The resulting emission of CO_2 from iron and steel production was amounted about 335000 tonnes in 1990 and about 111000 tonnes in 1991. CO_2 emissions are not included in Metal Production to avoid double-counting. These emissions are included in Energy sector because Coke Oven Coke used in blast furnace is given in energy balance.

3.9.2. FERROALLOYS

Emission of CO_2 was calculated by multiplying annual ferroalloys production by material-specific emission factor (1.7 tonnes CO_2/tonne silicon manganese, 1.6 tonnes CO_2/tonne ferromanganese and 1.3 tonnes CO_2/tonne ferrochromium). The activity data for ferroalloys production (see table 3.9-2) were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Table 3.9-2: Production of ferroalloys (1990-2001)

Year	Ferromanganese (tonnes)	Silicon manganese (tonnes)	Ferrochromium (tonnes)
1990	20535	48561	60859
1991	13053	38365	72845
1992	0	25572	56058
1993	0	8577	28028
1994	562	22071	31704
1995	0	0	26081
1996	0	0	10559
1997	0	0	24231
1998	0	0	11861
1999	0	0	0
2000	0	0	15753
2001	0	0	361

The resulting emissions of CO_2 from ferroalloys production in the period 1990-2001 are presented in figure 3.9-1.

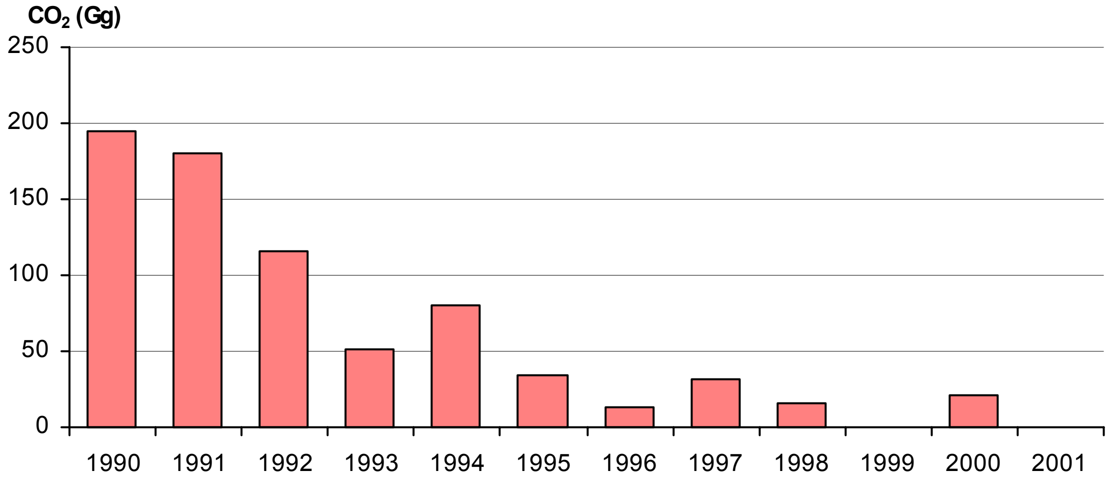

Figure 3.9-1: Emissions of CO_2 from ferroalloys production (1990-2001)

As well as in iron and steel production the most accurate method would be to calculate emissions using the amount of reducing agent which were used in the process; however these data were also not available.

3.9.3. ALUMINIUM

Primary aluminium producing process results in emission of several greenhouse gases including CO_2, and two PFCs: CF_4 and C_2F_6.

Data on primary aluminium production were collected by EKONERG from voluntary survey of aluminium manufacturer[13] .

The quantity of CO_2 released was estimated from the production of primary aluminium and the specific consumption of carbon which is oxidized to CO_2 in the process. During alumina reduction using prebaked anodes approximately 1.5 tonnes of CO_2 is emitted for each tonne of primary aluminium produced.

The resulting emission of CO_2 from aluminium production in 1990 was amounted about 111000 tonnes. In 1991 about 76000 tonnes of CO_2 was emitted.

PFCs emissions from aluminium production could represent a significant source of emissions due to high GWP values. Since only aluminium production statistics were available, emissions of CF_4 and C_2F_6 were estimated by multiplying annual primary aluminium production with default emission factors provided by *Good Practice Guidance and Uncertainty Management in National GHG Inventories*. Default emission factors equal 1.7 kg/tonne Al for CF_4 and 0.17 kg/tonne Al for C_2F_6 (Side Worked Prebaked Anodes).

In 1990 about 819000 tonnes eg-CO_2 of CF_4 and 120000 tonnes eg-CO_2 of C_2F_6 were emitted. In 1991 about 566000 tonnes eg-CO_2 of CF_4 and 83000 tonnes eg-CO_2 of C_2F_6 were emitted.

Occasionally, sulphur hexafluoride (SF_6) is also used by the aluminium industry as a cover gas for special foundry products. There are no available data on SF_6 consumption in aluminium industry.

Uncertainties related to calculation of CO_2 emissions are primarily due to applied emission factor. Emissions vary depending on the specific technology used by each plant, however evidence suggests that there is little variation in CO_2 emissions from plants utilising similar technology. A less uncertain method to calculate CO_2 emissions would be based upon the amount of reducing agent, i.e. amount of prebaked anodes used in a process but this information was not available. Nevertheless, it is very likely that use of the technology-specific emission factor, provided by *Revised 1996 IPCC Guidelines*, along with the correct production data produce accurate estimates. More uncertainties are related to calculation of PFCs emissions because continuous emission monitoring was not carried out, and smelter-specific operating parameters were not available. Default emission factors were therefore applied to calculate PFCs emissions.

[13] It should be noticed that primary aluminium production (electrolysis) were closed at the end of 1991 mainly due to war activities near the location aluminium plant.

3.10. EMISSION RELATED TO CONSUMPTION OF HFCs, PFCs AND SF_6

Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) are synthetic greenhouse gases whose present contribution to greenhouse effect is relatively small comparing to major greenhouse gases but due to their extremely long lifetime and Global Warming Potentials (GWP) they will continue to accumulate in the atmosphere as long as emissions continue.

As mentioned above, primary aluminium producing process results in emission of PFCs: CF_4 and C_2F_6. Activity data (production of primary aluminium) and adequate emission factors (provided by *Good Practice Guidance*) were used to calculate emissions.

A certain amount of SF_6 is contained in electrical equipment used in Croatian National Electricity (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.

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. In order to estimate consumption of HFCs, PFCs and SF_6 in the period 1990-2001 a questionnaires have been sent to trading, service and manufacturing companies previously identified as possible sources of handling or consumption of these compounds. Several institutions such as Ministry of Environmental Protection and Physical Planning, Customs Department and Central Bureau of Statistics were contacted and asked to provide information on import and export of HFCs, PFCs and SF_6.

Results of a survey were unable to provide certain data in required extent. Also, National Classification of Activities used by Central Bureau of Statistics, in the same manner, does not particularly mark HFCs, PFCs and SF_6. Customs Departments Tariff Number does not precisely distinguish these compounds from other fluorinated chemicals which are controlled with Montreal Protocol.

The only useful information is those related to import and export of HFCs in the period 1995-2001, provided by Ministry of Environmental Protection and Physical Planning. According to this information potential HFCs emissions were calculated by difference of import and export of these gases (Tier 1a method, *Revised 1996 IPCC Guidelines*). Annual emissions of HFCs, expressed in Gg eq-CO_2, in the period 1995-2001, are presented in table 3.10-1.

Table 3.10-1: Emissions of HFCs *(Gg eq-CO_2) (1995 – 2001)*

Gas	1995	1996	1997	1998	1999	2000	2001
HFC 32	0.00	0.00	0.00	0.00	0.00	0.04	0.13
HFC 125	0.00	22.20	22.18	1.15	1.75	5.35	12.91
HFC 134a	7.80	2.34	33.44	14.60	4.63	8.92	14.53
HFC 143a	0.00	35.61	35.57	1.84	2.70	8.79	21.42
Total	**7.80**	**60.15**	**91.19**	**17.59**	**9.08**	**23.10**	**48.99**

The main uncertainties of estimation concerning to activity data. Quantities of HFCs contained in various products imported into or exported from a country were difficult to estimate. Also, the application of abovementioned methodology may lead to underestimation or overestimation of potential emissions, depending on whether the majority of HFC containing products is being imported or exported.

3.11. INDUSTRIAL SOURCES OF OZONE AND AEROSOL PRECURSOR GASES

Many non-energy industrial processes generate emissions of ozone and aerosol precursor gases including carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2) (see table 3.11-1). Total annual emissions of these gases in the period 1990- 2001 are reported in table 3.11-2.

Table 3.11-1: Gases generated from different non-energy industrial process

Gas	Industrial process
SO_2	Cement Production
	Production of other chemicals
	Aluminium production
	Pulp and paper production
NO_x	Nitric acid production
	Production of other chemicals
	Aluminium production
	Pulp and paper production
CO	Asphalt Roofing Production
	Ammonia production
	Production of other chemicals
	Aluminium production
	Pulp and paper production
NMVOC	Asphalt Roofing Production
	Road paving with asphalt
	Glass production
	Production of other chemicals
	Pulp and paper production
	Alcoholic beverage production
	Bread and other food production

Table 3.11-2: Emissions of ozone and aerosol precursor gases in the period 1990-2001

Year	SO_2 (Gg)	NO_x (Gg)	CO (Gg)	NMVOC (Gg)
1990	5.28	0.36	3.12	419.93
1991	3.87	0.30	2.94	397.28
1992	5.46	0.39	3.49	336.22
1993	3.68	0.30	2.89	317.88
1994	4.28	0.32	2.98	215.03
1995	4.67	0.31	3.25	213.55
1996	4.54	0.29	3.22	118.42
1997	4.24	0.30	3.42	172.39
1998	3.61	0.23	2.60	168.80
1999	4.22	0.27	3.24	183.20
2000	4.39	0.32	3.32	165.26
2001	3.25	0.27	2.70	130.60

3.12. EMISSION REVIEW

Table 3.12-1: Emissions of greenhouse gases from Industrial processes (1990-2001)

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg eqCO_2)	Per cent in Industrial Processes	Per cent in Total Country Emission
Cement production	1990	CO_2	1022.00	1	1022.00	26.28	3.24
	1991		647.46		647.46	21.76	2.61
	1992		774.68		774.68	29.20	3.36
	1993		648.49		648.49	31.38	2.85
	1994		793.81		793.81	34.26	3.63
	1995		584.89		584.89	28.94	2.63
	1996		634.01		634.01	30.26	2.72
	1997		753.47		753.47	31.85	3.02
	1998		811.39		811.39	40.53	3.23
	1999		1072.55		1072.55	43.71	4.10
	2000		1242.25		1242.25	44.12	4.76
	2001		1419.61		1419.61	50.97	5.29
Lime production	1990	CO_2	145.07	1	145.07	3.73	0.46
	1991		86.93		86.93	2.92	0.35
	1992		54.49		54.49	2.05	0.24
	1993		60.25		60.25	2.92	0.26
	1994		59.65		59.65	2.57	0.27
	1995		62.27		62.27	3.08	0.28
	1996		79.15		79.15	3.78	0.34
	1997		101.63		101.63	4.30	0.41
	1998		105.77		105.77	5.29	0.42
	1999		102.57		102.57	4.19	0.39
	2000		124.25		124.25	4.42	0.48
	2001		143.48		143.48	5.16	0.53
Limestone and dolomite use	1990	CO_2	18.91	1	18.91	0.49	0.06
	1991		15.69		15.69	0.53	0.06
	1992		10.54		10.54	0.40	0.05
	1993		9.00		9.00	0.46	0.04
	1994		15.50		15.50	0.67	0.07
	1995		11.19		11.19	0.55	0.05
	1996		8.50		8.50	0.41	0.04
	1997		7.25		7.25	0.31	0.03
	1998		8.60		8.60	0.43	0.03
	1999		7.95		7.95	0.32	0.03
	2000		8.41		8.41	0.30	0.03
	2001		9.24		9.24	0.33	0.03
Soda ash production and use	1990	CO_2	25.74	1	25.74	0.66	0.08
	1991		21.75		21.75	0.73	0.09
	1992		14.68		14.68	0.55	0.06
	1993		12.53		12.53	0.61	0.06
	1994		15.21		15.21	0.66	0.07
	1995		14.39		14.39	0.71	0.06
	1996		11.41		11.41	0.54	0.05
	1997		9.68		9.68	0.41	0.04
	1998		11.49		11.49	0.57	0.05
	1999		10.60		10.60	0.43	0.04
	2000		11.01		11.01	0.39	0.04
	2001		12.37		12.37	0.44	0.05

Table 3.12-1: Emissions of greenhouse gases from Industrial processes (1990-2001) - continuation

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg eqCO_2)	Per cent in Industrial Processes	Per cent in Total Country Emission
Ammonia production	1990	CO_2	491.55	1	491.55	12.63	1.56
	1991		471.50		471.50	15.85	1.90
	1992		606.76		606.76	22.87	2.63
	1993		471.34		471.34	22.81	2.07
	1994		474.73		474.73	20.49	2.17
	1995		462.85		462.85	22.91	2.08
	1996		502.68		502.68	23.99	2.15
	1997		546.23		546.23	23.09	2.19
	1998		409.73		409.73	20.47	1.63
	1999		519.12		519.12	21.16	1.99
	2000		525.25		525.25	18.66	2.01
	2001		425.83		425.83	15.29	1.59
Nitric acid production	1990	N_2O	2.99	310	927.52	23.83	2.93
	1991		2.63		814.68	27.38	3.28
	1992		3.44		1065.16	40.15	4.61
	1993		2.59		802.90	38.86	3.52
	1994		2.80		868.31	37.47	3.97
	1995		2.69		835.14	41.32	3.75
	1996		2.51		777.53	37.11	3.33
	1997		2.64		817.17	34.55	3.28
	1998		1.98		615.22	30.73	2.45
	1999		2.34		725.95	29.59	2.78
	2000		2.76		854.30	30.34	3.27
	2001		2.32		718.52	25.80	2.68
Production of other chemicals	1990	CH_4	0.75	21	15.79	0.41	0.05
	1991		0.55		11.49	0.39	0.05
	1992		0.46		9.74	0.37	0.04
	1993		0.50		10.48	0.51	0.05
	1994		0.48		10.06	0.43	0.05
	1995		0.40		8.40	0.42	0.04
	1996		0.38		7.94	0.38	0.03
	1997		0.34		7.15	0.30	0.03
	1998		0.32		6.65	0.33	0.03
	1999		0.27		5.73	0.23	0.02
	2000		0.29		6.04	0.21	0.02
	2001		0.31		6.41	0.23	0.02
Ferroalloys production	1990	CO_2	194.93	1	194.93	5.01	0.62
	1991		181.42		181.42	6.10	0.73
	1992		116.73		116.73	4.40	0.51
	1993		50.88		50.88	2.46	0.22
	1994		79.88		79.88	3.45	0.37
	1995		33.91		33.91	1.68	0.15
	1996		13.73		13.73	0.66	0.06
	1997		31.50		31.50	1.33	0.13
	1998		15.42		15.42	0.77	0.06
	1999		0.00		0.00	0.00	0.00
	2000		20.48		20.48	0.73	0.08
	2001		0.47		0.47	0.02	0.002

Table 3.12-1: Emissions of greenhouse gases from Industrial processes (1990-2001) - continuation

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg eqCO_2)	Per cent in Industrial Processes	Per cent in Total Country Emission
Aluminium production	1990	CO_2	111.37	1	111.37	2.86	0.35
	1991		76.40		76.40	2.57	0.31
	1992		0.00		0.00	0.00	0.00
	1993		0.00		0.00	0.00	0.00
	1994		0.00		0.00	0.00	0.00
	1995		0.00		0.00	0.00	0.00
	1996		0.00		0.00	0.00	0.00
	1997		0.00		0.00	0.00	0.00
	1998		0.00		0.00	0.00	0.00
	1999		0.00		0.00	0.00	0.00
	2000		0.00		0.00	0.00	0.00
	2001		0.00		0.00	0.00	0.00
	1990	CF_4	0.126	6500	819.00	21.05	2.59
	1991		0.087		565.50	19.04	2.28
	1992		0.00		0.00	0.00	0.00
	1993		0.00		0.00	0.00	0.00
	1994		0.00		0.00	0.00	0.00
	1995		0.00		0.00	0.00	0.00
	1996		0.00		0.00	0.00	0.00
	1997		0.00		0.00	0.00	0.00
	1998		0.00		0.00	0.00	0.00
	1999		0.00		0.00	0.00	0.00
	2000		0.00		0.00	0.00	0.00
	2001		0.00		0.00	0.00	0.00
	1990	C_2F_6	0.013	9200	119.60	3.07	0.39
	1991		0.009		82.80	2.79	0.33
	1992		0.00		0.00	0.00	0.00
	1993		0.00		0.00	0.00	0.00
	1994		0.00		0.00	0.00	0.00
	1995		0.00		0.00	0.00	0.00
	1996		0.00		0.00	0.00	0.00
	1997		0.00		0.00	0.00	0.00
	1998		0.00		0.00	0.00	0.00
	1999		0.00		0.00	0.00	0.00
	2000		0.00		0.00	0.00	0.00
	2001		0.00		0.00	0.00	0.00

Table 3.12-1: Emissions of greenhouse gases from Industrial processes (1990-2001) - continuation

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg eqCO_2)	Per cent in Industrial Processes	Per cent in Total Country Emission
Consumption of HFCs, PFCs and SF_6[2]	1990	HFC[3,4]	0.00	*	0.00	0.00	0.00
	1991		NE		NE	-	-
	1992		NE		NE	-	-
	1993		NE		NE	-	-
	1994		NE		NE	-	-
	1995		0.006	*	7.80	0.39	0.04
	1996		0.02	*	60.15	2.87	0.26
	1997		0.04	*	91.19	3.85	0.37
	1998		0.01	*	17.59	0.88	0.07
	1999		0.002	*	9.09	0.37	0.04
	2000		0.01	*	23.10	0.82	0.09
	2001		0.02	*	48.99	1.76	0.18

[1] Time horizon chosen for GWP values is 100 years

[2] Consumption of SF_6 is not included because data on consumption are not well documented

[3*] HFC 134a (GWP=1300) – emission is estimated for 1995

[4*] HFC 32 (GWP=650), HFC 125 (GWP=2800), HFC 134a (GWP=1300), HFC 143a (GWP=3800) – emission is estimated in the period 1996-2001

NE – emission is not estimated

3.13. UNCERTAINTIES

Uncertainties in the estimation of greenhouse gas emissions from industrial processes are primarily associated with default emission factors from published references and activity data i.e. production and consumption extracted from statistical reports or surveys.

Uncertainty estimates associated with emission factors for some industrial processes are well reported in *Good Practice Guidance* while those associated with activity data are based on expert judgements since statistics and manufacturers have not been particularly assessed the uncertainties (see table 3.13-1).

Table 3.13-1: Range of uncertainties related to emissions of GHG from industrial processes

Industrial process	**Uncertainties associated with:**	
	Emission factor	**Activity data**
Cement production	4-8 %	1-5%
Lime production	15 %	5-10 %
Limestone and dolomite use	NE	5-10 %
Soda ash production and use	NE	5-10 %
Ammonia production	5 %	1-5 %
Nitric acid production	NE	1-5 %
Production of other chemicals	NE	5-10 %
Iron and steel production	NE	1-5 %
Ferroalloys production	NE	5-10 %
Aluminium production	NE	1-5 %
Consumption of HFCs, PFCs and SF_6	NE	10-50 %

NE – not estimated

3.14. REFERENCES

IPCC/UNEP/OECD/IEA (1997), *Greenhouse Gas Inventory Workbook*, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, and United Kingdom

IPCC/UNEP/OECD/IEA (1997), *Greenhouse Gas Inventory Reference Manual*, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, United Kingdom

Ministry of Environmental Protection and Physical Planning (2001) *The First National Communication of the Republic of Croatia to the United Nations Framework Convention on Climate Change (UNFCCC)*, Zagreb

EKONERG (2000) *Inventory of Croatian Greenhouse Gas Emissions and Sinks,* Final Report, Zagreb

Central Bureau of Statistics, Department of Manufacturing and Mining, *Monthly Industrial Report (1990 – 2001).*

4. SOLVENT USE

4.1. NMVOC EMISSION

The most significant emission in this sector is the emission of non-methane volatile organic compounds (NMVOCs). The use of solvents is the cause of less than 15 percent of anthropogenic national emission of NMVOC.

The emission of NMVOC is caused by use of solvent based paint and varnish, degreasing of metal and dry cleaning, in production of chemicals, in printing industry, by use of glue, by use of solvents in households and by all other activities where solvents are used.

The contribution of group of activities to NMVOC emission is given in the Figure 4-1. The highest NMVOC emission was from other solvent use (more than 40 percent), which covers domestic solvent use, application of glue and printing industry. Paint application contributes 14-28 percent, degreasing and dry cleaning 6-9 percent, and chemical products 14-22 percent. Individually, the highest emission was from domestic solvent use, use of solvent based paint and application of glue.

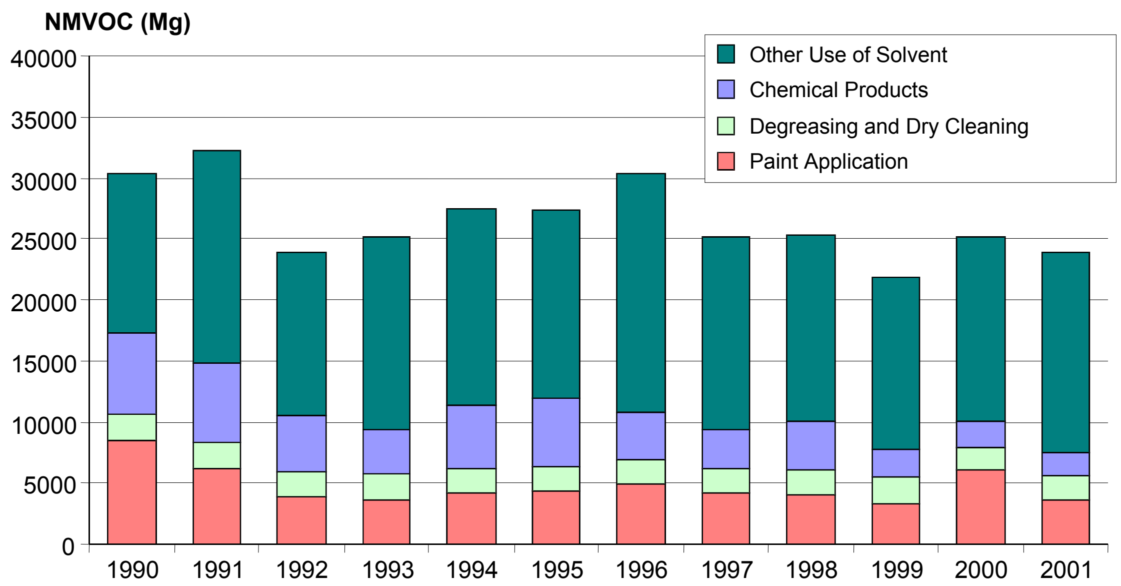

Figure 4.1-1: The NMVOC emission of solvent and other product use

Activity data, NMVOC emissions and average emission factors for each individual activity are shown in Table 4.1-1.

Table 4.1.1: NMVOC Emission of Solvent Use

	Source and Sink Categories	Activity Data						NMVOC Emission						Emission Factor
		1990	1991	1992	1993	1994	1995	1990	1991	1992	1993	1994	1995	1990-2001
		Mg (1000 capita)						Mg						kg/Mg (cap)
3	**Total – Solvent Use**							**30358**	**32254**	**23859**	**25232**	**27473**	**27410**	
3A	**Paint Application**							**8499**	**6257**	**3826**	**3606**	**4139**	**4272**	
	Use of Solvent Base Paint	16999	12513	7652	7212	8278	8543	8499	6257	3826	3606	4139	4272	500
3B	**Degreasing and Dry Cleaning**							**2150**	**2031**	**2012**	**2088**	**2092**	**2101**	
	Metal Degreasing *	4778	4514	4470	4641	4649	4669	956	903	894	928	930	934	0.2
	Dry Cleaning *	4778	4514	4470	4641	4649	4669	1195	1129	1118	1160	1162	1167	0.25
3C	**Chemical Products**							**6562**	**6506**	**4656**	**3611**	**5103**	**5517**	
	Polyurethane – rigid foam	147	81	16	21	35	29	2	1	0	0	1	0	15
	Polyurethane – soft foam	3616	2717	1660	2025	2427	2880	90	68	42	51	61	72	25
	Polyester Resins	6047	4159	3523	2570	2546	2225	242	166	141	103	102	89	40
	Polystyrene Foam	50412	61179	63787	64269	67498	55805	756	918	957	964	1012	837	15
	Polyvinylchloride	104602	69357	70969	44259	78331	93352	4184	4184	2839	1770	3133	3734	40
	Rubber Processing	5739	5442	2439	2477	2338	2285	86	82	37	37	35	34	15
	Pharmaceutical Products Manufacturing*	4778	4514	4470	4641	4649	4669	67	63	63	65	65	65	0.014
	Paint and Varnish Manufacturing	58617	43149	26386	24869	28546	29460	879	647	396	373	428	442	15
	Ink Manufacturing	5074	3605	1343	985	1416	1367	152	108	40	30	42	41	30
	Glue Manufacturing	5139	13451	7151	10910	11166	10076	103	269	143	218	223	202	20
3D	**Other Use of Solvent**							**13147**	**17459**	**13365**	**15927**	**16139**	**15520**	
	Printing Industry	5074	3605	1343	985	1416	1367	507	361	134	99	142	137	100
	Application of Glue	5139	13451	7151	10910	11166	10076	3083	8071	4291	6546	6700	6046	600
	Domestic Solvent Use*	4778	4514	4470	4641	4649	4669	9556	9028	8940	9282	9298	9338	2

* - Activity Data is Number of Inhabitants in Croatia

Table 4.1.1: NMVOC Emission of Solvent Use (continue)

	Source and Sink Categories	Activity Data						NMVOC Emission						Emission Factor
		1996	1997	1998	1999	2000	2001	1996	1997	1998	1999	2000	2001	1990-2001
		Mg (1000 capita)						Mg						kg/Mg (cap)
3	**Total – Solvent Use**							**30304**	**25165**	**25342**	**21810**	**25201**	**23911**	
3A	**Paint Application**							**4931**	**4118**	**4057**	**3380**	**5986**	**3603**	
	Use of Solvent Base Paint	9861	8235	8114	6761	11972	7206	4931	4118	4057	3380	5986	3603	500
3B	**Degreasing and Dry Cleaning**							**2022**	**2058**	**2025**	**2049**	**1971**	**1997**	
	Metal Degreasing *	4494	4572.5	4501	4554	4381	4437.5	899	915	900	911	876	887	0.2
	Dry Cleaning *	4494	4572.5	4501	4554	4381	4437.5	1124	1143	1125	1139	1095	1109	0.25
3C	**Chemical Products**							**3903**	**3178**	**3923**	**2269**	**2086**	**1923**	
	Polyurethane – rigid foam	22	44	39	60	60	95	0	1	1	1	1	1	15
	Polyurethane – soft foam	1800	1710	1790	1770	1800	2655	45	43	45	44	45	66	25
	Polyester Resins	3367	7022	8258	5609	12848	9661	135	281	330	224	514	386	40
	Polystyrene Foam	64121	78580	99960	84928	36690	49025	962	1179	1499	1274	550	735	15
	Polyvinylchloride	44565	23094	33134	3085	811	640	1783	924	1325	123	32	26	40
	Rubber Processing	1279	26	17	20	21	21	19	0	0	0	0	0	15
	Pharmaceutical Products Manufacturing*	4494	4572.5	4501	4554	4381	4437.5	63	64	63	64	61	62	0.014
	Paint and Varnish Manufacturing	34004	28398	27979	23313	41283	24849	510	426	420	350	619	373	15
	Ink Manufacturing	1420	1430	1071	797	1832	822	43	43	32	24	55	25	30
	Glue Manufacturing	17197	10874	10379	8206	10355	12385	344	217	208	164	207	248	20
3D	**Other Use of Solvent**							**19448**	**15812**	**15337**	**14111**	**15158**	**16388**	
	Printing Industry	1420	1430	1071	797	1832	822	142	143	107	80	183	82	100
	Application of Glue	17197	10874	10379	8206	10355	12385	10318	6524	6227	4924	6213	7431	600
	Domestic Solvent Use*	4494	4572.5	4501	4554	4381	4437.5	8988	9145	9002	9108	8762	8875	2

* - Activity Data is Number of Inhabitants in Croatia

4.1.1. METHODOLOGY AND DATA SOURCES

For the emission estimate from this sector, emission factors suggested by EMEP/CORINAIR Guidebook are mainly used. The input data needed for the estimate are obtained from the State Bureau of Statistics.

4.1.2. UNCERTAINTY

Uncertainties in these estimates are mainly due to the accuracy of emission factors used and reliability of calculation is very low.

4.2. REFERENCES

Central Bureau of Statistics (1992): *Monthly Industrial Report – 1990 & 1991, Zagreb*

Central Bureau of Statistics (1997): *Monthly Industrial Report – for the period from 1992 to 1996, Zagreb*

Central Bureau of Statistics (1997): *Statistical Yearbook - 1996, Zagreb*

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Central Bureau of Statistics (2002): *Industry in 2001 – Annual Report, Zagreb*

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5. AGRICULTURE

5.1. INTRODUCTION

The agricultural activities contribute directly to the emission of greenhouse gases through various processes. The following sources have been identified to make a more complete break down in the emission calculation:

- Livestock: enteric fermentation (CH_4) and manure management (CH_4, N_2O)
- Agricultural soils (N_2O)
- Field burning of agricultural residue (CH_4, NO_2, NO, NO_x)

The emission in 2001 produced by the agricultural activities was 3035 Gg CO_2-eq, which is 11.3 percent of the emission of the total emission inventory. The methane (CH_4) and nitrous oxide (N_2O) are primary greenhouse gases discharged as a consequence of agricultural activities (Figure 5.1-1). Of all the ruminants, the dairy cattle are the largest source of methane (CH_4) emission. The results of the agricultural soil management, manure management, and the agricultural engineering in cultivation of some crops are relatively high emissions of nitrous oxide (N_2O). The emission generated by burning the agricultural residues was calculated only for 1990. It was not calculated for the period from 1991 to 2001 due to the great uncertainty of the input data.

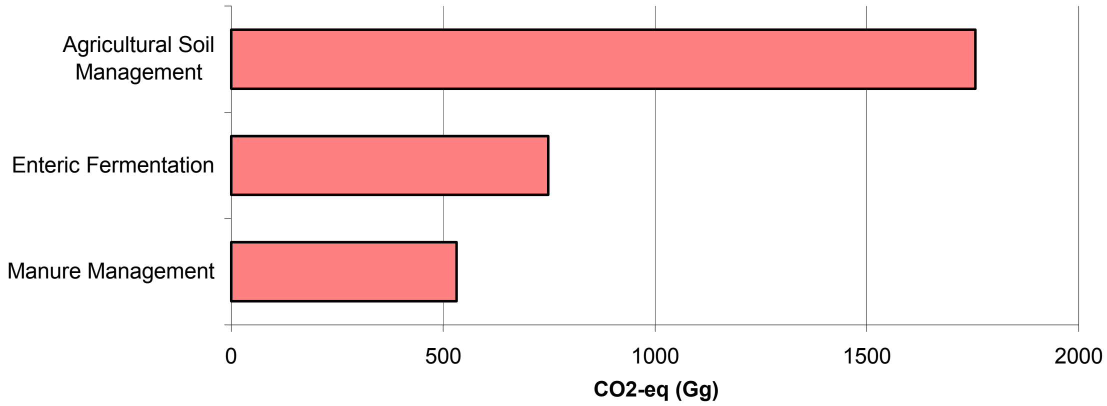

Figure 5.1-1: Agriculture GHG Sources

Tables 5.1-1 and 5.1-2 show the total emission from agriculture by gases and emission sources for the period 1990-2001. The emission in table 5.1-2 is given in the equivalents of CO_2.

Table 5.1-1: Emission of greenhouse gases from agriculture (Gg)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CH_4	**75.32**	**71.91**	**67.08**	**55.57**	**50.78**	**48.06**	**45.34**	**44.50**	**43.11**	**43.95**	**42.57**	**43.09**
Enteric Fermentation	64.06	61.06	56.59	47.14	42.36	40.44	37.86	37.17	35.90	35.96	35.16	35.64
Manure management	11.05	10.85	10.49	8.42	8.42	7.62	7.48	7.34	7.22	7.99	7.41	7.45
Residue burning	0.21	-	-	-	-	-	-	-	-	-	-	-
N_2O	**8.83**	**9.14**	**8.54**	**6.80**	**6.59**	**6.06**	**7.23**	**8.21**	**7.36**	**7.61**	**7.77**	**6.87**
Manure management	1.21	1.16	1.09	0.907	0.83	0.79	1.21	1.20	1.17	1.24	1.20	1.21
Agricultural soil	7.61	7.97	7.46	5.90	5.75	5.27	6.02	7.01	6.19	6.38	6.57	5.66
Residue burning	0.004	-	-	-	-	-	-	-	-	-	-	-

Table 5.1-2: Emission of greenhouse gases from agriculture CO2-eq (Gg)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CH_4	**1581.8**	**1510.2**	**1408.7**	**1167.0**	**1066.4**	**952.1**	**934.6**	**905.4**	**922.9**	**894.0**	**904.9**	**952.1**
Enteric Fermentation	1345.3	1282.3	1188.3	990	889.5	795.1	780.5	753.8	755.2	738.3	748.4	795.1
Manure management	232.1	227.9	220.4	177.0	176.9	157.0	154.0	151.5	167.7	155.7	156.5	157.0
Residue burning	4.4	-	-	-	-	-	-	-	-	-	-	-
N_2O	**2738.9**	**2833.7**	**2651.7**	**2110.5**	**2042.9**	**2240.3**	**2544.0**	**2280.8**	**2359.0**	**2408.7**	**2130.7**	**2240.3**
Manure management	376.7	361.12	337.9	281.2	259.2	374.9	371.4	362.2	382.9	372.4	375.1	374.9
Agricultural soil	2361.0	2472.6	2313.9	1829.3	1783.7	1865.4	2172.6	1918.6	1976.1	2036.4	1755.6	1865.4
Residue burning	1.2	-	-	-	-	-	-	-	-	-	-	-

Below there is a review of the greenhouse gas emission calculation according to previously stated sources.

5.2. LIVESTOCK

5.2.1. ENTERIC FERMENTATION (CH_4)

The methane is a direct product of animal metabolism generated during the digestion process. The greatest producers of methane are ruminants (cows, cattle, and sheep). The amount of methane produced and excreted depends on the animal digestive system and the amount and type of the animal feed. Figure 5.2-1 shows the emission of methane from enteric fermentation for the period from 1990-2001.

