Republic of Croatia

Ministry of Environmental Protection,
Physical Planning and Construction

NATIONAL INVENTORY REPORT 2006

Submission to the United Nations
Framework Convention on Climate Change

With the contribution of the LIFE
Financial instrument of the EC

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Ordered by:	Ministry of Environmental Protection, Physical Planning and Construction
Contract No.:	Klasa: 112-04/05-01/47 Ur. Broj: 531-05/02-VG-05-02

Title:

NATIONAL INVENTORY REPORT 2006

**Croatian greenhouse gas inventory
for the period 1990-2004**

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Zagreb, September 2006

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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 Rang 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

Annual greenhouse gas inventory report of the Republic of Croatia is being prepared according to guidelines of the Convention's Secretariat and methodology of Intergovernmental Panel on Climate Change, continuously from 2001 when the first National Inventory Report was created in the framework of the preparation of the First National Communication. The preparation and submission of the National Inventory Report to the Convention's Secreteriat is supervised by the Ministry of Environmental Protection, Physical Planning and Construction. The preparation of the Inventory itself is entrusted to local national institutions which have the experience and capacities for data collection and emissions calculation. The quality assurance (QA) of the emission inventory is achieved through technical reviews organized by the Secreteriat together with nominated international experts in this field. The main goal of the process of inventory preparation and inventory check is continuous improvement of its quality in the sense of accuracy, completeness, integrity, transparency and consistency. In this NIR, the inventory of the emissions and removals of the greenhouse gases is reported for the period from 1990 to 2004.

For the purposes of the greenhouse gas inventory preparation the methodology which is in details described in *IPCC Guidelines for National GHG Inventories, Revised 1996 (IPCC/UNEP/OECD/IEA) and Good Practice Guidance and Uncertainty Management in National GHG Inventories, 2000 (IPCC/NGGIP)* is being used. The important part of the inventory preparation is uncertainty assessment of the calculation and verification of the input data and results, all this with the aim to increase the quality and reliability of the emissions estimation.

The calculation includes the emissions which are the result of anthropogenic activities and these include the following greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated carbons (HFCs, PFCs), sulphur hexafluoride (SF_6) and indirect greenhouse gases: carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane volatile organic compounds (NMVOCs). The greenhouse gases covered by the Montreal Protocol are reported in the framework of this protocol and therefore are excluded from this Report.

Greenhouse gas emission sources and sinks are divided into six main sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Land Use, Land-Use Change and Forestry and Waste. Generally, the methodology for emission calculation could be described as a product of the particular economic activity (e.g. fuel consumption, cement production, number of animals, increase of wood stock etc.) with corresponding emission factor. The use of specific national emission factors is recommended wherever possible and justified, whereas on the contrary, the methodology gives typical values of emission factors for all relevant activities of the particular sectors.

Greenhouse gas emission inventory is an integral element of the National system defined by the article 5.1 of the Kyoto protocol as a *system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol* *which should be in place, no later than one year prior to the start of the first commitment period (the 1st of January, 2007)*. The greenhouse gas emission inventory will have imoportant role in the period of the first commitment period of the Kyoto Protocol, from 2008 to 2012, and particularly, in monitoring of the implementation of GHG mitigation policy and measures.

ES.1.1. INSTITUTIONAL AND ORGANIZATIONAL STRUCTURE OF GREENHOUSE GAS EMISSIONS INVENTORY PREPARATION

The important prerequisite for the efficient data management system and inventory preparation is clearly defined organization, authority and responsibility of the institutions participating in the process of inventory preparation, which consists of number of steps in data collection and processing, calculating, control and verification of emission calculation, documentation, archiving and reporting to competent international institutions. It can be stated that Croatia, respectively the Ministry of Environmental Protection, Physical Planning and Construction as a competent authority for inventory preparation uses, in organizational sense, decentralized model in which it transfers the authorization for preparation of individual tasks in process of inventory preparation on collaborative institutions which are partially public or governmental and partially in private ownership.

The main data sources for greenhouse gas emission calculation are Energy Institute Hrvoje Pozar which prepares the national energy balance, Central Bureau of Statistics which collects data on raw materials and products for activities defined by National classification of economic activities on grounds of statistical research programmes, Croatian Center for Vehicles and Ministry of Internal Affairs which posses data bases on road and off-road vehicles and Ministry of Agriculture, Forestry and Water Management which possesses data on forest-covered area. For the inventory preparation, the data gathered through questionnaires directly from individual emission sources and other scientific or professional institutions are also being used either for calculation or control of data obtained from the official publications. EKONERG - Energy and Environmental Protection Institute is inventroy focal point executive institution, responsible for data collection, emission calculation and preparation of annual greenhouse gas emission inventories according to contract with Ministry of Environmental Protection, Physical Planning and Construction. It should be noted that the financing of the inventory in the past period was mainly provided through programme LIFE – Third Countries. This financial arrangement has certain advantages primarily in a sense of the efficient use of the existing resources, but on the other hand there are certain weaknesses of this system regarding middle-term and long-term planning and inventory improvement.

Considering the need for sustainable system of greenhouse gas emission monitoring, and commitment for establishment of the above mentioned National system for the purposes of the Kyoto Protocol the Ministry of Environmental Protection, Physical Planning and Construction under Article 46 of the Air Protection Act (Official Gazette No. 178/2004) has started the process of preparation of the By-law on the Greenhouse Gases Emissions Monitoring in the Republic of Croatia in July 2006 which should improve existiong system of greenhouse gas emission monitoring and reporting in accordance with the requirements of the Kyoto protocol and relevant legislation of the EU. It is expected that the By-law on Emission Monitoring of the Greenhouse Gases will enter into force by the end of 2006.

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

In this chapter the results of the greenhouse gas emission calculation in the Republic of Croatia are presented for the period from 1990 to 2004. The results are presented as total emissions of all greenhouse gases in CO_2 equivalents over sectors and then as emissions for the individual greenhouse gas by sectors. Since the certain greenhouse gases have different irradiation properties and consequently, differently contribute to the greenhouse effect, it is necessary to multiply the emission of every pollutant with proper Global Warming Potential (GWP). The Global Warming Potential is a measure of the impact on greenhouse effect of the certain pollutant compared to CO_2 impact which is accordingly defined as a referent value. In that case the emission of greenhouse gases is presented as the equivalent emission of carbon dioxide (CO_2 eq). If the removal of greenhouse gases occurs (e.g. the absorption of CO2 at increase of wood stock in forests) than it refers to sinks of greenhouse gases and the amount is presented as a negative value. Table ES.2-1 shows the global warming potentials for particular gases.

Table ES.2-1: Global warming potentials for certain gases

Gas	Global Warming Potential
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_20)	310
HFC-32	650
HFC-125	2800
HFC-134a	1300
HFC-143a	3800
CF_4	6500
C_2F_6	9200
SF_6	23900

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

Total emission/removal of greenhouse gases for a set of years and their trend in Sectors is given in table ES.3-1, while the contribution of the individual gases is given in table ES.3-2.

Table ES.3-1: Emissions/removals of GHG by sectors for the period from 1990-2004 (Gg CO_2 eq)

Source	Emissions and removals of GHG (Gg eq-CO_2)						
	1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
Energy	22489	16391	18858	19907	21137	22536	22050
Industrial Processes	3930	2021	2840	2816	2704	2823	3181
Agriculture	4406	3121	3095	3196	3235	3278	3558
Waste	298	380	475	504	533	555	642
Total (excluding net CO_2 from LULUCF)	**31124**	**21913**	**25268**	**26424**	**27609**	**29192**	**29432**
Removals (LUCF)	-14437	-20535	-19285	-17777	-16796	-16648	-16321
Total (including LULUCF)	**16687**	**1378**	**5983**	**8647**	**10813**	**12544**	**13111**

Table ES.3-2: Emissions/removals of GHG by gases for the period from 1990-2004 (Gg CO_2 eq)

Source	Emissions and removals of GHG (Gg eq-CO_2)						
	1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
Carbon dioxide (CO_2)	23035	16250	19417	20434	21498	22883	22551
Methane (CH_4)	3233	2532	2544	2690	2745	2925	3015
Nitrous oxide (N_2O)	3920	3123	3284	3251	3317	3221	3677
HFCs, PFCs and SF_6	937	8	23	49	49	164	189
Total (excluding net CO_2 from LULUCF)	**31124**	**21913**	**25268**	**26424**	**27609**	**29192**	**29432**
Removals (LUCF)	-14437	-20535	-19285	-17777	-16796	-16648	-16321
Total (including LULUCF)	**16687**	**1378**	**5983**	**8647**	**10813**	**12544**	**13111**

Figure ES.3-1 graphically represents the contribution of the individual sectors to total emissions and removals of the greenhouse gases. The largest contribution to the greenhouse gas emission in 2004 has the Energy Sector with 74.9 percent, followed by Agriculture with 12.1 percent, Industrial Processes with 10.8 percent and Waste with 2.2 percent. This structure is with minor changes consistent through all the observed period from 1990 to 2004. In the year 2004 the amount of removed emissions of the greenhouse gases by CO_2 from the forestry sector was 55.5 percent.

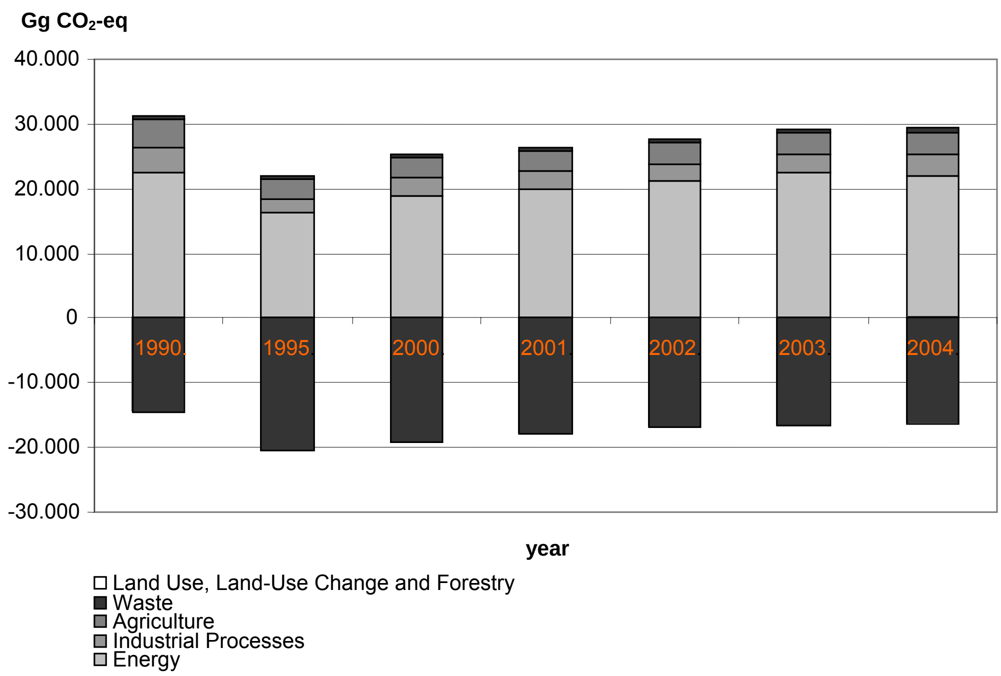

Figure ES.3-1: Emissions and removals of the greenhouse gases in the Republic of Croatia by sectors in the period from 1990-2004 (Gg CO_2 eq)

In Energy sector, which the largest contributor to greenhouse emissions, in the year 2004 the total energy consumption was 4.1 percent higher than in the former year 2003, whereat the total largest increase was in coal consumption (13.4 percent), which is also the most intensive energy-generating product from the point of view of CO_2 emission (92.7 t/TJ). Due to extremely favorable hydrological year, the increasing trend of energy consumption from water power resources was recorded with the amount of 48.5 percent. The CO_2 emission from electric and heat power production in thermal power plants, public heating plants and public cogeneration plants was 4.6 millions of tons in 2004, representing 15.6 percents in total greenhouse emission in the Republic of Croatia.

Emission of CH_4 and N_2O in the Agricultural sector is conditioned by different agricultural activities. For the emission of CH_4 the most important source is livestock farming (Enteric Fermentation). The number of cattle showed continuous decrease in the period from 1990 to 2000. As a consequence, this led to CH_4 emission reduction. In the year 2000, the number of cattle has started increasing and this trend was retained until 2004. The emission of N_2O is considered as a direct emission from cultivation of agricultural soils, emission from the animal manure (Manure Management) and indirect emission. Likewise as the CH_4 emission, the increasing trend of N_2O emission from 2000 is recorded due to increased use of mineral nitrogen fertilizers.

In the sector of Industrial Processes the key emission sources are cement, ammonia and nitrogen acid production, which all together contribute with 87.5 percent in total emission. The iron production in blast furnaces and ammonia production were ended in 1992, and ferroalloys production ended in 2002. The cement production in the period from 1997-2004 was constantly increasing and exceeded the production from 1990. The aim of the producer is maximum use of the present capacities which amounts about 3.4 millions of tons of clinker in total per year, whereas in the year 2004, 2.9 millions of tons of clinker was produced. The ammonia and nitrous acid production in 2004 was 21.9 percent higher (regarding the consumption of natural gas), respectively 22 percent comparing the previous year. The aim of producers is use of present capacities in a way that the production and emission accordingly depends primarily on consumer demand for particular type of mineral fertilizer at the market.

Waste management includes waste disposal, thermal treatment and waste water management, whereas the waste disposal represents dominant CH_4 emission source from that sector in the Republic of Croatia. The emission depends on the amount and composition of the waste and landfills management and implementation of measures for collection and processing of landfill gas. It is necessary to emphasize that in 2006, according to recommendations of the expert team for the technical examination of the inventory, the dynamic model of calculation was used for the first time, which replaced the former stationary model. Use of more complex model led to significantly lower CH_4 emissions from the Waste sector during the all observed period, as it was expected. The model was applied for emission calculation from 1990 to 2004 and therefore, the consistency criteria were satisfied in the process of recalculation. The results of the model show that the emission from this sector continuously increases mainly as a consequence of the larger amount of waste at the landfills and absence of secondary measures for emission reduction at the landfills (flaring, electricity production from the landfill gas). It should be emphasized that the Waste sector contributes to total greenhouse gas emissions with 2.2 percent.

ES.3.1. CARBON DIOXIDE EMISSION (CO_2)

Carbon dioxide is the most significant anthropogenic greenhouse gas. As in the majority of countries, the most significant anthropogenic sources of CO_2 emissions in Croatia are the processes of fossil fuel combustion for electricity or/and heat production, transport and industrial processes (cement production and ammonia). The results of the CO_2 emission calculation in Croatia are presented in table ES.3-3.

Table ES.3-3: CO_2 emission/removal by sectors from 1990-2004 (Gg CO_2)

Sector	**1990.**	**1995.**	**2000.**	**2001.**	**2002.**	**2003.**	**2004.**
Energy	20.985	15.080	17.460	18.391	19.546	20.886	20.367
Industrial processes	2.050	1.170	1.957	2.042	1.952	1.996	2.184
Forestry (sink)	-14.437	-20.535	-19.285	-17.777	-16.796	-16.648	-16.321
Total emission	**23.035**	**16.250**	**19.417**	**20.434**	**21.498**	**22.883**	**22.551**
Net emission	**8.598**	**-4.285**	**131**	**2.657**	**4.701**	**6.235**	**6.230**

ES.3.1.1. Energy sector

This sector covers all the activities which include fossil fuel consumption (fuel combustion and non-energy fuel use) and fugitive emission from fuels. Fugitive emission arises from production, transport, processing, storage and distribution of fossil fuels. The Energy sector is the main source of the anthropogenic greenhouse gas emission with share of 75 percent in total greenhouse gas emission. CO_2 emission from fuel combustion makes the largest part of it (more than 90 percent of emission in the Energy sector). Emission by sub-sectors is presented in table ES.3-4.

Table ES.3-4: CO_2 emission by sub-sectors from 1990-2004 (Gg CO_2)

Source	CO_2 emissions (Gg)						
	1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
Energy Industries	6823	5176	5882	6294	7213	7877	6772
Manufacturing Industries & Constr.	5645	2901	3078	3223	3110	3163	3664
Transport (Road & Off-Road)	4041	3328	4410	4510	4806	5182	5330
Comm./Inst., Resid., Agr /For./Fish.)	3620	2785	3357	3574	3653	3880	3801
Other (non-energy fuel consumption)	439	193	99	102	98	100	111
Natural gas scrubbing (CGS Molve)	416	697	633	688	665	684	710
Total CO_2 emissions	**20985**	**15080**	**17460**	**18391**	**19546**	**20886**	**20367**

Emission calculation is based on fuel consumption data recorded in annual national energy balance, where the fuel consumption and supply is presented at the sufficient level of detail which enables more detailed calculation by sub-sectors in the framework of the formal IPCC methodology (i.e. Sectoral approach). Furthermore, the simplest method of the calculation was carried out (i.e. Reference approach) which takes into account only the total balance of fuel, without sub-sector analysis. The relative deviation of CO_2 emissions between sectoral and reference approach for Croatia is around 5 percent which is within the acceptable values (table ES.3-5).

Table ES.3-5: CO_2 emission comparison due to fuel combustion

	1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
CO_2 emission - Reference appr. (Gg)	20994.0	15286.0	17906.1	18677.6	19925.8	21306.5	20722.8
CO_2 emission - Sectoral appr. (Gg)	20568.8	14383.4	16827.0	17703.7	18880.4	20202.4	19656.8
Relative Difference (%)	**2.07**	**6.28**	**6.41**	**5.50**	**5.54**	**5.47**	**5.42**

Two energy most intensive sub-sectors are energy transformation (thermal power plants, heating plants, refineries and oil and gas field combustion) and manufacturing industry and construction. In the framework of the sub-sector Manufacturing Industry and Construction, the largest CO_2 emissions are the result of fuel combustion in construction material industry and than in iron and steel industry, non-metal industry, chemical industry, industry of pulp, paper and print, food and drink production, tobacco production etc. Furthermore, this sub-sector includes electricity and heat production in manufacturing industry for manufacturing processes.

Transport is also one of more important CO_2 emission sources. The largest part of the emission arises from Road transportation (86 – 94 percent depending on the year) followed by railways and domestic civil aviation and navigation. Emission from fuel sold for the international aviation and marine transportation is reported separately and it's not included in total national emission balance. In the year 2004, emission from Transport sector contributed with 18.8 percent (reduced on the CO_2 equivalents emission) to total greenhouse gas emission.

Furthermore, in this sector the CO_2 emission from non-energy fuel consumption is calculated. When the fossil fuels are not completely combusted, one part or even the whole carbon is stored in product for a longer period of time, and the remaining carbon is oxidized and emitted to atmosphere. Non-energy consumption includes natural gas consumption for ammonia production as well as the naphtha, ethane, paraffin and wax consumption in chemical industry, and other industry, and lubricants in different area of application. The use of bitumen in construction industry doesn't cause the CO_2 emission because all the carbon is stored in product. Emission from non-energy fuel consumption is reported in sub-sector Other. To avoid double counting of emission calculation, the CO_2 emission from non-energy fuel consumption in ammonia production is not calculated in Energy sector, yet it is calculated and reported in the sector Industrial Processes.

Biomass combustion (fuel wood and waste wood, biodiesel, biogas) also results in greenhouse gas emissions. CO_2 emission from biomass is not included in balance according the guidelines, due to assumption that life-cycle CO_2 emitted is formerly absorbed for the growth of biomass. Sinks or CO_2 emissions resulted in change of forest biomass is calculated in sector Land Use, Land-Use Change and Forestry.

Fugitive greenhouse gas emission from coal, liquid fuels and natural gas, resulted from exploration of minerals, production, processing, transport, distribution and activities during mineral use is also included in this sector. Although this emission is not characteristic for CO_2, yet for CH_4, there is a CO_2 emission present during the process of scrubbing of natural gas in Central Gas Station Molve. The natural gas exploited on Croatian fields is rich in carbon dioxide (more than 15 percent) and before the natural gas is distributed in commercial gas pipeline it is necessary to remove the CO_2 (scrubbing) so that the maximum volume share of CO_2 in natural gas is 3 percent. Emission assessment during the removal is based on material balance method and amounts up to 5 percent of the total CO_2 emission in Energy sector.

ES.3.1.2. Industrial processes

The greenhouse gas emission is a by-product in various industrial processes where the raw material is chemically transformed in final product. Industrial processes where the contribution to CO_2 emission is identified as relevant are: cement production, lime, ammonia, ferroalloys production as well as limestone use and soda ash use in various industrial activities.

General methodology used for emission calculation from industrial processes, recommended by the Convention, includes the product of annual produced or consumed amount of a product or material with appropriate emission factor per unit of this production or consumption. Annual production or consumption data for particular industrial processes are extracted, in most cases, from monthly industrial reports published by Central Bureau of Statistics. Certain activity data is was collected from voluntary survey of manufacturers. The results of the CO_2 emission in industrial processes are shown in table ES.3-6.

Table ES.3-6: CO_2 emission from Industrial Processes for the period from 1990- 2004 (Gg CO_2)

Industrial Processes	CO_2 emissions (Gg)						
	1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
Cement production	1022.9	584.9	1266.8	1450.8	1382.4	1376.8	1459.0
Lime production	159.8	62.3	124.3	143.5	164.0	161.0	174.3
Limestone and dol. use	43.2	11.2	8.4	9.2	9.6	11.8	11.5
Soda ash prod. and use	25.7	14.4	11.0	12.4	12.2	14.7	16.5
Ammonia production	491.6	462.9	525.3	425.9	383.7	431.8	522.6
Ferroalloys production	194.5	33.9	20.5	0.5	0.0	0.0	0.0
Aluminum production	111.4	0.0	0.0	0.0	0.0	0.0	0.0
Total	**2050.0**	**1169.6**	**1956.6**	**2042,5**	**1952,1**	**1996.3**	**2184.4**

The most significant CO_2 industrial processes emission sources are cement production and ammonia production. The CO_2 emission from cement production contributes, depending on the year, with 40 to 70 percent of total CO_2 emission from industrial sector, and the CO_2 emission from ammonia production contributes with 20 to 40 percent of the total sectoral emission. Generally, CO_2 emissions from industrial processes declined from 1990 to 1995, due to the decline in industrial activities. However in the next period from 1996-2004 the emission was increasing to the level reported in 1990.

The quantity of the CO_2 emitted during cement production is directly proportional to the lime content of the clinker. Therefore, the CO_2 emissions are calculated using an emission factor, in tones of CO_2 released per tone 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.

Emission of CO_2 from ammonia production is stehiometrically determined based on carbon content in natural gas. One part of the CO_2 produced in ammonia production is further used as feedstock in urea production, i.e. mineral fertilizer. Emission of intermediately bound CO_2 occurs during the use of urea as a fertilizer in agriculture. However, according to IPCC methodology this approach is not distinguished. Therefore, the total CO_2 emission from natural gas used as a feedstock for ammonia production is reported here.

ES.3.1.3. CO_2 removals

According to Forest Management Area Plan of the Republic of Croatia (1996-2005), 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 Republic of Croatia reports only CO_2 emissions related with data for changes in the forest and other woody biomass stocks. For other segments in the sector Land- Use Change and Forestry like forest land and grassland converted to cropland or other land, and carbon change in soil, there were no reliable input data available.

Annual carbon increment in Croatian forests is 9.643.000 m^3. 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 cutting 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 principles of sustainability the described cut should not be larger than the increment value. The problem of deforestation in Croatia doesn't exist. According to present data the total forest area has not been reduced in the last 100 years. Clear-cuttings, as a measure of forest recovery are prohibited, according to "Forestry Act" of the Republic of Croatia from 1995, and natural regeneration is the main way of forest renewal.

The methodology used for CO_2 removal calculation is taken from the IPCC and it is based on data on annual increment and cutting. The figure ES.3-2 shows the CO_2 emission removal trend in the forestry sector.

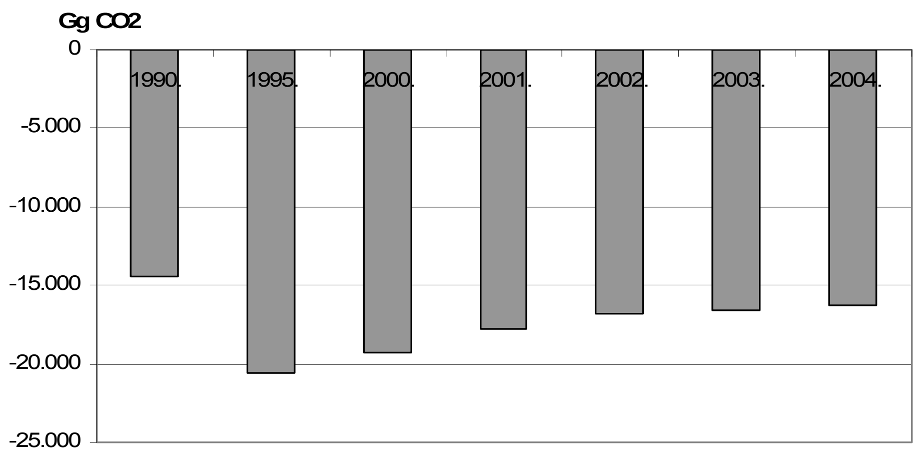

Figure ES.3-2: CO_2 emission removal in forestry sector from 1990-2004 (Gg CO_2)

ES.3.2. METHANE EMISSION (CH_4)

The major sources of methane (CH_4) emission are fugitive emission from production, processing, transportation and activities related with fuel use in Energy sector, Agriculture and Waste Disposal on Land. In table ES.3-7, sectoral and total CH_4 emissions are reported.

Table ES.3-7: CH_4 emission in Croatia in the period from 1990-2004 (Gg CH_4)

Source	CH_4 emissions (Gg)						
	1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
Energy	67.8	58.4	59.2	64.5	67.0	68.4	69.6
Industrial Processes	0.8	0.4	0.3	0.3	0.3	0.3	0.3
Agriculture	74.8	48.0	43.0	43.6	42.7	48,6	47.4
Waste	10.5	13.7	18.6	19.7	20.8	22.0	26.2
Total	**153.9**	**120.6**	**121.2**	**128.1**	**130.8**	**139.3**	**143.5**

Fugitive methane emission is mainly the result of exploration, production, processing, transportation and distribution of natural gas (about 97 percent). The fugitive emission from oil accounts with about 1 percent and venting and flaring of gas/oil production accounts with approximately 2 percent. In 1999 by closing of the coal mines in Istra, large amount of fugitive emissions arising from the exploration, processing and transportation of coal, were avoided.

In the agricultural sector there are two significant methane emission sources present: enteric fermentation in the process of digestion of ruminants (dairy cows represent the major source) and different activities related with storage and use of organic fertilizers (manure management). The total methane emission for domestic animals is being calculated as a sum of emission from enteric fermentation and emission related to manure management.
Methane emission from solid waste disposal sites (SWDSs) is a result of anaerobic decomposition of organic waste by methanogenic bacteria. The amount of methane emitted during the process of decomposition is directly proportional to the fraction of degradable organic carbon (DOC) which is defined as carbon content in different types of organic biodegradable wastes. In Croatia, more than million tons of communal waste is produced annually and the average composition of it biodegradable part is: paper and textile (21 percent), garden and park waste (17 percent), food waste (22 percent), wood waste and straw (1 percent). As for the wastewater treatment in Croatia, there are no anaerobic treatments of wastewater. In the existing properly managed aerobic processes, no emission of methane occurs.

ES.3.3. NITROUS OXIDE EMISSION (N_2O)

The most important sources of N_2O emissions in Croatia are agricultural activities, nitric acid production, but as well, the N_2O emissions occur in energy sector and waste management. In table ES.3-8 the N_2O emission is reported according to sectors.

Table ES.3-8: N_2O emission in Croatia for the period from 1990-2004 (Gg N_2O)

Source	N_2O emissions (Gg)						
	1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
Energy	0.3	0.3	0.5	0.5	0.6	0.7	0.7
Industrial Processes	3.0	2.7	2.8	2.3	2.3	2.1	2.6
Agriculture	9.1	6.8	7.1	7.4	7.5	7.3	8.3
Waste	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Total	**12.6**	**10.1**	**10.6**	**10.5**	**10.7**	**10.4**	**11.9**

In the framework of Agricultural sector, three N_2O emission sources are determined: direct N_2O emission from agricultural soils, direct N_2O emission from livestock farming and indirect N2O emission induced by agricultural activities. The largest emission is a result of direct emission from agricultural soils and it includes total amount of carbon which occurs in systems of plant cultivation. According to IPCC methodology, the mineral nitrogen, nitrogen from organic fertilizers, amount of nitrogen in fixing crops, amount of nitrogen emitted due to decomposition of crop waste and amount of nitrogen which is released from crop residue mineralization and soil nitrogen mineralization due to cultivation of histosols are separately analyzed.

In the sector Industrial Processes the N_2O emission occurs in nitric acid production which is used as a raw material in nitrogen mineral fertilizers. In the framework of the N_2O reduction measure analysis, the possibility for application of non-selective catalytic reduction device was considered, whereby the nitric acid production influence on N_2O emissions would be practically eliminated.

In Energy sector the emission was calculated on the basis of fuel consumption and adequate emission factors (IPCC). The N_2O emission increase in Energy sector is the consequence of greater use of three-way catalytic converters in road transport motor vehicles, which have about 30 times greater N_2O emission comparing to vehicles without a catalytic converter.

In general, the N_2O emission from the Waste sector indirectly occurs from the human sewage. It is calculated on the basis of the total number of inhabitants and annual protein consumption per inhabitant. As the data for protein consumption are not available for the period 1990 to 1995, average protein consumption from the eastern European countries was taken. For the period from 1996 to 2001 there were data on annual protein consumption per inhabitant for Croatia in Statistical data base published by the Organization for Food and Agriculture (FAO) under auspices of the United Nations.

ES.3.4. HALOGENATED CARBONS (HFCS, PFCS) AND SF_6 EMISSIONS

Synthetic greenhouse gases include halogenated carbons (HFCs and PFCs) and sulphur hexafluoride (SF6). 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. According to survey carried out among major agents, users and consumers of these gases and information related to import and export of HFCs, provided by the Ministry of Environmental Protection, Physical Planning and Construction, was used for emission calculation which is presented in Gg of CO_2-eq and showed on the figure ES.3-3.

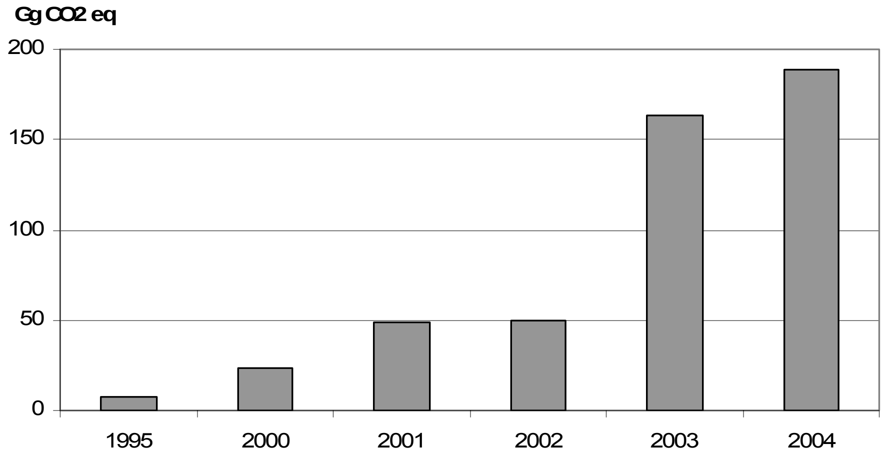

Figure ES.3-3: Halogenated carbons emission in the period from 1995-2004 (Gg CO_2-eq)

ES.4. EMISSION OF INDIRECT GREENHOUSE GASES

As previously stated, the photochemicaly active gases, carbon monoxide (CO), oxides of nitrogen (NOx) and non-methane volatile organic compounds (NMVOCs) indirectly contribute to the greenhouse gas effect. These are generally called indirect greenhouse gases or ozone precursors, because they are involved in creation and degradation of ozone which is also one of the greenhouse gases. Sulphur dioxide (SO_2), as a precursor of sulphate and aerosols, is believed to contribute negatively to the greenhouse effect. The calculation of aggregated results for the emissions of indirect gases in the period 1990-2004 are given in table ES.4-1.

Table ES.4-1: Emissions of ozone precursors and SO_2 by different sectors

Gas	Emissions (Gg)						
	1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
NO_x Emission	**91.9**	**65.2**	**76.7**	**76.7**	**77.1**	**73.9**	**71.4**
Energy Industries	18.8	14.0	16.6	17.8	20.4	15.8	14.1
Manufacturing Ind. & Construction	15.5	8.2	8.6	9.0	8.7	8.9	10.3
Transport	38.8	30.0	33.7	33.0	32.0	32.2	31.6
Other Energy (fuel combustion)	17.6	12.3	17.2	16.3	15.5	16.4	14.8
Fugitive Emission from Fuels	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Industrial Processes	0.5	0.3	0.3	0.3	0.3	0.2	0.3
CO Emission	**439,3**	**255.1**	**285.2**	**240.4**	**226.5**	**230.4**	**217.0**
Energy Industries	1.6	1.2	1.4	1.5	1.8	1.4	1.4
Manufacturing Ind. & Construction.	10.9	6.5	5.8	5.4	5.4	6.5	7.6
Transport	290.5	178.5	193.4	166.4	152.3	138.9	127.3
Other Energy (fuel combustion)	118.2	65.2	80.7	64.0	64.0	80.4	76.9
Fugitive Emission from Fuels	0.6	0.5	0.5	0.4	0.4	0.4	0.5
Industrial Processes	13.1	3.3	3.3	2.7	2.5	2.8	3.4

Table ES.4-1: Emissions of ozone precursors and SO_2 by different sectors (cont.)

Gas	Emissions (Gg)						
	1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
NMVOC Emission	**184.2**	**168.0**	**234.4**	**196.8**	**317.4**	**446.3**	**520.8**
Energy Industries	0.5	0.4	0.4	0.4	0.5	0.5	0.5
Manufacturing Ind. & Construction	0.8	0.4	0.4	0.4	0.4	0.4	0.5
Transport	54.8	32.6	31.6	28.3	25.8	22.3	19.7
Other Energy (fuel combustion)	14.8	8.4	10.5	8.5	8.4	10.4	9.9
Fugitive Emission from Fuels	4.3	3.4	3.3	3.0	3.1	3.0	3.2
Industrial Processes	81.6	95.5	164.7	130.6	245.5	373.0	441.2
Solvent Use	27.4	27.4	23.4	25.5	33.8	36.7	45.9
SO_2 Emission	**169.9**	**77.8**	**68.0**	**69.1**	**74.8**	**75.8**	**68.7**
Energy Industries	96.0	44.1	37.3	31.1	31.2	33.8	25.2
Manufacturing Ind. & Construction	53.6	18.1	15.1	18.8	21.5	19.0	19.3
Transport	7.6	6.0	6.0	4.9	6.3	7.4	7.9
Other Energy (fuel combustion)	21.7	4.2	5.8	6.2	7.6	7.6	6.9
Fugitive Emission from Fuels	6.4	5.1	4.9	4.6	4.6	4.5	4.7
Industrial Processes	6.3	4.7	4.6	3.5	3.6	3.5	4.6

INTRODUCTION

1.1. BACKGROUND INFORMATION ON GHG INVENTORIES AND CLIMATE CHANGE

The Republic of Croatia became a party to the United Nations Framework Convention on Climate Change (UNFCCC) in 1996, by parliamentary Decree on Ratification (O.G. 55/1996). Pursuant to that Decree, the Republic of Croatia has under Article 22 of the UNFCCC undertaken the commitments outlined in Annex I as a country with economy in transition. Croatia has thus committed itself to maintain greenhouse gas emissions at their 1990 level. The Republic of Croatia is also a signatory of the Kyoto Protocol. Upon its ratification by Parliament, Croatia will commit to further reduce its greenhouse gas emissions by 5 per cent in relation to the base year, over the commitment period from 2008 to 2012.

One of the commitments outlined in Article 4.1 of the UNFCCC is that Parties are required to *develop, periodically update, publish and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties.*

Furthermore, Article 5.1 of the Kyoto Protocol requires that *each Party included in Annex I shall have in place, no later than one year prior to the start of the first commitment period, a national system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol.* A national system includes all institutional, legal and procedural arrangements made within a Party included in Annex I for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and for reporting and archiving inventory information.

The Republic of Croatia is also a country which is currently in the process of accession to the EU. Accession is conditioned by the harmonization, adoption and implementation of the entire *acquis communautaire*, i.e. the body of legislation and rules already implemented in the EU. This process is very complex and requires changes that are systemic in its nature particularly in institutional and legislative sphere. As a future EU member state, Croatia will have to implement legislation concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol, which also stipulates establishment of mechanism for monitoring emissions by sources and removals by sinks of greenhouse gases, evaluating progress towards meeting commitments in respect of these emissions and for implementing the UNFCCC and the Kyoto Protocol, as regards national programmes, inventories, national system and registries.

In compliance with the UNFCCC reporting requirements, Croatia has submitted national emission inventory reports on an annual basis since 2001. In this NIR, the inventory of the emissions and removals of the greenhouse gases is reported for the period from 1990 to 2004. The NIR is prepared in accordance with the UNFCCC reporting guidelines on annual Inventories as adopted by the COP by its Decision 18/CP. 8. The methodologies used in the calculation of emissions are based on the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines) and the IPCC Good Practice Guidance and

Uncertainty Management in National Greenhouse Gas Inventories (IPCC Good Practice Guidance) prepared by the Intergovernmental Panel on Climate Change (IPCC). As recommended by the IPCC Guidelines country specific methods have been used where appropriate and where they provide more accurate emission data. The important part of the inventory preparation is uncertainty assessment of the calculation and verification of the input data and results, all this with the aim to increase the quality and reliability of the calculation.

Furthermore, since the introduction of annual technical reviews of the national inventories by experts review teams (ERT), Croatia has undergone two reviews so far, in-country review in 2004 and centralized review in 2005. Issues recommended by the ERT have been included in this report as far as possible.

The calculation includes the emissions which are the result of anthropogenic activities and these include the following greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated carbons (HFCs, PFCs) and sulphur hexafluoride (SF_6) and indirect greenhouse gases: carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane volatile organic compounds (NMVOCs). The greenhouse gases covered by Montreal Protocol on the pollutants related to ozone depletion (freons) are reported in the framework of this protocol and therefore are excluded from this Report.

Greenhouse gas emission sources and sinks are divided into six main sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Land Use, Land-Use Change and Forestry and Waste. Generally, the methodology for emission calculation could be described as a product of the particular economic activity (e.g. fuel consumption, cement production, number of animals, increase of wood stock etc.) with corresponding emission factors. The use of specific national emission factors is recommended wherever possible and justified, whereas on the contrary, the methodology gives typical values of emission factors for all relevant activities of the particular sectors.

1.2. BRIEF DESCRIPTION OF THE INSTITUTIONAL ARRANGEMENT FOR INVENTORY PREPARATION

Ministry of Environmental Protection, Physical Planning and Construction (MEPPPC) is a national focal point for the UNFCCC responsible for overall inventory management activities including organization of the institutions responsible for and involved in preparing the national inventory, coordination between these institutions and communication to the UNFCCC secretariat. It is expected that MEPPPC will delegate full scope or part of these tasks to Croatian Environment Agency (CEA) in the near future.

EKONERG - Energy Research and Environmental Protection Institute is an inventory focal point authorized by the MEPPPC and contractually obliged for the preparation of annual emission inventories, which include compilation of national inventory report, archiving of relevant data, documentation of activity data, emission factors and used methods, validation of data, and verification of inventory estimates.

There are few key collaborating institutions in the inventory preparation process, mainly activity data providers, including Energy Institute Hrvoje Požar (EIHP) which prepares national energy balance on annual basis, Croatian Bureau of Statisitics (CBS) and Croatian center for vehicles (CCV). These institutions are not formally/contractually bound to provide data to national focal point or national executive institutions but rather they provide these data on voluntary basis or through regular statistical publications.

One of the goals of the National GHG inventory improvement strategy is to prepare secondary legislation which will stipulate responsibilities and mandates for national institutions involved in inventory preparation process.

1.3. BRIEF DESCRIPTION OF THE PROCESS OF INVENTORY PREPARATION

The important prerequisite for the efficient data management system and inventory preparation is clearly defined organization, authority and responsibility of the abovementioned institutions participating in the process of inventory preparation, which consists of number of steps in data collection and processing, calculating, control and verification of emission calculation, documentation, archiving and reporting to competent international institutions. It can be stated that Croatia, respectively the Ministry of Environmental Protection, Physical Planning and Construction as a competent authority for inventory preparation uses, in organizational sense, decentralized model in which it transfers the authorization for preparation of individual tasks in process of inventory preparation on collaborative institutions which are partially public or governmental and partially in private ownership.

The main data sources for greenhouse gas emission calculation are Energy Institute Hrvoje Pozar which prepares the national energy balance, Central Bureau of Statistics which collects data on raw materials and products for activities defined at National classification of economic activities on grounds of programme of statistical research, Croatian Center for Vehicles and Ministry of Internal Affairs which posses data bases on road and off-road vehicles and Ministry of Agriculture, Forestry and Water Management which possesses data on forest-covered area. For the inventory preparation, the data gathered through questionnaires directly from individual emission sources and other scientific or professional institutions are also being used either for calculation or control of data obtained from the official publications. Energy and Environmental Protection Institute is executive institution, responsible for data collection, emission calculation and preparation of annual greenhouse gas emission inventories according to contract with Ministry of Environmental Protection, Physical Planning and Construction. It should be noted that the financing of the inventory in the past period was mainly provided through programme LIFE – Third Countries and GEF of the European Commission. The system organized in that way has certain advantages primarily in a sense of the efficient use of the existing resources, but on the other hand there are certain weaknesses of this system regarding middle-term and long-term planning and inventory improvement.

Considering the routine and need for sustainable system of greenhouse gas emission monitoring, and commitment for establishment of the above mentioned National system for the purposes of the Kyoto Protocol the Ministry of Environmental Protection, Physical Planning and Construction under Article 46 of the Air Protection Act (Official Gazette No. 178/2004) has started in July 2006 the process of preparation of the By-law on the Greenhouse Gases Emissions Monitoring in the Republic of Croatia which would improve present system of greenhouse gas emission monitoring and reporting in accordance with the requirements of the

Kyoto protocol and relevant legislation of the EU. It is expected that the Ordinance on Emission Monitoring of the Greenhouse Gases will enter into force by the end of 2006.

1.4. BRIEF DESCRIPTION OF METHODOLOGIES AND DATA SOURCES USED

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, cement production, wood stock increment and so forth) and an associated emission factor. The use of country-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.

Data sources for GHG inventory preparation are presented in the Table 1-1, but more detailed information is given in sectoral chapters.

Table 1-1: Data sources for GHG inventory preparation

CRF Sector/Sub-sector	Type of data	Source of data
Energy	Energy balance data Fuel consumption and fuel characteristic data for every boiler or gas turbine Database of motor vehicles Aggregated data about number of motor vehicles Fuel characteristic data Natural gas processed (scrubbed), CO_2 content before scrubbing and CO_2 emission	▪ Energy Institute "Hrvoje Požar" ▪ HEP - Croatian Electric Utility Company ▪ Croatian Centre for Vehicles ▪ Central Bureau of Statistics ▪ INA - Oil and Gas Company ▪ Central Gas Station MOLVE (INA)
Industrial Processes	Activity data on production/consumption of material for particular industrial process Data on consumption and composition of natural gas in ammonia production	▪ Central Bureau of Statistics, Department of Manufacturing and Mining ▪ Voluntary survey of manufacturers ▪ Ministry of Environmental Protection, Physical Planning and Construction ▪ Voluntary survey of ammonia manufacturer (Petrokemija Kutina) ▪ Central Bureau of Statistics, Department of Manufacturing and Mining
Solvent Use	Activity data on production for particular source category and number of inhabitants	• Central Bureau of Statistics, Department of Manufacturing and Mining
Agriculture	Livestock number Production of N-fixing crops and non N-fixing crops Area of histosols Synthetic fertiliser	▪ Report on agricultural production and Inventory of agriculture (Central Bureau of Statistics) ▪ Report on agricultural production (Central Bureau of Statistics) ▪ Expert judgment ▪ Expert judgment, Fertiliser company (Petrokemija Kutina)
LUC&F	Forest area and Commercial harvest	▪ Ministry of Agriculture, Forestry and Water Management ▪ Public enterprise "Hrvatske šume"
Waste	The total annual municipal solid waste disposed to different types of SWDSs Data on waste composition	▪ Report of Estimation of the Quantities of Municipal Solid Waste in Croatia (1990-1998 & 1998-2010) ▪ Report of Environment Condition, Ministry of Environmental Protection, Physical Planning and Construction ▪ Interpolation/extrapolation methods ▪ Waste management strategy • Report: The basis for methane emissions estimation in Croatia (1990-1998), part B: Data on Municipal Solid Waste in Croatia 1990-1998

1.5. BRIEF DESCRIPTION OF KEY CATEGORIES

According to the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* key categories are those which represent 95% of the total annual emissions in the last reported year or belonging to the total trend, when ranked from contributing the largest to smallest share in annual total and in the trend.

The analyis is based on the contributon of CO_2 equivalents from different sources and sinks on the sectoral level. The recommended IPCC categories as well as the categories recommended in *Good Practice Guidance for Land Use, Land-Use Change and Forestry* to be assessed in the key category analysis are presented in Table A1-1 of the Annex 1. Furthermore, Croatian esperts determined certain sub-categories which are particularly significant, such as CO_2 Emission from Natural Gas Scrubbing (also shown in Table A1-1 of the Annex 1).

The results of the Level Assessment including/excluding LULUCF are shown in Table A1-2 and Table A1-3 respectively, with the key categories shaded. The key categories are sorted in descending order of magnitude and the cumulative total is included in the final column of the table.

The results of the Trend Assessment including/excluding LULUCF are shown in Table A1-4 and Table A1-5 respectively, with the key categories shaded. The key categories are sorted in descending order of magnitude, and the cumulative total Is show in the final column of the table.

Finally, the results of the Key Category analysis including/excluding LULUCF are summarized by sector and gas in Table A1-6 and A1-7 respectively. The tables indicate whether a key category arises from the level assessment or the trend assessment or both level and trend assessment.

Some changes in the Key Categories occurred in this NIR in relation to NIR 2005, in particular, the incorporation of the LULUCF categories in calculation. These changes are shown in Table A1-8.

1.6. INFORMATION ON THE QA/QC PLAN INCLUDING VERIFICATION AND TREATMENT OF CONFIDENTIALITY ISSUES

1.6.1. QA/QC PLAN AND PROCEDURES

According to *Good Practice Guidance and Uncertainty Management in National GHG Inventories*, QA/QC plan is an internal document to organize, plan, and implement QA/QC activities. Croatia has drafted QA/QC framework plan in parallel to preparation of 2006 inventory submission, following the recommendations from document *Quality Assurance and Quality Control Plan, Samples and Manual for Development* which was prepared under regional UNDP/GEF project Capacity building for improving the quality of GHG inventories (RER/01/G31), Table A6-1, Annex 6.

Generally, QA/QC framework plan follows the proposed cycle of activities including:

- Development and approval of QA/QC plan (QA/QC manager and Inventory team leader)
- Data checking and inventory reviewing activities (QA/QC manager and sectorial experts)
- Compilation of findings (QA/QC manager)
- Recommendations for corrective actions (QA/QC manager)
- Implementing and reporting corrective actions (sectorial experts)
- Reporting (QA/QC manager)

Quality control activities are focused on following elements of inventory preparation process:

- Activity data gathering and handling activities
- Activity data documentation
- Choice of emission factors and emissions estimation

Quality assurance activities should include one or more of the following activities: peer review by third party, public review and technical review by the UNFCCC expert review team.

QA/QC framework plan is presented in Annex 8.

Although inventory team has not prepared written general and source-specific QC procedures for each QC activity outlined in *Good Practice Guidance and Uncertainty Management in National GHG Inventories* for each IPCC sector a *Sectorial methodological guidelines* were prepared in order to support inventory team with comprehensive guidelines for choice of methodology, emission factors and activity data, uncertainty estimates, QA/QC activities, reporting and documentation and inventory improvement plan. These guidelines are in accordance with IPCC Guidelines and Good Practice Guidance but also contain detail information on national circumstances particularly related to status of activity data, data gaps and short- and medium-term actions for improvement of the inventory.

For the purposes of transparency of the emission calculation, inventory team has continued with preparation of *Inventory Data Record Sheets* which were introduced in 2001 submission and which contain details of the person and/or organization responsible for an emission estimate, the primary or secondary sources of activity data and emission factors used, the methodology applied, data gaps, ways to cross-check, suggestion for future improvement in the estimates and relevant bibliographic references. The information provided in *Inventory Data Record Sheets* is available for each source category and for the entire time-series.

During the preparation of the NIR a number of checks were carried out by sector experts related to completeness, consistency, comparability, recalculation and uncertainty of activity data, emission factors and emission estimates. The details on these issues are elaborated in the NIR and the CRF.

Finally, before submitting this NIR an audit has been carried out by designated QA/QC manager. The audit covered all IPCC sectors in the NIR with purpose to check which quality control elements, both general and specific, as defined in the *IPCC Good Practice Guidance* are already implemented by sector experts and which improvements and corrective actions should be carried out in the future submissions.

1.6.2. VERIFICATION AND CONFIDENTIALITY ISSUES

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 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 sectoral 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:

- Comparison with the national inventory data of other countries was conducted by comparing CRF tables or through a direct communication.
- Activity data were compared using different sources such as Croatian Bureau of Statistics and individual emission sources.
- 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).

National inventory report 2005 was technically reviewed by the UNFCCC expert review team in October 2005 (centralized review). The main findings of the ERT are that Croatia has developed a sound and well-documented GHG inventory in only a few years and that the NIR and the CRF include information that makes the review of the methodologies and assumptions possible. Review report also states that structure of the NIR is not fully consistent with the structure outlined in the UNFCCC guidelines on annual inventories. Beside areas for further improvement identified by the Party and ERT it could be concluded that the NIR and the CRF have improved compared to the 2004 submission.

Regarding to confidentiality of activity data the only issue which arose during inventory preparation was related to usage of SF_6 in transformers by equipment producer.

1.7. GENERAL UNCERTAINTY EVALUATION

The uncertainties associated with both annual estimates of emissions, and emission trends over time are reported according to the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. The Croatian inventory team estimates uncertainties using Tier 1 method described by the IPCC, which provides estimates of uncertainties by pollutant. The uncertainties are estimated for both excluding LULUCF and including LULUCF due to the *Good Practice Guidance for Land Use, Land-Use Change and Forestry*.

According to the uncertainty analysis total level uncertainty excluding LULUCF is 14%, while total level uncertainty including LULUCF is somewhat higher than 28%. Total trend uncertainty excluding LULUCF is 3.4% and including LULUCF 16.4%.

The results of the Tier 1 approach are shown in Table A5-1 and A5-2 where the shaded rows represent key categories.

1.8. GENERAL ASSESSMENT OF THE COMPLETENESS

Croatian inventory consists of the emission estimates for the period from 1990-2004.

The completeness is evaluated following the IPCC methodology and appropriate use of the following notation keys: *NO* (not ocurred); *NE* (not estimated); *NA* (not available); *IE* (included elsewhere); *C* (confidential). Detailed description by activities and gases of the status of the emission calculation is given in corresponding CRF tables.

Generally, the objective of the completeness is achieved in compliance with the capabilities of the Republic of Croatia in collecting adequate and acceptable activity data. The problems related with lack of activity data are described in sectoral chapters where necessary. The aim of the Croatian inventory is to include all antropogenic sources of GHGs in the future.

The summary of the “not estimated” sources/sinks is given in Annex 4 – Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded, Table 4.1.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

2.1. DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR AGGREGATED GREENHOUSE GAS EMISSIONS

The total GHG emissions in 2004, excluding removals by sinks, amounted to 29.4 mill. t CO_2-eq (equivalent CO_2 emissions), which represents 5.4 percent emissions reduction compared to GHG emission in the year 1990 (Figure 2.1-1).

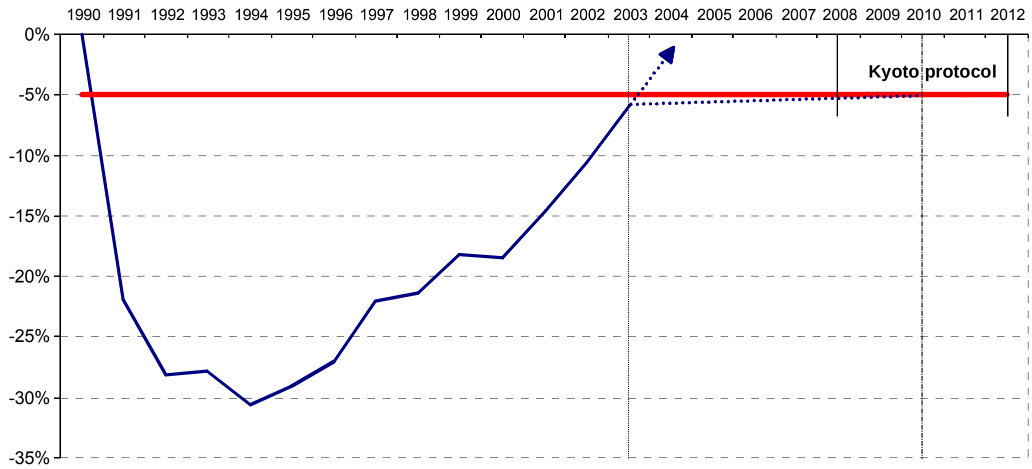

Figure 2.1-1: Croatian GHG emission trend (excluding removals by sinks)

Overall decline of economic activities and energy consumption in the period 1991-1994, 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 (e.g. blast furnaces in Sisak, primary aluminium production in Sibenik, coke plant in Bakar), which was considerably reflected in GHG emissions reduction. Emissions have started to increase in the period 1995-2002 at an average rate of 3.6 percent per year, because of economy revitalisation. Last three years average increase was even 4.8 percent per year. The main reason of GHG emission increase was Energy sector, because of emission growth in sub-sectors Energy Industries and Transport.