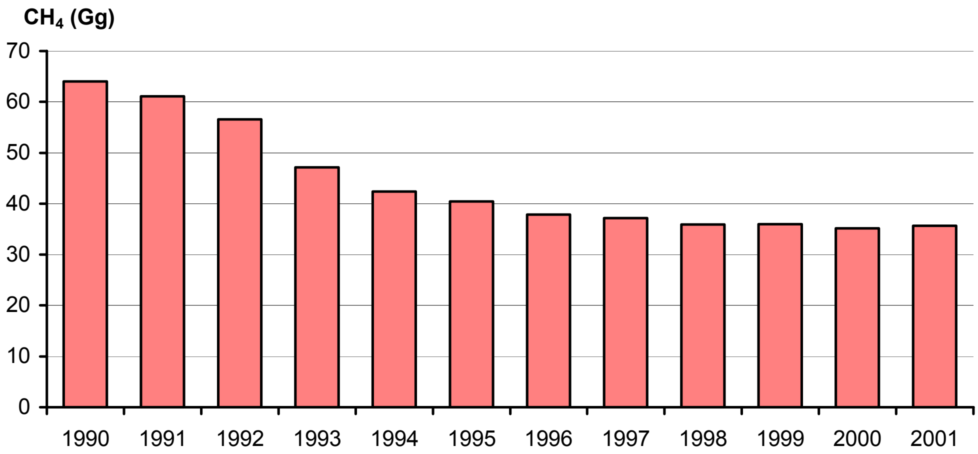

Figure 5.2-1: CH_4 emission from Enteric fermentation (Gg)

5.2.2. MANURE MANAGEMENT – CH_4 EMISSION

The management of livestock manure produces methane (CH_4) and nitrous oxide (N_2O) emissions. The methane is generated under the conditions of anaerobic decomposition of manure. The storing methods of the manure in which the anaerobic conditions prevail (liquid animal manure in septic pits) are favourable for anaerobic decomposition of organic substance and release of methane. The storing of solid animal manure results in aerobic decomposition and very low production of methane. The methane emission from manure management for the period from 1990 to 2001 is given on the Figure 5.2-2.

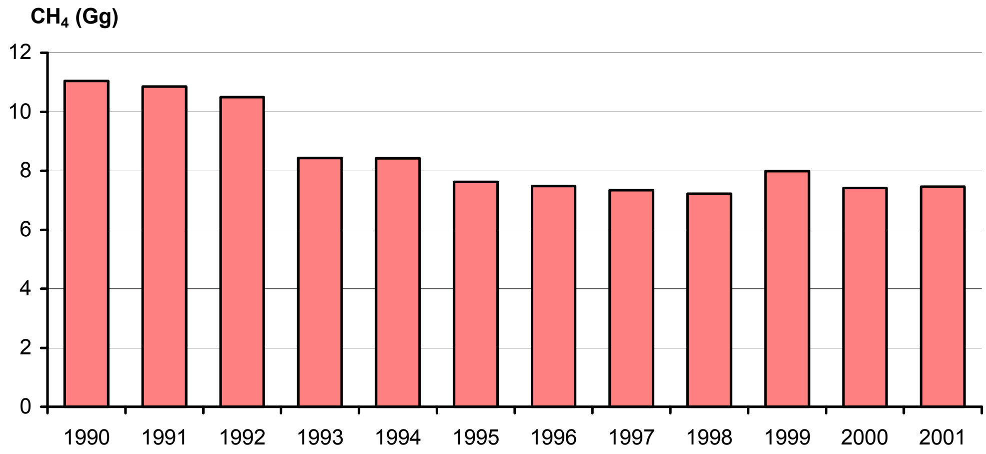

Figure 5.2-2: CH_4 emission from Manure Management (Gg)

Total methane emission for livestock is calculated as a sum of the emission resulting from enteric fermentation and manure management and given in Table 5.2-1 and Figure 5.2-3.

Table 5.2-1: Total (CH_4) Emissions from Domestic Livestock (Gg)

Source	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Enteric Fermentation	64.06	61.06	56.59	47.14	42.36	40.44	37.86	37.17	35.90	35.96	35.16	35.64
Manure management	11.05	10.85	10.49	8.43	8.42	7.62	7.48	7.34	7.22	7.99	7.41	7.45
Residue burning	0.21	-	-	-	-	-	-	-	-	-	-	-
Total	**75.32**	**71.91**	**67.08**	**55.57**	**50.78**	**48.06**	**45.34**	**44.50**	**43.11**	**43.95**	**42.57**	**43.09**

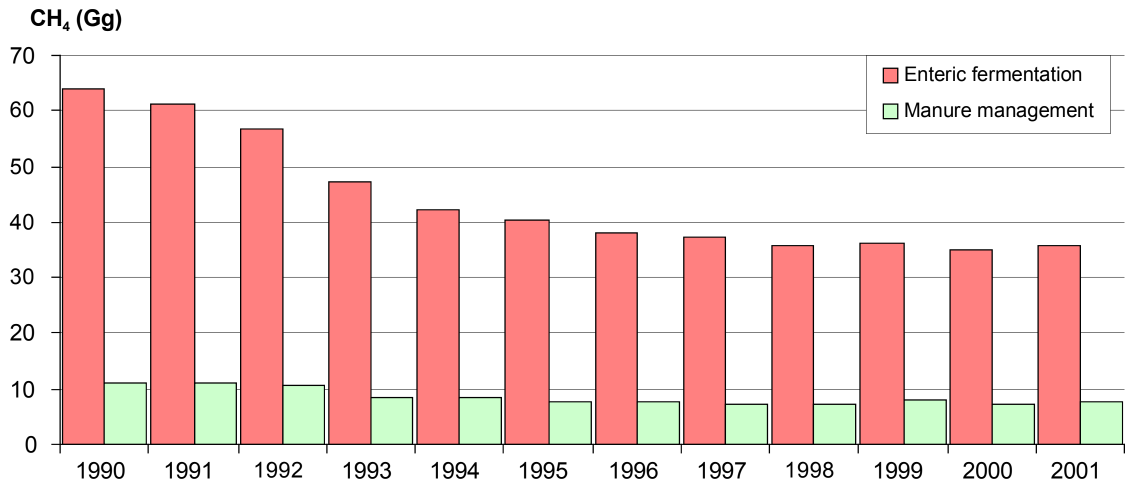

Figure 5.2-3: Total (CH_4) Emissions from Domestic Livestock (Gg)

Methodology

The IPCC methodology has been used to calculate the methane emission from enteric fermentation and manure management. The basic input is the head of cattle (dairy cattle, cattle, sheep, horses, pigs, and poultry). The emission factors specific for the animal type, the climate zone, geographic region, and the degree of the region development were used for the calculation of the emission.

Data Source

Three year average livestock population data for all livestock types for 1990 year were obtained from Croatian Statistical Report (1988, 1989 and 1990). FAO Statistics data were used for the period 1992-1995. The data have been taken from the statistical yearbooks for the period 1996-2001. The emission factors have been taken from the *Revised 1996 IPCC Reference Manual*.

5.2.3. MANURE MANAGEMENT – N_2O EMISSION

The emission of nitrous oxide (N_2O) from unmanaged livestock manure and urine is addressed in this part of the report only for the quantities stored as solid and liquid manure. The N_2O emission for excrements on pastures is addressed under 5.2-2.

Methodology

The IPCC calculation methodology has been used. The emission factors are taken from the *Revised 1996 IPCC Reference Manual.*

The nitrous oxide (N_2O) emission is calculated according to the following equation:

$$N_2O_{(AWMS)} = \Sigma\ [Nex_{(AWMS)} \times EF_3]$$

Where:

$N_2O_{(AWMS)}$ – N_2O emissions from all Animal Waste Management Systems (kg N/yr)
$Nex_{(AWMS)}$ – N excretion per Animal Waste Management System (kg/yr)
EF_3 – emission factor

The nitrous oxide (N_2O) emission conditioned by the manure management in the period from 1990 to 2001 is shown on figure 5.2-4.

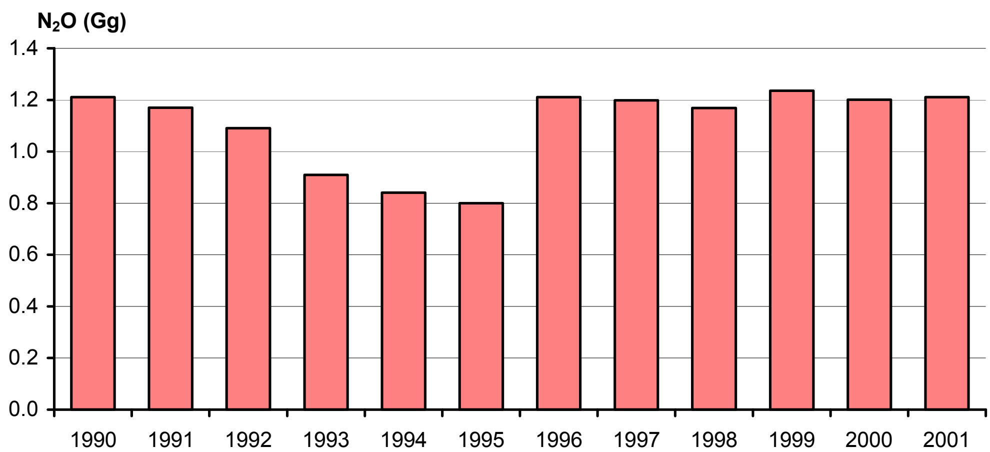

Figure 5.2-4: N_2O Emissions from Manure Management (Gg)

Data Source

Three year average livestock population data for all livestock types were obtained from Croatian Statistical Report (1988, 1989, 1990), (FAO data base for the period 1991-1995). The Statistical

Yearbooks (1996-2001) were used for the data on the head of cattle. The Statistical Yearbooks (1996-2001) were used for the data on the head of cattle. The nitrogen excretion for each manure management system and the emission factors were taken from the *Revised 1996 IPCC Reference Manual.*

5.3. AGRICULTURAL SOILS

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. The methodology used differentiates three sources of nitrous oxide emission:

- Direct emission of N_2O from agricultural soils
- Direct soil emission of N_2O from animal production
- Indirect emission of N_2O conditioned by agricultural activities

The highest among the above stated emission comes directly from the agricultural soils by cultivation of soil and crops. The activities stated include the use of synthetic and organic fertilizers, growing of leguminous plants and soybean (nitrogen fixation), the nitrogen and organic from the agricultural residues, and the treatment of histosols.

Methodology

For the emission from agricultural soils the IPCC methodology has been used. The emission factors have been taken from the *Revised 1996 IPCC Reference Manual.*

5.3.1. DIRECT EMISSION FROM AGRICULTURAL SOILS

Direct emissions N_2O from agricultural soils includes total amount of nitrogen to soils through cropping practices. These practices includes application of synthetic fertilizer, nitrogen from animal waste, production of nitrogen – fixing crops, nitrogen from crop residue mineralization and soil nitrogen mineralization due to cultivation of histosols. The input data required for this part of the calculation are: annual quantity of the synthetic fertilizer used, the quantity of organic fertilizer, the head of cattle by its category, the biomass of leguminous plants and soybean, and the surface of histosols. The direct emission from agricultural soils is calculated by the following equation:

$$N_2O_{\text{ DIRECT}} \text{ (kg N/yr)} = (F_{SN} + F_{AW} + F_{CR} + F_{BN}) \times EF_1 + F_{OS} \times EF_2$$

Where:

$N_2O_{\text{ DIRECT}}$ - direct N_2O emission from agricultural soils (kg N/yr)
F_{SN} - nitrogen from synthetic fertilizer excluding emissions of NH_3 and NO_x (kg N/yr)
F_{AW} - nitrogen from animal waste (kg N/yr)
F_{CR} - nitrogen from crop residues (kg N/yr)
F_{BN} - nitrogen from N-fixing crops (kg N/yr)
EF_1, EF_2 - emission factors
F_{OS} - nitrogen from histosols, (kg N/yr)

Figure 5.3-1 shows direct emission of nitrous oxide from agricultural soils.

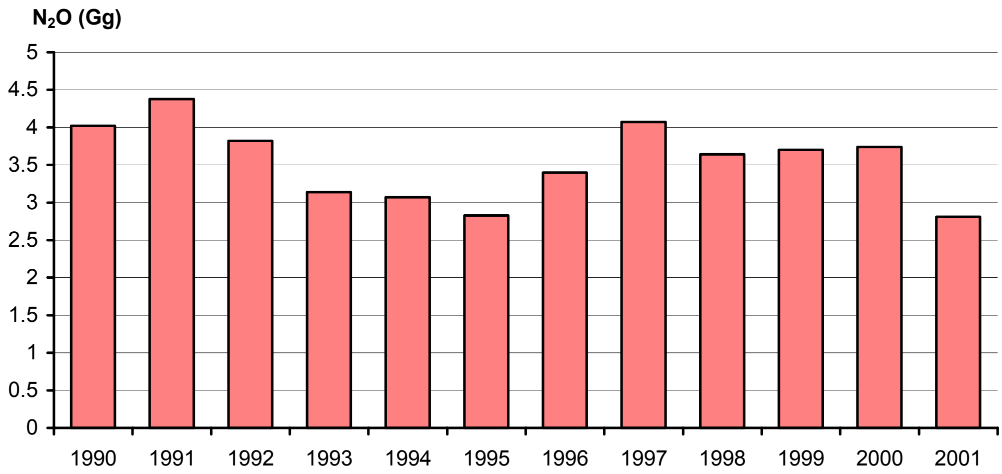

Figure 5.3-1: Direct N_2O Emissions from Agricultural Soils (Gg)

5.3.2. DIRECT EMISSION OF N_2O FROM ANIMALS

Estimates of N_2O emissions from animals were based on animal waste deposited directly on soils by animals in pasture, range and paddock. N_2O emissions from animals can be calculated as follows:

$$N_2O_{ANIMALS} = N_2O_{(AWMS)} = \Sigma_{(T)} [N_{(T)} \times Nex_{(T)} \times AWMS_{(T)} \times EF_{3(AWMS)}]$$

Where:

$N_2O_{ANIMALS}$	- N_2O emissions from animal production (kg N/yr)
$N_2O_{(AWMS)}$	- N_2O emissions from Animal Waste Management Systems (kg N/yr)
$N_{(T)}$	- number of animals of type T
$Nex_{(T)}$	- N excretion of animals of type T (kg N/animal/yr)
$AWMS_{(T)}$	- fraction of $Nex_{(T)}$ that is managed in one of the different distinguished animal waste management systems for animals of type T
$EF_{3(AWMS)}$	- emission factor

Figure 5.3-2 shows direct emission of nitrous oxide from animals.

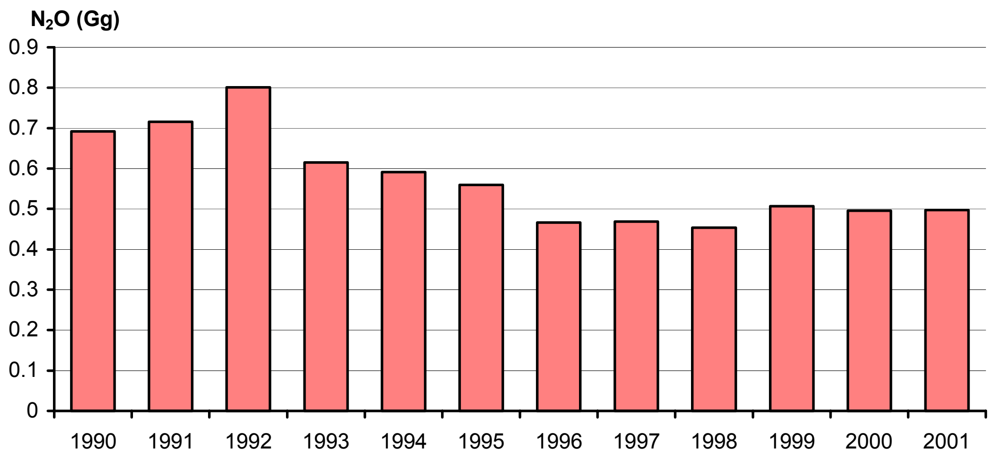

Figure 5.3-2: Direct N_2O Emissions from Animals (Gg)

5.3.3. INDIRECT N_2O EMISSIONS FROM NITROGEN USED IN AGRICULTURE

Estimates of N_2O emissions from this component were based on two pathways. These are: volatilization and subsequent atmospheric deposition of NH_3 and NO_x (originating from the application of fertilizers), and leaching and runoff of the N that is applied to, or deposited on soils. These two indirect emission pathways are treated separately, although the activity data used are identical. The indirect emission of N_2O from the agriculture is calculated by the following equation:

$$N_2O_{\ INDIRECT} = N_2O_{(G)} + N_2O_{(L)}$$

Where:

$N_2O_{\ INDIRECT}$ - indirect N_2O emissions (kg N/yr)
$N_2O_{(G)}$ - N_2O emissions due to atmospheric deposition of NH_3 and NO_x (kg N/yr)
$N_2O_{(L)}$ - N_2O emissions due to nitrogen leaching an runoff (kg N/yr)

Figure 5.3-3 shows the indirect emission of nitrous oxide from agriculture.

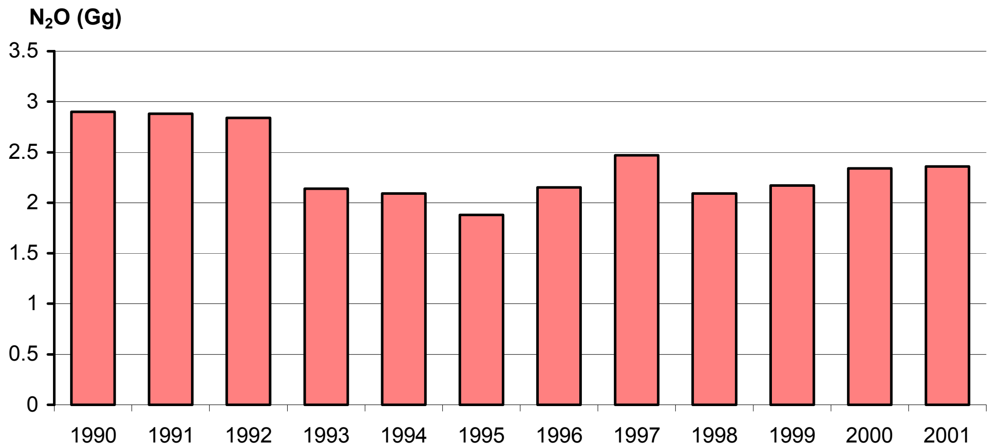

Figure 5.3-3: Indirect N_2O Emissions from Agricultural (Gg)

The total emission of nitrous oxide (N_2O) from the agricultural soils is calculated as a sum of direct emissions from agricultural soils, animals and the indirect emission from agriculture. Figure 5.3-4 shows the total emission from agricultural soils for the period from 1990 – 2001.

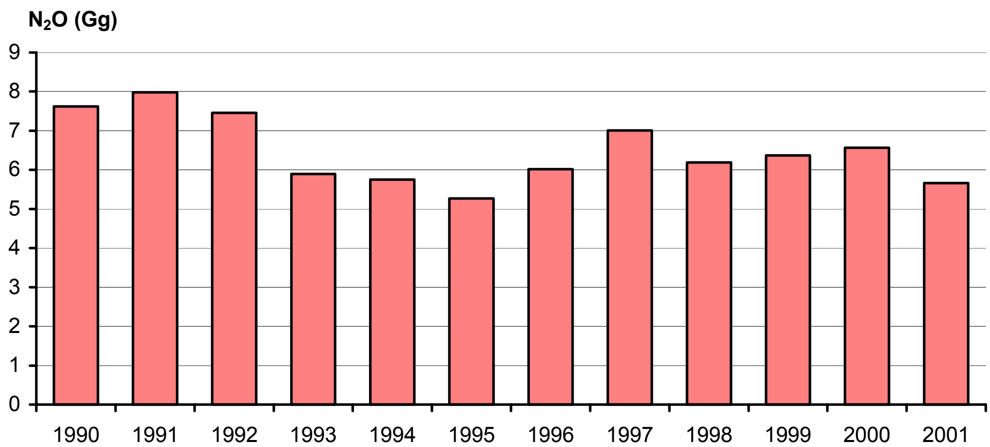

Figure 5.3-4: Total N_2O Emissions from Agricultural Soils (Gg)

Data Source

Three year average data were obtained from Croatian Statistical Report (1988, 1989, 1990), (FAO data base for the period 1991-1995).The Statistical Yearbooks (1996-2001) has been used for showing the head of cattle, agricultural land, yield of vital crops and the consumption of synthetic fertilizers. The data on soils, the impact on the yield, and the use of synthetic fertilizers are generally taken from the scientific papers and partly are the expert team assessments.

Calculation Uncertainty

The uncertainty of the calculation is conditioned by the use of the emission factors recommended by the methodology and the unreliability of the input data. According to the bibliography, the uncertainty of the recommended emission factors is high. Therefore, for the future research works the national emission factors should be developed to increase the calculation.

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6. LAND-USE CHANGE AND FORESTRY

Based on the Forest Management Area Plan of the Republic of Croatia, the forests and the forest land cover 43.5 percent of the total surface area. By its origin, approximately 95 percent of the forests in Croatia were formed by natural regeneration and the 5 percent of the forests are grown artificially. Out of the total surface area occupied by forests and the forest land, 2,089,607 ha (84 percent) is the forest-covered area, 327,630 ha (13 percent) is non forest land, and 74,063 ha (3 percent) is bare unproductive and unfertile forestland.

The total growing stock in the Croatian forests is 342 million m^3. It consists of approximately 84 percent of deciduous trees and 16 percent of evergreen trees. The most frequent species are beech, common fir, sessile oak, and other types of deciduous and evergreen trees. The average growing stock in the state-owned forests is 202 m^3/ha and in the privately owned forests 82 m^3/ha. The annual increment in Croatia forests is 9,643,000 m^3 of wood. The increment is an increase in the forest timber stock over a specific period and it is calculated as an annual, periodical and average increment. The check method or the method of bore-spills is most often used in Croatia to identify the increment. The quality and quantity of increment can be improved by different methods of forest cultivation. The annual cut is a part of the forest timber stock planned for commercial harvesting for a certain period (1 year, 10 years, 20 years) expressed in timber stock (m^3, m^3/ha) or by the surface area. To satisfy the basic principles of the sustainable forest management, the annual cut must not be larger than the increment value. Data on planned annual cut (56 percent of annual increment) in Croatia were used for the period from 1990-1995. There was no data on real annual cut for the mentioned period due to the political situation in Croatia. According to the data from Hrvatske šume (Croatian Forests Co.) the real annual cut for the period from 1996-2001 estimated is from 4.08 mill m^3 to 4.39 mill m^3, which is less than 50 percent of the annual increment.

According to the IPCC methodology, the activities affecting the emissions and removals of CO_2 are the following:

- Changes in the forest and other woody biomass stock – the most important effects of human interactions with existing forests are considered in a single broad category, which includes commercial management, harvest of industrial roundwood and fuelwood, production and use of wood commodities, and establishment and operation of forest plantations as well as planting of trees in urban, village and other non forest locations;
- Forest and grassland conversion – the conversion of forest land into grassland, pasture land, crop land;
- Abandonment of managed land;
- Changes in soil carbon.

The calculation of the CO_2 emissions and removals includes only the changes in the amount of forest and other woody biomass stock because there were no sufficient inputs for other activities. The law prohibits the renewal of forests by clear cutting, and the natural rejuvenation is the principal method for renewal of all natural forests.

6.1. CHANGES IN CARBON STOCK IN FORESTS

The carbon in forests is bound in trees, underbrush, soil and dead wood. As a result of biological processes in forests and anthropogenic activities the carbon is in a constant cycling process. Deforestation, among all anthropogenic activities, has the greatest impact on the change of carbon stock in the existing forests. The problem of deforestation in Croatia does not exist. According to the current data total forest area in Croatia has not decreased over the last 100 years.

Methodology

The IPCC methodology has been used for calculation of CO_2 emissions and removals.

Data Source

The Forest Management Area Plan of the Republic of Croatia for the period from 1996 to 2005 is the main source for the data on the forest land and the annual increment. The data on commercial harvesting are obtained from Hrvatske šume Company (The Croatian Forests Co.). The factors for calculation of emissions and removals are taken from the *Revised 1996 Reference Manual*. The conversion and expansion factors are the assessment of the expert team.

6.1.1. TOTAL CARBON UPTAKE INCREMENT

The total carbon uptake has been estimated on the basis of the data on the annual biomass increment, for each forest type. Total carbon uptake amounts 4011 Gg C.

6.1.2. ANNUAL CARBON RELEASE

The basic input is the total commercial harvest, which by subsequent oxidation of the carbon contained becomes a source of CO_2. As already mentioned earlier in the text the data on commercial harvest, which is below 50 percent of the increment have been used. The total carbon release is 1810 Gg C. In the calculation we used the conversion factors recommended by the IPCC Guidelines whereas the national team of experts assessed the expansion factors.

6.1.3. TOTAL CO_2 REMOVALS AND EMISSIONS

The total removals of CO_2 are calculated as a difference between the total carbon uptake and total annual release of carbon. For the period 1990-1995 annual CO_2 removal recalculated to CO_2 was 6505 Gg CO_2. For the period from 1996-2001 annual CO_2 removal recalculated to CO_2 was 8069 Gg CO_2.

6.1.4. UNCERTAINTIES

The uncertainty of the input data was estimated at 20 percent, and for the conversion and expansion factors at 30 percent. Further investigation are necessary to improve the calculation and to identify as precise as possible the amount of biomass of commercial harvest according to the final purpose. Total uncertainty of the calculation is estimated at 50-60 percent.

6.2. REFERENCES

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7. WASTE

7.1. INTRODUCTION

Waste management activities such as disposal and treatment of municipal and industrial solid waste and wastewaters can produce emissions of greenhouse gases including methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O).

Emission of CH_4 as a result of disposal and treatment of municipal and industrial solid waste and indirect N_2O emission from human sewage are included in emission estimates in this sector. Aerobic biological processes are used mostly in wastewater treatment. According to national wastewater experts anaerobic treatment is applied in some wastewater treatment. Total amount of gas is flared in these treatments, and therefore all methane from gas is oxidized to carbon dioxide and water vapour.

The methodology used to estimate emissions from waste management activities requires country-specific knowledge on waste generation, composition and management practice. The fact that waste management activities in Croatia are generally inadequately organized and implemented result in the lack and inconsistency of data. Therefore, the team of national waste experts was formed in order to evaluate and compile data coming from different sources and adjust them to recommended Intergovernmental Panel on Climate Change (IPCC) methodology for estimation of CH_4 emissions from solid waste disposal sites (SWDSs) and N_2O emissions from human sewage. The total annual emissions of greenhouse gases, expressed in Gg eq-CO_2, from waste management in the period 1990-2001 are presented in figure 7.1-1.

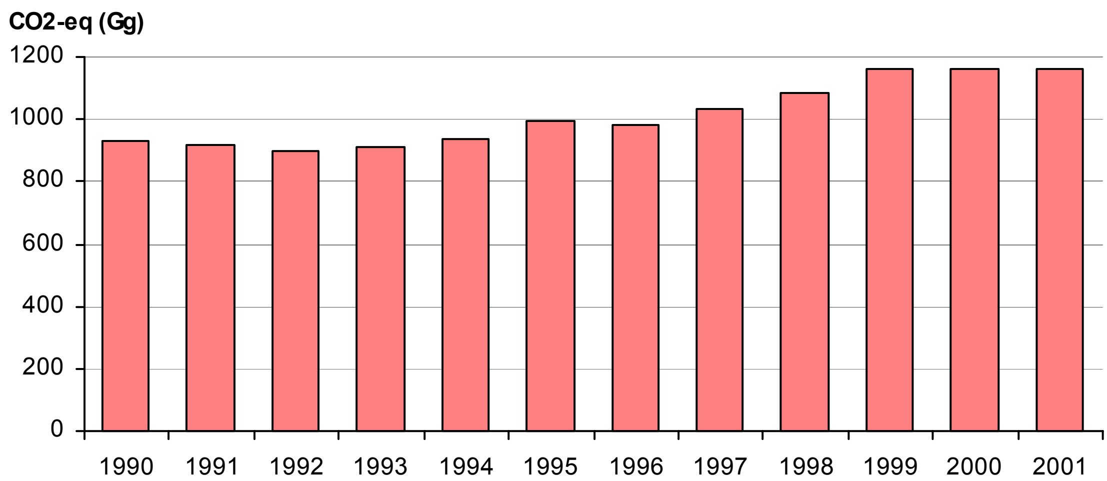

Figure 7.1-1: Emissions of greenhouse gases from waste (1990-2001)

7.2. LAND DISPOSAL OF SOLID WASTE

Anaerobic decomposition of organic matter in SWDSs results in the release of CH_4 to the atmosphere. A method used to calculate CH_4 emission according to *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories is* default method based on a mass balance approach which does not incorporate any time factors into the calculations. Basically, it assumes that all potential CH_4 is released from waste in the year that the waste is disposed of. The main reason for using this default method, instead of more accurate First Order Decay (FOD) method, is the scarce of data on historic waste quantities, composition and disposal practices, especially before 1990.

The quantity of the CH_4 emitted during decomposition process is directly proportional to the fraction of degradable organic carbon (DOC), which is defined as the carbon content of different types of organic biodegradable wastes such as paper and textiles, garden and park waste, food waste, wood and straw waste. DOC was estimated by using country-specific data on waste composition and quantities based on compiled data from Potočnik, V. (2000), *Report: The basis for methane emissions estimation in Croatia 1990-1998, B. Data on Municipal Solid Waste in Croatia 1990-1998*. The country-specific fraction of DOC in municipal solid waste (MSW) was estimated to be 0.17 in the period 1990–2001.

The decomposition of DOC does not occur completely and some of the potentially degradable materials always remain in the site over a long period of time. According to *Good Practice Guidance* approximately 50-60 per cent of total DOC actually degrades[14] and converts to landfill gas. A mean value, i.e. 55 percent, was taken into account for the purpose of CH_4 emission estimation from SWDSs.

The methodology provides a classification of SWDSs into “managed” and “unmanaged” sites through knowledge of site activities carried out. Unmanaged sites are further divided as deep (≥5m depth) or shallow (<5m depth). The classification is used to apply a methane correction factor (MCF) to account for the methane generation potential of the site. Land disposal is the only method of management of MSW in Croatia so far, therefore all generated MSW eventually ended in SWDSs. The total annual MSW disposed to different types of SWDSs in the period 1990-2001 and related MCF are reported in table 7.2-1.

Table 7.2-1: Total annual MSW disposed to SWDSs in Croatia and related MCF (1990-2001)

Year	Managed SWDS (Gg)	Unmanaged SWDS (≥5m) (Gg)	Unmanaged SWDS (<5m) (Gg)	Total (Gg/yr)	MCF (fraction)
1990	30	470	500	1000	0.606
1991	31	458	491	980	0.606
1992	32	449	488	970	0.605
1993	34	455	496	985	6.606
1994	38	478	489	1005	0.613
1995	44	524	492	1060	0.623
1996	48	548	504	1100	0.625
1997	54	587	509	1150	0.632
1998	60	620	525	1205	0.636
1999	70	691	492	1253	0.654
2000	75	773	325	1173	0.702
2001	75	773	325	1173	0.702

The resulting annual emissions of CH_4 from land disposal of municipal solid waste in the period 1990-2001 are presented in figure 7.2-1.

The uncertainties contained in these estimates are related primarily to applied default methodology which assumes that all potential methane is released in the year the waste is disposed of and county-specific data on waste generation and composition. The default methodology gives a reasonable estimation of actual emissions if the amount and composition of waste have been constant or slightly varying over a period of several decades. According to national waste experts it is practically impossible to estimate amounts and composition of waste

[14] The *Revised 1996 IPCC Guidelines* provide a default value of 77 percent for DOC that is converted to landfill gas, but this value, according to review of recent literature, is too high.

over a long period of time, especially before 1990, due to lack of adequate information, and therefore First Order Decay methodology could not be applied at this moment.

In addition, SWDSs in Croatia are classified into two categories: “Official” and “Unofficial” according to applied waste management activities. Municipal solid waste which is disposed to “Official” SWDSs is in most cases collected in an organized manner by registered companies. “Official” SWDSs do not necessarily fall under managed SWDSs category as defined by IPCC (site management activities carried out in “Official” SWDSs in most cases do not meet requirements to be characterized as managed). “Unofficial” SWDSs can be described as locations where all sorts of waste are dumped uncontrollably without any site management activities carried out. In order to adjust country-specific to IPCC SWDSs classification it was proposed that all “Unofficial” SWDSs fall under unmanaged shallow sites (<5m), whereas “Official” SWDSs fall under all three IPCC categories depending on management activities and dimensions of waste disposal sites. It is obvious that this distribution represents additional uncertainty in the estimation of country-specific MCF.

Another uncertainty is related to estimation of degradable organic carbon (DOC) in MSW. There were only few sorting of waste in Croatia, and in consequence of that these results were compared and adjust to relevant data in similar countries.

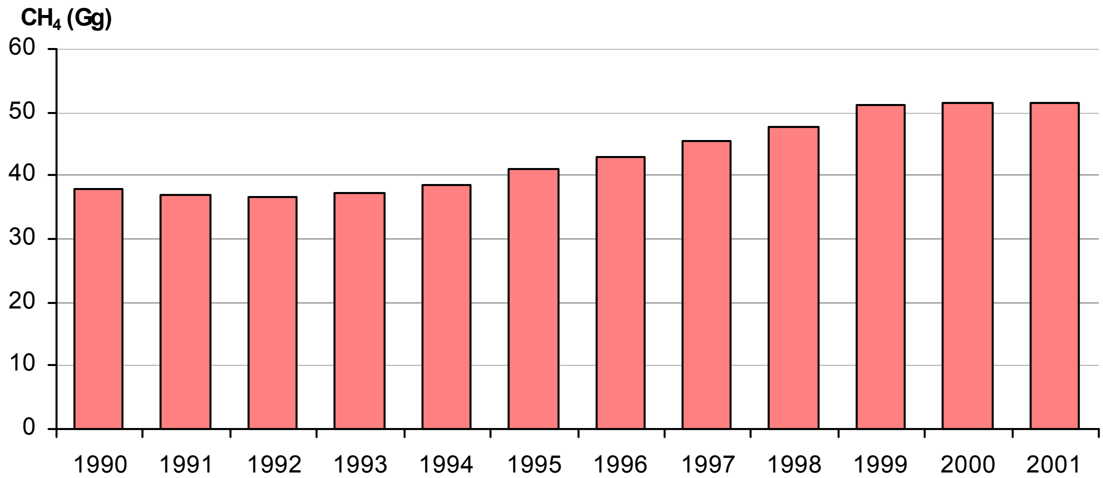

Figure 7.2-1: Emissions of CH_4 from land disposal of solid waste (1990-2001)

According to expert judgement and provided uncertainty assessment in *Good Practice Guidance* associated uncertainty is estimated to be of the order >$\pm$ 50 percent.

7.3. HUMAN SEWAGE

Indirect nitrous oxide (N_2O) emissions from human sewage were calculated using the methodology proposed by *Revised 1996 IPCC Guidelines* (by multiplying annual per capita protein intake, fraction of nitrogen in protein, number of people in country and default emission factor which equals 0.01 kg N_2O-N / kg sewage N produced).

During the period 1990-1995 in Croatia have been significant migrations of populations mainly due to war. There are no accurate statistical population data on annual basis; hence the results of 1991 census were taken into account for each year. For the period 1996-2001 population data were taken from Statistical Yearbooks published by Central Bureau of Statistics.

Data on the annual per capita protein consumption were taken from FAOSTAT Statistical Database provided by the United Nations Food and Agriculture Organization (FAO). Because data on protein intake were unavailable for Croatia in the period 1990-1995, an assumption has been made that an average protein intake in Croatia is equal to those in other European countries. For the period 1996-2001 data on protein intake for Croatia were taken from FAOSTAT Statistical Database (see table 7.3-1).