2.2. DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY GAS

The shares of GHG emission have not significantly changed during the entire period. The CO2 is the largest anthropogenic contributor to total national GHG emissions. In 2003 the shares of GHG emissions were as follows: 77.0 percent CO2, 12.1 percent CH4, 10.8 percent N2O and 0.1 percent HFCs. The trend of aggregated emissions/removals, divided by gasses, is shown in the Table 2.2-1 and the Figure 2.2-1.

Table 2.2-1: Aggregated emissions and removals of GHG by gases (1990-2004)

Gas	Emissions and removals of GHG (Gg eq-CO_2)														
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2	23035	16738	15810	16432	15690	16250	16941	18024	18915	19702	19417	20434	21498	22883	22551
CH_4 as CO_2-eq	3233	3007	2826	2771	2564	2532	2557	2624	2460	2496	2544	2690	2745	2925	3015
N_2O as CO_2-eq	3920	3827	3601	3200	3207	3123	3004	3348	2912	3103	3284	3251	3317	3221	3677
HFCs as CO_2-eq	NE	NE	NE	NE	NE	8	60	91	18	9	23	49	49	164	189
PFCs as CO_2-eq	937	642	0	0	0	0	0	0	0	0	0	0	0	0	0
SF_6 as CO_2-eq	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total GHG	**31124**	**24215**	**22237**	**22403**	**21462**	**21913**	**22561**	**24087**	**24304**	**25311**	**25268**	**26424**	**27609**	**29192**	**29432**
Removals (CO_2)	-14437	-14722	-14776	-14689	-16051	-20535	-20589	-20832	-20446	-20280	-19285	-17777	-16796	-16648	-16321
Total (including LULUCF)	16687	9492	7461	7714	5411	1378	1972	3255	3858	5031	5983	8647	10813	12544	13111

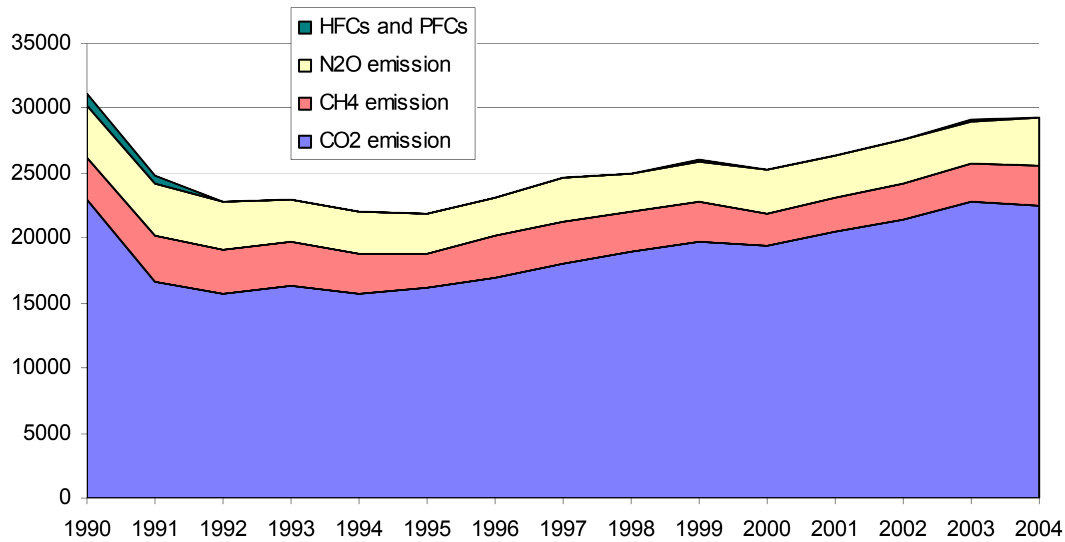

Figure 2.2-1: Trend of GHG emissions, by gases

2.2.1. CARBON DIOXIDE – CO_2

The most significant anthropogenic greenhouse gas is carbon dioxide (CO2). In 2004, CO2 emission were 2 percent lower than in 1990, while CO2 removals by sinks were 13 percent larger then removals in 1990. The largest CO2 emission growth was in Energy sector (Road Transport and Public Electricity & Heat Production). There was a permanent increase in mobility (number of road vehicles) and therefore increase in motor fuel consumption in last ten years.

There was also a significant increase in electricity demand and supply. Consequently, two new thermal power plants were installed in last few years (coal burned thermal power plant - 210 MW and combined cycled gas turbine – 200 MW).

2.2.2. METHANE – CH_4

The CH4 emission in 2004 was 7 percent below the emission in 1990, largely due to decrease in emission in Agriculture sector (Enteric Fermentation and Manure Management), as a consequence of lower number of domestic animals.

2.2.3. NITROUS OXIDE – N_2O

The N2O emission in 2004 was 6 percent lower than emission in 1990. Decrease of emission was in Energy Sector (Manufacturing Industries and Construction and Other Sectors), Industrial Processes and Agriculture (because of the diminishing of emission from agriculture soils, animal production and indirect emission from nitrogen used in agriculture).

2.2.4. FLUOROCARBONS – HFCs AND PFCs

PFCs emissions were generated in the production of primary aluminium. The Croatian aluminium industry was still operational in 1990/1991, but production was stopped in 1992. HFCs were used as substitutes for cooling gases in refrigerating and air-conditioning systems that deplete the ozone layer. According to provided calculations, the contribution of F-gases in total national GHG emission in the last two years was around 1 percent.

2.2.5. SULPHUR HEXAFLUORIDE SF_6

The SF_6 emission estimation is still not included in the inventory, because the input data is not reliable.

2.3. DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY CATEGORY

According to the UNFCCC reporting guidelines and IPCC methodological guidelines, total national emission are divided into six sectors: Energy, Industrial Processes, Solvent Use, Agriculture, Land-Use Change and Forestry and Waste. The total national GHG emissions and removals, divided by sectors, are presented in the Table 2.3-1 and the Figure 2.3-1.

Table 2.3-1: Aggregated emissions and removals of GHG by sectors (1990-2004)

Source	Emissions and removals of GHG (Gg eq-CO_2)														
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Energy	22489	16534	15527	16580	15542	16391	17081	18047	18871	19319	18858	19907	21137	22536	22050
Ind. Processes	3930	2988	2653	2067	2317	2021	2095	2366	2002	2454	2840	2816	2704	2823	3181
Agriculture	4406	4383	3734	3418	3247	3121	2993	3263	3001	3082	3095	3196	3235	3278	3558
Waste	298	309	323	338	356	380	393	412	430	456	475	504	533	555	642
Total GHG	**31124**	**24215**	**22237**	**22403**	**21462**	**21913**	**22561**	**24087**	**24304**	**25311**	**25268**	**26424**	**27609**	**29192**	**29432**
Removals (LUCF)	-14437	-14722	-14776	-14689	-16051	-20535	-20589	-20832	-20446	-20280	-19258	-17777	-16796	-16648	-16321
Total (including LULUCF)	16687	9492	7461	7714	5411	1378	1972	3255	3858	5031	5983	8647	10813	12544	13111

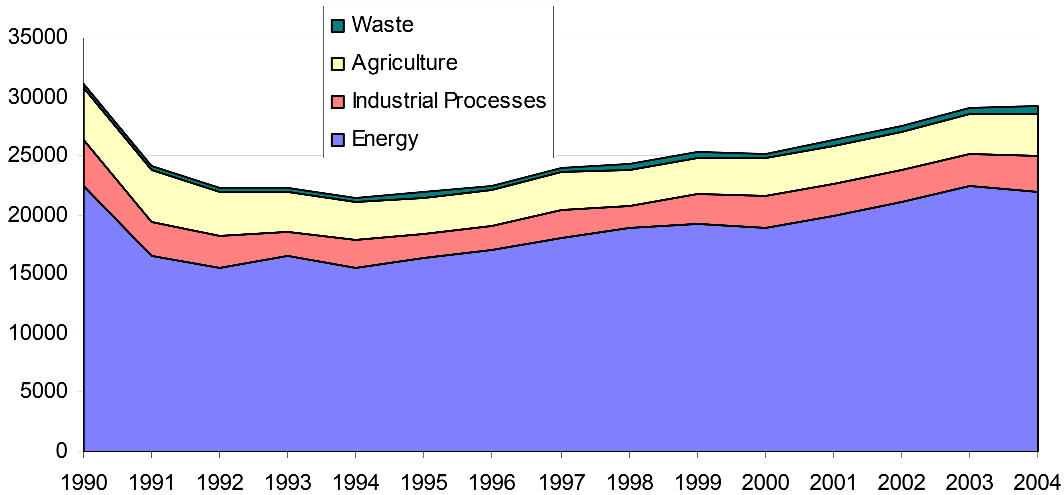

Figure 2.3-1: Trend of GHG emissions, by sectors

2.3.1. ENERGY

The most important IPCC sector, in Croatia, is Energy. The Energy sector accounted for some 75 percent of the total national GHG emissions (presented as equivalent emission of CO_2). In 2004 the GHG emission from Energy was 2 percent lower than emission in previous year (2003) and 2 percent lower than emission in 1990.

2.3.2. INDUSTRIAL PROCESSES

Industrial Processes contributes to total GHG emission with approximately 10 percent, depending on the year. There was a significant decrease of GHG emission from industrial processes. The GHG emission in 2004 was 19 percent lower than emission in 1990.

2.3.3. AGRICULTURE

The GHG emissions from Agriculture have also a decreasing trend. The GHG emission in 2004 was 19 percent lower in comparison with 1990 emission. According to estimation of Croatian experts for agriculture, approximately 12 percent of total GHG emissions belong to Agriculture.

2.3.4. WASTE

Emissions from Waste sector have been constantly increasing in the period 1990-2004. Increasing emissions are a consequence of greater quantities of waste. Contribution of waste sector to total GHG emission is approximately 2 percent.

2.4. DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR INDIRECT GREENHOUSE GASSES AND SO_2

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 take effect in 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 emissions of ozone precursors and SO_2 are shown in the Table 2.4-1.

Table 2.4-1: Emissions of ozone precursors and SO_2 by different sectors

Gas	Emissions (Gg)						
	1990	1995	2000	2001	2002	2003	2004
NO_x Emission	**91.9**	**65.2**	**76.7**	**76,7**	**77.1**	**73.9**	**71.4**
Energy Industries	18.8	14.0	16.6	17.8	20.4	15.8	14.1
Manufacturing Ind. & Construction	15.5	8.2	8.6	9.0	8.7	8.9	10.3
Transport	38.8	30.0	33.7	33.0	32.0	32.2	31.6
Other Energy (fuel combustion)	17.6	12.3	17.2	16.3	15.5	16.4	14.8
Fugitive Emission from Fuels	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Industrial Processes	0.5	0.3	0.3	0.3	0.3	0.2	0.3
CO Emission	**439.3**	**255.1**	**285.2**	**240.4**	**226.5**	**230.4**	**217.0**
Energy Industries	1.6	1.2	1.4	1.5	1.8	1.4	1.4
Manufacturing Ind. & Construction.	10.9	6.5	5.8	5.4	5.4	6.5	7.6
Transport	290.5	178.5	193.4	166.4	152.3	138.9	127.3
Other Energy (fuel combustion)	118.1	65.2	80.7	64.0	64.0	80.4	76.9
Fugitive Emission from Fuels	0.6	0.5	0.5	0.4	0.4	0.4	0.5
Industrial Processes	13.1	3.3	3.3	2.7	2.5	2.8	3.4
NMVOC Emission	**184.2**	**168.0**	**234.4**	**196.8**	**317.4**	**446.3**	**520.8**
Energy Industries	0.5	0.4	0.4	0.4	0.5	0.5	0.5
Manufacturing Ind. & Construction	0.8	0.4	0.4	0.4	0.4	0.4	0.5
Transport	54.8	32.6	31.6	28.3	25.8	22.3	19.7
Other Energy (fuel combustion)	14.8	8.4	10.5	8.5	8.4	10.4	9.9
Fugitive Emission from Fuels	4.3	3.4	3.3	3.0	3.1	3.0	3.1
Industrial Processes	81.6	95.5	164.7	130.6	245.4	373.0	441.2
Solvent Use	27.4	27.4	23.4	25.5	33.8	36.7	45.9
SO_2 Emission	**170.0**	**77.8**	**68.0**	**69.1**	**74.8**	**75.8**	**68.7**
Energy Industries	96.0	44.1	37.3	31.1	31.2	33.8	25.2
Manufacturing Ind. & Construction	53.6	18.1	15.1	18.8	21.5	19.0	19.3
Transport	7.6	6.0	6.0	4.9	6.3	7.4	7.9
Other Energy (fuel combustion)	NE*	NE*	NE*	6.2	7.6	7.6	6.9
Fugitive Emission from Fuels	6.4	5.1	4.9	4.6	4.6	4.5	4.7
Industrial Processes	6.3	4.7	4.6	3.5	3.6	3.5	4.6

**The SO_2 emissions for the category Other Energy in the period from 1990-2000 was calculated only at the top level – an error occurred in CRF Reporter because it was not possible to disagregate values at the level required and this was noticed after the submission of CRF tables.*

3. ENERGY (CRF sector 1)

3.1. OVERVIEW OF SECTOR

3.1.1. INTRODUCTION

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

The Energy sector is the main cause for anthropogenic emission of greenhouse gases. It accounts for approximately 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 (49 percent) while the contribution of nitrous oxide (N_2O) is quite small (about 6 percent).

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 appear. The CO_2 is the most important greenhouse gas from fuel combustion. This was the reason for making a detailed estimate by IPCC methodology. 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).

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 (2004), is presented in the Figure 3.1-1.

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.

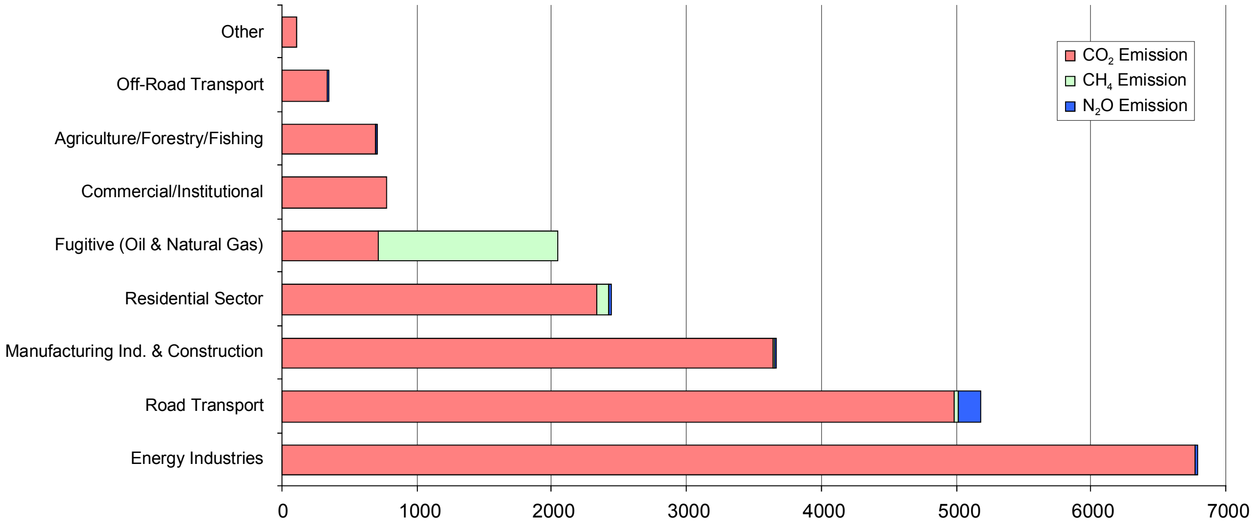

Figure 3.1-1: The contribution of different subsectors to GHG emission, year 2004

3.1.2. ENERGY STRUCTURE

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). National energy balance for 2004 is presented in Annex 4.

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 1990 to 2004 is shown in Figure 3.1-2.

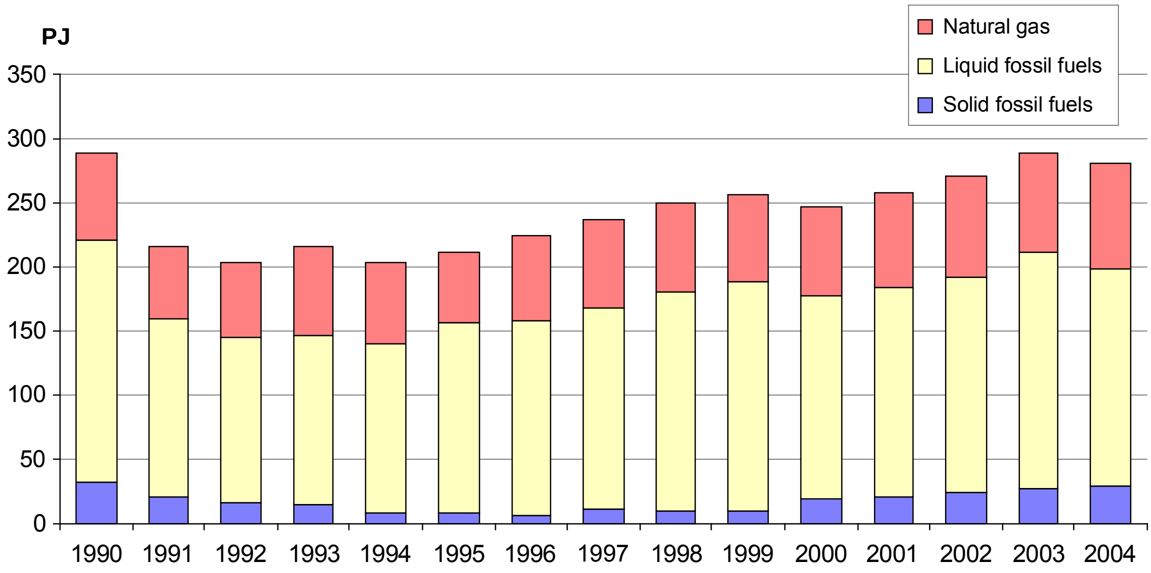

Figure 3.1-2: Structure of energy consumption

Liquid fossil fuels are mainly used with share between 60 to 70 percent, and natural gas with approximately 30 percent, while share of solid fossil fuels is 3-11 percent. Fuel woods and biomass-based fuels are neutral with regard to CO_2 emission. Therefore, they are not shown in the Figure 3.1-2.

3.1.3. COMPARISON OF THE SECTORAL APPROACH WITH THE REFERENCE APPROACH

The methodology used for estimating CO_2 emissions follows the *Revised 1996 IPCC Guidelines.* The emission of CO_2 is calculated using 2 different approaches: Reference approach and Sectoral approach. Sectoral emission estimates are based on fuel consumption data given in National Energy Balance, where energy demand and supply is given at sufficiently detailed level, what allows emissions estimation by sectors and subsectors. In Reference approach the input data are production, import, export, international bunkers and stock change for primary and secondary fuel. Comparison between these approaches was made and presented in Annex 4. The CO_2 emissions calculated by Reference approach are higher compare to Sectoral approach. The total differences in CO_2 emissions for chosen years are given in Table 3.1-1.

Table 3.1-1: The CO_2 emissions from fuel combustion (Reference & Sectoral approach)

	1990	1995	2000	2001	2002	2003	2004
CO_2 emission - Reference appr. (Gg)	20994.0	15286.0	17906.1	18677.6	19925.8	21306.5	20722.8
CO_2 emission - Sectoral appr. (Gg)	20568.8	14383.4	16827.0	17703.7	18880.4	20202.3	19656.8
Relative Difference (%)	**2.07**	**6.28**	**6.41**	**5.50**	**5.54**	**5.47**	**5.42**

The differences between Reference and National approach, in energy consumption and CO_2 emission from liquid and solid fuels, are relatively small. The largest difference appears in natural gas. The reasons are losses of natural gas in pipelines and the large amount of natural gas in non-energy consumption in Petrochemical industry and NGL plant.

3.1.4. INTERNATIONAL BUNKER FUELS

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. The fuel consumption (PJ) for International Aviation and Marine Bunkers and GHG emissions for observed period are shown in the Table 3.1-2.

International marine bunkers are included in national energy balance for the period from 1994 to 2004, as separate data. Until the year 1994, international marine bunkers are based on expert estimation. According to suggestion of review team (Page 8, Paragraph 24) the disaggregation of fuel between international and domestic aviation was recalculated based on International Energy Agency (IEA) data. International aviation bunker was included in national energy balance data first time for the year 2004.

Table 3.1-2: Fuel consumption and GHG emissions for International aviation and marine bunkers, from 1990 to 2004

	1990	1991	1992	1993	1994	1995	1996
Fuel combustion (PJ)							
Aviation bunkers	2.86	0.00	0.00	1.41	2.81	2.51	2.37
Marine bunkers	1.44	0.95	1.07	1.52	1.83	1.36	1.52
Total bunkers	**4.30**	**0.95**	**1.07**	**2.93**	**4.64**	**3.87**	**3.89**
CO_2-eq emission (Gg)							
Aviation bunkers	202.3	0.0	0.0	99.6	199.1	177.4	168.0
Marine bunkers	108.5	71.3	80.6	114.5	138.3	102.1	114.9
Total bunkers	**310.8**	**71.3**	**80.6**	**214.1**	**337.5**	**279.4**	**282.9**

Table 3.1-2: Fuel consumption and GHG emissions for International aviation and marine bunkers, from 1990 to 2004 (cont.)

	1997	1998	1999	2000	2001	2002	2003	2004
Fuel combustion (PJ)								
Aviation bunkers	2.51	2.68	1.58	1.41	0.88	0.84	1.01	1.23
Marine bunkers	0.97	1.08	0.88	0.76	1.19	0.98	0.91	0.97
Total bunkers	**3.48**	**3.76**	**2.46**	**2.17**	**2.07**	**1.82**	**1.92**	**2.20**
CO_2-eq emission (Gg)								
Aviation bunkers	177.4	189.8	112.0	99.6	62.2	59.1	71.6	87.1
Marine bunkers	73.6	81.0	65.7	57.0	89.3	73.2	68.7	73.1
Total bunkers	**251.0**	**270.8**	**177.7**	**156.7**	**151.6**	**132.4**	**140.2**	**160.2**

3.1.5. FEEDSTOCKS AND NON-ENERGY USE OF FUELS

Non-energy fuel consumptions (fuels used as feedstock) and appropriate emissions, 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, are described here. 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. The CO_2 emission of non-energy fuels consumption is also presented in Table A2-22, Annex 2.

3.1.6. CO_2 CAPTURE FROM FLUE GASES AND SUBSEQUENT CO_2 STORAGE

There are no plants for recovery and storage of CO_2 in Croatia. Natural gas produced in Croatian gas fields contains a large amount of CO_2, more than 15 percent, and before coming to commercial pipeline has to be cleaned (scrubbed), but CO_2 was emitted without capture and storage. The CO_2 emission from gas scrubbing in Central Gas Station Molve, estimated by material balance method is described in the Chapter 3.3.1.2.

3.1.7. COUNTRY-SPECIFIC ISSUES

There are also a few technical country-specific issues, which are connected to GHG emission calculation in Energy sector:

- 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 (material balance method).
- Country-specific net calorific values obtained from national energy balance are used in GHG emission calculation (Annex 2).

3.2. FUEL COMBUSTION ACTIVITIES (CRF 1.A.)

3.2.1. SOURCE CATEGORY DESCRIPTION

3.2.1.1. Energy Industries (CRF 1.A.1.)

This subsector comprises emission from fuel combustion in public electricity and heat production plants, petroleum refining plants, solid transformation plants, oil and gas extraction and coal mining. The total GHG emission from Energy Industries is given in the Table 3.2-1 and Figure 3.2-1.

Table 3.2-1: The CO_2-eq emissions (Gg) from Energy Industries

CO_2-eq emission (Gg)	**1990**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
Public Electricity and Heat Production	3713	2964	3805	4462	5152	5739	4583
Petroleum Refining	2566	1886	1786	1598	1793	1875	1910
Other Energy Industries	544	327	291	234	268	264	279
Total Energy Industries	**6823**	**5176**	**5882**	**6294**	**7213**	**7877**	**6772**

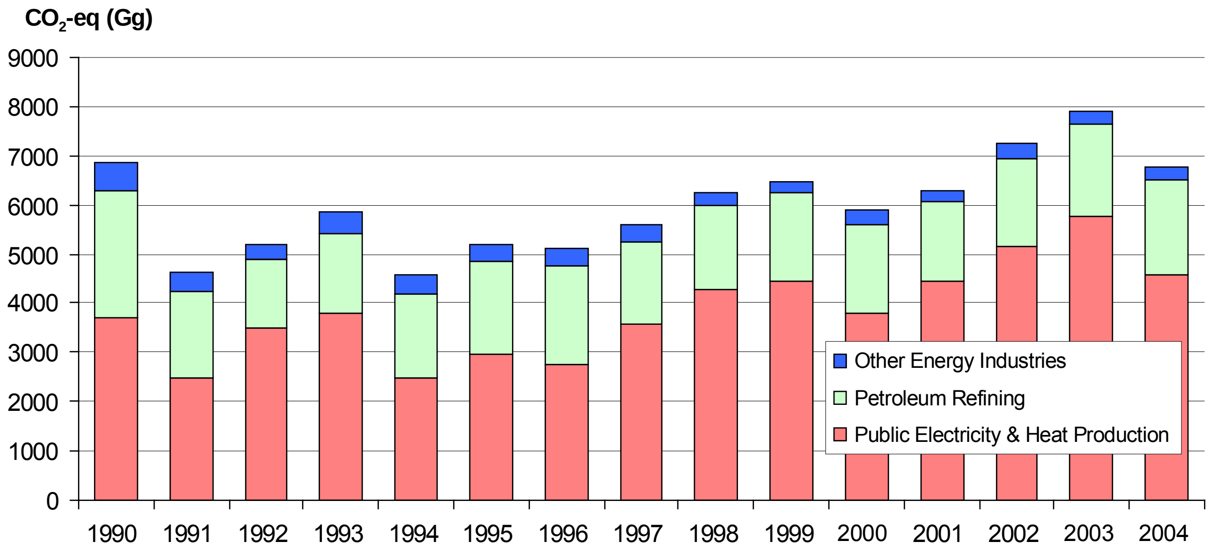

Figure 3.2-1: The CO_2-eq emissions from energy industries

It should be stressed out that a large part of the electrical energy is generated without GHG emission; therefore the emission from this sector is relatively small, 28-35 percent of emission from total Energy sector. The largest part (53-73 percent) of the emission is a consequence of fuel combustion in thermal power plants, then the combustion in oil refineries 24-40 percent. The remaining combustion in oil and gas fields, coal mines and the coke plant accounts for some 3-9 percent.

<u>**Public Electricity and Heat Production (CRF 1.A.1.A)**</u>

The installed electricity generating capacities in the Republic of Croatia include power plants owned by the HEP Group (Croatian Power Company), a certain number of industrial power plants and a few privately owned power plants (wind power plants, small hydro power plants).

Total capacities serving the needs of the Croatian electric power system amount to 4049 MW (with 50% of nuclear unit Krško in Slovenia). Out of this amount, 1632 MW is placed in thermal power plant, 2079 MW in hydro power plant and 338 MW in the nuclear unit Krško (50% of total available capacity). Generating capacities of HPPs, TPPs and NPP Krško are presented in the Table 3.2-2.

Table 3.2-2: Generating capacities of HPPs, TPPs and NPP Krško

	Available Power (MW)		Fuel
	Generator	Net Output	
HPPs		2079	water
NPP Krško*	353,5	338	UO2
TPP Plomin 1	105	98	coal
TPP Plomin 2**	210	192	coal
TPP Rijeka	320	303	fuel oil
TPP Sisak	2x210	396	fuel oil / n. gas
CHP Zagreb (east)	25 + 120 + 210	337	f.oil / n.gas / ELO
CHP Zagreb (west)	12,5 + 32 + 52	92	f.oil / n.gas / ELO
CPP Osijek	45 + 2x25	89	f.oil / n.gas / ELO
CCGT Jertovec	2x42,5	83	n.gas / ELO
Emergency diesel (4)	29	29	D2
Emergency diesel (1)	13	13	2GT
Total (HPPs+NPP+TPPs)		**4049**	

UO2 - uranium oxide
ELO - extra light oil
D2/2GT - special fuel oil for operation of emergency TPPs

* - 50% of NPP Krško is owned by HEP
** - TPP Plomin 2 Ltd. (HEP and RWE Power Co-ownership – share 50% : 50%)

During the observed period between 1990 and 2004 in Croatia only 18 to 38 percent of Croatian electricity demands were covered by thermal power plants. The largest contribution to electricity production in Croatia had hydro power plants 48 to 74 percent. Nuclear power plant Krško delivered 50 percent of it's electricity to Croatian power system until 1998 (the delivery was stopped). The delivery of electricity from NPP Krško started again in 2003. The past few years the electricity demand was compensated with import. Therefore, in 2000 the electricity import was larger than production in all Croatian thermal power plants (TPPs). In 2004, the import of electricity was about 7 percent of total electricity consumption in Croatia.

In this subsector, there are few types of plants:

- Thermal Power Plants (TPPs), which produce only electricity
- Public Cogeneration Plants (PCPs), which produce combined heat and electricity
- Public Heating Plants (PHPs), which produce only heat

Electricity and heat production, fuel consumption and GHG emissions for the years 1990, 1995, 2000, 2001, 2002, 2003 and 2004 are presented in tables A2-2 to A2-4 of the Annex 2.

Petroleum Refining (CRF 1.A.1.B)

Croatia has two oil refineries in Rijeka and Sisak, while lubricants are produced in Rijeka and Zagreb. Processing capacities of the Croatian refineries, which belong to INA – oil and gas company, are shown in the Table 3.2-3.

Table 3.2-3: Processing Capacities of Oil & Lube Refineries

PROCESSING CAPACITIES	INSTALLED (1000 t/year)
Oil Refinery Rijeka (Urinj)	
atmospheric distillation	5000
reforming	730
fluidized-bed catalytic cracking (FCC)	1000
visbreaking	600
isomerisation	250
hydrodesulphurisation (HDS)	1040
mild hidrocracking (MHC)	560
Lube Refinery Rijeka (Mlaka)	
vacuum distillation	630
deasphalting	110
furfural extraction	220
deparaffination	140
ferofining	230
deoiling	30
bitumen	350
Oil Refinery Sisak	
atmospheric distillation	4000
reforming	720
fluidized-bed catalytic cracking (FCC)	500
coking	240
vacuum distillation	800
bitumen	350
Lube Refinery Zagreb	
atmospheric distillation	-
lubricants	60

In the refineries, there are two types of fuel combustion – for heating and/or cogeneration and for own use of energy for production processes. National energy balance gives separate numbers for own use of energy in refineries, while fuel combustion for heating/cogeneration plants is presented together with similar industrial plants. Because of that, cogeneration and heating plants in refineries were calculated (previous submission) in the sub-sector Manufacturing Industries and Construction instead of Energy Industries (Petroleum Refining).

Fuel consumption and GHG emissions from petroleum refining are presented in tables A2-7 and A2-8 of the Annex 2.

Manufacturing of Solid Fuels and Other Energy Industries (CRF 1.A.1.C)

In Croatia the coal production was rather low. In 1999, last coal mines in Istria were closed. Coke-oven plant in Bakar, nearby Rijeka, was also closed in 1994.

Crude oil is produced from 35 oil fields and gas condensation products from 10 gas-condensations fields, which covers about 35 percent of the total domestic demand.

Natural gas is produced from 20 gas fields, which covers about 60 percent of the total demand. The largest quantities come from the Molve, Kalinovac and Stari Gradec, where the Central Gas

Stations (CGS Molve) for gas processing and transport preparation were built – Molve I, II and III. Their capacities are:

- 1 mill. m^3/day for Molve I
- 3 mill. m^3/day for Molve II
- 5 mill. m^3/day for Molve III

The underground gas storage Okoli was designed with the nominal capacity of 550 mill. m^3. Maximal injection capacity is 3.8 mill. m^3/day and maximal drawdown capacity is 5 mill. m^3/day.

Fuel consumption and GHG emissions from manufacturing of solid fuels and other energy industries are presented in table A2-9.

Fuel consumption and GHG emissions from Manufacturing Industries and Construction are presented in tables A2-10 and A2-11.

3.2.1.2. Manufacturing Industries and Construction (CRF 1.A.2.)

Manufacturing Industries and Construction include the emissions 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 emissions from fuel used for the generation of electricity and heat in industry (industrial cogeneration plants and industrial heating plants). The total GHG emission from Manufacturing Industries and Construction is given in the Table 3.2-2 and Figure 3.2-2.

Table 3.2-2: The CO_2-eq emissions (Gg) from Manufacturing Industries and Construction

	1990	1995	2000	2001	2002	2003	2004
Iron & Steel Industry				92	69	81	65
Non-Ferrous Metals				16	20	16	27
Chemical				539	419	480	654
Pulp, Paper & Print				123	109	113	124
Food Processing, Bev. & Tabacco				450	514	468	487
Other (Constr. Material., Glasses...)				2004	1980	2006	2303
Total Manufacturing Ind. & Constr.	**5645**	**2901**	**3078**	**3223**	**3110**	**3163**	**3660**

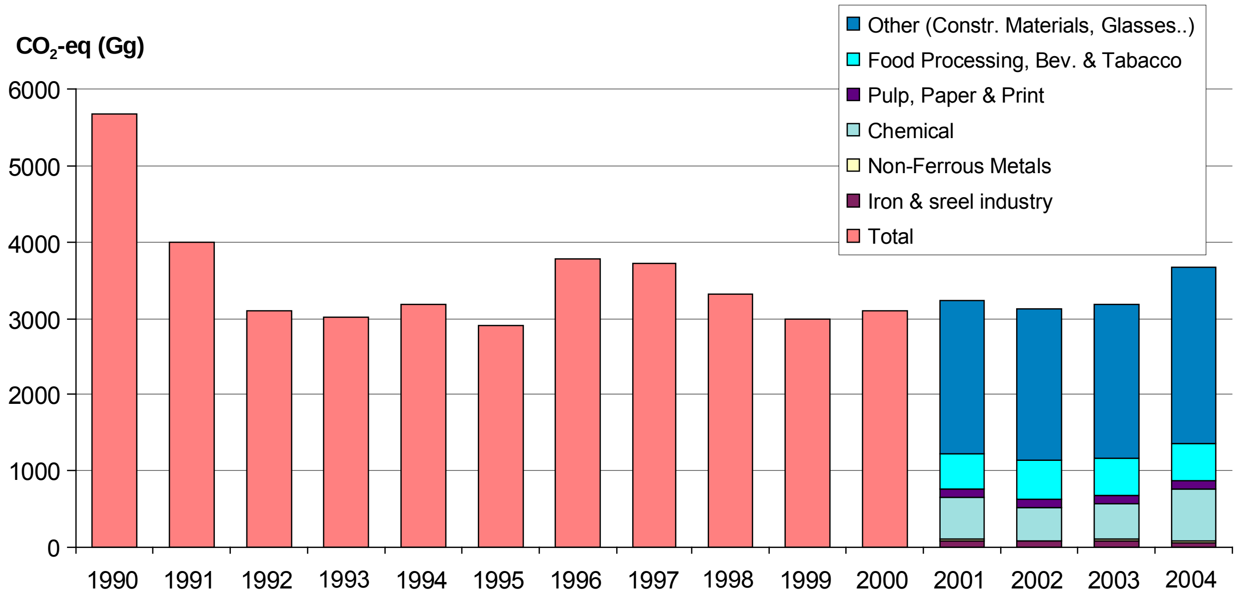

Figure 3.2-2: The CO_2-eq emissions from Manufacturing Industries and Construction

The emission from this sector contributes 14-25 percent of the total emission from Energy sector. 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 by industrial subsectors only for the years 2001, 2002, 2003 and 2004. The largest contributions to emissions have the fuel combustion in industry of contraction materials (subsector: Other in Figure 3.2-2), then follows chemical industry, food processing industry, iron and steel industry, industry of glass and non-metal, non-ferrous metal and paper industry.

The GHG emissions from Manufacturing Industries and Construction by fuels is shown in Table A2-10 and Table A2-11 of the Annex 2.

3.2.1.3. Transport (CRF 1.A.3.)

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 total GHG emission from Transport sector is given in the Table 3.2-3 and Figure 3.2-3.

Table 3.2-3: The CO_2-eq emissions (Gg) from Transport

	1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
Road Transport	3475	3036	4114	4169	4453	4843	4988
Domestic Aviation	296	87	125	162	156	141	159
Railways	138	106	85	88	87	88	92
National Navigation	133	98	86	92	111	111	91
Total Transport	**4041**	**3328**	**4410**	**4510**	**4806**	**5182**	**5330**

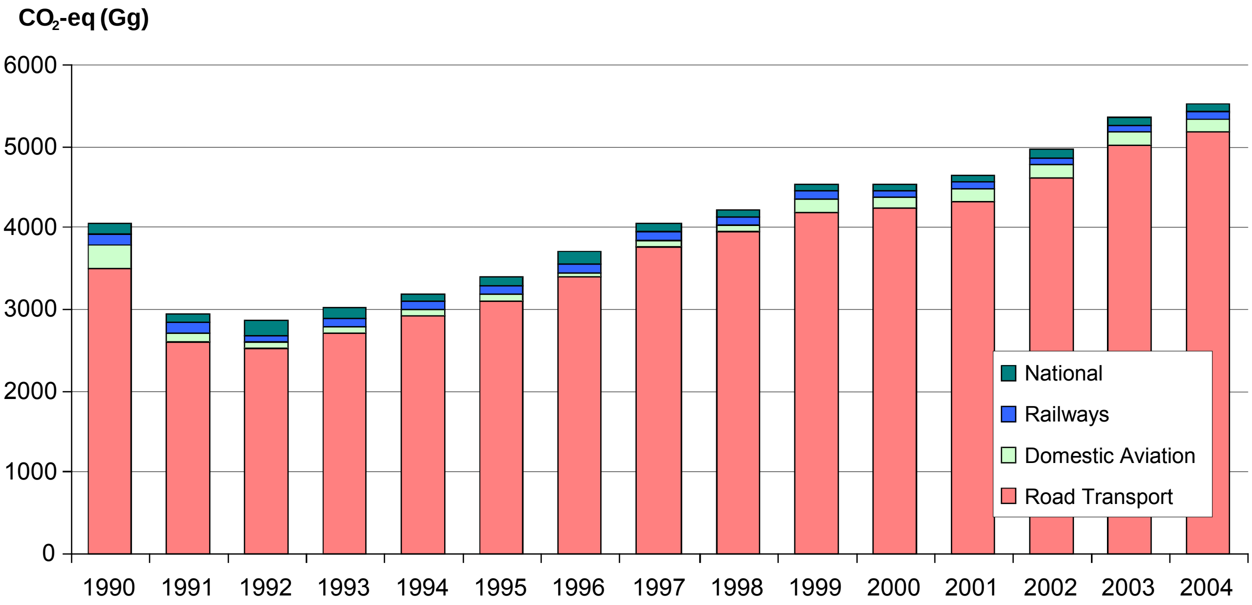

Figure 3.2-3: The CO_2-eq emissions from transport

The emissions from fuel consumption in aircraft or marine vessel engaged in international transport are excluded from the national total. These emissions are reported separately.

The contribution from Transport to total emissions from Energy sector was 18-25 percent. The most of the emission comes from road transport (86-94 percent), than from domestic air, rail and marine transport (Figure 3.2-3). The increase of emissions from this sector is a consequence of growth of mobility and number of road motor vehicles.

Road Transport

The CO_2 emission for the period 1990-2004 is estimated by Tier 1 approach, on the basis of fuel consumption and appropriate emission factors. According to suggestion of review team (Page 9, Paragraph 33) and insufficiency of detailed activity data for usage of COPERT for entire period, Tier 1 method for CO_2 emission calculation is used, because of trend consistency reasons. Consequently, recalculation of CO_2 emission was done for period 2001-2004 (in previous submission COPERT III software is used for CO_2 emission calculation). The CO_2 emissions, calculated with COPERT, were used for quality control. The COPERT III package (Tier 2/3 method) was used for CH_4 and N_2O emissions (and other pollutants) calculation from road transport in the period from 2001 to 2004, while the emissions of CH_4 and N_2O for period from 1990 to 2000 are calculated using interpolated emission factors between IPCC default for 1990 and average COPERT III emission factors per fuel types for 2001 (Croatian case).

The aggregate number of road motor vehicles is presented in the Table A2-12 of the Annex 2. Fuel consumption and GHG emissions from Road Transport are presented in tables A2-13 of the Annex 2.

Key assumption – motor fuel tanked (filled in vehicle reservoir) abroad and consumed in Croatia is equal with fuel tanked in Croatia and consumed abroad. Fuel consumption calculated by COPERT multiplying number of vehicles and annual average vehicle mileage should be equal with appropriate data from national energy balance (difference is less than 1%). It is necessary to avoid inconsistency in trend emissions.

Off-road Transport

The GHG emission calculation from off-road transport was calculated using Tier 1 approach, based on fuel consumption data (national energy balance) and default IPCC emission factors. The fuel consumption and appropriate GHG emissions for domestic air transport, national navigation and railway transport are shown in the tables A2-14, A2-15 and A2-16 of the Annex 2. According to suggestion of review team (Page 8, Paragraph 24) the disaggregation of fuel between international and domestic aviation was recalculated based on International Energy Agency (IEA) data.

3.2.1.4. Small Stationary Energy Sources (CRF 1.A.4.)

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 total GHG emissions from abovementioned small stationary energy sources are shown in the Table 3.2-4 and Figure 3.2-4.

Table 3.2-4: The CO_2-eq emissions (Gg) from small stationary energy sources

	1990	1995	2000	2001	2002	2003	2004
Commercial/Institutional	786	609	603	708	748	774	770
Residential	1995	1596	1896	2068	2167	2354	2332
Agriculture/Forestry/Fishing	839	580	858	798	739	752	699
Total	**3617**	**2785**	**3357**	**3574**	**3653**	**3880**	**3801**

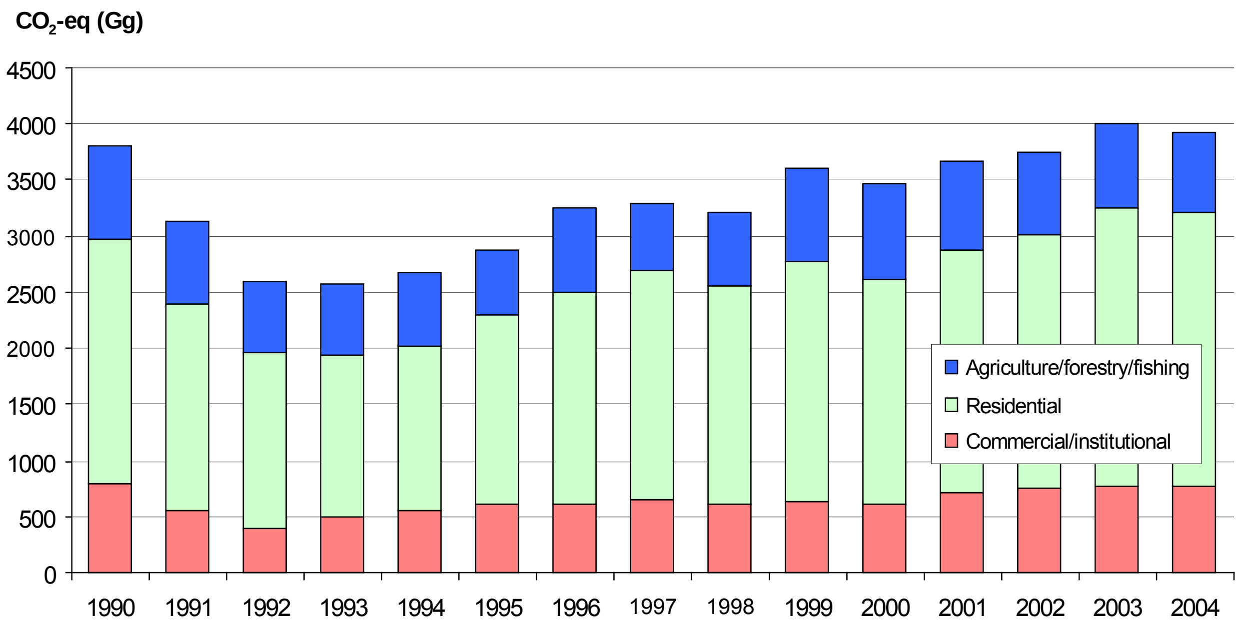

Figure 3.2-4: The CO_2-eq emissions from small stationary sources

The CO_2-eq emissions from these subsectors were about 17-20 percent of the total emissions from energy sector. The most of the emission comes from small household furnaces and boiler rooms (55-62 percent), then from service sector (15-21 percent), while the combustion of fuel in agriculture, forestry and fishing accounts for 18 to 25 percent (Figure 2.3-4).

The GHG emission calculation from these subsectors was calculated using Tier 1 approach, based on fuel consumption data (national energy balance) and default IPCC emission factors. The fuel consumption and GHG emissions for Commercial/Institutional, Residential and Agriculture/Forestry/Fishing are presented in the tables A2-17, A2-18 and A2-19, Annex 2.

3.2.1.5. Other (CRF 1.A.5.)

This sector includes the remaining GHG emission originating from fuel and not included in other sectors (Table 3.2-5 and Figure 3.2-5).

Table 3.2-5: The CO_2-eq emissions (Gg) from non-energy fuel consumption and statistical difference

	1990	1995	2000	2001	2002	2003	2004
Non-energy fuel consumption	348	193	99	102	98	100	110
Statistical difference	91	0	0	0	0	0	0
Total	**439**	**193**	**99**	**102**	**98**	**100**	**110**

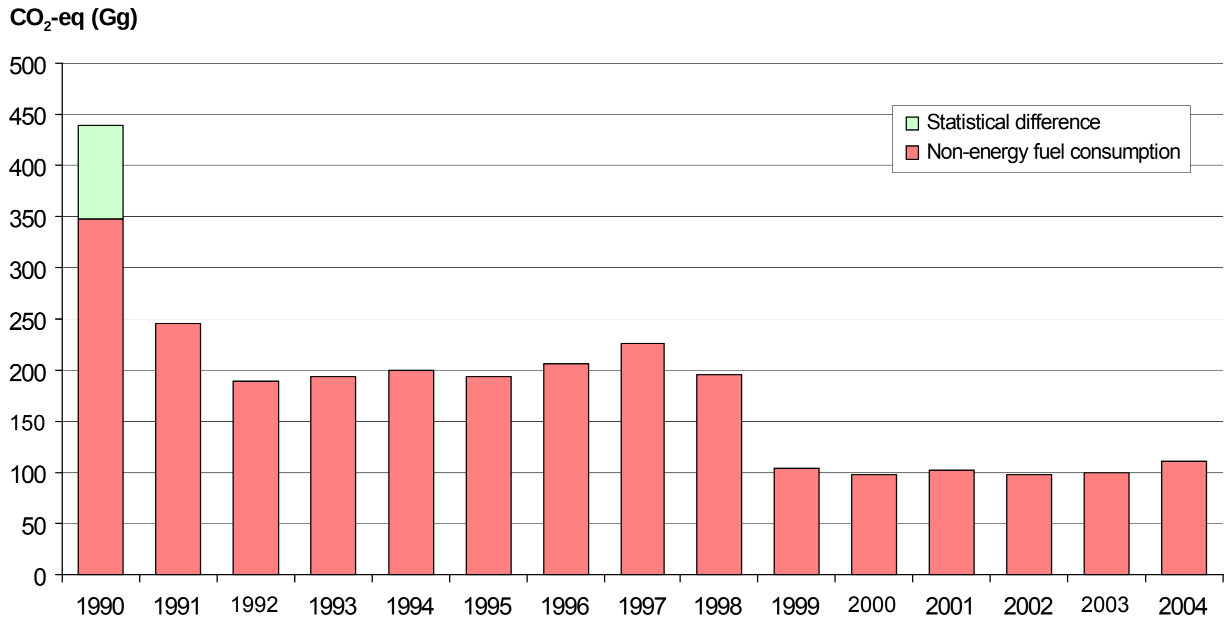

Figure 3.2-5: The CO_2-eq emissions from non-energy fuel consumption and statistical difference

A statistical difference occurred in the energy balance only for the year 1990 in consumption of natural 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 non-energy fuel consumption (fuels used as feedstock) carriers occur 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 CO_2 emission from non-energy consumption of natural gas in petrochemical industry is calculated under Industrial Processes to avoid double counting.

Fuel consumption and GHG emissions from non-energy fuel consumption and statistical difference are presented in tables A2-23, Annex 2.

3.2.1.6. Ozone Precursors and SO_2 Emissions

The emission of indirect greenhouse gases (NO_x, CO and NMVOC) and SO_2 is described in this chapter. 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.

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.

The emissions of ozone precursors and SO_2 are shown in the Table 3.2-6.

Table 3.2-6: Emissions of ozone precursors and SO_2 from fuel combustion

Emission (Gg)	**1990**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
NO_x Emission	**90.9**	**64.6**	**76.0**	**76.1**	**76.6**	**73.3**	**70.8**
Energy Industries	18.8	14.0	16.6	17.8	20.4	15.8	14.1
Manufacturing Ind. & Construction	15.5	8.2	8.6	9.0	8.7	8.9	10.3
Transport	38.8	30.0	33.7	33.0	32.0	32.2	31.6
Other Energy	17.6	12.3	17.2	16.3	15.5	16.4	14.8
CO Emission	**421.3**	**251.3**	**281.4**	**237.3**	**223.6**	**227.2**	**213.2**
Energy Industries	1.6	1.2	1.4	1.5	1.8	1.4	1.4
Manufacturing Ind. & Construction.	10.9	6.5	5.8	5.4	5.4	6.5	7.6
Transport	290.5	178.5	193.4	166.4	152.3	138.9	127.3
Other Energy	118.2	65.2	80.7	64.0	64.0	80.4	76.9
NMVOC Emission	**70.9**	**41.8**	**43.0**	**37.6**	**35.1**	**33.7**	**30.6**
Energy Industries	0.5	0.4	0.4	0.4	0.5	0.5	0.5
Manufacturing Ind. & Construction	0.8	0.4	0.4	0.4	0.4	0.4	0.5
Transport	54.8	32.6	31.6	28.3	25.8	22.3	19.7
Other Energy	14.8	8.4	10.5	8.5	8.4	10.4	9.9
SO_2 Emission	**178.9**	**72.3**	**64.3**	**61.0**	**66.6**	**67.8**	**59.3**
Energy Industries	96.0	44.1	37.3	31.1	31.2	33.8	25,2
Manufacturing Ind. & Construction	53.6	18.1	15.1	18.8	21.5	19.0	19.3
Transport	7.6	6.0	6.0	4.9	6.3	7.4	7.9
Other Energy	21.7	4.2	5.8	6.2	7.6	7.6	6.9

3.2.2. METHODOLOGICAL ISSUES

The GHG emission calculation is mainly provided using Tier 1 approach. There are two exceptions, as follows:

- Thermal power plants and public cogeneration plants (Energy Industries, CRF 1.A.1.a)
- Road transport (Transport, CRF 1.A.3.b)

3.2.2.1. Tier 1 Approach

CO_2 emissions

The majority of energy-related GHG emissions belong to CO_2. 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 percent 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 was not included in national totals.

Emissions of CH_4, N_2O and indirect greenhouse gases

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 collected from INA - Oil and Gas Company (for petroleum derivatives: gasoline, residual oil, diesel oil, jet fuel) and from HEP – Croatian Electric Utility Company (for fossil fuels consumed in thermal power plants).

3.2.2.2. Tier 2/3 Approach

Thermal power plants and public cogeneration plants (CRF 1.A.1.a)

The GHG emissions from thermal power plants and public cogeneration plants, for last four years (2001, 2002, 2003 and 2004), were calculated using more detailed Tier 2 approach. Tier 2 approach is based on bottom-up fuel consumption data from every boiler or gas turbine in plant. There were available data about monthly fuel consumption and detailed fuel characteristics data (net calorific value, sulphur and ash content…). For estimation of CO_2 emissions, default IPCC emission factors were used, while implied emission factors for CH_4 and N_2O are based on technology type and configuration (Tier 2).

Road transport (CRF 1.A.3.b)

The COPERT III package (Tier 2/3 method) was used for air emission calculation from road transport emission in the period from 2001 to 2003 (except CO_2). The CO_2 emission for the period 1990-2004 is estimated by Tier 1 approach, on the basis of fuel consumption and appropriate emission factors. The emissions of CH_4 and N_2O, for the period 1990-2000, are calculated using interpolated emission factors between IPCC default for 1990 and average COPERT III emission factors per fuel types for 2001 (Croatian case).

Very detailed set of input data is necessary for COPERT implementation. In Croatian case, main data provider is Croatian Centre for Vehicles, which is responsible for compilation of detailed motor vehicle database. The database assures the following information about:

- type of vehicles (passenger cars, light duty vehicles, heavy duty vehicles, buses, mopeds, motorcycles)
- type of motor (gasoline four-stroke, gasoline two-stroke, diesel, rotation motor and electromotor)
- cylinder capacity (<1.4 lit, 1.4-2.0 lit, >2.0 lit)
- weight class (<3.5 t, 3.5-7.5 t, 7.5-16 t, 16-32 t, >32 t)
- age of vehicles (distribution of vehicles per ECE categories according to EC directives)
- registration area (country distribution)
- annual average vehicle mileage

Fuel consumption data (from Energy Institute Hrvoje Požar) and fuel characteristics data (from INA - Oil and Gas Company) are also necessary for calculation of emissions from road transport using COPERT software.

Additional data, like highway, rural and urban transport mileage, average speed of different kind of vehicles and different road types, average daily trip distance, beta value (the fraction of the monthly mileage driven before the engine and any exhaust components have reached their nominal operation temperature) and temperature per month are estimated (based on data from statistics) or COPERT default data are used.

COPERT calculates emission factors according to driving conditions data (the average speed per vehicle type and per road), fuel variables and climate conditions (average monthly temperatures data).