Table 7.3-1: Average protein intake (1990-1995)

Year	Protein intake (kg/person/yr)	Population
1990	37.45	4784265
1991	37.38	4784265
1992	35.62	4784265
1993	35.26	4784265
1994	35.04	4784265
1995	35.00	4784265
1996	23.76	4494000
1997	23.14	4572500
1998	22.56	4501000
1999	24.71	4554000
2000	24.60	4381000
2001	24.66	4437460

The resulting annual emissions of N_2O from human sewage in the period 1990-2001 are presented in figure 7.3-1.

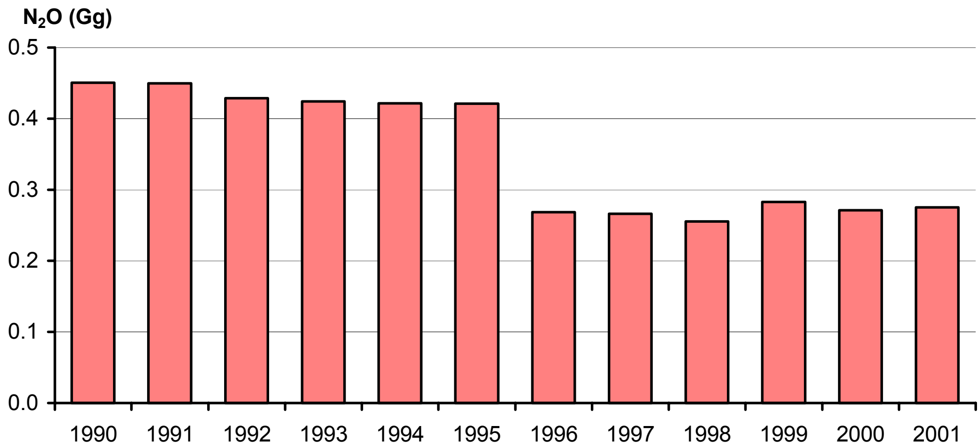

Figure 7.3-1: Emissions of N_2O from human sewage (1990-2001)

The uncertainties contained in these estimates are related to population data for the period 1990-1995 and protein intake for the period 1996-2001. Concerning the protein intake it is believed that there are no significant differences in domestic and European average protein intake for the period 1990-1995. Data for protein intake, which were taken from FAOSTAT Statistical Database for Croatia for the period 1996-2001 were considerable smaller from European average protein intake and could influence uncertainty of estimates of N_2O emissions.

According to expert judgement associated uncertainty is estimated to be in the medium level (from ±10 to ±50 percent).

7.4. WASTE INCINERATION

Incineration of waste produces emissions of CO_2, CH_4 and N_2O. According to *Revised 1996 IPCC Guidelines* only CO_2 emissions resulting from incineration of carbon in waste of fossil origin (e.g. plastics, textiles, rubber, liquid solvents and waste oil) without energy recovery, should be included in emission estimates from Waste sector. Emissions from incineration with energy recovery should be reported in the Energy sector.

Scarce of data on generation and composition of waste which were incinerated and type of incineration (with or without energy recovery) resulted that greenhouse gases emissions were not included in estimations for the period 1990-2001.

7.5. EMISSION REVIEW

Emissions of greenhouse gases from waste management activities in the period 1990-2001 are presented in table 7.5-1.

Table 7.5-1: Emissions from Waste (1990-2001)

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg eqCO_2)	Percent in Waste	Percent in Total Country Emission
Land Disposal of Solid Waste	1990	CH_4	37.77	21	793.25	85.03	2.51
	1991		37.02		777.40	84.80	3.13
	1992		36.58		768.18	85.26	3.33
	1993		37.20		781.37	85.59	3.43
	1994		38.40		806.42	86.06	3.69
	1995		41.16		864.44	86.88	3.88
	1996		42.85		899.94	91.54	3.86
	1997		45.30		951.38	92.03	3.82
	1998		47.77		1003.19	92.68	3.99
	1999		51.08		1072.68	92.44	4.10
	2000		51.33		1077.89	92.77	4.13
	2001		51.33		1077.89	92.67	4.01
Human Sewage	1990	N_2O	0.45	310	139.50	14.97	0.44
	1991		0.45		139.50	15.20	0.56
	1992		0.43		132.83	14.74	0.58
	1993		0.42		131.44	14.41	0.58
	1994		0.42		130.51	13.94	0.59
	1995		0.42		130.51	13.12	0.59
	1996		0.27		83.23	8.46	0.36
	1997		0.27		82.47	7.97	0.33
	1998		0.26		79.15	7.32	0.31
	1999		0.28		87.71	7.56	0.34
	2000		0.27		84.00	7.23	0.32
	2001		0.28		85.29	7.33	0.32
Waste Incineration	1990-2001	CO_2	NE	1	-	-	-

[1] Time horizon chosen for GWP values is 100 years

NE – emission is not estimated

7.6. REFERENCES

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Ministry of Environmental Protection and Physical Planning: *Report of Environment Condition, http://www.mzopu.hr/okolis*

8. INVENTORY ANALYSIS

8.1. COMPLETENESS

The data completeness means that the inventory includes all the sources and sinks, all the pollutants in the IPCC Guidelines, and all specific sources that are characteristic for the country but not covered by the Guidelines. The inventory provides transparent information about possible shortcomings due to an incomplete and/or inadequate methodology, and insufficient inputs for the calculation. The inventory indicates the sources and sinks not considered but methodologically addressed in the IPCC Guidelines and explains the reasons for their exemption. If adequate data are not available, we used adequate marking for filling the empty boxes in the table of the common reporting format (CRF); in the cases when emission is not occurring (NO), when the emission is not estimated (NE), when the emission is included elsewhere (IE) and when the data are confidential (C). Such an approach made possible to develop a complete inventory.

If a country estimates the emissions and removals from the country specific sources/sinks and they are not included in the IPCC Guidelines, these categories (sectors, sub-sectors) or the pollutants should be explicitly described including the methodology applied, and the emission factors and the activity data used for their identification. In Croatia a substantial source of CO_2 was identified as a result of natural gas scrubbing at Central Gas Station Molve, which is shown and elaborated within the Energy sector and in the CFR tables.

8.2. VERIFICATION

The verification process of calculation is aimed at the improvement of the input quality and identification of the 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.
- The 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 5.2 percent (Tables ES.4-5 and A2-6).
- The CO_2 emissions from road transport were estimated by the IPCC Tier 1 approach. Also, the rough estimate for 1990 was done by using COPERT 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.

In March 2002, Croatia organized an in-depth international review of the First National Communication, which also include the greenhouse gas inventory. Generally, their opinion of the inventory quality was good. A large number of comments and suggestions made for the inventory improvement during the international review have been taken into account when making this inventory.

8.3. UNCERTAINTIES

The uncertainty assessment of the calculation is a key element of the national emission inventory. The information about the uncertainty does not dispute the calculation validity but helps with the identification of the priority measures for higher accuracy of the calculation and for selection of the methodological options. There are several reasons why the actual emissions and sinks are different in comparison with the figures obtained by the calculation. Totally quantified uncertainty of the emission from certain sources is a combination of some uncertainties of the emission estimate elements:

- uncertainty related to the emission factors
- uncertainty related to the activity data

Some uncertainty sources could generate well defined and easy to characterize assessments of possible error range unlike the others that are difficult to define. The uncertainty assessed is either in function of the instrument properties, calibration and the frequency of sampling at direct measurement or (which is the most often case) a combination of uncertainty of the emission factors for typical sources and corresponding activity data.

When reporting on the emissions and removals of the greenhouse gases the uncertainty of the calculations should be shown together with the methodology used for its identification. The national experts for making inventories are encouraged to provide a good-quality assessment of uncertainty as far as practicable.

The experts involved in making this GHG emissions/removals inventory have assessed for the first time the total uncertainty of the entire inventory for 2001 and the emission trend for the period from 1990 to 2001 following the guidelines given in the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. The approach used was the simpler Tier 1 Level approach. The uncertainty of the total emission assessment for each year depends on the emission uncertainty for each sector/activity that is on the uncertainty of activity data and the emission factors used. Generally, the typical emission factors stated in the IPCC Guidelines have been used in the calculation for which the uncertainty (or reliability) has been determined. An expert evaluation has been made for the activity data and the remainder emission factors.

The quantitative assessment of uncertainty is presented in the Annex 3 (Table A3-1). The total uncertainty of GHG emission estimate for 2001 has been assessed at 36.8 percent whereas the trend uncertainty at 8.7 percent. The higher reliability of trend is easy to understand and results from the calculation consistency, one of the basic principles of the IPCC methodology. According to the IPCC methodology, if an error is noticed in the calculation, or the new emission source is identified or the new emission factor better than previously used is applied, a recalculation should be performed. In such a way the emission trend consistency is achieved i.e. the application of the same methodology and the same scope of data for the entire period considered. When compared with the inventories from other years, the inventory should be internally consistent in all its elements.

The uncertainty of the calculation of certain emissions from some sectors/sub-sectors is quantified and presented in Table 8.3-1 and categorized at several levels: to ±10 percent high reliability level, from ±10 to ±50 percent medium reliability level, and above ±50 percent low reliability level.

Table 8.3-1: Qualitative analysis of uncertainty

High reliability level
• CO_2 Emissions from Fuel Combustion • CO_2 Emissions from Natural Gas Scrubbing • CO_2 Emissions from Industrial Processes (Cement and Ammonia Production)
Medium reliability level
• CH_4 Emissions from Fuel Combustion • CO_2 Emissions from Industrial Processes (Lime Production, Limestone and Dolomite Use, Soda Ash Production and Use, Iron and Steal Production, Ferroalloys Production, Aluminium Production) • CH_4 Emissions from Industrial Processes (Other Chemical Production) • N_2O Emissions from Industrial Processes (Nitric Acid Production) • N_2O Emissions from Human Sewage
Low reliability level
• N_2O Emissions from Fuel Combustion • CH_4 Fugitive Emissions from Coal Mining and Handling • CH_4 Fugitive Emissions from Oil and Natural Gas • HFC Emissions from HFC Consumption • CH_4 Emissions from Enteric Fermentation in Domestic Livestock • CH_4 and N_2O Emissions from Manure Management • N_2O Emissions from Agricultural Soils • CH_4 Emissions from Solid Waste Disposal Sites

8.4. KEY SOURCES

The Annex I Parties to the Convention should identify their key emission sources for the base year, for the last year of inventory and for the emission trend. The key emission sources are the sources that substantially contribute to the total GHG emissions (95 percent) with all the emissions presented as equivalent emission of CO_2. The emissions from each source are summed up starting with the most significant to the less significant sources thus excluding from the emission key sources the least significant sources whose emissions cover the remaining 5 percent.

Table 8.4-1 shows the emission key sources in Croatia obtained by analyzing the total emission of the last year inventory (Level Assessment) and the trend analysis (Trend Assessment) according to the methodology given in the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. A detailed outline of the emission key sources analysis is given in the Annex 3, Table A3-2 to A3-4.

Table 8.4-1: Key sources of GHG emission in Croatia (Tier 1)

IPCC Category Source	GHG	Level/Trend
ENERGY		
Stationary Sources - Coal	CO_2	Level, Trend
Stationary Sources – Liquid Fuel	CO_2	Level, Trend
Stationary Sources – Natural Gas	CO_2	Level, Trend
Stationary Sources – All Fuel	CH_4	Trend
Mobile Sources – Road Transport	CO_2	Level, Trend
Mobile Sources – Domestic Aviation Transport	CO_2	Trend
Mobile Sources – Agriculture/Forestry/Fishing	CO_2	Level, Trend
Mobile Sources – Road Transport	N_2O	Trend
Fugitive Sources – Natural Gas and Oil	CH_4	Level, Trend
Natural Gas Scrubbing* - CPS Molve	CO_2	Level, Trend
INDUSTRIAL PROCESSES		
Cement Production	CO_2	Level, Trend
Ammonia Production	CO_2	Level
Ferroalloys Production	CO_2	Trend
Nitric Acid Production	N_2O	Level, Trend
AGRICULTURE		
Enteric Fermentation	CH_4	Level, Trend
Manure Management	N_2O	Level
Direct N_2O Emission from Agricultural Soils	N_2O	Level, Trend
Indirect N_2O Emission from Nitrogen Used in Agriculture	N_2O	Level
WASTE		
Managed Waste Disposal on Land	CH_4	Level, Trend

*** CO_2 Emission from Natural Gas Scrubbing** – IPCC doesn't offer methodology for estimating emission of CO_2 scrubbed from natural gas and subsequently emitted into atmosphere. Natural gas produced in Croatian gas fields has a large amount of CO_2, more than 15 percent. The maximum volume content CO_2 in commercial natural gas is 3 percent and gas must be cleaned before coming to pipeline and transport to users. Because of that, the Scrubbing Units exist at largest Croatian gas field. The CO_2, scrubbed from natural gas, is emitted into atmosphere. The emission is estimated by material balance method.

9. CONCLUSION

This inventory report comprises greenhouse gas emissions in the Republic of Croatia for the period 1990-2001. The structure of inventory report is in line with Annex I of the *Guidelines for the preparation of national communication by parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories* (FCCC/CP/2002/8). The methodology used for emissions calculation is in line with the *Revised 1996 IPCC Guidelines for National GHG Inventories (IPCC/UNEP/OECD/IEA)* and *Good Practice Guidance and Uncertainty Management in National GHG Inventories, 2000 (IPCC/NGGIP),* recommended by the UNFCCC.

The GHG emissions by sources and removals by sinks in Croatia for the period 1990-2001 are shown on Figure 9-1.

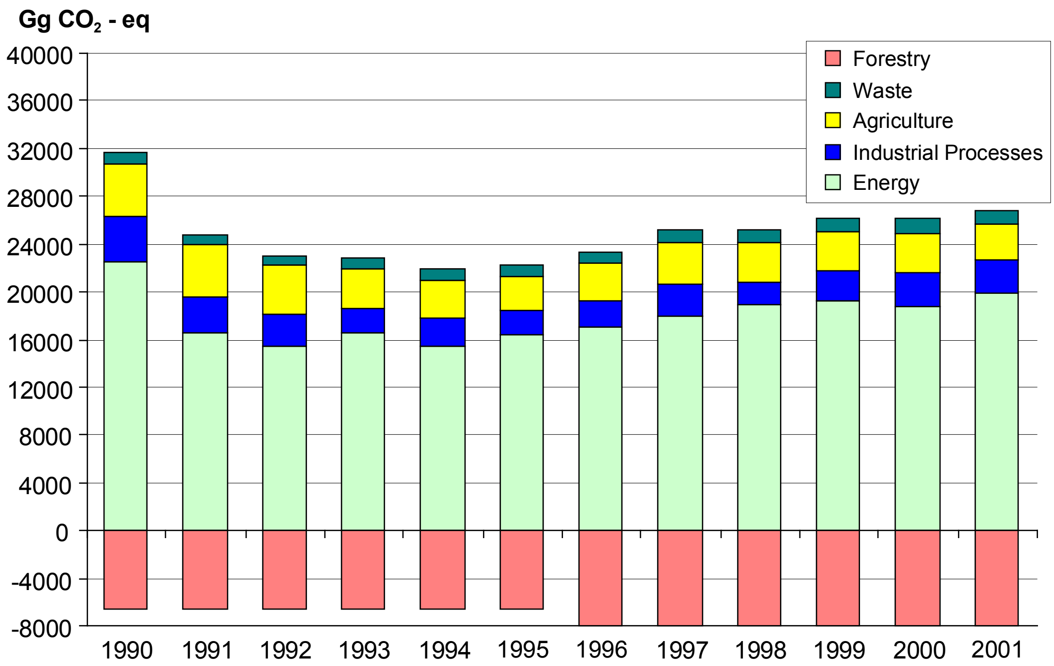

Figure 9-1: Total emissions/removals of GHGs from 1990 to 2001

After a considerable decrease of emissions in 1991, as a result of reduced economic activities and energy consumption, this negative trend continued until 1994. From 1995 to 2001 emissions increased with average rate of 3.2 percent. **If the emissions will continue to increase with this rate, emission limit set up by Kyoto protocol will be exceeded in 2005.**

According to the calculation results for the period from 1990 to 2001, the contribution of CO_2 to the total emission of GHGs on the territory of the Republic of Croatia was in range of 67-76 percent, CH_4 and N_2O in range of 12-15 percent each, and HFCs less than 0.5 percent.

The GHG emission key sources have been determined according to IPCC Tier I methodology. There are 19 key sources of emission (Annex 3, Tables A3-2 to A3-4) which have been identified by the analysis of the last year inventory of total emission and the analysis of the emission trend from 1990 to 2001.

Assessment of total uncertainty of the 2001 inventory and of the emission trend for the period 1990-2001 was estimated. The total uncertainty of GHG emission inventory in 2001 is 36.8 percent whereas the uncertainty of the trend is 8.7 percent (Annex 3, Table A3-1). Higher reliability of the trend is the result of the calculation consistency, which means the application of the same methodology and the same scope of data for the entire period considered.

Within the scope of this report, inventory team prepared all CRF tables for the period 1990-2001 and fulfil reporting requirements prescribed by UNFCCC, which gives good basis for future annual inventory submissions.

ANNEX 1

GREENHOUSE GAS EMISSION TREND

Table A1-1: Greenhouse gas emission in 1990, Croatia

Croatia	CO_2	CH_4		N_2O		HFC,PFC and SF_6		TOTAL	Share
Year 1990	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**20959.42**	**67.81**	**1423.94**	**0.26**	**79.58**	**0.00**	**0.00**	**22462.9**	**71.07**
Energy Industries	5896.55	0.18	3.86	0.04	13.84			5914.2	18.71
Manufacturing Industries and Constr.	6545.89	0.51	10.66	0.07	20.40			6576.9	20.81
Transport	4046.04	0.78	16.32	0.04	12.54			4074.9	12.89
Domestic Aviation	*295.61*	*0.00*	*0.04*	*0.01*	*2.59*			*298.2*	*0.94*
Road	*3479.92*	*0.76*	*15.87*	*0.03*	*9.22*			*3505.0*	*11.09*
Railways	*137.53*	*0.01*	*0.21*	*0.00*	*0.39*			*138.1*	*0.44*
National Navigation	*132.98*	*0.01*	*0.19*	*0.00*	*0.34*			*133.5*	*0.42*
Other Sectors	3616.10	7.52	157.90	0.11	32.73			3806.7	12.04
Commercial/Institutional	*782.14*	*0.09*	*1.97*	*0.01*	*1.77*			*785.9*	*2.49*
Residential	*1994.78*	*7.36*	*154.63*	*0.09*	*28.92*			*2178.3*	*6.89*
Agriculture / Forestry/Fishing	*839.19*	*0.06*	*1.30*	*0.01*	*2.04*			*842.5*	*2.67*
Other *	438.89	0.01	0.18	0.00	0.07			439.2	1.39
Fugitive	415.95	58.81	1235.02					1651.0	5.22
Coal		*2.32*	*48.76*					*48.8*	*0.15*
Oil & Natural gas	*415.95*	*56.49*	*1186.26*					*1602.2*	*5.07*
Industrial Processes	**2010.47**	**0.75**	**15.80**	**2.99**	**927.56**	**0.14**	**938.60**	**3892.4**	**12.31**
Cement production	1022.90							1022.9	3.24
Lime production	145.07							145.1	0.46
Limestone and dolomite use	18.91							18.9	0.06
Soda ash production and use	25.74							25.7	0.08
Ammonia production	491.55							491.6	1.56
Nitric acid production				2.99	927.56			927.6	2.93
Product. of other chemicals		0.75	15.80					15.8	0.05
Iron and steel production								0.0	0.00
Ferroalloys production	194.93							194.9	0.62
Aluminium production	111.37							111.4	0.35
HFC, PFC and SF_6 **						0.14	938.60	938.6	2.97
Agriculture	**0.00**	**75.32**	**1581.76**	**8.83**	**2738.84**	**0.00**	**0.00**	**4320.6**	**13.67**
Enteric fermentation		64.06	1345.34		0.00			1345.3	4.26
Manure management		11.05	232.08	1.21	376.52			608.6	1.93
Agricultural soils management				7.62	2361.08			2361.1	7.47
Agricultural residue burning		0.21	4.34	0.00	1.24			5.6	0.02
Land-use Change & Forestry	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.13							-6505.1	-20.58
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**37.77**	**793.25**	**0.45**	**139.65**	**0.00**	**0.00**	**932.9**	**2.95**
Land Disposal of Solid Waste		37.77	793.25					793.3	2.51
Human Sewage				0.45	139.65			139.7	0.44
Other	**0.00**		**0.00**		**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
TOTAL EMISSIONS	**22969.89**	**181.65**	**3814.75**	**12.53**	**3885.63**	**0.14**	**938.60**	**31608.9**	**100.00**
NET EMISSIONS (Sources and Sinks)	**16464.76**	**181.65**	**3814.75**	**12.53**	**3885.63**	**0.14**	**938.60**	**25103.7**	
Share of Gases in Total Emissions (%)	**72.67**		**12.07**		**12.29**		**2.97**	**100.0**	
Share of Gases in Net Emissions (%)	**65.59**		**15.20**		**15.48**		**3.74**	**100.0**	
International aviation bunkers * **	**202.26**	**0.00**	**0.03**	**0.01**	**1.77**			**204.1**	
International marine bunkers * **	**108.54**	**0.01**	**0.15**	**0.00**	**0.27**			**109.0**	

* - non-energy fuel cons. and statistical difference

** - PFC: 0.13 CF_4 + 0.013 C_2F_6

*** - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

Table A1-2: Greenhouse gas emission in 1991, Croatia

Croatia	CO_2	CH_4		N_2O		HFC,PFC and SF_6		TOTAL	Share
Year 1991	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**15200.46**	**62.49**	**1312.35**	**0.18**	**54.83**	**0.00**	**0.00**	**16567.6**	**66.79**
Energy Industries	3846.95	0.12	2.51	0.03	9.29			3858.7	15.56
Manufacturing Industries and Constr.	4732.07	0.39	8.24	0.05	15.25			4755.6	19.17
Transport	2916.56	0.59	12.30	0.03	8.21			2937.1	11.84
Domestic Aviation	*80.90*	*0.00*	*0.01*	*0.00*	*0.71*			*81.6*	*0.33*
Road	*2581.14*	*0.57*	*11.92*	*0.02*	*6.84*			*2599.9*	*10.48*
Railways	*146.65*	*0.01*	*0.22*	*0.00*	*0.39*			*147.3*	*0.59*
National Navigation	*107.86*	*0.01*	0.15	*0.00*	*0.27*			*108.3*	*0.44*
Other Sectors	3003.32	4.92	103.22	0.07	22.08			3128.6	12.61
Commercial/Institutional	*539.80*	*0.07*	*1.37*	*0.00*	*1.18*			*542.3*	*2.19*
Residential	*1735.55*	*4.79*	*100.66*	*0.06*	*19.13*			*1855.3*	*7.48*
Agriculture / Forestry/Fishing	*727.97*	*0.06*	*1.19*	*0.01*	*1.76*			*730.9*	*2.95*
Other (non-energy fuel consumption)	245.73							245.7	0.99
Fugitive	455.83	56.48	1186.08					1641.9	6.62
Coal		*4.88*	*102.40*					*102.4*	*0.41*
Oil & Natural gas	*455.83*	*51.60*	*1083.68*					*1539.5*	*6.21*
Industrial Processes	**1501.16**	**0.55**	**11.49**	**2.63**	**814.67**	**0.10**	**648.30**	**2975.6**	**12.00**
Cement production	647.46							647.5	2.61
Lime production	86.93							86.9	0.35
Limestone and dolomite use	15.69							15.7	0.06
Soda ash production and use	21.75							21.8	0.09
Ammonia production	471.50							471.5	1.90
Nitric acid production				2.63	814.67			814.7	3.28
Product. of other chemicals		0.55	11.49					11.5	0.05
Iron and steel production								0.0	0.00
Ferroalloys production	181.42							181.4	0.73
Aluminium production	76.40							76.4	0.31
HFC, PFC and SF6 *						0.10	648.30	648.3	2.61
Agriculture	**0.00**	**71.91**	**1510.13**	**9.14**	**2833.80**	**0.00**	**0.00**	**4343.9**	**17.51**
Enteric fermentation		61.06	1282.29		0.00			1282.3	5.17
Manure management		10.85	227.84	1.17	361.27			589.1	2.38
Agricultural soils management				7.98	2472.52			2472.5	9.97
Agricultural residue burning								0.0	0.00
Land-use Change & Forestry	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.13							-6505.1	-26.23
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**37.02**	**777.52**	**0.45**	**139.39**	**0.00**	**0.00**	**916.9**	**3.70**
Land Disposal of Solid Waste		37.02	777.52					777.5	3.13
Human Sewage				0.45	139.39			139.4	0.56
Other	**0.00**		**0.00**		**0.00**			**0.0**	**0.00**
TOTAL EMISSIONS	**16701.61**	**171.98**	**3611.50**	**12.40**	**3842.68**	**0.10**	**648.30**	**24804.1**	**100.00**
NET EMISSIONS (Sources and Sinks)	**10196.48**	**171.98**	**3611.50**	**12.40**	**3842.68**	**0.10**	**648.30**	**18299.0**	
Share of Gases in Total Emissions (%)	**67.33**		**14.56**		**15.49**		**2.61**	**100.0**	
Share of Gases in Net Emissions (%)	**55.72**		**19.74**		**21.00**		**3.54**	**100.0**	
International aviation bunkers **	**17.11**	**0.00**	**0.00**	**0.00**	**0.15**			**17.3**	
International marine bunkers **	**71.34**	**0.00**	**0.10**	**0.00**	**0.18**			**71.6**	

*- PFC: 0.087 CF_4 + 0.009 C_2F_6

** - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

Table A1-3: Greenhouse gas emission in 1992, Croatia

Croatia	**CO_2**	**CH_4**		**N_2O**		**HFC, PFC and SF_6**		**TOTAL**	Share
Year 1992	**(Gg)**	**(Gg)**	**(Gg CO2eq)**	**(Gg)**	**(Gg CO2eq)**	**(Gg)**	**(Gg CO2eq)**	**(Gg CO2eq)**	%
Energy	**14186.64**	**58.69**	**1232.51**	**0.16**	**48.55**	**0.00**	**0.00**	**15467.7**	**67.01**
Energy Industries	4514.10	0.14	2.86	0.03	10.79			4527.7	19.62
Manufacturing Industries and Constr.	3730.07	0.32	6.68	0.04	11.74			3748.5	16.24
Transport	2781.33	0.52	11.01	0.02	7.44			2799.8	12.13
Domestic Aviation	*32.05*	*0.00*	*0.00*	*0.00*	*0.28*			*32.3*	*0.14*
Road	*2485.77*	*0.51*	*10.62*	*0.02*	*6.49*			*2502.9*	*10.84*
Railways	*96.72*	*0.01*	*0.14*	*0.00*	*0.25*			*97.1*	*0.42*
National Navigation	*166.79*	*0.01*	*0.24*	*0.00*	*0.42*			*167.5*	*0.73*
Other Sectors	2494.70	3.88	81.53	0.06	18.58			2594.8	11.24
Commercial/Institutional	*393.71*	*0.05*	*0.98*	*0.00*	*0.76*			*395.4*	*1.71*
Residential	*1463.01*	*3.79*	*79.53*	*0.05*	*16.33*			*1558.9*	*6.75*
Agriculture / Forestry/Fishing	*637.98*	*0.05*	*1.02*	*0.00*	*1.50*			*640.5*	*2.77*
Other (non-energy fuel consumption)	189.10							189.1	0.82
Fugitive	477.33	53.83	1130.44					1607.8	6.97
Coal		*1.61*	*33.77*					*33.8*	*0.15*
Oil & Natural gas	*477.33*	*52.22*	*1096.68*					*1574.0*	*6.82*
Industrial Processes	**1577.88**	**0.46**	**9.74**	**3.44**	**1065.21**	**0.00**	**0.00**	**2652.8**	**11.49**
Cement production	774.68							774.7	3.36
Lime production	54.49							54.5	0.24
Limestone and dolomite use	10.54							10.5	0.05
Soda ash production and use	14.68							14.7	0.06
Ammonia production	606.76							606.8	2.63
Nitric acid production				3.44	1065.21			1065.2	4.61
Product. of other chemicals		0.46	9.74					9.7	0.04
Iron and steel production	0.00							0.0	0.00
Ferroalloys production	116.73							116.7	0.51
Aluminium production	0.00							0.0	0.00
HFC, PFC and SF_6						0.00	0.00	0.0	0.00
Agriculture	**0.00**	**67.08**	**1408.69**	**8.55**	**2651.88**	**0.00**	**0.00**	**4060.6**	**17.59**
Enteric fermentation		56.59	1188.34		0.00			1188.3	5.15
Manure management		10.49	220.35	1.09	338.01			558.4	2.42
Agricultural soils management				7.46	2313.87			2313.9	10.02
Agricultural residue burning								0.0	0.00
Land-use Change & Forestry	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.13							-6505.1	-28.18
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**36.59**	**768.45**	**0.43**	**132.83**	**0.00**	**0.00**	**901.3**	**3.90**
Land Disposal of Solid Waste		36.59	768.45					768.4	3.33
Human Sewage				0.43	132.83			132.8	0.58
Other	**0.00**		**0.00**		**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
TOTAL EMISSIONS	**15764.52**	**162.83**	**3419.39**	**12.58**	**3898.47**	**0.00**	**0.00**	**23082.4**	**100.00**
NET EMISSIONS (Sources and Sinks)	**9259.39**	**162.83**	**3419.39**	**12.58**	**3898.47**	**0.00**	**0.00**	**16577.2**	
Share of Gases in Total Emissions (%)	**68.30**		**14.81**		**16.89**		**0.00**	**100.0**	
Share of Gases in Net Emissions (%)	**55.86**		**20.63**		**23.52**		**0.00**	**100.0**	
International aviation bunkers *	**46.36**	**0.00**	**0.01**	**0.00**	**0.41**			**46.8**	
International marine bunkers *	**80.62**	**0.01**	**0.11**	**0.00**	**0.20**			**80.9**	

* - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

Table A1-4: Greenhouse gas emission in 1993, Croatia

Croatia	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	Share
Year 1993	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO2eq)	(Gg)	(Gg CO2eq)	(Gg CO_2eq)	%
Energy	**15146.11**	**63.45**	**1332.40**	**0.15**	**47.88**	**0.00**	**0.00**	**16526.4**	**72.54**
Energy Industries	5184.89	0.16	3.26	0.04	11.10			5199.3	22.82
Manufacturing Industries and Constr	3657.88	0.31	6.50	0.04	11.32			3675.7	16.13
Transport	2948.63	0.52	11.01	0.03	8.03			2967.7	13.03
Domestic Aviation	*64.41*	*0.00*	*0.01*	*0.00*	*0.56*			*65.0*	*0.29*
Road	*2661.91*	*0.51*	*10.68*	*0.02*	*6.91*			*2679.5*	*11.76*
Railways	*101.08*	*0.01*	*0.14*	*0.00*	*0.26*			*101.5*	*0.45*
National Navigation	*121.24*	*0.01*	*0.17*	*0.00*	*0.30*			*121.7*	*0.53*
Other Sectors	2484.26	3.52	73.99	0.06	17.43			2575.7	11.31
Commercial/Institutional	*489.32*	*0.06*	*1.16*	*0.00*	*0.96*			*491.4*	*2.16*
Residential	*1356.90*	*3.42*	*71.84*	*0.05*	*14.93*			*1443.7*	*6.34*
Agriculture / Forestry/Fishing	*638.04*	*0.05*	*0.99*	*0.00*	*1.54*			*640.6*	*2.81*
Other (non-energy fuel consumption)	194.34							194.3	0.85
Fugitive	676.12	58.94	1237.64					1913.8	8.40
Coal		*1.54*	*32.31*					*32.3*	*0.14*
Oil & Natural gas	*676.12*	*57.40*	*1205.33*					*1881.5*	*8.26*
Industrial Processes	**1253.10**	**0.50**	**10.48**	**2.59**	**802.98**	**0.00**	**0.00**	**2066.6**	**9.07**
Cement production	648.49							648.5	2.85
Lime production	60.25							60.3	0.26
Limestone and dolomite use	9.60							9.6	0.04
Soda ash production and use	12.53							12.5	0.06
Ammonia production	471.34							471.3	2.07
Nitric acid production				2.59	802.98			803.0	3.52
Product. of other chemicals		0.50	10.48					10.5	0.05
Iron and steel production	0.00							0.0	0.00
Ferroalloys production	50.88							50.9	0.22
Aluminium production	0.00							0.0	0.00
HFC, PFC and SF_6						0.00	0.00	0.0	0.00
Agriculture	**0.00**	**55.57**	**1166.96**	**6.81**	**2110.53**	**0.00**	**0.00**	**3277.5**	**14.39**
Enteric fermentation		47.14	990.00		0.00			990.0	4.35
Manure management		8.43	176.96	0.91	281.22			458.2	2.01
Agricultural soils management				5.90	1829.31			1829.3	8.03
Agricultural residue burning								0.0	0.00
Land-use Change & Forestry	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.13							-6505.1	-28.55
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**37.18**	**780.88**	**0.42**	**131.48**	**0.00**	**0.00**	**912.4**	**4.00**
Land Disposal of Solid Waste		37.18	780.88					780.9	3.43
Human Sewage				0.42	131.48			131.5	0.58
Other	**0.00**		**0.00**		**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
TOTAL EMISSIONS	**16399.21**	**156.70**	**3290.73**	**9.98**	**3092.88**	**0.00**	**0.00**	**22782.8**	**100.00**
NET EMISSIONS (Sources and Sinks)	**9894.08**	**156.70**	**3290.73**	**9.98**	**3092.88**	**0.00**	**0.00**	**16277.7**	
Share of Gases in Total Emissions (%)	**71.98**		**14.44**		**13.58**		**0.00**	**100.0**	
Share of Gases in Net Emissions (%)	**60.78**		**20.22**		**19.00**		**0.00**	**100.0**	
International aviation bunkers *	**130.69**	**0.00**	**0.02**	**0.00**	**1.14**			**131.9**	
International marine bunkers *	**114.54**	**0.01**	**0.16**	**0.00**	**0.28**			**115.0**	

* - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

Table A1-5: Greenhouse gas emission in 1994, Croatia

Croatia	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	Share
Year 1994	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO2eq)	(Gg CO_2eq)	%
Energy	**14235.12**	**57.80**	**1213.74**	**0.15**	**45.53**	**0.00**	**0.00**	**15494.4**	**70.89**
Energy Industries	3924.56	0.12	2.61	0.02	7.71			3934.9	18.00
Manufacturing Industries and Constr.	3814.87	0.30	6.33	0.03	10.80			3832.0	17.53
Transport	3124.04	0.57	11.95	0.03	8.50			3144.5	14.39
Domestic Aviation	*64.41*	*0.00*	*0.01*	*0.00*	*0.56*			*65.0*	*0.30*
Road	*2878.22*	*0.56*	*11.68*	*0.02*	*7.48*			*2897.4*	*13.26*
Railways	*94.21*	*0.01*	*0.13*	*0.00*	*0.24*			*94.6*	*0.43*
National Navigation	*87.20*	*0.01*	*0.12*	*0.00*	*0.22*			*87.5*	*0.40*
Other Sectors	2567.65	3.67	77.01	0.06	18.52			2663.2	12.18
Commercial/Institutional	*552.40*	*0.06*	*1.36*	*0.00*	*1.04*			*554.8*	*2.54*
Residential	*1372.24*	*3.56*	*74.67*	*0.05*	*15.90*			*1462.8*	*6.69*
Agriculture / Forestry/Fishing	*643.00*	*0.05*	*0.98*	*0.01*	*1.58*			*645.6*	*2.95*
Other (non-energy fuel consumption)	199.13							199.1	0.91
Fugitive	604.87	53.14	1115.84					1720.7	7.87
Coal		*1.38*	*28.97*					*29.0*	*0.13*
Oil & Natural gas	*604.87*	*51.76*	*1086.87*					*1691.7*	*7.74*
Industrial Processes	**1438.78**	**0.48**	**10.06**	**2.80**	**868.35**	**0.00**	**0.00**	**2317.2**	**10.60**
Cement production	793.81							793.8	3.63
Lime production	59.65							59.7	0.27
Limestone and dolomite use	15.50							15.5	0.07
Soda ash production and use	15.21							15.2	0.07
Ammonia production	474.73							474.7	2.17
Nitric acid production				2.80	868.35			868.3	3.97
Product. of other chemicals		0.48	10.06					10.1	0.05
Iron and steel production	0.00							0.0	0.00
Ferroalloys production	79.88							79.9	0.37
Aluminium production	0.00							0.0	0.00
HFC, PFC and SF_6						0.00	0.00	0.0	0.00
Agriculture	**0.00**	**50.78**	**1066.37**	**6.59**	**2042.72**	**0.00**	**0.00**	**3109.1**	**14.22**
Enteric fermentation		42.36	889.51		0.00			889.5	4.07
Manure management		8.42	176.86	0.84	259.10			436.0	1.99
Agricultural soils management				5.75	1783.62			1783.6	8.16
Agricultural residue burning								0.0	0.00
Land-use Change & Forestry	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.13							-6505.1	-29.76
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**38.41**	**806.63**	**0.42**	**130.66**	**0.00**	**0.00**	**937.3**	**4.29**
Land Disposal of Solid Waste		38.41	806.63					806.6	3.69
Human Sewage				0.42	130.66			130.7	0.60
Other	**0.00**		**0.00**		**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
NET EMISSIONS (Sources and Sinks)	**15673.90**	**147.47**	**3096.79**	**9.96**	**3087.26**	**0.00**	**0.00**	**21857.9**	**100.00**
Share of Gases in Total Emissions (%)	**9168.77**	**147.47**	**3096.79**	**9.96**	**3087.26**	**0.00**	**0.00**	**15352.8**	
Share of Gases in Net Emissions (%)	**71.71**		**14.17**		**14.12**		**0.00**	**100.0**	
Udjel plinova u neto emisiji (%)	**59.72**		**20.17**		**20.11**		**0.00**	**100.0**	
International aviation bunkers *	**199.46**	**0.00**	**0.03**	**0.01**	**1.75**			**201.2**	
International marine bunkers *	**138.33**	**0.01**	**0.19**	**0.00**	**0.34**			**138.9**	

* - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

Table A1-6: Greenhouse gas emission in 1995, Croatia

Croatia	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	Share
Year 1995	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**15081.87**	**58.19**	**1222.05**	**0.16**	**48.83**	**0.00**	**0.00**	**16352.7**	**73.47**
Energy Industries	4459.92	0.16	3.26	0.03	10.07			4473.2	20.10
Manufacturing Industries and Constr.	3617.02	0.28	5.97	0.03	10.54			3633.5	16.32
Transport	3337.20	0.60	12.60	0.03	9.19			3359.0	15.09
Domestic Aviation	*88.68*	*0.00*	*0.01*	*0.00*	*0.78*			*89.5*	*0.40*
Road	*3044.16*	*0.59*	*12.30*	*0.03*	*7.90*			*3064.4*	*13.77*
Railways	*106.09*	*0.01*	*0.15*	*0.00*	*0.27*			*106.5*	*0.48*
National Navigation	*98.28*	*0.01*	*0.14*	*0.00*	*0.25*			*98.7*	*0.44*
Other Sectors	2777.69	3.76	79.02	0.06	19.03			2875.7	12.92
Commercial/Institutional	*601.40*	*0.07*	*1.46*	*0.00*	*1.08*			*603.9*	*2.71*
Residential	*1595.98*	*3.65*	*76.66*	*0.05*	*16.53*			*1689.2*	*7.59*
Agriculture / Forestry/Fishing	*580.31*	*0.04*	*0.89*	*0.00*	*1.42*			*582.6*	*2.62*
Other (non-energy fuel consumption)	193.10							193.1	0.87
Fugitive	696.92	53.39	1121.20					1818.1	8.17
Coal		*1.10*	*23.07*					*23.1*	*0.10*
Oil & Natural gas	*696.92*	*52.29*	*1098.13*					*1795.1*	*8.06*
Industrial Processes	**1169.49**	**0.40**	**8.41**	**2.69**	**835.04**	**0.01**	**7.80**	**2020.7**	**9.08**
Cement production	584.89							584.9	2.63
Lime production	62.27							62.3	0.28
Limestone and dolomite use	11.19							11.2	0.05
Soda ash production and use	14.39							14.4	0.06
Ammonia production	462.85							462.9	2.08
Nitric acid production				2.69	835.04			835.0	3.75
Product. of other chemicals		0.40	8.41					8.4	0.04
Iron and steel production	0.00							0.0	0.00
Ferroalloys production	33.91							33.9	0.15
Aluminum production	0.00							0.0	0.00
HFC, PFC and SF_6 *						0.01	7.80	7.8	0.04
Agriculture	**0.00**	**48.06**	**1009.28**	**6.07**	**1881.37**	**0.00**	**0.00**	**2890.7**	**12.99**
Enteric fermentation		40.44	849.30		0.00			849.3	3.82
Manure management		7.62	159.98	0.80	246.87			406.8	1.83
Agricultural soils management				5.27	1634.50			1634.5	7.34
Agricultural residue burning								0.0	0.00
Land-use Change & Forestry	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
Forest and other woody biomass stocks (sink)	-6505.13							-6505.1	-29.23
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**41.15**	**864.11**	**0.42**	**130.51**	**0.00**	**0.00**	**994.6**	**4.47**
Land Disposal of Solid Waste		41.15	864.11					864.1	3.88
Human Sewage				0.42	130.51			130.5	0.59
Other	**0.00**		**0.00**		**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
TOTAL EMISSIONS	**16251.36**	**147.80**	**3103.85**	**9.34**	**2895.75**	**0.01**	**7.80**	**22258.8**	**100.00**
NET EMISSIONS (Sources and Sinks)	**9746.23**	**147.80**	**3103.85**	**9.34**	**2895.75**	**0.01**	**7.80**	**15753.6**	
Share of Gases in Total Emissions (%)	**73.01**		**13.94**		**13.01**		**0.04**	**100.0**	
Share of Gases in Net Emissions (%)	**61.87**		**19.70**		**18.38**		**0.05**	**100.0**	
International aviation bunkers **	**175.19**	**0.00**	**0.03**	**0.00**	**1.53**			**176.7**	
International marine bunkers **	**102.01**	**0.01**	**0.14**	**0.00**	**0.25**			**102.4**	

* - HFC_3 consumption
** - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

Table A1-7: Greenhouse gas emission in 1996, Croatia

Croatia	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	Share
Year 1996	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**15726.64**	**61.22**	**1285.63**	**0.21**	**63.93**	**0.00**	**0.00**	**17076.2**	**73.14**
Energy Industries	4310.04	0.14	3.00	0.03	8.76			4321.8	18.51
Manufacturing Industries and Constr.	3762.87	0.29	6.05	0.03	10.74			3779.7	16.19
Transport	3668.07	0.67	14.03	0.07	21.56			3703.7	15.86
Domestic Aviation	*106.73*	*0.00*	0.02	*0.00*	0.93			*107.7*	*0.46*
Road	*3312.91*	*0.65*	13.66	*0.06*	20.00			*3346.6*	*14.33*
Railways	*99.59*	*0.01*	0.14	*0.00*	0.25			*100.0*	*0.43*
National Navigation	*148.84*	*0.01*	0.21	*0.00*	0.37			*149.4*	*0.64*
Other Sectors	3135.86	4.59	96.29	0.07	22.87			3255.0	13.94
Commercial/Institutional	*608.13*	*0.07*	1.50	*0.00*	1.13			*610.8*	*2.62*
Residential	*1779.25*	*4.46*	93.64	*0.06*	19.93			*1892.8*	*8.11*
Agriculture/ Forestry/Fishing	*748.48*	*0.06*	1.16	*0.01*	1.81			*751.4*	*3.22*
Other (non-energy fuel consumption)	205.76							205.8	0.88
Fugitive	644.04	55.54	1166.26					1810.3	7.75
Coal		*0.89*	18.61					*18.6*	*0.08*
Oil & Natural gas	*644.04*	*54.65*	1147.65					*1791.7*	*7.67*
Industrial Processes	**1249.49**	**0.38**	**7.94**	**2.51**	**777.53**	**0.19**	**60.15**	**2095.1**	**8.97**
Cement production	634.01							634.0	2.72
Lime production	79.15							79.2	0.34
Limestone and dolomite use	8.50							8.5	0.04
Soda ash production and use	11.41							11.4	0.05
Ammonia production	502.68							502.7	2.15
Nitric acid production				2.51	777.53			777.5	3.33
Product. of other chemicals		0.38	7.94					7.9	0.03
Iron and steel production								0.0	0.00
Ferroalloys production	13.73							13.7	0.06
Aluminium production								0.0	0.00
HFC, PFC and SF_6						0.19	60.15	60.2	0.26
Agriculture	**0.00**	**45.34**	**952.05**	**7.23**	**2240.33**	**0.00**	**0.00**	**3192.4**	**13.67**
Enteric fermentation		37.86	795.06					795.1	3.41
Manure management		7.48	156.99	1.21	374.93			531.9	2.28
Agricultural soils management				6.02	1865.41			1865.4	7.99
Agricultural residue burning								0.0	0.00
Land-use Change & Forestry	**-8069.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-8069.2**	**-34.56**
Forest and other woody biomass stocks (sink)	-8069.18							-8069.2	-34.56
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**42.89**	**900.62**	**0.27**	**83.23**	**0.00**	**0.00**	**983.8**	**4.21**
Land Disposal of Solid Waste		42.89	900.62					900.6	3.86
Human Sewage				0.27	83.23			83.2	0.36
Other	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
TOTAL EMISSIONS	**16976.13**	**149.82**	**3146.25**	**10.21**	**3165.02**	**0.19**	**60.15**	**23347.5**	**100.00**
NET EMISSIONS (Sources and Sinks)	**8906.95**	**149.82**	**3146.25**	**10.21**	**3165.02**	**0.19**	**60.15**	**15278.4**	
Share of Gases in Total Emissions (%)	**72.71**		**13.48**		**13.56**		**0.26**	**100.0**	
Share of Gases in Net Emissions (%)	**58.30**		**20.59**		**20.72**		**0.39**	**100.0**	
International aviation bunkers *	**114.91**	**0.01**	**0.16**	**0.00**	**0.28**			**175.5**	
International marine bunkers *	**173.94**	**0.00**	**0.03**	**0.00**	**1.52**			**115.4**	

* - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

Table A1-8: Greenhouse gas emission in 1997, Croatia

Croatia	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	Share
Year 1997	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**16607.11**	**64.30**	**1350.24**	**0.26**	**79.57**	**0.00**	**0.00**	**18036.9**	**72.39**
Energy Industries	4874.87	0.15	3.22	0.04	11.21			4889.3	19.62
Manufacturing Industries and Constr.	3714.10	0.31	6.55	0.04	11.21			3731.9	14.98
Transport	4013.22	0.73	15.27	0.11	34.61			4063.1	16.31
Domestic Aviation	*110.14*	*0.00*	0.02	*0.00*	0.96			*111.1*	*0.45*
Road	*3689.48*	*0.71*	14.95	*0.11*	33.11			*3737.5*	*15.00*
Railways	*95.52*	*0.01*	0.14	*0.00*	0.22			*95.9*	*0.38*
National Navigation	*118.07*	*0.01*	0.17	*0.00*	0.30			*118.5*	*0.48*
Other Sectors	3179.94	4.55	95.48	0.07	22.76			3298.2	13.24
Commercial/Institutional	*646.59*	*0.08*	1.63	*0.00*	1.26			*649.5*	*2.61*
Residential	*1939.19*	*4.43*	92.96	*0.06*	20.08			*2052.2*	*8.24*
Agriculture/ Forestry/Fishing	*594.16*	*0.04*	0.89	*0.00*	1.43			*596.5*	*2.39*
Other (non-energy fuel consumption)	225.21							225.2	0.90
Fugitive	599.78	58.56	1229.73					1829.5	7.34
Coal		*0.65*	13.61					*13.6*	*0.05*
Oil & Natural gas	*599.78*	*57.91*	1216.11					*1815.9*	*7.29*
Industrial Processes	**1449.75**	**0.34**	**7.15**	**2.64**	**817.17**	**0.04**	**91.18**	**2365.3**	**9.49**
Cement production	753.47							753.5	3.02
Lime production	101.63							101.6	0.41
Limestone and dolomite use	7.25							7.2	0.03
Soda ash production and use	9.68							9.7	0.04
Ammonia production	546.23							546.2	2.19
Nitric acid production				2.64	817.17			817.2	3.28
Product. of other chemicals		0.34	7.15					7.1	0.03
Iron and steel production								0.0	0.00
Ferroalloys production	31.50							31.5	0.13
Aluminium production								0.0	0.00
HFC, PFC and SF_6						0.04	91.18	91.2	0.37
Agriculture	**0.00**	**44.50**	**934.57**	**8.21**	**2543.96**	**0.00**	**0.00**	**3478.5**	**13.96**
Enteric fermentation		37.17	780.53					780.5	3.13
Manure management		7.34	154.04	1.20	371.36			525.4	2.11
Agricultural soils management				7.01	2172.60			2172.6	8.72
Agricultural residue burning								0.0	0.00
Land-use Change & Forestry	**-8069.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-8069.2**	**-32.39**
Forest and other woody biomass stocks (sink)	-8069.18							-8069.2	-32.39
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**45.33**	**952.02**	**0.27**	**82.47**	**0.00**	**0.00**	**1034.5**	**4.15**
Land Disposal of Solid Waste		45.33	952.02					952.0	3.82
Human Sewage				0.27	82.47			82.5	0.33
Other	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
TOTAL EMISSIONS	**18056.87**	**154.48**	**3243.98**	**11.37**	**3523.17**	**0.04**	**91.18**	**24915.2**	**100.00**
NET EMISSIONS (Sources and Sinks)	**9987.69**	**154.48**	**3243.98**	**11.37**	**3523.17**	**0.04**	**91.18**	**16846.0**	
Share of Gases in Total Emissions (%)	**72.47**		**13.02**		**14.14**		**0.4**	**100.0**	
Share of Gases in Net Emissions (%)	**59.29**		**19.26**		**20.91**		**0.5**	**100.0**	
International aviation bunkers *	**73.63**	**0.00**	**0.10**	**0.00**	**0.18**			**146.3**	
International marine bunkers *	**145.01**	**0.00**	**0.03**	**0.00**	**1.52**			**73.9**	

* - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

Table A1-9: Greenhouse gas emission in 1998, Croatia

Croatia / Year 1998	CO_2 (Gg)	CH_4 (Gg)	CH_4 (Gg CO_2eq)	N_2O (Gg)	N_2O (Gg CO_2eq)	HFC, PFC and SF_6 (Gg)	HFC, PFC and SF_6 (Gg CO_2eq)	TOTAL (Gg CO_2eq)	Share %
Energy	**17593.74**	**56.37**	**1183.68**	**0.31**	**94.87**	**0.00**	**0.00**	**18872.3**	**75.06**
Energy Industries	5530.92	0.18	3.78	0.04	12.71			5547.4	22.06
Manufacturing Industries and Constr.	4008.26	0.32	6.64	0.04	11.44			4026.3	16.01
Transport	4162.63	0.78	16.30	0.16	50.48			4229.4	16.82
Domestic Aviation	*126.95*	*0.00*	0.02	*0.00*	1.11			*128.1*	*0.51*
Road	*3847.35*	*0.76*	16.02	*0.16*	48.89			*3912.3*	*15.56*
Railways	*98.02*	*0.01*	0.14	*0.00*	0.25			*98.4*	*0.39*
National Navigation	*90.31*	*0.01*	0.13	*0.00*	0.23			*90.7*	*0.36*
Other Sectors	3107.25	4.00	84.08	0.07	20.24			3211.6	12.77
Commercial/Institutional	*614.74*	*0.07*	1.52	*0.00*	1.19			*617.5*	*2.46*
Residential	*1841.45*	*3.88*	81.58	*0.06*	17.46			*1940.5*	*7.72*
Agriculture/ Forestry/Fishing	*651.06*	*0.05*	0.98	*0.01*	1.59			*653.6*	*2.60*
Other (non-energy fuel consumption)	195.50							195.5	0.78
Fugitive	589.17	51.09	1072.88					1662.0	6.61
Coal		*0.68*	14.26					*14.3*	*0.06*
Oil & Natural gas	*589.17*	*50.41*	1058.62					*1647.8*	*6.55*
Industrial Processes	**1362.41**	**0.32**	**6.65**	**1.98**	**615.22**	**0.01**	**17.57**	**2001.8**	**7.96**
Cement production	811.39							811.4	3.23
Lime production	105.77							105.8	0.42
Limestone and dolomite use	8.60							8.6	0.03
Soda ash production and use	11.49							11.5	0.05
Ammonia production	409.73							409.7	1.63
Nitric acid production				1.98	615.22			615.2	2.45
Product. of other chemicals		0.32	6.65					6.6	0.03
Iron and steel production								0.0	0.00
Ferroalloys production	15.42							15.4	0.06
Aluminium production								0.0	0.00
HFC, PFC and SF_6						0.01	17.57	17.6	0.07
Agriculture	**0.00**	**43.11**	**905.37**	**7.36**	**2280.81**	**0.00**	**0.00**	**3186.2**	**12.67**
Enteric fermentation		35.90	753.84					753.8	3.00
Manure management		7.22	151.53	1.17	362.23			513.8	2.04
Agricultural soils management				6.19	1918.58			1918.6	7.63
Agricultural residue burning								0.0	0.00
Land-use Change & Forestry	**-8069.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-8069.2**	**-32.09**
Forest and other woody biomass stocks (sink)	-8069.18							-8069.2	-32.09
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**47.75**	**1002.69**	**0.26**	**79.15**	**0.00**	**0.00**	**1081.8**	**4.30**
Land Disposal of Solid Waste		47.75	1002.69					1002.7	3.99
Human Sewage				0.26	79.15			79.1	0.31
Other	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
TOTAL EMISSIONS	**18956.14**	**147.54**	**3098.38**	**9.90**	**3070.05**	**0.01**	**17.57**	**25142.1**	**100.0**
NET EMISSIONS (Sources and Sinks)	**10886.97**	**147.54**	**3098.38**	**9.90**	**3070.05**	**0.01**	**17.57**	**17073.0**	
Share of Gases in Total Emissions (%)	**75.40**		**12.32**		**12.21**		**0.07**	**100.0**	
Share of Gases in Net Emissions (%)	**63.77**		**18.15**		**17.98**		**0.10**	**100.0**	
International aviation bunkers *	**81.00**	**0.01**	**0.11**	**0.00**	**0.20**			**149.7**	
International marine bunkers *	**148.43**	**0.00**	**0.02**	**0.00**	**1.30**			**81.3**	

* - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

Table A1-10: Greenhouse gas emission in 1999, Croatia

Croatia	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	Share
Year 1999	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**17965.86**	**56.10**	**1178.03**	**0.36**	**111.92**	**0.00**	**0.00**	**19255.8**	**73.63**
Energy Industries	5698.76	0.19	3.96	0.04	13.07			5715.8	21.86
Manufacturing Industries and Constr.	3729.40	0.27	5.69	0.03	10.04			3745.1	14.32
Transport	4394.36	0.82	17.17	0.22	67.83			4479.4	17.13
Domestic Aviation	*130.63*	*0.00*	0.02	*0.00*	1.15			*131.8*	*0.50*
Road	*4083.79*	*0.80*	16.89	*0.21*	66.23			*4166.9*	*15.93*
Railways	*92.39*	*0.01*	0.13	*0.00*	0.23			*92.8*	*0.35*
National Navigation	*87.55*	*0.01*	0.13	*0.00*	0.22			*87.9*	*0.34*
Other Sectors	3513.27	4.07	85.52	0.07	20.99			3619.8	13.84
Commercial/Institutional	*639.60*	*0.08*	1.59	*0.00*	1.20			*642.4*	*2.46*
Residential	*2032.85*	*3.93*	82.56	*0.06*	17.71			*2133.1*	*8.16*
Agriculture/ Forestry/Fishing	*840.81*	*0.07*	1.37	*0.01*	2.08			*844.3*	*3.23*
Other (non-energy fuel consumption)	104.83							104.8	0.40
Fugitive	525.25	50.75	1065.70					1590.9	6.08
Coal		*0.20*	4.29					*4.3*	*0.02*
Oil & Natural gas	*525.25*	*50.54*	1061.40					*1586.6*	*6.07*
Industrial Processes	**1712.78**	**0.27**	**5.73**	**2.34**	**725.95**	**0.00**	**9.09**	**2453.6**	**9.38**
Cement production	1072.55							1072.5	4.10
Lime production	102.57							102.6	0.39
Limestone and dolomite use	7.95							7.9	0.03
Soda ash production and use	10.60							10.6	0.04
Ammonia production	519.12							519.1	1.98
Nitric acid production				2.34	725.95			726.0	2.78
Product. of other chemicals		0.27	5.73					5.7	0.02
Iron and steel production								0.0	0.00
Ferroalloys production								0.0	0.00
Aluminium production								0.0	0.00
HFC, PFC and SF_6						0.00	9.09	9.1	0.03
Agriculture	**0.00**	**43.95**	**922.94**	**7.61**	**2359.05**	**0.00**	**0.00**	**3282.0**	**12.55**
Enteric fermentation		35.96	755.24					755.2	2.89
Manure management		7.99	167.70	1.24	382.89			550.6	2.11
Agricultural soils management				6.37	1976.15			1976.2	7.56
Agricultural residue burning								0.0	0.00
Land-use Change & Forestry	**-8069.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-8069.2**	**-30.85**
Forest and other woody biomass stocks (sink)	-8069.18							-8069.2	-30.85
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**51.10**	**1073.08**	**0.28**	**87.71**	**0.00**	**0.00**	**1160.8**	**4.44**
Land Disposal of Solid Waste		51.10	1073.08					1073.1	4.10
Human Sewage				0.28	87.71			87.7	0.34
Other	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
TOTAL EMISSIONS	**19678.64**	**151.42**	**3179.78**	**10.60**	**3284.63**	**0.00**	**9.09**	**26152.1**	**100.00**
NET EMISSIONS (Sources and Sinks)	**11609.46**	**151.42**	**3179.78**	**10.60**	**3284.63**	**0.00**	**9.09**	**18083.0**	
Share of Gases in Total Emissions (%)	**75.25**		**12.16**		**12.56**		**0.03**	**100.0**	
Share of Gases in Net Emissions (%)	**64.20**		**17.58**		**18.16**		**0.05**	**100.0**	
International aviation bunkers *	**65.68**	**0.00**	**0.09**	**0.00**	**0.16**			**138.4**	
International marine bunkers *	**137.23**	**0.00**	**0.02**	**0.00**	**1.20**			**65.9**	

* - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

Table A1-11: Greenhouse gas emission in 2000, Croatia

Croatia	CO_2	CH_4		N_2O		HFC, PFC and SF_6		TOTAL	Share
Year 2000	(Gg)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg)	(Gg CO_2eq)	(Gg CO_2eq)	%
Energy	**17447.46**	**58.69**	**1232.54**	**0.44**	**137.35**	**0.00**	**0.00**	**18817.3**	**72.11**
Energy Industries	5155.94	0.14	2.87	0.04	13.28			5172.1	19.82
Manufacturing Industries and Constr.	3804.63	0.28	5.83	0.03	10.31			3820.8	14.64
Transport	4396.02	0.82	17.27	0.29	90.66			4503.9	17.26
Domestic Aviation	*110.46*	*0.00*	0.02	*0.00*	0.97			*111.4*	*0.43*
Road	*4114.35*	*0.81*	17.01	*0.29*	89.26			*4220.6*	*16.17*
Railways	*85.49*	*0.01*	0.12	*0.00*	0.22			*85.8*	*0.33*
National Navigation	*85.71*	*0.01*	0.12	*0.00*	0.22			*86.1*	*0.33*
Other Sectors	3358.97	4.55	95.47	0.07	23.10			3477.5	13.33
Commercial/Institutional	*605.13*	*0.07*	1.54	*0.00*	1.21			*607.9*	*2.33*
Residential	*1896.34*	*4.41*	92.62	*0.06*	19.77			*2008.7*	*7.70*
Agriculture/ Forestry/Fishing	*857.50*	*0.06*	1.31	*0.01*	2.13			*860.9*	*3.30*
Other (non-energy fuel consumption)	98.90							98.9	0.38
Fugitive	633.02	52.91	1111.10					1744.1	6.68
Coal								*0.0*	*0.00*
Oil & Natural gas	*633.02*	*52.91*	1111.10					*1744.1*	*6.68*
Industrial Processes	**1931.65**	**0.29**	**6.04**	**2.76**	**854.30**	**0.01**	**23.10**	**2815.1**	**10.79**
Cement production	1242.25							1242.2	4.76
Lime production	124.25							124.3	0.48
Limestone and dolomite use	8.41							8.4	0.03
Soda ash production and use	11.01							11.0	0.04
Ammonia production	525.25							525.2	2.01
Nitric acid production				2.76	854.30			854.3	3.27
Product. of other chemicals		0.29	6.04					6.0	0.02
Iron and steel production								0.0	0.00
Ferroalloys production	20.48							20.5	0.08
Aluminium production								0.0	0.00
HFC, PFC and SF_6						0.01	23.10	23.1	0.09
Agriculture	**0.00**	**42.57**	**894.01**	**7.77**	**2408.74**	**0.00**	**0.00**	**3302.8**	**12.66**
Enteric fermentation		35.16	738.32					738.3	2.83
Manure management		7.41	155.69	1.20	372.39			528.1	2.02
Agricultural soils management				6.57	2036.35			2036.4	7.80
Agricultural residue burning								0.0	0.00
Land-use Change & Forestry	**-8069.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-8069.2**	**-30.92**
Forest and other woody biomass stocks (sink)	-8069.18							-8069.2	-30.92
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**51.33**	**1077.89**	**0.27**	**84.00**	**0.00**	**0.00**	**1161.9**	**4.45**
Land Disposal of Solid Waste		51.33	1077.89					1077.9	4.13
Human Sewage				0.27	84.00			84.0	0.32
Other	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
TOTAL EMISSIONS	**19379.11**	**152.88**	**3210.49**	**11.24**	**3484.39**	**0.01**	**23.10**	**26097.1**	**100.00**
NET EMISSIONS (Sources and Sinks)	**11309.93**	**152.88**	**3210.49**	**11.24**	**3484.39**	**0.01**	**23.10**	**18027.9**	
Share of Gases in Total Emissions (%)	**74.26**		**12.30**		**13.35**		**0.09**	**100.0**	
Share of Gases in Net Emissions (%)	**62.74**		**17.81**		**19.33**		**0.13**	**100.0**	
International aviation bunkers *	**57.02**	**0.00**	**0.08**	**0.00**	**0.14**			**115.8**	
International marine bunkers *	**114.82**	**0.00**	**0.02**	**0.00**	**1.01**			**57.2**	

* - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

Table A1-12: Greenhouse gas emission in 2001, Croatia

Croatia Year 2001	CO_2 (Gg)	CH_4 (Gg)	CH_4 (Gg CO_2eq)	N_2O (Gg)	N_2O (Gg CO_2eq)	HFC, PFC i SF_6 (Gg)	HFC, PFC i SF_6 (Gg CO_2eq)	TOTAL (Gg CO_2eq)	Share %
Energy	**18378.69**	**63.92**	**1342.35**	**0.50**	**153.86**	**0.00**	**0.00**	**19874.9**	**74.00**
Energy Industries	5650.32	0.15	3.14	0.05	14.48			5667.9	21.10
Manufacturing Industries and Constr.	3903.14	0.27	5.77	0.03	10.19			3919.1	14.59
Transport	4459.15	0.81	16.98	0.35	109.89			4586.0	17.07
Domestic Aviation	*110.78*	*0.00*	0.02	*0.00*	0.97			*111.8*	*0.42*
Road	*4168.82*	*0.80*	16.71	*0.35*	108.47			*4294.0*	*15.99*
Railways	*87.69*	*0.01*	0.13	*0.00*	0.22			*88.0*	*0.33*
National Navigation	*91.86*	*0.01*	0.13	*0.00*	0.23			*92.2*	*0.34*
Other Sectors	3576.41	3.56	74.85	0.06	19.30			3670.6	13.67
Commercial/Institutional	*709.66*	*0.08*	1.78	*0.00*	1.34			*712.8*	*2.65*
Residential	*2068.47*	*3.42*	71.88	*0.05*	16.02			*2156.4*	*8.03*
Agriculture/ Forestry/Fishing	*798.29*	*0.06*	1.20	*0.01*	1.94			*801.4*	*2.98*
Other (non-energy fuel consumption)	102.03							102.0	0.38
Fugitive	687.64	59.12	1241.59					1929.2	7.18
Coal								*0.0*	*0.00*
Oil & Natural gas	*687.64*	*59.12*	1241.59					*1929.2*	*7.18*
Industrial Processes	**2010.99**	**0.31**	**6.41**	**2.32**	**718.52**	**0.02**	**48.99**	**2784.9**	**10.37**
Cement production	1419.61							1419.6	5.29
Lime production	143.48							143.5	0.53
Limestone and dolomite use	9.24							9.2	0.03
Soda ash production and use	12.37							12.4	0.05
Ammonia production	425.83							425.8	1.59
Nitric acid production				2.32	718.52			718.5	2.68
Product. of other chemicals		0.31	6.41					6.4	0.02
Iron and steel production								0.0	0.00
Ferroalloys production	0.47							0.5	0.00
Aluminium production								0.0	0.00
HFC, PFC and SF_6						0.02	48.99	49.0	0.18
Agriculture	**0.00**	**43.09**	**904.91**	**6.87**	**2130.66**	**0.00**	**0.00**	**3035.6**	**11.30**
Enteric fermentation		35.64	748.38					748.4	2.79
Manure management		7.45	156.53	1.21	375.11			531.6	1.98
Agricultural soils management				5.66	1755.56			1755.6	6.54
Agricultural residue burning								0.0	0.00
Land-use Change & Forestry	**-8069.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-8069.2**	**-30.04**
Forest and other woody biomass stocks (sink)	-8069.18							-8069.2	-30.04
Changes in soil carbon								0.0	0.00
Waste	**0.00**	**51.33**	**1077.89**	**0.28**	**85.29**	**0.00**	**0.00**	**1163.2**	**4.33**
Land Disposal of Solid Waste		51.33	1077.89					1077.9	4.01
Human Sewage				0.28	85.29			85.3	0.32
Other	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**
TOTAL EMISSIONS	**20389.68**	**158.65**	**3331.56**	**9.96**	**3088.34**	**0.02**	**48.99**	**26858.6**	**100.00**
NET EMISSIONS (Sources and Sinks)	**12320.51**	**158.65**	**3331.56**	**9.96**	**3088.34**	**0.02**	**48.99**	**18789.4**	
Share of Gases in Total Emissions (%)	**75.91**		**12.40**		**11.50**		**0.18**	**100.0**	
Share of Gases in Net Emissions (%)	**65.57**		**17.73**		**16.44**		**0.26**	**100.0**	
International aviation bunkers *	**89.37**	**0.01**	**0.13**	**0.00**	**0.22**			**115.5**	
International marine bunkers *	**114.51**	**0.00**	**0.02**	**0.00**	**1.00**			**89.7**	

* - Emissions from International Marine and Aviation Bunkers are not included in nationals totals.