3.2.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

3.2.3.1. Uncertainty of CO_2 emissions

The CO_2 emission, from the fossil fuel combustion, depends of the amount of fuel consumed (from energy balance), net calorific values (from 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 companies 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 significant affect on 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 oxidized, 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 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.

3.2.3.2. Uncertainty of CH_4, N_2O and indirect greenhouse gases emissions

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 ±40 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. Implementation of Tier 2/3 approach for estimation of CH_4 and N_2O emissions from thermal power plants and public cogeneration plants (CRF 1.A.1.a) and road transport (CRF 1.A.3.b) lead to certain uncertainty reduction (Annex 4).

3.2.3.3. Time-series consistency

Activity data, emission factors and methodology implied for GHG emission calculation from fuel combustion activities is very consistent for entire period. Negligible inconsistency is a consequence of implementation of more detailed approach (Tier 2/3) for last four years in Energy Industries and Transport. In order to reduce inconsistency, CO_2 emission from road transport was calculated using Tier 1 method, while CH_4 and N_2O emissions from road transport are calculated using interpolated emission factors between IPCC default for 1990 and average COPERT III emission factors per fuel types for 2001 (Croatian case).

3.2.4. SOURCE-SPECIFIC QA/QC

Quality control activities were divided in two phases, first phase included activities during the inventory preparation performed by sector expert, and the second phase included audit conducted by the expert designated for QA/QC after the preparation of final draft of the NIR.

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. Also, several checks have been carried out in order to ensure correct aggregation from lower to higher reporting level and correct use of conversion factors.

The basis for emission estimates in Energy sector is Energy balance prepared by Energy Institute Hrvoje Požar and mainly default emission factors provided by the IPCC. Background information and assumptions for entire time-series are transparently recorded in *Inventory Data Record Sheets* which allow third party to evaluate quality of estimates in this sector.

After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures and Tier 2 source-specific QC procedures. The audit revealed that most of the Tier 1 QC activities were correctly carried out during preparation of the inventory despite the fact that formal QC procedures were not prepared.

Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. In Energy industries, Public Electricity and Heat Production a more detailed Tier 2 methodology was applied for the period 2001-2004, due to availability of detail information on fuel consumption in the facilities. These data are still not available for other sub-categories therefore Tier 1 methodology was applied. Also, inventory team used country-specific fuel net calorific values for emission estimates. In Mobile combustion – Road, a COPERT III model was used for the period 2001-2004. This model requires a very detailed set of input data and could be considered as a Tier 3 methodology. In Mobile combustion – Domestic and International Aviation, a data from International Energy Agency statistics was used in order to reduce trend inconsistency, but it was point out that uncertainty of international bunkers is relatively higher comparing to other data.

3.2.5. SOURCE-SPECIFIC RECALCULATIONS

All recalculations were made in response to the review process, according to suggestions given by expert review team.

Road Transportation (1.A.3.b.)

According to suggestion of review team (Page 9, Paragraph 33) and insufficiency of detailed activity data for usage of COPERT for entire period, Tier 1 method for CO_2 emission calculation is used, because of trend consistency reasons. Consequently, CO_2 emissions from Road transport (2001-2003) were recalculated, as follows:

Years: 2001-2003

Gases: CO_2

Method: Tier 1 methodology for calculation of CO_2 emission from Road transport is implied, because of trend consistency (in previous submission COPERT III was used for calculation of all GHG emissions, for period 2001-2003).

Em. factors: Default IPCC emission factor for CO_2 is implied, instead of emission factor based on COPERT III software.

Domestic Air Transport

According to suggestion of review team (Page 8, Paragraph 24) the disaggregation of fuel between international and domestic aviation was recalculated based on International Energy Agency (IEA) data. Consequently, GHG emissions from Domestic Air transport (1991-2003) were recalculated, as follows:

Years: 1991-2003

Gases: CO_2, CH_4 and N_2O

Activity data: Activity data for Domestic Air transport is changed in accordance with International Energy Agency Statistics.

International Aviation Bunkers

According to suggestion of review team (Page 8, Paragraph 24) the disaggregation of fuel between international and domestic aviation was recalculated based on International Energy Agency (IEA) data. Consequently, GHG emissions from International Aviation Bunkers (1991-2003) were recalculated, as follows:

Years: 1991-2003

Gases: CO_2, CH_4 and N_2O

Activity data: Activity data for International Aviation Bunkers is changed in accordance with International Energy Agency Statistics.

3.2.6. SOURCE-SPECIFIC PLANNED IMPROVEMENTS

For the purpose of GHG inventory improvement, missing data should be collected and also quality of existing data, emission factors and methods should be improved. Implementation of well-documented country specific emission factors and appropriate detailed methods are recommended. Consequently, the main objectives of the GHG inventory improvement plan are:

- data gaps reduction,
- data collection improvement,
- activity data and emission factors uncertainties reduction,
- activities on improvement methodologies and emission factors, documentation and description of inventory system.

As a result of comprehensive analysis of GHG inventory quality, based on information prepared in the framework of Centralized Review Report, short-term and long-term goals for GHG inventory improvement are obtained.

Short-term goals (< 1 years)

Generally, the changes from Tier 1 to Tier 2/3 estimation methodologies for Energy key sources, as much as possible, are recommended. The priority should be the key sources with high uncertainties of emission estimation. But, significant constrains are availability of activity data, especially for the beginning years of concerned period. Consequently, implementation of more detailed methodology approach (Tier 2/3) for key sources, for entire period (1990-2004), will be very difficult.

COPERT III software (Tier 3) is used for emission estimation from Road Transport, for the period 2001-2004. Automatic delivery of detailed motor vehicle database and annual average vehicle mileage from Croatian Centre for Vehicles, beside other needed data, is essential for COPERT implementation. The difficulties lie in gathering of appropriate historical activity data

(1990-2000). In any case, the improvement of the emission estimation for entire period, based on COPERT model results, is a short-term goal.

The extensive use of detailed methodology (Tier 2/3) for Energy Industries is also one of the short-term goals. For achievement of abovementioned goal is necessary to ensure delivery of detailed activity data for Energy Industries. The good example is the usage of technology/plant-specific data for sub-sector Thermal power plants and public cogeneration plants (Tier 2) for the last four inventory years.

Long-term goals (> 1 years)

The extensive use of plant-specific data collected in the framework of Cadastre of Emissions to Environment (CEE) is recommended ("bottom up" approach). In addition, usage of more source-specific QA/QC procedures will improve the quality of GHG inventory in Energy sector.

3.3. FUGITIVE EMISSIONS FROM FUELS (CRF 1.B.)

3.3.1. SOURCE CATEGORY DESCRIPTION

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.

3.3.1.1. Solid fuels (CRF 1.B.1.)

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 was rather low. Until 1999 only underground coal mines in Istria were in operation (Tupljak. Ripenda and Koromačno) and they produced some 0.015 to 0.174 mill. tons of coal, Global Average Method (Tier 1) was used for the methane emission estimation and the estimated emission was 0.2 to 2.3 Gg. The emissions of methane from mining and post-mining activities are showed in the Figure 3.3-1 and Table A2-20, Annex 2.

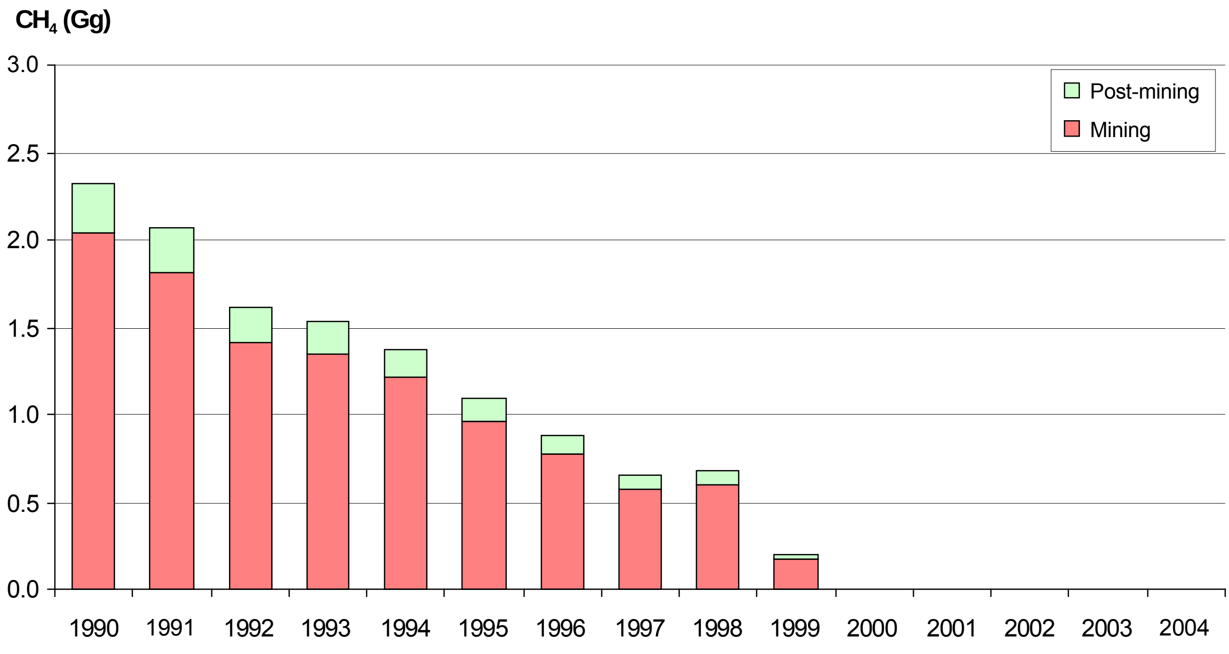

Figure 3.3-1: The fugitive emissions of methane from coal mines

3.3.1.2. Oil and natural gas (CRF 1.B.2.)

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.

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 3.3-2 and Table A2-21, Annex 2.

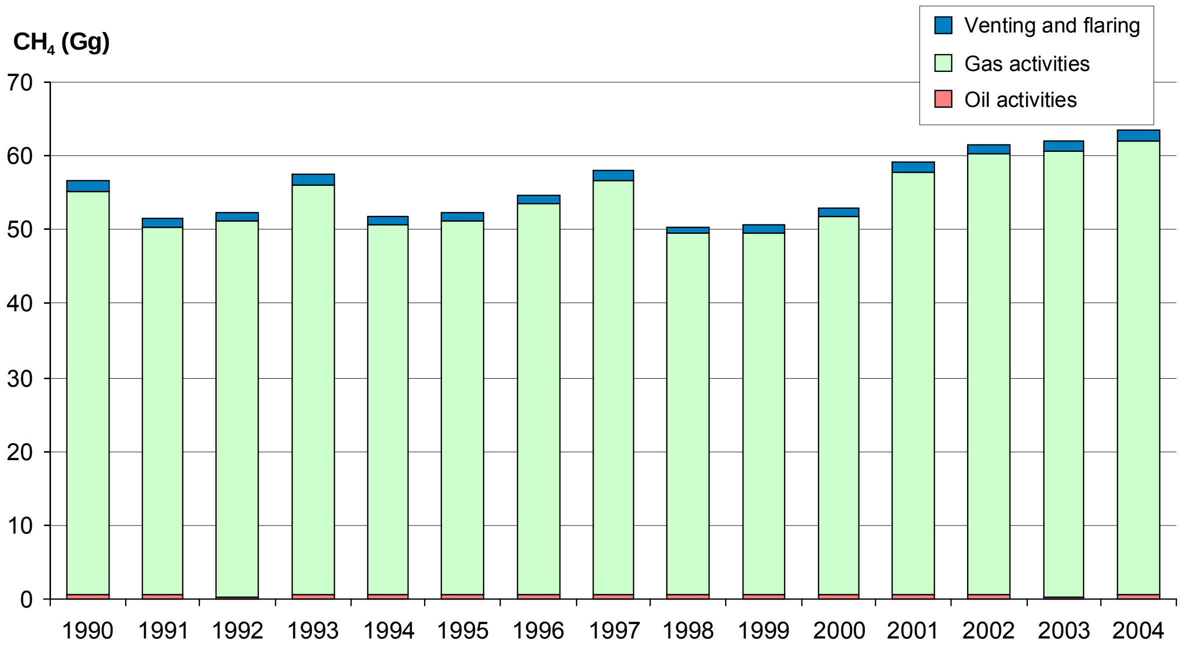

Figure 3.3-2: The fugitive emissions of methane from oil and gas activities

The fugitive emission of methane is mainly (about 97 percent) 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.

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 entire period from 1990 to 2004. The simplified procedure is based on the quantity of crude oil processed in oil refineries. 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 3.3-1.

Table 3.3-1: The fugitive emissions of ozone precursors and SO_2 from oil refining

Emissions (Gg)	1990	1995	2000	2001	2002	2003	2004
CO emission	0.62	0.49	0.47	0.44	0.44	0.44	0.46
NO_x emission	0.41	0.33	0.32	0.29	0.30	0.29	0.30
NMVOC emission	4.25	3.37	3.26	3.04	3.05	3.02	3.15
SO_2 emission	6.38	5.06	4.90	4.57	4.58	4.53	4.72

CO_2 emission from natural gas scrubbing

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, specifically in Croatia emission of CO_2 from natural gas scrubbing in Central Gas Station Molve is assigned here. 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, and before coming to commercial pipeline has to be cleaned (scrubbed). 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 3.3-2.

Table 3.3-2: The CO_2 emissions (Gg) from natural gas scrubbing in CGS Molve

CO_2 emission (Gg)	1990	1995	2000	2001	2002	2003	2004
Central Gas Station MOLVE	416	697	633	688	665	684	710

3.3.2. METHODOLOGICAL ISSUES

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.

3.3.3. UNCERTAINTIES AND TIME SERIES CONSISTENCY

3.3.3.1. 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 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).

3.3.3.2. Time-series consistency

Activity data, emission factors and methodology implied for fugitive emission from fuels is consistent for entire period.

3.3.4. SOURCE-SPECIFIC QA/QC

Quality control activities were divided in two phases, first phase included activities during the inventory preparation performed by sector expert, and the second phase included audit conducted by the expert designated for QA/QC after the preparation of final draft of the NIR.

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. Also, several checks have been carried out in order to ensure correct aggregation from lower to higher reporting level and correct use of conversion factors.

The basis for emission estimates in Energy sector is Energy balance prepared by Energy Institute Hrvoje Požar and mainly default emission factors provided by the IPCC. Background information and assumptions for entire time-series are transparently recorded in *Inventory Data Record Sheets* which allow third party to evaluate quality of estimates in this sector.

After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures and Tier 2 source-specific QC procedures. The audit revealed that most of the Tier 1 QC activities were correctly carried out during preparation of the inventory despite the fact that formal QC procedures were not prepared.

For Fugitive emissions from oil and gas operations a Tier 1 method was applied and emission factor is a mean value of the range proposed in the IPCC Manual. The CO_2 emission form natural gas scrubbing in CPS Molve was estimated using country specific methodology since IPCC Guidelines does not provide methodology for this source category.

3.3.5. SOURCE-SPECIFIC RECALCULATIONS

There are no source-specific recalculations in sub-sector Fugitive Emissions from Fuels.

3.3.6. SOURCE-SPECIFIC PLANNED IMPROVEMENTS

For estimation of fugitive emissions from oil and natural gas operations, a Tier 1 method was applied. Used emission factors are an average value of the range proposed in the IPCC Manual. However, fugitive emission from natural gas is key source and implementation of rigorous source-specific evaluations approach (Tier 3) is necessary. The Tier 3 approach will generally will generally involve compiling the following types of information:

- detailed inventories of the amount and types of process infrastructure (e.g. wells, field installations and production/processing facilities),
- production disposition analyses oil and gas production, vented, flared and reinjected volumes of gas, and fuel gas consumption,
- accidental releases (i.e. well blow-outs and pipeline ruptures),
- typical design and operating practices and their impact on the overall level of emission control.

For implementation of rigorous source-specific evaluations approach (Tier 3) is necessary additional technical and financial resources.

3.3.7. OVERVIEW OF GHG EMISSIONS FROM ENERGY SECTOR

This chapter gives overview of the GHG emissions. The contribution of individual energy subsectors to the total emissions of greenhouse gases for the observed period is given in the Table 3.4-1 and Figure 3.4-1.

Table 3.4-1: The CO_2-eq emissions (Gg) from Energy sector

	1990	1995	2000	2001	2002	2003	2004
Energy Industries	6843	5193	5902	6314	7236	7900	6795
Manufacturing Ind. and Construction	5674	2917	3094	3239	3126	3179	3663
Transport	4070	3388	4548	4657	4973	5677	5526
Other Energy	4251	3076	3574	3771	3845	4101	4028
Fugitive Emissions	1651	1818	1744	1929	1959	1988	2041
Total	**22501**	**16399**	**18858**	**19900**	**21139**	**22539**	**22046**

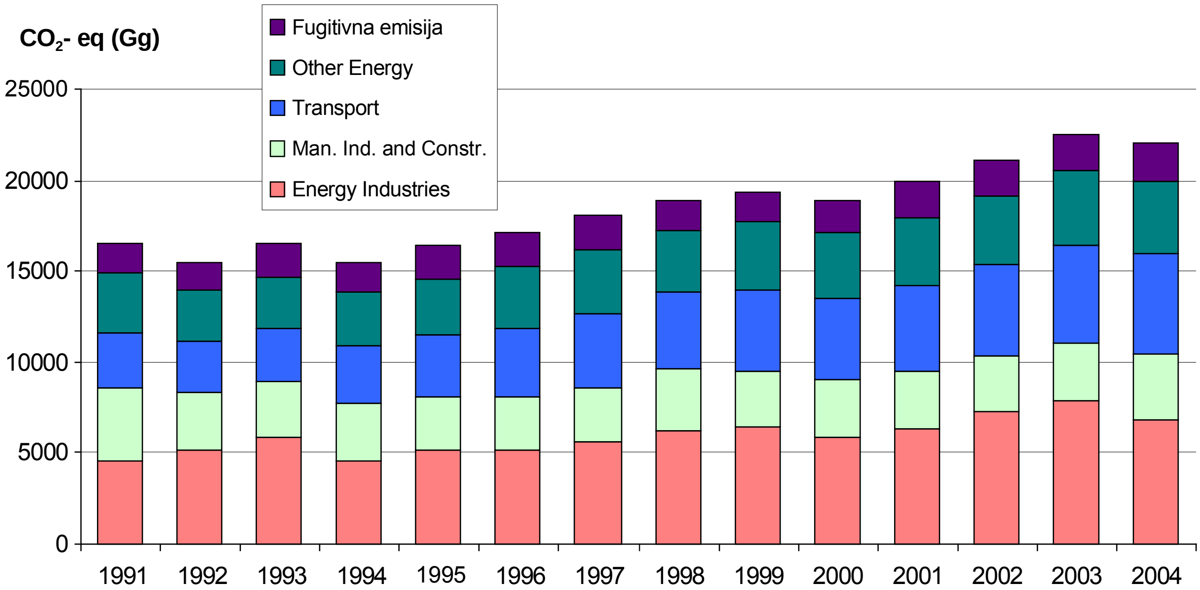

Figure 3.4-1: The CO_2-eq emissions from Energy sector

The Energy sector was the main cause for anthropogenic emission of greenhouse gases. It accounted for approximately 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 approximately 90 percent. The contribution of energy in methane (CH_4) emission is substantially smaller (48%) while the contribution of nitrous oxide (N_2O) is quite small (6%).

The largest part (28% to 35%) of the emissions are a consequence of fuel combustion in Energy Industries, then the combustion in Transport with increasing trend (18% in 1990; 25% in 2004) and the combustion in Manufacturing Industries and Construction with decreasing trend (25% in 1990; 17% in 2004). Small stationary energy sources, such as Commercial/Institutional, Residential and Agriculture/Forestry/Fishing, contribute to total emission from Energy sector with 17 to 20 percent, while fugitive emissions from fuels contribute with about 10 percent. The majority of energy-related GHG emissions belong to CO_2 (91% - 93%), then follows CH_4 (6% - 8%) and N_2O (less than 1%).

3.4. REFERENCES

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4. INDUSTRIAL PROCESSES (CRF sector 2)

4.1. OVERVIEW OF SECTOR

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 (GHGs) 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 are, in most cases, extracted from Monthly Industrial Reports, published by Central Bureau of Statistics, Department of Manufacturing and Mining. These reports cover 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 1996-2004 emissions slightly increased. Production of iron and aluminium were stopped in 1992.

The total annual emissions of GHGs, expressed in Gg eq-CO_2, from Industrial Processes in the period 1990-2004 are presented in the Figure 4.1-1.

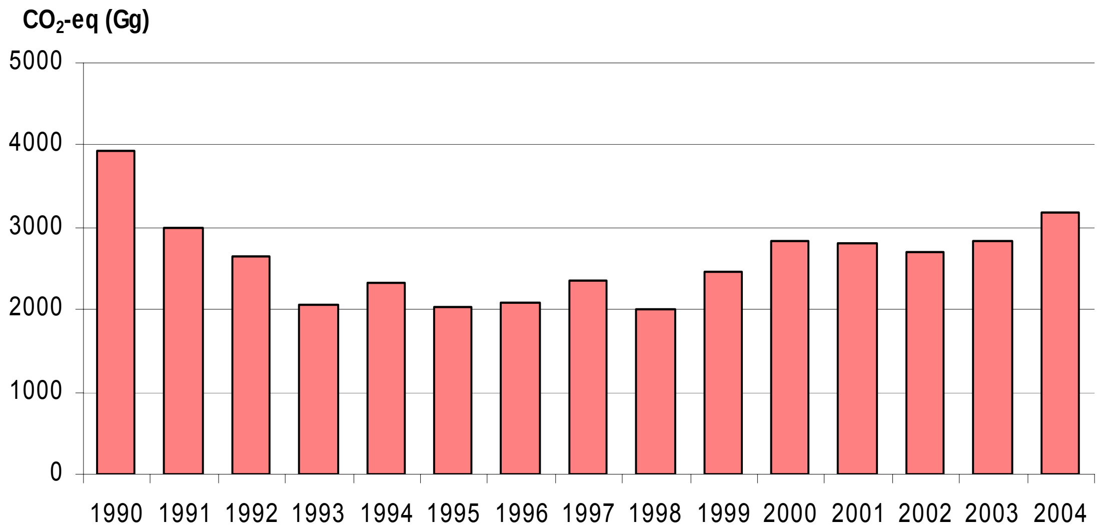

Figure 4.1-1: Emissions of GHGs from Industrial Processes (1990-2004)

4.2. MINERAL PRODUCTS (CRF 2.A.)

4.2.1. CEMENT PRODUCTION

4.2.1.1. Source category description

During cement production, calcium carbonate ($CaCO_3$) is heated in a cement kiln at high temperatures to form lime (i.e. calcium oxide, CaO) and CO_2 in a process known as calcination or calcining:

$$CaCO_3 + Heat \rightarrow CaO + CO_2\uparrow$$

Lime is combined with silica-containing materials (clays or shales) to form dicalcium and tricalcium silicates which are the main constituents of cement clinker, with the earlier CO_2 being released in the atmosphere as a by-product. The clinker is then removed from the cement kiln, cooled, pulverized and mixed with small amount of gypsum to form final product called Portland cement.

There are four manufacturers of cement in Croatia, producing mostly Portland cement. There is production of aluminate cement in the minor quantities. CO_2 emitted during the cement production process represents the most important source of non-energy industrial process of total CO_2 emissions. Different row materials are used for Portland cement and aluminate cement production. The quantity of the CO_2 emitted during Portland cement production is directly proportional to the lime content of the clinker. Emissions of SO_2 (non-combustion emissions) in the cement production originate from sulphur in the clay raw material.

4.2.1.2. Methodological issues

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 for Portland cement 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. The emission factor for aluminate cement, which was obtained by cement manufacturer, equals 0.325 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. According to information obtained by cement manufacturers, CKD is collected and recycled but data is very scarce. 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 4.2-1) were collected by EKONERG 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, 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 quantities of clinker imported has not been considered in the emission estimations.

Table 4.2.1: Clinker production (1990 - 2004)

Year	Clinker production (Portland cement)/ tonnes[1]	Clinker production (aluminate cement)/ tonnes[1]	Actual clinker production / tonnes[2]
1990	1,978,000	0	2,017,560
1991	1,252,000	0	1,277,040
1992	1,498,000	0	1,527,960
1993	1,254,000	0	1,279,080
1994	1,535,000	0	1,565,700
1995	1,131,000	0	1,153,620
1996	1,226,000	0	1,250,520
1997	1,457,000	0	1,486,140
1998	1,569,000	0	1,600,380
1999	2,074,000	0	2,115,480
2000	2,402,147	73,999	2,525,669
2001	2,745,112	94,065	2,895,961
2002	2,627,934	70,664	2,752,570
2003	2,609,349	82,741	2,745,932
2004	2,764,941	87,911	2,909,909

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

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

The resulting emissions of CO_2 from Cement Production in the period 1990-2004 are presented in the Figure 4.1-1.

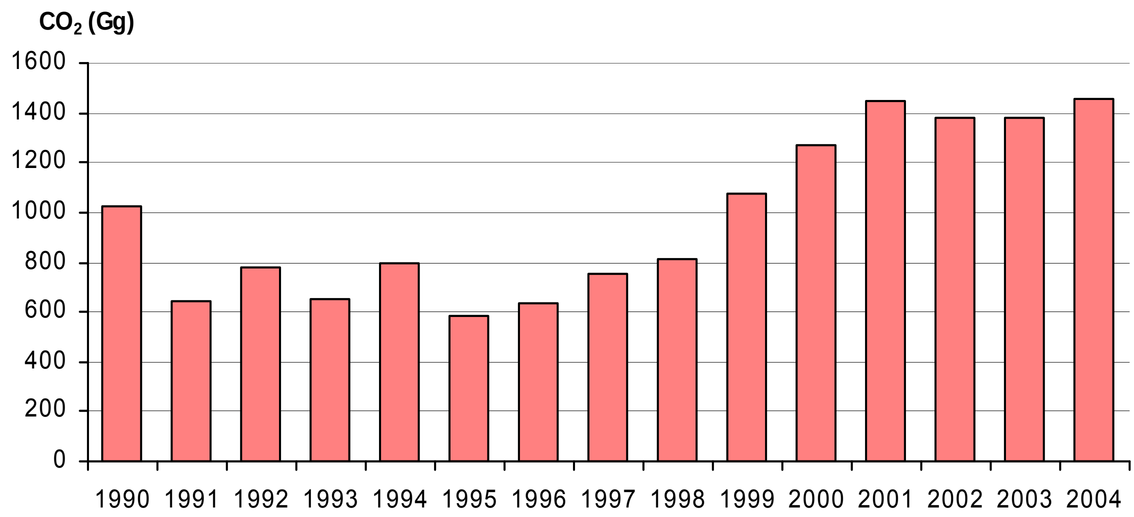

Figure 4.2-1: Emissions of CO_2 from Cement Production (1990-2004)

The activity data for cement production (see Table 4.2-2) were collected by EKONERG 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.

Table 4.2-2: Cement production (1990-2004)

Year	Cement production (tonnes)[1]
1990	2,577,000
1991	1,694,000
1992	1,710,000
1993	1,640,000
1994	2,022,000
1995	1,656,000
1996	1,793,000
1997	2,084,000
1998	2,229,000
1999	2,620,000
2000	2,852,490
2001	3,245,910
2002	3,482,716
2003	3,667,391
2004	3,663,468

SO_2 emissions originate from sulphur in the fuel and in the clay raw material. The fuel emissions are counted as energy emissions (these emissions are presented in the chapter on emissions from energy sources). SO_2 emissions from the clay are counted as process emissions and calculated on the basis of produced quantities of cement. About 70-95 percent of the SO_2 generated in the process is absorbed in the produced alkaline clinker. SO_2 emissions have been calculated by applying emission factor of 0.3 kg SO_2/tonne cement according to *Revised 1996 IPCC Guidelines.*

The resulting emissions of SO_2 from Cement Production in the period 1990-2004 are presented in the review on indirect GHG emissions from non-energy industrial processes.

4.2.1.3. Uncertainties and time-series consistency

Uncertainties contained in CO_2 emissions 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[1], which contains 60-67 percent lime by weight.

Uncertainty estimate associated with default emission factors amounts to 6 percent, accordingly to values (4 to 8 percent) reported in *Good Practice Guidance*. Uncertainty estimate associated with activity data amounts to 3 percent (1 to 5 percent), based on expert judgements since statistics and manufacturers have not been particularly assessed the uncertainties.

Emissions from Cement Production have been calculated using the same method and data sets for every year in the time series.

[1] In the period 1990-2004 average 98 percent of cement produced in Croatia were of Portland cement type.

4.2.1.4. Source-specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables.

After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures and Tier 2 source-specific QC procedures. Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. Cement Production is one of the three source categories represent key source category in Industrial Processes. CO_2 emissions from cement production were estimated using Tier 2 method which is a *good practice.*

4.2.1.5. Source–specific recalculations

In the previous report, CO_2 emissions from clinker production for aluminate cement have not been considered. In this report, actual clinker production for aluminate cement is added to the inventory and CO_2 emissions are recalculated for the period 2000-2003.

4.2.1.6. Source–specific planned improvements

Since Cement Production is a key source category, more detailed information about row materials are planned to include in the next inventory submission, especially about fraction of lime in the domestic cement clinker and actual fraction of CKD. It is a *good practice* to estimate the CaO content in clinker by collecting data from individual plants.

More information about the quantities of clinker imported since 1990 are planned to include in the next inventory submission, in order to inventory completeness.

4.2.2. LIME PRODUCTION

4.2.2.1. Source category description

The production of lime involves a series of steps which include qurrying the raw material, crushing and sizing, calcination and hydration. CO_2 is generated during the calcination stage, when limestone ($CaCO_3$) or dolomite ($CaCO_3$*$MgCO_3$) are burned at high temperature (900-1200 ^oC) in a rotary kiln to produce quicklime (CaO) or dolomitic lime (CaO*MgO) and CO_2 which is released in the atmosphere:

$$CaCO_3 \text{ (limestone)} + \text{Heat} \rightarrow CaO \text{ (quicklime)} + CO_2\uparrow$$
$$CaCO_3{*}MgCO_3 \text{ (dolomite)} + \text{Heat} \rightarrow CaO{*}MgO \text{ (dolomitic lime)} + 2CO_2\uparrow$$

4.2.2.2. Methodological issues

Calculation of CO_2 emissions 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 percent 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 4.2-3) 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. Also, certain amounts of quicklime were produced in the blast furnace processes, during 1990 and 1991.

Table 4.2-3: Lime production (1990-2004)

Year	Quicklime production (tonnes)	Dolomitic lime production (tonnes)[1]
1990	202,253	0
1991	121,710	0
1992	68,976	0
1993	76,269	0
1994	75,511	0
1995	78,820	0
1996	57,522	37,042
1997	65,231	55,047
1998	72,419	53,367
1999	68,684	53,088
2000	77,804	68,999
2001	102,802	68,427
2002	98,325	94,831
2003	92,263	96,820
2004	153,056	58,711

[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).

CO_2 emissions from quicklime and dolomitic lime production are presented in the Table 4.2.4.

Table 4.2-4: CO_2 emissions from quicklime and dolomitic lime production (1990-2004)

Year	Quicklime production (Gg CO_2)	Dolomitic lime production (Gg CO_2)
1990	159.78	0.00
1991	96.15	0.00
1992	54.49	0.00
1993	60.25	0.00
1994	59.65	0.00
1995	62.27	0.00
1996	45.44	33.71
1997	51.53	50.09
1998	57.21	48.56
1999	54.26	48.31

Table 4.2-4: CO_2 emissions from quicklime and dolomitic lime production (1990-2004), cont.

Year	Quicklime production (Gg CO_2)	Dolomitic lime production (Gg CO_2)
2000	61.47	62.79
2001	81.21	62.27
2002	77.68	86.30
2003	72.89	88.11
2004	120.91	53.43

The resulting emissions of CO_2 from Lime Production in the period 1990-2004 are presented in the Figure 4.2-2.

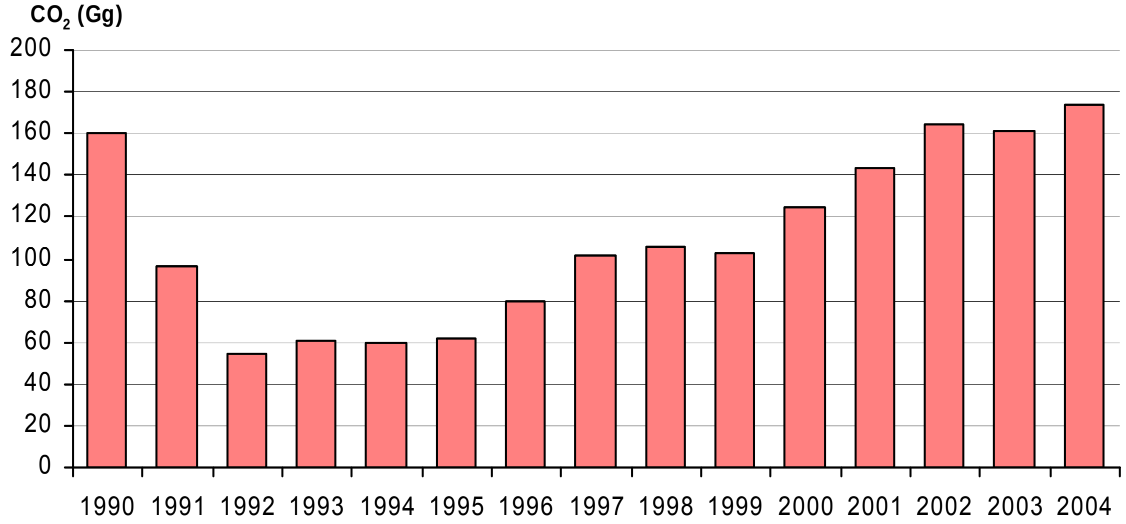

Figure 4.2-2: Emissions of CO_2 from Lime Production (1990-2004)

The methodology for calculating SO_2 emissions from Lime Production is not available in *Revised 1996 IPCC Guidelines*. Process (non-combustion) SO_2 emissions depend on the sulphur content and mineralogical form of the stone feed, the quality of the lime produced and the type of kiln. Until more information becomes available, it is recommended that only emissions from fuel combustion (which are presented in the chapter on emissions from energy sources) are considered.

4.2.2.3. Uncertainties and time-series consistency

Uncertainties contained in CO_2 estimates are due to provided default emission factors which assume 100 percent of CaO in lime (in some cases purity may range from 85 to 95 percent 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.

Uncertainty estimate associated with default emission factors amounts to 15 percent, accordingly to value recommended in *Good Practice Guidance*. Uncertainty estimate associated with activity data amounts to 7.5 percent (5 to 10 percent), based on expert judgements since statistics and manufacturers have not been particularly assessed the uncertainties.

Emissions from Lime Production have been calculated using the same method and data sets for every year in the time series.

4.2.2.4. Source specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures.

4.2.2.5. Source specific recalculations

There are no source-specific recalculations in sub-sector Lime Production.

4.2.2.6. Source–specific planned improvements

For the purpose of accurate calculation of national emission factors for quicklime and dolomitic lime production, Croatia planned to analyze the content of CaO and MgO in lime and in raw materials which are used for lime production.

4.2.3. LIMESTONE AND DOLOMITE USE

4.2.3.1. Source category description

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, agriculture, construction and environmental pollution control. For some of these applications carbonates are sufficiently heated to high temperature as part of the process to generate CO_2 as a by-product. The major utilization of dolomite in Croatia is in glass, ceramic and refractory materials manufacture as well as the limestone use in the pig iron production (during 1990 and 1991).

4.2.3.2. Methodological issues

Emissions of CO_2 from use of limestone and dolomite have been 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. Emissions of CO_2 from the use of limestone have been estimated by using emission factor which equals 440 kg CO_2/tonne limestone. Emissions of CO_2 from the use of dolomite have been estimated by using emission factor which equals 477 kg CO_2/tonne dolomite, assuming 100 percent purity of raw material (*Revised 1996 IPCC Guidelines*).

The activity data for limestone use in the pig iron production for the 1990 and 1991 were collected by EKONERG from voluntary survey of iron manufacturer.

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 1996-2004 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 4.2-5).

Table 4.2-5: Limestone and dolomite use (1990-2004)

Year	Limestone use (tonnes)	Dolomite use (tonnes)
1990	41,816	52,031
1991	12,037	40,452
1992	0	22,091
1993	0	20,134
1994	0	32,504
1995	0	23,461
1996	0	17,827
1997	0	15,191
1998	0	18,028
1999	0	16,666
2000	0	17,634
2001	0	19,364
2002	0	20,167
2003	0	24,687
2004	0	24,141

The resulting emissions of CO_2 from Limestone and Dolomite Use in the period 1990-2004 are presented in the Figure 4.2-3.

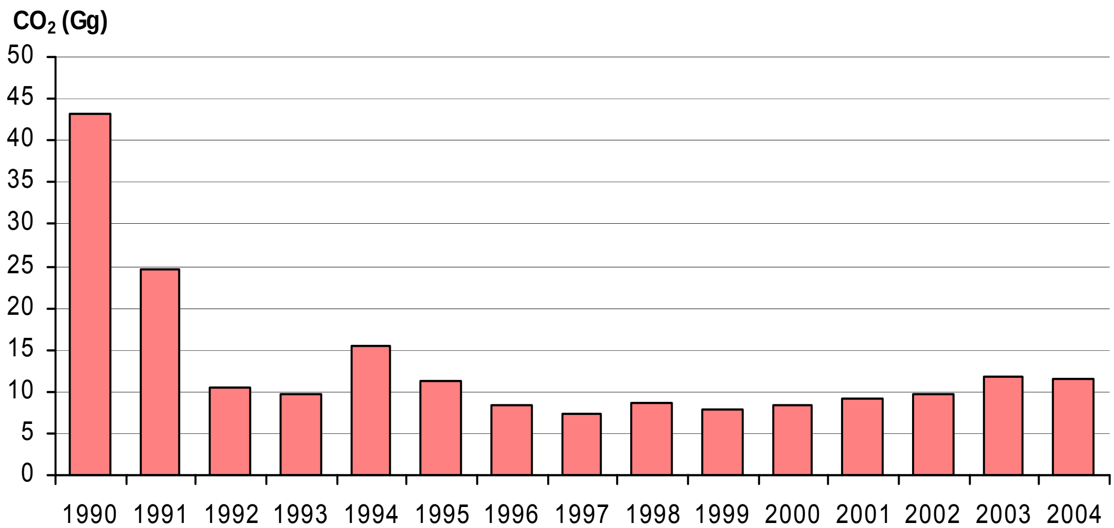

Figure 4.2-3: Emissions of CO_2 from Limestone and Dolomite Use (1990-2004)

4.2.3.3. Uncertainties and time-series consistency

Uncertainties in CO_2 estimates are related to possible variations in the chemical composition of limestone and dolomite (carbonates may contain smaller amounts of impurities i.e. magnesia, silica, and sulphur). Uncertainties contained in these estimates are due to provided default emission factor which assume 100 percent purity of raw material.

Uncertainty estimate associated with default emission factors amounts to 30 percent, based on expert judgements. Uncertainty estimate associated with activity data amounts to 7.5 percent (5 to 10 percent), based on expert judgements since statistics and manufacturers have not been particularly assessed the uncertainties.

Emissions from Limestone and Dolomite Use have been calculated using the same method for every year in the time series. Data sets are different for the period 1990-1995 in relation to the period 1996-2004.

4.2.3.4. Source specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures.

4.2.3.5. Source specific recalculations

There are no source-specific recalculations in sub-sector Limestone and Dolomite Use.

4.2.3.6. Source–specific planned improvements

For the purpose of accurate calculation of national emission factors, Croatia planned to investigate chemical composition of dolomite wich are used as raw materials in abovementioned commercial applications (glass, ceramic and refractory materials manufacture).

4.2.4. SODA ASH PRODUCTION AND USE

4.2.4.1. Source category description

Soda ash (sodium carbonate, Na_2CO_3) is a white crystalline solid that is commercially used as a raw material in a large number of 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 1990-2004. Therefore, only CO_2 emissions arising in soda ash consumption in glass and ceramic manufacture, and in the production of soap and detergents, have been estimated.

4.2.4.2. Methodological issues

Emissions of CO_2 from the soda ash use have been calculated by multiplying annual consumption of 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/tonne 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 1996-2004 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 4.2-6).

Table 4.2-6: Soda ash use (1990-2004)

Year	Soda ash use (tonnes)
1990	62,024
1991	52,415
1992	35,376
1993	30,202
1994	36,659
1995	34,668
1996	27,493
1997	23,320
1998	27,694
1999	25,538
2000	26,536
2001	29,818
2002	29,446
2003	35,335
2004	39,821

The resulting emissions of CO_2 from Soda Ash Use in the period 1990-2004 are presented in the Figure 4.2-4.

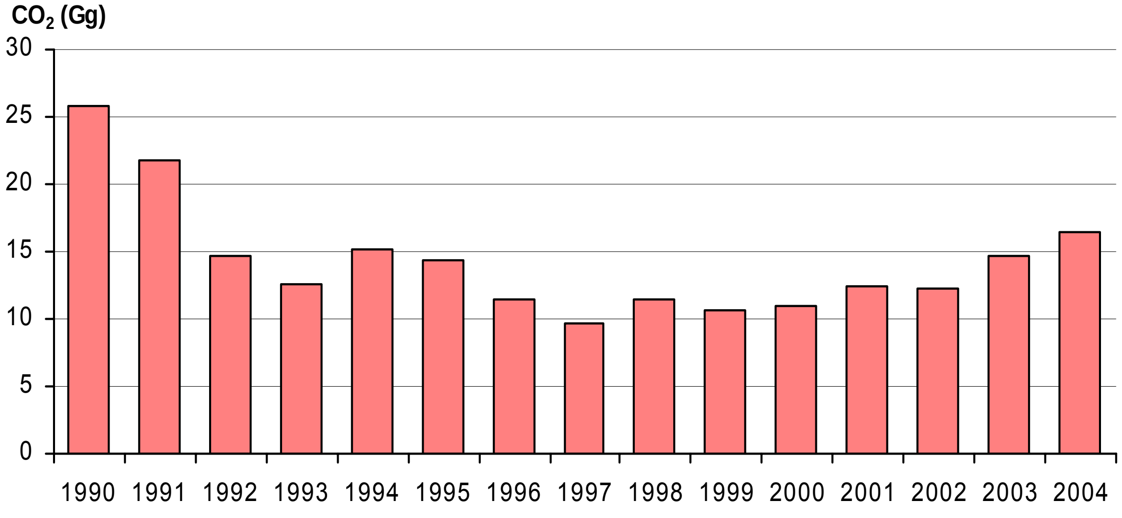

Figure 4.2-4: Emissions of CO_2 from Soda Ash Use (1990-2004)

4.2.4.3. Uncertainties and time-series consistency

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.

Uncertainty estimate associated with default emission factors amounts to 30 percent, based on expert judgements. Uncertainty estimate associated with activity data amounts to 7.5 percent (5 to 10 percent), based on expert judgements since statistics and manufacturers have not been particularly assessed the uncertainties.

Emissions from Soda Ash Use have been calculated using the same method for every year in the time series. Data sets are different for the period 1990-1995 in relation to the period 1996-2004.

4.2.4.4. Source-specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures.

4.2.4.5. Source specific recalculations

There are no source-specific recalculations in sub-sector Soda Ash Use.

4.2.4.6. Source–specific planned improvements

For the purpose of accurate calculation of national emission factors, Croatia planned to analyze specific information characterizing the emissions from particular end-use processes.

4.2.5. PRODUCTION AND USE OF MISCELLANEOUS MINERAL PRODUCTS

4.2.5.1. Source category description

There are several mineral production processes which caused emissions of indirect GHGs: Asphalt Roofing Production, Road Paving with Asphalt and Glass Manufacturing.

4.2.5.2. Methodological issues

Asphalt Roofing Production

Asphalt roofing production includes production of asphalt roofing and process of asphalt blowing. Emissions of indirect GHGs have been calculated by multiplying annual produced quantities with related emission factor provided by *Revised 1996 IPCC Guidelines.*

For indirect GHGs emissions estimation in the Asphalt Roofing Production the emission factors of 0.049 kg NMVOC/tonne asphalt roofing and 0.0095 kg CO/tonne asphalt roofing have been applied. In the Asphalt Blowing process the emission factor of 2.4 kg NMVOC/tonne asphalt blown has been applied.

The annual produced quantities were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining. The resulting emissions of indirect GHGs from Asphalt Roofing Production Processes in the period 1990-2004 are presented in the review on indirect GHG emissions from non-energy industrial processes.

Road Paving with Asphalt

Emissions of indirect GHGs from Road Paving with Asphalt include emissions from asphalt plant, from road surfacing operations and from subsequent road surface. Emissions of indirect GHGs have been calculated by multiplying annual produced quantities of asphalt with related emission factor provided by *Revised 1996 IPCC Guidelines.*

For NMVOC emissions estimation from Asphalt Plant the emission factor of 0.023 kg NMVOC/tonne asphalt has been applied. The emission factor of 320 kg NMVOC/tonne asphalt has been applied for NMVOC emissions estimation from Road Surface.

The annual produced quantities of asphalt were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining. The resulting emissions of indirect GHGs from Road Paving with Asphalt in the period 1990-2004 are presented in the review on indirect GHG emissions from non-energy industrial processes.

Glass Manufacturing

Emissions from Container Glass Production and Flat Glass Production have been calculated by multiplying annual produced quantities of container and flat glass with emission factor provided by *Revised 1996 IPCC Guidelines.* The emission factor of 4.5 kg NMVOC/tonne glass has been applied.

The annual produced quantities of glass were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining. The resulting emissions of NMVOC from Glass Manufacturing in the period 1990-2004 are presented in the review on indirect GHG emissions from non-energy industrial processes.

4.2.5.3. Uncertainties and time-series consistency

Uncertainties related to emissions of indirect GHGs are related primarily to the accuracy of the emission factor. *Good Practice Guidance* didn't recommend uncertainty estimate associated with default emission factors for Production and Use of Miscellaneous Mineral Products. Uncertainties associated with default emission factors and activity data were not estimated for Production and Use of Miscellaneous Mineral Products.

Emissions from Production and Use of Miscellaneous Mineral Products have been calculated using the same method and data sets for every year in the time series.

4.2.5.4. Source-specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures.

4.2.5.5. Source specific recalculations

In previous report, errors were done during activity data compilation in sub-sectors Asphalt Roofing Production and Road Paving with Asphalt. For sub-sector Asphalt Roofing Production errors were done for the years 1990, 1991, 1995 - 2000, 2002 and 2003. For sub-sector Road Paving with Asphalt errors were done for the years 1990, 1991, 1994 and 1995. There are no source-specific recalculations because only NMVOC emissions are calculated in abovementioned sub-sectors. The IPCC Guidelines do not provide methodologies for calculation of CO_2 emission from these sources.

4.2.5.6. Source–specific planned improvements

For the purpose of accurate calculation of national emission factors, Croatia planned to analyze and investigate specific information related to type of asphalt roofing production processes and type of asphalt as well as amounts of diluent which are used in asphalt production.

4.3. CHEMICAL INDUSTRY (CRF 2.B.)

4.3.1. AMMONIA PRODUCTION

4.3.1.1. Source category description

Ammonia is produced by catalytic steam reforming of natural gas in which hydrogen is chemically separated from the natural gas and combined with nitrogen to produce ammonia (NH_3). Carbon dioxide which is formed from carbon monoxide in CO shift converter is removed by using two methods: monoethanolamine scrubbing and hot potassium scrubbing. After absorbing the CO_2, the amine solution is preheated and regenerated which results in removing the CO_2 by steam stripping and then by heating. The CO_2 is either vented to the atmosphere or used as a feedstock in other parts of the plant complex (for production of UREA or dry ice).

4.3.1.2. Methodological issues

Emissions of CO_2 from ammonia production have been 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, *Revised 1996 IPCC Guidelines*).

Data on consumption and composition of natural gas (see Table 4.3-1) used as a feedstock in a process were collected by EKONERG from voluntary survey of ammonia manufacturer (Petrokemija d.d Fertilizer Company Kutina) and cross-checked with ammonia production data from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining. Carbon content of gas (kg C/m^3) has been estimated from volume fraction of CH_4, C_2H_6, C_3H_8, C_4H_{10}, C_5H_{12}, CO_2 and N_2 in natural gas.

Table 4.3-1: Consumption and composition of gas in Ammonia Production (1990-2004)

Year	Gas consumption (m^3)	Carbon content of gas (kg C/m^3)
1990	242,905,233	0.5519
1991	230,492,226	0.5579
1992	299,567,927	0.5524
1993	238,269,046	0.5395
1994	239,717,137	0.5401
1995	232,773,362	0.5423
1996	254,116,356	0.5395
1997	277,311,935	0.5372
1998	207,973,360	0.5373
1999	262,772,017	0.5388
2000	266,433,375	0.5377
2001	214,441,408	0.5416
2002	193,045,364	0.5421
2003	216,859,822	0.5431
2004	264,367,950	0.5391

The resulting emissions of CO_2 from Ammonia Production in the period 1990-2004 are presented in the Figure 4.3-1.

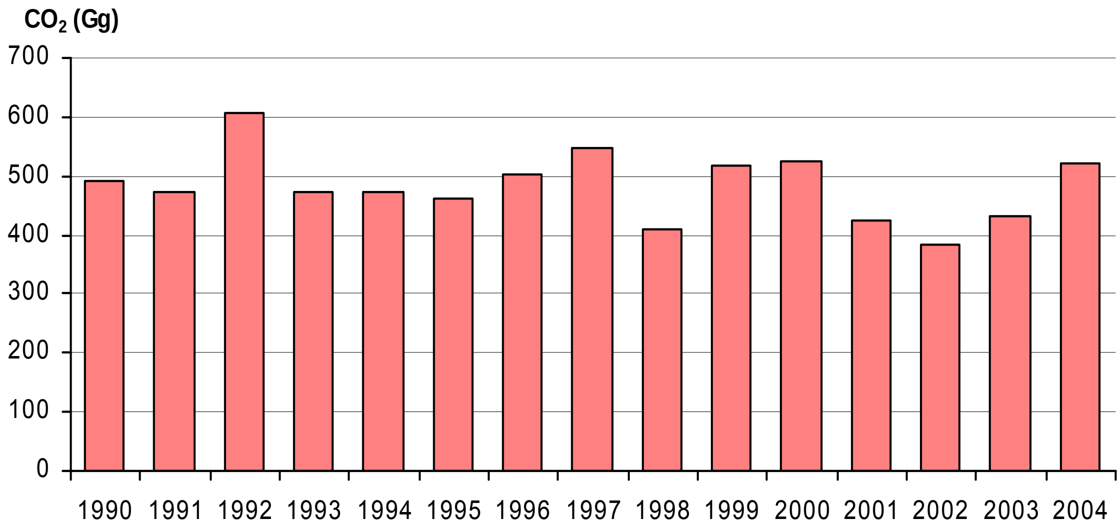

Figure 4.3-1: Emissions of CO_2 from Ammonia Production (1990-2004)

4.3.1.3. Uncertainties and time-series consistency

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[2]. 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.

Uncertainty estimate associated with default emission factors amounts to 5 percent, accordingly to value recommended in *Good Practice Guidance*. Uncertainty estimate associated with activity data amounts to 3 percent (1 to 5 percent), based on expert judgements since statistics and manufacturers have not been particularly assessed the uncertainties.

Emissions from Ammonia Production have been calculated using the same method and data sets for every year in the time series.

4.3.1.4. Source-specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables.

After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures and Tier 2 source-specific QC procedures. Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. Ammonia Production is one of the three source categories represent key source category in Industrial Processes. Emissions of CO_2 from ammonia production were

[2] 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.

estimated using Tier 1a method which is based on gas consumption and could be considered as a *good practice*.

4.3.1.5. Source–specific recalculations

There are no source-specific recalculations in sub-sector Ammonia Production.

4.3.1.6. Source–specific planned improvements

Since Ammonia Production is a key source category, more detailed information about use of CO_2 as a feedstock in downstream manufacturing processes, in the production of urea, dry ice and fertilizer are planned to include in the next inventory submission.

4.3.2. NITRIC ACID PRODUCTION

4.3.2.1. Source category description

There is one manufacturer of nitric acid in Croatia, with dual pressure type of production process, according to the pressure used in the oxidation and absorption stages. Ammonia, which is used as a feedstock, is vaporized, mixed with air and burned over a platinum/rhodium alloy catalyst. Nitrogen monoxyde is formed and oxidized to nitrogen dioxide at medium pressures and absorbed in water at high pressure to give nitric acid. During oxidation stage, nitrogen and nitrous oxyde are formed as a by-product and released from reactor vents into the atmosphere. There is no abatement technology installed at the plant. Nitric acid is used in the manufacture of fertzilizers.

4.3.2.2. Methodological issues

Emissions of N_2O from nitric acid production have been calculated by multiplying annual nitric acid production by emission factor which reflects the process type, i.e. dual pressure type. According to *Good Practice Guidance* emission factor given for European designed dual pressure plants is in the range from 8 to 10 kg N_2O/tonne nitric acid. 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 4.3-2) 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.

Table 4.3-2: Nitric acid production (1990-2004)

Year	Nitric acid production (tonnes)
1990	332,459
1991	291,997
1992	381,797
1993	287,805
1994	311,236
1995	299,297
1996	278,683
1997	292,892
1998	220,509

Table 4.3-2: Nitric acid production (1990-2004), cont.

Year	Nitric acid production (tonnes)
1999	260,198
2000	306,201
2001	257,534
2002	249,992
2003	235,645
2004	287,567

The resulting emissions of N_2O from Nitric Acid Production in the period 1990-2004 are presented in the Figure 4.3-2.

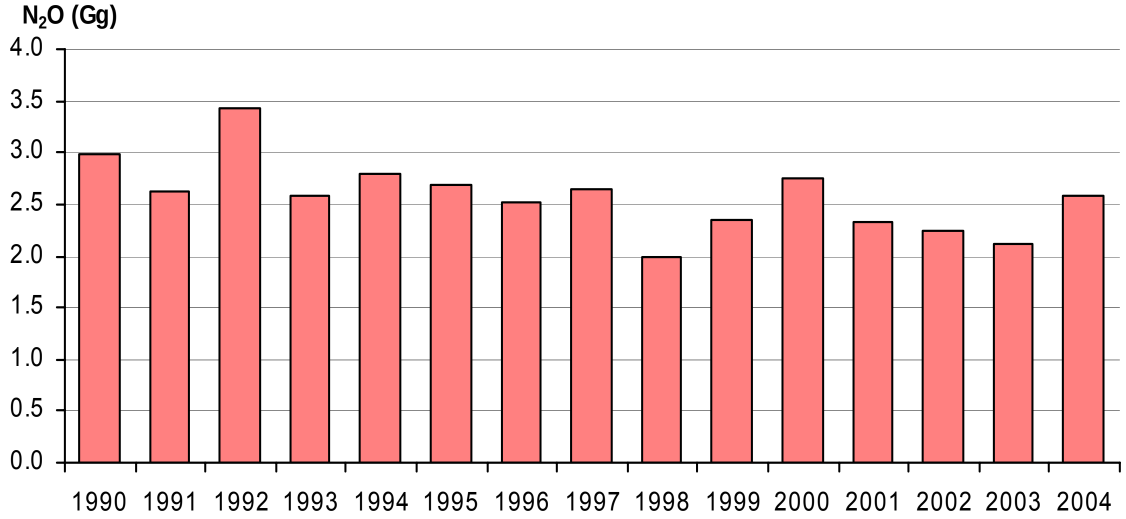

Figure 4.3-2: Emissions of N_2O from Nitric Acid Production (1990-2004)

4.3.2.3. Uncertainties and time-series consistency

The main uncertainties concerning the emissions of N_2O from nitric acid production are due to applied emission factor.

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*[3].

Uncertainty estimate associated with default emission factors amounts to 30 percent, based on expert judgements. Uncertainty estimate associated with activity data amounts tot 3 percent (1 to 5 percent), based on expert judgements since statistics and manufacturers have not been particularly assessed the uncertainties.

Emissions from Nitric Acid Production have been calculated using the same method and data sets for every year in the time series.

[3] *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.

4.3.2.4. Source-specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables.

After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures and Tier 2 source-specific QC procedures. Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. Nitric Acid Production is one of the three source categories represent key source category in Industrial Processes. Emissions of N_2O from nitric acid production were based on default emission factor from IPCC Good Practice Guidance and annual amount of nitric acid production. It is a *good practice* to use direct emission measurement for national emission factor calculation.

4.3.2.5. Source–specific recalculations

There are no source-specific recalculations in sub-sector Nitric Acid Production.

4.3.2.6. Source–specific planned improvements

Since Nitric Acid Production is a key source category, more detailed information about using of direct emission measurement for calculation of national emission factor are planned to include in the next inventory submission. Furthermore, this data are not available since CEM system is not installed and manufacturer is not obliged yet to conduct spot measurement according to relevant regulation.

4.3.3. PRODUCTION OF OTHER CHEMICALS

4.3.3.1. Source category description

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.

4.3.3.2. Methodological issues

Emissions of CH_4 from the production of other chemicals have been 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 4.3-3) was extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Table 4.3-3: Production of other chemicals (1990-2004)

Year	Carbon black (tonnes)	Ethylene (tonnes)	Dichloro-ethylene (tonnes)	Styrene (tonnes)	Coke (tonnes)
1990	30,624	72,631	72,653	8,923	556,084
1991	18,783	66,871	68,325	6,376	441,584
1992	13,479	68,318	92,089	1,381	409,371
1993	17,123	68,634	79,608	0	420,676
1994	21,468	65,285	97,528	0	276,854
1995	27,185	67,547	84,374	0	0
1996	26,735	64,782	48,630	0	0
1997	24,214	63,554	26,264	0	0
1998	22,165	60,148	31,308	0	0
1999	17,589	60,295	47,686	0	0
2000	20,029	38,918	71,364	0	0
2001	21,180	46,632	64,442	0	0
2002	19,385	43,554	0	0	0
2003	21,497	41,252	0	0	0
2004	20,271	49,886	0	0	0

The resulting emissions of CH_4 from Production of Other Chemicals in the period 1990-2004 are reported in Table 4.3-4.

Table 4.3-4: Emissions of CH_4 from Production of Other Chemicals (1990-2004)

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
2002	0.21	0.04	0.00	0.00	0.00
2003	0.24	0.04	0.00	0.00	0.00
2004	0.22	0.05	0.00	0.00	0.00

Emissions of indirect GHGs from Production of Other Chemicals have been calculated by multiplying an annual production of each chemical with related emission factor provided by *Revised 1996 IPCC Guidelines*.

The resulting emissions of indirect GHGs from Production from Other Chemicals in the period 1990-2004 are presented in the review on indirect GHG emissions from non-energy industrial processes.

4.3.3.3. Uncertainties and time-series consistency

Uncertainty estimate associated with default emission factor for CH_4 emissions amounts to 30 percent, based on expert judgements. Uncertainty estimate associated with activity data for CH_4 emissions amounts to 7.5 percent (5 to 10 percent), based on expert judgements since statistics and manufacturers have not been particularly assessed the uncertainties.

Emissions from Production from Other Chemicals have been calculated using the same method and data sets for every year in the time series.

4.3.3.4. Source-specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures.

4.3.3.5. Source–specific recalculations

There are no source-specific recalculations in sub-sector Production of Other Chemicals.

4.3.3.6. Source–specific planned improvements

For the purpose of accurate emission calculations, Croatia planned to analyze specific chemical production processes.

4.4. METAL Production (CRF 2.C.)

4.4.1. IRON AND STEEL PRODUCTION

4.4.1.1. Source category description

Primary production of pig iron in blast furnace was halted in 1992.

Steel production in electric arc furnaces (EAF) are used to produce carbon and alloy steel. The input material to EAFs is 100 percent scrap. Cylindrical lined EAFs are equipped with carbon electrodes. Alloying agents and fluxing materials (limestone) are added. Electric current of opposite polarity electrodes generates heat between the electrodes and through the scrap. The operations which generate emissions during the EAF steelmaking process are melting, refining, charging scrap, tapping steel and dumping slag. During the melting phase carbon electrodes are kept above the steel melt and the electrical arc oxidises the carbon to CO or CO_2.

4.4.1.2. Methodological issues

Pig Iron Production

Emissions of CO_2 have been 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 emission factor applied was assumed to be applicable to both pig iron production and integrated pig iron and steel production.

The activity data for pig iron 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[4].

The resulting emission of CO_2 from Pig Iron Production in 1990 was amounted 335000 tonnes. In 1991 about 111000 tonnes of CO_2 was emitted. 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.

Steel Production

Emissions of CO_2 have been calculated by multiplying annual steel production with related emission factor provided by *Revised 1996 IPCC Guidelines*. The carbon emission factor is based on carbon loss from the electrode. Accordingly to value recommended in *Good Practice Guidance* for carbon released from consumed electrodes (roughly 1-1.5 kg carbon/tonne steel), the arithmetic mean has been taken (1.25 kg carbon/tonne steel) and emission factor of 4.58 kg CO_2/tonne steel has been applied.

The activity data for steel production (see Table 4.4-1) were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining.

[4] 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.

Table 4.4-1: Steel production (1990-2004)

Year	Steel production (tonnes)
1990	189,368
1991	171,147
1992	119,733
1993	101,942
1994	32,674
1995	17,021
1996	46,424
1997	70,660
1998	104,854
1999	77,213
2000	70,998
2001	57,963
2002	33,839
2003	42,235
2004	85,947

The resulting emissions of CO_2 from Steel Production in the period 1990-2004 are presented in the Figure 4.4-1.

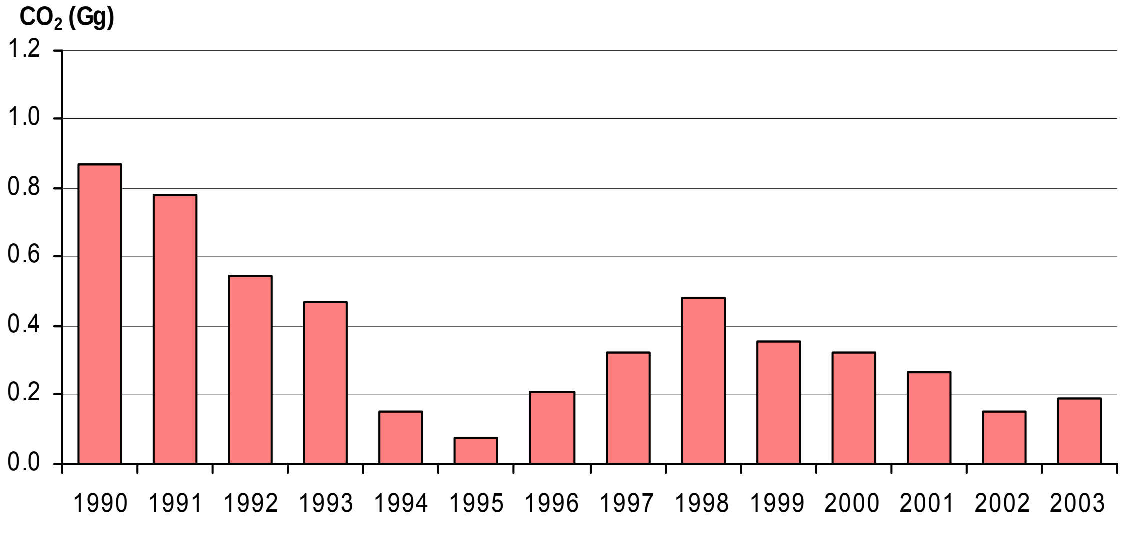

Figure 4.4-1: Emissions of CO_2 from Steel Production (1990-2004)

4.4.1.3. Uncertainties and time-series consistency

The main uncertainties concerning the emission of CO_2 from steel production are due to applied emission factor. The use of plant-specific emission factors would minimize uncertainty, but these factors were not available in adequate form. Uncertainty estimate associated with default emission factors amounts to 30 percent, based on expert judgements. Uncertainty estimate associated with activity data amounts to 7.5 percent (5 to 10 percent), based on expert judgements since statistics and manufacturers have not been particularly assessed the uncertainties.

Emissions from Steel Production have been calculated using the same method and data sets for every year in the time series.

4.4.1.4. Source specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures.

4.4.1.5. Source–specific recalculations

There are no source-specific recalculations in sub-sector Steel Production.

4.4.1.6. Source–specific planned improvements

For the purpose of accurate calculation of national emission factors, Croatia planned to investigate the plant-specific emission factor to minimize emission calculation uncertainty.

4.4.2. FERROALLOYS PRODUCTION

4.4.2.1. Source category description

Ferroalloys are alloys of iron and metals such as silicon, manganese and chromium. Similar to emissions from the production of iron and steel, CO_2 is emitted when metallurgical coke is oxidized during a high-temperature reaction with iron and the selected alloying element. Ferroallloys production was halted in 2002.

4.4.2.2. Methodological issues

Emissions of CO_2 have been 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 4.4-2) were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Table 4.4-2: Production of ferroalloys (1990-2004)

Year	Ferromanganese (tonnes)	Silicon manganese (tonnes)	Ferrochromium (tonnes)
1990	20,535	48,561	60,859
1991	13,053	38,365	72,845
1992	0	25,572	56,058
1993	0	8,577	28,028
1994	562	22,071	31,704
1995	0	0	26,081
1996	0	0	10,559
1997	0	0	24,231
1998	0	0	11,861
1999	0	0	0

Table 4.4-2: Production of ferroalloys (1990-2004), cont.

Year	Ferromanganese (tonnes)	Silicon manganese (tonnes)	Ferrochromium (tonnes)
2000	0	0	15,753
2001	0	0	361
2002	0	0	0
2003	0	0	0
2004	0	0	0

The resulting emissions of CO_2 from Ferroalloys Production in the period 1990-2004 are presented in the Figure 4.4-2.

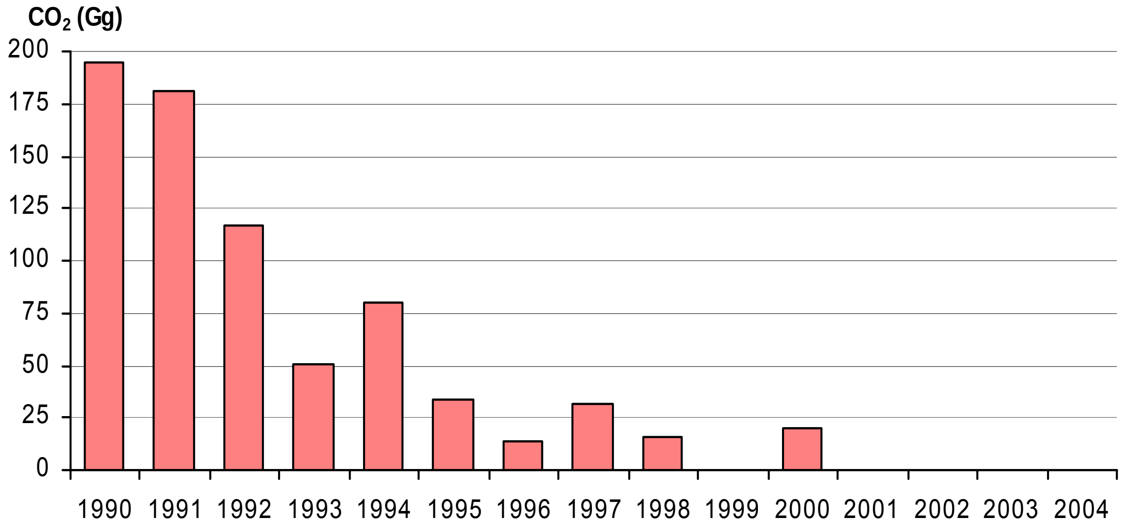

Figure 4.4-2: Emissions of CO_2 from Ferroalloys Production (1990-2004)

4.4.2.3. Uncertainties and time-series consistency

Uncertainty estimate associated with default emission factors amounts to 30 percent, based on expert judgements. Uncertainty estimate associated with activity data amounts to 7.5 percent (5 to 10 percent), based on expert judgements since statistics and manufacturers have not been particularly assessed the uncertainties.

Emissions from Ferroalloys Production have been calculated using the same method and data sets for every year in the time series.

4.4.3. ALUMINIUM PRODUCTION

4.4.3.1. Source category description

Primary aluminium is produced in two steps. First bauxite ore is ground, purified and calcined to produce alumina (Al_2O_3). Following this, the alumina is electrically reduced to aluminium by smelting in large pots. This process results in emission of several greenhouse gases including CO_2, and two PFCs: CF_4 and C_2F_6. Primary aluminium production was halted in 1991.

4.4.3.2. Methodological issues

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.

Data on primary aluminium production were collected by EKONERG from voluntary survey of aluminium manufacturer[5] .

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*. 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 eq-CO_2 of CF_4 and 120000 tonnes eq-CO_2 of C_2F_6 were emitted. In 1991 about 566000 tonnes eq-CO_2 of CF_4 and 83000 tonnes eq-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.

The resulting emissions of indirect GHGs from Aluminium Production in the period 1990-1991 are presented in the review on indirect GHG emissions from non-energy industrial processes.

4.4.3.3. Uncertainties and time-series consistency

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.

Uncertainty estimate associated with default emission factor for CO_2 emissions amounts to 30 percent, based on expert judgements. Uncertainty estimate associated with activity data for CO_2 emissions amounts to 3 percent (1 to 5 percent), based on expert judgements since statistics and manufacturers have not been particularly assessed the uncertainties.

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.

Uncertainty estimate associated with default emission factor for PFCs emissions amounts to 50 percent, based on expert judgements. Uncertainty estimate associated with activity data for PFCs emissions amounts to 30 percent, based on expert judgements.

Emissions from Aluminium Production have been calculated using the same method and data sets for every year in the time series.

[5] 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.

4.5. OTHER PRODUCTION (CRF 2.D.)

4.5.1. PULP AND PAPER

4.5.1.1. Source category description

Kraft (sulphate) pulping, acid sulphite pulping and neutral sulphite semi-chemical process are three types of paper production processes. Kraft pulping was used in 1990 and acid sulphite pulping was used until 1994 for paper production. After that, only neutral sulphite semi-chemical process has been used for paper production.

4.5.1.2. Methodological issues

Emissions of indirect GHGs have been calculated by multiplying annual production quantities with related emission factor provided by *Revised 1996 IPCC Guidelines*. For Kraft Pulping following default emission factors have been used: 7 kg SO_2/tonne dried pulp, 1.5 kg NO_x/tonne dried pulp, 3.7 kg NMVOC/tonne dried pulp and 5.6 kg CO/tonne dried pulp. For Acid Sulphite Pulping emission factor of 30 kg SO_2/tonne dried pulp has been used. According to *Revised 1996 IPCC Guidelines*, only data for emissions estimation from Kraft and Acid Sulphite Process are available. The methods for emission estimation from Neutral Sulphite Semi-Chemical Process are not available and emissions from that process have therefore not been taken into account.

The activity data for pulp and paper production were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining.

The resulting emissions of indirect GHGs from Pulp and Paper in the period 1990-1994 are presented in the review on indirect GHG emissions from non-energy industrial processes.

4.5.1.3. Uncertainties and time-series consistency

Uncertainties associated with default emission factors and activity data were not estimated for Pulp and Paper Production.

Emissions from Pulp and Paper have been calculated using the same method and data sets for every year in the time series.

4.5.2. FOOD AND DRINK

4.5.2.1. Source category description

Emissions of NMVOC from following types of Food and Drink production processes have been calculated: meat, fish and poultry; sugar; margarine and solid cooking fats; cakes, biscuits and cereals; bread; animal feed; coffee roasting; wine; white wine; beer; spirits and brandy.

4.5.2.2. Methodological issues

Emissions of indirect GHGs from the production of food and drink have been calculated by multiplying annual production quantities with related emission factors provided by *Revised 1996 IPCC Guidelines*.

The activity data for food and drink production were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining. The resulting emissions of indirect GHGs from Food and Drink in the period 1990-2004 are presented in the review on indirect GHG emissions from non-energy industrial processes.

4.5.2.3. Uncertainties and time-series consistency

Uncertainties associated with default emission factors and activity data were not estimated for Food and Drink. Emissions from Food and Drink have been calculated using the same method and data sets for every year in the time series.

4.6. CONSUMPTION OF HALOCARBONS AND SF_6 (CRF 2.F.)

4.6.1. REFRIGERATION AND AIR CONDITIONING EQUIPMENT

4.6.1.1. Source category description

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.

Emissions are released by the handling and consumption of synthetic greenhouse gases. HFCs (HFC-32, HFC-125 HFC-134a and HFC-143a) are used as substitutes for cooling gases in refrigerating and air-conditioning systems that deplete the ozone layer. There is no production of HFCs in Croatia, therefore all quantities of HFCs are imported. Minor quantities of some substances are exported.

4.6.1.2. Methodological issues

In order to estimate consumption of HFCs in the period 1990-2004 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, Physical Planning and Construction, Customs Department and Central Bureau of Statistics were contacted and asked to provide information on import and export of HFCs.

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 provided by Ministry of Environmental Protection, Physical Planning and Construction. According to this information potential HFCs emissions, for the period 1995–2004, 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 1995-2004, are presented in Table 4.6-1. HFCs emissions for the year 1990-1994 have not been calculated because of the difficulty in obtaining the relevant activity data for these estimates.

Table 4.6-1: Emissions of HFCs (Gg eq-CO_2) (1995 – 2004)

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HFC 32	NE	NE	NE	NE	NE	0.07	0.12	0.06	1.29	1.58
HFC 125	NE	22.20	22.18	1.12	1.76	5.35	12.91	13.29	45.09	52.12
HFC 134a	7.80	2.34	33.44	14.60	4.63	8.92	14.53	14.32	41.80	47.81
HFC 143a	NE	35.61	35.57	1.82	2.70	8.82	21.43	21.64	75.52	87.36
Total	**7.80**	**60.15**	**91.18**	**17.54**	**9.09**	**23.15**	**49.00**	**49.31**	**163.71**	**188.87**

4.6.1.3. Uncertainties and time-series consistency

The main uncertainties of HFCs emissions 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.

Uncertainty estimate associated with estimation of potential emissions of HFC-32, HFC-125 HFC-134a and HFC-143a amounts to 70 percent, based on expert judgements.

Emissions from Consumption of HFCs in Refrigeration and Air Conditioning Equipment have been calculated using the same method for every year in the time series. Emissions have not been calculated using the same data sets for every year in the time series. Data for 2003 and 2004 have been calculated by extrapolation method using the pattern over entire time series and data for 2005, which were obtained by Ministry of Environmental Protection, Physical Planning and Construction.

4.6.1.4. Source-specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures.

4.6.1.5. Source–specific recalculations

Previous data on Consumption of HFCs in Refrigeration and Air Conditioning Equipment for 2003 was corrected with new value which was obtained by extrapolation method using the pattern over entire time series and data for 2005.

4.6.1.6. Source–specific planned improvements

For the purpose of accurate emission calculations, Croatia planned to examine the quantities of HFCs contained in various products imported into or exported from a country. Also, it is essential to adjust National Classification of Activities used by Central Bureau of Statistics in order to particularly mark HFCs, PFCs and SF_6 and Customs Departments Tariff Number to distinguish these compounds from other fluorinated chemicals which are controlled with Montreal Protocol.

4.6.2. OTHER CONSUMPTION OF HFCs, PFCs AND SF_6

Potential emissions from Consumption of HFCs for Foam Blowing, Fire Extinguishers, Aerosols/Metered Dose Inhalers, Solvents and Semiconductor Manufacturing have not been calculated because activity data are not available.
A certain amount of SF_6 is contained in electrical equipment used in Croatian National Electricity and KONCAR Electrical Industries Inc. 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 available.

4.7. EMISSION OVERVIEW

4.7.1. GHG EMISSIONS

Emissions of GHGs from Industrial Processes in the period 1990-2004 are presented in Table 4.7-1.

Table 4.7-1: Emissions of GHGs from Industrial Processes (1990-2004)

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg eqCO_2)	Percent in Industrial Processes	Percent in Total Country Emission
Cement production	1990	CO_2	1022.90	1	1022.90	26.03	3.22
	1991		647.46		647.46	21.67	2.61
	1992		774.68		774.68	29.20	3.39
	1993		648.49		648.49	31.37	2.83
	1994		793.81		793.81	34.26	3.60
	1995		584.89		584.89	28.94	2.60
	1996		634.01		634.01	30.26	2.73
	1997		753.47		753.47	31.85	3.05
	1998		811.39		811.39	40.52	3.25
	1999		1072.55		1072.55	43.71	4.13
	2000		1266.78		1266.78	44.60	4.89
	2001		1450.79		1450.79	51.51	5.35
	2002		1382.43		1382.43	51.12	4.87
	2003		1376.83		1376.83	48.76	4.61
	2004		1459.00		1459.00	45.86	4.96
Lime production	1990	CO_2	159.78	1	159.78	4.07	0.51
	1991		96.15		96.15	3.22	0.39
	1992		54.49		54.49	2.05	0.24
	1993		60.25		60.25	2.91	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	5.28	0.42
	1999		102.57		102.57	4.18	0.39
	2000		124.25		124.25	4.38	0.48
	2001		143.48		143.48	5.09	0.53
	2002		163.97		163.97	6.06	0.58
	2003		160.99		160.99	5.70	0.54
	2004		174.34		174.34	5.48	0.59

Table 4.7-1: Emissions of GHGs from Industrial Processes (1990-2004), cont.

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg eqCO_2)	Percent in Industrial Processes	Percent in Total Country Emission
Limestone and dolomite use	1990	CO_2	43.22	1	43.22	1.10	0.14
	1991		24.59		24.59	0.82	0.10
	1992		10.54		10.54	0.40	0.05
	1993		9.60		9.60	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
	2002		9.62		9.62	0.36	0.03
	2003		11.78		11.78	0.42	0.04
	2004		11.52		11.52	0.36	0.04
Soda ash production and use	1990	CO_2	25.74	1	25.74	0.65	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
	2002		12.22		12.22	0.45	0.04
	2003		14.66		14.66	0.52	0.05
	2004		16.53		16.53	0.52	0.06
Ammonia production	1990	CO_2	491.55	1	491.55	12.51	1.56
	1991		471.50		471.50	15.78	1.90
	1992		606.76		606.76	22.87	2.63
	1993		471.34		471.34	22.80	2.07
	1994		474.73		474.73	20.49	2.17
	1995		462.85		462.85	22.90	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	20.46	1.63
	1999		519.12		519.12	21.16	1.99
	2000		525.25		525.25	18.50	2.01
	2001		425.83		425.83	15.12	1.59
	2002		383.72		383.72	14.19	1.37
	2003		431.85		431.85	15.30	1.45
	2004		522.58		522.58	16.43	1.78

Table 4.7-1: Emissions of GHGs from Industrial Processes (1990-2004), cont.

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg eqCO_2)	Percent in Industrial Processes	Percent in Total Country Emission
Nitric acid production	1990	N_2O	2.99	310	927.56	23.60	3.0
	1991		2.63		814.67	27.26	3.4
	1992		3.44		1065.21	40.15	4.8
	1993		2.59		802.98	38.84	3.6
	1994		2.80		868.35	37.48	4.0
	1995		2.69		835.04	41.32	3.8
	1996		2.51		777.53	37.11	3.4
	1997		2.64		817.17	34.54	3.4
	1998		1.98		615.22	30.73	2.5
	1999		2.34		725.95	29.58	2.9
	2000		2.76		854.30	30.08	3.4
	2001		2.32		718.52	25.51	2.7
	2002		2.25		697.48	25.79	2.5
	2003		2.12		657.45	23.29	2.3
	2004		2.59		802.31	25.22	2.7
Production of other chemicals	1990	CH_4	0.75	21	15.80	0.40	0.05
	1991		0.55		11.49	0.38	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		8.41	0.42	0.04
	1996		0.38		7.94	0.38	0.04
	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
	2002		0.26		5.39	0.20	0.02
	2003		0.29		5.99	0.21	0.02
	2004		0.28		5.89	0.19	0.02
Steel production	1990	CO_2	0.87	1	0.87	0.02	0.003
	1991		0.78		0.78	0.03	0.003
	1992		0.55		0.55	0.02	0.002
	1993		0.47		0.47	0.02	0.002
	1994		0.15		0.15	0.01	0.001
	1995		0.08		0.08	0.004	0,0004
	1996		0.21		0.21	0.01	0,001
	1997		0.32		0.32	0.01	0.001
	1998		0.48		0.48	0.02	0.002
	1999		0.35		0.35	0.01	0.001
	2000		0.33		0.33	0.01	0.001
	2001		0.27		0.27	0.01	0.001
	2002		0.15		0.15	0.01	0.001
	2003		0.19		0.19	0.01	0.001
	2004		0.39		0.39	0.01	0.001

Table 4.7-1: Emissions of GHGs from Industrial Processes (1990-2004), cont.

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg eqCO_2)	Percent in Industrial Processes	Percent in Total Country Emission
Ferroalloys production	1990	CO_2	194.53	1	194.53	4.95	0.63
	1991		180.80		180.80	6.05	0.75
	1992		116.35		116.35	4.39	0.52
	1993		51.02		51.02	2.47	0.23
	1994		79.64		79.64	3.44	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	0.72	0.08
	2001		0.47		0.47	0.02	0.002
	2002		0.00		0.00	0.00	0.00
	2003		0.00		0.00	0.00	0.00
	2004		0.00		0.00	0.00	0.00
Aluminium production	1990	CO_2	111.37	1	111.37	2.64	0.36
	1991		76.40		76.40	2.48	0.32
	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
	2002		0.00		0.00	0.00	0.00
	2003		0.00		0.00	0.00	0.00
	2004		0.00		0.00	0.00	0.00
	1990	CF_4	0.126	6500	819.00	19.42	2.63
	1991		0.087		565.50	18.27	2.34
	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
	2002		0.00		0.00	0.00	0.00
	2003		0.00		0.00	0.00	0.00
	2004		0.00		0.00	0.00	0.00

Table 4.7-1: Emissions of GHGs from Industrial Processes (1990-2004), cont.

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg eqCO_2)	Percent in Industrial Processes	Percent in Total Country Emission
Aluminium production	1990	C_2F_6	0.013	9200	119.60	2.75	0.38
	1991		0.009		82.80	2.59	0.34
	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
	2002		0.00		0.00	0.00	0.00
	2003		0.00		0.00	0.00	0.00
	2004		0.00		0.00	0.00	0.00
Consumption of HFCs, PFCs and SF_6[2]	1990	HFC[3,4]	NE	*	NE	-	-
	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	0.27
	1997		0.04	*	91.19	3.85	0.38
	1998		0.01	*	17.54	0.88	0.07
	1999		0.002	*	9.09	0.37	0.04
	2000		0.01	*	23.16	0.82	0.09
	2001		0.02	*	48.99	1.74	0.19
	2002		0.02		49.31	1.82	0.18
	2003		[5]		163.71	5.80	0.56
	2004		[5]		188.87	5.94	0.64

[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 1996-2003
NE – emission is not estimated
[5] Data are obtained by extrapolation

4.7.2. INDIRECT GHG EMISSIONS

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 4.7-2).

Table 4.7-2: Gases generated from different non-energy industrial process

Gas	Industrial Process
SO_2	Cement Production
	Production of other chemicals
	Pulp and paper production
NO_x	Nitric acid production
	Production of other chemicals
	Pulp and paper production
CO	Asphalt Roofing Production
	Ammonia production
	Production of other chemicals
	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

Total annual emissions of indirect GHGs in the period 1990-2004 are reported in table 4.7-3.

Table 4.7-3: Emissions of indirect GHGs from Industrial Processes (1990-2004)

Year	SO_2 (Gg)	NO_x (Gg)	CO (Gg)	NMVOC (Gg)
1990	5.25	0.37	3.11	81.64
1991	3.87	0.30	2.93	60.19
1992	5.45	0.39	3.50	22.58
1993	3.68	0.29	2.90	19.32
1994	4.27	0.32	2.98	89.59
1995	4.66	0.31	3.25	95.49
1996	4.53	0.29	3.22	118.22
1997	4.24	0.30	3.42	172.33
1998	3.61	0.23	2.61	168.74
1999	4.21	0.27	3.23	183.15
2000	4.59	0.31	3.32	164.74
2001	3.49	0.27	2.70	130.60
2002	3.63	0.26	2.45	245.45
2003	3.45	0.24	2.76	372.96
2004	4.63	0.30	3.40	441.16

4.8. REFERENCES

Central Bureau of Statistics, Department of Manufacturing and Mining, *Monthly Industrial Reports (1990 – 2004)*

Central Bureau of Statistics (2005): *Statistical Yearbook - 2004, Zagreb*

EKONERG (2000) *Inventory of Croatian Greenhouse Gas Emissions and Sinks,* Final Report, Ministry of Environmental Protection and Physical Planning, Zagreb

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5. SOLVENT AND OTHER PRODUCT USE (CRF sector 3)

5.1. SOLVENT AND OTHER PRODUCT USE

5.1.1. SOURCE CATEGORY DESCRIPTION

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

CO_2 emissions are not estimated because IPCC Guidelines do not provide methodologies for the calculation of CO_2 emissions from Solvent and Other Product. N_2O emissions from medical uses and other possible sources are not estimated because activity data are not available.

5.1.2. METHODOLOGICAL ISSUES

Estimation of NMVOC emissions from Solvent and Other Product Use (provided by *EMEP-CORINAIR Emission Inventory Guidebook*) has been carried out by estimating the amount of solvent containing products consumed. The NMVOC emissions from Solvent and Other Product Use have been calculated by using simpler methodology. Default emission factor (*EMEP-CORINAIR Emission Inventory Guidebook*) has been applied for each source category. For several source categories (degreasing and dry cleaning, pharmaceutical products manufacturing and domestic solvent use) the NMVOC emissions calculation is based on per capita data. The activity data for the other sources were extracted from Monthly Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining. The contribution of group of activities to NMVOC emissions is given in the Figure 5.1-1.

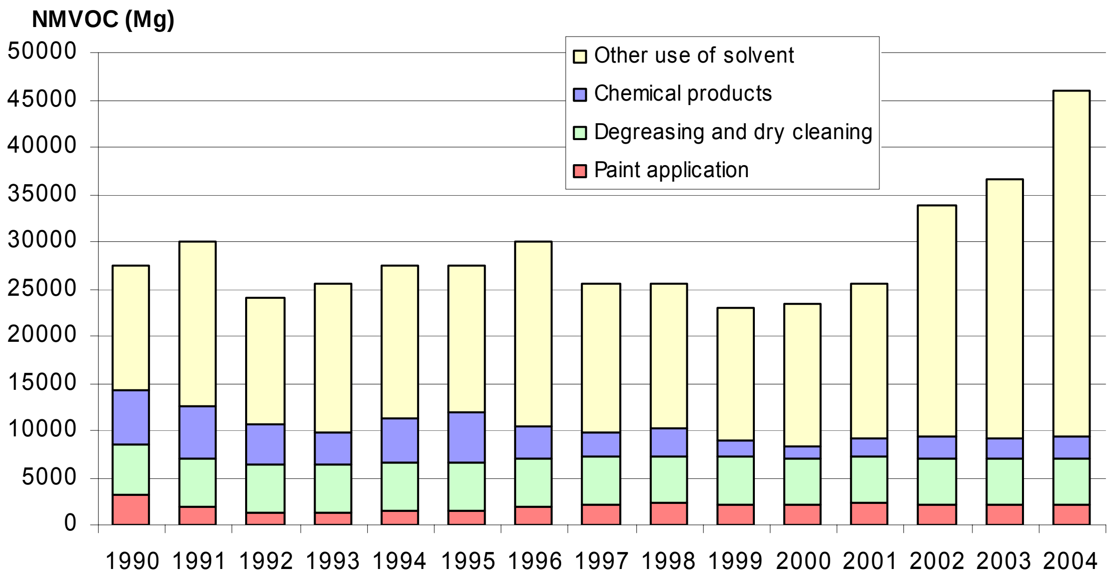

Figure 5.1-1: The NMVOC emissions from Solvent and Other Product Use

Activity data, NMVOC emissions and average emission factors for each individual activity are shown in Table 5.1-1.

Table 5.1-1: NMVOC emissions from Solvent and Other Product Use

	Source and Sink Categories	Activity Data							NMVOC Emission							Emission Factor
		1990	1991	1992	1993	1994	1995	1996	1990	1991	1992	1993	1994	1995	1996	1990-2003
		Mg (1000 capita)							Mg							kg/Mg (cap)
3	**Total – Solvent Use**								**27376**	**29984**	**23960**	**25621**	**27516**	**27358**	**29900**	
3A	**Paint Application**								**3184**	**2011**	**1376**	**1314**	**1566**	**1562**	**2020**	
	Use of Solvent Base Paint	6367	4023	2753	2629	3131	3124	4041	3184	2011	1376	1314	1566	1562	2020	500
3B	**Degreasing and Dry Cleaning**								**5256**	**4965**	**4917**	**5105**	**5114**	**5136**	**4943**	
	Metal Degreasing *	4778	4514	4470	4641	4649	4669	4494	4061	3837	3800	3945	3952	3969	3820	0.85
	Dry Cleaning *	4778	4514	4470	4641	4649	4669	4494	1195	1129	1118	1160	1162	1167	1124	0.25
3C	**Chemical Products**								**5830**	**5546**	**4302**	**3275**	**4697**	**5140**	**3488**	
	Polyurethane – rigid foam	147	81	16	21	35	29	22	2	1	0	0	1	0	0	15
	Polyurethane – soft foam	3616	2717	1660	2025	2427	2880	1800	90	68	42	51	61	72	45	25
	Polyester Resins	6047	4159	3523	2570	2546	2225	3367	242	166	141	103	102	89	135	40
	Polystyrene Foam	39069	26383	570457	57666	58215	49356	56513	586	396	856	865	873	740	848	15
	Polyvinylchloride	104602	69357	70969	44259	78331	93352	44565	4184	4184	2839	1770	3133	3734	1783	40
	Rubber Processing	5739	5442	2439	2477	2338	2285	1279	86	82	37	37	35	34	19	15
	Pharmaceutical Products Manufacturing*	4778	4514	4470	4641	4649	4669	4494	67	63	63	65	65	65	63	0.014
	Paint and Varnish Manufacturing	21956	13872	9493	9064	10797	10773	13933	329	208	142	136	162	162	209	15
	Ink Manufacturing	4672	3626	1343	985	1416	1367	1420	140	109	40	30	42	41	43	30
	Glue Manufacturing	5139	13451	7151	10910	11166	10076	17197	103	269	143	218	223	202	344	20
3D	**Other Use of Solvent**								**13107**	**17461**	**13365**	**15927**	**16139**	**15520**	**19448**	
	Printing Industry	4672	3626	1343	985	1416	1367	1420	467	363	134	99	142	137	142	100
	Application of Glue	5139	13451	7151	10910	11166	10076	17197	3083	8071	4291	6546	6700	6046	10318	600
	Domestic Solvent Use*	4778	4514	4470	4641	4649	4669	4494	9556	9028	8940	9282	9298	9338	8988	2

* - Activity Data is Number of Inhabitants in Croatia (1000 capita)

Table 5.1-1: NMVOC emissions from Solvent and Other Product Use (continue)

	Source and Sink Categories	Activity Data								NMVOC Emission								Emission Factor
		1997	1998	1999	2000	2001	2002	2003	2004	1997	1998	1999	2000	2001	2002	2003	2004	1990-2004
		Mg (1000 capita)								Mg								kg/Mg (cap)
3	**Total – Solvent Use**									**25577**	**25581**	**22992**	**23439**	**25477**	**33836**	**36694**	**45918**	
3A	**Paint Application**									**2175**	**2244**	**2203**	**2191**	**2435**	**2200**	**2223**	**2173**	
	Use of Solvent Base Paint	4351	4487	4406	4381	4870	4400	4446	4345	2175	2244	2203	2191	2435	2200	2223	2173	500
3B	**Degreasing and Dry Cleaning**									**5029**	**4951**	**5009**	**4819**	**4881**	**4887**	**4886**	**4883**	
	Metal Degreasing *	4572	4501	4554	4381	4437	4443	4442	4439	3886	3826	3871	3724	3771	3777	3776	3773	0.85
	Dry Cleaning *	4572	4501	4554	4381	4437	4443	4442	4439	1143	1125	1139	1095	1109	1111	1111	1110	0.25
3C	**Chemical Products**									**2561**	**3050**	**1669**	**1363**	**1774**	**2265**	**2098**	**2246**	
	Polyurethane – rigid foam	44	39	60	60	95	180	70	60	1	1	1	1	1	3	1	1	15
	Polyurethane – soft foam	1710	1790	1770	1800	2655	5431	2855	2424	43	45	44	45	66	136	71	61	25
	Polyester Resins	7022	8258	5609	12848	9661	14693	9704	10948	281	330	224	514	386	588	388	438	40
	Polystyrene Foam	50894	54240	53047	16518	47146	45439	46361	34311	763	814	796	248	707	682	695	515	15
	Polyvinylchloride	23094	33134	3085	811	640	617	206	55	924	1325	123	32	26	25	8	2	40
	Rubber Processing	26	17	20	21	21	15	6	11	0	0	0	0	0	0	0	0	15
	Pharmaceutical Products Manufacturing*	4572	4501	4554	4381	4437	4443	4442	4439	64	63	64	61	62	62	62	62	0.014
	Paint and Varnish Manufacturing	15002	15473	15194	15107	16794	15174	15332	14984	225	232	228	227	252	228	230	225	15
	Ink Manufacturing	1430	1071	797	916	822	863	789	673	43	32	24	27	25	26	24	20	30
	Glue Manufacturing	10874	10379	8206	10355	12385	25851	30873	46119	217	208	164	207	248	517	617	922	20
3D	**Other Use of Solvent**									**15811**	**15337**	**14111**	**15067**	**16387**	**24483**	**27487**	**36617**	
	Printing Industry	1430	1071	797	916	822	863	789	673	143	107	80	92	82	86	79	67	100
	Application of Glue	10874	10379	8206	10355	12385	25851	30873	46119	6524	6227	4924	6213	7431	15511	18524	27671	600
	Domestic Solvent Use*	4572	4501	4554	4381	4437	4443	4442	4439	9144	9002	9108	8762	8874	8886	8884	8878	2

* - Activity Data is Number of Inhabitants in Croatia (1000 capita)

5.1.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties in these estimates are mainly due to the accuracy of emission factors used and reliability of calculation is very low. Uncertainties associated with default emission factors and activity data were not estimated for Solvent and Other Product Use.

Emissions from Solvent and Other Product Use have been calculated using the same method and data sets for every year in the time series.

5.1.4. SOURCE-SPECIFIC QA/QC AND VERIFICATION

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures.

5.1.5. SOURCE–SPECIFIC RECALCULATIONS

There are no source-specific recalculations in sector Solvent and Other Product Use.

5.1.6. SOURCE–SPECIFIC PLANNED IMPROVEMENTS

For the purpose of accurate emission calculations, Croatia planned to analyze and investigate source category degreasing and dry cleaning, pharmaceutical products manufacturing and domestic solvent use. The NMVOC emissions calculation in these categories is based on per capita data.

5.2. REFERENCES

Central Bureau of Statistics, Department of Manufacturing and Mining, *Monthly Industrial Reports (1990 – 2004)*

Central Bureau of Statistics (2005): *Statistical Yearbook - 2004, Zagreb*

EKONERG (2000) *Inventory of Croatian Greenhouse Gas Emissions and Sinks,* Final Report, Ministry of Environmental Protection and Physical Planning, Zagreb

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EMEP/CORINAIR (1996): *Atmospheric Emission Inventory Guidebook*, European Environmental Agency, Denmark

6. AGRICULTURE (CRF sector 4)

6.1. OVERVIEW OF SECTOR

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)

The total emissions in 2004 produced by the agricultural activities were 3,558.38 Gg CO_2-eq, which represents 12.17 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 6.1-1). 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 not included in calculation because its activity is prohibited by low in Republic of Croatia. There are no ecosystems in Republic of Croatia that could be considered natural savannas or rice fields; consequently, no greenhouse gas emissions therefore exist for this sub-category.

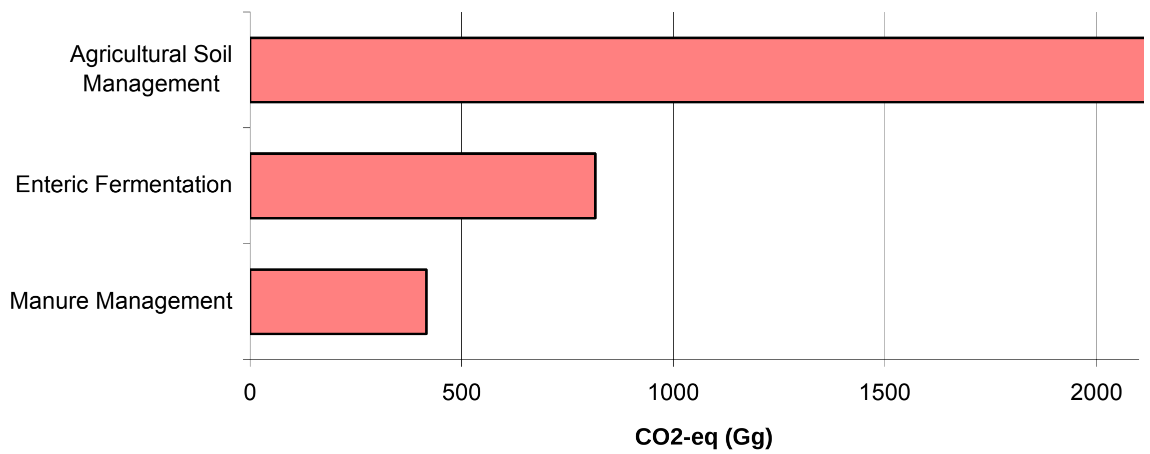

Figure 6.1-1: Agriculture GHG Sources (year 2004)

Tables 6.1-1 and 6.1-2 show the total emission from agriculture by gases and emission sources for the period 1990-2004. The emission in table 6.1-2 is given in the equivalents of CO_2.

Table 6.1-1: Emission of greenhouse gases from agriculture (Gg)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CH_4	**74.82**	**71.78**	**63.62**	**55.55**	**50.69**	**48.00**	**45.32**	**44.50**	**43.59**	**44.48**	**43.02**	**43.61**	**42.70**	**48.58**	**47.44**
Enteric Fermentation	63.99	60.99	54.97	47.16	42.29	40.43	37.86	37.17	36.36	36.48	35.60	36.14	35.11	40.38	38.84
Manure management	10.83	10.79	8.66	8.39	8.39	7.57	7.46	7.34	7.23	8.00	7.42	7.47	7.59	8.20	8.60
N_2O	**9.15**	**9.28**	**7.73**	**7.26**	**7.04**	**6.82**	**6.58**	**7.51**	**6.73**	**6.93**	**7.07**	**7.35**	**7.54**	**7.31**	**8.10**
Manure management	1.22	1.17	1.09	0.91	0.84	0.80	0.74	0.73	0.71	0.73	0.71	0.71	0.70	0.73	0.76
Agricultural soil	7.93	8.11	6.64	6.35	6.21	6.02	5.84	6.78	6.01	6.20	6.36	6.64	6.85	6.57	7.34

Table 6.1-2: Emission of greenhouse gases from agriculture CO_2-eq (Gg)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CH_4	**1571.26**	**1507.46**	**1336.09**	**1166.50**	**1064.39**	**1007.99**	**951.75**	**934.57**	**915.31**	**933.98**	**903.42**
Enteric Fermentation	1343.85	1280.81	1154.33	990.30	888.17	849.05	795.06	780.53	763.54	766.02	747.50
Manure management	227.41	226.65	181.76	176.20	176.22	158.94	156.69	154.04	151.77	167.96	155.93
N_2O	**2835.09**	**2875.69**	**2397.61**	**2251.19**	**2182.81**	**2112.97**	**2040.85**	**2328.41**	**2085.99**	**2147.62**	**2191.73**
Manure management	376.71	361.27	338.01	281.22	259.10	246.87	230.44	226.09	221.53	225.91	218.86
Agricultural soil	2458.38	2514.42	2059.60	1969.97	1923.71	1866.10	1810.41	2102.33	1864.46	1921.70	1972.86

Table 6.1-2: Emission of greenhouse gases from agriculture CO_2-eq (Gg) (cont.)

Gas/Source	2001	2002	2003	2004
CH_4	**915.77**	**896.69**	**1020.28**	**996.19**
Enteric Fermentation	758.97	737.37	847.98	815.64
Manure management	156.79	159.32	172.30	180.55
N_2O	**2279.83**	**2338.70**	**2258.02**	**2562.19**
Manure management	221.10	216.73	227.75	235.19
Agricultural soil	2058.73	2121.96	2030.27	2327.00

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

6.2. CH_4 EMISSIONS FROM ENTERIC FERMENTATION (CRF 4.A.)

6.2.1. SOURCE CATEGORY DESCRIPTION

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 6.2-1 shows the emission of methane from enteric fermentation for the period from 1990-2003. The estimates in this inventory include only emissions in farm animals. Buffalo, camels, and llamas do not occur in the Republic of Croatia. Emissions from wild animals and semi domesticated game are not quantified and neither are emissions from humans or pet animals. CH_4 emission from enteric fermentation is a key source, both by level and trend. Dairy cattle is the single major source of emissions represent more than 50% of total CH_4 emissions from enteric fermentation, followed by non dairy cattle represent about 30% of total CH_4 from enteric fermentation. Jointly, cattle are responsible for more than 80% of total CH_4 emission from enteric fermentation. No methodology for calculating CH_4 emission from poultry is available in IPCC guidelines.

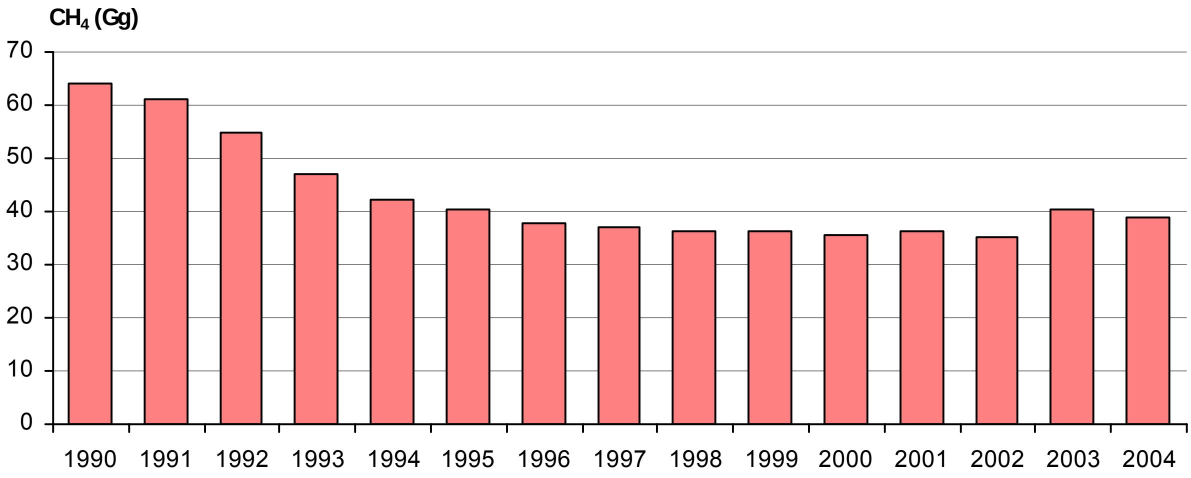

Figure 6.2-1: CH_4 emission from Enteric fermentation (Gg)

6.2.2. METHODOLOGICAL ISSUES

The IPCC methodology has been used to calculate the methane emission from enteric fermentation. IPCC methodology provides two different methods for estimating the quantity of methane from enteric fermentation. Tier I (simplified method) has been used as well as default EF specific for the animal type, the climate zone (cool), geographic region (eastern Europe) and the degree of the region development(developing countries), (IPCC, 1996). 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 and Croatian Statistical Report data were used for the period 1992-2002. Inventory of agriculture 2003., Report on agricultural activities for year 2004., and Statistical Yearbook 2004., are used to obtain data for year 2004. The numbers of animals 1990-2004 are reported in Figure 6.2.-3 and Figure 6.2.-4. Tier 2 method was not applied to dairy cattle because accurate activity data was not available.

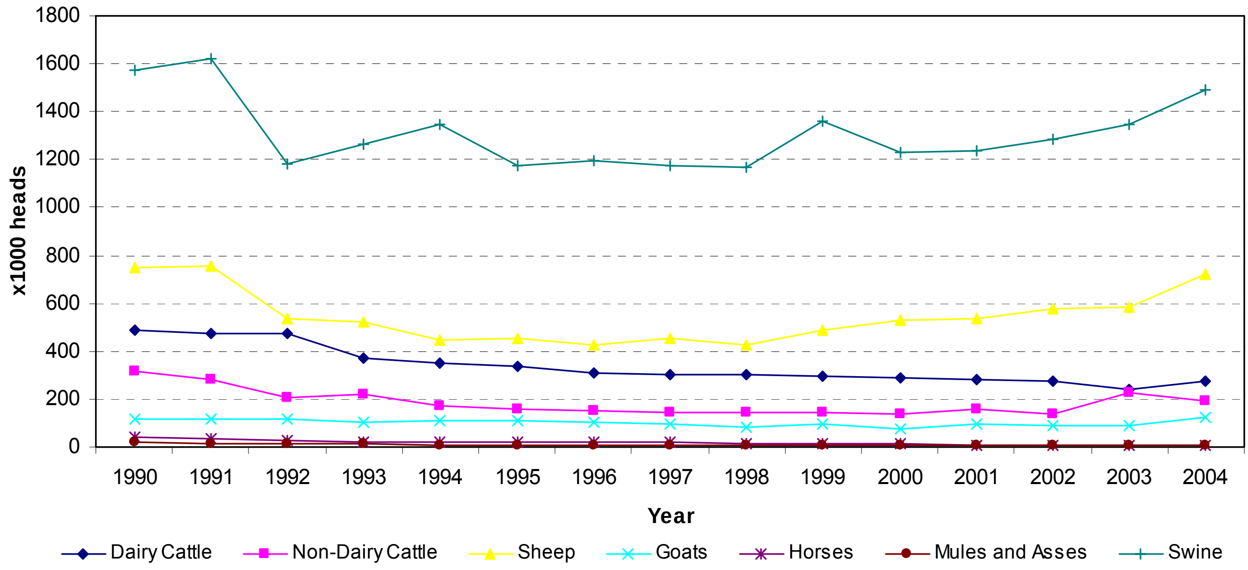

Figure 6.2.-2: Number of dairy cattle, cattle, swine sheep, goats and horses in thousands

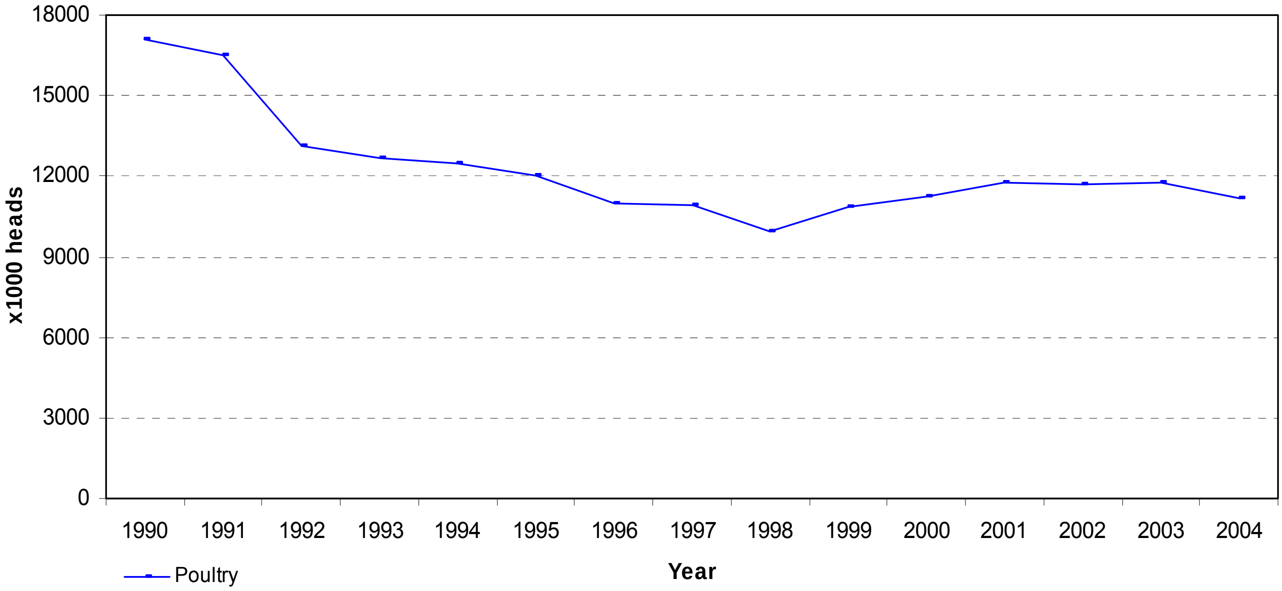

Figure 6.2.-3: Number of poultry in thousands

6.2.3. UNCERTAINTIES

Uncertainty estimates based on expert judgement. Uncertainty of activity data amounts 30%. Uncertainty of emission factors amounts 40%.