ANNEX 2

ADDITIONAL ENERGY INDICATORS

Table A2-1: Fuel consumption from 1990 to 2001

Total Fossil Fuels (TJ)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Energy Industries	84144	55738	64537	76771	59135	62945
Manuf. Industries and Constr.	86605	65446	53968	53626	56141	52807
Transport	57433	41430	39432	41693	44227	47236
Commercial/Institutional	11142	7993	6022	7445	8375	9246
Residential	28397	25978	22659	21321	21470	25232
Agriculture/Forestry/Fishing	11668	10223	8995	8908	8918	8074
Total	272883	206808	195611	209764	198266	205539
Non-energy Consumption	15777	8574	7087	6108	5622	5417
Biomass	22680	15640	13610	12890	13100	14200
International Bunkers	4302	1191	1728	3364	4649	3832

Table A2-1: Fuel consumption from 1990 to 2001 (continue)

Total Fossil Fuel (TJ)	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Energy Industries	62795	69615	78033	79823	71687	78485
Manuf. Industries and Constr.	55005	54966	59342	54959	56069	57264
Transport	51886	56748	58969	62236	62266	63059
Commercial/Institutional	9226	9678	9237	9659	8998	10731
Residential	28447	30783	29493	32648	30188	33128
Agriculture/Forestry/Fishing	10436	8314	9062	11563	11841	11119
Total	**217795**	**230104**	**244138**	**250888**	**241048**	**253786**
Non-energy consumption	5668	6204	5386	5351	5156	4862
Biomass	16140	16700	14660	13927	15640	12240
International Bunkers	3982	3023	3177	2821	2380	2809

Table A2-2: Liquid fossil fuel consumption from 1990 to 1995

Liquid Fossil Fuels (TJ)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Energy Industries	49720	31991	35817	39304	32678	46083
Manuf. Industries and Constr.	40183	30141	24211	24547	25440	25742
Transport	57218	41347	39432	41693	44227	47236
Commercial/Institutional	6685	4452	3131	2939	4331	4448
Residential	15769	12129	11579	9754	10518	11778
Agriculture/Forestry/Fishing	10818	9335	7873	8174	8415	7547
Other	14339					
Total	**188226**	**129395**	**122043**	**126412**	**125608**	**142833**

Table A2-2: Liquid fossil fuel consumption from 1990 to 2001(continue)

Liquid Fossil (TJ)	1996	1997	1998	1999	2000	2001
Energy Industries	40083	41791	50925	54260	32572	35638
Manuf. Industries and Constr.	27450	25809	29179	28516	28805	29459
Transport	51886	56748	58969	62236	62266	63059
Commercial/Institutional	4736	5561	4885	5282	5429	6041
Residential	12087	13761	11880	12592	12717	13662
Agriculture/Forestry/Fishing	9579	7549	8430	11131	11348	10316
Other						
Total	**145821**	**151219**	**164268**	**174017**	**153137**	**158175**

Table A2-3: Solid fossil fuel consumption from 1990 to 2001

Solid Fossil Fuels (TJ)	1990	1991	1992	1993	1994	1995
Energy Industries	8740	6459	8024	6530	2004	2418
Manuf. Industries and Constr.	17417	10751	6742	5608	5619	4493
Transport	214	83				
Commercial/Institutional	972	596	208	668	270	252
Residential	4808	3156	1366	911	528	490
Agriculture/Forestry/Fishing						
Other						
Total	**32152**	**21044**	**16340**	**13717**	**8422**	**7653**

Table A2-3: Solid fossil fuel consumption from 1990 to 2001(continue)

Solid Fossil (TJ)	1996	1997	1998	1999	2000	2001
Energy Industries	1493	5863	5960	5412	14900	16184
Manuf. Industries and Constr.	4303	3980	3361	2734	3328	3461
Transport	0	0	0	0	0	0
Commercial/Institutional	281	238	360	212	213	168
Residential	516	471	610	703	587	375
Agriculture/Forestry/Fishing	0	0	0	0	0	0
Other						
Total	**6593**	**10552**	**10290**	**9061**	**19027**	**20189**

Table A2-4: Gaseous fossil fuel consumption from 1990 to 2001

Gaseous Fossil Fuels (TJ)	1990	1991	1992	1993	1994	1995
Energy Industries	25684	17289	20696	30937	24453	14443
Manuf. Industries and Constr.	29005	24555	23015	23470	25082	22573
Transport						
Commercial/Institutional	3485	2944	2683	3839	3774	4546
Residential	7820	10693	9714	10656	10424	12964
Agriculture/Forestry/Fishing	850	887	1122	734	503	527
Other	1438					
Total	**68282**	**56369**	**57229**	**69635**	**64236**	**55053**

Table A2-4: Gaseous fossil fuel consumption from 1990 to 2001(continue)

Natural Gas (TJ)	1996	1997	1998	1999	2000	2001
Energy Industries	21219	21961	21148	20152	24215	26663
Manuf. Industries and Constr.	23253	25177	26802	23708	23936	24344
Transport	0	0	0	0	0	0
Commercial/Institutional	4209	3879	3992	4165	3356	4522
Residential	15844	16551	17003	19353	16884	19091
Agriculture/Forestry/Fishing	857	765	632	432	493	802
Other						
Total	**65382**	**68333**	**69578**	**67810**	**68884**	**75422**

Table A2-5 Net calorific values for different fossil fuels from 1990 to 2001

			Net calorific values 1990- 2001
			MJ/kg(m^3)
Liquid Fossil	Primary Fuel	Crude Oil	41.87-42.4
	Secondary Fuel	Motor Gasoline	44.59
		Jet Kerosene	43.96
		Gas/Diesel Oil	42.71
		Residual Fuel Oil	40.19
		LPG	46.89
		Naphtha	44.57
		Bitumen	33.5
		Lubricants	33.5
		Refinery Gas	48.57
		Petroleum Coke	29.31-31
		Ethane	47.31
Solid Fossil	Primary Fuel	Anthracite	29.29-29.31
		Other Bituminous Coal	25.14-26.9
		Sub Bituminous Coal	16.74-18.73
		Lignite	10.52-12.15
	Secondary Fuel	Gas Work Gas	15.82 -19.49
		Coke Oven Coke	29.31
			TJ/Mm^3
Natural Gas		Natural Gas	34
Biomass		Solid Biomass. Fuel Wood	9

Table A2-6: Fuel Combustion CO_2 Emissions (Reference and Sectoral Approach)

YEAR	FUEL TYPES	Reference approach		National approach		Difference	
		Energy consumption (PJ)	**CO_2 emissions (Gg)**	**Energy consumption (PJ)**	**CO_2 emissions (Gg)**	**Energy consumption (%)**	**CO_2 emissions (%)**
1990	Liquid Fuels *	191.29	13.028.53	188.23	13.570.17	1.63	-3.99
	Solid Fuels *	34.27	3.102.87	32.15	3.161.82	6.60	-1.86
	Gaseous Fuels	68.28	3.811.48	68.28	3.811.48	0.00	0.00
	Total	**293.85**	**19.942.88**	**288.66**	**20.543.47**	**1.80**	**-2.92**
1991	Liquid Fuels *	133.52	9.190.25	137.97	9.652.72	-3.22	-4.79
	Solid Fuels *	21.07	1.850.52	21.04	1.945.44	0.13	-4.88
	Gaseous Fuels	56.37	3.146.47	56.37	3.146.47	0.00	0.00
	Total	**210.96**	**14.187.24**	**215.38**	**14.744.63**	**-2.05**	**-3.78**
1992	Liquid Fuels *	124.69	8.606.63	129.13	9.109.08	-3.44	-5.52
	Solid Fuels *	16.80	1.433.76	16.34	1.405.74	2.79	1.99
	Gaseous Fuels	57.23	3.194.48	57.23	3.194.48	0.00	0.00
	Total	**198.72**	**13.234.87**	**202.70**	**13.709.30**	**-1.96**	**-3.46**
1993	Liquid Fuels *	123.46	8.656.56	132.52	9.417.21	-6.84	-8.08
	Solid Fuels *	14.19	1.176.38	13.72	1.165.77	3.42	0.91
	Gaseous Fuels	69.64	3.887.01	69.64	3.887.01	0.00	0.00
	Total	**207.28**	**13.719.95**	**215.87**	**14.470.00**	**-3.98**	**-5.18**
1994	Liquid Fuels *	129.12	9.246.44	131.23	9.323.79	-1.60	-0.83
	Solid Fuels *	8.99	753.01	8.42	720.83	6.74	4.47
	Gaseous Fuels	64.24	3.585.63	64.24	3.585.63	0.00	0.00
	Total	**202.35**	**13.585.09**	**203.89**	**13.630.25**	**-0.75**	**-0.33**
1995	Liquid Fuels *	144.32	10.286.50	148.25	10.598.64	-2.65	-2.95
	Solid Fuels *	7.29	696.28	7.65	713.28	-4.75	-2.38
	Gaseous Fuels	55.05	3.073.02	55.05	3.073.02	0.00	0.00
	Total	**206.66**	**14.055.80**	**210.96**	**14.384.94**	**-2.04**	**-2.29**
1996	Liquid Fuels *	150.78	10.601.74	151.49	10.819.21	-0.47	-2.01
	Solid Fuels *	6.21	581.76	6.59	613.80	-5.86	-5.22
	Gaseous Fuels	65.38	3.649.59	65.38	3.649.59	0.00	0.00
	Total	**222.37**	**14.833.09**	**223.46**	**15.082.60**	**-0.49**	**-1.65**
1997	Liquid Fuels *	151.59	10.608.77	157.42	11.213.67	-3.70	-5.39
	Solid Fuels *	10.17	948.59	10.55	979.34	-3.57	-3.14
	Gaseous Fuels	68.33	3.814.33	68.33	3.814.33	0.00	0.00
	Total	**230.10**	**15.371.69**	**236.31**	**16.007.34**	**-2.63**	**-3.97**
1998	Liquid Fuels *	167.88	11.790.93	169.65	12.170.03	-1.04	-3.12
	Solid Fuels *	9.87	920.05	10.29	950.75	-4.05	-3.23
	Gaseous Fuels	69.58	3.883.79	69.58	3.883.79	0.00	0.00
	Total	**247.33**	**16.594.77**	**249.52**	**17.004.57**	**-0.88**	**-2.41**
1999	Liquid Fuels *	180.87	12.695.27	179.37	12.822.59	0.84	-0.99
	Solid Fuels *	8.63	803.39	9.06	832.92	-4.81	-3.55
	Gaseous Fuels	67.81	3.785.10	67.81	3.785.10	0.00	0.00
	Total	**257.31**	**17.283.75**	**256.24**	**17.440.61**	**0.42**	**-0.90**
2000	Liquid Fuels *	157.40	11.039.96	158.29	11.202.60	-0.57	-1.45
	Solid Fuels *	18.65	1.732.78	19.03	1.766.77	-1.98	-1.92
	Gaseous Fuels	68.88	3.845.07	68.88	3.845.07	0.00	0.00
	Total	**244.93**	**16.617.81**	**246.20**	**16.814.44**	**-0.52**	**-1.17**
2001	Liquid Fuels *	162.16	11.456.23	163.04	11.612.81	-0.54	-1.35
	Solid Fuels *	19.83	1.842.48	20.19	1.868.22	-1.78	-1.38
	Gaseous Fuels	75.42	4.210.03	75.42	4.210.03	0.00	0.00
	Total	**257.41**	**17.508.74**	**258.65**	**17.691.05**	**-0.48**	**-1.03**

* - Excluding international bunkers

Table A2-7: Fuel combustion and emission from 1990 to 2001

Source and Sink Categories		Activity Data	Emission Estimates						
		Consumption TJ	CO_2 Gg	CH_4 Mg	N_2O Mg	NO_x Mg	CO Mg	NMVOC Mg	SO_2 Mg
Year 1990									
1A	**Fuel Comb.**	**311340**	**20543**	**8996**	**257**	**90862**	**421269**	**70947**	**177112**
	Liquid	188226	13570	1288	114	71222	302224	57426	
	Solid	3162	3162	1637	45	8489	14381	1552	
	Gas	68282	3811	239	7	8883	2063	341	
	Biomass	22680		5832	91	2268	102600	11628	
Year 1991									
1A	**Fuel Comb.**	**231022**	**14745**	**6013**	**177**	**67359**	**307790**	**52188**	**105943**
	Liquid	137969	9653	959	79	53230	228723	43393	
	Solid	21044	1945	1067	29	5563	9258	999	
	Gas	56369	3146	213	6	7003	1809	282	
	Biomass	15640		3774	63	1564	68000	7514	
Year 1992									
1A	**Fuel Comb.**	**216308**	**13709**	**4860**	**157**	**64015**	**266891**	**45600**	**104744**
	Liquid	129129	9109	870	74	50834	201441	38253	
	Solid	16340	1406	487	23	4587	4320	490	
	Gas	57229	3194	203	6	7232	1780	286	
	Biomass	13610		3300	54	1361	59350	6571	
Year 1993									
1A	**Fuel Comb.**	**228762**	**14470**	**4513**	**154**	**67071**	**261685**	**44932**	**111799**
	Liquid	132520	9417	862	77	53060	199722	37984	
	Solid	13717	1166	343	19	3799	4129	460	
	Gas	69635	3887	224	7	8922	2084	348	
	Biomass	12890		3084	52	1289	55750	6139	
Year 1994									
1A	**Fuel Comb.**	**216988**	**13630**	**4662**	**147**	**65637**	**280703**	**48543**	**87800**
	Liquid	131230	9324	910	76	53795	217646	41345	
	Solid	8422	721	219	12	2367	2481	282	
	Gas	64236	3586	223	6	8165	1977	321	
	Biomass	13100		3309	52	1310	58600	6595	
Year 1995									
1A	**Fuel Comb.**	**224528**	**14385**	**4802**	**158**	**67662**	**292450**	**50632**	**69876**
	Liquid	148252	10599	992	87	57704	228025	43340	
	Solid	7653	713	197	11	2148	2207	250	
	Gas	55053	3073	217	6	6454	1868	275	
	Biomass	13570		3396	54	1357	60350	6767	

Note: CO_2 emissions from biomass combustion are not included in national totals

Table A2-7: Fuel combustion and emission from 1990 to 2001(continue)

Source and Sink Categories		**Activity Data**	**Emission Estimates**						
		Consumption TJ	CO_2 Gg	CH_4 Mg	N_2O Mg	NO_x Mg	CO Mg	NMVOC Mg	SO_2 Mg
Year 1996									
1A	**Fuel Comb.**	**239603**	**15083**	**5684**	**206**	**74553**	**328797**	**56693**	**65395**
	Liquid	151488	10819	1062	126	62817	249345	47391	
	Solid	6593	614	202	9	1819	2270	253	
	Gaseous	65382	3650	242	7	8303	3862	718	
	Biomass	16140		4178	65	1614	73320	8331	
Year 1997									
1A	**Fuel Comb.**	**253009**	**16007**	**5739**	**257**	**77563**	**349345**	**60394**	**79131**
	Liquid	157424	11214	1136	168	64207	269372	51159	
	Solid	10552	979	189	15	3024	2132	251	
	Gaseous	68333	3814	254	7	8662	3790	696	
	Biomass	16700		4160	67	1670	74050	8288	
Year 1998									
1A	**Fuel Comb.**	**264182**	**17005**	**5276**	**306**	**81481**	**361878**	**63413**	**88276**
	Liquid	169655	12170	1199	226	68392	291389	55324	
	Solid	10290	951	226	14	2893	2563	291	
	Gaseous	69578	3884	263	7	8730	3625	652	
	Biomass	14660		3588	59	1466	64300	7146	
Year 1999									
1A	**Fuel Comb.**	**270166**	**17441**	**5349**	**361**	**85282**	**376994**	**66530**	**89218**
	Liquid	179367	12823	1279	286	73185	308366	58555	
	Solid	9061	833	246	13	2535	2348	265	
	Gaseous	67810	3785	258	7	8169	3446	601	
	Biomass	13927		3566	56	1393	62834	7109	
Year 2000									
1A	**Fuel Comb.**	**261844**	**16814**	**5783**	**443**	**85894**	**388107**	**68042**	**56602**
	Liquid	153137	11203	1219	347	70109	310767	58963	
	Solid	19027	1767	226	27	5548	2396	301	
	Gaseous	68884	3845	248	7	8673	3434	620	
	Biomass	15640		4090	63	1564	71510	8158	
Year 2001									
1A	**Fuel Comb.**	**270888**	**17691**	**4798**	**496**	**87582**	**362943**	**64541**	**61093**
	Liquid	163037	11613	1225	412	71006	301733	57295	
	Solid	20189	1868	165	28	5948	1929	259	
	Gaseous	75422	4210	270	8	9404	4020	732	
	Biomass	12240		3137	49	1224	55260	6255	

Note: CO_2 Emissions from biomass are not included in national totals.

Table A2-8: Fuel Consumption and CO_2 emissions for International Aviation and Marine Bunkers from 1990 to 2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Marine bunkers [PJ]	1.44	0.95	1.07	1.52	1.83	1.36	1.52	0.97	1.08	0.88	0.76	1.19
Aviation bunkers [PJ]	2.86	0.24	0.66	1.85	2.82	2.47	2.46	2.05	2.10	1.94	1.62	1.62
Total bunkers [PJ]	**4.30**	**1.19**	**1.73**	**3.36**	**4.65**	**3.83**	**3.98**	**3.02**	**3.18**	**2.82**	**2.38**	**2.81**
Marine b. CO_2 [Mt]	0.11	0.07	0.08	0.11	0.14	0.10	0.11	0.07	0.08	0.07	0.06	0.09
Aviation b. CO_2 [Mt]	0.20	0.02	0.05	0.13	0.20	0.18	0.17	0.15	0.15	0.14	0.11	0.11
Total b. CO_2 em. [Mt]	**0.31**	**0.09**	**0.13**	**0.25**	**0.34**	**0.28**	**0.29**	**0.22**	**0.23**	**0.20**	**0.17**	**0.20**

Table A2-9: Number of different type of road vehicles from 1990 to 2001

Vehicles	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Motorcycles (> 50 ccm)	11847	13072	9590	7378	9304	9933
Passengers cars	852585	735650	669761	646210	698391	710910
Light-duty vehicles	5787	4584	4070	4310	5226	6215
Heavy-duty vehicles	64690	49987	45900	46807	59212	67282
Buses	6398	4876	4104	3895	4026	3897
Total number of vehicles	**941307**	**808169**	**733425**	**708600**	**776159**	**798237**

Table A2-9: Number of different motor vehicle types from 1990 to 2001(continue)

Vehicle	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Motorcycles (> 50 ccm)	14128	17401	18957	20499	21868	24305
Passengers cars	835714	932278	1000052	1063546	1124825	1195450
Light-duty vehicles	7893	8683	9134	9317	9382	9598
Heavy-duty vehicles	87028	101051	106634	109387	113134	119899
Buses	4596	4771	4814	4743	4660	4770
Total	**949359**	**1064184**	**1139591**	**1207492**	**1273869**	**1354022**

Table A2-10: Fuel consumption in road transport from 1990 to 2001

Fuel consumption (TJ)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Gasoline	33871	25581	22085	21533	23686	24890
Diesel	15704	11211	12830	15602	16516	17575
LPG			408	586	586	642
Residual fuel oil	60	52	56	52	72	100
Total fuel consumption	**49635**	**36845**	**35380**	**37773**	**40861**	**43208**
Share of unleaded gasoline	< 5.0	9.6	15.9	15.5	16.0	26.0

Table A2-10: Fuel consumption in road transport from 1990 to 2001(continue)

Fuel Consumption (TJ)	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Gasoline	27035	29425	32136	33866	34076	32778
Diesel	19331	22282	21970	23636	23836	25682
LPG	652	591	506	436	460	591
Residual fuel oil	0	0	0	0	0	0
Total Fuel Consumption	**47017**	**52298**	**54612**	**57938**	**58372**	**59050**
Share of unleaded fuel	31.3	42.2	49.8	55.2	65.7	73.5

Table A2-11: Non-energy fuel consumption (feedstock)

Energy carrier	Feedstock use	Emission factor	Potential emission CO_2	Storage CO_2		Emission CO_2
	[PJ]	[Gg/PJ]	[Gg]	[Gg]	[%]	[Gg]
Year 1990						
Naphtha	7.68	20	557.53	446.02	80	111.51
Bitumen	3.35	22	267.45	267.45	100	0.00
Other Fuels	6.51	20	472.33	236.16	50	236.16
TOTAL	**17.53**		**1297.30**	**949.63**		**347.67**
Year 1991						
Naphtha	3.01	20	218.42	174.73	80	43.68
Bitumen	2.37	22	189.62	189.62	100	0.00
Other Fuels	5.57	20	404.05	202.02	50	202.02
TOTAL	**10.95**		**812.08**	**566.38**		**245.71**
Year 1992						
Naphtha	3.13	20	227.15	181.72	80	45.43
Bitumen	2.04	22	162.61	162.61	100	0.00
Other Fuels	3.96	20	287.34	143.67	50	143.67
TOTAL	**9.12**		**677.11**	**488.00**		**189.10**
Year 1993						
Naphtha	1.26	20	91.25	73.00	80	18.25
Bitumen	1.48	22	118.21	118.21	100	0.00
Other Fuels	4.85	20	352.17	176.09	50	176.09
TOTAL	**7.59**		**561.64**	**367.30**		**194.34**
Year 1994						
Naphtha	0.23	20	16.50	13.20	80	3.30
Bitumen	1.81	22	144.16	144.16	100	0.00
Other Fuels	5.39	20	391.66	195.83	50	195.83
TOTAL	**7.43**		**552.31**	**353.19**		**199.13**
Year 1995						
Naphtha	0.21	20	15.21	12.17	80	3.04
Bitumen	1.36	22	108.85	108.85	100	0.00
Other Fuels	5.25	20	381.42	190.71	50	190.71
TOTAL	**6.83**		**505.48**	**311.73**		**193.75**
Year 1996						
Bitumen	3.52	22	280.91	280.91	100	0
Other Fuels	5.67	20	374.48	187.24	50	187.24
TOTAL	**9.19**		**655.38**	**468.15**		**187.24**
Year 1997						
Bitumen	3.71	22	295.89	295.89	100	0.00
Other Fuels	6.20	20	409.89	204.94	50	204.94
TOTAL	**9.91**		**705.78**	**500.83**		**204.94**
Year 1998						
Bitumen	4.15	22	331.74	331.74	100	0.00
Other Fuels	5.39	20	391.00	195.50	50	195.50
TOTAL	**9.54**		**722.74**	**527.24**		**195.50**
Year 1999						
Lubricants	1.64	20	119.17	59.59	50	59.59
Bitumen	3.96	22	316.49	316.49	100	0.00
Ethane	3.71	16.8	226.20	180.96	80	45.24
TOTAL	**9.31**		**661.86**	**557.03**		**104.83**
Year 2000						
Lubricants	1.49	20	108.47	54.24	50	54.24
Bitumen	3.55	22	283.58	283.58	100	0.00
Ethane	3.66	16.8	223.31	178.65	80	44.66
TOTAL	**8.71**		**615.37**	**516.47**		**98.90**
Year 2001						
Lubricants	1.53	20	110.90	55.45	50	55.45
Bitumen	3.15	22	251.48	251.48	100	0.00
Ethane	3.09	16.8	188.40	150.72	80	37.68
Other Fuels	0.25	20	17.80	8.90	50	8.90
TOTAL	**8.01**		**568.58**	**466.55**		**102.03**

Table A2-12: CH_4 emission from fuel combustion from 1990 to 2001

CH_4 (Gg)			1990	1991	1992	1993	1994	1995
Energy Industries			0.184	0.120	0.136	0.155	0.124	0.155
Manufacturing Industries and Construction			0.508	0.393	0.318	0.310	0.301	0.284
Transport	Domestic Aviation		0.002	0.001	0.000	0.000	0.000	0.001
	Road		0.756	0.568	0.506	0.509	0.556	0.586
	Railways		0.010	0.010	0.007	0.007	0.006	0.007
	National Navigation		0.009	0.007	0.011	0.008	0.006	0.007
Other Sectors	Commercial / Institutional		0.094	0.065	0.047	0.055	0.065	0.070
	Residential		7.363	4.793	3.787	3.421	3.556	3.651
	Agriculture/Forestry /Fishing	Stationary	0.011	0.015	0.012	0.009	0.006	0.007
		Mobile	0.051	0.041	0.036	0.038	0.040	0.036
Other (not elsewhere specified)			0.009					
Total			**8.996**	**6.013**	**4.860**	**4.513**	**4.662**	**4.802**
International Marine Bunkers			0.007	0.005	0.005	0.008	0.009	0.007
International Aviation Bunkers			0.001	$1x10^{-4}$	$3x10^{-4}$	0.001	0.001	0.001

Table A2-12: CH_4 Emission from Fuel Consumption from 1990 to 2001(continue)

CH_4 (Gg)			1996	1997	1998	1999	2000	2001
Energy Industries			0.143	0.153	0.180	0.188	0.137	0.150
Manufacturing Industries and Construction			0.288	0.312	0.316	0.271	0.277	0.275
Transport	Domestic Aviation		0.001	0.001	0.001	0.001	0.001	0.001
	Road		0.650	0.712	0.763	0.804	0.810	0.796
	Railways		0.007	0.007	0.007	0.006	0.006	0.006
	National Navigation		0.010	0.008	0.006	0.006	0.006	0.006
Other Sectors	Commercial/Institutional		0.071	0.077	0.072	0.076	0.073	0.085
	Residual		4.459	4.427	3.885	3.932	4.411	3.423
	Agriculture/Forestry /Fishing	Stationary	0.010	0.006	0.006	0.017	0.009	0.007
		Mobile	0.045	0.037	0.041	0.048	0.053	0.050
Other			0.000	0.000	0.000	0.000	0.000	0.000
Total			**5.684**	**5.739**	**5.276**	**5.349**	**5.783**	**4.798**
International Marine Bunkers			0.008	0.005	0.005	0.004	0.004	0.006
International Aviation Bunkers			0.0012	0.0012	0.0010	0.0010	0.0008	0.0008

Table A2-13: N_2O emission from fuel combustion from 1990 to 2001

N_2O (Gg)			1990	1991	1992	1993	1994	1995
Energy Industries			0.045	0.030	0.035	0.036	0.025	0.032
Manufacturing Industries and Construction			0.066	0.049	0.038	0.037	0.035	0.034
Transport	Domestic Aviation		0.008	0.002	0.001	0.002	0.002	0.003
	Road		0.030	0.022	0.021	0.022	0.024	0.025
	Railways		0.001	0.001	0.001	0.001	0.001	0.001
	National Navigation		0.001	0.001	0.001	0.001	0.001	0.001
Other Sectors	Commercial / Institutional		0.006	0.004	0.002	0.003	0.003	0.003
	Residential		0.093	0.062	0.053	0.048	0.051	0.053
	Agriculture/Forestry /Fishing	Stationary	0.001	0.001	0.001	4×10^{-4}	3×10^{-4}	3×10^{-4}
		Mobile	0.006	0.005	0.004	0.005	0.005	0.004
Other (not elsewhere specified)			2×10^{-4}					
Total			**0.257**	**0.177**	**0.157**	**0.154**	**0.147**	**0.158**
International Marine Bunkers			0.001	0.001	0.001	0.001	0.001	0.001
International Aviation Bunkers			0.006	5×10^{-4}	0.001	0.004	0.006	0.005

Table A2-13: N_2O emission from fuel combustion from 1990 to 2001(continue)

N_2O (Gg)			1996	1997	1998	1999	2000	2001
Energy Industries			0.028	0.035	0.041	0.042	0.043	0.047
Manufacturing Industries and Construction				0.036	0.037	0.032	0.033	0.033
Transport	Domestic Aviation		0.003	0.003	0.004	0.004	0.003	0.003
	Road		0.065	0.107	0.158	0.214	0.288	0.350
	Railways		0.001	0.001	0.001	0.001	0.001	0.001
	National Navigation		0.001	0.001	0.001	0.001	0.001	0.001
Other Sectors	Commercial/Institutional		0.004	0.004	0.004	0.004	0.004	0.004
	Residual		0.064	0.065	0.056	0.057	0.064	0.052
	Agriculture/Forestry /Fishing	Stationary	$4 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$9 \cdot 10^{-4}$	$4 \cdot 10^{-4}$	$3 \cdot 10^{-4}$
		Mobile	0.005	0.004	0.005	0.006	0.006	0.006
Other			0.000	0.000	0.000	0.000	0.000	0.000
Total			**0.206**	**0.257**	**0.306**	**0.361**	**0.443**	**0.496**
International Marine Bunkers			0.001	0.001	0.001	0.001	0.000	0.001
International Aviation Bunkers			0.005	0.0041	0.004	0.004	0.003	0.003

Table A2-14: NO_x emission from fuel combustion from 1990 to 2001

NO_x (Gg)			1990	1991	1992	1993	1994	1995
Energy Industries			16.42	10.93	12.67	14.46	10.80	12.11
Manufacturing Industries and Construction			17.97	13.28	10.61	10.40	10.77	10.13
Transport	Domestic Aviation		1.25	0.34	0.14	0.27	0.27	0.38
	Road		32.89	24.32	23.52	25.40	27.42	28.99
	Railways		1.98	2.29	1.58	1.65	1.54	1.73
	National Navigation		2.72	2.20	3.42	2.45	1.76	2.00
Other Sectors	Commercial / Institutional		0.94	0.65	0.47	0.55	0.65	0.70
	Residential		4.36	3.29	2.85	2.60	2.71	2.98
	Agriculture/Forestry /Fishing	Stationary	0.11	0.15	0.12	0.09	0.06	0.07
		Mobile	12.14	9.90	8.64	9.19	9.65	8.58
Other (not elsewhere specified)			0.09					
Total			**90.86**	**67.36**	**64.01**	**67.07**	**65.64**	**67.66**
International Marine Bunkers			2.17	1.42	1.61	2.28	2.75	2.04
International Aviation Bunkers			0.86	0.07	0.20	0.55	0.85	0.74

Table A2-14: NO_x emission from fuel combustion from 1990 to 2001(continue)

NO_x (Gg)			1996	1997	1998	1999	2000	2001
Energy Industries			11.65	13.41	15.15	15.50	14.62	15.98
Manufacturing Industries and Construction				10.45	11.16	10.31	10.57	10.78
Transport	Domestic Aviation		0.45	0.47	0.54	0.55	0.47	0.47
	Road		32.27	36.01	37.31	39.62	39.93	40.74
	Railways		1.63	1.56	1.60	1.51	1.39	1.44
	National Navigation		3.00	2.39	1.84	1.79	1.75	1.87
Other Sectors	Commercial/Institutional		0.71	0.77	0.72	0.76	0.73	0.85
	Residual		3.42	3.61	3.27	3.46	3.52	3.38
	Agriculture/Forestry /Fishing	Stationary	0.10	0.06	0.06	0.17	0.09	0.07
		Mobile	10.80	8.84	9.83	11.62	12.82	12.00
Other			0.00	0.00	0.00	0.00	0.00	0.00
Total			**74.55**	**77.56**	**81.48**	**85.28**	**85.89**	**87.58**
International Marine Bunkers			2.29	1.46	1.62	1.32	1.14	1.79
International Aviation Bunkers			0.74	0.61	0.63	0.58	0.49	0.49

Table A2-15: CO emission from fuel combustion from 1990 to 2001

CO (Gg)			1990	1991	1992	1993	1994	1995
Energy Industries			1.46	0.95	1.11	1.34	1.02	1.03
Manufacturing Industries and Construction			11.09	9.45	7.74	7.59	6.45	6.61
Transport	Domestic Aviation		0.42	0.11	0.05	0.09	0.09	0.13
	Road		286.7	215.9	189.5	187.9	206.0	216.7
	Railways		1.63	1.90	1.32	1.38	1.28	1.44
	National Navigation		1.81	1.47	2.28	1.63	1.17	1.33
Other Sectors	Commercial / Institutional		2.25	1.43	0.61	1.59	0.82	0.82
	Residential		105.7	68.3	57.0	52.5	55.8	57.2
	Agriculture/Forestry /Fishing	Stationary	0.06	0.07	0.07	0.05	0.03	0.03
		Mobile	10.12	8.25	7.20	7.66	8.04	7.15
Other (not elsewhere specified)			0.07					
Total			**421.3**	**307.8**	**266.9**	**261.7**	**280.7**	**292.5**
International Marine Bunkers			1.44	0.95	1.07	1.52	1.83	1.44
International Aviation Bunkers			0.29	0.02	0.07	0.18	0.28	0.29

Table A2-15: CO emission from fuel combustion from 1990 to 2001(continue)

CO (Gg)			1996	1997	1998	1999	2000	2001
Energy Industries			1.06	1.18	1.31	1.33	1.27	1.39
Manufacturing Industries and Construction				7.91	7.60	5.94	5.97	5.50
Transport	Domestic Aviation		0.15	0.16	0.18	0.18	0.16	0.16
	Road		237.3	259.2	280.3	295.7	297.6	289.4
	Railways		1.36	1.30	1.34	1.26	1.16	1.20
	National Navigation		2.00	1.59	1.23	1.19	1.17	1.25
Other Sectors	Commercial/Institutional		0.87	0.78	1.02	0.74	0.70	0.68
	Residual		70.47	69.79	60.61	60.93	69.32	53.28
	Agriculture/Forestry /Fishing	Stationary	0.05	0.04	0.04	0.05	0.04	0.05
		Mobile	9.00	7.37	8.19	9.68	10.69	10.00
Other			0.00	0.00	0.00	0.00	0.00	0.00
Total			**328.8**	**349.3**	**361.9**	**377.0**	**388.1**	**363.0**
International Marine Bunkers			1.52	0.97	1.08	0.88	0.76	1.19
International Aviation Bunkers			0.25	0.20	0.21	0.19	0.16	0.16

Table A2-16: NMVOC emission from fuel combustion from 1990 to 2001

NMVOC (Gg)			1990	1991	1992	1993	1994	1995
Energy Industries			0.43	0.28	0.32	0.38	0.30	0.31
Manufacturing Industries and Construction			0.88	0.66	0.52	0.50	0.48	0.46
Transport	Domestic Aviation		0.21	0.06	0.02	0.05	0.05	0.06
	Road		53.95	40.61	35.69	35.42	38.83	40.85
	Railways		0.32	0.38	0.26	0.28	0.26	0.29
	National Navigation		0.36	0.29	0.46	0.33	0.23	0.27
Other Sectors	Commercial / Institutional		0.25	0.16	0.07	0.17	0.09	0.10
	Residential		12.53	8.09	6.81	6.28	6.69	6.86
	Agriculture/Forestry /Fishing	Stationary	0.008	0.010	0.009	0.006	0.004	0.005
		Mobile	2.02	1.65	1.44	1.53	1.61	1.43
Other (not elsewhere specified)			0.01					
Total			**70.95**	**52.19**	**45.60**	**44.93**	**48.54**	**50.63**
International Marine Bunkers			0.29	0.19	0.21	0.30	0.37	0.27
International Aviation Bunkers			0.14	0.01	0.03	0.09	0.14	0.12

Table A2-16: NMVOC emission from fuel combustion from 1990 to 2001(continue)

NMVOC (Gg)			1996	1997	1998	1999	2000	2001
Energy Industries			0.31	0.35	0.39	0.40	0.36	0.39
Manufacturing Industries and Construction				0.49	0.50	0.43	0.44	0.44
Transport	Domestic Aviation		0.08	0.08	0.09	0.09	0.08	0.08
	Road		44.81	48.95	52.90	55.79	56.16	54.66
	Railways		0.27	0.26	0.27	0.25	0.23	0.24
	National Navigation		0.40	0.32	0.25	0.24	0.23	0.25
Other Sectors	Commercial/Institutional		0.10	0.09	0.12	0.09	0.09	0.09
	Residual		8.45	8.38	7.26	7.30	8.31	6.39
	Agriculture/Forestry /Fishing	Stationary	0.007	0.005	0.004	0.009	0.006	0.006
		Mobile	1.80	1.47	1.64	1.94	2.14	2.00
Other			0.00	0.00	0.00	0.00	0.00	0.00
Total			**56.69**	**60.39**	**63.41**	**66.53**	**68.04**	**64.54**
International Marine Bunkers			0.30	0.19	0.22	0.18	0.15	0.24
International Aviation Bunkers			0.12	0.10	0.10	0.10	0.08	0.08

Table A2-17: SO_2 emission from fuel combustion from 1990 to 2001

SO_2 (Gg)	1990	1991	1992	1993	1994	1995
Energy Industries	86.9	48.8	61.3	59.0	35.9	36.1
Manufacturing Industries and Construction	62.7	34.3	30.5	37.5	40.3	26.0
Transport	5.8	9.5	5.6	6.3	4.6	3.6
Residential Sector	13.0	8.1	4.0	4.7	4.1	2.1
Other Sectors (Residual. Commercial...)	8.7	5.3	3.3	4.3	2.9	2.1
Total	177.1	105.9	104.7	111.8	87.8	69.9

Table A2-17: SO_2 emission from fuel combustion from 1996 to 2001(continue)

SO_2 (Gg)	1996	1997	1998	1999	2000	2001
Energy Industries	31.7	45.9	59.8	61.5	29.6	23.3
Manufacturing Industries and Construction	17.9	18.1	15.2	14.5	12.5	26.6
Transport	9.4	8.2	7.1	7.1	8.7	4.9
Other Sectors (Residual. Commercial...)	6.4	7.0	6.2	6.2	5.8	6.2
Total	**65.4**	**79.1**	**88.3**	**89.2**	**56.6**	**61.0**

Table A2-18: Methane Emissions from Coal Mining and Handling from 1990 to 2001

Source and Sink Categories		**Activity Data** Production (PJ)	**Emission Estimates** CH_4 (Gg)	**Emission Factor** $kgCH_4/t$	**Emission Factor** m^3CH_4/t
1B 1 Solid Fuel					
Year 1990					
1B 1a Underground mines			**2.32**		
	Mining	0.174	2.04	11.73	17.50
	Post-Mining	0.174	0.29	1.64	2.45
Year 1991					
1B 1a Underground mines			**4.88**		
	Mining	0.365	4.28	11.73	17.50
	Post-Mining	0.365	0.60	1.64	2.45
Year 1992					
1B 1a Underground mines			**1.61**		
	Mining	0.120	1.41	11.73	17.50
	Post-Mining	0.120	0.20	1.64	2.45
Year 1993					
1B 1a Underground mines			**1.54**		
	Mining	0.115	1.35	11.73	17.50
	Post-Mining	0.115	0.19	1.64	2.45
Year 1994					
1B 1a Underground mines			**1.38**		
	Mining	0.103	1.21	11.73	17.50
	Post-Mining	0.103	0.17	1.64	2.45
Year 1995					
1B 1a Underground mines			**1.10**		
	Mining	0.082	0.96	11.73	17.50
	Post-Mining	0.082	0.13	1.64	2.45
Year 1996					
1B 1a Underground Mines			**0.89**		
	Mining	0.066	0.78	11.73	17.50
	Post-Mining	0.066	0.11	1.64	2.45
Year 1997					
1B 1a Underground Mines			**0.65**		
	Mining	0.049	0.57	11.73	17.50
	Post-Mining	0.049	0.08	1.64	2.45
Year 1998					
1B 1a Underground Mines			**0.68**		
	Mining	0.051	0.60	11.73	17.50
	Post-Mining	0.051	0.08	1.64	2.45
Year 1999					
1B 1a Underground Mines			**0.20**		
	Mining	0.015	0.18	11.73	17.50
	Post-Mining	0.015	0.03	1.64	2.45
Year 2000					
1B 1a Underground Mines			**0.00**		
	Mining	0.000	0.00	0	0
	Post-Mining	0.000	0.00	0	0
Year 2001					
1B 1a Underground Mines			**0.00**		
	Mining	0	0	0	0
	Post-Mining	0	0	0	0

* - 0.67 kg/m^3 – Methane density at 20 ºC and pressure 1 atm.