6.2.4. SOURCE SPECIFIC RECALCULATIONS

All the activity data for number of animals were taken from the Statistical Yearbook.

6.3. MANURE MANAGEMENT – CH_4 EMISSIONS (CRF 4.B.)

6.3.1. SOURCE CATEGORY DESCRIPTION

The management of livestock manure produces both 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 2004 is given on the. Figure 6.3-1.

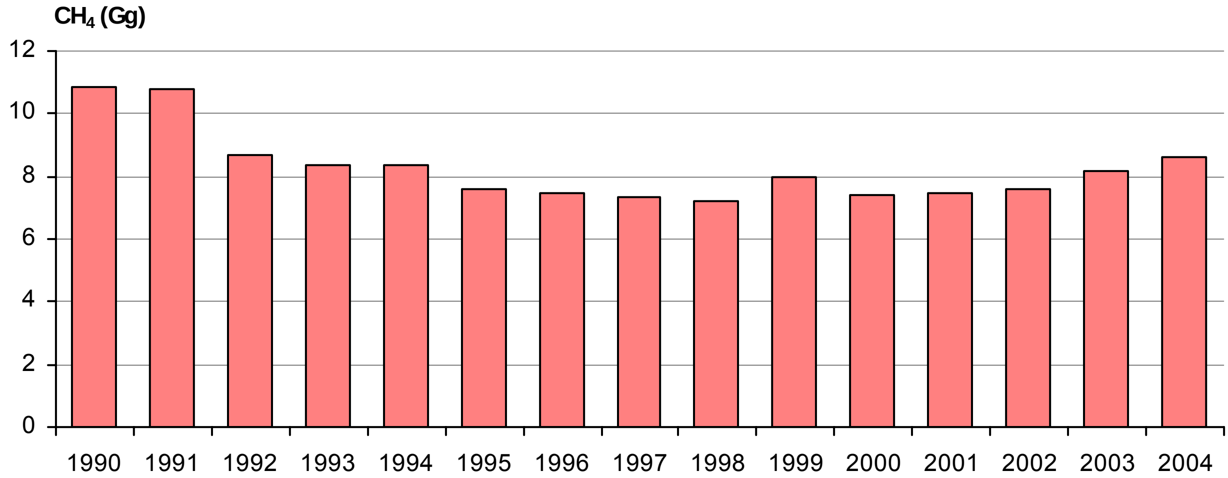

Figure 6.3-1: CH_4 emission from Manure Management (Gg)

6.3.2. METHODOLOGICAL ISSUES

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 (cool), geographic region (Eastern Europe), and the degree of the region development (developing countries) were used for the calculation of the emission. 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 and FAO data base for the period 1996-2003. For the year 2004. activity data were used from three sources statistical yearbook for the year 2004, Agricultural report for 2004 and Inventory of agriculture in Croatia 2004. The reason why that is, no one of above mentioned sources contained data for all animal types. All three sources are official. The emission factors have been taken from the *Revised 1996 IPCC Reference Manual*.

6.3.3. UNCERTAINTIES

Uncertainty estimates based on expert judgement. Uncertainty of activity data amounts 30%. Uncertainty of emission factors amounts 40%.

6.3.4. SOURCE SPECIFIC RECALCULATIONS

All the activity data for number of animals were taken from the Statistical Yearbook.

6.4. N_2O EMISSIONS FROM MANURE MANAGEMENT (CRF 4.B.)

6.4.1. SOURCE CATEGORY DESCRIPTION

The emissions of nitrous oxide (N_2O) from all Animal Waste Management Systems are estimated here. A considerable amount of nitrous oxide evolves during storage of animal waste and is attributed to livestock breeding. This includes emissions from anaerobic lagoons, liquid systems, solid storage, dry lot, and other systems. The N_2O emissions from pasture range and paddock are reported under Agricultural soils. Farm animals emit directly very little nitrous oxide and have not been considered in estimating GHG. In Republic of Croatia manure is not used for fuel.

6.4.2. METHODOLOGICAL ISSUES

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 equations:

$$Nex_{(AWMS)} = \Sigma_{(T)} [N_{(T)} \times Nex_{(T)} \times AMWS_{(T)}]$$

Where:

$Nex(_{AWMS})$ = N excretion per Animal Waste Management System
N(T) = numbers of animals of type
$Nex_{(T)}$ = N excretion of animals of type
$AMWS_{(T)}$ = fraction of Nex(T) that is managed in one of the different distinguished animal waste management systems
T = type of animal category

And

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

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) emissions from manure management for the period from 1990 to 2004 are shown on figure 6.4-1.

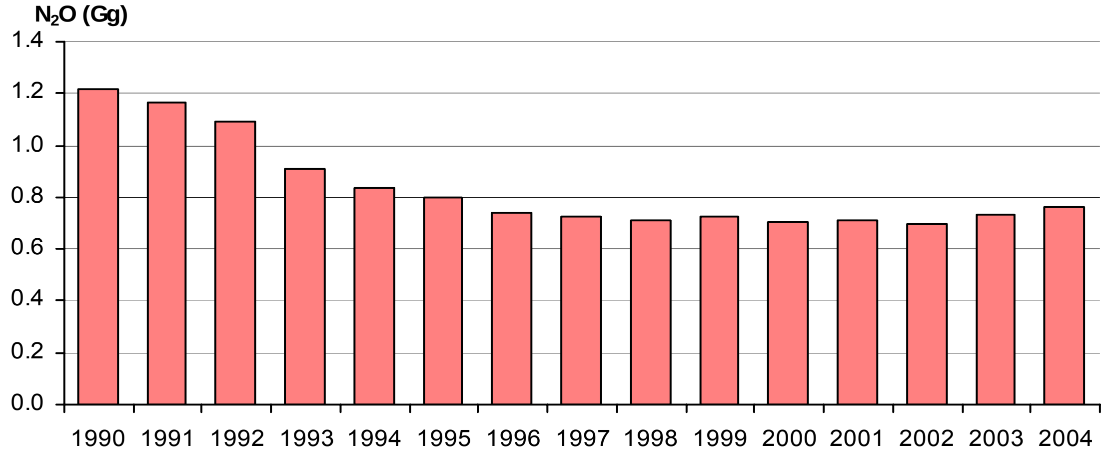

Figure 6.4-1: N_2O Emissions from Manure Management (Gg)

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 and FAO data base (1996-2003) were used for the data on the head of cattle. For the year 2004. activity data were used from three sources statistical yearbook for the year 2004, Agricultural report for 2004 and Inventory of agriculture in Croatia 2004. The reason why that is, no one of above mentioned sources contained data for all animal types. All three sources are official.The nitrogen excretion for each manure management system and the emission factors were taken from the *Revised 1996 IPCC Reference Manual (Table 5.1.7).*

6.4.3. UNCERTAINTIES

Uncertainty estimates based on expert judgement. Uncertainty of activity data amounts 30%. Uncertainty of emission factors amounts 60%.

6.4.4. SOURCE SPECIFIC RECALCULATIONS

All the activity data for number of animals were taken from the Statistical Yearbook.

6.5. AGRICULTURAL SOILS (CRF 4.D.)

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 nitrous oxide emissions are distinguished in methodology:

- Direct emissions of N_2O from agricultural soils
- Direct soil emissions of N_2O from animal production
- Indirect emissions 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.

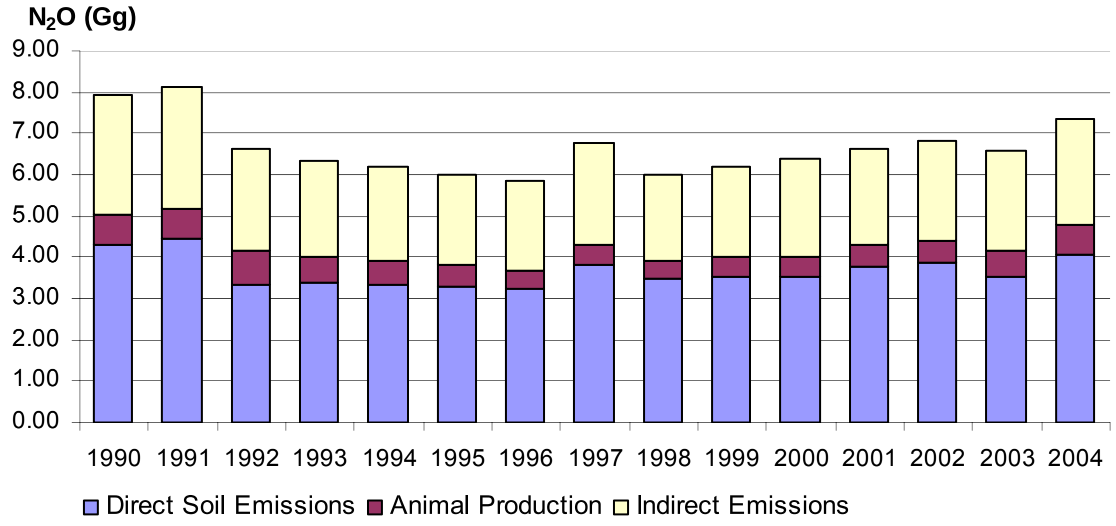

Figure 6.5-1: Total N_2O Emissions from Agricultural Soils (Gg)

6.5.1. DIRECT EMISSION FROM AGRICULTURAL SOILS

6.5.1.1. Source category description

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 animals 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:

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

Where:

- N_2O_{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 6.5-2 shows direct emission of nitrous oxide from agricultural soils (1990 – 2004).

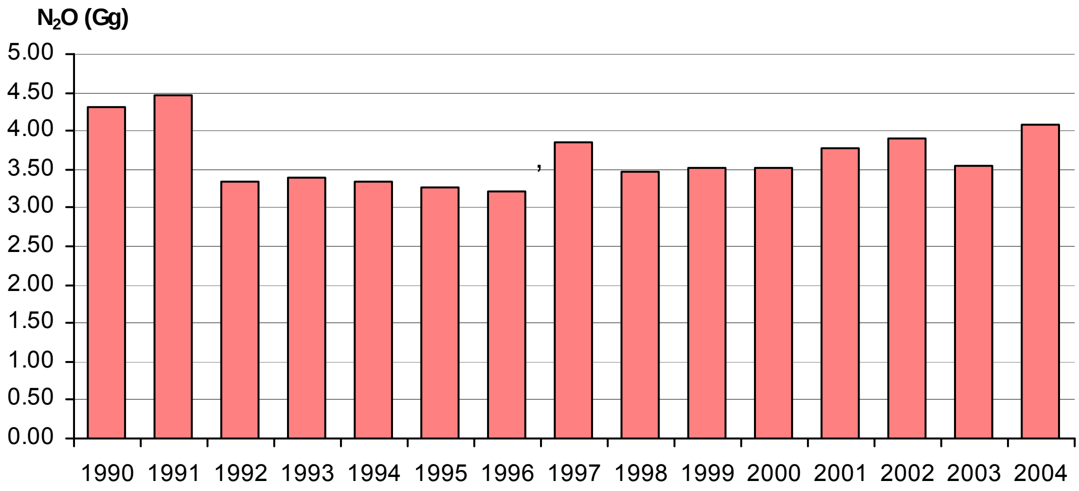

Figure 6.5-2: Direct N_2O Emissions from Agricultural Soils (Gg)

6.5.1.2. Methodological issues

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.*

Nitrous oxide from mineral fertilisers

This estimate is based on the amount of N in mineral fertiliser that are annually consumed in the Republic of Croatia. The consumption of nitrogen from mineral fertilisers that are annually consumed in Croatia is obtained from Fertiliser Company Kutina, Statistical Yearbook and expert judgment. Of the total estimated quantity of emitted nitrogen the N, which is dispersed into atmosphere in the form of ammonia and NOx (10%; IPCC, 1996), was subtracted. The emission of nitrous oxide was then calculated by multiplying the quantity of the remaining N with emission factor 0.125 kg N_2O-N/kg N (IPCC, 1996).

Nitrous oxide from animal manure and liquid/slurry

The estimate is based on the amount of N in solid manure and liquid manure /slurry, which is annually used for fertilizing crops. Of the total estimated quantity of emitted N, the N that is emitted on the pasture (24% country specific), and N that is dispersed into the atmosphere in the form of ammonia and NOx (20%, IPCC, 1996.) was subtracted. The emission of nitrous oxide was then calculated by multiplying the quantity of the remaining N with emission factor 0.125 kg N_2O-N/kg N (IPCC, 1996).

Nitrous oxide from biological fixation of N

The estimate is based on the amount of pulses and soybeans (Statistical Yearbook) produced in country as a dry biomass. According to IPCC 1996, dry biomass of N- fixing crops was multiplied by factor 2 and by fraction of nitrogen in N-fixing crops (3%, IPCC, 1996). The emission of nitrous oxide was then calculated by multiplying the quantity of the remaining N with emission factor 0.125 kg N_2O-N/kg N (IPCC, 1996).

Emissions of nitrous oxide from crop residue

The estimate is based on IPCC (1996) methodology which is based on the assumption that the total biomass produced is approximately twice the amount of the produced edible parts of crops, which means that 45% of the produced total biomass is removed from agricultural soils. Dry biomass production of pulses and soybeans and dry biomass production of other crops are the basic data for the calculation (Statistical Yearbook and expert judgment). Dry biomass is calculated by applying factor to account for crop water content. Fraction of N-fixing crops (3%), fraction of nitrogen in non N-fixing crops (1.5%), fraction of crop residue that is removed from the field as crop (45%) and fraction of crop residue that is burned rather then left on field (10%) were obtained from IPCC (1996). The emission of nitrous oxide was then calculated by multiplying the quantity of the remaining N with emission factor 0.125 kg N_2O-N/kg N (IPCC, 1996).

Emissions of nitrous oxide due to cultivation of organic soils

Cultivation of soils with high contents of organic materials causes a release of a long term bound N. The area of organic soil in Republic of Croatia has been obtained from expert judgment. The emission of nitrous oxide due to cultivation of histosols was then calculated by multiplying the area of histosols with emission factor 5 kg N/ha/yr (IPCC, 1996).

6.5.1.3. Uncertainties

Uncertainty estimates based on expert judgement. Uncertainty of activity data amounts 30%. Uncertainty of emission factors amounts 40%.

6.5.1.4. Source specific recalculations

IPCC Methodology is strictly applied (A difference from previous submission Calculation of synthetic fertiliser use is made according to IPCC 1996 equation $F_{SN}= N_{FERT}$ x(1-$F_{RACgasf}$)). All emission (1990-2004) calculations have therefore been amended by applying IPCC equation. Activity data for area of histosols updated from 1992 to 2002. All emission calculations have therefore been amended by applying new data.

6.5.2. DIRECT EMISSION OF N_2O FROM ANIMALS

6.5.2.1. Methodological issues

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

The same emission factor (0.02 kg N2O-N/kg of emitted N) suggested by IPCC (1996) was used for all grazing animals, regardless of their species and climatic conditions.

Figure 6.5-3 shows direct emission of nitrous oxide from animals (1990 – 2004).

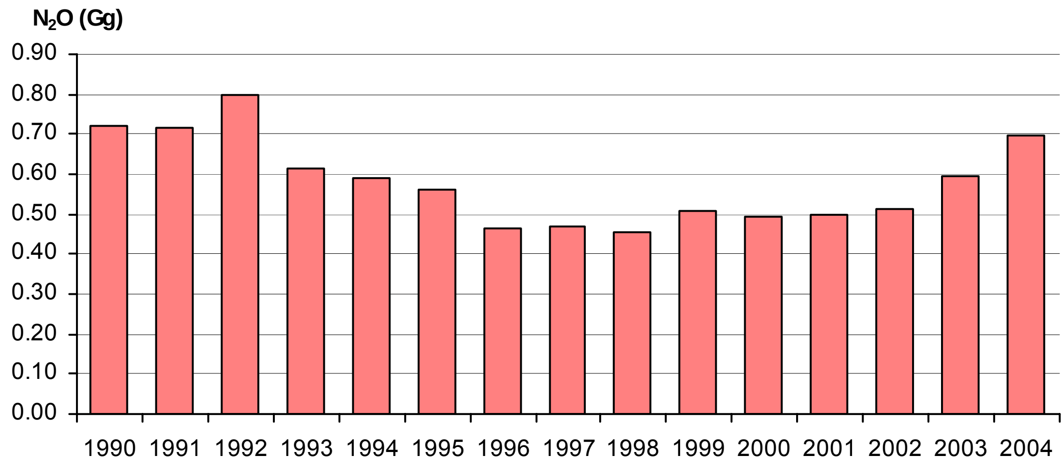

Figure 6.5-3: Direct N_2O Emissions from Animals (Gg)

6.5.2.2. Uncertainties

Uncertainty estimates based on expert judgement. Uncertainty of activity data amounts 30%. Uncertainty of emission factors amounts 40%.

6.5.3. INDIRECT N_2O EMISSIONS FROM NITROGEN USED IN AGRICULTURE

6.5.3.1. Source category description

Calculations of indirect N_2O emissions from nitrogen used in agriculture are based on two pathways. These are: volatilization and subsequent atmospheric deposition of NH_3 and NO_x (originating from the application of fertilizers and animal manure), 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)

The emissions of N_2O produced from the discharge of human sewage N into rivers are reported under the sector Waste.

Figure 6.5-4 shows the indirect emission of nitrous oxide from agriculture (1990 – 2004).

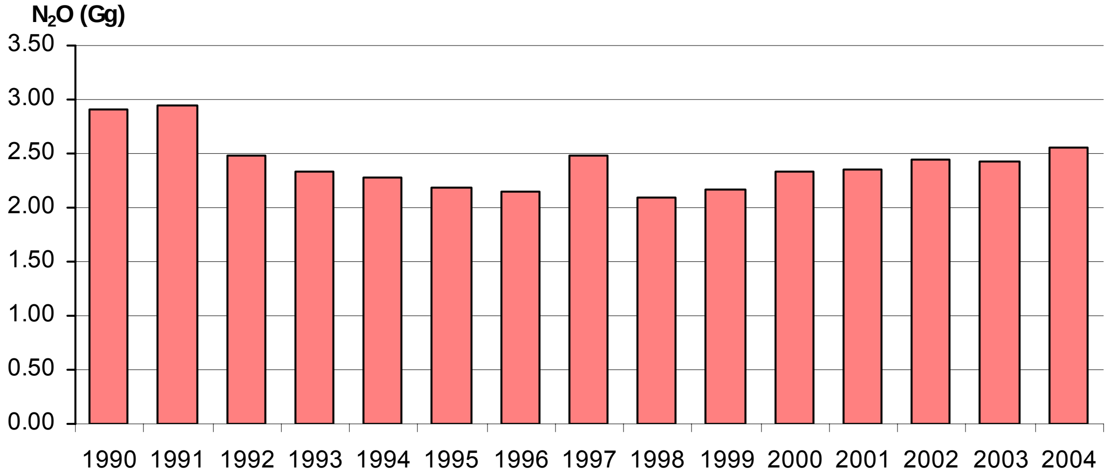

Figure 6.5-4: Indirect N_2O Emissions from Agricultural (Gg)

6.5.3.2. Methodological issues

Nitrous oxide arising due to volatilization of ammonia (NH_3) and nitrogen oxides (NOx)

In fertilizing agricultural soils with nitrogen fertilizers, some N volatilises in form of ammonia and nitrogen oxides (N_2O). This nitrogen is deposited by precipitation and particulate matter on agricultural soil, in forests and waters and thus indirectly contributes to emissions of N_2O. Emissions are attributed to the place of origin of ammonia and NOx, not to the place where N is re-deposited, causing N_2O emissions.

Emissions from mineral fertilizers

Indirect emissions of nitrous oxide from mineral fertilizers depend to a large extent on the fraction of N that volatilises during fertilizing. The amount of volatilised N depends very strongly on the type of fertilizer as well as on weather conditions and the manner of application. In the Republic of Croatia, data on the consumption of various nitrogen fertilizers are not available. It has been considered that 10% of N from mineral fertilizers volatilises (IPCC, 1996). For calculating indirect emissions of nitrous oxide, the emission factor 0.01 kg N_2O-N/kg NH_3 and NOx-N (IPCC, 1996) has been considered.

Emissions from animal manure

Numerous factors influence the fraction of volatilised N in form of ammonia and nitrogen oxides, such as: the ratio between N excreted in dung and N excreted in urine, the manner of slurry storage, the manner of slurry application etc. Generic IPCC (1996) emission factor (20%) of the excreted N is supposed to volatilise in form of ammonia and nitrogen oxides. Emissions of nitrous oxide have been calculated by multiplying the estimated quantities of volatilised N with emission factor 0.01 kg N_2O-N/kg NH_3-N and NOx-N (IPCC, 1996).

Nitrous oxide from leaching and runoff of nitrogen compounds into surface waters, groundwater, and watercourses

Surface runoff of leaching of N into groundwater, surface waters, and watercourses due to mineral fertilisers:
It has been considered that 30% of N from mineral fertilizers are leached and run off into the groundwater and watercourses. In calculating emissions of nitrous oxide, it has been considered that for every kg of leached/run-off nitrogen, 0.025 kg of N_2O-N is emitted (IPCC, 1996).

Nitrogen leaching and runoff into groundwater, surface waters, and watercourses due to animal manure:
It has been considered that for every kg of N, which is excreted by farm animals, 0.3 kg of N run off to watercourses and groundwater (IPCC, 1996). In calculating emissions of nitrous oxide, the same emission factors has been considered as in the case of nitrogen leaching /runoff due to mineral fertilizer (0.025 kg N_2O-N/kg of leached/run-off N)

6.5.3.3. 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. Uncertainty estimates based on expert judgement. Uncertainty of activity data amounts 30%. Uncertainty of emission factors amounts 60%. Therefore, for the future research works the national emission factors should be developed to increase the calculation quality.

6.5.4. SOURCE SPECIFIC QA/QC

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures which revealed that most of the activities were correctly carried out during preparation of the inventory despite the fact that formal QC procedures were not prepared.

Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. In Agriculture four source categories represent key source category: enteric fermentation in domestic livestock, manure management, direct emission form agricultural soils and indirect emissions from nitrogen use in agriculture.

Emission of CH_4 from enteric fermentation in domestic livestock were estimated using Tier 1 method since detailed data on livestock population is not available at the moment and a comprehensive research is required in the future to provide these data. The availability and consistency of activity data is still a major problem in other key source categories within this sector and application of higher tier methodologies will be possible in the future after detailed research and adjustments of statistical methods for data collection.

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7. LAND-USE, LAND USE CHANGE AND FORESTRY (CRF sector 5)

7.1. OVERVIEW OF SECTOR

Forests and woodland in the Republic of Croatia are goods of a general interest and are under special protection of the state. The terms and the way of their use have been prescribed in Forestry Act. Based on the Forest Management Area Plan of the Republic of Croatia (1996-2005), 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. In the Republic of Croatia 81% of the forest are state owned and 19% are private. Out of the total surface area occupied by forests 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 basic principles of the Croatian forestry are sustainable forest management along with the preservation of the natural structure and diversity of the forests, as well as the permanent enhancement of the stability and quality of the forests commercial and welfare functions.

The total growing stock in the Croatian forests is around 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 (*Fogus sylvatica*), common fir (*Abies alba*), sessile oak (*Quercus petraca*), 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 around 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 (continuous management), the annual cut must not be larger than the increment value.

According to the GPG 2003 methodology, the top-level categories for greenhouse gas (GHG) reporting are:

- Forest land
- Cropland
- Grassland
- Wetlands
- Settlements
- Other land

The Republic of Croatia only reports data for Forest land category. Data needed for calculations of emissions/removals for other land categories are partly available but not enough adequate, consistent and complete. Working group for calculations emissions/removals from LULCF sector was established by Ministry of Agriculture, Forestry and Water Management in the May 2005. with the objective to improve the quality of inventory and data collection. During the year

2005. Working group worked on harmonisation of national definition refer to GPG 2003 definition and internationally accepted definition to minimise gaps and overlaps.

7.2. SOURCE CATEGORY

7.2.1. SOURCE CATEGORY DESCRIPTION

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.

7.2.2. METHODOLOGICAL ISSUES

The IPCC methodology (GPG 2003) has been used for calculation of CO_2 emissions and removals from LULUCF sector. GHG inventory for the land-use category Forest Land Remaining Forest land (FF) is reported using Tier 1 method. Regarding emission factors, all were used according to GPG 2003 except BEFs (Biomass Expansion Factors), which are taken according to Revised 1996 IPPC Guidelines. The Forest Management Area Plan of the Republic of Croatia for the period from 1986 to 1996 and from 1996 to 2005 is the main source for the data on the forest land and the annual increment (Table 7.1.). The data on commercial harvesting and wood fuel are obtained from Statistical yearbook of the Republic of Croatia (1986-1999 and 1991-1996). Data on commercial harvest including wood for fuel for the year 1990 and years 1997-2004 are obtained from experts preparing data for UNECE. According to good practice, data on commercial harvest and wood fuel are verified and validate with TBFRA and FAO data but only for the years from 1997-2004. The criteria in choosing data were the following: continuity, quality comparability as well as accessibility of sources. Forest Management Plan for the period 2006-2012 is in final stage of preparation. More accurate data will be available at the end of 2006. Contemporarily National Forestry Inventory project (CRONFI) is ongoing and will be completed in year 2008. The law prohibits the renewal of forests by clear cutting, and the natural rejuvenation is the principal method for renewal of all natural forests.

Table 7.1: Forest areas an annual increment of forests in Croatia according to Forest Management Plan (1986-1996; 1996-2006)

Year	Forest Area managed (ha)	Annual volume increment (m^3)
1986 - 1996	2 061 509	9 643 000
1996 - 2006	2 089 606	9 643 000

7.2.2.1. Forest Land Remaining Forest Land

According to GPG 2003., Tier 1 method, GHG inventory for the Forest land remaining Forest land (FF) is estimated only for aboveground and belowground biomass. Other carbon pools are not taken in consideration since Tier I method is applied and due to lack of activity data.

Change in carbon stocks in living biomass is calculated by multiplying difference in oven dry weight of biomass increments and losses with appropriate carbon fraction. Method 1 (default method) is applied for estimating carbon stock changes in biomass. Method 1 required the biomass carbon loss (ΔC_{FFL}) to be subtracted from the biomass carbon increment (ΔC_{FFG}) for the reporting year (GPG 2003 Equation 3.2.2.)

Annual Increase in Carbon Stock due to biomass increment (ΔC_{FFG}) in FF is estimated according to Equation 3.2.4. , GPG 2003. Estimation of annual increase in carbon stock due to biomass increment required estimates of area and annual increment of total biomass for each forest type (coniferous, deciduous) (G_{TOTAL}) and climatic zone (temperate) in Croatia. The carbon fraction of biomass (CF) used is default value of 0.5.
G_{TOTAL} is the expansion of annual increment rate of aboveground biomass (Gw) to include belowground part involving multiplication by the ratio of belowground biomass to aboveground biomass (root to shoot ratio) that applies to increments. Since Gw data are not available directly the increment in volume (Iv) was used with biomass expansion factor for conversion of annual net increment to aboveground increment.
Average annual increment in biomass (Gw) is calculated according to Equation 3.2.5. GPG 2003., using data on:

- Iv = average annual net increment in volume suitable for industrial processing, m^3 ha^{-1} yr^{-1} (Forestry Management Plan 1986-2006)
- D = basic wood density , tonnes d.m. m^{-3}, (Revised 1996 IPPC Guidelines)
- BEF1 = biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass, dimensionless (Revised 1996 IPCC Guidelines)
- R = root to shoot ratio, dimensionless; GPG 2003, Table 3A.1.8
- CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d. m.) $^{-1}$

Average Increment in Biomass (G_{TOTAL}) is calculated multiplying average increment in biomass (Gw) per root to shoot ratio ® appropriate to increment, dimensionless (GPG 2003, Table 3A.1.8.)

Annual Decrease in Carbon Stock Due to Biomass Loss in FF (ΔC_{FFL}) is calculated as a sum of losses from commercial roundwood feelings ($L_{fellings}$) and fuelwood gathering ($L_{fuelwood}$) (GPG 2003, Equation 3.2.6). Other losses are not included due to lack of accurate data available.

Annual Carbon Loss due to Commercial Feelings ($L_{fellings}$) is calculated according to Equation 3.2.7, GPG 2003., using input data on:

- H= annual extracted volume, roundwood, m^3 yr-1 (Statistical Yearbook, 1986-1996, UNECE 1996-2004)
- D = basic wood density , tonnes d.m. m^{-3}, (Revised 1996 IPPC Guidelines)
- BEF2= biomass expansion factor for conversion volumes of extracted roundwood to total aboveground (including bark) biomass, dimensionless (Revised 1996 IPCC Guidelines)
- f_{BL}= fraction of biomass left to decay in forest
- CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d. m.) $^{-1}$

In applying above mentioned equation, f_{bl} is set to 0 according to assumption that total biomass associated with volume of the extracted rounwood is considered as an immediate emission.

Annual Carbon Loss due to Fuelwood gathering is estimated according to Equation 3.2.8., GPG 2003 using input data on:

- FG = annual volume of fuelwood gathering, tonnes C yr-1. ((Statistical Yearbook, 1986-1996, UNECE 1996-2004)
- D = basic wood density , tonnes d.m. m^{-3}, (Revised 1996 IPPC Guidelines)
- BEF2= biomass expansion factor for conversion volumes of extracted roundwood to total aboveground (including bark) biomass, dimensionless (Revised 1996 IPCC Guidelines)
- CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d. m. $)^{-1}$

Other carbon losses that include losses from disturbances such as pest outbreaks, fires are not estimated due to lack of accurate data availability and are planned to be in future reports.

Table 7.2 provides information on factors used in estimations.

Table 7.2: Default factors used in estimations

Forest type	D	BEF1	R	BEF2	CF
Coniferous	0.45	1.9	0.32	1.9	0.5
Deciduous	0.65	1.9	0.26	1.9	0.5

- D = basic wood density , tonnes d.m. m^{-3}, (Revised 1996 IPPC Guidelines)
- BEF1 = biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass, dimensionless (Revised 1996 IPCC Guidelines)
- R = root to shoot ratio, dimensionless; (GPG 2003, Table 3A.1.8)

- BEF2= biomass expansion factor for conversion volumes of extracted roundwood to total aboveground (including bark) biomass, dimensionless (Revised 1996 IPCC Guidelines)
- CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d. m. $)^{-1}$

Table 7.3 provides information on Annual change in Carbon Stock in living biomass in Forest remaining Forest land .

Table 7.3: Annual change in Carbon Stock in living biomass in Forest remaining Forest land in Gg CO_2

Year	Annual increase in carbon stocks (Gg CO_2)	Annual decrease in carbon due to carbon loss (Gg CO_2)	Annual change in carbon stock in living biomass (Gg CO_2)
1986	26.662.80	12226,0	14.436,8
1987	26.662.80	11940,7	14.722,1
1988	26.662.80	11886,7	14.776,1
1989	26.662.80	11973,6	14.689,2
1990	26.662.80	10611,8	16.051,0
1991	26.662.80	6127,9	20.534,9
1992	26.662.80	6073,5	20.589,3
1993	26.662.80	5830,8	20.832,0
1994	26.662.80	6216,5	20.446,3

Table 7.3: Annual change in Carbon Stock in living biomass in Forest remaining Forest land in Gg CO_2 (cont.)

Year	Annual increase in carbon stocks (Gg CO_2)	Annual decrease in carbon due to carbon loss (Gg CO_2)	Annual change in carbon stock in living biomass (Gg CO_2)
1995	26.662.80	6383,0	20.279,8
1996	26.662.80	7377,7	19.285,1
1997	26.662.80	8886,0	17.776,8
1998	26.662.80	9866,4	16.796,4
1999	26.662.80	10014,6	16.648,2
2000	26.662.80	10342,0	16.320,8
2001	26.662.80	9060,0	17.602,8
2002	26.662.80	9556,9	17.105,9
2003	26.662.80	10543,7	16.119,1
2004	26.662.80	10443,6	16.219,2

7.2.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty of the input data was estimated 40 to 50 percent. The major source of estimates is in using default wood density and BEFs estimated at 60 percent.

7.2.4. QA/QC AND VERIFICATION

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures which revealed that most of the activities were correctly carried out during preparation of the inventory despite the fact that formal QC procedures were not prepared.

A Working group on LULUCF was established this in the year 2005 in order to collect and verify activity data used in emission/removal estimates since data from previous years have not been subject to official review.

7.2.5. RECALCULATIONS

GPG 2003 methods for estimating carbon stock changes and greenhouse gas emissions and removals associated with changes in biomass on forest land remaining forest land was followed. The method is consistent with IPCC 1996 Guidelines. Recalculation is done for all time series 1986-2004 using GPG 2003 methods and activity data (commercial harvest, fuelwood) different from previous years.

7.2.6. PLANNED IMPROVEMENTS

There are two major areas for improvement:

- Development of land –use database needed for greenhouse gas inventories with aim to collect more quality data from existing databases and use of complete land inventories
- Development of country specific factors (BEF)

Working group for calculations emissions/removals from LULCF sector was established by Ministry of Agriculture, Forestry and Water Management in the May 2005. with the objective to improve the quality of inventory and data collection. A comparative analysis of data on forest areas, increase of timber – growing stock and commercial harvest as well as their availability for whole period 1986-2004 has shown certain discrepancies between data from different sources. Working group should in future choose criteria for data collection finding the model to choose most reliable of the existing data respecting continuity, quality and reciprocal comparability as well accessibility of sources.

Development of country specific BEFs is seen as priority activity since using default values is major source of uncertainty.

7.3. REFERENCES

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8. WASTE (CRF sector 6)

8.1. OVERVIEW OF SECTOR

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

Emissions of CH_4 as a result of disposal and treatment of municipal and industrial solid waste and indirect N_2O emissions from human sewage are included in emissions 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. Disposal of domestic and commercial wastewater, particularly in rural areas where systems such as septic tanks are used, are partly anaerobic without flaring, which results with CH_4 emissions.

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 results 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 GHGs emissions estimation from Solid Waste Disposal on Land and Domestic and Commercial Wastewater. The total annual emissions of GHGs, expressed in Gg eq-CO_2, from waste management in the period 1990-2004 are presented in the Figure 8.1-1.

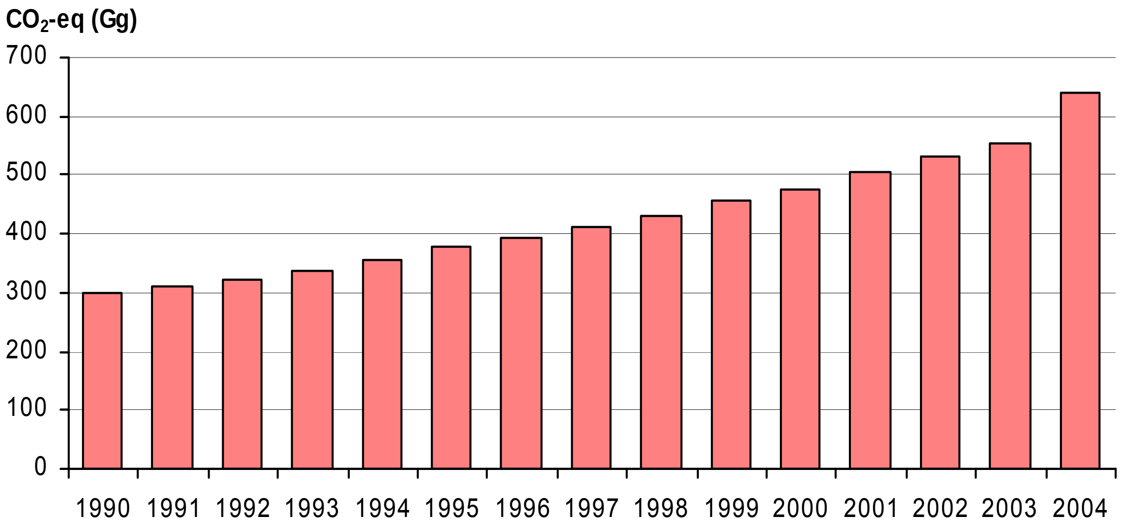

Figure 8.1-1: Emissions of GHGs from Waste (1990-2004)

8.2. SOLID WASTE DISPOSAL ON LAND (CRF 6.A.)

8.2.1. SOURCE CATEGORY DESCRIPTION

Landfill gas consists of approximately 50 percent CO_2 and 50 percent CH_4 by volume. Anaerobic decomposition of organic matter in Solid Waste Disposal Sites (SWDSs) results in the release of CH_4 to the atmosphere. The composition of waste is one of the main factors influencing the amount and the extent of CH_4 production within SWDSs. Temperature, moisture content and pH are important physical factors influencing fermentation of degradable organic substances and gas production.

8.2.2. METHODOLOGICAL ISSUES

A method used to calculate CH_4 emissions according to *Revised 1996 IPCC Guidelines* is First Order Decay (FOD) method.

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), according to data from Table 8.2-1, was estimated to be 0.17 in the period 1990-2004.

Table 8.2-1: Country-specific composition of waste and related DOC

Waste stream	Percent in the MSW	Percent DOC
A. Paper and textiles	22	40
B. Garden and park waste	19	17
C. Food waste	24	15
D. Wood and straw waste	3	30

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 percent of total DOC actually degrades[6] and converts to landfill gas. A mean value, i.e. 55 percent, was taken into account for the purpose of CH_4 emissions 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 ($\geq$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. The team of national waste experts evaluated quality and composition of disposed MSW and the main characteristic of SWDSs for the entire time series. Historical data for the total amount of generated waste and disposed MSW for the period 1970-1990 have been estimated based on national rate for waste generation and fraction of MSW disposed at different types of SWDSs. Extrapolation/interpolation methods has been used to obtain insufficient data. Total annual MSW disposed to SWDSs for the period 1990-1998 has been evaluated from available relevant data compiled into Report; Fundurulja, D., Mužinić, M. (2000) *Estimation of the Quantities of Municipal Solid Waste in the Republic of Croatia in the period 1990 – 1998 and 1998 – 2010,* Zagreb. Data for the quantity of disposed MSW in 1999 were evaluated by interpolation method. Data for the quantity of disposed MSW in 2000 were obtained from *Report of Environment Condition,* Ministry of Environmental Protection, Physical Planning and Construction. Data for the quantity of disposed MSW in 2004 were obtained from *The State of the Environment Report*, Croatian Environment Agency. Taking into account the pattern over 2000 and 2004 (total quantity of disposed MSW), quantity of MSW disposed to different types of SWDSs and the main characteristic of SWDSs for the period 2000 to 2004 were evaluated by interpolation/extrapolation method.

The total annual MSW disposed to different types of SWDSs in the period 1990-2004 and related MCF are reported in Table 8.8-2.

Table 8.2-2: Total annual MSW disposed to SWDSs and related MCF (1990-2004)

Year	Managed SWDS (Gg)	Unmanaged SWDS (≥5m) (Gg)	Unmanaged SWDS (<5m) (Gg)	MCF (fraction)
1990	18	277	295	0.606
1991	19	280	300	0.606
1992	20	284	309	0.605
1993	22	297	324	0.606
1994	26	322	329	0.613
1995	31	364	342	0.623
1996	35	392	361	0.625
1997	40	433	375	0.632
1998	45	470	398	0.636
1999*	54	538	383	0.654
2000	60	618	260	0.702
2001*	62	631	273	0.700
2002*	67	672	238	0.716
2003*	73	718	209	0.731
2004*	79	769	201	0.738

*- Data on the annual MSW disposed to different types of SWDSs were obtained by interpolation/extrapolation method.

The resulting annual emissions of CH_4 from land disposal of MSW in the period 1990-2004 are presented in the Figure 8.2-1.

[6] 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.

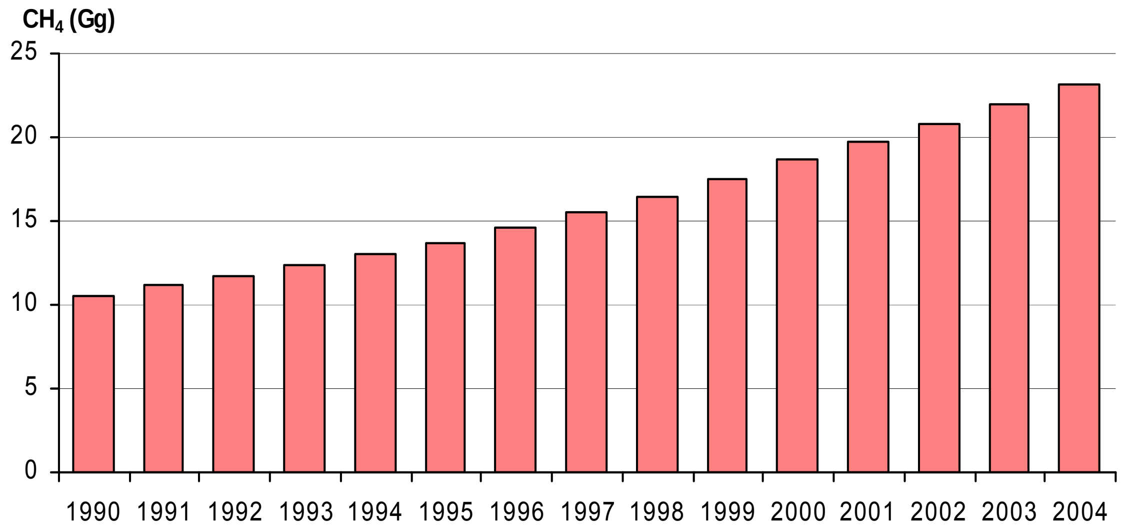

Figure 8.2-1: Emissions of CH_4 from Solid Waste Disposal on Land (1990-2004)

8.2.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainties contained in CH_4 emissions estimates are related primarily to assessment of historical data for quantity of MSW disposed to different types of SWDSs and the main characteristic of SWDSs as well as the usage of default IPCC methane generation rate constant (k=0.05).

In addition, SWDSs in Croatia are classified into several categories, according to applied waste management activities, legality, volume (capacity and quantity of disposed MSW) as well as status. 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.

Uncertainty estimate associated with emission factor amounts to 50 percent, accordingly to provided uncertainty assessment in *Good Practice Guidance*. Uncertainty estimate associated with activity data amounts to 50 percent, based on expert judgements.

Emissions from Solid waste Disposal on Land have been calculated using the same method for every year in the time series. Different source of information were used for data sets.

8.2.4. SOURCE-SPECIFIC QA/QC AND VERIFICATION

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables.

After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures and Tier 2 source-specific QC procedures. Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. Solid waste disposal on land represent key source category in Waste sector. CH_4 emissions from solid waste disposal on land were estimated using Tier 2 method which is a *good practice.* The uncertainty of activity data is very high due to high discrepancy between various data sources.

8.2.5. SOURCE SPECIFIC RECALCULATIONS

In the previous report, CH_4 emissions were calculated according to default method according to *Revised 1996 IPCC Guidelines.* In this report, First Order Decay (FOD) method has been used for CH_4 emission estimation. Historical data for the total amount of generated waste and disposed MSW for the period 1970-1990 have been estimated based on national rate for waste generation and fraction of MSW disposed at different types of SWDSs. Data on the total annual MSW disposed to SWDSs for the period 1990-2003 were corrected by new values which include amended fraction of MSW disposed at different types of SWDSs.

CH_4 emission calculations according to First Order Decay (FOD) have been recalculated for entire time series.

8.2.6. SOURCE-SPECIFIC PLANNED IMPROVEMENTS

According to National Environmental Action Plan (NEAP) (Official Gazette 46/02) and Waste Management Strategy of the Republic of Croatia (Official Gazette 130/05), infrastructure development for integral system of waste management has been emphasized, respectively, conditions for effectively waste management activities have been created.

8.2.6.1. Activity data improvement

By-law on Cadastre of Emission to Environment (Official Gazette 36/96) and The Waste Law (Official Gazette 151/03) define administration commitments of manufacturers and all entities which contributed in waste management. The base for systematic gathering and saving activity data was created by establishment of the Revision of Cadastre of Waste Disposal Sites (KEO). This will present part of new KEO software which is developed as a electronic managed data base with georeferent application (*Geographical Information System, GIS)* and access to the data base through web site of Croatian Environment Agency. By means of data base in GIS-tools, assessment and quantitative categorization of waste disposal sites are provided.

For the purposes of improvement activity data gathering from solid waste disposal activities it is necessary to improve quality of existing data:

- equipping the major landfills with automatic weigh-bridges in order to accurately estimate the quantities of delivered MSW;
- providing methodology to determine country-specific MSW composition;
- periodic analysis of waste composition at major landfills according to provided methodology;
- modification of Cadastre of Emission to Environment (KEO) Reporting Forms regarding to MSW with additional information on waste quantities and composition.

8.2.6.2. Emission factor and methodology improvement

For the purposes of emission inventory improvement it is necessary to adjust country-specific to IPCC SWDSs classification, in order to accurately estimate the MCF. Due to lack of adequate information, extrapolation method has been applied for estimation of waste and landfills characteristics over a long period of time. For the purposes of emission inventory improvement and application of Tier 2 method, it is necessary to improve the quality of existing data and to reconstruct historical data. It is also necessary to apply a unique methodology to determinate waste quantity and composition.

By-law on Conditions for Waste Treatment (Official Gazette 123/97, 112/01) defines priority for improvement and organization of disposal sites and waste disposal on managed disposal sites.

8.3. WASTEWATER HANDLING (CRF 6.B.)

8.3.1. SOURCE CATEGORY DESCRIPTION

Aerobic biological process is used mostly in wastewater treatment. Anaerobic process is applied in some industrial 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.

Disposal of domestic and commercial wastewater, particularly in rural areas where systems such as septic tanks are used, are partly anaerobic without flaring, which results with CH_4 emissions. CH_4 emissions from these systems are estimated only for 2004, because activity data for CH_4 emission calculations for the period 1990-2003 are not available.

Indirect N_2O emissions from human sewage are included in emission estimates.

8.3.2. METHODOLOGICAL ISSUES

8.3.2.1. Domestic and commercial wastewater

Methane emissions from domestic and commercial wastewater have been calculated using the methodology proposed by *Revised 1996 IPCC Guidelines,* by multiplying the total domestic organic wastewater in kg BOD/yr and emission factor which was obtained using default value for maximum methane producing capacity (0.25 kg CH_4/kg BOD).

Data for calculation of degradable organic component in kg BOD/1000 person/yr were obtained by state company Croatian Water Resources Management (Hrvatske vode). Data are available only for 2004 and base on the Water Management Strategy.

8.3.2.2. Human sewage

Indirect nitrous oxide (N_2O) emissions from human sewage have been 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.

The population estimate of the Republic of Croatia for the period 1990-2004 were taken from Statistical Yearbook 2005. Croatian data on the annual per capita Protein intake value (PIV), for the period 1992-2003, were obtained by the FAOSTAT Statistical Database. Adjustment method “Extrapolation of emissions based on a driver” has been used for calculation of insufficient data. Taking into account the PIV trend, the pattern over three years from 1992 to 1994 has been used for calculation of N_2O emissions in 1990 and 1991. Conservativeness factor, proposed by the *Technical Guidance on Methodologies for Adjustments Under Article 5, Paragraph 2, of the Kyoto Protocol,* was used for the base year (1990). Emissions values for 2002 and 2003 have been used as the pattern for N_2O emission calculation in 2004 by extrapolation method. Data for N_2O emission calculation from Human Sewage for the the period 1990-2004 are presented in theTable 8.3.1.

Table 8.3-1: Data for N_2O emission calculation from Human Sewage (1990-2004)

Year	Protein intake (kg/person/yr)	Population
1990	20.71	4,778,000
1991	21.53	4,513,000
1992	22.16	4,470,000
1993	21.86	4,641,000
1994	22.96	4,649,000
1995	25.00	4,669,000
1996	24.78	4,494,000
1997	24.38	4,572,000
1998	23.98	4,501,000
1999	24.86	4,554,000
2000	24.67	4,381,000
2001	26.1	4,437,000
2002	27.52	4,443,000
2003	26.94	4,442,000
2004	26.38	4,439,000

The resulting annual emissions of N_2O from Human Sewage in the period 1990-2004 are presented in the Figure 8.3-1.

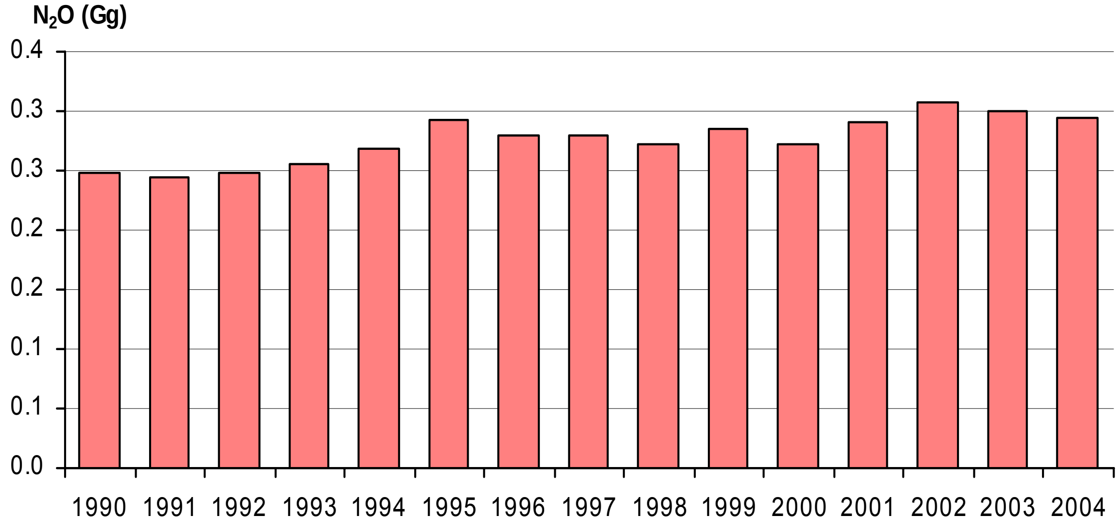

Figure 8.3-1: Emissions of N_2O from Human Sewage (1990-2004)

8.3.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainties contained in N_2O emissions estimates are related primarily to applied default emission factor and extrapolated values for protein intake.

Uncertainty estimate associated with emission factor amounts to 30 percent, accordingly to provided uncertainty assessment in *Good Practice Guidance*. Uncertainty estimate associated with activity data amounts to 10 percent, based on expert judgements.

Emissions from Human Sewage have been calculated using the same method and data sets (except insufficient data which have been calculated by extrapolation method) for every year in the time series.

8.3.4. SOURCE-SPECIFIC QA/QC AND VERIFICATION

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures.

8.3.5. SOURCE SPECIFIC RECALCULATIONS

In the previous report, population data were taken from two sources of information. 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 1996-2003 population data were taken from Statistical Yearbooks published by Central Bureau of Statistics. In this report, the population estimate of the Republic of Croatia for the period 1990-2004 were taken from Statistical Yearbook 2005.

Because data on protein intake from FAOSTAT Statistical Database 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 European countries. For the period 1996-2003 data on protein intake for Croatia were taken from FAOSTAT Statistical Database. In this report, Croatian data on the annual per capita protein intake value for the period 1992-2003, were obtained by the FAOSTAT Statistical Database. Extrapolation method has been used for calculation of insufficient data for 1990, 1991 and 2004.

N_2O emissions were recalculated for entire time series by means of new corrected values.

8.3.6. SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Improvements in the sub-sector Disposal of domestic and commercial wastewater are related primarily to aggregation of data for CH_4 emission calculations from systems such as septic tanks which are used in rural areas. CH_4 emissions from these systems are estimated only for 2004, because activity data for CH_4 emission calculations for the period 1990-2003 are not available. For the purpose of completeness of inventory, it is necessary to collect and assess data for entite time series.

In order to accurate calculation of N_2O emissions from Human Sewage, Croatia planned to analyze the influence of tourism on the population influx due to summer months, as well as fact that nearly 25 percent of the Croatian population lives close to the sea, which has influence on the emission factor.

8.4. WASTE INCINERATION (CRF 6.C.)

8.4.1. SOURCE CATEGORY DESCRIPTION

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 emissions estimates from Waste sector. Emissions from incineration with energy recovery should be reported in the Energy sector.

An incinerator of hazardous waste was functioning in Croatia between 1998 and 2002. CO_2 emissions from incineration of hazardous waste are not estimated because data for categorisation of waste types is lacking.

There is also incineration of clinical waste. Emissions from incineration of clinical waste are estimated only for 2004, because activity data for CH_4 emission calculations for the period 1990-2003 are not available.

8.4.2. METHODOLOGICAL ISSUES

Methane emissions from incineration of clinical waste have been calculated using the methodology proposed by *Revised 1996 IPCC Guidelines,* by multiplying the total incinerated clinical waste with default values for fraction of carbon content, fraction of fossil carbon and burn out efficiency of combustion.

Data for quantity of incinerated waste were obtained by Croatian Environment Agency. Data are available only for 2004 and are accepted from Cadastre of Emission to Environment (KEO) Reporting Forms regarding to hazardous waste.

8.4.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainties contained in CH_4 emissions estimates from incineration of clinical waste are related primarily to applied default emission factor.

Uncertainty estimate associated with emission factor amounts to 30 percent, accordingly to provided uncertainty assessment in *Good Practice Guidance*. Uncertainty estimate associated with activity data amounts to 10 percent, based on expert judgements.

8.4.4. SOURCE-SPECIFIC QA/QC AND VERIFICATION

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables. After preparation of final draft of this chapter an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures.

8.4.5. SOURCE SPECIFIC RECALCULATIONS

There are no source-specific recalculations in sub-sector Waste Incineration.

8.4.6. SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Improvements in the sub-sector Waste Incineration are related primarily to aggregation of data for CH_4 emission calculations from incineration of hazardous and clinical waste. CH_4 emissions from incineration of clinical waste are estimated only for 2004, because activity data for CH_4 emission calculations for the period 1990-2003 are not available. For the purpose of inventory completeness, it is necessary to collect and assess data for entite time series.

8.5. EMISSION OVERVIEW

Emissions of GHGs from Waste in the period 1990-2004 are presented in Table 8.5-1.

Table 8.5-1: Emissions from Waste (1990-2004)

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg eqCO_2)	Percent in Waste	Percentage in Total Country Emission
Solid Waste Disposal on Land	1990	CH_4	10.53	21	221.21	74.15	0.70
	1991		11.12		233.57	75.51	0.96
	1992		11.71		245.84	76.10	1.05
	1993		12.32		258.72	76.59	1.15
	1994		12.98		272.60	76.62	1.27
	1995		13.74		288.59	76.03	1.31
	1996		14.57		305.92	77.90	1.36
	1997		15.48		325.17	78.92	1.35
	1998		16.45		345.38	80.41	1.42
	1999		17.53		368.16	80.67	1.45
	2000		18.62		391.10	82.28	1.55
	2001		19.71		414.01	82.10	1.57
	2002		20.82		437.24	82.10	1.58
	2003		21.96		461.25	83.18	1.58
	2004		23.18		486.81	75.85	1.65
Domestic and Commercial Wastewater	1990-2003	CH_4	NE	21	-	-	-
	2004		3.03		63.65	9.92	0.22
Human Sewage	1990	N_2O	0.25	310	77.12	25.85	0.25
	1991		0.24		75.73	24.49	0.31
	1992		0.25		77.21	23.90	0.35
	1993		0.26		79.07	23.41	0.35
	1994		0.27		83.20	23.38	0.39
	1995		0.29		90.98	23.97	0.42
	1996		0.28		86.80	22.10	0.38
	1997		0.28		86.88	21.08	0.36
	1998		0.27		84.13	19.59	0.35
	1999		0.28		88.24	19.33	0.35
	2000		0.27		84.24	17.72	0.33
	2001		0.29		90.26	17.90	0.34
	2002		0.31		95.30	17.90	0.34
	2003		0.30		93.27	16.82	0.32
	2004		0.29		91.27	14.22	0.31
Waste Incineration	1990-2003	CO_2	NE	1	-	-	-
	2004		0.08		0.08	0.01	0.0003

[1] Time horizon chosen for GWP values is 100 years
NE – emission is not estimated

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9. RECALCULATIONS AND IMPROVEMENTS

The key differences between the previous and latest submission of CRF tables for the time series 1990-2003 are outlined in this chapter. Detailed description and explanations for recalculations are shown in recalculation sections in the sector chapters, Chapters 3 to 8.

9.1.EXPLANATIONS AND JUSTIFICATIONS FOR RECALCULATIONS, INCLUDING IN RESPONSE TO THE REVIEW PROCESS

The recalculations are performed in accordance with:
1) decisions of sectoral experts
2) suggestions of expert review team

According to suggestions reported in "Report of the individual review of the greenhouse gas inventory of Croatia submitted in 2005" Croatia performed recalculations in the following sectors:

- Energy (Road Transportation, Civil Aviation, International Bunkers),
- Industrial Processes (Cement Production),
- Land Use, Land-Use Change and Forestry
- Waste (Solid Waste Disposal on Land, Human Sewage).

Other recalculations are related with certain refinements such as use of consistent data source (Agriculture) and "recalculations" due to New CRF Reporter which occurred during the transport of CRF tables for the previous NIR into New CRF Reporter.

In this section, the summary of the recalculations performed and justification is given using the following categories of distinction:

- Changes or refinements in methods (Chapter 9.1.1.)
- Correction of errors (Chapter 9.1.2.)

9.1.1. CHANGES OR REFINEMENTS IN METHODS

The following methodological changes were made for the calculation of greenhouse gases according to:

- Changes in available data
- Consistency with good practice guidance
- New methods

<u>Changes in available data:</u>

Energy

Civil Aviation (1.AA.3.A) and International Aviation Bunkers (1.C1.A) – the justification for the recalculation is consistency with International Energy Agency Stastistics which provided more accurate disaggregation of fuel between international and domestic aviation.

Industrial processes

Cement Production (2.A.1) – the justification for that recalculation is correction of actual amount of clinker produced in the cement kiln.

Agriculture

Enteric Fermentation (4.A) and Manure Management (4.B) – the justification for that recalculation is use of consistent activity data source for the entire period. In the previous NIR the activity data for number of animals (Goats, Mules and Asses) for 1990 and 1991 was not available and therefore the extrapolation was used. In this Report all the activity data for number of Goats, Mules and Asses were taken from Croatian Statistical Yearbook and according to that source all the other activity data on number of animals were adjusted.

Waste

Solid Waste Disposal on Land (6.A) – the justification for recalculation is correction of data on total annual MSW disposed to SWDSs for the entire period from 1990-2003.

Human Sewage (6.B.2.2) – the justification for recalculation is use of one source for population for the entire period (Statistical Yearbook 2005). Furthermore, data on annual per capita protein intake value for the period 1992-2003 was obtained by the FAOSTAT Statistical Database and data for 1990, 1991 and 2004 were extrapolated. This has provided re-evaluation of protein intake value in consistent manner for all years as suggested by the expert review team.

Consistency with good practice guidance:

Energy

Road Transportation (1.AA.3.B) – the justification for the recalculation of CO_2 emission from Road Transport is trend consistancy. Therefore, the Tier 1 methodology was applied for the entire period from 1990-2003.

Land Use, Land-Use Change and Forestry

Land Use, Land-Use Change and Forestry (5.) – the justification for that recalculation is consistency with Good Practice Guidance for Land Use, Land-Use Change and Forestry.

New methods:

Land Use, Land-Use Change and Forestry

Land Use, Land-use Change and Forestry (5.) – the recalculation is justified as required by the decision 13/CP.9 of the Conference of the Parties and according to expert review team suggestions.

Waste

Solid Waste Disposal on Land (6.A) – the recalculation is justified because First Order Decay method was used according to *Revised 1996 IPCC Guidelines* and according to suggestion of the expert review team.

9.1.2. CORRECTION OF ERRORS

The majority of recalculations performed were due to errors which can be divided as follows:

- errors due to transport of previously submitted CRF tables to New CRF Reporter. These errors refer to allocation errors, double counting or missing data.
- errors regarding decimal places
- errors regarding notation keys:

Consumption of HFCs, PFCs and SF_6 – The notation keys were corrected in accordance with expert review team suggestions.

All the explanations for errors of these types are provided directly in the CRF Reporter. Table 8(b) Recalculation – explanatory information doesn't provide information on such errors due to large amount of these types of errors.

9.2. THE IMPLICATION OF THE RECALCULATIONS ON THE LEVEL AND TREND, INCLUDING TIME SERIES CONSISTENCY

This section outlines the implications over time for the emission levels as well as the implications for emission trends, including time-series consistency.

Table 9.2-1 shows the differences between the last submission (NIR 2005) and current submission (NIR 2006), on the level of the different greenhouse gases.

Table 9.2-1: Differences between NIR 2005 and NIR 2006 for 1990-2003 due to recalculations

Gas	Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO_2 (Tg) **Incl. LUCF**	NIR 2005	10.35	4.03	3.08	3.71	2.99	3.56	4.28	3.61	4.51	5.23	4.94	6.01	6.20	7.63
	NIR 2006	8.60	2.02	1.03	1.74	-0.36	-4.29	-3.65	2.81	-1.53	-0.58	0.13	2.66	4.70	6.23
	Difference	***-17***	***-50***	***-66***	***-53***	***-112***	***-220***	***-185***	***-178***	***-134***	***-111***	***-97***	***-56***	***-24***	***-18***
CO_2 (Tg) **Excl. LUCF**	NIR 2005	23.04	16.72	15.76	16.40	15.67	16.25	16.97	18.06	18.95	19.68	19.38	20.45	21.58	23.00
	NIR 2006	23.03	16.74	15.81	16.43	15.69	16.25	16.94	18.02	18.91	19.70	19.42	20.43	21.50	22.88
	Difference	***0.0***	***0.1***	***0.3***	***0.2***	***0.1***	***0.0***	***-0.2***	***-0.2***	***-0.2***	***0.1***	***0.2***	***-0.1***	***-0.4***	***-0.5***
CH_4 (CO_2-eq Gg)	NIR 2005	3809	3551	3418	3293	3098	3107	3152	3251	3118	3201	3233	3383	3452	3611
	NIR 2006	3233	3007	2826	2771	2564	2532	2557	2624	2460	2496	2544	2690	2745	2925
	Difference	***-15***	***-15***	***-17***	***-16***	***-17***	***-19***	***-19***	***-19***	***-21***	***-22***	***-21***	***-20***	***-20***	***-19***
N_2O (CO_2-eq Gg)	NIR 2005	3983	3890	3656	3253	3254	3163	3001	3344	2908	3102	3284	3254	3316	3230
	NIR 2006	3920	3827	3601	3200	3207	3123	3004	3348	2912	3103	3284	3251	3317	3221
	Difference	***-1.6***	***-1.6***	***-1.5***	***-1.6***	***-1.5***	***-1.3***	***0.1***	***0.1***	***0.2***	***0.0***	***0.0***	***-0.1***	***0.0***	***-0.3***
PFCs (CO_2-eq Gg)	NIR 2005	939	648	0	0	0	0	0	0	0	0	0	0	0	0
	NIR 2006	937	642	0	0	0	0	0	0	0	0	0	0	0	0
	Difference	***-0.2***	***-0.9***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
HFCs (CO_2-eq Gg)	NIR 2005	0	0	0	0	0	7.80	60.15	91.18	17.54	9.09	23.15	49.00	49.31	26.71
	NIR 2006	0	0	0	0	0	7.80	60.15	91.18	17.54	9.09	23.15	49.00	49.32	163.7
	Difference	***0***	***0***	***0***	***0***	***0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***513***
SF_6 (CO_2-eq Gg)	NIR 2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NIR 2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total (Tg CO_2-eq) **Incl. LUCF**	NIR 2005	19.08	12.12	10.15	10.26	9.34	9.84	10.50	10.30	10.56	11.55	11.48	12.70	13.03	14.49
	NIR 2006	16.69	9.49	7.46	7.71	5.41	1.38	1.97	3.26	3.86	5.03	5.98	8.65	10.81	12.54
	Difference	***-13***	***-22***	***-26***	***-25***	***-42***	***-86***	***-81***	***-68***	***-63***	***-56***	***-48***	***-32***	***-17***	***-13***
Total (Tg CO_2-eq) **Excl. LUCF**	NIR 2005	31.77	24.81	22.84	22.95	22.03	22.53	23.19	24.74	25.00	25.99	25.92	27.14	28.39	29.87
	NIR 2006	31.12	24.21	22.24	22.40	21.46	21.91	22.56	24.09	24.30	25.31	25.27	26.42	27.61	29.19
	Difference	***-2.0***	***-2.4***	***-2.6***	***-2.4***	***-2.6***	***-2.7***	***-2.7***	***-2.6***	***-2.8***	***-2.6***	***-2.5***	***-2.6***	***-2.8***	***-2.3***

The change in the 1990-2003 trend for the greenhouse gas emissions compared to the previous submission is presented in Table 9.2 It can be concluded that the trend in the total national emissions decreased by 0.51 percent compared to NIR 2005. The largest absolute changes in emission trends are recorded for CO_2, HFCs, total CO_2-eq and CH_4, described in Chapter 9.2-2.

Table 9.2-2: Differences between NIR 2005 and NIR 2006 for the emission trends 1990-2003

Gas	**Trend (absolute)**			**Trend (percent)**		
CO_2-eq (Gg)	**NIR 2005***	**NIR 2006****	*Difference*	**NIR 2005***	**NIR 2006****	*Difference*
CO_2	-2.720.61	-2.363.393	*-357.21*	35.672	37.91	*-2.24*
CH_4	-198.43	-308.029	*109.60*	5.496	10.53	*-5.04*
N_2O	-752.80	-698.462	*-54.34*	23.308	21.68	*1.62*
HFCs	26.71	-163.706	*190.41*	-100.000	-100.00	*0.00*
PFCs	-938.60	-936.564	*-2.04*	100.000	100.00	*0.00*
Total	-35.48	-151.998	*116.52*	0.154	0.66	*-0.51*

* - Difference, in previous submission, between emission in 2003 and 1990 (absolute and percent)

** - Difference, in latest submission, between emission in 2003 and 1990 (absolute and percent)

9.3. PLANNED IMPROVEMENTS TO THE INVENTORY

The framework for development of Croatian greenhouse gas emissions inventory was established during preparation of the First National Communication to the UNFCCC in 2000. The framework was built upon experiences and lessons learned from the previously established scheme for national reporting and international data exchange through the EEA/ETC-ACC system and reporting under Convention on Long-range Transboundary Air Pollution (CLRTAP). Since then Croatia has submitted National Inventory Reports in 2003 for period 1995-2001, 2004 for period 1990-2002, 2005 for period 1990-2003 and this latest submission in September 2006.

Generally, Croatia has developed a sound and well-documented greenhouse gas inventory system in only a few years but it still requires continuous improvements in almost all key elements related to compilation and submission of the inventory. In order to fulfill these requirements Croatia has taken strategic approach and as a result a draft of National GHG Inventory Improvement Strategy has been prepared[7]. The purpose of this strategic document is to recognize strengths and weaknesses of the existing national GHG inventory system and to determine a realistic short- and long- term objectives in order to establish cost-effective GHG inventory preparation system that will enable timely, accurate, transparent and consistent international reporting, taking into account national circumstances, resources and available information.

In brief, there are several priority tasks for improvements of the inventory system which are outlined in the strategy:

- preparation of By-law on Greenhouse gas emissions monitoring that defines institutional responsibilities and mandates for national inventory compilation; this legislation should be in line with EU monitoring legislation (Decision 280/2004/EC)
- authorization of appropriate national institution to be in charge of approving the inventory.
- establish national reference centre for air and climate change,
- ensuring sustainable inventory preparation process including establishment of QA/QC system
- carrying out awareness-raising campaign targeting policy-makers and other stakeholders on importance and benefits of sustainable inventory process.
- improving collection of activity data, emission factors and overall emission calculation for key sources, based on long term inventory preparation program
- increasing the financial, technical and human resources for inventory preparation, based on long-term inventory program.

[7] National GHG Inventory Improvement Strategy was prepared under UNDP/GEF regional project Capacity Building for Improving the Quality of GHG Inventories (Europe and CIS Region).

Sector specific goals are outlined below:

ENERGY

Short-term goals (< 1 years)

Generally, the changes from Tier 1 to Tier 2/3 estimation methodologies for Energy key sources, as much as possible, are recommended. The priority should be the key sources with high uncertainties of emission estimation. But, significant constrains are availability of activity data, especially for the beginning years of concerned period. Consequently, implementation of more detailed methodology approach (Tier 2/3) for key sources, for entire period (1990-2003), will be very difficult.

In the framework of this Regional project, COPERT III software (Tier 3) is used for emission estimation from Road Transport, for the period 2001-2003. Automatic delivery of detailed motor vehicle database and annual average vehicle mileage from Croatian Centre for Vehicles, beside other needed data, is essential for COPERT implementation. The difficulties lie in gathering of appropriate historical activity data (1990-2000). In any case, the improvement of the emission estimation for entire period, based on COPERT model results, is a short-term goal.

The extensive use of detailed methodology (Tier 2/3) for Energy Industries is also one of the short-term goals. For achievement of abovementioned goal is necessary to ensure delivery of detailed activity data for Energy Industries. The good example is the usage of technology/plant-specific data for sub-sector Thermal power plants and public cogeneration plants (Tier 2) for the last three inventory years.

Additionally, better distribution of fossil fuel combusted in Aviation on Domestic and International Aviation should be short-term goal. In energy balance, appropriate distribution was performed only for the year 2004, while for the other years of observed period (1990-2003) distribution was based on expert judgement.

Long-term goals (> 1 years)

For estimation of fugitive emissions from oil and natural gas operations, a Tier 1 method was applied. Used emission factors are an average value of the range proposed in the IPCC Manual. However, fugitive emission from natural gas is key source and implementation of rigorous source-specific evaluations approach (Tier 3) is necessary. The Tier 3 approach will generally will generally involve compiling the following types of information:

- detailed inventories of the amount and types of process infrastructure (e.g. wells, field installations and production/processing facilities),
- production disposition analyses oil and gas production, vented, flared and reinjected volumes of gas, and fuel gas consumption,
- accidental releases (i.e. well blow-outs and pipeline ruptures),
- typical design and operating practices and their impact on the overall level of emission control.

The extensive use of plant-specific data collected in the framework of Cadastre of Emissions to Environment (CEE) is recommended ("bottom up" approach). In addition, usage of more source-specific QA/QC procedures will improve the quality of GHG inventory in Energy sector.

INDUSTRIAL PROCESSES AND SOLVENT USE

Short-term goals (< 1 years)

Uncertainty of emission estimation is mainly caused by implementation of default IPCC emission factors. Consequently, wider use of well documented country-specific (technology-specific and plant-specific) emission factors, in sectors Industrial Processes and Solvent Use, is an important short-term goal. The use of country-specific EFs, where available, as a way to minimize uncertainty, is recommended.

Short-term goals are also improvements of halocarbons and SF_6 emission estimations.

There are gaps in the time series of some productions, provided by statistical institutions. Filling these gaps by using direct surveys and comparison with time series of other related data is recommended.

Long-term goals (> 1 years)

As a small country with a small number of plants and good-quality production statistics, Croatia has often adopted higher-tier methodologies for Industrial Processes, based on plant-level information. Croatia considers wider use of source-specific verification procedures, through systematic cross-checking of plant-specific information with production statistics, and also the use other sources of information, such as CEE and the national energy balance.

AGRICULTURE

Short-term goals (< 1 years)

The QA/QC procedures should be applied to avoid possible mistakes. Expert group for agriculture should be established in the aim to improve the quality of inventory and data collection. The applicability of higher-tier methods for key sources should be explored, depending on availability of data.

Long-term goals (> 1 years)

Source-specific explorations should be done in order to determinate country-specific emission factors and collect detailed set of activity data, which will improve CH_4 and N_2O emission calculation (Tier 2/3) in key agriculture sources, such as: CH_4 Emission from Enteric Fermentation, N_2O Emission from Manure Management, Direct N_2O emission from Agricultural Soils and Animals and N_2O Emission from Nitrogen Used in Agriculture.

LAND-USE CHANGE AND FORESTRY

Short-term goals (< 1 years)

The Republic of Croatia only reports data for changes in the forest and other woody biomass stocks. Expert group for calculations emissions/removals from LULUCF sector was established by Ministry of Agriculture, Forestry and Water Management in the May 2005, with the objective to improve the quality of data collection and inventory preparation. Expert group should in future choose criteria for data collection, finding the model to choose most reliable existing data, respecting continuity, quality and reciprocal comparability, as well as accessibility of sources. Usage of new very detailed CRF tables, as much as possible, is also short-term goal.

Long-term goals (> 1 years)

The GHG emissions/removals calculation for sub-sectors: Forest and Grassland Conversion (5B), Abandonment of Managed Lands (5C) and CO_2 Emissions and Removals from Soil (5D) should be included, as much as possible, depending on availability of activity data. It is planned to complete those sub-sectors in future inventories, and to do inventory according to the Good Practice Guidelines for Land Use, Land Use Change and Forestry.

WASTE

Short-term goals (< 1 years)

Croatia plans to improve its waste statistics and to carry out sector-specific studies related to Solid Waste Disposal in order to use the Tier 2 method.

By-law on Cadastre of Emission to Environment (Official Gazette 36/96) and The Waste Law (Official Gazette 151/03) define administration commitments of manufacturers and all entities which contributed in waste management. The base for systematic gathering and saving activity data was created by establishment of the Revision of Cadastre of Waste Disposal Sites (CEE). This will present part of new CEE software which is developed as an electronic managed data base with georeferent application (*Geographical Information System, GIS)* and access to the data base through web site of Croatian Environment Agency. By means of data base in GIS-tools, assessment and quantitative categorization of waste disposal sites will be provided.

By-law on Conditions for Waste Treatment (Official Gazette 123/97, 112/01) defines priority for improvement and organization of disposal sites and waste disposal on the managed disposal sites.

For the purposes of emission inventory improvement it is necessary to adjust country-specific to IPCC SWDSs classification, in order to accurately estimate the MCF.

Also, it is necessary to apply a unique methodology to determine waste quantity and composition. For the purposes of improvement activity data gathering from solid waste disposal activities it is necessary to improve quality of existing data:

- equipping the major landfills with automatic weigh-bridges in order to accurately estimate the quantities of delivered MSW;

- providing methodology to determine country-specific MSW composition;
- periodic analysis of waste composition at major landfills according to provided methodology;
- modification of Cadastre of Emission to Environment (CEE) Reporting Forms regarding to MSW with additional information on waste quantities and composition.

Long-term goals (> 1 years)

New waste statistics and sector-specific studies should be used to reconstruct historical activity data in applying the Tier 2 method for key sources.

Emissions from Wastewater Handling and Waste Incineration should be included for the sake of completeness.

ANNEX 1

KEY CATEGORIES

A1.1. DESCRIPTION OF METHODOLOGY USED FOR INDENTIFYING KEY CATEGORIES

Key categories according to the IPCC Good Practice Guidance (IPCC, 2000) are those found in the accumulative 95% of the total annual emissions in the last reported year or belonging to the total trend, when ranked from contributing the largest to smallest share in annual total and in the trend. As originally designed it applied only to source categories. In addition, *Good Practice Guidance for Land Use, Land-Use Change and Forestry* expands the original approach to enable the identification of key categories that are either sources or sinks, which provides on how to indentify key categories for the LULUCF. Therefore, the key category analysis was determined using both approches:

- excluding LULUCF
- including LULUCF

Following the *good practice guidelines*, Croatia undertook a key category analysis using Tier 1 Level and Trend methods.

The IPCC and *Good Practice Guidance for Land Use, Land-Use Change and Forestry* also recommended which sources should be checked for their key category status, Table A1-1.

Table A1-1: Categories Assessed in Key Category Analysis

Source Categories Assessed in Key Source Category Analysis	**Direct GHG**	**Special Considerations**
ENERGY SECTOR		
CO_2 Emissions from Stationary Combustion - Coal	CO_2	
CO_2 Emissions from Stationary Combustion - Oil	CO_2	
CO_2 Emissions from Stationary Combustion - Gas	CO_2	
Non-CO_2 Emissions from Stationary Combustion	CH_4	
Non-CO_2 Emissions from Stationary Combustion	N_2O	
Mobile Combustion - Road Vehicles	CO_2	
Mobile Combustion - Road Vehicles	CH_4	
Mobile Combustion - Road Vehicles	N_2O	
Mobile Combustion: Water-borne Navigation	CO_2	
Mobile Combustion: Water-borne Navigation	CH_4	
Mobile Combustion: Water-borne Navigation	N_2O	
Mobile Combustion: Aircraft	CO_2	
Mobile Combustion: Aircraft	CH_4	
Mobile Combustion: Aircraft	N_2O	
Mobile Combustion - Agriculture/Forestry/Fishing	CO_2	
Mobile Combustion - Agriculture/Forestry/Fishing	CH_4	
Mobile Combustion - Agriculture/Forestry/Fishing	N_2O	
Fugitive Emissions from Coal Mining and Handling	CH_4	
Fugitive Emissions from Oil and Gas Operations	CH_4	
CO_2 Emissions from Natural Gas Scrubbing	CO_2	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 of 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.
INDUSTRIAL SECTOR		
CO_2 Emissions from Cement Production	CO_2	
CO_2 Emissions from Lime Production	CO_2	
CO_2 Emissions from Iron and Steel Production	CO_2	
N_2O Emissions from Nitric Acid Production	N_2O	
N_2O Emissions from Adipic Acid Production	N_2O	
PFC Emissions from Aluminium production	PFC	
CO_2 Emissions from Ammonia Production	CO_2	
CO_2 Emissions from Ferroalloys Production	CO_2	
CO_2 Emissions from Aluminium production	CO_2	

Table A1-1: Categories Assessed in Key Category Analysis (cont.)

Sulfur hexaflouride (SF_6) from Magnesium Production	SF_6	
SF_6 Emissions from Electical Equipment	SF_6	
SF_6 Emissions from Other Sources of SF_6	SF_6	
SF_6 Emissions from Production of SF_6	SF_6	
PFC, HFC, SF_6 Emissions from Semiconductor manufacturing		
Emissions from Substitutes for Ozone Depleting Substances (ODS Substitutes)		
HFC-23 Emissions from HCFC-22 Manufacture	HFC -23	
HFC Emissions from Consumption of HFCs, PFCs and SF_6	HFC	
LULUCF		
Forest land remaining forest land	CO_2	
Forest land remaining forest land	CH_4	
Forest land remaining forest land	N_2O	
AGRICULTURE SECTOR		
CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	
CH_4 Emissions from Manure Management	CH_4	
N_2O Emissions from Manure Management	N_2O	
CH_4 and N_2O Emissions from Savanna Burning		
CH_4 and N_2O Emissions from Agricultural Residue Burning		
Direct N_2O Emissions from Agricultural Soils	N_2O	
N_2O Emissions from Pasture, Range and Paddock Manure	N_2O	
Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O	
CH_4 Emissions from Rice Cultivation	CH_4	
WASTE SECTOR		
CH_4 Emissions from Solid Waste Disposal Sites	CH_4	
Emissions from Waste Water Handling	CO_2	
Emissions from Waste Water Handling	N_2O	
Emissions from Waste Incineration	CO_2	
Emissions from Waste Incineration	N_2O	

The reference to the summary overview for Key Categories 2004 in CRF tables is the Excel file HRV-2006-2004-v1.1, Table 7.

The level of disaggregation is in accordance with the suggested source categories split of the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* and aditionally, with the LULUCF category following the *Good Practice Guidance for Land Use, Land-Use Change and Forestry*. There is one additional category included in the key category analysis, e.g. CO_2 Emissions from Natural Gas Scrubbing.

A1.4. TABLES 7.A1-7.A3 OF THE IPCC GOOD PRACTICE GUIDANCE

Table A1-2: Key categories analysis – Level Assessment - Tier 1(Excluding LULUCF)

Tier 1 Analysis - Level Assessment – Excluding LULUCF					
IPCC Source Categories	**Direct Greenhouse Gas**	**Base Year (1990) Estimate (Gg eq-CO_2)**	**Current Year (2004) Estimate (Gg eq-CO_2)**	**Level Assessment**	**Cumulative Total (%)**
Emissions from Stationary Combustion: Oil	CO_2	8,782.686	6,317.157	0.215	21.5%
Mobile Combustion: Road Vehicles	CO_2	3,475.304	4,987.540	0.169	38.4%
Emissions from Stationary Combustion: Gas	CO_2	3,764.030	4,648.125	0.158	54.2%
Emissions from Stationary Combustion: Coal	CO_2	3,141.488	2,663.037	0.090	63.3%
Emissions from Cement Production	CO_2	1,022.903	1,459.004	0.050	68.2%
Fugitive Emissions from Oil and Gas Operations	CH_4	1,186.258	1331.00	0.045	72.7%
Direct Emissions from Agricultural Soils	N_2O	1,334.723	1,266.466	0.043	77.0%
Indirect Emissions from Nitrogen Used in Agriculture	N_2O	900.332	844.003	0.029	79.9%
Emissions from Enteric Fermentation in Domestic Livestock	CH_4	1,343.853	815.640	0.028	82.7%
Emissions from Nitric Acid Production	N_2O	927.561	802.311	0.027	85.4%
Emissions from Natural Gas Scrubbing*	CO_2	415.95	710.000	0.024	87.8%
Mobile Combustion: Agriculture/Forestry/Fishing	CO_2	839.186	698.8	0.024	90.2%
Emissions from Ammonia Production	CO_2	491.551	522.576	0.018	92.0%
Emissions from Solid Waste Disposal Sites	CH_4	221.208	486.807	0.017	93.6%
Emissions from Manure Management	N_2O	376.710	235.194	0.008	94.4%
Emissions from Pasture, Range and Paddock Manure	N_2O	223.323	216.527	0.007	95.1%
Emissions from Consumption of HFCs, PFCs and SF_6	HFC		188.871	0.006	95.8%
Emissions from Manure Management	CH_4	227.409	180.547	0.006	96.4%
Emissions from Lime Production	CO_2	159.780	174.341	0.006	97.0%
Mobile Combustion: Road Vehicles	N_2O	9.221	167.400	0.006	97.6%
Mobile Combustion: Aircraft	CO_2	295.612	158.951	0.005	98.1%
Non-CO_2 Emissions from Stationary Combustion	CH_4	171.702	104.510	0.004	98.5%
Mobile Combustion: Railways	CO_2	137.525	92.070	0.003	98.8%
Emissions from Waste Water Handling	N_2O	77.117	91.272	0.003	99.1%
Mobile Combustion: Water-borne Navigation	CO_2	132.980	91.130	0.003	99.4%
Emissions from Waste Water Handling	CH_4		63.650	0.002	99.6%
Non-CO_2 Emissions from Stationary Combustion	N_2O	65.307	50.253	0.002	99.8%
Mobile Combustion: Road Vehicles	CH_4	15.875	25.364	0.001	99.9%
Emissions from Soda Ash Production and Use	CO_2	25.740	16.526	0.001	99.9%
Emissions from Limestone and Dolomite Use	CO_2	43.218	11.515	0.000	100.0%
Emissions from Other Chemicals	CH_4	15.798	5.890	0.000	100.0%
Mobile Combustion: Agriculture/Forestry/Fishing	N_2O	2.038	1.7	0.000	100.0%
Mobile Combustion: Aircraft	N_2O	2.589	1.393	0.000	100.0%
Mobile Combustion: Agriculture/Forestry/Fishing	CH_4	1.299	1.1	0.000	100.0%
Emissions from Iron and Steel Production	CO_2	0.867	0.394	0.000	100.0%
Mobile Combustion: Railways	N_2O	0.390	0.234	0.000	100.0%
Mobile Combustion: Water-borne Navigation	N_2O	0.337	0.231	0.000	100.0%
Mobile Combustion: Railways	CH_4	0.213	0.132	0.000	100.0%
Mobile Combustion: Water-borne Navigation	CH_4	0.190	0.131	0.000	100.0%
Emissions from Waste Incineration	CO_2		0.078	0.000	100.0%
Mobile Combustion: Aircraft	CH_4	0.044	0.024	0.000	100.0%
Fugitive Emissions from Coal Mining and Handling	CH_4	48.757			
Emissions from Adipic Acid Production	N_2O				
Emissions from Aluminium Production	PFC	936.564			
Emissions from Aluminium Production	CO_2	111.372			
Emissions from Ferroalloys Production	CO_2	194.526			
	TOTAL	**31,123.535**	**29,431.859**		

Table A1-3: Key categories analysis – Level Assessment - Tier 1 (Including LULUCF)

Tier 1 Analysis - Level Assessment - Including LULUCF					
IPCC Source Categories	Direct Greenhouse Gas	Base Year (1990) Estimate (Gg eq-CO_2)	Current Year (2004) Estimate (Gg eq-CO_2)	Level Assessment	Cumulative Total (%)
Forest land remaining forest land	CO_2	14,436.821	16,320.782	0.357	35.7%
Emissions from Stationary Combustion: Oil	CO_2	8,782.686	6,317.157	0.138	49.5%
Mobile Combustion: Road Vehicles	CO_2	3,475.304	4,987.540	0.109	60.4%
Emissions from Stationary Combustion: Gas	CO_2	3,764.030	4,648.125	0.102	70.5%
Emissions from Stationary Combustion: Coal	CO_2	3,141.488	2,663.037	0.058	76.4%
Emissions from Cement Production	CO_2	1,022.903	1,459.004	0.032	79.5%
Fugitive Emissions from Oil and Gas Operations	CH_4	1,186.258	1331.00	0.029	82.5%
Direct Emissions from Agricultural Soils	N_2O	1,334.723	1,266.466	0.028	85.2%
Indirect Emissions from Nitrogen Used in Agriculture	N_2O	900.332	844.003	0.018	87.1%
Emissions from Enteric Fermentation in Domestic Livestock	CH_4	1,343.853	815.640	0.018	88.9%
Emissions from Nitric Acid Production	N_2O	927.561	802.311	0.018	90.6%
Emissions from Natural Gas Scrubbing	CO_2	415.95	710.000	0.016	92.2%
Mobile Combustion: Agriculture/Forestry/Fishing	CO_2	839.186	698.8	0.015	93.7%
Emissions from Ammonia Production	CO_2	491.551	522.576	0.011	94.8%
Emissions from Solid Waste Disposal Sites	CH_4	221.208	486.807	0.011	95.9%
Emissions from Manure Management	N_2O	376.710	235.194	0.005	96.4%
Emissions from Pasture, Range and Paddock Manure	N_2O	223.323	216.527	0.005	96.9%
HFC Emissions from Consumption of HFCs, PFCs and SF_6	HFC		188.871	0.004	97.3%
Emissions from Manure Management	CH_4	227.409	180.547	0.004	97.7%
Emissions from Lime Production	CO_2	159.780	174.341	0.004	98.1%
Mobile Combustion: Road Vehicles	N_2O	9.221	167.400	0.004	98.4%
Mobile Combustion: Aircraft	CO_2	295.612	158.951	0.003	98.8%
Non-CO_2 Emissions from Stationary Combustion	CH_4	171.702	104.510	0.002	99.0%
Mobile Combustion: Railways	CO_2	137.525	92.070	0.002	99.2%
Emissions from Waste Water Handling	N_2O	77.117	91.272	0.002	99.4%
Mobile Combustion: Water-borne Navigation	CO_2	132.980	91.130	0.002	99.6%
Emissions from Waste Water Handling	CH_4		63.650	0.001	99.7%
Non-CO_2 Emissions from Stationary Combustion	N_2O	65.307	50.253	0.001	99.9%
Mobile Combustion: Road Vehicles	CH_4	15.875	25.364	0.001	99.9%
Emissions from Soda Ash Production and Use	CO_2	25.740	16.526	0.000	100.0%
Emissions from Limestone and Dolomite Use	CO_2	43.218	11.515	0.000	100.0%
Emissions from Other Chemicals	CH_4	15.798	5.890	0.000	100.0%
Mobile Combustion: Agriculture/Forestry/Fishing	N_2O	2.038	1.7	0.000	100.0%
Mobile Combustion: Aircraft	N_2O	2.589	1.393	0.000	100.0%
Mobile Combustion: Agriculture/Forestry/Fishing	CH_4	1.299	1.1	0.000	100.0%
Emissions from Iron and Steel Production	CO_2	0.867	0.394	0.000	100.0%
Mobile Combustion: Railways	N_2O	0.390	0.234	0.000	100.0%
Mobile Combustion: Water-borne Navigation	N_2O	0.337	0.231	0.000	100.0%
Mobile Combustion: Railways	CH_4	0.213	0.132	0.000	100.0%
Mobile Combustion: Water-borne Navigation	CH_4	0.190	0.131	0.000	100.0%
Emissions from Waste Incineration	CO_2		0.078	0.000	100.0%
Mobile Combustion: Aircraft	CH_4	0.044	0.024	0.000	100.0%
Fugitive Emissions from Coal Mining and Handling	CH_4	48.757			
Emissions from Adipic Acid Production	N_2O				
Emissions from Aluminium Production	PFC	936.564			
Emissions from Aluminium Production	CO_2	111.372			
Emissions from Ferroalloys Production	CO_2	194.526			
	ABSOLUTE TOTAL	45,560.356	45,752.642		

Table A1-4: Key categories analysis – Trend Assessment - Tier 1 (Excluding LULUCF)

Tier 1 Analysis - Trend Assessment – Excluding LULUCF						
IPCC Source Categories	**Direct GHG**	**Base Year (1990) Estimate (Gg eq-CO_2)**	**Last Year (2004) Estimate (Gg eq-CO_2)**	**Trend Assessment**	**% Contribution to trend**	**Cumulative Total of Column F**
Mobile Combustion: Road Vehicles	N_2O	9.221	167.400	0.09789567	22.8941%	22.89%
Mobile Combustion: Road Vehicles	CO_2	3,475.304	4,987.540	0.08347891	19.5226%	42.42%
Emissions from Stationary Combustion: Oil	CO_2	8,782.686	6,317.157	0.04791730	11.2060%	53.62%
Emissions from Stationary Combustion: Gas	CO_2	3,764.030	4,648.125	0.04617158	10.7978%	64.42%
Emissions from Aluminium Production	PFC	936.564		0.03182144	7.4418%	71.86%
Emissions from Cement Production	CO_2	1,022.903	1,459.004	0.02398378	5.6089%	77.47%
Emissions from Solid Waste Disposal Sites	CH_4	221.208	486.807	0.02081011	4.8667%	82.34%
Emissions from Natural Gas Scrubbing	CO_2	415.95	710.000	0.01844043	4.3125%	86.65%
Emissions from Enteric Fermentation in Domestic Livestock	CH_4	1,343.853	815.640	0.00929990	2.1749%	88.83%
Emissions from Stationary Combustion: Coal	CO_2	3,141.488	2,663.037	0.00857973	2.0065%	90.83%
Fugitive Emissions from Oil and Gas Operations	CH_4	1,186.258	1331.00	0.00811741	1.8984%	92.73%
Emissions from Ferroalloys Production	CO_2	194.526		0.00660938	1.5457%	94.28%
Emissions from Aluminium Production	CO_2	111.372		0.00378406	0.8849%	95.16%
Mobile Combustion: Agriculture/Forestry/Fishing	CO_2	839.186	698.8	0.00260711	0.6097%	95.77%
Emissions from Manure Management	N_2O	376.710	235.194	0.00254266	0.5946%	96.37%
Mobile Combustion: Aircraft	CO_2	295.612	158.951	0.00218630	0.5113%	96.88%
Emissions from Ammonia Production	CO_2	491.551	522.576	0.00214121	0.5007%	97.38%
Emissions from Nitric Acid Production	N_2O	927.561	802.311	0.00211411	0.4944%	97.87%
Fugitive Emissions from Coal Mining and Handling	CH_4	48.757		0.00165661	0.3874%	98.26%
Non-CO_2 Emissions from Stationary Combustion	CH_4	171.702	104.510	0.00118548	0.2772%	98.54%
Emissions from Manure Management	CH_4	227.409	180.547	0.00091152	0.2132%	98.75%
Emissions from Lime Production	CO_2	159.780	174.341	0.00088031	0.2059%	98.96%
Mobile Combustion: Railways	CO_2	137.525	92.070	0.00085415	0.1998%	99.16%
Mobile Combustion: Water-borne Navigation	CO_2	132.980	91.130	0.00079647	0.1863%	99.34%
Emissions from Waste Water Handling	N_2O	77.117	91.272	0.00074747	0.1748%	99.52%
Mobile Combustion: Road Vehicles	CH_4	15.875	25.364	0.00056467	0.1321%	99.65%
Non-CO_2 Emissions from Stationary Combustion	N_2O	65.307	50.253	0.00029543	0.0691%	99.72%
Direct Emissions from Agricultural Soils	N_2O	1,334.723	1,266.466	0.00027274	0.0638%	99.78%
Emissions from Limestone and Dolomite Use	CO_2	43.218	11.515	0.00026451	0.0619%	99.84%
Emissions from Pasture, Range and Paddock Manure	N_2O	223.323	216.527	0.00019897	0.0465%	99.89%
Emissions from Soda Ash Production and Use	CO_2	25.740	16.526	0.00016872	0.0395%	99.93%
Indirect Emissions from Nitrogen Used in Agriculture	N_2O	900.332	844.003	0.00014590	0.0341%	99.96%
Emissions from Other Chemicals	CH_4	15.798	5.890	0.00011401	0.0267%	99.99%
Mobile Combustion: Aircraft	N_2O	2.589	1.393	0.00001915	0.0045%	99.99%
Emissions from Iron and Steel Production	CO_2	0.867	0.394	0.00000654	0.0015%	100.00%
Mobile Combustion: Agriculture/Forestry/Fishing	N_2O	2.038	1.7	0.00000613	0.0014%	100.00%
Mobile Combustion: Agriculture/Forestry/Fishing	CH_4	1.299	1.1	0.00000471	0.0011%	100.00%
Mobile Combustion: Railways	N_2O	0.390	0.234	0.00000273	0.0006%	100.00%
Mobile Combustion: Water-borne Navigation	N_2O	0.337	0.231	0.00000201	0.0005%	100.00%
Mobile Combustion: Railways	CH_4	0.213	0.132	0.00000144	0.0003%	100.00%
Mobile Combustion: Water-borne Navigation	CH_4	0.190	0.131	0.00000113	0.0003%	100.00%
Mobile Combustion: Aircraft	CH_4	0.044	0.024	0.00000032	0.0001%	100.00%
HFC Emissions from Consumption of HFCs, PFCs and SF_6	HFC		188.871	0.00000000	0.0000%	100.00%
Emissions from Waste Water Handling	CH_4		63.650	0.00000000	0.0000%	100.00%
Emissions from Waste Incineration	CO_2		0.078	0.00000000	0.0000%	100.00%
	TOTAL	**31,123.535**	**29,431.859**			

Table A1-5: Key categories analysis – Trend Assessment - Tier 1 (Including LULUCF)

Tier 1 Analysis - Trend Assessment - Including LULUCF						
IPCC Source/Sink Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO_2)	Last Year (2004) Estimate (Gg eq-CO_2)	Trend Assessment	% Contribution to trend	Cumulative Total
Forest land remaining forest land	CO_2	-14,436.821	-16,320.782	0.50192628	31.0%	31.04%
Mobile Combustion: Road Vehicles	CO_2	3,475.304	4,987.540	0.26927326	16.6503649%	47.69%
Mobile Combustion: Road Vehicles	N_2O	9.221	167.400	0.22250521	13.7584879%	61.45%
Emissions from Stationary Combustion: Gas	CO_2	3,764.030	4,648.125	0.17995337	11.1273182%	72.57%
Emissions from Cement Production	CO_2	1,022.903	1,459.004	0.07779108	4.8101687%	77.38%
Emissions from Aluminium Production	PFC	936.564		0.07143305	4.4170237%	81.80%
Emissions from Solid Waste Disposal Sites	CH_4	221.208	486.807	0.05470650	3.3827463%	85.18%
Emissions from Natural Gas Scrubbing	CO_2	415.95	710.000	0.05305111	3.2803866%	88.46%
Fugitive Emissions from Oil and Gas Operations	CH_4	1,186.258	1,331.00	0.04007275	2.4778765%	90.94%
Emissions from Stationary Combustion: Coal	CO_2	3,141.488	2,663.037	0.02445850	1.5123777%	92.45%
Direct Emissions from Agricultural Soils	N_2O	1,334.723	1,266.466	0.02140349	1.3234731%	93.78%
Emissions from Ferroalloys Production	CO_2	194.526		0.01483680	0.9174253%	94.69%
Indirect Emissions from Nitrogen Used in Agriculture	N_2O	900.332	844.003	0.01352826	0.8365123%	95.53%
Emissions from Ammonia Production	CO_2	491.551	522.576	0.01338559	0.8276905%	96.36%
Emissions from Aluminium Production	CO_2	111.372		0.00849450	0.5252525%	96.88%
Emissions from Nitric Acid Production	N_2O	927.561	802.311	0.00842555	0.5209892%	97.40%
Emissions from Enteric Fermentation in Domestic Livestock	CH_4	1,343.853	815.640	0.00748635	0.4629141%	97.87%
Mobile Combustion: Agriculture/Forestry/Fishing	CO_2	839.186	698.8	0.00561962	0.3474862%	98.21%
Emissions from Lime Production	CO_2	159.780	174.341	0.00483824	0.2991699%	98.51%
Emissions from Pasture, Range and Paddock Manure	N_2O	223.323	216.527	0.00400132	0.2474194%	98.76%
Emissions from Stationary Combustion: Oil	CO_2	8,782.686	6,317.157	0.00385812	0.2385646%	99.00%
Fugitive Emissions from Coal Mining and Handling	CH_4	48.757		0.00371876	0.2299476%	99.23%
Emissions from Waste Water Handling	N_2O	77.117	91.272	0.00317631	0.1964053%	99.43%
Mobile Combustion: Aircraft	CO_2	295.612	158.951	0.00229837	0.1421187%	99.57%
Emissions from Manure Management	N_2O	376.710	235.194	0.00184667	0.1141879%	99.68%
Mobile Combustion: Road Vehicles	CH_4	15.875	25.364	0.00168397	0.1041272%	99.79%
Non-CO_2 Emissions from Stationary Combustion	CH_4	171.702	104.510	0.00094547	0.0584625%	99.85%
Emissions from Manure Management	CH_4	227.409	180.547	0.00091780	0.0567514%	99.90%
Mobile Combustion: Railways	CO_2	137.525	92.070	0.00040592	0.0250997%	99.93%
Emissions from Limestone and Dolomite Use	CO_2	43.218	11.515	0.00040474	0.0250269%	99.95%
Mobile Combustion: Water-borne Navigation	CO_2	132.980	91.130	0.00029186	0.0180468%	99.97%
Non-CO_2 Emissions from Stationary Combustion	N_2O	65.307	50.253	0.00016181	0.0100054%	99.98%
Emissions from Other Chemicals	CH_4	15.798	5.890	0.00015923	0.0098461%	99.99%
Emissions from Soda Ash Production and Use	CO_2	25.740	16.526	0.00010745	0.0066442%	100.00%
Mobile Combustion: Aircraft	N_2O	2.589	1.393	0.00002011	0.0012433%	100.00%
Mobile Combustion: Agriculture/Forestry/Fishing	N_2O	2.038	1.7	0.00001424	0.0008804%	100.00%
Emissions from Iron and Steel Production	CO_2	0.867	0.394	0.00000821	0.0005076%	100.00%
Mobile Combustion: Agriculture/Forestry/Fishing	CH_4	1.299	1.1	0.00000672	0.0004156%	100.00%
Mobile Combustion: Railways	N_2O	0.390	0.234	0.00000229	0.0001415%	100.00%
Mobile Combustion: Railways	CH_4	0.213	0.132	0.00000108	0.0000667%	100.00%
Mobile Combustion: Water-borne Navigation	N_2O	0.337	0.231	0.00000072	0.0000443%	100.00%
Mobile Combustion: Water-borne Navigation	CH_4	0.190	0.131	0.00000040	0.0000250%	100.00%
Mobile Combustion: Aircraft	CH_4	0.044	0.024	0.00000034	0.0000211%	100.00%
HFC Emissions from Consumption of HFCs, PFCs and SF_6	HFC		188.871	0.00000000	0.0000000%	100.00%
Emissions from Waste Water Handling	CH_4		63.650	0.00000000	0.0000000%	100.00%
Emissions from Waste Incineration	CO_2		0.078	0.00000000	0.0000000%	100.00%
	TOTAL	**16,686.713**	**13,111.077**			

Table A1-6: Key categories for Croatia – summary (Excluding LULUCF)

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
CO_2 Emissions from Stationary Combustion - Gas	CO_2	Yes	Level
Non-CO_2 Emissions from Stationary Combustion	CH_4	No	
Non-CO_2 Emissions from Stationary Combustion	N_2O	No	
Mobile Combustion – Road Vehicles	CO_2	Yes	Level, Trend
Mobile Combustion - Railways	CO_2	No	
Mobile Combustion - Domestic Aviation	CO_2	No	
Mobile Combustion - National Navigation	CO_2	No	
Mobile Combustion - Agriculture/Forestry/Fishing	CO_2	Yes	Level
Mobile Combustion – Road Vehicles	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 Vehicles	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
HFC Emissions from Consumption of HFCs, PFCs and SF_6	HFC	No	
PFC Emissions from Aluminium production	PFC	No	Trend
AGRICULTURE SECTOR			
CH_4 Emissions from Enteric Fermentation 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
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	

Table A1-7: Key categories for Croatia – summary (Including LULUCF)

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, Level
CO_2 Emissions from Stationary Combustion - Oil	CO_2	Yes	Level
CO_2 Emissions from Stationary Combustion - Gas	CO_2	Yes	Level, Trend
Non-CO_2 Emissions from Stationary Combustion	CH_4	No	
Non-CO_2 Emissions from Stationary Combustion	N_2O	No	
Mobile Combustion – Road Vehicles	CO_2	Yes	Level, Trend
Mobile Combustion - Railways	CO_2	No	
Mobile Combustion - Domestic Aviation	CO_2	Yes	
Mobile Combustion - National Navigation	CO_2	No	
Mobile Combustion - Agriculture/Forestry/Fishing	CO_2	No	
Mobile Combustion – Road Vehicles	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	Yes	Level
Mobile Combustion – Road Vehicles	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
HFC Emissions from Consumption of HFCs, PFCs and SF_6	HFC	No	
PFC Emissions from Aluminium production	PFC	No	Trend
AGRICULTURE SECTOR			
CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	Yes	Level
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	No	
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	
LULUCF			
Forest land remaining forest land	CO_2	Yes	Level, Trend
Forest land remaining forest land	CH_4		
Forest land remaining forest land	N_2O		
WASTE SECTOR			
CH_4 Emissions from Solid Waste Disposal Sites	CH_4	Yes	Trend
N_2O Emissions from Human Sewage	N_2O	No	

Table A1-8: Changes in Key categories for Croatia based on the Level and Trend of Emissions

Tier 1 Analysis – Source Analysis Summary (Croatian Inventory)					
IPCC Source Categories	**Direct Greenhouse Gas**	**Criteria for Identification**			
		Level		**Trend**	
		2003	**2004**	**2003**	**2004**
ENERGY SECTOR					
CO_2 Emissions from Stationary Combustion: Coal	CO_2	Yes	Yes	Yes	Yes
CO_2 Emissions from Stationary Combustion: Oil	CO_2	Yes	Yes	Yes	Yes
CO_2 Emissions from Stationary Combustion: Gas	CO_2	Yes	Yes	Yes	Yes
Mobile Combustion: Road Vehicles	CO_2	Yes	Yes	Yes	Yes
Mobile Combustion: Domestic Aviation	CO_2			Yes	No
Mobile Combustion: Agriculture/Forestry/Fishing	CO_2	Yes	Yes		
Mobile Combustion: Road Vehicles	N_2O			Yes	Yes
Fugitive Emissions from Oil and Gas Operations	CH_4	Yes	Yes	Yes	Yes
CO_2 Emissions from Natural Gas Scrubbing	CO_2	Yes	Yes	Yes	Yes
INDUSTRIAL SECTOR					
CO_2 Emissions from Cement Production	CO_2	Yes	Yes	Yes	Yes
CO_2 Emissions from Ammonia Production	CO_2	Yes	Yes		
CO_2 Emissions from Ferroalloys Production	CO_2			No	Yes
N_2O Emissions from Nitric Acid Production	N_2O	Yes	Yes	Yes	No
PFC Emissions from Aluminium production	PFC			No	Yes
AGRICULTURE SECTOR					
CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	Yes	Yes	Yes	Yes
CH_4 Emissions from Manure Management	CH_4	No	Yes	Yes	No
Direct N_2O Emissions from Agricultural Soils and Animals	N_2O	Yes	Yes	Yes	Yes
Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O	Yes	Yes	Yes	No
LULUCF					
Forest Land Remaining Forest Land	CO_2	No	Yes	No	Yes
WASTE SECTOR					
CH_4 Emissions from Solid Waste Disposal Sites	CH_4	Yes	Yes	Yes	Yes

ANNEX 2

DETAILED DISCUSSION OF ACTIVITY DATA AND EMISSION FACTORS FOR ESTIMATING CO_2 EMISSIONS FROM FOSSIL FUEL COMBUSTION

Table A2-2: The GHG emissions from Thermal Power Plants

	1990	1995	2000	2001	2002	2003	2004
Production							
Electricity production (GWh)	3760.2	1901.1	3049.4	3530.9	4627.9	4750.1	3326.4
Fuel consumption							
Hard coal (1000 t)	253.7	96.2	569.8	627.3	800.4	904.2	852.4
NCV for hard coal (MJ/kg)	25.1	25.1	26.2	25.6	25.6	24.4	23.8
Coke gas (1000000 m3)	24.5						
NCV for coke gas (MJ/m3)	17.9						
Fuel oil (1000 t)	570.7	327.8	283.4	397.5	406.8	559.5	246.5
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.7	40.8	40.4	40.4
Extra light oil (1000 t)		24.1	0.2			8.6	0.04
NCV for extra light oil (MJ/kg)		42.7	42.7			41.8	41.8
Natural gas (1000000 m^3)	201.7	114.1	155.8	165.2	318.8	99.9	130.4
NCV for natural gas (MJ/m^3)	34.0	34.0	34.0	33.3	33.3	33.3	33.3
Total fuel consumption (TJ)	**36606.0**	**20501.5**	**31595.9**	**37748.4**	**47739.7**	**48355.8**	**34562.1**
Emissions							
EF CO_2 – hard coal (t/TJ)	92.7	92.7	92.7	92.7	92.7	92.7	92.7
EF CO_2 – coke gas (t/TJ)	46.7	46.7	46.7	46.7	46.7	46.7	46.7
EF CO_2 – fuel oil (t/TJ)	76,6	76,6	76,6	76,6	76,6	76,6	76,6
EF CO_2 – extra light oil (t/TJ)	73,3	73,3	73,3	73,3	73,3	73,3	73,3
EF CO_2 – natural gas (t/TJ)	55,8	55,8	55,8	55,8	55,8	55,8	55,8
CO_2 emission (Gg)	**2750,9**	**1525.3**	**2550,1**	**3035,6**	**3766,5**	**3988,8**	**2883,3**
EF CH_4 – hard coal (kg/TJ)	1.0	1.0	1.0	0.7	0.7	0.7	0.7
EF CH_4 – coke gas (kg/TJ)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
EF CH_4 – fuel oil (kg/TJ)	3.0	3.0	3.0	0.9	0.9	0.9	0.9
EF CH_4 – extra light oil (kg/TJ)	3.0	3.0	3.0	0.9	0.9	0.9	0.9
EF CH_4 – natural gas (kg/TJ)	1.0	1.0	1.0	0.3	0.9	0.8	0.3
CH_4 emission (Mg)	**82.5**	**48.9**	**54.4**	**27.3**	**38.6**	**38.7**	**24.5**
EF N_2O – hard coal (kg/TJ)	1.4	1.4	1.4	1.6	1.6	1.6	1.6
EF N_2O – coke gas (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – fuel oil (kg/TJ)	0.6	0.6	0.6	0.3	0.3	0.3	0.3
EF N_2O – extra light oil (kg/TJ)	0.6	0.6	0.6	0.4	0.4	0.4	0.4
EF N_2O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O emission (Mg)	**24.0**	**12.3**	**28.2**	**31.1**	**38.9**	**42.5**	**35.8**

Table A2-3: The GHG emissions from Public Cogeneration Plants

	1990	1995	2000	2001	2002	2003	2004
Production							
Electricity production (GWh)	555.6	778.0	836.1	1184.0	1273.7	1952.7	2075.3
Heat production (TJ)	11741.3	10446.5	7024.6	8672.1	8668.0	8116.1	7789.5
Total (TJ)	**13741.5**	**13247.2**	**10034.6**	**12934.5**	**13253.2**	**15146.0**	**15260.4**
Fuel consumption							
Fuel oil (1000 t)	118.0	337.1	108.6	115.4	92.5	166.2	114.6
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.4	40.3	40.6	40.6
Extra light oil (1000 t)		0.9	0.9				0.3
NCV for extra light oil (MJ/kg)		42.7	42.7				41.8
Natural gas (1000000 m^3)	315.5	103.5	363.4	433.1	455.9	521.0	580.1
NCV for natural gas (MJ/m^3)	34.0	34.0	34.0	33.3	33.3	33.3	33.3
Total fuel consumption (TJ)	**15469.4**	**17105.5**	**16758.7**	**19101.6**	**18925.8**	**24126.6**	**24007.5**

Table A2-3: The GHG emissions from Public Cogeneration Plants (cont.)