Table A2-19: Methane Emissions from Oil and Gas Activities from 1990 to 2001

Source and sink categories		Activity data Fuel Quantity PJ	Emission Estimates CH_4 Gg	Emission Factor $kgCH_4/PJ$
Year 1990				
1B 2a Oil			**0.68**	
	Production	112.9	0.30	2650
	Transport	174.1	0.13	745
	Refining	287.3	0.21	745
	Storage	287.3	0.04	135
1B 2b Natural gas			**54.59**	
	Prod./Process./Trans./Distrib.	67.4	30.87 [1)]	458000
	Other Leakage (non-residential)	78.4	21.93 [2)]	279500
	Other Leakage (residential)	12.9	1.80 [3)]	139500
1B 2c Venting and flaring			**1.21**	
	Gas	67.4	1.21	18000
Year 1991				
1B 2a Oil			**0.47**	
	Production	80.8	0.21	2650
	Transport	121.6	0.09	745
	Refining	190.0	0.14	745
	Storage	190.0	0.03	135
1B 2b Natural gas			**50.02**	
	Prod./Process./Trans./Distrib.	62.0	28.41 [1)]	458000
	Other Leakage (non-residential)	70.1	19.58 [2)]	279500
	Other Leakage (residential)	14.5	2.02 [3)]	139500
1B 2c Venting and flaring			**1.12**	
	Gas	62.0	1.12	18000
Year 1992				
1B 2a Oil			**0.42**	
	Production	73.0	0.19	2650
	Transport	114.1	0.09	745
	Refining	165.9	0.12	745
	Storage	165.9	0.02	135
1B 2b Natural gas			**50.69**	
	Prod./Process./Trans./Distrib.	61.3	28.08 [1)]	458000
	Other Leakage (non-residential)	74.2	20.74 [2)]	279500
	Other Leakage (residential)	13.5	1.88 [3)]	139500
1B 2c Venting and flaring			**1.10**	
	Gas	61.3	1.10	18000
Year 1993				
1B 2a Oil			**0.49**	
	Production	72.3	0.19	2650
	Transport	114.3	0.09	745
	Refining	238.2	0.18	745
	Storage	238.2	0.03	135
1B 2b Natural gas			**55.66**	
	Prod./Process./Trans./Distrib.	69.7	31.91 [1)]	458000
	Other Leakage (non-residential)	77.4	21.63 [2)]	279500
	Other Leakage (residential)	15.2	2.12 [3)]	139500
1B 2c Venting and flaring			**1.25**	
	Gas	69.7	1.25	18000

Table A2-19: Methane Emissions from Oil and Gas Activities from 1990 to 2001(continue)

Source and Sink Categories		Activity Data Fuel Quantity (PJ)	Emission Estimated CH_4 (Gg)	Emission Factor $kgCH_4/PJ$
Year 1994				
1B 2a Oil			**0.46**	
	Production	66.0	0.17	2650
	Transport	132.0	0.10	745
	Refining	213.0	0.16	745
	Storage	213.0	0.03	135
1B 2b Natural gas			**50.20**	
	Prod./Process./Trans./Distrib.	60.9	27.91 1)	458000
	Other Leakage (non-residential)	72.4	20.25 2)	279500
	Other Leakage (residential)	14.7	2.05 3)	139500
1B 2c Venting and flaring			**1.10**	
	Gas	60.9	1.10	18000
Year 1995				
1B 2a Oil			**0.49**	
	Production	62.8	0.17	2650
	Transport	159.3	0.12	745
	Refining	227.6	0.17	745
	Storage	227.6	0.03	135
1B 2b Natural gas			**50.60**	
	Prod./Process./Trans./Distrib.	66.9	30.62 1)	458000
	Other Leakage (non-residential)	62.5	17.47 2)	279500
	Other Leakage (residential)	18.0	2.51 3)	139500
1B 2c Venting and flaring			**1.20**	
	Gas	66.9	1.20	18000
Year 1996				
1B 2a Liquid Fossil Fuel			**0.48**	
	Production	61.5	0.16	2650
	Transport	171.7	0.13	745
	Refining	214.1	0.16	745
	Storage	214.1	0.03	135
1B 2b Natural Gas			**53.02**	
	Prod./Process./Trans./Distrib.	63.7	29.18 1)	458000
	Other Leakage(non-residential)	77.4	21.63 2)	279500
	Other Leakage (residential)	15.8	2.21 3)	139500
1B 2c Venting and Flaring			**1.15**	
	Gas	63.7	1.15	18000
Year 1997				
1B 2a Liquid Fossil Fuel			**0.47**	
	Production	62.6	0.17	2650
	Transport	154.9	0.12	745
	Refining	214.0	0.16	745
	Storage	214.0	0.03	135
1B 2b Natural Gas			**56.25**	
	Prod./Process./Trans./Distrib.	66.1	30.27 1)	458000
	Other Leakage(non-residential)	84.7	23.67 2)	279500
	Other Leakage (residential)	16.6	2.31 3)	139500
1B 2c Venting and Flaring			**1.19**	
	Gas	66.1	1.19	18000

Table A2-19: Methane Emissions from Oil and Gas Activities from 1990 to 2001 (continue)

Source and Sink Categories		Activity Data Fuel Quantity PJ	Emission Estimated CH_4 Gg	Emission Factor $kgCH_4/PJ$
Year 1998				
1B 2a Liquid Fossil Fuel			**0.45**	
	Production	58.2	0.15	2650
	Transport	148.1	0.11	745
	Refining	209.7	0.16	745
	Storage	209.7	0.03	135
1B 2b Natural Gas			**48.96**	
	Prod./Process./Trans./Distrib.	55.8	25.54 [1)]	458000
	Other Leakage(non-residential)	75.3	21.04 [2)]	279500
	Other Leakage (residential)	17.0	2.37 [3)]	139500
1B 2c Venting and Flaring			**1.00**	
	Gas	55.8	1.00	18000
Year 1999				
1B 2a Liquid Fossil Fuel			**0.49**	
	Production	54.7	0.14	2650
	Transport	189.4	0.14	745
	Refining	231.6	0.17	745
	Storage	231.6	0.03	135
1B 2b Natural Gas			**49.05**	
	Prod./Process./Trans./Distrib.	55.6	25.47 [1)]	458000
	Other Leakage(non-residential)	74.7	20.88 [2)]	279500
	Other Leakage (residential)	19.4	2.70 [3)]	139500
1B 2c Venting and Flaring			**1.00**	
	Gas	55.6	1.00	18000
Year 2000				
1B 2a Liquid Fossil Fuel			**0.45**	
	Production	51.4	0.14	2650
	Transport	165.6	0.12	745
	Refining	218.4	0.16	745
	Storage	218.4	0.03	135
1B 2b Natural Gas			**51.39**	
	Prod./Process./Trans./Distrib.	59.4	27.21 [1)]	458000
	Other Leakage(non-residential)	78.1	21.83 [2)]	279500
	Other Leakage (residential)	16.9	2.35 [3)]	139500
1B 2c Venting and Flaring			**1.07**	
	Gas	59.4	1.07	18000
Year 2001				
1B 2a Liquid Fossil Fuel			**0.43**	
	Production	47.5	0.13	2650
	Transport	165.7	0.12	745
	Refining	208.2	0.16	745
	Storage	208.2	0.03	135
1B 2b Natural Gas			**57.42**	
	Prod./Process./Trans./Distrib.	70.9	32.45 [1)]	458000
	Other Leakage(non-residential)	79.8	22.30 [2)]	279500
	Other Leakage (residential)	19.1	2.66 [3)]	139500
1B 2c Venting and Flaring			**1.28**	
	Gas	70.9	1.28	18000

[1)] – Methane Emissions from Processing. Transmission and Distribution
[2)] – Other Leakage at Industrial Plants and Power Stations
[3)] – Other Leakage in Residential and Commercial Sectors

ANNEX 3

UNCERTAINTY AND KEY SOURCES

Table A3-1. Uncertainty calculation for the year 2001 and trend from 1990 to 2001- Tier 1

IPCC Source Category		GHG	GHG emissions 1990	Last year emissions 2001	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total emissions in year 2001	Type A sensitivity	Type B sensitivity	Uncertainty in trend (by emission factor uncertainty)	Uncertainty in trend (by activity data uncertainty)	Uncertainty in trend (total)
			Gg CO_2 - eq	Gg CO_2 - eq	%	%	%	%	%	%	%	%	%
1A	Fuel Combustion - Coal	CO_2	3161.8	1868.2	5	5	7.07	0.49	-0.03	0.06	-0.18	0.42	0.46
1A	Fuel Combustion - Oil	CO_2	13570.2	11612.8	5	5	7.07	3.06	0.00	0.37	0.02	2.60	2.60
1A	Fuel Combustion - Natural Gas	CO_2	3811.5	4210.0	5	5	7.07	1.11	0.03	0.13	0.22	0.94	0.97
1B	Natural Gas Scrubbing*	CO_2	416.0	688.0	8	3	8.54	0.22	0.01	0.02	0.04	0.25	0.25
2A	Cement Production	CO_2	1022.9	1419.6	3	6	6.71	0.35	0.02	0.04	0.15	0.19	0.24
2A	Lime Production	CO_2	145.1	143.5	7.5	15	16.77	0.09	0.00	0.00	0.01	0.05	0.05
2A	Limestone and Dolomite Use	CO_2	18.9	9.2	7.5	30	30.92	0.01	0.00	0.00	-0.01	0.00	0.01
2A	Soda Ash Production and Use	CO_2	25.7	12.4	7.5	30	30.92	0.01	0.00	0.00	-0.01	0.00	0.01
2B	Ammonia Production	CO_2	491.6	425.8	3	5	5.83	0.09	0.00	0.01	0.00	0.06	0.06
2C	Ferroalloys Production	CO_2	194.9	0.5	7.5	30	30.92	0.00	-0.01	0.00	-0.22	0.00	0.22
2C	Aluminium Production	CO_2	111.4	0.0	3	30	30.15	0.00	0.00	0.00	-0.13	0.00	0.13
		CO_2Total	**22970.0**	**20390.0**									
1A	Fuel Combust. - Stationary S.	CH_4	172.7	83.8	5	40	40.31	0.13	0.00	0.00	-0.11	0.02	0.11
1A	Fuel Combustion - Transport	CH_4	16.3	17.0	5	40	40.31	0.03	0.00	0.00	0.01	0.00	0.01
1B	Coal Mining and Handling	CH_4	48.8	0.0	5	250	250.05	0.00	0.00	0.00	-0.46	0.00	0.46
1B	Fugitive Emissions-Oil & Gas	CH_4	1186.2	1241.6	5	300	300.04	13.87	0.01	0.04	3.13	0.28	3.15
2B	Production of Other Chemicals	CH_4	15.8	6.4	7.5	30	30.92	0.01	0.00	0.00	-0.01	0.00	0.01
4A	Enteric Fermentation	CH_4	1345.3	748.4	25	150	152.07	4.24	-0.01	0.02	-2.65	0.84	2.78
4B	Manure Management	CH_4	232.1	156.5	25	150	152.07	0.89	0.00	0.00	-0.27	0.18	0.32
4F	Agricultural Residue Burning	CH_4	4.3	0.0	100	500	509.90	0.00	0.00	0.00	-0.08	0.00	0.08
6A	Solid Waste Disposal Sites	CH_4	793.3	1077.9	50	50	70.71	2.84	0.01	0.03	0.90	2.41	2.57
		CH_4 Total	**3814.9**	**3331.6**									
1A	Fuel Combust - Stationary S.	N_2O	67.6	44.0	5	200	200.06	0.33	0.00	0.00	-0.12	0.01	0.12
1A	Fuel Combustion - Transport	N_2O	12.4	109.9	5	200	200.06	0.82	0.00	0.00	0.89	0.02	0.89
2B	Nitric Acid Production	N_2O	927.5	718.5	3	30	30.15	0.81	0.00	0.02	-0.09	0.10	0.13
4B	Manure Management	N_2O	376.7	375.1	30	500	500.90	7.00	0.00	0.01	1.23	0.50	1.33
4D	Agricultural Soils Management	N_2O	2361.0	1755.6	30	500	500.90	32.74	-0.01	0.06	-5.60	2.36	6.08
4F	Agricultural Residue Burning	N_2O	1.2	0.0	100	500	509.90	0.00	0.00	0.00	-0.02	0.00	0.02
6B	Human Sewage	N_2O	139.5	85.3	10	30	31.62	0.10	0.00	0.00	-0.04	0.04	0.06
		N_2O Total	**3885.9**	**3088.3**									
2F	Cons. of HFCs. PFCs and SF_6	HFC		49.0	30	50	58.31	0.11	0.00	0.00	0.11	0.07	0.13
2C	Aluminium production	PFC	938.6		30	50	58.31	0.00	-0.03	0.00	-1.78	0.00	1.78
		HFC/PFC/SF_6	**938.6**	**49.0**			0.00	0.00	-0.02	0.00	0.00	0.00	0.00
	Total GHG Emissions	**CO_2-eq**	**31609.3**	**26858.9**									
	Total Uncert. (Level/Trend)							**36.78**					**8.68**

Table A3-2: Key source analysis – Level Assessment - Tier 1

IPCC Source Categories	Direct GHG	Base Year (1990) (Gg eq-CO_2)	Last Year (2001) (Gg eq-CO_2)	Level Assessment	Cumulative Total (%)
Stationary Combustion - Oil	CO_2	8803.54	6422.84	0.239	23.9%
Stationary Combustion - Gas	CO_2	3811.48	4210.03	0.157	39.6%
Mobile Combustion - Road	CO_2	3479.92	4168.82	0.155	55.1%
Stationary Combustion - Coal	CO_2	3141.42	1868.21	0.070	62.1%
Cement Production	CO_2	1022.90	1419.61	0.053	67.4%
Fugitive Emissions from Oil and Gas	CH_4	1186.25	1241.59	0.046	72.0%
Direct N_2O Em. from Agr. Soils and Animals	N_2O	1465.10	1024.90	0.038	75.8%
Solid Waste Disposal Sites	CH_4	793.25	1077.89	0.040	79.8%
Enteric Fermentation in Dom. Livestock	CH_4	1345.34	748.38	0.028	82.6%
Mobile Combustion – Agric./Forestry/Fishing	CO_2	741.00	730.82	0.027	85.3%
Indirect N_2O Em. from Nitrogen Used in Agr.	N_2O	895.90	730.66	0.027	88.0%
Nitric Acid Production	N_2O	927.52	718.52	0.027	90.7%
Natural Gas Scrubbing*	CO_2	416.00	688.00	0.026	93.3%
Ammonia Production	CO_2	491.55	425.83	0.016	94.9%
Manure Management	N_2O	376.65	375.11	0.014	96.2%
Manure Management	CH_4	232.07	156.53	0.006	96.8%
Lime Production	CO_2	145.07	143.48	0.005	97.4%
Mobile Combustion - Domestic Aviation	CO_2	295.61	110.78	0.004	97.8%
Mobile Combustion - Road	N_2O	9.30	108.47	0.004	98.2%
Mobile Combustion - National Navigation	CO_2	132.98	91.86	0.003	98.5%
Mobile Combustion - Railways	CO_2	137.53	87.69	0.003	98.8%
N_2O Emissions from Human Sewage	N_2O	139.50	85.29	0.003	99.2%
Stationary Combustion	CH_4	171.66	82.72	0.003	99.5%
Consumption of HFCs. PFCs and SF6	HFC		48.99	0.002	99.7%
Stationary Combustion	N_2O	65.70	42.11	0.002	99.8%
Mobile Combustion - Road	CH_4	15.88	16.71	0.001	99.9%
Mobile Combustion – Agric./Forestry/Fishing	N_2O	1.88	1.86	0.000	100.0%
Mobile Combustion – Agric./Forestry/Fishing	CH_4	1.06	1.05	0.000	100.0%
Mobile Combustion - Domestic Aviation	N_2O	2.48	0.97	0.000	100.0%
Ferroalloys Production	CO_2	194.93	0.47	0.000	100.0%
Mobile Combustion - National Navigation	N_2O	0.31	0.23	0.000	100.0%
Mobile Combustion - Railways	N_2O	0.31	0.22	0.000	100.0%
Mobile Combustion - National Navigation	CH_4	0.19	0.13	0.000	100.0%
Mobile Combustion - Railways	CH_4	0.21	0.13	0.000	100.0%
Mobile Combustion - Domestic Aviation	CH_4	0.04	0.02	0.000	100.0%
Aluminium production	PFC	938.60		0.000	100.0%
Aluminium Production	CO_2	111.37		0.000	100.0%
Fugitive Emissions from Coal	CH_4	48.76		0.000	100.0%
Agricultural Residue Burning	CH_4	4.35		0.000	100.0%
Agricultural Residue Burning	N_2O	1.24		0.000	100.0%
Total GHG Emission (Gg CO_2-eq)		**31609**	**26859**		

Table A3-3: Key source analysis – Trend Assessment - Tier 1

IPCC Source Categories	Direct GHG	Base Year (1990) (Gg eq-CO_2)	Last Year (2001) (Gg eq-CO_2)	Trend Assessm.	Contrib. to trend	Cumulative Total (%)
Mobile Combustion - Road	CO_2	3479.9	4168.8	0.055035	0.175	17.5%
Stationary Combustion – Gas	CO_2	3811.5	4210.0	0.044515	0.142	31.7%
Stationary Combustion – Oil	CO_2	8803.5	6422.8	0.043362	0.138	45.5%
Stationary Combustion – Coal	CO_2	3141.4	1868.2	0.034234	0.109	56.4%
Cement Production	CO_2	1022.9	1419.6	0.024777	0.079	64.2%
Solid Waste Disposal Sites	CH_4	793.3	1077.9	0.018196	0.058	70.0%
Enteric Fermentation in Dom. Livestock	CH_4	1345.3	748.4	0.016951	0.054	75.4%
Natural Gas Scrubbing*	CO_2	416.0	688.0	0.014977	0.048	80.2%
Fugitive Emissions from Oil and Gas	CH_4	1186.2	1241.6	0.010813	0.034	83.6%
Direct N_2O Em. from Agr. Soils and Animals	N_2O	1465.1	1024.9	0.009163	0.029	86.5%
Ferroalloys Production	CO_2	194.9	0.5	0.007237	0.023	88.8%
Mobile Combustion - Domestic Aviation	CO_2	295.6	110.8	0.006101	0.019	90.8%
Mobile Combustion – Agr./Forestry/Fishing	CO_2	741.00	730.82	0.004773	0.015	92.3%
Mobile Combustion - Road	N_2O	9.3	108.5	0.004457	0.014	93.7%
Stationary Combustion	CH_4	171.66	82.72	0.002728	0.009	94.6%
Nitric Acid Production	N_2O	927.5	718.5	0.002717	0.009	95.4%
Manure Management	N_2O	376.7	375.1	0.002587	0.008	96.3%
Consumption of HFCs. PFCs and SF_6	HFC		49.0	0.002169	0.007	97.0%
Manure Management	CH_4	232.1	156.5	0.001709	0.005	97.5%
Human Sewage	N_2O	139.5	85.3	0.001417	0.005	97.9%
Mobile Combustion - Railways	CO_2	137.5	87.7	0.001237	0.004	98.3%
Indirect N_2O Em. from Nitrogen Used in Agr.	N_2O	895.9	730.7	0.001002	0.003	98.7%
Lime Production	CO_2	145.1	143.5	0.000952	0.003	99.0%
Mobile Combustion - National Navigation	CO_2	133.0	91.9	0.000883	0.003	99.2%
Non-CO_2 Emissions from Stat. Combustion	N_2O	65.70	42.11	0.000581	0.002	99.4%
Ammonia Production	CO_2	491.6	425.8	0.000555	0.002	99.6%
Soda Ash Production and Use	CO_2	25.7	12.4	0.000410	0.001	99.7%
Production of Other Chemicals	CH_4	15.8	6.4	0.000304	0.001	99.8%
Limestone and Dolomite Use	CO_2	18.9	9.2	0.000295	0.001	99.9%
Mobile Combustion - Road	CH_4	15.9	16.7	0.000149	0.000	100.0%
Mobile Combustion - Domestic Aviation	N_2O	2.5	1.0	0.000049	0.000	100.0%
Mobile Combustion – Agr./Forestry/Fishing	N_2O	1.88	1.86	0.000012	0.000	100.0%
Mobile Combustion – Agr./Forestry/Fishing	CH_4	1.06	1.05	0.000007	0.000	100.0%
Mobile Combustion - Railways	CH_4	0.2	0.1	0.000002	0.000	100.0%
Mobile Combustion - Railways	N_2O	0.3	0.2	0.000002	0.000	100.0%
Mobile Combustion - National Navigation	N_2O	0.3	0.2	0.000001	0.000	100.0%
Mobile Combustion - National Navigation	CH_4	0.2	0.1	0.000001	0.000	100.0%
Mobile Combustion - Domestic Aviation	CH_4	0.0	0.0	0.000001	0.000	100.0%
Fugitive Emissions from Coal	CH_4	48.8			0.000	100.0%
Aluminium production	PFC	938.6			0.000	100.0%
Aluminium Production	CO_2	111.4			0.000	100.0%
Agricultural Residue Burning	CH_4	4.3			0.000	100.0%
Agricultural Residue Burning	N_2O	1.2			0.000	100.0%
Total GHG Emission (Gg CO_2-eq)		**31609**	**26859**	**0.314**	**1.000**	

Table A3-4: Key source categories for Croatia – summary

Tier 1 Analysis – Source Analysis Summary (Croatian Inventory)			
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag**	**Criteria for Identification**
ENERGY SECTOR			
CO_2 Emissions from Stationary Combustion – Coal	CO_2	Yes	Level, Trend
CO_2 Emissions from Stationary Combustion – Oil	CO_2	Yes	Level, Trend
CO_2 Emissions from Stationary Combustion – Gas	CO_2	Yes	Level, Trend
Non- CO_2 Emissions from Stationary Combustion	CH_4	Yes	Trend
Non- CO_2 Emissions from Stationary Combustion	N_2O	No	
Mobile Combustion – Road	CO_2	Yes	Level, Trend
Mobile Combustion – Railways	CO_2	No	
Mobile Combustion – Domestic Aviation	CO_2	Yes	Trend
Mobile Combustion – National Navigation	CO_2	No	
Mobile Combustion – Agriculture/Forestry/Fishing	CO_2	Yes	Level, Trend
Mobile Combustion – Road	CH_4	No	
Mobile Combustion – Railways	CH_4	No	
Mobile Combustion – Domestic Aviation	CH_4	No	
Mobile Combustion – National Navigation	CH_4	No	
Mobile Combustion – Agriculture/Forestry/Fishing	CH_4	No	
Mobile Combustion – Road	N_2O	Yes	Trend
Mobile Combustion – Railways	N_2O	No	
Mobile Combustion – Domestic Aviation	N_2O	No	
Mobile Combustion – National Navigation	N_2O	No	
Mobile Combustion – Agriculture/Forestry/Fishing	N_2O	No	
Fugitive Emissions from Coal Mining and Handling	CH_4	No	
Fugitive Emissions from Oil and Gas Operations	CH_4	Yes	Level, Trend
CO_2 Emissions from Natural Gas Scrubbing*	CO_2	Yes	Level, Trend
INDUSTRIAL SECTOR			
CO_2 Emissions from Cement Production	CO_2	Yes	Level, Trend
CO_2 Emissions from Lime Production	CO_2	No	
CO_2 Emissions from Limestone and Dolomite Use	CO_2	No	
CO_2 Emissions from Soda Ash Production and Use	CO_2	No	
CO_2 Emissions from Ammonia Production	CO_2	Yes	Level
CO_2 Emissions from Iron and Steel Production	CO_2	No	
CO_2 Emissions from Ferroalloys Production	CO_2	Yes	Trend
CO_2 Emissions from Aluminium Production	CO_2	No	
CH_4 Emissions from Production of Other Chemicals	CH_4	No	
N_2O Emissions from Nitric Acid Production	N_2O	Yes	Level, Trend
HFC Emissions from Consumption of HFCs. PFCs and SF6	HFC	No	
PFC Emissions from Aluminium production	PFC	No	
AGRICULTURE SECTOR			
CH_4 Emissions from Enteric Ferm. In Domestic Livestock	CH_4	Yes	Level, Trend
CH_4 Emissions from Manure Management	CH_4	No	
CH_4 and N_2O Emissions from Agricultural Residue Burning	CH_4	No	
N_2O Emissions from Manure Management	N_2O	Yes	Level
Direct N_2O Emissions from Agricultural Soils and Animals	N_2O	Yes	Level, Trend
Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O	Yes	Level
CH_4 and N_2O Emissions from Agricultural Residue Burning	N_2O	No	
WASTE SECTOR			
CH_4 Emissions from Solid Waste Disposal Sites	CH_4	Yes	Level, Trend
N_2O Emissions from Human Sewage	N_2O	No	

*** CO_2 Emission from Natural Gas Scrubbing** – IPCC doesn't offer methodology for estimating emission of CO_2 scrubbed from natural gas and subsequently emitted into atmosphere. Natural gas produced in Croatian gas fields has a large amount of CO_2. more than 15 percent. The maximum volume content CO_2 in commercial natural gas is 3 percent and gas must be cleaned before coming to pipeline and transport to users. Because of that. the Scrubbing Units exist at largest Croatian gas field. The CO_2. scrubbed from natural gas. is emitted into atmosphere. The emission is estimated by material balance method.

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REPUBLIC OF CROATIA

PROJECTIONS OF GREENHOUSE GAS EMISSIONS

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1. INTRODUCTORY NOTES

The purpose of this report is to give evaluation of future trends in greenhouse gas emissions and removals in Croatia in a form of projections for scenarios “Without measures”, “With measures”, and “With additional measures”, as well as historical emissions data, for the period 1990-2020, according to document FCCC/CP/1999/7. For evaluating the future trends there are three scenarios which represent different assumptions with respect to implemented, adopted or planned policies and measures.

- **“Without measures” 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. However, this scenario does not represent a completely “frozen” status and an intention to continue the business-as-usual scenario. It also includes the improvements that are to happen regardless of the climate change mitigation program requirements.

- **“With measures” scenario** – is based on the most feasible scenario from Energy Sector Development Strategy *(Ref.1.)*. The key assumptions are equivalent to “Without measures” scenario, except one which is related to subsequent introduction of renewable energy sources and efficiency increase. The Energy Sector Development Strategy is adopted policy document and there are approximately 30 regulatory documents which support its implementation, of which five will regulate use of renewable energy and energy efficiency. This secondary regulation is currently in the process of drafting and/or adoption. Apart from Energy, other sectors do not have developed strategic or regulatory documents which address climate change mitigation measures.

- **“With additional measures” scenario** – assumes that the climate change and sustainable development concept shall cause significant change in orientation of the overall Croatian industry and economy. This scenario takes into account the highest possible potential of analyzed measures for GHG emissions reduction. Considerable effects of these measures are expected beyond the year 2010.

There are two strategic objectives with respect to Croatian long-term social and economical development which play important role in analyzing future developments:

- Political stabilization in the region and
- Accession to European Union

These three above scenarios are different than those described in the First National Communication of Republic Croatia, submitted to the UNFCCC in the year 2001. Scenarios in the First National Communication have been developed on the basis of the projection vision existed in the year 1995, which has optimistic trend for years immediately after 1995. Unfortunately, economic development in the period from 1995 to 1999 was slower than predicted, and expected forecast figures were moved for few years in future.

In the year 2001 the new Energy Strategy was adopted under framework of comprehensive policy document named ‘Economic Strategy – Croatia for the 21 Century’. Here described scenarios derivate from the most feasible Energy Strategy’s scenario, called S1. Scenario ‘With measures’ corresponds to S1 scenario and it is hereafter described in details. Other scenarios, ‘Without measures’ and ‘With additional measures’ are analytically developed by subtracting or adding GHG reduction potentials of different mitigation measures

For development of abovementioned scenarios, macroeconomic parameters were taken from Macro economical development strategy *(Ref.2.)*. It is expected that growth of GDP will be approximately 5.2 percent in the period 2001-2004, 3.9 percent in the period 2005-2010, and 4.8 percent in the period 2011-2015. The future trends of GDP and number of population is presented in table 1-1.

Table 1-1: Historical and future trends of GDP and number of population in Croatia

	1990	1995	2000	2005	2010	2015	2020
GDP (USD/capita)	5106	3873	4669	5942	7535	9355	11521
Number of population (mil.)	4.778	4.669	4.437	4.560	4.627	4.700	4.756

2. ENERGY SECTOR

Energy sector development depends on large number of significant factors among which the most important are:

- economic development,
- energy sector reform and government measures,
- international energy market development and international influence,
- technological development,
- global environmental protection limitations

Each of these factors has its influence dimension and the consequences will be different energy consumption levels and energy generation structures. In Energy sector three different scenarios are analysed: “With measures”, “Without measures” and “With additional measures”, which is generally described in previous chapter.

2.1. SCENARIO “WITH MEASURES”

2.1.1. ENERGY CONSUMPTION DATA FOR SCENARIO “WITH MEASURES”

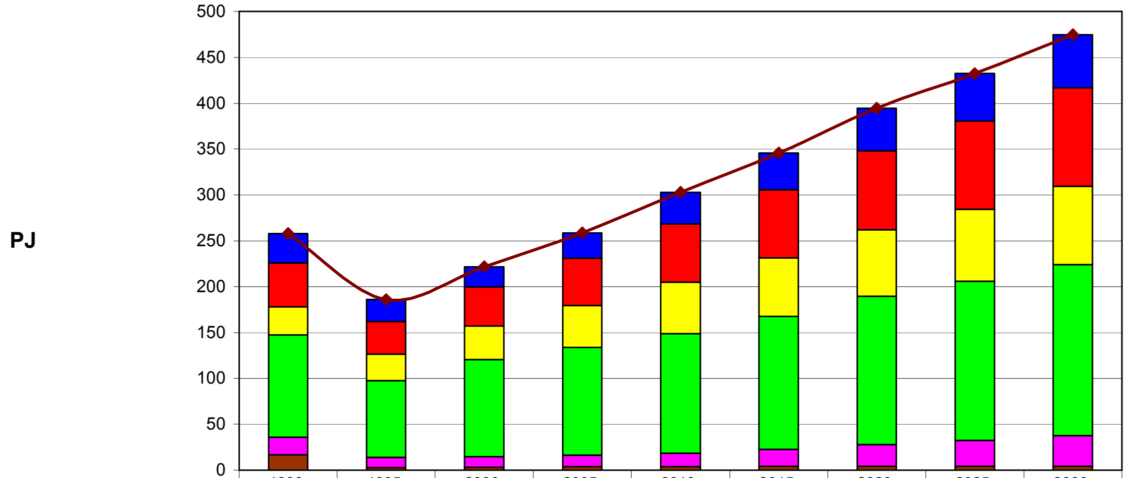
The projection of energy sector development scenario is presented through following energy indicators:

- final energy demand by energy carriers
- final energy demand in different sectors
- electricity generation structure
- energy source structure for the electric utility demand
- total energy consumption divided by fuels
- renewable energy resource structure
- energy import and domestic production structure

2.1.1.1. Final energy demand by energy carriers

The analysis was carried out with expected increase of final energy consumption by average annual growth rate of 2.6 percent. The consumption of all energy sources will increase unequally which will lead to certain changes in energy source structure (Figure 2.1-1).

The steam and hot water consumption will be from 9.9 percent in 2000 to 11.7 percent in 2020. Electric energy participation will grow gradually because of electricity non-heat consumption increase. Gas fuel participation will increase and stabilise on the level of 18 percent. However, the liquid fuel participation and coal will decrease. The renewable resource participation will rise a little and remain on the level of 7 percent.

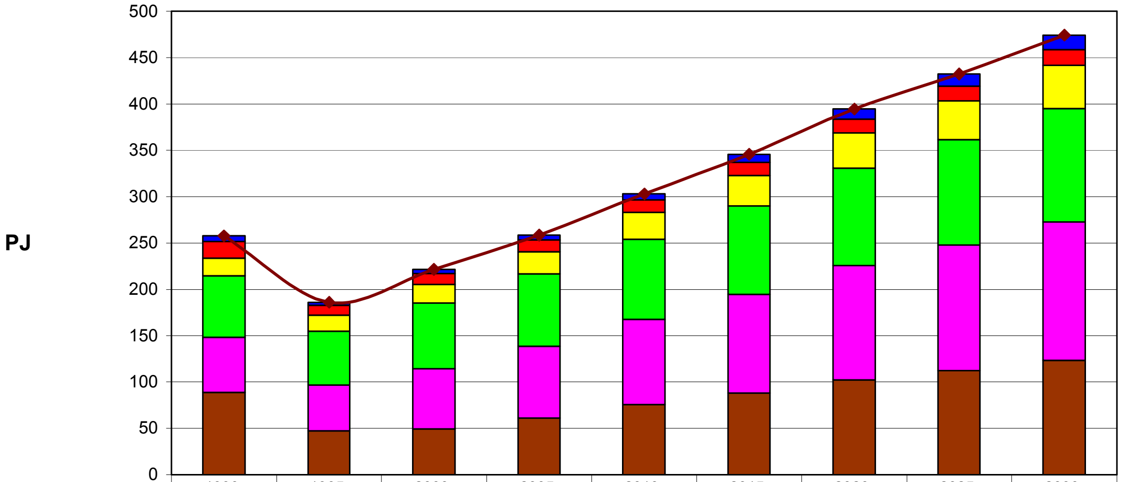


	1990.	1995.	2000.	2005.	2010.	2015.	2020.	2025.	2030.
Steam&hot water	31.93	23.61	22.01	27.63	34.67	40.06	46.29	51.78	57.93
Electricity	47.76	35.74	42.12	51.79	63.69	74.17	86.37	96.16	107.05
Natural gas	30.80	28.82	36.85	45.56	56.31	63.76	72.19	78.42	85.19
Liquid fuel	111.48	83.78	105.67	117.14	129.86	144.87	161.62	173.68	186.64
Renewable resources	19.08	11.07	11.66	13.09	14.71	18.74	23.89	28.34	33.63
Coal	16.68	2.95	3.21	3.52	3.85	3.95	4.04	4.02	4.00
Total	257.74	185.96	221.52	258.73	303.10	345.55	394.40	432.41	474.45

Figure 2.1-1: Final energy demand by energy carriers, PJ

2.1.1.2. Final energy demand in different sectors

In some sectors there will be no other important energy consumption changes because the most important changes have already happened partially because of the war consequences and partially for the economic reasons. Economic activities of intense energy consumption in industry have been considerably reduced, thus in the future major technological promotions can be expected, but with no energy consumption increase of the intensive energy consumers. Transport participation will increase to the level of 31 percent in 2020 while the household share will decrease to fewer than 30 percent after 2010. Gradual agriculture share will decrease owing to an efficient economy organisation and expected technological improvement. In construction and services the gradual increase of energy consumption is expected (Figure 2.1-2).