	1990	1995	2000	2001	2002	2003	2004
Emissions							
EF CO_2 – fuel oil (t/TJ)	76.6	76.6	76.6	76.6	76.6	76.6	76.6
EF CO_2 – extra light oil (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
EF CO_2 – natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
CO_2 emission (Gg)	**962.0**	**1236.9**	**1026.8**	**1163.1**	**1133.8**	**1487.1**	**1437.0**
EF CH_4 – fuel oil (kg/TJ)	3.0	3.0	3.0	0.9	0.9	0.9	0.9
EF CH_4 – extra light oil (kg/TJ)	3.0	3.0	3.0	0.9	0.9	0.9	0.9
EF CH_4 – natural gas (kg/TJ)	1.0	1.0	1.0	3.6	3.9	4.7	4.6
CH_4 emission (Mg)	**25.0**	**44.3**	**25.6**	**56.1**	**62.0**	**86.9**	**93.1**
EF N_2O – fuel oil (kg/TJ)	0.6	0.6	0.6	0.3	0.3	0.3	0.3
EF N_2O – extra light oil (kg/TJ)	0.6	0.6	0.6	0.4	0.4	0.4	0.4
EF N_2O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O emission (Mg)	**3.9**	**8.5**	**3.9**	**2.8**	**2.6**	**3.8**	**3.3**

Table A2-4: The GHG emissions from Public Heating Plants

	1990	1995	2000	2001	2002	2003	2004
Production							
Heat production (TJ)	0	2493	2708	3338.4	3171.4	3469.7	3303.5
Fuel consumption							
Fuel oil (1000 t)	0.0	35.6	37.0	38.6	36.4	38.1	38.6
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.2	40.2	40.2	40.2
Extra light oil (1000 t)	0.0	6.0	4.4	3.6	3.7	4.3	6.8
NCV for extra light oil (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Natural gas (1000000 m^3)	0.0	36.2	53.0	70.1	67.2	69.6	64.3
NCV for natural gas (MJ/m^3)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Total fuel consumption (TJ)	**0.0**	**2917.8**	**3477.0**	**4088.5**	**3905.7**	**4081.3**	**4028.0**
Emissions							
EF CO_2 – fuel oil (t/TJ)	76.6	76.6	76.6	76.6	76.6	76.6	76.6
EF CO_2 – extra light oil (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
EF CO_2 – natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
CO_2 emission (Gg)	**0.0**	**197.1**	**228.3**	**263.1**	**251.2**	**262.8**	**262.1**
EF CH_4 – fuel oil (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH_4 – extra light oil (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH_4 – natural gas (kg/TJ)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CH_4 emission (Mg)	**0.0**	**6.3**	**6.8**	**7.5**	**7.1**	**7.5**	**7.7**
EF N_2O – fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – extra light oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O emission (Mg)	**0.0**	**1.1**	**1.2**	**1.3**	**1.2**	**1.3**	**1.3**

The GHG emissions from thermal power plants and public cogeneration plants, for last four years (2001, 2002, 2003 and 2004), were calculated using more detailed Tier 2 approach. Tier 2 approach is based on bottom-up fuel consumption data from every boiler or gas turbine in plant. There were available data about monthly fuel consumption and detailed fuel characteristics data (net calorific value, sulphur and ash content…). Every plant also has the equipment for continual measurements of SO_2, NO_x, CO and particulates emission.

For estimation of CO_2 emissions, default IPCC emission factors were used, while emission factors for CH_4 and N_2O are based on technology type and configuration (Tier 2). The results of GHG emission calculation, using more detailed approach are presented in tables 3.2-3 and 3.2-4 for the last four years, on aggregated level. The GHG emissions on plant level, for the year 2004, are given in the Table A2-5.

Table A2-5: The GHG emissions from TPPs and PCPs (Tier 2), year 2004

	TPP Plomin	**TPP Rijeka**	**TPP Sisak**	**CHP Zagreb – east**	**CHP Zagreb – west**	**CHP Osijek**	**CCGT Jertovec**
Production							
Electricity production (GWh)	1931.4	634.1	748.7	1496.4	444.9	134.0	12.2
Heat production (TJ)				3947.1	2636.5	1205.9	
Total (TJ)	**6952.9**	**2282.9**	**2695.2**	**9334.1**	**4238.2**	**1688.1**	**44.0**
Fuel consumption							
Hard coal (1000 t)	852.4						
NCV for hard coal (MJ/kg)	23.8						
Fuel oil (1000 t)		146.6	100.0	60.9	38.0	15.8	
NCV for fuel oil (MJ/kg)		40.19	40.70	40.54	40.53	41.09	
Extra light oil (1000 t)				0.3			0.04
NCV for extra light oil (MJ/kg)				41.8			41.8
Natural gas (1000000 m^3)			126.0	356.8	164.1	59.2	4.4
NCV for natural gas (MJ/m^3)			33.3	33.3	33.3	33.3	33.3
Total fuel consumption (TJ)	**20253.5**	**5890.8**	**8267.8**	**14373.5**	**7010.9**	**2623.1**	**150.0**
Emissions							
EF CO_2 – hard coal (t/TJ)	92.7	92.7	92.7	92.7	92.7	92.7	92.7
EF CO_2 – fuel oil (t/TJ)	76.6	76.6	76.6	76.6	76.6	76.6	76.6
EF CO_2 – extra light oil (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
EF CO_2 – natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
CO_2 emission (Gg)	**1877.7**	**451.2**	**546.0**	**853.8**	**423.3**	**159.9**	**8.4**
EF CH_4 – hard coal (kg/TJ)	0.7	0.7	0.7	0.7	0.7	0.7	0.7
EF CH_4 – fuel oil (kg/TJ)	0.9	0.9	0.9	0.9	0.9	0.9	0.9
EF CH_4 – extra light oil (kg/TJ)	0.9	0.9	0.9	0.9	0.9	0.9	0.9
EF CH_4 – natural gas (kg/TJ)	0.1	0.1	0.1	5.2	4.9	0.4	6.0
CH_4 emission (Mg)	**14.2**	**5.3**	**4.1**	**63.7**	**28.1**	**1.3**	**0.9**
EF N_2O – hard coal (kg/TJ)	1.6	1.6	1.6	1.6	1.6	1.6	1.6
EF N_2O – fuel oil (kg/TJ)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
EF N_2O – extra light oil (kg/TJ)	0.4	0.4	0.4	0.4	0.4	0.4	0.4
EF N_2O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O emission (Mg)	**32.4**	**1.8**	**1.6**	**1.9**	**1.0**	**0.4**	**0.0**

Table A2-6: The GHG emissions from Petroleum refining – own use of energy

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Fuel oil (1000 t)	127.7	101.2	47.8	36.8	57.4	51.7	66.2
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.2	40.2	40.2	40.2
LPG (1000 t)		35.0	2.2	4.3	7.7	8.8	5.7
NCV for LPG (MJ/kg)	46.9	46.9	46.9	46.9	46.9	46.9	46.9
Petroleum coke (1000 t)	53.7	42.6	63.0	51.5	57.8	59.1	63.4
NCV for petroleum coke (MJ/kg)	29.3	29.3	31.0	31.0	31.0	31.0	31.0
Refinery gas (1000 t)	347.5	196.5	221.7	195.3	214.5	229.9	241.7
NCV for refinery gas (MJ/kg)	48.6	48.6	48.6	48.6	48.6	48.6	48.6
Natural gas (1000000 m^3)				3.3	0.3	0.3	0.3
NCV for natural gas (MJ/m^3)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Total fuel consumption (TJ)	**23584.3**	**16501.0**	**14745.2**	**12875.0**	**14888.2**	**15499.0**	**16642.8**
Emissions							
EF CO_2 – fuel oil (t/TJ)	76.6	76.6	76.6	76.6	76.6	76.6	76.6
EF CO_2 – LPG (t/TJ)	62.4	62.4	62.4	62.4	62.4	62.4	62.4
EF CO_2 – petroleum coke (t/TJ)	99.8	99.8	99.8	99.8	99.8	99.8	99.8
EF CO_2 – refinery gas (t/TJ)	66.1	66.1	66.1	66.1	66.1	66.1	66.1
EF CO_2 – natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
CO_2 emission (Gg)	**1665.3**	**1169.2**	**1059.9**	**918.2**	**1067.0**	**1106.1**	**1192.8**
EF CH_4 – fuel oil (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH_4 – LPG (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH_4 – petroleum coke (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH_4 – refinery gas (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH_4 – natural gas (kg/TJ)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CH_4 emission (Mg)	**70.8**	**49.5**	**44.2**	**38.4**	**44.6**	**46.5**	**49.9**
EF N_2O – fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – petroleum coke (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – refinery gas (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O emission (Mg)	**14.2**	**9.9**	**8.8**	**7.7**	**8.9**	**9.3**	**10.0**

*Table A2-7: The GHG emissions from Petroleum refining – heating/cogeneration plants**

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Fuel oil (1000 t)	227.2	199.5	193.4	183.8	205.9	212.9	192.6
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.2	40.2	40.2	40.2
LPG (1000 t)				6.5			11.6
NCV for LPG (MJ/kg)	46.9	46.9	46.9	46.9	46.9	46.9	46.9
Petroleum coke (1000 t)				4.1	6.3	6.9	6.2
NCV for petroleum coke (MJ/kg)				31.0	31.0	31.0	31.0
Refinery gas (1000 t)	58.4	27.7	40.7	25.3	22.7	28.6	22.1
NCV for refinery gas (MJ/kg)	48.6	48.6	48.6	48.6	48.6	48.6	48.6
Natural gas (1000000 m^3)	7.3	7.1	0.2	0.6			
NCV for natural gas (MJ/m^3)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Total fuel consumption (TJ)	**12215.9**	**9604.7**	**9756.3**	**9068.0**	**9573.0**	**10159.5**	**9550.1**

Table A2-7: The GHG emissions from Petroleum refining – heating/cogeneration plants (cont.)*

	1990	1995	2000	2001	2002	2003	2004
Emissions							
EF CO_2 – fuel oil (t/TJ)	76.6	76.6	76.6	76.6	76.6	76.6	76.6
EF CO_2 – LPG (t/TJ)	62.4	62.4	62.4	62.4	62.4	62.4	62.4
EF CO_2 – petroleum coke (t/TJ)	99.8	99.8	99.8	99.8	99.8	99.8	99.8
EF CO_2 – refinery gas (t/TJ)	66.1	66.1	66.1	66.1	66.1	66.1	66.1
EF CO_2 – natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
CO_2 emission (Gg)	**900.6**	**716.5**	**726.3**	**679.8**	**726.2**	**768.5**	**716.9**
EF CH_4 – fuel oil (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH_4 – LPG (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH_4 – petroleum coke (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH_4 – refinery gas (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH_4 – natural gas (kg/TJ)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CH_4 emission (Mg)	**36.2**	**28.3**	**29.3**	**27.2**	**28.7**	**30.5**	**28.7**
EF N_2O – fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – petroleum coke (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – refinery gas (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O emission (Mg)	**7.2**	**5.6**	**5.9**	**5.4**	**5.7**	**6.1**	**5.7**

- Cogeneration and heating plants in refineries were calculated (previous submission) in the sub-sector Manufacturing Industries and Construction instead of Energy Industries (Petroleum Refining)

Table A2-8: The GHG emissions from manufacturing of solid fuels and other energy industries

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
LPG (1000 t)			1.0				
NCV for LPG (MJ/kg)			46.9				
Coke gas (1000000 m^3)	107.4						
NCV for coke gas (MJ/m^3)	17.9						
Extra light oil (1000 t)	0.7	0.8	7.1	6.3	6.4	9.5	6.3
NCV for extra light oil (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Natural gas (1000000 m^3)	238.2	171	140	112.8	130.9	123.2	136.5
NCV for natural gas (MJ/m^3)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Total fuel consumption (TJ)	**10052.2**	**5848.2**	**5110.1**	**4104.3**	**4723.9**	**4594.5**	**4910.1**
Emissions							
EF CO_2 – LPG (t/TJ)	62.4	62.4	62.4	62.4	62.4	62.4	62.4
EF CO_2 – coke gas (t/TJ)	46.7	46.7	46.7	46.7	46.7	46.7	46.7
EF CO_2 – extra light oil (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
EF CO_2 – natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
CO_2 emission (Gg)	**544.1**	**327.0**	**290.9**	**233.8**	**268.5**	**263.6**	**278.8**
EF CH_4 – hard coal (kg/TJ)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
EF CH_4 – coke gas (kg/TJ)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
EF CH_4 – extra light oil (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH_4 – natural gas (kg/TJ)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CH_4 emission (Mg)	**10.1**	**5.9**	**5.7**	**4.6**	**5.3**	**5.4**	**5.4**
EF N_2O – hard coal (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – coke gas (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – extra light oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O emission (Mg)	**3.5**	**0.6**	**0.7**	**0.5**	**0.6**	**0.7**	**0.6**

Table A2-9: The GHG emissions from Manufacturing Industries and Construction – liquid fuels and natural gas

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Gasoline (1000 t)	0.2	8.5	7.6	7.8	7.6	9.1	10.2
NCV for gasoline (MJ/kg)	44.6	44.6	44.6	44.6	44.6	44.6	44.6
Petroleum (1000 t)	0.1						
NCV for petroleum (MJ/kg)	44.0						
Gas/diesel oil (1000 t)	246.6	101.5	130.8	129.9	119.3	145.0	135.9
NCV for gas/diesel oil (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Fuel oil (1000 t)	419.1	269.7	302.2	325.5	324.4	284.7	230.5
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.2	40.2	40.2	40.2
LPG (1000 t)	17.6	17.6	21.0	19.8	19.3	20.9	17.3
NCV for LPG (MJ/kg)	46.9	46.9	46.9	46.9	46.9	46.9	46.9
Lubricants (1000 t)	8.6						
NCV for lubricants (MJ/kg)	33.6						
Petroleum coke (1000 t)				16.3	11.9	6.3	68.4
NCV for petroleum coke (MJ/kg)				31.0	31.0	31.0	31.0
Natural gas (1000000 m^3)	845.8	656.8	703.8	715.4	674.1	683.9	711.5

Table A2-9: The GHG emissions from Manufacturing Industries and Construction – liquid fuels and natural gas (cont.)

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
NCV for natural gas (MJ/m^3)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Total fuel consumption (TJ)	**57260.4**	**38709.8**	**42984.7**	**44735.0**	**42665.1**	**42468.7**	**42645.5**
Emissions							
EF CO_2 – gasoline (t/TJ)	68.6	68.6	68.6	68.6	68.6	68.6	68.6
EF CO_2 – petroleum (t/TJ)	71.1	71.1	71.1	71.1	71.1	71.1	71.1
EF CO_2 – gas/diesel oil (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
EF CO_2 – fuel oil (t/TJ)	76.6	76.6	76.6	76.6	76.6	76.6	76.6
EF CO_2 – LPG (t/TJ)	62.4	62.4	62.4	62.4	62.4	62.4	62.4
EF CO_2 – lubricants (t/TJ)	72.6	72.6	72.6	72.6	72.6	72.6	72.6
EF CO_2 – petroleum coke (t/TJ)	99.8	99.8	99.8	99.8	99.8	99.8	99.8
EF CO_2 – natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
CO_2 emission (Gg)	**3741.0**	**2472.1**	**2760.3**	**2898.8**	**2768.1**	**2737.0**	**2779.0**
EF CH_4 – gasoline (kg/TJ)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
EF CH_4 – petroleum (kg/TJ)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
EF CH_4 – gas/diesel oil (kg/TJ)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
EF CH_4 – fuel oil (kg/TJ)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
EF CH_4 – LPG (kg/TJ)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
EF CH_4 – lubricants (kg/TJ)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
EF CH_4 – petroleum coke (kg/TJ)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
EF CH_4 – natural gas (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CH_4 emission (Mg)	**200.8**	**144.4**	**157.8**	**162.4**	**154.1**	**154.7**	**157.9**
EF N_2O – gasoline (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – petroleum (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – gas/diesel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – lubricants (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – petroleum coke (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N2O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O emission (Mg)	**20.0**	**12.1**	**13.8**	**14.7**	**14.1**	**13.9**	**13.5**

Table A2-10: The GHG emissions from Manufacturing Industries and Construction – solid fuels

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Anthracite (1000 t)	107.2	5.0	0.1		7.2		0.4
NCV for anthracite (MJ/kg)	29.3	29.3	29.3		29.3		29.3
Hard coal (1000 t)	42.0	41.9	53.2	68.8	70.3	125.7	253.7
NCV for hard coal (MJ/kg)	25.1	25.1	26.2	25.8	25.8	24.5	24.3
Brown Coal (1000 t)	261.2	95.8	28.2	42.3	35.5	34.4	59.2
NCV for brown coal (MJ/kg)	16.7	16.7	17.8	18.2	18.2	18.5	18.3
Lignite (1000 t)	73.0	56.3	14.4	20.2	25.6	18.4	0.7
NCV for lignite (MJ/kg)	10.9	10.9	12.0	12.2	12.2	12.3	12.2
Briquettes (1000 t)	3.3						
NCV for briquettes (MJ/kg)	16.7						
Coke oven coke (1000 t)	199.8	31.4	37.7	18.3	17.1	17.3	19.3
NCV for coke oven coke (MJ/kg)	29.3	29.3	29.3	29.3	29.3	29.3	29.3
Gas work gas (1000000 m^3)	6.1	9.8	7.9	6.9	9.6	4.4	3.0

Table A2-10: The GHG emissions from Manufacturing Industries and Construction – solid fuels (cont.)

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
NCV for gas work gas (MJ/m^3)	15.8	15.8	19.5	19.5	19.5	22.6	21.5
Coke oven gas (1000000 m^3)	29.9						
NCV for coke oven gas (MJ/m^3)	17.9						
Blast furnace gas (1000000 m^3)	418.1						
NCV for blast furnace gas (MJ/m$_3$)	3.6						
Total fuel consumption (TJ)	**17416.7**	**4492.5**	**3327.8**	**3461.2**	**3670.2**	**4547.6**	**7897.9**
Emissions							
EF CO_2 – anthracite (t/TJ)	96.3	96.3	96.3	96.3	96.3	96.3	96.3
EF CO_2 – hard coal (t/TJ)	92.7	92.7	92.7	92.7	92.7	92.7	92.7
EF CO_2 – brown coal (t/TJ)	94.1	94.1	94.1	94.1	94.1	94.1	94.1
EF CO_2 – lignite (t/TJ)	99.2	99.2	99.2	99.2	99.2	99.2	99.2
EF CO_2 – briquettes (t/TJ)	92.7	92.7	92.7	92.7	92.7	92.7	92.7
EF CO_2 – coke oven coke (t/TJ)	106.0	106.0	106.0	106.0	106.0	106.0	106.0
EF CO_2 – gas work gas (t/TJ)	46.7	46.7	46.7	46.7	46.7	46.7	46.7
EF CO_2 – coke oven gas (t/TJ)	46.7	46.7	46.7	46.7	46.7	46.7	46.7
EF CO_2 – blast furnace gas (t/TJ)	237.2	237.2	237.2	237.2	237.2	237.2	237.2
CO_2 emission (Gg)	**1904.2**	**428.4**	**318.0**	**324.5**	**342.0**	**426.2**	**738.4**
EF CH_4 – anthracite (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – hard coal (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – brown coal (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – lignite (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – briquettes (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – coke oven coke (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – gas work gas (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – coke oven gas (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – blast furnace gas (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
CH_4 emission (Mg)	**174.2**	**44.9**	**33.3**	**34.6**	**36.7**	**45.5**	**79.0**
EF N_2O – anthracite (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – hard coal (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – brown coal (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – lignite (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – briquettes (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – coke oven coke (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – gas work gas (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – coke oven gas (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – blast furnace gas (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
N_2O emission (Mg)	**24.4**	**6.3**	**4.7**	**4.8**	**5.1**	**6.4**	**11.1**

Table A2-11: The number of road motor vehicles in Croatia

	1990	1995	2000	2001	2002	2003	2004
Passenger Cars	852585	710910	1124825	1195450	1244252	1293421	1337538
Light and Heavy Duty Vehicles	70477	73497	122516	129497	138743	148275	154790
Buses	6398	3897	4660	4770	4792	4833	4869
Motorcycles	11847	9933	21868	24305	28188	33925	39315
Total	**941307**	**798237**	**1273869**	**1354022**	**1415975**	**1480454**	**1536512**

Table A2-12: GHG emissions from Road Transport

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Gasoline (1000 t)	759.6	558.2	764.2	735.1	742.8	739.6	705.2
NCV for gasoline (MJ/kg)	44.6	44.6	44.6	44.6	44.6	44.6	44.6
Diesel (1000 t)	367.7	411.5	558.1	601.3	683.8	811.5	888.1
NCV for diesel (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
LPG (1000 t)		13.7	9.8	12.6	13.2	13.2	16.7
NCV for LPG (MJ/kg)		46.9	46.9	46.9	46.9	46.9	46.9
Total fuel consumption (TJ)	**49575.0**	**43107.7**	**58371.7**	**59050.4**	**62945.5**	**68256.9**	**70158.7**
Emissions							
EF CO_2 – gasoline (t/TJ)	68.6	68.6	68.6	68.6	68.6	68.6	68.6
EF CO_2 – diesel (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
EF CO_2 – LPG (t/TJ)	62.4	62.4	62.4	62.4	62.4	62.4	62.4
CO_2 emission (Gg)	**3475.3**	**3036.5**	**4114.4**	**4168.8**	**4452.5**	**4842.6**	**4987.5**
EF CH_4 – gasoline (kg/TJ)	20.0	28.2	36.3	38.0	35.7	33.7	33.6
EF CH_4 – diesel (kg/TJ)	5.0	4.5	4.0	3.9	3.7	3.5	3.6
EF CH_4 – LPG (kg/TJ)	20.0	19.4	18.7	18.6	17.8	17.8	19.2
CH_4 emission (Mg)	**755.9**	**792.7**	**1342.3**	**1356.0**	**1303.0**	**1244.0**	**1207.8**
EF N_2O – gasoline (kg/TJ)	0.6	3.0	5.4	5.9	6.9	7.8	8.3
EF N_2O – diesel (kg/TJ)	0.6	3.6	6.5	7.1	7.3	7.1	7.3
EF N_2O – LPG (kg/TJ)	5.0	5.0	5.0	5.1	4.8	4.8	5.1
N_2O emission (Mg)	**29.7**	**140.3**	**341.3**	**378.0**	**443.0**	**508.8**	**540.0**

Table A2-13: The GHG emissions from Domestic Air Transport

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Gasoline (1000 t)			0.1		0.1	0.2	1.1
NCV for gasoline (MJ/kg)			44.6		44.6	44.6	44.6
Jet kerosene (1000 t)	95	28	40	52	50	45	50
NCV for jet kerosene (MJ/kg)	44.0	44.0	44.0	44.0	44.0	44.0	44.0
Total fuel consumption (TJ)	**4176.2**	**1230.9**	**1762.9**	**2285.9**	**2202.5**	**1987.1**	**2233.9**
Emissions							
EF CO_2 – gasoline (t/TJ)	68.6	68.6	68.6	68.6	68.6	68.6	68.6
EF CO_2 – jet kerosene (t/TJ)	70.8	70.8	70.8	70.8	70.8	70.8	70.8
CO_2 emission (Gg)	**295.6**	**87.1**	**124.8**	**161.8**	**155.9**	**140.6**	**159.0**
EF CH_4 – gasoline (kg/TJ)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
EF CH_4 – jet kerosene (kg/TJ)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
CH_4 emission (Mg)	**2.1**	**0.6**	**0.9**	**1.1**	**1.1**	**1.0**	**1.1**
EF N_2O – gasoline (kg/TJ)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
EF N_2O – jet kerosene (kg/TJ)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
N_2O emission (Mg)	**8.4**	**2.5**	**3.5**	**4.6**	**4.4**	**4.0**	**4.5**

Table A2-14: The GHG emissions from National Navigation

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Gasoline (1000 t)	0.1	0.6	0.3	0.4	0.3	0.3	
NCV for gasoline (MJ/kg)	44.6	44.6	44.6	44.6	44.6	44.6	
Diesel (1000 t)	40.3	24.7	25.7	25.6	27.9	28.6	29.1
NCV for diesel (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Fuel oil (1000 t)	2.1	6.2	1.4	3.4	7.3	6.7	
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.2	40.2	40.2	
Total fuel consumption (TJ)	**1810.1**	**1330.9**	**1167.3**	**1247.9**	**1498.4**	**1504.2**	**1242.9**
Emissions							
EF CO_2 – gasoline (t/TJ)	68.6	68.6	68.6	68.6	68.6	68.6	68.6
EF CO_2 – diesel (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
EF CO_2 – fuel oil (t/TJ)	76.6	76.6	76.6	76.6	76.6	76.6	76.6
CO_2 emission (Gg)	**133.0**	**98.3**	**85.7**	**91.9**	**110.8**	**111.1**	**91.1**
EF CH_4 – gasoline (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
EF CH_4 – diesel (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
EF CH_4 – fuel oil (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CH_4 emission (Mg)	**9.1**	**6.7**	**5.8**	**6.2**	**7.5**	**7.5**	**6.2**
EF N_2O – gasoline (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – diesel (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
N_2O emission (Mg)	**1.1**	**0.8**	**0.7**	**0.7**	**0.9**	**0.9**	**0.7**

Table A2-15: The GHG emissions from Railways

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Gasoline (1000 t)			0.1				
NCV for gasoline (MJ/kg)			44.6				
Diesel (1000 t)	37.2	32.4	27.2	28.0	27.8	28.1	29.4
NCV for diesel (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Fuel oil (1000 t)	0.2	1.5					
NCV for fuel oil (MJ/kg)	40.2	40.2					
Brown coal (1000 t)	10.0						
NCV for brown coal (MJ/kg)	16.7						
Lignite (1000 t)	4.3						
NCV for lignite (MJ/kg)	10.9						
Total fuel consumption (TJ)	**1811.1**	**1444.1**	**1166.2**	**1195.9**	**1187.3**	**1200.2**	**1255.7**
Emissions							
EF CO_2 – gasoline (t/TJ)	68.6	68.6	68.6	68.6	68.6	68.6	68.6
EF CO_2 – diesel (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
EF CO_2 – fuel oil (t/TJ)	76.6	76.6	76.6	76.6	76.6	76.6	76.6
EF CO_2 – brown coal (t/TJ)	94.1	94.1	94.1	94.1	94.1	94.1	94.1
EF CO_2 – lignite (t/TJ)	99.2	99.2	99.2	99.2	99.2	99.2	99.2
CO_2 emission (Gg)	**137.5**	**106.1**	**85.5**	**87.7**	**87.1**	**88.0**	**92.1**
EF CH_4 – gasoline (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
EF CH_4 – diesel (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
EF CH_4 – fuel oil (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
EF CH_4 – brown coal (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – lignite (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Table A2-15: The GHG emissions from Railways (cont.)

	1990	1995	2000	2001	2002	2003	2004
Emissions							
CH_4 emission (Mg)	**10.1**	**7.2**	**5.8**	**6.0**	**5.9**	**6.0**	**6.3**
EF N_2O – gasoline (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – diesel (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O – brown coal (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O – lignite (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
N_2O emission (Mg)	**1.3**	**0.9**	**0.7**	**0.7**	**0.7**	**0.7**	**0.8**

Table A2-16: The GHG emissions from Commercial/Institutional

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Petroleum (1000 t)	0.1						
NCV for petroleum (MJ/kg)	44.0						
Extra light oil (1000 t)	89.5	101.4	120.6	130.7	141.4	144.5	143.8
NCV for extra light oil (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Fuel oil (1000 t)	66.1		3.9	5	10.6	8.8	6.6
NCV for fuel oil (MJ/kg)	40.2		40.2	40.2	40.2	40.2	40.2
LPG (1000 t)	4.3	2.5	2.6	5.5	6.0	7.1	8.1
NCV for LPG (MJ/kg)	46.9	46.9	46.9	46.9	46.9	46.9	46.9
Anthracite (1000 t)				0.2			
NCV for anthracite (MJ/kg)				29.3			
Brown coal (1000 t)	24.5	12.7	9.5	5.6	8.4	10.9	4.8
NCV for brown coal (MJ/kg)	16.7	16.7	17.8	18.2	18.2	18.5	18.3
Lignite (1000 t)	40.0	1.6	1.2	2.4	2.6	2.2	0.6
NCV for lignite (MJ/kg)	10.9	10.9	12.0	12.2	12.2	12.3	12.2
Briquettes (1000 t)	2.9						
NCV for briquettes (MJ/kg)	16.7						16.7
Gas work gas (1000000 m^3)	4.9	1.4	1.5	1.6	1.7	5.0	3.8
NCV for gas work gas (MJ/m^3)	15.8	15.8	19.5	19.5	19.5	22.6	21.5
Natural gas (1000000 m^3)	102.5	133.7	98.7	133.0	124.1	129.9	138.4
NCV for natural gas (MJ/m^3)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Total fuel consumption (TJ)	**11142.3**	**9246.0**	**8998.0**	**10731.2**	**11183.6**	**11616.3**	**11669.6**
Emissions							
EF CO_2 – petroleum (t/TJ)	71.1	71.1	71.1	71.1	71.1	71.1	71.1
EF CO_2 – diesel (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
EF CO_2 – fuel oil (t/TJ)	76.6	76.6	76.6	76.6	76.6	76.6	76.6
EF CO_2 – LPG (t/TJ)	62.4	62.4	62.4	62.4	62.4	62.4	62.4
EF CO_2 – anthracite (t/TJ)	96.3	96.3	96.3	96.3	96.3	96.3	96.3
EF CO_2 – brown coal (t/TJ)	94.1	94.1	94.1	94.1	94.1	94.1	94.1
EF CO_2 – lignite (t/TJ)	99.2	99.2	99.2	99.2	99.2	99.2	99.2
EF CO_2 – briquettes (t/TJ)	94.1	94.1	94.1	94.1	94.1	94.1	94.1
EF CO_2 – gas work gas (t/TJ)	46.7	46.7	46.7	46.7	46.7	46.7	46.7
EF CO_2 – natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8

Table A2-16: The GHG emissions from Commercial/Institutional (cont.)

	1990	1995	2000	2001	2002	2003	2004
CO_2 emission (Gg)	**785.9**	**609.1**	**603.3**	**707.7**	**747.6**	**773.9**	**769.9**
EF CH_4 – petroleum (k/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – diesel (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – fuel oil (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 – LPG (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - anthracite (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - brown coal (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - lignite (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - briquettes (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - gas work gas (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - natural gas (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CH_4 emission (Mg)	**94.6**	**70.7**	**73.2**	**84.7**	**90.7**	**94.1**	**93.2**
EF N_2O - petroleum (k/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - diesel (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - anthracite (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O - brown coal (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O - lignite (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O - briquettes (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O - gas work gas (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O - natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O emission (Mg)	**5.7**	**3.5**	**3.9**	**4.3**	**4.8**	**5.0**	**4.8**

Table A2-17: The GHG emissions from Residential sector

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Petroleum (1000 t)		7.9	1.6	0.8	0.8	1.2	0.8
NCV for petroleum (MJ/kg)		44.0	44.0	44.0	44.0	44.0	44.0
Extra light oil (1000 t)	215.9	198.6	231.5	249.4	270.8	276.9	279.2
NCV for extra light oil (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Fuel oil (1000 t)	48.7	6.5	8.1	11.6	24.5	21.5	15.3
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.2	40.2	40.2	40.2
LPG (1000 t)	97.9	57.3	51.9	53.5	55.9	57.4	61.3
NCV for LPG (MJ/kg)	46.9	46.9	46.9	46.9	46.9	46.9	46.9
Brown coal (1000 t)	123.1	11.1	12.0	1.8	2.7	7.0	5.2
NCV for brown coal (MJ/kg)	16.7	16.7	17.8	18.2	18.2	18.5	18.3
Lignite (1000 t)	207.3	10.8	15.0	12.3	18.0	19.6	12.0
NCV for lignite (MJ/kg)	10.9	10.9	12.0	12.2	12.2	12.3	12.2
Briquettes (1000 t)	6.1						
NCV for briquettes (MJ/kg)	16.7						
Gas work gas (1000000 m^3)	24.4	11.8	9.9	9.9	10.8	10.8	10.6
NCV for gas work gas (MJ/m^3)	15.8	15.8	19.5	19.5	19.5	22.6	21.5
Natural gas (1000000 m^3)	230.0	381.3	496.6	561.5	548.7	633.1	629.5
NCV for natural gas (MJ/m^3)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Biomass (TJ)	19080	11070	13410	10260	10370	13455	13140
Total fuel consumption (TJ)	**47477.3**	**36301.9**	**43597.8**	**43388.0**	**44711.0**	**51028.3**	**50461.0**

Table A2-17: The GHG emissions from Residential sector (cont.)

	1990	1995	2000	2001	2002	2003	2004
Emissions							
EF CO_2 - petroleum (t/TJ)	71.1	71.1	71.1	71.1	71.1	71.1	71.1
EF CO_2 - diesel (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
EF CO_2 - fuel oil (t/TJ)	76.6	76.6	76.6	76.6	76.6	76.6	76.6
EF CO_2 - LPG (t/TJ)	62.4	62.4	62.4	62.4	62.4	62.4	62.4
EF CO_2 - brown coal (t/TJ)	94.1	94.1	94.1	94.1	94.1	94.1	94.1
EF CO_2 - lignite (t/TJ)	99.2	99.2	99.2	99.2	99.2	99.2	99.2
EF CO_2 - briquettes (t/TJ)	94.1	94.1	94.1	94.1	94.1	94.1	94.1
EF CO_2 - gas work gas (t/TJ)	46.7	46.7	46.7	46.7	46.7	46.7	46.7
EF CO_2 - natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
EF CO_2 - biomass (t/TJ)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO_2 Emission (Gg)	**1994.8**	**1596.0**	**1896.3**	**2068.5**	**2167.2**	**2354.1**	**2332.2**
EF CH_4 - petroleum (k/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - diesel (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - fuel oil (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - LPG (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - brown coal (kg/TJ)	300.0	300.0	300.0	300.0	300.0	300.0	300.0
EF CH_4 - lignite (kg/TJ)	300.0	300.0	300.0	300.0	300.0	300.0	300.0
EF CH_4 - briquettes (kg/TJ)	300.0	300.0	300.0	300.0	300.0	300.0	300.0
EF CH_4 - gas work gas (kg/TJ)	300.0	300.0	300.0	300.0	300.0	300.0	300.0
EF CH_4 - natural gas (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
EF CH_4 - biomass (kg/TJ)	300.0	300.0	300.0	300.0	300.0	300.0	300.0
CH_4 Emission (Mg)	**7363.3**	**3650.7**	**4410.6**	**3422.6**	**3499.8**	**4482.4**	**4344.2**
EF N_2O - petroleum (k/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - diesel (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - brown coal (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O - lignite (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O - briquettes (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O - gas work gas (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O - natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N_2O - biomass (kg/TJ)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
N_2O Emission (Mg)	**93.3**	**53.3**	**63.8**	**51.7**	**53.1**	**66.1**	**64.6**

Table A2-18: The GHG emissions from Agriculture/Forestry/Fishing

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Gasoline (1000 t)	4.0	7.8	12.1	10.5	8.2	8.1	7.2
NCV for gasoline (MJ/kg)	44.6	44.6	44.6	44.6	44.6	44.6	44.6
Other kerosene (1000 t)	0.1	0.1					
NCV for other kerosene (MJ/kg)	44.0	44.0					
Extra light oil (1000 t)	232.6	159.1	237.6	223.1	206	212.8	197.3
NCV for extra light oil (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Fuel consumption - mobile (TJ)	10117.1	7147.4	10687.4	9996.8	9163.9	9449.9	8747.7

Table A2-18: The GHG emissions from Agriculture/Forestry/Fishing (cont.)

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Fuel oil (1000 t)	12.3	6.2	13.4	4.8	4.7	4.7	4.6
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.2	40.2	40.2	40.2
LPG (1000 t)	4.4	3.2	2.6	2.7	2.6	2.8	2.7
NCV for LPG (MJ/kg)	46.9	46.9	46.9	46.9	46.9	46.9	46.9
Gas work gas (1000000 m^3)					0.1		
NCV for gas work gas (MJ/m^3)					19.5		
Natural gas (1000000 m^3)	25.0	15.5	14.5	23.6	24.3	19.9	19.4
NCV for natural gas (MJ/m^3)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Fuel consumption - stationary (TJ)	1550.7	926.2	1153.5	1121.9	1139.0	996.8	971.1
Total fuel consumption (TJ)	**11667.8**	**8073.6**	**11840.9**	**11118.7**	**10302.9**	**10446.7**	**9718.8**
Emissions							
EF CO_2 - gasoline (t/TJ)	68.6	68.6	68.6	68.6	68.6	68.6	68.6
EF CO_2 - other kerosene (t/TJ)	71.1	71.1	71.1	71.1	71.1	71.1	71.1
EF CO_2 - diesel (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
CO_2 emission (Gg) - mobile	**741.0**	**522.4**	**781.1**	**730.8**	**670.2**	**691.2**	**639.9**
EF CO_2 - fuel oil (t/TJ)	76.6	76.6	76.6	76.6	76.6	76.6	76.6
EF CO_2 - LPG (t/TJ)	62.4	62.4	62.4	62.4	62.4	62.4	62.4
EF CO_2 - gas work gas (t/TJ)	106.0	106.0	106.0	106.0	106.0	106.0	106.0
EF CO_2 - natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
CO_2 emission (Gg) - stationary	**98.2**	**57.9**	**76.4**	**67.5**	**68.4**	**60.4**	**58.9**
Total CO_2 emission (Gg)	**839.2**	**580.3**	**857.5**	**798.3**	**738.6**	**751.6**	**698.8**
EF CH_4 - gasoline (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
EF CH_4 - other kerosene (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
EF CH_4 - diesel (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CH_4 emission (Mg) - mobile	**50.6**	**35.7**	**53.4**	**50.0**	**45.8**	**47.2**	**43.7**
EF CH_4 - fuel oil (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - LPG (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - gas work gas (kg/TJ)	300.0	300.0	300.0	300.0	300.0	300.0	300.0
EF CH_4 - natural gas (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CH_4 emission (Mg) - stationary	**11.3**	**6.6**	**9.1**	**7.2**	**7.8**	**6.6**	**6.4**
Total CH_4 emission (Mg)	**61.8**	**42.4**	**62.5**	**57.2**	**53.6**	**53.8**	**50.2**
EF N_2O - gasoline (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - other kerosene (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - diesel (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
N_2O emission (Mg) - mobile	**6.1**	**4.3**	**6.4**	**6.0**	**5.5**	**5.7**	**5.2**
EF N_2O - fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - gas work gas (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N_2O - natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O emission (Mg) - stationary	**0.5**	**0.3**	**0.4**	**0.3**	**0.3**	**0.3**	**0.3**
Total N_2O emission (Mg)	**6.6**	**4.6**	**6.9**	**6.3**	**5.8**	**5.9**	**5.5**

Table A2-19: Methane emissions from Coal Mining and Handling from 1990 to 1999

Source and Sink Categories		Activity Data Production (PJ)	Emission Estimates CH_4 (Gg)	Emission Factor $kgCH_4/t$	Emission Factor m^3CH_4/t
Year 1990					
1B 1a Underground mines			**2.32**		
	Mining	0.174	2.04	5.86	17.50
	Post-Mining	0.174	0.29	0.82	2.45
Year 1991					
1B 1a Underground mines			**2.07**		
	Mining	0.155	1.82	5.86	17.50
	Post-Mining	0.155	0.25	0.82	2.45
Year 1992					
1B 1a Underground mines			**1.61**		
	Mining	0.120	1.41	5.86	17.50
	Post-Mining	0.120	0.20	0.82	2.45
Year 1993					
1B 1a Underground mines			**1.54**		
	Mining	0.115	1.35	5.86	17.50
	Post-Mining	0.115	0.19	0.82	2.45
Year 1994					
1B 1a Underground mines			**1.38**		
	Mining	0.103	1.21	5.86	17.50
	Post-Mining	0.103	0.17	0.82	2.45
Year 1995					
1B 1a Underground mines			**1.10**		
	Mining	0.082	0.96	5.86	17.50
	Post-Mining	0.082	0.13	0.82	2.45
Year 1996					
1B 1a Underground Mines			**0.89**		
	Mining	0.066	0.78	5.86	17.50
	Post-Mining	0.066	0.11	0.82	2.45
Year 1997					
1B 1a Underground Mines			**0.65**		
	Mining	0.049	0.57	5.86	17.50
	Post-Mining	0.049	0.08	0.82	2.45
Year 1998					
1B 1a Underground Mines			**0.68**		
	Mining	0.051	0.60	5.86	17.50
	Post-Mining	0.051	0.08	0.82	2.45
Year 1999					
1B 1a Underground Mines			**0.20**		
	Mining	0.015	0.18	5.86	17.50
	Post-Mining	0.015	0.03	0.82	2.45

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

Table A2-20: Methane emissions from Oil and Gas Activities, years 1990, 1995, 2000, 2004

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	135
	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 1995				
1B 2a Oil			**0.49**	
	Production	62.8	0.17	2650
	Transport	159.3	0.12	745
	Refining	227.6	0.17	135
	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 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	135
	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 2004				
1B 2a Liquid Fossil Fuel			**0.43**	
	Production	42.4	0.11	2650
	Transport	178.0	0.13	745
	Refining	215.4	0.16	135
	Storage	215.4	0.03	135
1B 2b Natural Gas			**61.56**	
	Prod./Process./Trans./Distrib.	77.1	35.30 1)	458000
	Other Leakage(non-residential)	83.3	23.27 2)	279500
	Other Leakage (residential)	21.4	2.99 3)	139500
1B 2c Venting and Flaring			**1.39**	
	Gas	77.1	1.39	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

Table A2-21: Non-energy fuel consumption (feedstock), 1990-2004

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	450.53	80	112.63
Bitumen	3.35	22	267.45	270.15	100	0.00
Other Fuels	6.51	20	472.33	238.55	50	238.55
TOTAL	**17.53**		**1297.30**	**959.23**		**351.18**
Year 1991						
Naphtha	3.01	20	218.42	176.50	80	44.12
Bitumen	2.37	22	189.62	191.54	100	0.00
Other Fuels	5.57	20	404.05	204.06	50	204.06
TOTAL	**10.95**		**812.08**	**572.10**		**248.19**
Year 1992						
Naphtha	3.13	20	227.15	183.56	80	45.89
Bitumen	2.04	22	162.61	164.25	100	0.00
Other Fuels	3.96	20	287.34	145.12	50	145.12
TOTAL	**9.12**		**677.11**	**492.93**		**191.01**
Year 1993						
Naphtha	1.26	20	91.25	73.74	80	18.43
Bitumen	1.48	22	118.21	119.41	100	0.00
Other Fuels	4.85	20	352.17	177.87	50	177.87
TOTAL	**7.59**		**561.64**	**371.01**		**196.30**
Year 1994						
Naphtha	0.23	20	16.50	13.34	80	3.33
Bitumen	1.81	22	144.16	145.61	100	0.00
Other Fuels	5.39	20	391.66	197.81	50	197.81
TOTAL	**7.43**		**552.31**	**356.75**		**201.14**
Year 1995						
Naphtha	0.21	20	15.21	12.29	80	3.07
Bitumen	1.36	22	108.85	109.95	100	0.00
Other Fuels	5.25	20	381.42	192.64	50	192.64
TOTAL	**6.83**		**505.48**	**314.88**		**195.71**
Year 1996						
Bitumen	3.52	22	280.91	283.75	100	0
Other Fuels	5.67	20	374.48	189.13	50	189.13
TOTAL	**9.19**		**655.38**	**472.87**		**189.13**
Year 1997						
Bitumen	3.71	22	295.89	298.88	100	0.00
Other Fuels	6.20	20	409.89	207.01	50	207.01
TOTAL	**9.91**		**705.78**	**505.89**		**207.01**
Year 1998						
Bitumen	4.15	22	331.74	335.09	100	0.00
Other Fuels	5.39	20	391.00	197.48	50	197.48
TOTAL	**9.54**		**722.74**	**532.57**		**197.48**
Year 1999						
Lubricants	1.64	20	119.17	60.19	50	60.19
Bitumen	3.96	22	316.49	319.69	100	0.00
Ethane	3.71	16.8	226.20	182.78	80	45.70
TOTAL	**9.31**		**661.86**	**562.66**		**105.88**

Table A2-21: Non-energy fuel consumption (feedstock), 1990-2004 (cont.)

Energy carrier	Feedstock use	Emission factor	Potential emission CO_2	Storage CO_2		Emission CO_2
	[PJ]	[Gg/PJ]	[Gg]	[Gg]	[%]	[Gg]
Year 2000						
Lubricants	1.49	20	108.47	54.78	50	54.78
Bitumen	3.55	22	283.58	286.45	100	0.00
Ethane	3.66	16.8	223.31	180.45	80	45.11
TOTAL	**8.71**		**615.37**	**521.68**		**99.90**
Year 2001						
Lubricants	1.53	20	110.90	56.01	50	56.01
Bitumen	3.15	22	251.48	254.02	100	0.00
Ethane	3.09	16.8	188.40	152.24	80	38.06
Other Fuels	0.25	20	17.80	8.98	50	8.99
TOTAL	**8.01**		**568.58**	**471.26**		**103.06**
Year 2002						
Lubricants	1.60	20	116.01	58.59	50	58.01
Bitumen	4.60	22	367.05	370.76	100	0.00
Ethane	2.86	16.8	174.55	141.05	80	34.91
Other Fuels	0.13	20	9.34	4.72	50	4.67
TOTAL	**9.19**		**666.95**	**575.12**		**98.57**
Year 2003						
Lubricants	1.53	20	112.52	56.26	50	56.26
Bitumen	7.25	22	584.78	584.78	100	0.00
Ethane	3.67	16.8	164.66	131.73	80	32.93
Other Fuels	0.33	20	24.46	12.23	50	12.23
TOTAL	**11.79**		**886.42**	**785.00**		**101.42**
Year 2004						
Lubricants	1.86	20	136.59	68.30	50	68.30
Bitumen	8.26	22	666.40	666.38	100	0.00
Ethane	315	16.8	193.80	155.04	80	38.76
Other Fuels	0.13	20	9.43	4.72	50	4.72
TOTAL	**13.40**		**1006.22**	**894.43**		**111.77**

Table A2-22: The GHG emissions from non-energy fuel consumption and statistical difference

	1990	1995	2000	2001	2002	2003	2004
Fuel consumption							
Ethane (1000 t)			77.4	65.3	60.5	56.5	65.5
NCV for ethane (MJ/kg)			47.3	47.3	47.3	47.3	47.3
Carbon stored - ethane (%)			80	80	80	80	0.8
Lubricants (1000 t)	193.8	156.5	44.6	45.6	47.7	45.8	55.6
NCV for lubricants (MJ/kg)	33.6	33.6	33.5	33.5	33.5	33.5	33.5
Carbon stored - lubricants (%)	50	50	50	50	50	50	0.5
Other products (1000 t)				6.1	3.2	8.3	3.2
NCV for other products (MJ/kg)				40.2	40.2	40.2	40.2
Carbon stored - other products (%)				50	50	50	0.5
Naphtha (1000 t)	172.3	3.7					
NCV for naphtha (MJ/kg)	44.6	44.6					
Carbon stored - naphtha (%)	80	80					
Fuel cons. - non-energy (TJ)	**14185.3**	**5418.6**	**5155.9**	**4862.1**	**4588.8**	**4540.9**	**5090,0**
Petroleum (1000 t)	3.5						
NCV for petroleum (MJ/kg)	44.0						
Natural gas (1000000 m3)	42.3						

Table A2-22: The GHG emissions from non-energy fuel consumption and statistical difference (cont.)

NCV for natural gas (MJ/m3)	34.0						
Fuel cons. – stat. difference (TJ)	**1592.1**						
Total fuel consumption (TJ)	**15777.3**	**5418.6**	**5155.9**	**4862.1**	**4588.8**	**4540.9**	**5090,0**
Emissions							
EF CO_2 - ethane (t/TJ)	61.0	61.0	61.0	61.0	61.0	61.0	61.0
EF CO_2 - lubricants (t/TJ)	72.6	72.6	72.6	72.6	72.6	72.6	72.6
EF CO_2 - other products (t/TJ)	72.6	72.6	72.6	72.6	72.6	72.6	72.6
EF CO_2 - naphtha (t/TJ)	72.6	72.6	72.6	72.6	72.6	72.6	72.6
CO_2 emission - non-energy (Gg)	**347.7**	**193.1**	**98.9**	**102.0**	**97.6**	**100.4**	**110.7**
Fuel consumption							
EF CO_2 - natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
CO_2 emission – stat. difference (Gg)	**91.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Total CO_2 emission (Gg)	**438.9**	**193.1**	**98.9**	**102.0**	**97.6**	**100.4**	**110.7**
EF CH_4 - petroleum (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH_4 - natural gas (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CH_4 emission – stat. difference (Mg)	**8.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
EF N_2O - petroleum (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N_2O - natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O emission – stat. difference (Mg)	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

ANNEX 3

CO_2 REFERENCE APPROACH AND COMPARISON WITH SECTORAL APPROACH, AND RELEVANT INFORMATION ON THE NATIONAL ENERGY BALANCE

Table A3-1: Fuel combustion CO_2 emissions (Reference and Sectoral Approach)

YEAR	FUEL TYPES	Reference approach		Sectoral 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	12792.36	196.31	13595.44	-2.55	-5.91
	Solid Fuels	34.27	3102.87	32.15	3161.82	6.60	-1.87
	Gaseous Fuels	91.34	5098.80	68.28	3811.48	33.77	33.77
	Total	**316.91**	**20994.04**	**319.42**	**20568.81**	**6.80**	**2.07**
1991	Liquid Fuels	133.52	8988.23	138.23	9671.01	-3.41	-7.06
	Solid Fuels	21.07	1850.52	21.04	1945.44	0.13	-4.88
	Gaseous Fuels	84.57	4720.74	56.37	3146.47	50.03	50.03
	Total	**239.16**	**15559.49**	**231.29**	**14762.91**	**10.91**	**5.40**
1992	Liquid Fuels	124.69	8462.96	129.78	9154.72	-3.92	-7.56
	Solid Fuels	16.80	1433.76	16.34	1405.74	2.79	1.99
	Gaseous Fuels	87.68	4894.21	57.23	3194.48	53.21	53.21
	Total	**229.17**	**14790.93**	**216.95**	**13754.95**	**12.70**	**7.53**
1993	Liquid Fuels	122.29	8395.35	132.97	9449.17	-8.04	-11.15
	Solid Fuels	14.19	1176.38	13.72	1165.77	3.42	0.91
	Gaseous Fuels	100.47	5608.19	69.64	3887.01	44.28	44.28
	Total	**236.94**	**15179.92**	**229.21**	**14501.95**	**9.53**	**4.67**
1994	Liquid Fuels	129.12	9050.62	131.23	9340.18	-1.67	-3.10
	Solid Fuels	8.99	753.01	8.42	720.82	6.74	4.47
	Gaseous Fuels	87.11	4862.33	64.24	3585.63	35.61	35.61
	Total	**225.22**	**14665.95**	**217.08**	**13646.64**	**10.41**	**7.47**
1995	Liquid Fuels	144.32	10095.79	148.23	10597.08	-2.64	-4.73
	Solid Fuels	7.29	696.28	7.65	713.28	-4.75	-2.38
	Gaseous Fuels	80.51	4493.95	55.05	3073.02	46.24	46.24
	Total	**232.12**	**15286.02**	**224.51**	**14383.39**	**10.04**	**6.28**
1996	Liquid Fuels	150.78	10601.74	151.03	10787.16	-0.17	-1.72
	Solid Fuels	6.21	581.76	6.59	610.03	-5.86	-4.63
	Gaseous Fuels	90.22	5035.79	65.38	3649.59	37.98	37.98
	Total	**247.20**	**16219.29**	**239.15**	**15046.77**	**10.85**	**7.79**
1997	Liquid Fuels	151.59	10608.77	156.98	11181.83	-3.43	-5.12
	Solid Fuels	10.17	948.59	10.55	977.74	-3.57	-2.98
	Gaseous Fuels	93.52	5220.07	68.33	3814.33	36.85	36.85
	Total	**255.29**	**16777.44**	**252.56**	**15973.90**	**8.24**	**5.03**
1998	Liquid Fuels	167.88	11790.93	169.05	12127.33	-0.69	-2.77
	Solid Fuels	9.87	920.05	10.29	948.91	-4.05	-3.04
	Gaseous Fuels	89.91	5018.52	69.63	3886.63	29.12	29.12
	Total	**267.66**	**17729.50**	**263.63**	**16962.87**	**7.51**	**4.52**
1999	Liquid Fuels	180.87	12695.27	179.37	12848.04	0.64	-1.19
	Solid Fuels	8.63	803.39	9.06	830.61	-4.81	-3.28
	Gaseous Fuels	91.15	5087.79	67.81	3785.10	34.42	34.42
	Total	**280.65**	**18586.44**	**270.53**	**17463.75**	**9.37**	**6.43**
2000	Liquid Fuels	157.40	11039.96	158.49	11216.86	-0.69	-1.58
	Solid Fuels	18.65	1732.78	19.03	1765.04	-1.98	-1.83
	Gaseous Fuels	91.96	5133.34	68.88	3845.07	33.50	33.50
	Total	**268.01**	**17906.08**	**262.05**	**16826.98**	**8.77**	**6.41**
2001	Liquid Fuels	162.16	11456.23	163.70	11660.55	-0.94	-1.75
	Solid Fuels	19.83	1842.48	20.06	1854.62	-1.16	-0.65
	Gaseous Fuels	96.36	5378.92	75.04	4188.52	28.42	28.42
	Total	**278.36**	**18677.64**	**271.04**	**17703.68**	**7.56**	**5.50**

Table A3-1: Fuel combustion CO_2 emissions (Reference and Sectoral Approach) - cont.