	1990.	1995.	2000.	2005.	2010.	2015.	2020.	2025.	2030.
Construction	5.91	3.01	4.36	5.43	6.76	8.54	10.78	13.15	16.05
Agriculture	18.03	10.58	11.80	12.53	13.32	13.99	14.70	15.59	16.54
Services	19.42	17.65	19.89	23.96	28.88	33.17	38.12	42.20	46.73
Households	66.21	57.82	71.05	78.28	86.30	95.22	105.09	113.38	122.36
Transport	59.24	49.59	65.05	77.44	92.24	106.77	123.61	135.78	149.21
Industry	88.93	47.30	49.36	61.07	75.60	87.85	102.10	112.30	123.56
Total	257.74	185.96	221.52	258.73	303.10	345.55	394.40	432.41	474.45

Figure 2.1-2: Final energy demand in different sectors, PJ

2.1.1.3. Power Supply System

The Croatian power supply system has total installed capacity of around 4019 MW. There are 17 hydro power plants with 2063 MW that share 51.3 percent of total power supply and 6 thermal power plants with 1618 MW that share 40.3 percent of total power supply. One nuclear power plant of 680 MW capacity situated in Slovenia, delivers 50 percent of its production to the Croatia grid.

Table 2.1-1: Net Power in Croatian Electricity Utility

Power plants	Net Power (MW)
HPP	2063
TPP coal fired	290
TPP on liquid fuel	303
TPP - nat. gas+liquid fuel	479
CHP TPP	469
Gas turbine	48
Diesel engine	29
NPP Krško (50%)	338
Total	**4019**

At present there is no plan on revitalisation of existing thermal power plants, except for NPP Krško which has permanent modernisation programme to operate till the year 2023, with possible extension in years after. Therefore, all scenarios assumes closing down the existing thermal power plants, after their life time expire in average 35 to 40 years

Regarding the hydro power plants, the assumption is that all existing hydro power plants will, with some necessary renewal of some of its parts, operate at least until the end of the planning period (2030). The dynamics of closing down of existing thermal power plants shows that up to year 2020 around 1220 MW of thermal power plants will be closed as it is shown in Figure 2.1-3.

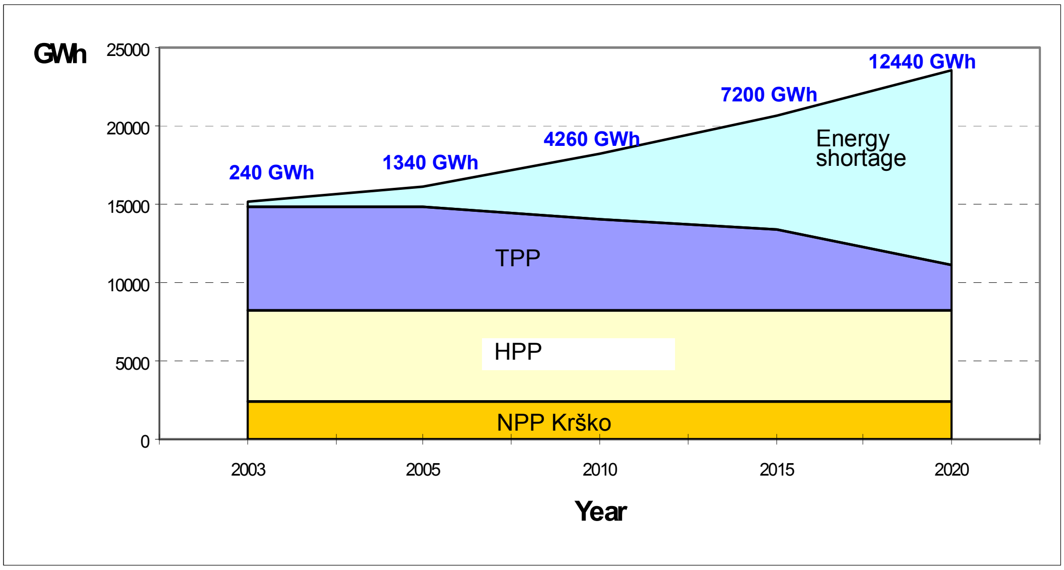
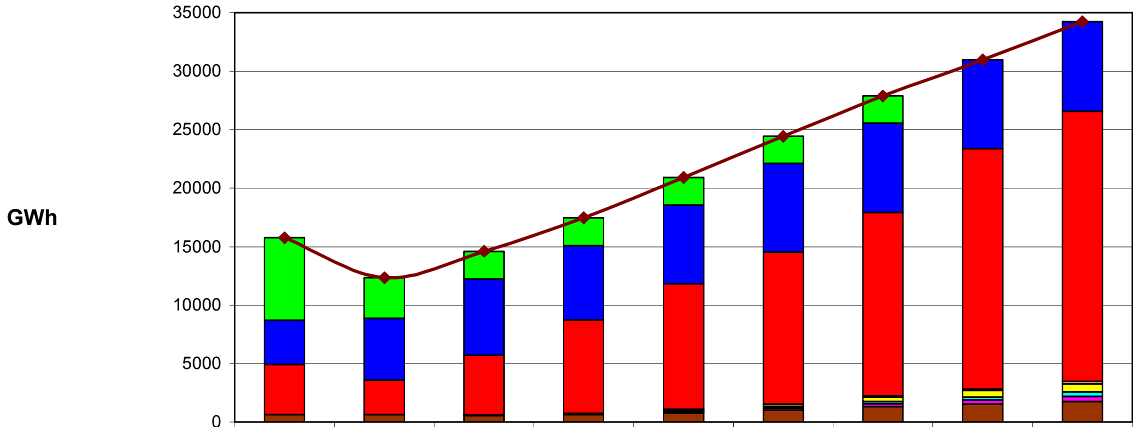


Figure 2.1-3: The dynamics of closing down the existing thermal power plants

Electric energy generation will be performed on the public network level. A small part of the public network participates in decentralized generation plants e.g. combine heat and power generation, renewable resource and small consumer part (hydrogen in future). Electric energy generation structure is presented in Figure 2.1-4.



	1990.	1995.	2000.	2005.	2010.	2015.	2020.	2025.	2030.
NPP Krsko&import	7061.9	3495.9	2360.4	2400.8	2336.2	2337.0	2337.1	0.0	0.0
HPP in Utility	3748.0	5264.5	6509.4	6350.6	6747.9	7577.9	7622.5	7617.2	7616.9
TPP in Utility	4315.8	2965.3	5108.0	7977.8	10735.7	12965.6	15670.2	20499.6	23106.4
Fuel cells	0.0	0.0	0.0	0.0	17.8	36.2	73.7	140.0	233.0
Renewable sources	0.0	0.0	0.0	18.5	109.3	201.1	416.9	558.1	697.1
Small hydro PP	0.0	0.0	82.7	62.0	81.9	124.0	189.0	266.0	372.0
Small cogen.	0.0	0.0	0.0	33.0	94.0	167.0	263.0	351.0	430.0
Industrial cogen.	628.8	632.3	541.4	630.0	785.0	1025.0	1306.0	1537.0	1764.0
Total	15754.5	12358.0	14601.9	17472.7	20908.0	24433.9	27878.4	30968.9	34219.4

Figure 2.1-4: Electric energy generation structure

The fundamental act governing country's energy policy and energy system planning is Energy Sector Development Strategy which outlines major guidelines for power system development. Among others, the most important outlines are:

- The strategic interest of the Republic of Croatia is to construct networked energy systems, i.e. natural gas system and power system that have to complement each other.
- Intensive construction of hydro power plants, in line with the National Hydro Construction Program, as multipurpose plants that stimulate the development of national building construction and electro-mechanical industry
- Diversification of electricity resources (natural gas, coal)
- Multidirectional natural gas & electricity supply is required

When considering hydro power plants, use of remainder of the Croatian hydro potentials will be the top priority. According to that, several HPP are planned to be build in the planning period 2003-2020.

The first power plant which could enter into operation at the earliest by 2008 is HPP Lešće, 40 MW. After that in 2009 HPP Podsused, 44 MW should enter into operation followed by HPP Drenje, 39 MW in 2011, Acumulation&HPP Kosinj, 52 MW should enter into operation in 2012 and in the period 2013 - 2020 around 70 MW in HPP should enter into operation.

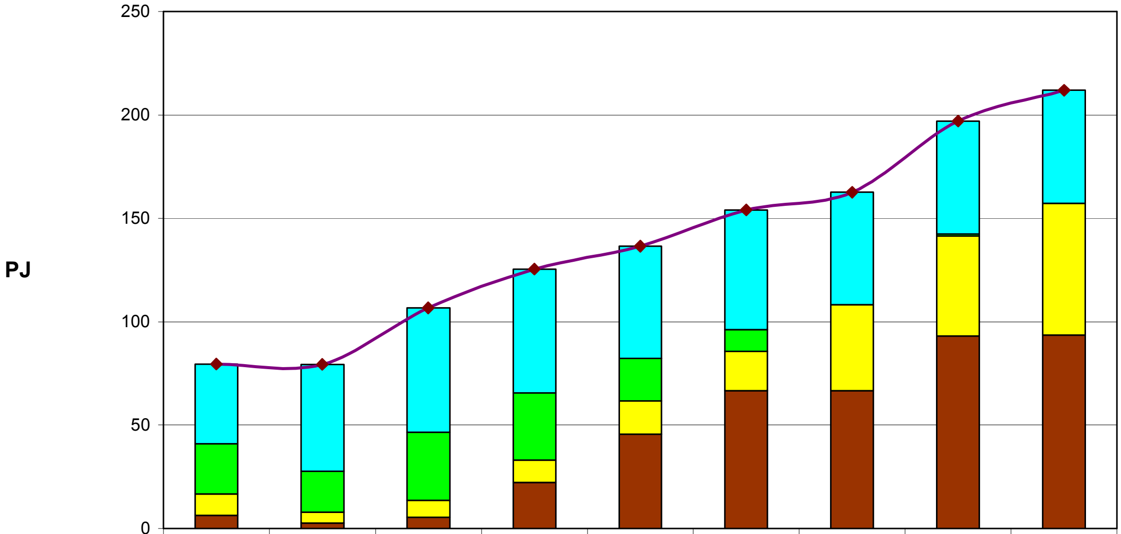
Regarding TPP units, the most favourable option is the construction of gas-fired power plants. In techno-economical competition with coal fired plants, this option is in favour by lower environmental impact and positive public attitude towards them. The first candidate plant is a 300 MW gas-fired combined-cycle thermal unit which should enter into operation in 2007. As it was explained earlier, mainly because of diversification criteria, the next TPP should be coal fired 500 MW power plant which should enter into operation in 2010. In 2010 some existing power plants will stop operating. This, together with the rise of the electricity consumption could be compensated with one thermal power plant with the capacity of 500 MW. From 2010 to 2020 one 500 MW coal fired thermal power plant should enter into operation, followed by four gas power plants of 300 MW each. In this planned period (2003 – 2020) 2500 MW of new TPP units should enter into operation and around 200 MW of HPP. The structure of production units in 2010 and 2020 are shown in Table 2.1-2.

Table 2.1-2: Structure of production units in 2010 and 2020

Power plants	2010 (MW)	2010 (%)	2020 (MW)	2010 (%)
HPP	2147	46.2	2308	41.7
TPP coal fired	790	17.0	1192	21.5
TPP on liquid fuel	303	6.5	-	
TPP - nat. gas + liquid fuel	479	10.3	-	
CHP TPP- nat. gas + liquid fuel	243	5.2	201	3.6
CCGT	300	6.5	1500	27.1
Gas turbines	48	1.0	-	
Diesel engine	-		-	
NPP Krško (50%)	338	7.3	338	6.1
Total	**4648**	**100.0**	**5539**	**100.0**

After the decommissioning of fuel oil burned thermal power plants (TPP Sisak 1 and 2 – 2x210 MW, TPP Rijeka – 320 MW), the fuel oil will not be used in electricity generation. According to this scenario, the fuel oil will be replaced with gas and coal power plants which will satisfy all the needs for electricity. At the end of the observed period the energy from coal and gas will be used equally, however the share of coal will be somewhat bigger.

The structure of fuel used for electricity production is shown in Figure 2.1-4.



	1990.	1995.	2000.	2005.	2010.	2015.	2020.	2025.	2030.
Hydro	38.55	51.75	60.10	59.80	54.27	57.94	54.34	54.62	54.61
Liquid fuel	24.30	19.64	32.90	32.50	20.50	10.39	0.00	1.00	0.00
Natural gas	10.38	5.29	8.25	10.77	16.04	19.10	41.71	48.39	63.74
Coal	6.37	2.66	5.39	22.36	45.69	66.58	66.62	93.00	93.64
Total	79.60	79.34	106.65	125.43	136.50	154.00	162.67	197.01	211.99

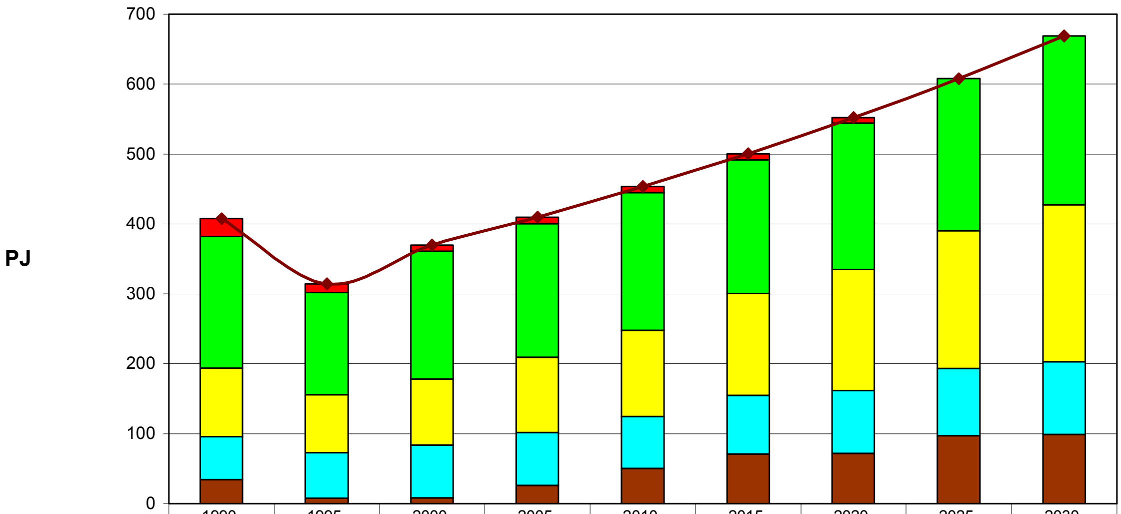
Figure 2.1-5: Structure of fuel used for electricity production

It should be noted, this scenario emphasizes diversification and security of electric-power supply system. In a period by year 2010 the emphasis is given to gas because the gas is more economical than coal, and also it is ecologically more acceptable. After realisation of project GEA (Gas Energy Adria), and liberalization and more opened trade in Europe it is expected that it will be possible to provide enough gas.

2.1.1.4. Energy source structure in total energy demand

Complete energy demands depend on economic improvement, technological development, energy efficiency and electric energy import.

According to this scenario in the period between 2000 and 2020, total energy demand will increase with the rate of 2 percent (Figure 2.1-4). The increase rates will be different and the structure will change. Equally, liquid fuel decrease will continue from 49.6 percent in 2000 to 37.9 percent in 2020. Natural gas as a second energy source will continue increasing with the end participation of gas demand of approximately 31.3 percent.

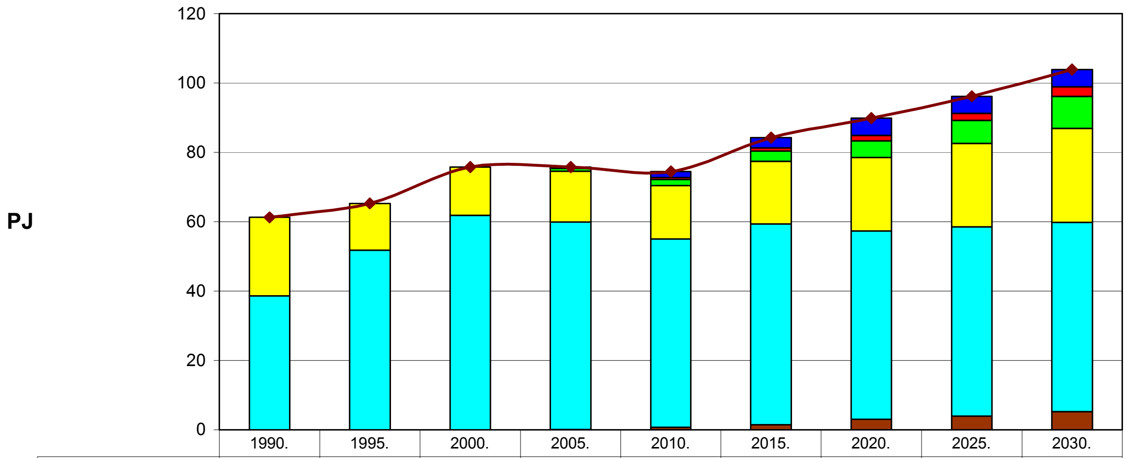


	1990.	1995.	2000.	2005.	2010.	2015.	2020.	2025.	2030.
Electricity	25.42	12.59	8.50	8.64	8.41	8.41	8.41	0.00	0.00
Liquid fuel	188.57	146.03	183.40	191.43	196.86	191.24	209.27	217.36	241.19
Natural gas	98.22	82.77	94.05	107.57	123.05	145.89	172.98	196.98	224.31
Renewables	61.23	65.27	75.79	75.84	74.47	84.23	89.80	96.22	103.90
Coal	34.07	7.42	8.04	25.88	50.42	70.52	71.83	97.02	99.02
Total	407.51	314.08	369.77	409.37	453.21	500.30	552.29	607.59	668.43

Figure 2.1-6: Energy source structure in total energy demand, PJ

2.1.1.5. Renewable energy resource structure

In this scenario based on present-day technologies and experiences, new technology contribution in the field of energy efficiency and renewable resource utilisation is planned to increase. It is related to two traditional sources used until now: hydro power plant and biomass (wood for heating). This scenario structure anticipates the increase of geothermal energy after the 2000 with the end at 5.5 percent in total renewable energy consumption. Wind energy utilisation increases in period after the 2000 and it is expected to be 1.7 percent in 2020. In this scenario solar energy will reach 5.4 percent. At the end of the period renewable resource share should be approximately 23.6 percent. Hydro potential should absolutely increase. Hydro potential should decrease from more than 80 percent in 2000 to 60.5 percent in 2020. Biofuel utilisation is expected to begin around 2010 and in 2020 its share is expected to be approximately 3.3 percent (Figure 2.1-5).



	1990.	1995.	2000.	2005.	2010.	2015.	2020.	2025.	2030.
Geothermal energy			0.00	0.34	1.75	2.93	4.90	4.96	5.02
Wind energy			0.00	0.15	0.50	0.88	1.55	2.06	2.74
Solar energy			0.00	0.77	1.78	2.93	4.82	6.65	9.16
Biomass	22.68	13.52	13.92	14.67	15.48	18.13	21.22	24.00	27.15
Hydro power	38.55	51.75	61.86	59.80	54.27	57.94	54.34	54.62	54.61
Biodiesel			0.00	0.10	0.69	1.43	2.97	3.94	5.22
Total	61.23	65.27	75.79	75.84	74.47	84.23	89.80	96.22	103.90

Figure 2.1-7: Renewable energy resource structure, PJ

2.1.1.6. Import and domestic energy

Domestic energy sources were used in energy sector development of the Republic of Croatia. In the past 5 years period share of domestic sources decreased from 63.4 percent to little bit more than 50.4 percent in 2000. According to this scenario, by the year 2010 the import will increase to 64 percent and at the end of the observed period the share in total demand will be 74 percent (Table 2.1-3).

Table 2.1-3: Import and domestic energy, PJ

	Past			Projected	
	1990	1995	2000	2010	2020
Imported energy	40.1	36.6	49.6	64.0	73.8
Domestic energy	59.9	63.4	50.4	36.0	26.2

2.1.2. GHG EMISSION FOR SCENARIO “WITH MEASURES”

2.1.2.1. Measures

The scenario "With measures" outlines total energy demand, assuming the implementation of a variety of measures, such as the use of renewable energy resources and the implementation of energy efficiency measures.

The following measures are included in "With measures" scenario:

- Wind Power Plants
- Small Hydro Power Plants
- Biomass Use in Cogeneration Plants
- Fuel Cells
- Biodiesel and Hydrogen
- Solar Energy
- Geothermal Energy
- Heat Generation Efficiency Increase

The table 2.1-4 shows GHG emission reduction potential of the mentioned measures for the years 2010 and 2020. More detailed information about GHG emission reduction potential of listed measures is presented in Annex 1. The mentioned measures cannot be implemented without special incentives and an adequate energy policy. Implementation of concerned measures is adopted through Energy Sector Development Strategy (policy document adopted by Parliament). There are approximately 30 regulatory documents which support its implementation, of which five will regulate use of renewable energy and energy efficiency. This secondary regulation is currently in the process of drafting and/or adoption.

The secondary regulation for introduction of renewable energy sources (wind, small hydro, bioenergy and geothermal) will stipulate connections of these sources to the grid by providing energy subsidies. Every power supplier will be obliged to have certain proportion of renewable energy in its portfolio, and revenue for subsidies will be collected through energy taxation.

Table 2.1-4: Potential of GHG mitigation measures (Gg) in Energy sector

	2010				**2020**			
	CO_2	**CH_4**	**N_2O**	**CO_2-eq**	**CO_2**	**CH_4**	**N_2O**	**CO_2-eq**
Wind Power Plants	108.9	2.1	1.3	**109.4**	285.1	3.6	3.4	**286.3**
Small Hydro Power Plants	64.2	1.2	0.8	**64.4**	125.1	1.6	1.5	**125.6**
Biomass Use in Cogeneration Plants	44.1	1.1	0.2	**44.2**	204.9	5.1	0.8	**205.2**
Fuel Cells	14.0	0.3	0.2	**14.0**	48.8	0.6	0.6	**49.0**
Biodiesel and Hydrogen	53.8	4.4	0.4	**54.1**	261.7	27.7	2.2	**263.0**
Solar Energy	311.6	15.4	3.4	**313.0**	624.8	32.7	6.0	**627.3**
Geothermal Energy	239.1	11.0	2.6	**240.1**	539.2	25.8	5.3	**541.4**
Heat Generation Efficiency Increase	33.7	2.7	0.5	**33.9**	78.6	6.5	1.2	**79.1**
Total	**869.4**	**38.2**	**9.4**	**873.1**	**2168.2**	**103.6**	**21.0**	**2176.9**

2.1.2.2. Projections

The fossil fuels consumption projections and the adequate emission factors recommended by IPCC method, enable the determination of greenhouse gas emissions. The CO_2 emission will increase, according to “With measure” scenario. The highest increase is expected in the power generation sector as a result of two new coal-fired thermal power plants in operation, and in transport due to increase of vehicles and mobility (Table 2.1-5).

Table 2.1-5: CO_2 emission from Energy subsectors

CO_2 Emission (Gg)	1990	1995	2001	2005	2010	2015	2020
Energy Industries	5896.5	4459.9	5650.3	7152.5	8691.5	9403.2	10131.1
Man. Ind. & Constr.	6545.9	3617.0	3903.1	4486.3	5095.8	5843.1	6590.3
Transport	4046.0	3337.2	4459.1	5452.4	6345.2	7329.2	8313.1
Residential	1994.8	1596.0	2068.5	2332.9	2572.8	2789.0	3005.2
Commercial/Institutional	782.1	601.4	709.7	698.7	688.3	716.3	744.4
Agriculture and Other	1278.1	773.4	900.3	868.0	877.6	905.8	917.8
Natural Gas Scrubbing	415.9	696.9	687.6	687.6	687.6	687.6	687.6
Total Energy Sector	**20959.4**	**15081.9**	**18378.7**	**21678.4**	**24958.9**	**27674.2**	**30389.6**

In addition, the total emissions of individual greenhouse gases from Energy Sector are presented (Table 2.1-6). According to scenario ”With measures”, the increase in greenhouse gas emission will occur so that in 2010 the emission will be 34 percent larger than emission in 2001, or 19 percent larger than emission in 1990.

Table 2.1-6: Total GHG emission from Energy sector

GHG Emission (Gg)	1990	1995	2001	2005	2010	2015	2020
CO_2 Emission	20959.4	15081.9	18378.7	21678.4	24958.9	27674.2	30389.6
CH_4 Emission	67.806	58.193	63.921	64.702	65.296	66.187	67.077
N_2O Emission	0.257	0.158	0.496	0.792	1.039	1.191	1.343
CO_2-eq Emission	**22462.9**	**16352.7**	**19874.9**	**23282.6**	**26652.0**	**29433.2**	**32214.4**

More detailed information about GHG emissions for “With measures” scenario is shown in Annex 1.

2.1.2.3. Analysis of “With measures” scenario

The expected increase of gross domestic product, total energy demand, electricity consumption and CO_2 emission, for “With measure” scenario, is presented in the Table 2.1-7.

Table 2.1-7: Expected increase of main indicators, “With measure” scenario

	1990	1995	2000	2005	2010	2015	2020
GDP/capita, \$/cap.	5106	3873	4669	5942	7535	9355	11521
Total energy demand, PJ	408	314	370	411	453	503	552
CO_2 emission - "With measure", Gg	20959	15082	17447	21678	24959	27674	30390
Electricity consumption, GWh	14749	11404	13836	16048	19127	22103	24865

According to expected values of main indicators for the period from 2000 to 2020, GDP will annually increase by 4.6 percent on average, total energy demand by 3.0 percent, CO_2 emission by 2.8 percent and electricity consumption by 2.0 percent. Indexes of abovementioned indicators, normalized on 1990 values (100% in 1990), are shown in the Figure 2.1-6.

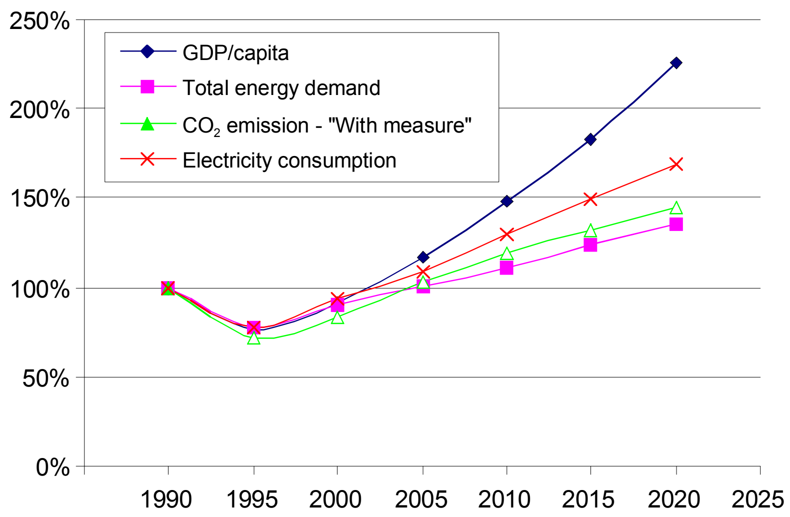


Figure 2.1-8: Indexes of main indicators for “With measure” scenario

2.2. SCENARIO “WITHOUT MEASURES”

As it was noted in introductory chapter this scenario is constructed from the ‘With Measures’ scenarios by subtracting the GHG reduction potentials of selected measures that belongs to the category of ‘Climate Change’ driven measures.

Although a number of measures were simulated under the scenario "With measures", only some of them, more significant in terms of their respective potential, were selected for the creation of the scenario "Without measures" (Table 2.1-4). Therefore, the scenario "Without measures" does not represent a frozen scenario, i.e. energy demand projections based on the present state of energy technologies. In addition to the mentioned measures, a gradual improvement in energy efficiency without special incentives was also simulated. This suggests that the energy demand under the scenario “Without measures” would be slightly lower than that under the straight frozen scenario. At the same time, the GHG emission would be higher under the frozen scenario than under the analyzed scenario "Without measures".

2.3. SCENARIO "WITH ADDITIONAL MEASURES"

Additional mitigation measures is analysed in official development strategy of Energy sector and First National Communication to the UNFCCC. According to above-mentioned documents, potential of measures for Power sector and Energy consumption sectors is developed (Table 2.3-1). More detailed information about additional measures is presented in Annex.

Table 2.3-1: Potential of additional GHG mitigation measures (Gg) in Energy sector

	2010				2020			
	CO_2	CH_4	N_2O	CO_2-eq	CO_2	CH_4	N_2O	CO_2-eq
Power Generation Sector	**727.3**	**13.9**	**8.5**	**730.2**	**1225.4**	**15.3**	**14.5**	**1230.2**
Savings in power trans. and distrib.	39.6	0.8	0.5	39.8	99.2	1.2	1.2	99.6
Wind Power Plants	451.1	8.6	5.3	452.9	762.1	9.5	9.0	765.1
Small Hydro Power Plants	62.7	1.2	0.7	62.9	105.9	1.3	1.3	106.3
Biomass in Cogeneration	174.0	3.3	2.0	174.7	258.2	3.2	3.1	259.2
Industry	**258.8**	**12.6**	**3.4**	**260.1**	**795.6**	**19.0**	**12.2**	**799.8**
Motor Drives Regulation	12.2	0.2	0.2	12.3	470.7	5.9	7.4	473.1
Cogeneration Plants	52.8	0.9	0.9	53.1	150.1	2.7	2.7	151.0
Low-temp. heat gener. effic. increase	115.2	5.4	1.1	115.7	102.1	4.8	1.0	102.5
High-temp. heat gener. effic. increase	78.5	6.0	1.2	79.0	72.7	5.6	1.1	73.1
Transport	**59.4**	**4.1**	**0.5**	**59.6**	**910.2**	**70.4**	**34.5**	**922.3**
Interurban passenger transport	0.0	0.0	0.0	0.0	93.0	21.5	16.6	98.6
Urban passenger transport	0.0	0.0	0.0	0.0	77.0	15.4	11.9	81.0
Freight transport	0.0	0.0	0.0	0.0	458.5	14.4	3.7	460.0
Increase in biodiesel use	59.4	4.1	0.5	59.6	281.6	19.2	2.3	282.7
Services	**406.8**	**21.4**	**4.4**	**408.6**	**835.5**	**44.3**	**7.9**	**838.8**
DSM measures	14.4	0.3	0.2	14.5	32.1	0.4	0.4	32.2
Solar energy use increase	78.5	3.9	0.8	78.8	140.2	7.3	1.3	140.7
Geothermal energy use increase	16.4	0.8	0.2	16.4	27.9	1.3	0.3	28.0
Distr. heating and cogen.use increase	66.8	3.6	0.7	67.1	145.6	8.0	1.4	146.2
Insulation improvement	230.8	12.8	2.5	231.8	489.6	27.2	4.6	491.6
Residential	**586.8**	**22.4**	**4.4**	**588.6**	**1789.2**	**87.0**	**13.9**	**1795.3**
Solar energy use increase	28.4	1.8	0.2	28.5	286.7	21.3	1.9	287.7
DSM measures	12.4	0.2	0.1	12.5	192.3	2.4	2.3	193.0
District heating use increase	20.7	2.2	0.1	20.8	156.8	17.2	1.1	157.5
Insulation improvement	73.0	2.5	0.7	73.2	376.4	18.7	3.1	377.8
Biomass in cogen. and boiler plants	452.2	15.6	3.1	453.5	777.0	27.4	5.5	779.3
Total potential	**2039.1**	**74.3**	**21.2**	**2047.2**	**5555.8**	**236.1**	**83.1**	**5586.5**

2.3.1. POWER SECTOR

One of the main characteristic of Croatian Power sector is that more than 65 percent of electricity supply is provided without direct GHG emissions, by hydro power plants, nuclear power plant Krško and import. Import of electricity is very large in last few years, i.e. in 2000 the import (4037 GWh) was more than production in all thermal power plants in Croatia (3958 GWh). According to Power sector development scenarios, all electricity demands should be supplied from Croatian power plants.

In “With additional measures” scenarios, about 300 MW installed capacity of renewable power plants in wind power plants, small hydro plants and biomass cogeneration plants is assumed. Those plants should produce 878 GWh of electricity in 2010. Accordingly, 690 Gg of equivalent CO_2 emissions will be avoided (Table 2.3-1).

This scenario assumes 576 GWh of electricity production from wind turbines, in 2010. Using wind-electricity, appropriate fossil fuels consumption will be reduced, because of decrease of thermal power electricity production.

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 100 stretches will be used in 2010, and about 80 GWh of power generated, the GHG emission would be reduced by 63 Gg.

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 equal to the generated heat quantity. In calculation is assumed 222 GWh of electricity production from biomass-fired cogeneration plants in 2010.

Additionally, distribution efficiency improvement is also analysed. The technical losses from the distribution network are evaluated at 5 to 5.5 percent. The loses in distribution network could be reduced to approximately 1 percent till 2020. These measures demand high additional investment, for reduction of losses from the existing network, which is usually not cost-effective.

2.3.2. ENERGY CONSUMPTION SECTORS

2.3.2.1. Measures in Industry

This 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 15 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 10 percent.

In Industry is analysed heat generation efficiency increase, electromotor drive regulation and industrial cogenerations. Expected GHG emission reduction potential of planned measures is about 260 Gg in 2010 (Table 2.3-1).

2.3.2.2. Measures in Transport

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. The shares of motor gasoline and diesel fuels would notably decline. Additionally, in this sector increase of biodiesel use ia also analysed.

The estimated potential of reducing energy consumption in transport sector is calculated with the equal efficiency and equal level of passenger and freight transport effects. The GHG emission reduction potential of planned mitigation measures in Transport sector is presented in the Table 2.3-1.

2.3.2.3. Measures in Services

Unlike the scenarios “With measures” and “Without measures”, this 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 13.4 percent and geothermal energy with 4.5 percent in 2020, which is higher than in the “With measures” scenario. An even faster introduction of heat generated in small cogeneration plants and of district heating is expected.

In this sector is recognized few types of measures, as follow: demand side measures, increase usage of solar and geothermal energy, increase usage of district heating plants and cogenerations and thermal insulation improvement. The GHG reduction potential of these measures is presented in the Table 2.3-1.

2.3.2.4. Measures in Residential sector

In relation to the other scenarios, 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 district heating and cogeneration plants). Improvements of thermal insulation of existing households and electricity savings for non-heat purposes is also analysed in this “With additional measures” scenario (Table 2.3-1).

2.4. GHG EMISSION PROJECTION OF ENERGY SECTOR

The greenhouse gases emission for previously mentioned scenarios of energy sector development, so called “With measures”, “Without measures” and “With additional measures” scenarios, are presented in the Figure 2.4.1. The projection of fuel combustion sectors is based on Energy sector development strategy, while fugitive emission projection is not determined. In projections, the fugitive emission from the year 2001 is used.

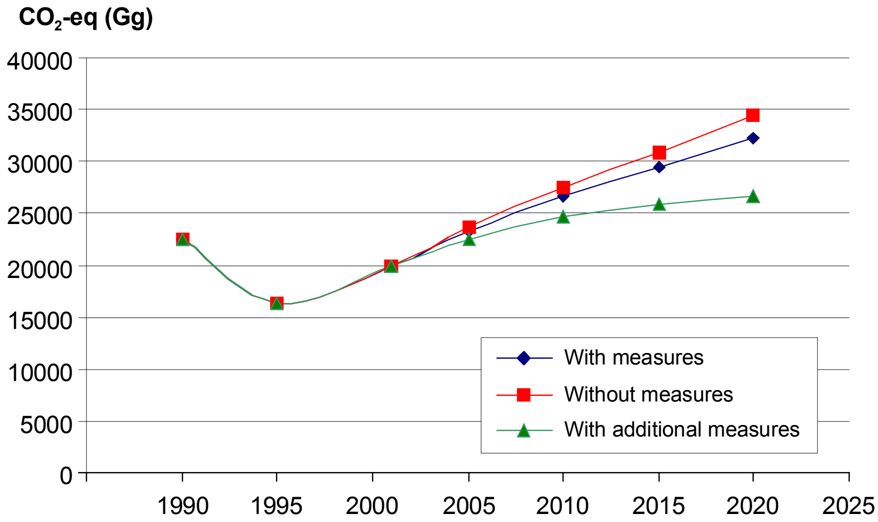


Figure 2.4-1: GHG emission projection for Energy sector

According to all analysed scenarios, the increase of GHG emission will occur. For scenario “With additional measures” in 2010, the GHG emission will be 10.5 percent larger than emission 1990, while the scenario “Without measures“ even 22.5 percent. It is important to stress, that in scenario “With additional measures”, about 300 MW installed capacity in renewable power plants (wind power plants, small hydro plants and biomass cogeneration plants) is involved.

3. INDUSTRIAL PROCESSES

The projections of emission from industrial processes assume that Croatia is not going to install additional capacities of the energy-intensive industry, and that there will be no revival of iron and primary aluminium production which were closed down in 1991. The industrial processes analyzed here have the major share in the total sector emission (around 92 per cent) and have prepared medium or long-term bussines strategies. These are production of cement, ammonia and nitric acid. The projections does not encompass the closed down processes and ones for which there are no developed medium or long-term bussiness plans/strategies as well as those that have negligible contribution to total emission from this sector.

In respect to classification of measures (“With measures” and “With additional measures”) it should be stressed that there are no currently implemented and adopted policies and mitigation measures in industrial processes in Croatia, and therefore it is not possible to report “With measures” projections. Only “Without measures” and “With additional measures” projections are reported.

3.1. “WITHOUT MEASURES” PROJECTIONS

The “Without measures” projections of emission from industrial processes assumes that production of selected processes (cement, ammonia and nitric acid) in the period 2005-2020 will reach its planned capacities, and that no measure for reduction of greenhouse gases will be implemented. The emissions of CO_2 and N_2O for “Without measure” scenario are presented in tables 3-1 and 3-2.

3.1.1. CO_2 EMISSION

Table 3.1-1: CO_2 emissions from Industrial processes (Gg)

Industrial processes	**1990**	**1995**	**2001**	**2005**	**2010**	**2015**	**2020**
Cement production	1022	585	1420	1557	1557	1557	1557
Lime production	145	62	144	NE	NE	NE	NE
Limestone use	19	11	9	NE	NE	NE	NE
Soda ash use	26	14	12	NE	NE	NE	NE
Ammonia production	492	463	426	509	542	542	542
Metal production[1]	641	34	0.5	NE	NE	NE	NE
Total	**2345**	**1169**	**2012**	**2066**	**2099**	**2099**	**2099**

[1] Includes: iron and steel production, ferroalloys production and aluminium production
NE – Not estimated

3.1.2. N_2O EMISSION

Table 3.1-2: N_2O emissions from Industrial processes (Gg)

Industrial processes	**1990**	**1995**	**2001**	**2005**	**2010**	**2015**	**2020**
Nitric acid production	2,99	2,69	2,32	2,92	3,11	3,11	3,11
Total	**2,99**	**2,69**	**2,32**	**2,92**	**3,11**	**3,11**	**3,11**

3.2. "WITH ADDITIONAL MEASURES" PROJECTIONS

The only mitigation measure in industrial processes which is considered as "additional measure" in this analysis is installation of NSCR (Non-Selective Catalytic Reduction) in the nitric acid production plant. This measure is included in manufacturer's business strategy as medium term objective if N_2O fee will be in place (not planned at the moment), or to achieve allocated greenhouse gas emission limit according to national emission allocation scheme (still not developed). For this purpose it is assumed that this measure will be implemented in 2010, and that NSCR has 85 per cent efficiency.

Table 3.2-1: N_2O emissions from nitric acid production "With additional measures"(Gg)

Industrial processes	1990	1995	2001	2005	2010	2015	2020
Nitric acid production	2.99	2.69	2.32	2.92	0.47	0.47	0.47
Total	**2.99**	**2.69**	**2.32**	**2.92**	**0.47**	**0.47**	**0.47**

Table 3.2-2 presents difference between "Without measure" and "With additional measure" scenario.

Table 3.2-2: CO_2-eq emissions from Industrial processes (Gg)

Industrial processes	1990	1995	2001	2005	2010	2015	2020
"Without measures"	3272.6	2004.0	2730.0	2972.0	3063.6	3063.6	3063.6
"With add. measures"	3272.6	2004.0	2730.0	2972.0	2243.7	2243.7	2243.7
Mitigation	**0**	**0**	**0**	**0**	**819.9**	**819.9**	**819.9**

4. 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.

4.1. 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 rate, 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).

4.2. 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.

4.3. MOST PROBABLE 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).

5. LAND USE CHANGE AND FORESTRY

The “without measures” or 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 8.069 million tons per year.

Measures for increase of carbon sequestration with forest biomass with the highest contribution are reforestation and better use of biomass in power generation, or use of waste wood. Reforestation does not bring short-term results and the procedure for determination of the GHG 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 this sector 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 331000 ha could result in an increase in the annual increment of 2.2 million m^3, which means the emission sink increase by 2 million tons.

6. WASTE

The projections of emissions from waste sector includes only municipal solid waste disposal on land since there are no realistic plans for anaerobic wastewater treatment and waste incineration without energy recovery in Croatia in the future period.

In respect to classification of measures ("With measures" and "With additional measures") it should be stressed that there are no currently implemented and adopted policies and mitigation measures in waste sector in Croatia, and therefore it is not possible to report "With measures" projections. Only "Without measures" and "With additional measures" projections are reported.

6.1. "WITHOUT MEASURES" PROJECTIONS

The "Without measures" projections of emission from solid waste disposal assume continuous increase of municipal solid waste caused by increase in the standard of living and size of population, and subsequent decrease with time due to waste avoidance/minimization and recycling measures. In the period 1990-2000, the estimated annual waste increase was 2.7 percent. The estimated increase for the period 2001-2010 is in the range of 1.5 to 2.5 percent, and for the period 2011-2020 from 1.0 to 2.0 percent.

At such increase rates, the average annual municipal waste production shall grow from 1 million tonnes in 1990 to approximately 1.6 million tonnes in 2010 and 1.8 million tonnes in 2020. IPCC default methodology was used to estimate methane emissions from solid waste disposal sites (table 6.1-1).

Table 6.1-1: CH_4 emissions from Waste "Without measures" (Gg)

Waste	1990	1995	2001	2005	2010	2015	2020
Solid waste disposal	37.77	41.16	51.33	62.57	69.89	65.37	57.57

6.2. "WITH ADDITIONAL MEASURES" PROJECTIONS

The "With additional measures" projections include implementation of "waste-to-energy" plants for municipal solid waste instead of waste disposal to land. According to actual plans for building of the first waste incineration plant it is assumed that approximately 20 percent of total municipal solid waste generated in Croatia will be incinerated in 2010 and 40 percent in 2020.

Table 6.2-1: CH_4 emissions from Waste "With additional measures" (Gg)

Waste	1990	1995	2001	2005	2010	2015	2020
Solid waste disposal	37.77	41.16	51.33	54.26	53.36	42.29	31.25

Table 6.2.2 presents difference between "Without measure" and "With additional measure" scenario.

Table 6.2-2: CO_2-eq emissions from waste (Gg)

Waste	1990	1995	2001	2005	2010	2015	2020
"Without measures"	793	864	1078	1314	1468	1373	1209
"With add. measures"	793	864	1078	1139	1120	888	662
Mitigation	**0**	**0**	**0**	**175**	**348**	**485**	**547**

7. SUMMARY OF SCENARIOS

Total greenhouse gas emissions in the “Without measures” scenario, and contribution of individual sectors, are shown in Figure 7-1. It must be noted that this projection has not been considered for some individual sub-sectors, such as: fugitive emission from fuels, some less important industrial processes, and human sewage. Their contribution to the total emission was about 8.3 percent in 2001, and all scenarios assume that the emissions from these sub-sectors remain at the 2001 level.

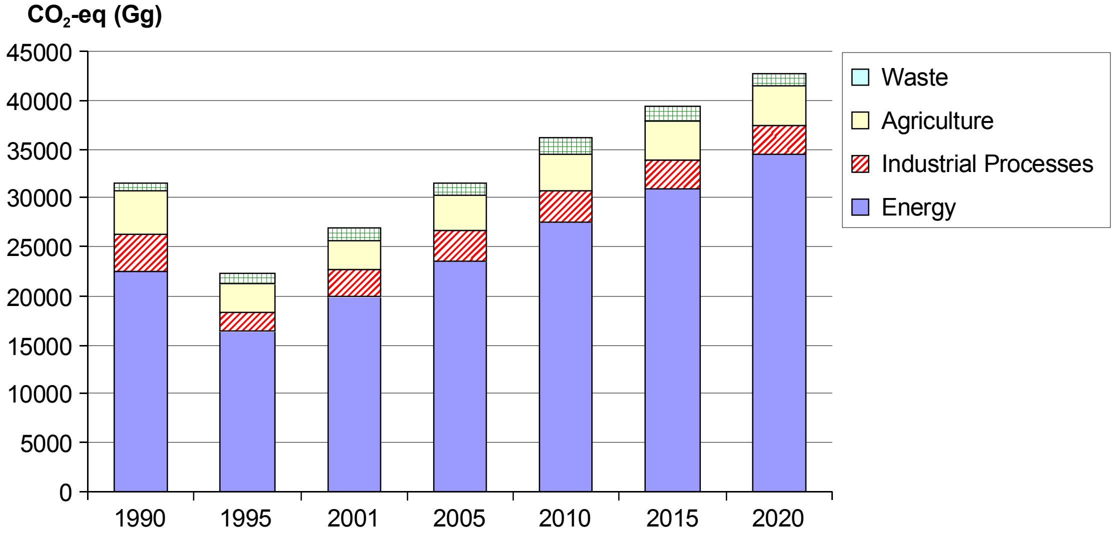


Figure 7-1: Total GHG emission according to “Without measure” scenario

Figure 7.2 presents cumulative GHG emission reduction potential, including both “with measures” and “with additional measures”.

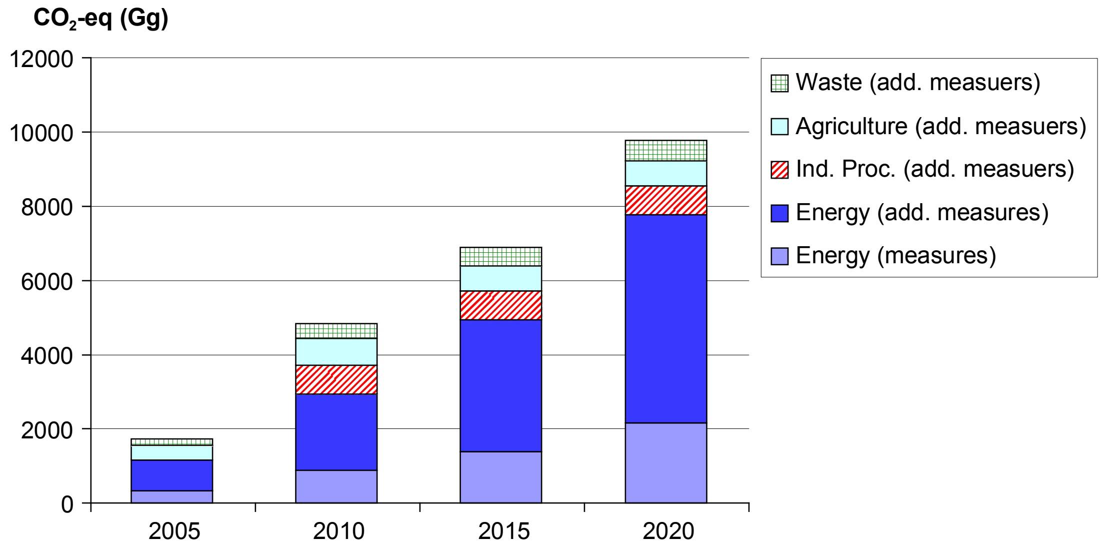


Figure 7-2: Total GHG emission reduction potential of analysed measures

Total GHG emission projections for “Without measures”, “With measures” and “With additional measures” scenarios are shown in Figure 7-3. Kyoto protocol target presented on figure 7-3 is on the level which does not involve Proposal of the Croatian under article 4.6 (7.4 million of tons of CO_2-eq above standard approach for defining base year emission).

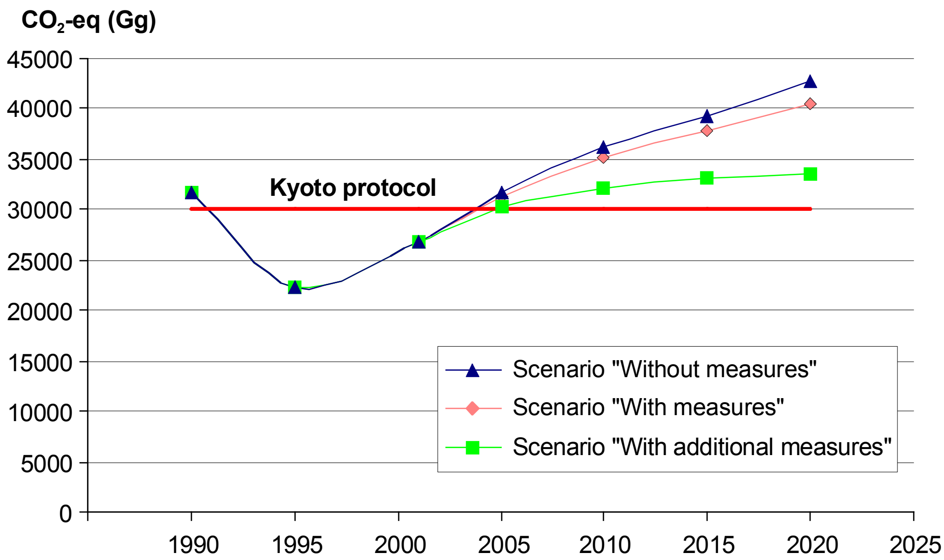


Figure 7-3: Greenhouse gases emission projection for Croatia

In assessing projection scenarios from figure 7-3 it is important to have on mind the following:

- Projection scenarios assume realistic growth rates in energy sector. The total energy growth rate is 3 percent and for the electricity consumption is 2 percent, less than growth of GDP (Figure 2.1-8). With this growth rates which are already in place, Croatia will have in the year 2010 per capita energy and electricity consumption lower than each country of the enlarged EU. Emission intensity (t CO_2/GDP) will decrease in the year 2010 for 16.7 percent comparing to year 1990, for the scenario “With measures”.
- The share of fossil fuel consumption in all sectors, including power production, will be still relatively low, much less then in many other EU countries, particularly less than in EIT countries.
- Croatia has to build new power plant not only for covering the new growing demands but also to substitute capacities that have been available, on long term basis, from another republics of former Yugoslavia.
- Croatia is still suffering the consequences of the war and instability in region for the period until the end of the first commitment period. For Croatia, the main priority was recovering the life in war effected areas, the great part of public expenses, including the National Electricity Company investments, is going on recovering of war destroyed grid and transmition facilities (for example the greatest power switch yard in this part of the Europe destroyed in the war, named Ernestinovo, has needed ten years to be re-build).
- In the year 2010 imported energy will have share of 64 percent. To enable secure energy supply, Croatia needs to have diversified fuel sources.
- Potential for renewable energy are quite limited, location for the wind farms are not close to consumers and often in areas where visible landscape impact is problematic because of tourism. Croatian hydro potentials are explored and new capacities could be built with high costs and great environmental impact. Share of biomass use is currently quite high, in rural settlements where there is no natural gas, fuel wood is dominant fuel. In total energy supply, fuel wood share is 4.3 percent in the year 2000.

- Currently 14.4 percent (in 2000) of electricity is produced in cogeneration plants. There is no public or industrial consume available for big new electricity cogeneration units.
- Energy intensity in Croatia is about 310 toe/mill.US$90 which is on the level of some very developed countries like USA. This shows that there is no great potential in industry restructuring.
- Since the great part of industrial and service sector is struggling with survival and with transition to open market, it is not possible to use benefits of energy efficiency implementation.
- Policy priority in energy sector is to build regulatory and institutional basis for new energy open market system. Significant penetration of renewable electricity will be possible when Energy Regulating Agency and Independed Operator of the Energy Market will have instruments in place for absorbing this energy in the system. Process of deregulation of energy market is slow and current situations about shortage of electricity and black outs in Europe calls for very careful change steps which will definitely slow down the whole restructuring process.
- Some important projects, like “Removing Barriers for Energy Efficiency in Service and domestic Sector”, “Croatian Energy Efficiency Project” and “Croatian Renewable Project”, all supported by the GEF with total budget of 56 million US$, show that barrier for implementation of energy efficiency and renewables are still large.

Figure 7-3 shows that even with implementation of all additional measures, Croatia is not able to achieve the GHG emission stabilization on the level of the base year emission and Kyoto target. It should be emphasised that “With additional measures” scenario could be hardly achieved. This scenario 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 bottom-up approach. Current Government initiative to collect candidate project for JI under Kyoto protocol shows that project base level potential of GHG reduction is considerable lower than aggregate scenario figures give.

Even with “Without measure” scenario Croatia will have per capita GHG emission on the level between the lowest of EU and EIT countries. Feasible scenario “With measures” gives 5.2 million tons of CO_2-eq above the Kyoto protocol target. Including forest sink (976 Gg CO_2), which is 15 percent of total removal of forestry management activities, the emission of Croatia in the year 2010 will be 4.2 million tons above Kyoto target.

Scenario “With additional measures”, exceeds Kyoto emission target by 2 million tons CO_2-eq. This scenario assumes reduction of emission by 5.2 million of tons comparing to “Without measures” (business as usual) scenario in the year 2010, in 2020 reduction needs to be 10 million tons. National cost calculation curve of mitigation measures shows that in energy sector with approach above 1.5 million of tons reduction, costs reach 30 – 40 US$ per ton of CO_2 *(Ref.3.).* This means that scenario “With additional measures” will have a considerable socio-economic impact, which is not in proportion to the Croatian economic capabilities and its priorities.

8. REFERENCES

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ANNEX

GHG EMISSION PROJECTION OF ENERGY SECTOR

Table A-1: Projection of CO_2 emission for Energy - "With measures" scenario

CO_2 Emission (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2005	2010	2015	2020
Energy Industries	5897	3847	4514	5185	3925	4460	4310	4875	5531	5699	5156	5650	7152	8691	9403	10131
Manufact. Ind. and Constr.	6546	4732	3730	3658	3815	3617	3763	3714	4008	3729	3805	3903	4486	5096	5843	6590
Transport	4046	2917	2781	2949	3124	3337	3668	4013	4163	4394	4396	4459	5452	6345	7329	8313
Residential	1995	1736	1463	1357	1372	1596	1779	1939	1841	2033	1896	2068	2333	2573	2789	3005
Commercial/Institutional	782	540	394	489	552	601	608	647	615	640	605	710	699	688	716	744
Agriculture and Other	1278	974	827	832	842	773	954	819	847	946	956	900	868	878	906	918
Fugitive emission	416	456	477	676	605	697	644	600	589	525	633	688	688	688	688	688
Total	**20959**	**15200**	**14187**	**15146**	**14235**	**15082**	**15727**	**16607**	**17594**	**17966**	**17447**	**18379**	**21678**	**24959**	**27674**	**30390**

Table A-2: Projection of CH_4 emission for Energy - "With measures" scenario

CH_4 Emission (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2005	2010	2015	2020
Energy Industries	0.18	0.12	0.14	0.16	0.12	0.16	0.14	0.15	0.18	0.19	0.14	0.15	0.17	0.19	0.17	0.16
Manufact. Ind. and Constr.	0.51	0.39	0.32	0.31	0.30	0.28	0.29	0.31	0.32	0.27	0.28	0.27	0.38	0.47	0.55	0.63
Transport	0.78	0.59	0.52	0.52	0.57	0.60	0.67	0.73	0.78	0.82	0.82	0.81	1.08	1.26	1.46	1.65
Residential	7.36	4.79	3.79	3.42	3.56	3.65	4.46	4.43	3.88	3.93	4.41	3.42	3.70	3.98	4.59	5.20
Commercial/Institutional	0.09	0.07	0.05	0.06	0.06	0.07	0.07	0.08	0.07	0.08	0.07	0.08	0.08	0.08	0.08	0.09
Agriculture and Other	0.07	0.06	0.05	0.05	0.05	0.04	0.06	0.04	0.05	0.07	0.06	0.06	0.16	0.20	0.21	0.22
Fugitive emission	58.81	56.48	53.83	58.94	53.14	53.39	55.54	58.56	51.09	50.75	52.91	59.12	59.12	59.12	59.12	59.12
Total	**67.81**	**62.49**	**58.69**	**63.45**	**57.80**	**58.19**	**61.22**	**64.30**	**56.37**	**56.10**	**58.69**	**63.92**	**64.70**	**65.30**	**66.19**	**67.08**

Table A-3: Projection of N_2O emission for Energy - "With measures" scenario

N_2O Emission (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2005	2010	2015	2020
Energy Industries	0.04	0.03	0.03	0.04	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.07	0.09	0.10	0.11
Manufact. Ind. and Constr.	0.07	0.05	0.04	0.04	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.04	0.04	0.05	0.05
Transport	0.04	0.03	0.02	0.03	0.03	0.03	0.07	0.11	0.16	0.22	0.29	0.35	0.62	0.84	0.97	1.10
Residential	0.09	0.06	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.06	0.07	0.07
Commercial/Institutional	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture and Other	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Fugitive emission																
Total	**0.26**	**0.18**	**0.16**	**0.15**	**0.15**	**0.16**	**0.21**	**0.26**	**0.31**	**0.36**	**0.44**	**0.50**	**0.79**	**1.04**	**1.19**	**1.34**

Table A-4: Projection of CO_2-eq emission for Energy - "With measures" scenario

CO_2-eq Emission (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2005	2010	2015	2020
Energy Industries	5914	3859	4528	5199	3935	4473	4322	4889	5547	5716	5172	5668	7177	8723	9437	10167
Manufact. Ind. and Constr.	6577	4756	3748	3676	3832	3634	3780	3732	4026	3745	3821	3919	4506	5119	5869	6620
Transport	4075	2937	2800	2968	3144	3359	3704	4063	4229	4479	4504	4586	5667	6631	7659	8688
Residential	2178	1855	1559	1444	1463	1689	1893	2052	1940	2133	2009	2156	2428	2674	2906	3138
Commercial/Institutional	786	542	395	491	555	604	611	649	617	642	608	713	702	691	719	748
Agriculture and Other	1282	977	830	835	845	776	957	822	849	949	960	903	874	884	913	925
Fugitive emission	1651	1642	1608	1914	1721	1818	1810	1830	1662	1591	1744	1929	1929	1929	1929	1929
Total	**22463**	**16568**	**15468**	**16526**	**15494**	**16353**	**17076**	**18037**	**18872**	**19256**	**18817**	**19875**	**23283**	**26652**	**29433**	**32214**

Table A-5: GHG mitigation measures involved in scenario "With measures"

GHG emission reduction (Gg)	2005				2010				2015				2020			
	CO_2	CH_4	N_2O	CO_2-eq	CO_2	CH_4	N_2O	CO_2-eq	CO_2	CH_4	N_2O	CO_2-eq	CO_2	CH_4	N_2O	CO_2-eq
Wind Power Plants	33.5	0.8	0.4	33.6	108.9	2.1	1.3	109.4	175.9	2.8	2.1	176.6	285.1	3.6	3.4	286.3
Small Hydro Power Plants	49.8	1.2	0.5	50	64.2	1.2	0.8	64.4	89.1	1.4	1	89.5	125.1	1.6	1.5	125.6
Biomass in Cogeneration	21.6	0.6	0.1	21.6	44.1	1.1	0.2	44.2	118.4	3	0.5	118.6	204.9	5.1	0.8	205.2
Fuel Cells	0	0	0	0	14	0.3	0.2	14	26	0.4	0.3	26.1	48.8	0.6	0.6	49
Biodiesel and Hydrogen	7.3	0.5	0.1	7.4	53.8	4.4	0.4	54.1	121.7	12	1	122.3	261.7	27.7	2.2	263
Solar Energy	160	6.6	1.6	160.6	311.6	15.4	3.4	313	436.9	22.3	4.4	438.7	624.8	32.7	6	627.3
Geothermal Energy	50.7	2	0.5	50.9	239.1	11	2.6	240.1	354.4	16.7	3.6	355.9	539.2	25.8	5.3	541.4
Heat Gen. Eff. Increase	15.2	1.2	0.2	15.3	33.7	2.7	0.5	33.9	55.2	4.5	0.8	55.6	78.6	6.5	1.2	79.1
Total	**338.1**	**12.9**	**3.4**	**339.4**	**869.4**	**38.2**	**9.4**	**873.1**	**1378**	**63.1**	**13.7**	**1383.3**	**2168**	**103.6**	**21**	**2176.9**

Table A-6: Additional measures

GHG emission reduction measures	2005				2010			
	CO_2	CH_4	N_2O	CO_2-eq	CO_2	CH_4	N_2O	CO_2-eq
Power Generation Sector	**373.0**	**8.9**	**3.9**	**374.3**	**727.3**	**13.9**	**8.5**	**730.2**
Savings in power trans. and distrib.	20.3	0.5	0.2	20.4	39.6	0.8	0.5	39.8
Wind Power Plants	231.3	5.5	2.4	232.2	451.1	8.6	5.3	452.9
Small Hydro Power Plants	32.1	0.8	0.3	32.3	62.7	1.2	0.7	62.9
Biomass in Cogeneration	89.2	2.1	0.9	89.5	174.0	3.3	2.0	174.7
Industry	**174.8**	**10.2**	**2.1**	**175.7**	**258.8**	**12.6**	**3.4**	**260.1**
Motor Drives Regulation	0.0	0.0	0.0	0.0	12.2	0.2	0.2	12.3
Cogeneration Plants	0.0	0.0	0.0	0.0	52.8	0.9	0.9	53.1
Low-temp. heat gener. efficiency increase	104.6	5.0	1.0	105.0	115.2	5.4	1.1	115.7
High-temp. heat gener. efficiency increase	70.2	5.2	1.0	70.6	78.5	6.0	1.2	79.0
Transport	**0.0**	**0.0**	**0.0**	**0.0**	**59.4**	**4.1**	**0.5**	**59.6**
Interurban passenger transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urban passenger transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Freight transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Increase in biodiesel use	0.0	0.0	0.0	0.0	59.4	4.1	0.5	59.6
Services	**60.0**	**2.6**	**0.6**	**60.3**	**406.8**	**21.4**	**4.4**	**408.6**
DSM measures	0.0	0.0	0.0	0.0	14.4	0.3	0.2	14.5
Solar energy use increase	32.6	1.3	0.3	32.7	78.5	3.9	0.8	78.8
Geothermal energy use increase	7.8	0.3	0.1	7.8	16.4	0.8	0.2	16.4
Distr. heating and cogen.use increase	19.6	0.9	0.2	19.7	66.8	3.6	0.7	67.1
Thermal insulation improvement	0.0	0.0	0.0	0.0	230.8	12.8	2.5	231.8
Residential	**226.1**	**7.8**	**1.6**	**226.8**	**586.8**	**22.4**	**4.4**	**588.6**
Solar energy use increase	0.0	0.0	0.0	0.0	28.4	1.8	0.2	28.5
DSM measures	0.0	0.0	0.0	0.0	12.4	0.2	0.1	12.5
District heating use increase	0.0	0.0	0.0	0.0	20.7	2.2	0.1	20.8
Thermal insulation improvement	0.0	0.0	0.0	0.0	73.0	2.5	0.7	73.2
Biomass in cogen. and boiler plants	226.1	7.8	1.6	226.8	452.2	15.6	3.1	453.5
Total potential	**833.9**	**29.5**	**8.2**	**837.1**	**2039.1**	**74.3**	**21.2**	**2047.2**

Table A-6: Additional measures (continue)

GHG emission reduction measures	2015				2020			
	CO_2	CH_4	N_2O	CO_2-eq	CO_2	CH_4	N_2O	CO_2-eq
Power Generation Sector	**999.2**	**15.6**	**11.8**	**1003.2**	**1225.4**	**15.3**	**14.5**	**1230.2**
Savings in power trans. and distrib.	72.0	1.1	0.8	72.3	99.2	1.2	1.2	99.6
Wind Power Plants	620.9	9.7	7.3	623.3	762.1	9.5	9.0	765.1
Small Hydro Power Plants	86.3	1.3	1.0	86.6	105.9	1.3	1.3	106.3
Biomass in Cogeneration	220.0	3.4	2.6	220.9	258.2	3.2	3.1	259.2
Industry	**474.3**	**16.1**	**6.8**	**476.8**	**795.6**	**19.0**	**12.2**	**799.8**
Motor Drives Regulation	164.8	2.6	2.4	165.6	470.7	5.9	7.4	473.1
Cogeneration Plants	115.2	2.1	2.1	115.9	150.1	2.7	2.7	151.0
Low-temp. heat gener. efficiency increase	114.3	5.4	1.1	114.8	102.1	4.8	1.0	102.5
High-temp. heat gener. efficiency increase	80.0	6.1	1.2	80.5	72.7	5.6	1.1	73.1
Transport	**342.1**	**29.6**	**14.0**	**347.1**	**910.2**	**70.4**	**34.5**	**922.3**
Interurban passenger transport	42.1	9.8	7.7	44.6	93.0	21.5	16.6	98.6
Urban passenger transport	26.6	5.3	4.1	28.0	77.0	15.4	11.9	81.0
Freight transport	103.0	2.9	0.8	103.3	458.5	14.4	3.7	460.0
Increase in biodiesel use	170.5	11.6	1.4	171.2	281.6	19.2	2.3	282.7
Services	**662.7**	**35.4**	**6.6**	**665.5**	**835.5**	**44.3**	**7.9**	**838.8**
DSM measures	22.1	0.3	0.3	22.2	32.1	0.4	0.4	32.2
Solar energy use increase	112.0	5.7	1.1	112.5	140.2	7.3	1.3	140.7
Geothermal energy use increase	22.0	1.0	0.2	22.1	27.9	1.3	0.3	28.0
Distr. heating and cogen.use increase	113.9	6.3	1.1	114.3	145.6	8.0	1.4	146.2
Thermal insulation improvement	392.7	22.0	3.9	394.3	489.6	27.2	4.6	491.6
Residential	**1045.2**	**43.9**	**8.2**	**1048.7**	**1789.2**	**87.0**	**13.9**	**1795.3**
Solar energy use increase	107.4	7.9	0.8	107.8	286.7	21.3	1.9	287.7
DSM measures	88.2	1.4	1.0	88.5	192.3	2.4	2.3	193.0
District heating use increase	55.2	5.8	0.4	55.5	156.8	17.2	1.1	157.5
Thermal insulation improvement	179.8	7.4	1.7	180.5	376.4	18.7	3.1	377.8
Biomass in cogen. and boiler plants	614.6	21.5	4.3	616.4	777.0	27.4	5.5	779.3
Total potential	**3523.5**	**140.7**	**47.5**	**3541.1**	**5555.8**	**236.1**	**83.1**	**5586.5**

Table A-7: "With measures" scenario

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2005	2010	2015	2020
CO_2 Emission (Gg)	20959.4	15200.5	14186.6	15146.1	14235.1	15081.9	15726.6	16607.1	17593.7	17965.9	17447.5	18378.7	21678.4	24958.9	27674.2	30389.6
CH_4 Emission (Gg)	67.806	62.493	58.691	63.448	57.797	58.193	61.220	64.297	56.366	56.097	58.693	63.921	64.702	65.296	66.187	67.077
N_2O Emission (Gg)	0.257	0.177	0.157	0.154	0.147	0.158	0.206	0.257	0.306	0.361	0.443	0.496	0.792	1.039	1.191	1.343
CO_2-eq Emission (Gg)	22462.9	16567.6	15467.7	16526.4	15494.4	16352.7	17076.2	18036.9	18872.3	19255.8	18817.3	19874.9	23282.6	26652.0	29433.2	32214.4

Table A-8: "Without measures" scenario

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2005	2010	2015	2020
CO_2 Emission (Gg)	20959.4	15200.5	14186.6	15146.1	14235.1	15081.9	15726.6	16607.1	17593.7	17965.9	17447.5	18378.7	22016.6	25828.3	29052.0	32557.8
CH_4 Emission (Gg)	67.806	62.493	58.691	63.448	57.797	58.193	61.220	64.297	56.366	56.097	58.693	63.921	64.715	65.334	66.250	67.181
N_2O Emission (Gg)	0.257	0.177	0.157	0.154	0.147	0.158	0.206	0.257	0.306	0.361	0.443	0.496	0.795	1.048	1.204	1.363
CO_2-eq Emission (Gg)	22462.9	16567.6	15467.7	16526.4	15494.4	16352.7	17076.2	18036.9	18872.3	19255.8	18817.3	19874.9	23622.1	27525.1	30816.6	34391.2

Table A-9: "With additional measures" scenario

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2005	2010	2015	2020
CO_2 Emission (Gg)	20959.4	15200.5	14186.6	15146.1	14235.1	15081.9	15726.6	16607.1	17593.7	17965.9	17447.5	18378.7	21678.4	24958.9	27674.2	30389.6
CH_4 Emission (Gg)	67.806	62.493	58.691	63.448	57.797	58.193	61.220	64.297	56.366	56.097	58.693	63.921	64.702	65.296	66.187	67.077
N_2O Emission (Gg)	0.257	0.177	0.157	0.154	0.147	0.158	0.206	0.257	0.306	0.361	0.443	0.496	0.792	1.039	1.191	1.343
CO_2-eq Emission (Gg)	22462.9	16567.6	15467.7	16526.4	15494.4	16352.7	17076.2	18036.9	18872.3	19255.8	18817.3	19874.9	23282.6	26652.0	29433.2	32214.4