YEAR	FUEL TYPES	Reference approach		Sectoral approach		Difference	
		Energy consumption (PJ)	**CO_2 emissions (Gg)**	**Energy consumption (PJ)**	**CO_2 emissions (Gg)**	**Energy consumption (%)**	**CO_2 emissions (%)**
2002	Liquid Fuels	173.50	12194.47	170.25	12159.44	1.91	0.29
	Solid Fuels	23.93	2224.09	24.90	2300.42	-3.88	-3.32
	Gaseous Fuels	98.66	5507.22	79.19	4420.54	24.58	24.58
	Total	**296.09**	**19925.78**	**286.74**	**18880.41**	**7.93**	**5.54**
2003	Liquid Fuels	190.69	13299.37	186.26	13351.42	2.38	-0.39
	Solid Fuels	27.20	2532.94	27.56	2545.21	-1.30	-0.48
	Gaseous Fuels	98.07	5474.20	77.14	4305.75	27.14	27.14
	Total	**315.96**	**21306.51**	**306.92**	**20202.38**	**8.59**	**5.47**
2004	Liquid Fuels	178.90	12324.06	172.59	12308.83	3.66	0.12
	Solid Fuels	28.88	2687.52	28.80	2663.04	0.27	0.92
	Gaseous Fuels	102.32	5711.24	83.93	4684.94	21.91	21.91
	Total	**310.09**	**20722.82**	**301.18**	**19656.81**	**8.68**	**5.42**

* - Excluding international bunkers

Table A3-2: Net calorific values for different fossil fuels from 1990 to 2004

			Net calorific values 1990- 2004 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	44.59
		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	24.3-26.9
		Sub Bituminous Coal	16.74-18.73
		Lignite	10.52-12.15
	Secondary Fuel	Gas Work Gas	15.82-22.63
		Coke Oven Coke	29.31
			TJ/Mm^3
Natural Gas		Natural Gas	34
Biomass		Solid Biomass Fuel Wood	9

Table A3-3: National energy balance for 2004

	Anthracite		Hard coal		Brown coal		Lignite	
	10^3 t	PJ	10^3 t	PJ	10^3 t	PJ	10^3 t	PJ
Production	-	-	-	-	-	-	-	-
Import	0.4	0.01	1218.1	29.60	69.3	1.26	13.3	0.16
Export	-	-	1.0	0.02	0.1	0.0	-	-
Stock change	-	-	-111.0	-2.70	-	-	-	-
International marine bunkers	-	-	-	-	-	-	-	-
Energy supplied	**0.4**	**0.01**	**1106.1**	**26.88**	**69.2**	**1.26**	**13.3**	**0.16**
Energy sector own use	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
-oil and gas extraction	-	-	-	-	-	-	-	-
-electric energy supply industry	-	-	-	-	-	-	-	-
-oil refineries	-	-	-	-	-	-	-	-
-NGL plant	-	-	-	-	-	-	-	-
Total transformation sector	**0.0**	**0.0**	**852.4**	**20.71**	**53.3**	**0.97**	**0.0**	**0.0**
-hydro power plants	-	-	-	-	-	-	-	-
-thermal power plants	-	-	852.4	20.71	-	-	-	-
-public cogeneration plants	-	-	-	-	-	-	-	-
-public heating plants	-	-	-	-	-	-	-	-
-industrial cogeneration plants	-	-	-	-	51.3	0.93	14.3	0.18
-industrial heating plants	-	-	-	-	2.0	0.04	1.2	0.01
-petroleum refineries	-	-	-	-	-	-	-	-
-NGL-plant	-	-	-	-	-	-	-	-
-gas works	-	-	-	-	-	-	-	-
Non energy use	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Losses	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Final energy demand	**0.4**	**0.01**	**253.7**	**6.16**	**15.9**	**0.29**	**13.3**	**0.16**
Industry	**0.4**	**0.01**	**253.7**	**6.16**	**5.9**	**0.11**	**0.7**	**0.01**
-iron and steel	-	-	-	-	-	-	-	-
-non-ferrous metals	-	-	-	-	-	-	-	-
-non-metallic minerals	-	-	-	-	-	-	-	-
-chemical	-	-	1.6	0.04	-	-	-	-
-construction materials	-	-	252.1	6.13	5.7	0.10	0.5	0.01
-pulp and paper	-	-	-	-	-	-	-	-
-food production	-	-	-	-	-	-	-	-
-not elsewhere specified	0.4	0.01	-	-	0.2	0.00	0.2	0.00
Other sectors	-	-	-	-	**10.0**	**0.18**	**12.6**	**0.15**
-households	-	-	-	-	5.2	0.09	12.0	0.15
-services	-	-	-	-	4.8	0.09	0.6	0.01
-agriculture	-	-	-	-	-	-	-	-
-construction	-	-	-	-	-	-	-	-
Transport	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
-rail	-	-	-	-	-	-	-	-
-road	-	-	-	-	-	-	-	-
-air	-	-	-	-	-	-	-	-
-sea and river	-	-	-	-	-	-	-	-
-public city	-	-	-	-	-	-	-	-

Table A3-3: National energy balance for 2004 (continue)

	Crude Oil		Natural gas		Fuel wood		Industrial waste
	10^3 t	PJ	10^6 m^3	PJ	10^3 m^3	PJ	TJ
Production	1001.0	42.44	2198.1	77.08	-	-	2723
Import	4197.6	177.98	1053.6	35.82	1460.0	13.14	-
Export	-	-	347.6	11.82	-	-	-
Stock change	-8.7	-0.37	105.2	3.58	-	-	-
International marine bunkers	-	-	-	-	-	-	-
Energy supplied	**5189.9**	**220.05**	**3009.3**	**104.66**	**1460.0**	**13.14**	**2723**
Energy sector own use	**0.0**	**0.0**	**70.2**	**2.39**	**0.0**	**0.0**	**0.0**
-oil and gas extraction	-	-	56.1	1.91	-	-	-
-electric energy supply industry	-	-	-	-	-	-	-
-oil refineries	-	-	0.3	0.01	-	-	-
-NGL plant	-	-	13.8	0.47	-	-	-
Total transformation sector	**5189.9**	**220.05**	**1206.7**	**43.37**	**0.0**	**0.0**	**2723**
-hydro power plants	-	-	-	-	-	-	-
-thermal power plants	-	-	130.4	4.43	-	-	-
-public cogeneration plants	-	-	581.0	19.75	-	-	-
-public heating plants	-	-	64.3	2.19	-	-	-
-industrial cogeneration plants	-	-	287.8	9.79	-	-	105
-industrial heating plants	-	-	104.8	3.56	-	-	2618
-petroleum refineries	5079.3	215.36	-	-	-	-	-
-NGL-plant	110.6	4.69	38.4	3.65	-	-	-
-gas works	-	-	-	-	-	-	-
Non energy use	**0.0**	**0.0**	**487.7**	**16.48**	**0.0**	**0.0**	**0.0**
Losses	**0.0**	**0.0**	**74.9**	**2.55**	**0.0**	**0.0**	**0.0**
Final energy demand	**0.0**	**0.0**	**1172.8**	**39.88**	**1460.0**	**13.14**	-
Industry	**0.0**	**0.0**	**385.5**	**13.11**	**0.0**	**0.0**	**0.0**
-iron and steel	-	-	19.1	0.65	-	-	-
-non-ferrous metals	-	-	1.8	0.06	-	-	-
-non-metallic minerals	-	-	67.9	2.31	-	-	-
-chemical	-	-	76.7	2.61	-	-	-
-construction materials	-	-	119.8	4.07	-	-	-
-pulp and paper	-	-	1.7	0.06	-	-	-
-food production	-	-	56.4	1.92	-	-	-
-not elsewhere specified	-	-	42.1	1.43	-	-	-
Other sectors	**0.0**	**0.0**	**787.3**	**26.77**	**1460.0**	**13.14**	**0.0**
-households	-	-	629.5	21.40	1460.0	13.14	-
-services	-	-	138.4	4.71	-	-	-
-agriculture	-	-	19.4	0.66	-	-	-
-construction	-	-	-	-	-	-	-
Transport	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
-rail	-	-	-	-	-	-	-
-road	-	-	-	-	-	-	-
-air	-	-	-	-	-	-	-
-sea and river	-	-	-	-	-	-	-
-public city	-	-	-	-	-	-	-

Table A3-3: National energy balance for 2004 (continue)

	Coke oven coke		Liquefied petroleum gases		Unleaded motor gasoline		Standard motor gasoline	
	10^3 t	PJ	10^3 t	PJ	10^3 t	PJ	10^3 t	PJ
Production	-	-	375.9	17.63	961.1	42.86	265.2	11.83
Import	19.4	0.57	7.6	0.36	136.0	6.06	1.0	0.04
Export	0.1	0.00	249.2	11.68	400.1	17.84	209.4	9.34
Stock change	-	-	0.2	0.01	-28.4	-1.27	-1.7	-0.08
International marine bunkers	-	-	-	-	-	-	-	-
Energy supplied	**19.3**	**0.57**	**134.5**	**6.31**	**668.6**	**29.81**	**55.1**	**2.46**
Energy sector own use	**0.0**	**0.0**	**5.7**	**0.27**	**0.0**	**0.0**	**0.0**	**0.0**
-oil and gas extraction	-	-	-	-	-	-	-	-
-electric energy supply industry	-	-	-	-	-	-	-	-
-oil refineries	-	-	5.7	0.27	-	-	-	-
-NGL plant	-	-	-	-	-	-	-	-
Total transformation sector	**0.0**	**0.0**	**23.7**	**1.11**	**0.0**	**0.0**	**0.0**	**0.0**
-hydro power plants	-	-	-	-	-	-	-	-
-thermal power plants	-	-	-	-	-	-	-	-
-public cogeneration plants	-	-	-	-	-	-	-	-
-public heating plants	-	-	-	-	-	-	-	-
-industrial cogeneration plants	-	-	11.6	0.54	-	-	-	-
-industrial heating plants	-	-	1.0	0.05	-	-	-	-
-petroleum refineries	-	-	-	-	-	-	-	-
-NGL-plant	-	-	-	-	-	-	-	-
-gas works	-	-	11.1	0.52	-	-	-	-
Non energy use	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Losses	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Final energy demand	**19.3**	**0.57**	**105.1**	**4.93**	**668.6**	**29.81**	**55.1**	**2.46**
Industry	**19.3**	**0.57**	**15.5**	**0.73**	**0.0**	**0.0**	**0.0**	**0.0**
-iron and steel	-	-	3.6	0.17	-	-	-	-
-non-ferrous metals	-	-	1.8	0.08	-	-	-	-
-non-metallic minerals	7.3	0.21	2.1	0.10	-	-	-	-
-chemical	-	-	-	-	-	-	-	-
-construction materials	5.2	0.15	3.8	0.18	-	-	-	-
-pulp and paper	-	-	0.1	0.00	-	-	-	-
-food production	6.8	0.20	0.2	0.01	-	-	-	-
-not elsewhere specified	-	-	3.9	0.18	-	-	-	-
Other sectors	**0.0**	**0.0**	**72.9**	**3.42**	**17.2**	**0.77**	**0.0**	**0.0**
-households	-	-	61.3	2.87	-	-	-	-
-services	-	-	8.1	0.38	-	-	-	-
-agriculture	-	-	2.7	0.13	7.2	0.32	-	-
-construction	-	-	0.8	0.04	10.2	0.45	-	-
Transport	**0.0**	**0.0**	**16.7**	**0.78**	**651.2**	**29.04**	**55.1**	**2.46**
-rail	-	-	-	-	-	-	-	-
-road	-	-	16.7	0.78	651.2	29.04	54.0	2.41
-air	-	-	-	-	-	-	1.1	0.05
-sea and river	-	-	-	-	-	-	-	-
-public city	-	-	-	-	-	-	-	-

Table A3-3: National energy balance for 2004 (continue)

	Petroleum		Jet fuel		Diesel oil		Light heating oil	
	10^3 t	PJ	10^3 t	PJ	10^3 t	PJ	10^3 t	PJ
Production	0.8	0.04	91.3	4.01	1191.9	50.91	549.0	23.45
Import	0.6	0.03	-	-	423.2	18.07	47.9	2.05
Export	0.6	0.03	8.9	0.39	367.2	15.68	127.9	5.46
Stock change	-	-	-4.2	-0.18	-18.3	0.78	27.6	1.18
International marine bunkers	-	-	-	-	7.8	0.33	-	-
Energy supplied	**0.8**	**0.04**	**78.2**	**3.44**	**1221.8**	**52.18**	**496.6**	**21.21**
Energy sector own use	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**6.3**	**0.27**
-oil and gas extraction	-	-	-	-	-	-	6.3	0.27
-electric energy supply industry	-	-	-	-	-	-	-	-
-oil refineries	-	-	-	-	-	-	-	-
-NGL plant	-	-	-	-	-	-	-	-
Total transformation sector	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**17.1**	**0.73**
-hydro power plants	-	-	-	-	-	-	-	-
-thermal power plants	-	-	-	-	-	-	2.2	0.09
-public cogeneration plants	-	-	-	-	-	-	0.3	0.01
-public heating plants	-	-	-	-	-	-	6.8	0.29
-industrial cogeneration plants	-	-	-	-	-	-	-	-
-industrial heating plants	-	-	-	-	-	-	7.8	0.33
-petroleum refineries	-	-	-	-	-	-	-	-
-NGL-plant	-	-	-	-	-	-	-	-
-gas works	-	-	-	-	-	-	-	-
Non energy use	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Losses	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Final energy demand	**0.8**	**0.04**	**78.2**	**3.44**	**1221.8**	**52.18**	**473.2**	**20.21**
Industry	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**36.0**	**1.54**
-iron and steel	-	-	-	-	-	-	1.8	0.08
-non-ferrous metals	-	-	-	-	-	-	3.4	0.15
-non-metallic minerals	-	-	-	-	-	-	4.1	0.18
-chemical	-	-	-	-	-	-	0.7	0.03
-construction materials	-	-	-	-	-	-	7.6	0.32
-pulp and paper	-	-	-	-	-	-	0.0	-
-food production	-	-	-	-	-	-	9.5	0.41
-not elsewhere specified	-	-	-	-	-	-	8.9	0.38
Other sectors	**0.8**	**0.04**	**0.0**	**0.0**	**275.2**	**11.75**	**437.2**	**18.67**
-households	0.8	0.04	-	-	-	-	279.2	11.92
-services	-	-	-	-	-	-	143.8	6.14
-agriculture	-	-	-	-	183.1	7.82	14.2	0.61
-construction	-	-	-	-	92.1	3.93	-	-
Transport	**0.0**	**0.0**	**78.2**	**3.44**	**946.6**	**40.43**	**0.0**	**0.0**
-rail	-	-	-	-	29.4	1.26	-	-
-road	-	-	-	-	861.5	36.79	-	-
-air	-	-	78.2	3.44	-	-	-	-
-sea and river	-	-	-	-	29.1	1.24	-	-
-public city	-	-	-	-	26.6	1.14	-	-

Table A3-3: National energy balance for 2004 (continue)

	Low sulphur fuel oil		Standard fuel oil		Naphta		White spirit	
	10^3 t	PJ	10^3 t	PJ	10^3 t	PJ	10^3 t	PJ
Production	4.7	0.19	1007.1	40.48	247.4	11.03	-	-
Import	100.3	4.03	113.3	4.55	-	-	5.4	0.18
Export	6.1	0.25	298.4	11.99	212.6	9.48	-	-
Stock change	4.3	0.17	10.0	0.40	-34.8	-1.55	-	-
International marine bunkers	-	-	15.8	0.64	-	-	-	-
Energy supplied	**103.2**	**4.15**	**816.2**	**32.80**	**0.0**	**0.0**	**5.4**	**0.18**
Energy sector own use	**0.0**	**0.0**	**66.2**	**2.66**	**0.0**	**0.0**	**0.0**	**0.0**
-oil and gas extraction	-	-	-	-	-	-	-	-
-electric energy supply industry	-	-	-	-	-	-	-	-
-oil refineries	-	-	66.2	2.66	-	-	-	-
-NGL plant	-	-	-	-	-	-	-	-
Total transformation sector	**34.5**	**1.39**	**654.5**	**26.30**	**0.0**	**0.0**	**0.0**	**0.0**
-hydro power plants	-	-	-	-	-	-	-	-
-thermal power plants	34.5	1.39	217.0	8.72	-	-	-	-
-public cogeneration plants	-	-	113.5	4.56	-	-	-	-
-public heating plants	-	-	38.6	1.55	-	-	-	-
-industrial cogeneration plants	-	-	249.9	10.04	-	-	-	-
-industrial heating plants	-	-	35.5	1.43	-	-	-	-
-petroleum refineries	-	-	-	-	-	-	-	-
-NGL-plant	-	-	-	-	-	-	-	-
-gas works	-	-	-	-	-	-	-	-
Non energy use	**0.0**	**0.0**	**0.0**	**-**	**0.0**	**0.0**	**5.4**	**0.18**
Losses	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Final energy demand	**68.7**	**2.76**	**95.5**	**3.84**	**0.0**	**0.0**	**0.0**	**0.0**
Industry	**68.7**	**2.76**	**69.0**	**2.77**	**0.0**	**0.0**	**0.0**	**0.0**
-iron and steel	0.2	0.01	-	-	-	-	-	-
-non-ferrous metals	2.6	0.10	-	-	-	-	-	-
-non-metallic minerals	3.0	0.12	-	-	-	-	-	-
-chemical	57.4	2.31	1.9	0.08	-	-	-	-
-construction materials	0.0	-	59.2	2.38	-	-	-	-
-pulp and paper	0.0	-	1.6	0.06	-	-	-	-
-food production	2.6	0.10	1.0	0.04	-	-	-	-
-not elsewhere specified	2.9	0.12	5.3	0.21	-	-	-	-
Other sectors	**0.0**	**0.0**	**26.5**	**1.07**	**0.0**	**0.0**	**0.0**	**0.0**
-households	-	-	15.3	0.61	-	-	-	-
-services	-	-	6.6	0.27	-	-	-	-
-agriculture	-	-	4.6	0.18	-	-	-	-
-construction	-	-	-	-	-	-	-	-
Transport	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
-rail	-	-	-	-	-	-	-	-
-road	-	-	-	-	-	-	-	-
-air	-	-	-	-	-	-	-	-
-sea and river	-	-	-	-	-	-	-	-
-public city	-	-	-	-	-	-	-	-

Table A3-3: National energy balance for 2004 (continue)

	Bitumen		Lubricants		Paraffin and wax		Petroleum coke	
	10^3 t	**PJ**	**10^3 t**	**PJ**	**10^3 t**	**PJ**	**10^3 t**	**PJ**
Production	217.2	7.28	62.0	2.08	9.0	0.30	111.6	3.46
Import	107.8	3.61	21.6	0.72	5.4	0.18	68.5	2.12
Export	71.0	2.38	46.2	1.55	3.4	0.11	40.3	1.25
Stock change	-7.4	-0.25	2.0	0.07	-0.2	-0.01	-1.8	-0.06
International marine bunkers	-	-	-	-	-	-	-	-
Energy supplied	**246.6**	**8.26**	**39.4**	**1.32**	**10.8**	**0.36**	**138.0**	**4.28**
Energy sector own use	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**63.4**	**1.97**
-oil and gas extraction	-	-	-	-	-	-	-	-
-electric energy supply industry	-	-	-	-	-	-	-	-
-oil refineries	-	-	-	-	-	-	63.4	1.97
-NGL plant	-	-	-	-	-	-	-	-
Total transformation sector	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**6.2**	**0.19**
-hydro power plants	-	-	-	-	-	-	-	-
-thermal power plants	-	-	-	-	-	-	-	-
-public cogeneration plants	-	-	-	-	-	-	-	-
-public heating plants	-	-	-	-	-	-	-	-
-industrial cogeneration plants	-	-	-	-	-	-	6.2	0.19
-industrial heating plants	-	-	-	-	-	-	-	-
-petroleum refineries	-	-	-	-	-	-	-	-
-NGL-plant	-	-	-	-	-	-	-	-
-gas works	-	-	-	-	-	-	-	-
Non energy use	**246.6**	**8.26**	**39.4**	**1.32**	**10.8**	**0.36**	**0.0**	**0.0**
Losses	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Final energy demand	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**68.4**	**2.12**
Industry	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**68.4**	**2.12**
-iron and steel	-	-	-	-	-	-	0.2	0.01
-non-ferrous metals	-	-	-	-	-	-	-	-
-non-metallic minerals	-	-	-	-	-	-	-	-
-chemical	-	-	-	-	-	-	1.1	0.03
-construction materials	-	-	-	-	-	-	67.1	2.08
-pulp and paper	-	-	-	-	-	-	-	-
-food production	-	-	-	-	-	-	-	-
-not elsewhere specified	-	-	-	-	-	-	-	-
Other sectors	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
-households	-	-	-	-	-	-	-	-
-services	-	-	-	-	-	-	-	-
-agriculture	-	-	-	-	-	-	-	-
-construction	-	-	-	-	-	-	-	-
Transport	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
-rail	-	-	-	-	-	-	-	-
-road	-	-	-	-	-	-	-	-
-air	-	-	-	-	-	-	-	-
-sea and river	-	-	-	-	-	-	-	-
-public city	-	-	-	-	-	-	-	-

Table A3-3: National energy balance for 2004 (continue)

	Ethane		Refinery gas		Refinery semiproducts		Aditives	
	10^3 t	PJ	10^3 t	PJ	10^3 t	PJ	10^3 t	PJ
Production	65.5	3.10	263.8	12.81	-	-	-	-
Import	-	-	-	-	256.5	10.88	15.0	0.64
Export	-	-	-	-	-	-	-	-
Stock change	-	-	-	-	10.3	0.44	0.4	0.02
International marine bunkers	-	-	-	-	-	-	-	-
Energy supplied	**65.5**	**3.10**	**263.8**	**12.81**	**266.8**	**11.31**	**15.4**	**0.65**
Energy sector own use	**0.0**	**0.0**	**241.7**	**11.74**	**0.0**	**0.0**	**0.0**	**0.0**
-oil and gas extraction	-	-	-	-	-	-	-	-
-electric energy supply industry	-	-	-	-	-	-	-	-
-oil refineries	-	-	241.7	11.74	-	-	-	-
-NGL plant	-	-	-	-	-	-	-	-
Total transformation sector	**0.0**	**0.0**	**22.1**	**1.07**	**266.8**	**11.31**	**15.4**	**0.65**
-hydro power plants	-	-	-	-	-	-	-	-
-thermal power plants	-	-	-	-	-	-	-	-
-public cogeneration plants	-	-	-	-	-	-	-	-
-public heating plants	-	-	-	-	-	-	-	-
-industrial cogeneration plants	-	-	22.1	1.07	-	-	-	-
-industrial heating plants	-	-	-	-	-	-	-	-
-petroleum refineries	-	-	-	-	266.8	11.31	15.4	0.65
-NGL-plant	-	-	-	-	-	-	-	-
-gas works	-	-	-	-	-	-	-	-
Non energy use	**65.5**	**3.10**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Losses	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Final energy demand	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Industry	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
-iron and steel	-	-	-	-	-	-	-	-
-non-ferrous metals	-	-	-	-	-	-	-	-
-non-metallic minerals	-	-	-	-	-	-	-	-
-chemical	-	-	-	-	-	-	-	-
-construction materials	-	-	-	-	-	-	-	-
-pulp and paper	-	-	-	-	-	-	-	-
-food production	-	-	-	-	-	-	-	-
-not elsewhere specified	-	-	-	-	-	-	-	-
Other sectors	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
-households	-	-	-	-	-	-	-	-
-services	-	-	-	-	-	-	-	-
-agriculture	-	-	-	-	-	-	-	-
-construction	-	-	-	-	-	-	-	-
Transport	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
-rail	-	-	-	-	-	-	-	-
-road	-	-	-	-	-	-	-	-
-air	-	-	-	-	-	-	-	-
-sea and river	-	-	-	-	-	-	-	-
-public city	-	-	-	-	-	-	-	-

Table A3-3: National energy balance for 2004 (cont.)

	Gas works gas		Other products		Electricity		Steam and hot water
	10^3 m^3	PJ	10^3 t	PJ	GWh	PJ	TJ
Production	20040.5	0.43	74.3	2.99	13321.3	47.96	35092.8
Import	-	-	2.9	0.12	5298.0	19.07	-
Export	-	-	13.2	0.53	1632.8	5.88	-
Stock change	-	-	-60.8	-2.44	-	-	-
International marine bunkers	-	-	-	-	-	-	-
Energy supplied	**20040.5**	**0.43**	**3.2**	**0.13**	**16987.0**	**61.15**	**35092.8**
Energy sector own use	**0.0**	**0.0**	**0.0**	**0.0**	**1074.8**	**3.87**	**9620.8**
-oil and gas extraction	-	-	-	-	106.7	0.38	1366.0
-electric energy supply industry	-	-	-	-	30.9	0.11	-
-hydro power plants	-	-	-	-	166.0	0.60	-
-thermal power plants	-	-	-	-	285.0	1.03	-
-public cogeneration plants	-	-	-	-	148.6	0.53	890.8
-oil refineries	-	-	-	-	323.4	1.16	7364.0
-NGL plant	-	-	-	-	14.2	0.05	-
Total transform. production	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
-hydro power plants	-	-	-	-	-	-	-
-thermal power plants	-	-	-	-	-	-	-
-public cogeneration plants	-	-	-	-	-	-	-
-public heating plants	-	-	-	-	-	-	-
-industrial cogeneration plants	-	-	-	-	-	-	-
-industrial heating plants	-	-	-	-	-	-	-
-gas works	-	-	-	-	-	-	
Total transformation sector	**1335.0**	**0.03**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
-public heating plants	1335.0	0.03	-	-	-	-	
Non energy use	**0.0**	**0.0**	**3.2**	**0.13**	**0.0**	**0.0**	**0.0**
Losses	**1298.0**	**0.03**	**0.0**	**0.0**	**2223.9**	**8.01**	**1563.9**
Final energy demand	**17407.5**	**0.37**	**0.0**	**0.0**	**13687.8**	**49.28**	**23908.1**
Industry	**2966.5**	**0.06**	**0.0**	**0.0**	**3215.8**	**11.58**	**15625.0**
-iron and steel	-	-	-	-	252.8	0.91	164.0
-non-ferrous metals	-	-	-	-	80.2	0.29	0.0
-non-metallic minerals	797.0	0.02	-	-	126.4	0.46	91.0
-chemical	-	-	-	-	478.6	1.72	5115.0
-construction materials	-	-	-	-	590.5	2.13	36.0
-pulp and paper	-	-	-	-	241.4	0.87	1975.0
-food production	102.5	0.00	-	-	571.7	2.06	4726.0
-not elsewhere specified	2067.0	0.04	-	-	874.2	3.15	3518.0
Other sectors	**14441.0**	**0.31**	**0.0**	**0.0**	**10185.9**	**36.67**	**8283.1**
-households	10617.0	0.23	-	-	6072.1	21.86	6587.0
-services	3824.0	0.08	-	-	3715.9	13.38	1696.1
-agriculture	-	-	-	-	65.4	0.24	-
-construction	-	-	-	-	332.5	1.20	-
Transport	**0.0**	**0.0**	**0.0**	**0.0**	**286.1**	**1.03**	**0.0**
-rail	-	-	-	-	161.9	0.58	-
-road	-	-	-	-	-	-	-
-air	-	-	-	-	14.9	0.05	-
-sea and river	-	-	-	-	29.7	0.11	-
-public city	-	-	-	-	56.8	0.20	-
-other	-	-	-	-	22.8	0.08	-

ANNEX 4

ASSESSMENT OF COMPLETENESS AND (POTENTIAL) SOURCES AND SINKS OF GREENHOUSE GAS EMISSIONS AND REMOVALS EXCLUDED

Table A4-1 shows source/sink categories of GHGs that are not estimated in the Croatian GHG inventory, and the explanations for those categories being omitted. This table is taken from the CRF Table9s1.

Table A4-1 GHGs and source/sink categories not considered in the Croatian GHG inventory

GHG	Sector	Source/sink category	Explanation
CO_2	2. Industrial Processes	2.A.5 Asphalt Roofing	The IPCC Guidelines do not provide methodologies for calculation of CO_2 emission
CO_2	2. Industrial Processes	2.A.6 Road Paving with Asphalt	The IPCC Guidelines do not provide methodologies for calculation of CO_2 emission
CO_2	2. Industrial Processes	2.A.7.1 Glass Production	The IPCC Guidelines do not provide methodologies for calculation of CO_2 emission
CO_2	2. Industrial Processes	2.B.5.2 Ethylene	The IPCC Guidelines do not provide methodologies for calculation of CO_2 emission
CO_2	2. Industrial Processes	2.D.2 Food and Drink	CO_2 from Food and Drink Production (e.g. gasification of water) can be of biogenic or non-biogenic origin. Only information on CO_2 emissions of non-biogenic origin should be reported.
CO_2	2. Industrial Processes	Propylene	The IPCC Guidelines do not provide methodologies for calculation of CO_2 emission.
CO_2	2. Industrial Processes	Polyvinilchloride	The IPCC Guidelines do not provide methodologies for calculation of CO_2 emission.
CO_2	2. Industrial Processes	Polystyrene	The IPCC Guidelines do not provide methodologies for calculation of CO_2 emission
CO_2	2. Industrial Processes	Sulphuric acid production	The IPCC Guidelines do not provide methodologies for calculation of CO_2 emission.
CO_2	2. Industrial Processes	Polyethene low density	The IPCC Guidelines do not provide methodologies for calculation of CO_2 emission.
CO_2	3. Solvent and Other Product Use	3.A Paint Application	The IPCC Guidelines do not provide methodologies for the calculation of CO_2 emissions from Solvent and Other Product.
CO_2	3. Solvent and Other Product Use	3.B Degreasing and Dry Cleaning	The IPCC Guidelines do not provide methodologies for the calculation of CO_2 emissions from Solvent and Other Product.
CO_2	3. Solvent and Other Product Use	3.C Chemical Products, Manufacture and Processing	The IPCC Guidelines don not provide methodologies for the calculation of CO_2 emissions from Solvent and Other Products.
CO_2	5. LULUCF	5.A.1 Forest Land remaining Forest Land	Dificulies in collecting adequate activity data.
CO_2	5. LULUCF	5.B.1 Cropland remaining Cropland	Dificulties in collecting adequate activity data.
CO_2	5. LULUCF	5.B.2 Land converted to Cropland	Dificulties in collecting adequate activity data.
CO_2	5. LULUCF	5.B.2.1 Forest Land converted to Cropland	Dificulties in collecting adequate activity data.
CO_2	5. LULUCF	5.C.1 Grassland remaining Grassland	Dificulties in collecting adequate activity data.
CO_2	5. LULUCF	5.D.1 Wetlands remaining Wetlands	Dificulties in collecting adequate activity data.
CO_2	5. LULUCF	Harvested Wood Products	Dificulties in collecting adequate activity data.

Table A4-1 GHGs and source/sink categories not considered in the Croatian GHG inventory (cont.)

GHG	Sector	Source/sink category	Explanation
CO_2	6. Waste	6.A.1 Managed Waste Disposal on Land	IPCC Guidelines do not provide methodology for the calculation of CO_2 emissions from Solid Waste Disposal on Land.
CO_2	6. Waste	Other non-specified	No waste incineration occurs except of incineration of clinical waste. Emissions from incineration of clinical waste are not estimated because activity data are not available.
CH_4	1. Energy	1.B.2.A.1 Exploration	Activity data and emission factors were not available.
CH_4	1. Energy	1.B.2.B.1 Exploration	Activity data and emission factors were not available.
CH_4	2. Industrial Processes	2.A.7.1 Glass Production	The IPCC Guidelines do not provide methodologies for calculation of CH_4 emission.
CH_4	2. Industrial Processes	2.B.1 Ammonia Production	The IPCC Guidelines do not provide methodologies for calculation of CH_4 emission.
CH_4	2. Industrial Processes	2.C.1.1 Steel	The IPCC Guidelines do not provide methodologies for calculation of CH_4 emission.
CH_4	2. Industrial Processes	Propylene	The IPCC Guidelines do not provide methodologies for calculation of CH_4 emission.
CH_4	2. Industrial Processes	Polyvinilchloride	The IPCC Guidelines do not provide methodologies for calculation of CH_4 emission.
CH_4	2. Industrial Processes	Polystyrene	The IPCC Guidelines do not provide methodologies for calculation of CH_4 emission.
CH_4	2. Industrial Processes	Sulphuric acid production	The IPCC Guidelines do not provide methodologies for calculation of CH_4 emission.
CH_4	2. Industrial Processes	Polyethene low density	The IPCC Guidelines do not provide methodologies for calculation of CH_4 emission.
CH_4	4. Agriculture	4.F.3.1 Potatoes	Data are not available.
CH_4	4. Agriculture	4.F.4 Sugar Cane	Data are not available.
CH_4	4. Agriculture	Other non-specified	Data are not available.
CH_4	4. Agriculture	Other non-specified	Data are not available.
CH_4	5. LULUCF	5.A.1 Forest Land remaining Forest Land	Dificulties in collecting adequate activity data.
CH_4	5. LULUCF	5.A.2 Land converted to Forest Land	Dificulties in collecting adequate activity data.
CH_4	5. LULUCF	5.B.1 Cropland remaining Cropland	Dificulties in collecting adequate activity data.
CH_4	5. LULUCF	5.B.2 Land converted to Cropland	Dificulties in collecting adequate activity data.
CH_4	5. LULUCF	5.B.2.1 Forest Land converted to Cropland	Dificulties in collecting adequate activity data.
CH_4	5. LULUCF	5.C.1 Grassland remaining Grassland	Dificulties in collecting adequate activity data.

Table A4-1 GHGs and source/sink categories not considered in the Croatian GHG inventory (cont.)

GHG	Sector	Source/sink category	Explanation
CH_4	5. LULUCF	5.D.1 Wetlands remaining Wetlands	Dificulties in collecting adequate activity data.
CH_4	5. LULUCF	5.E.1 Settlements remaining Settlements	Dificulties in collecting adequate activity data.
CH_4	5. LULUCF	5.E.2 Land converted to Settlements	Dificulties in collecting adequate activity data.
CH_4	5. LULUCF	5.F.1 Other Land remaining Other Land	Dificulties in collecting adequate activity data.
CH_4	5. LULUCF	Harvested Wood Products	Dificulties in collecting adequate activity data.
CH_4	6. Waste	6.B.2.1 Domestic and Commercial (w/o human sewage)	Activity data are not available
CH_4	6. Waste	Incineration of hospital wastes	No waste incineration occurs except of incineration of clinical waste. Emissions from incineration of clinical waste are not estimated because activity data are not available.
CH_4	6. Waste	Other non-specified	No waste incineration occurs except of incineration of clinical waste. Emissions from incineration of clinical waste are not estimated because activity data are not available.
N_2O	2. Industrial Processes	2.A.7.1 Glass Production	The IPCC Guidelines do not provide methodologies for calculation of N_2O emission
N_2O	2. Industrial Processes	2.B.1 Ammonia Production	The IPCC Guidelines do not provide methodologies for calculation of N_2O emission
N_2O	2. Industrial Processes	2.B.5.2 Ethylene	The IPCC Guidelines do not provide methodologies for calculation of N_2O emission
N_2O	2. Industrial Processes	Propylene	The IPCC Guidelines do not provide methodologies for calculation of N_2O emission
N_2O	2. Industrial Processes	Polyvinilchloride	The IPCC Guidelines do not provide methodologies for calculation of N_2O emission
N_2O	2. Industrial Processes	Polystyrene	The IPCC Guidelines do not provide methodologies for calculation of N_2O emission
N_2O	2. Industrial Processes	Sulphuric acid production	The IPCC Guidelines do not provide methodologies for calculation of N_2O emission
N_2O	2. Industrial Processes	Polyethene low density	The IPCC Guidelines do not provide methodologies for calculation of N_2O emission
N_2O	3. Solvent and Other Product Use	3.B Degreasing and Dry Cleaning	N_2O emissions from medical uses and other posible sources are not estimated because activity data are not available.
N_2O	3. Solvent and Other Product Use	3.D.1 Use of N2O for Anaesthesia	N_2O emissions from medical uses and other posible sources are not estimated because activity data are not available.
N_2O	3. Solvent and Other Product Use	3.D.2 Fire Extinguishers	N_2O emissions from medical uses and other posible sources are not estimated because activity data are not available.
N_2O	3. Solvent and Other Product Use	3.D.3 N_2O from Aerosol Cans	N_2O emissions from medical uses and other posible sources are not estimated because activity data are not available.
N_2O	3. Solvent and Other Product Use	3.D.4 Other Use of N_2O	N_2O emissions from medical uses and other posible sources are not estimated because activity data are not available.

Table A4-1 GHGs and source/sink categories not considered in the Croatian GHG inventory (cont.)

GHG	Sector	Source/sink category	Explanation
N_2O	4. Agriculture	4.F.3.1 Potatoes	Data are not available.
N_2O	4. Agriculture	4.F.4 Sugar Cane	Data are not available.
N_2O	4. Agriculture	Other non-specified	Data are not available.
N_2O	4. Agriculture	Other non-specified	Data are not available.
N_2O	5. LULUCF	5.A Forest Land	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.A Forest Land	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.A.1 Forest Land remaining Forest Land	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.A.2 Land converted to Forest Land	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.B.1 Cropland remaining Cropland	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.B.2 Land converted to Cropland	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.B.2.1 Forest Land converted to Cropland	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.B.2.1 Forest Land converted to Cropland	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.B.2.1 Forest Land converted to Cropland	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.B.2.2 Grassland converted to Cropland	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.B.2.2 Grassland converted to Cropland	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.B.2.5 Other Land converted to Cropland	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.B.2.5 Other Land converted to Cropland	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.C.1 Grassland remaining Grassland	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.D Wetlands	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.D Wetlands	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.D.1 Wetlands remaining Wetlands	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.E.1 Settlements remaining Settlements	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	5.E.2 Land converted to Settlements	Dificulties in collecting adequate activity data.

Table A4-1 GHGs and source/sink categories not considered in the Croatian GHG inventory (cont.)

GHG	Sector	Source/sink category	Explanation
N_2O	5. LULUCF	5.F.1 Other Land remaining Other Land	Dificulties in collecting adequate activity data.
N_2O	5. LULUCF	Harvested Wood Products	Dificulties in collecting adequate activity data.
N_2O	6. Waste	6.B.2.1 Domestic and Commercial (w/o human sewage)	Activity data are not available.
N_2O	6. Waste	Incineration of hospital wastes	No waste incineration occurs except of incineration of clinical waste. Emissions from incineration of clinical waste are not estimated because activity data are not available.
N_2O	6. Waste	Other non-specified	No waste incineration occurs except of incineration of clinical waste. Emissions from incineration of clinical waste are not estimated because activity data are not available.
HFCs	2. Industrial Processes	2.F.2 Foam Blowing	Total potential emissions were not estimated because input data for those emissions were not available.
HFCs	2. Industrial Processes	2.F.3 Fire Extinguishers	Total potential emissions were not estimated because input data for those emissions were not available.
HFCs	2. Industrial Processes	2.F.4 Aerosols/ Metered Dose Inhalers	Total potential emissions were not estimated because input data for those emissions were not available.
HFCs	2. Industrial Processes	2.F.5 Solvents	Total potential emissions were not estimated because input data for those emissions were not available.
SF_6	2. Industrial Processes	2.F.8 Electrical Equipment	Total potential emission from Consumption of SF6 is not estimated because input data for emission calculation is not available.
SF_6	2. Industrial Processes	2.F.8 Electrical Equipment	Total actual emission from Consumption of SF6 is not estimated because input data for emission calculation is not available.
SF_6	2. Industrial Processes	2.F.P2.1 In bulk	The potential emissions of SF6 are not estimated because there are no data available.
SF_6	2. Industrial Processes	2.F.P3.1 In bulk	Total potential emissions of SF6 are not estimated because no data are available.
Carbon	5. LULUCF	5.A.2.2 Grassland converted to Forest Land	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.1 Cropland remaining Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.2.2 Grassland converted to Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.2.4 Settlements converted to Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.2.5 Other Land converted to Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.C.1 Grassland remaining Grassland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.D.1 Wetlands remaining Wetlands	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.E.1 Settlements remaining Settlements	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.E.2.5 Other Land converted to Settlements	Dificulties in collecting adequate activity data.

Table A4-1 GHGs and source/sink categories not considered in the Croatian GHG inventory (cont.)

GHG	Sector	Source/sink category	Explanation
Carbon	5. LULUCF	5.A.2.2 Grassland converted to Forest Land	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.1 Cropland remaining Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.2.2 Grassland converted to Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.2.4 Settlements converted to Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.2.5 Other Land converted to Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.C.1 Grassland remaining Grassland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.D.1 Wetlands remaining Wetlands	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.E.1 Settlements remaining Settlements	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.E.2.5 Other Land converted to Settlements	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.C Grassland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.C Grassland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.A.2.2 Grassland converted to Forest Land	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.1 Cropland remaining Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.2.2 Grassland converted to Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.2.4 Settlements converted to Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.2.5 Other Land converted to Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.C.1 Grassland remaining Grassland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.D.1 Wetlands remaining Wetlands	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.E.1 Settlements remaining Settlements	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.E.2.5 Other Land converted to Settlements	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.A.2.2 Grassland converted to Forest Land	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.1 Cropland remaining Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.2.2 Grassland converted to Cropland	Dificulties in collecting adequate activity data.

Table A4-1 GHGs and source/sink categories not considered in the Croatian GHG inventory (cont.)

GHG	Sector	Source/sink category	Explanation
Carbon	5. LULUCF	5.B.2.4 Settlements converted to Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.B.2.5 Other Land converted to Cropland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.C.1 Grassland remaining Grassland	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.D.1 Wetlands remaining Wetlands	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.E.1 Settlements remaining Settlements	Dificulties in collecting adequate activity data.
Carbon	5. LULUCF	5.E.2.5 Other Land converted to Settlements	Dificulties in collecting adequate activity data.

ANNEX 5

TABLE 6.1 OF THE IPCC GOOD PRACTICE GUIDANCE

Table A5-1: Tier 1 Uncertainty Calculation and Reporting – excluding LULUCF (Table 6.1 – IPCC Good Practice Guidance)

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC Source Category	**GHG**	**Base year emissions 1990**	**Year t emissions 2004**	**Activity data uncertainty**	**Emission factor uncertainty**	**Combined uncertainty**	**Combined uncertainty as % of total emissions in year t**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor uncertainty**	**Uncertainty in trend in national emissions introduced by activity data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
			Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%	%	%	%	%	%	%
1A	CO_2 Emissions from Stationary Combustion - Coal	CO_2	3,141.488	2,663.037	5	5	7.07	0.64	-0.01	0.09	-0.05	0.43	0.43
1A	CO_2 Emissions from Stationary Combustion - Oil	CO_2	8,782.686	6,317.157	5	5	7.07	1.52	-0.06	0.20	-0.32	1.01	1.06
1A	CO_2 Emissions from Stationary Combustion - Gas	CO_2	3,764.030	4,648.125	5	5	7.07	1.12	0.03	0.15	0.17	0.75	0.77
1A	Mobile Combustion - Road Vehicles	CO_2	3,475.304	4,987.540	5	5	7.07	1.20	0.05	0.16	0.27	0.80	0.85
1A	Mobile Combustion: Water-borne Navigation	CO_2	132.980	91.130	5	5	7.07	0.02	0.00	0.00	-0.01	0.01	0.02
1A	Mobile Combustion: Aircraft	CO_2	295.612	158.951	5	5	7.07	0.04	0.00	0.01	-0.02	0.03	0.03
1A	Mobile Combustion: Railways	CO_2	137.525	92.070	5	5	7.07	0.02	0.00	0.00	-0.01	0.01	0.02
1A	Mobile Combustion - Agriculture/Forestry/Fishing	CO_2	839.186	698.8	5	5	7.07	0.17	0.00	0.02	-0.02	0.11	0.11
1B	CO_2 Emissions from Natural Gas Scrubbing*	CO_2	415.95	710.000	10	3	10.44	0.25	0.01	0.02	0.03	0.23	0.23
2A	CO_2 Emissions from Cement Production	CO_2	1,022.903	1,459.004	3	6	6.71	0.33	0.02	0.05	0.09	0.14	0.17
2A	CO_2 Emissions from Lime Production	CO_2	159.780	174.341	7.5	15	16.77	0.10	0.00	0.01	0.01	0.04	0.04
2A	CO_2 Emissions from Limestone and Dolomite Use	CO_2	43.218	11.515	7.5	30	30.92	0.01	0.00	0.00	-0.03	0.00	0.03
2A	CO_2 Emissions from Soda Ash Production and Use	CO_2	25.740	16.526	7.5	30	30.92	0.0174	-0.0003	0.0005	-0.0075	0.0040	0.0085
2C	CO_2 Emissions from Iron and Steel Production	CO_2	0.867	0.394	7.5	30	30.92	0.0004	0.0000	0.0000	-0.0004	0.0001	0.0004
2B	CO_2 Emissions from Ammonia Production	CO_2	491.551	522.576	3	5	5.83	0.1035	0.0019	0.0168	0.0093	0.0504	0.0512
2C	CO_2 Emissions from Ferroalloys Production	CO_2	194.526		7.5	30	30.92	0.0000	-0.0059	0.0000	-0.1773	0.0000	0.1773
2C	Aluminium Production	CO_2	111.372		3	30	30.15	0.0000	-0.0034	0.0000	-0.1015	0.0000	0.1015
6C	Emissions from Waste Incineration	CO_2		0.078	10	30	31.62	0.000084	0.000003	0.000003	0.000075	0.000025	0.000079
		CO_2 Total	**23,034.7**	**22,551.2**									
1A	Fuel Combustion - Stationary Sources	CH_4	171.702	104.510	5	20	20.62	0.0732	-0.0019	0.0034	-0.0372	0.0168	0.0408
1A	Mobile Combustion - Road Vehicles	CH_4	15.875	25.364	5	40	40.31	0.0347	0.0003	0.0008	0.0133	0.0041	0.0139
1A	Mobile Combustion: Water-borne Navigation	CH_4	0.190	0.131	5	40	40.31	0.0002	0.0000	0.0000	-0.0001	0.0000	0.0001
1A	Mobile Combustion: Aircraft	CH_4	0.044	0.024	5	40	40.31	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1A	Mobile Combustion: Railways	CH_4	0.213	0.132	5	40	40.31	0.0002	0.0000	0.0000	-0.0001	0.0000	0.0001
1A	Mobile Combustion - Agriculture/Forestry/Fishing	CH_4	1.299	1.1	5	40	40.31	0.0014	0.0000	0.0000	-0.0002	0.0002	0.0003

Table A5-1: Tier 1 Uncertainty Calculation and Reporting – excluding LULUCF (Table 6.1 – IPCC Good Practice Guidance) (cont.)

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC Source Category	**GHG**	**Base year emissions 1990**	**Year t emissions 2004**	**Activity data uncertainty**	**Emission factor uncertainty**	**Combined uncertainty**	**Combined uncertainty as % of total emissions in year t**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor uncertainty**	**Uncertainty in trend in national emissions introduced by activity data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
			Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%	%	%	%	%	%	%
1B	Fugitive Emissions from Coal Mining and Handling	CH_4	48.757		5	250	250.05	0.0000	-0.0015	0.0000	-0.3703	0.0000	0.3703
1B	Fugitive Emissions from Oil and Gas Operations	CH_4	1,186.258	1331.00	5	300	300.04	13.5689	0.0067	0.0428	2.0159	0.2138	2.0272
2B	Production of Other Chemicals	CH_4	15.798	5.890	7.5	30	30.92	0.0062	-0.0003	0.0002	-0.0087	0.0014	0.0088
4A	CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	1,343.853	815.640	30	40	50.00	1.3856	-0.0146	0.0262	-0.5847	0.7862	0.9798
4B	CH_4 Emissions from Manure Management	CH_4	227.409	180.547	30	40	50.00	0.3067	-0.0011	0.0058	-0.0443	0.1740	0.1796
4F	Agricultural Residue Burning	CH_4					0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6A	Solid Waste Disposal Sites	CH_4	221.208	486.807	50	50	70.71	1.1696	0.0089	0.0156	0.4460	0.7821	0.9003
6B	Emissions from Waste Water Handling	CH_4		63.650	10	30	31.62	0.0684	0.0020	0.0020	0.0614	0.0205	0.0647
	CH_4 Total		**3232.6**	**3014.8**									
1A	Fuel Combustion - Stationary Sources	N_2O	65.307	50.253	5	200	200.06	0.3416	-0.0004	0.0016	-0.0739	0.0081	0.0744
1A	Mobile Combustion - Road Vehicles	N_2O	9.221	167.400	5	200	200.06	1.1379	0.0051	0.0054	1.0197	0.0269	1.0200
1A	Mobile Combustion: Water-borne Navigation	N_2O	0.337	0.231	5	200	200.06	0.0016	0.0000	0.0000	-0.0006	0.0000	0.0006
1A	Mobile Combustion: Aircraft	N_2O	2.589	1.393	5	200	200.06	0.0095	0.0000	0.0000	-0.0068	0.0002	0.0068
1A	Mobile Combustion: Railways	N_2O	0.390	0.234	5	200	200.06	0.0016	0.0000	0.0000	-0.0009	0.0000	0.0009
1A	Mobile Combustion - Agriculture/Forestry/Fishing	N_2O	2.038	1.7	5	200	200.06	0.0116	0.0000	0.0001	-0.0014	0.0003	0.0015
2B	Nitric Acid Production	N_2O	927.561	802.311	3	30	30.15	0.8219	-0.0024	0.0258	-0.0721	0.0773	0.1057
4B	N_2O Emissions from Manure Management	N_2O	376.710	235.194	30	60	50.00	0.3996	-0.0039	0.0076	-0.2333	0.2267	0.3253
4B	Direct N_2O Emissions from Agricultural Soils	N_2O	1,334.723	1,266.466	30	40	50.00	2.1515	0.0001	0.0407	0.0055	1.2207	1.2208
4D	N_2O Emissions from Pasture, Range and Paddock Manure	N_2O	223.323	216.527	30	40	50.00	0.3678	0.0002	0.0070	0.0069	0.2087	0.2088
4F	Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O	900.332	844.003	30	60	67.08	1.9237	-0.0002	0.0271	-0.0142	0.8135	0.8137
6C	Emissions from Waste Incineration	N_2O		0.078	10	30	31.62	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001
6B	Emissions from Waste Water Handling	N_2O	77.117	91.272	10	30	31.62	0.0981	0.0006	0.0029	0.0177	0.0293	0.0342
	N_2O Total		**3919.6**	**3677.1**									

Table A5-1: Tier 1 Uncertainty Calculation and Reporting – excluding LULUCF (Table 6.1 – IPCC Good Practice Guidance) (cont.)

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC Source Category	**GHG**	**Base year emissions 1990**	**Year t emissions 2004**	**Activity data uncertainty**	**Emission factor uncertainty**	**Combined uncertainty**	**Combined uncertainty as % of total emissions in year t**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor uncertainty**	**Uncertainty in trend in national emissions introduced by activity data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
			Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%	%	%	%	%	%	%
2F	HFC Emissions from Consumption of HFCs, PFCs and SF6	HFC		188.871	70		70.00	0.4492	0.0061	0.0061	0.0000	0.4248	0.4248
2C	PFC Emissions from Aluminium production	PFC	936.564		30	50	58.31	0.0000	-0.0284	0.0000	-1.4224	0.0000	1.4224
	HFC/PFC/SF_6 Total		**936.6**	**188.9**									
	Total GHG Emissions	**CO_2-eq**	**31,123.53**	**29,431.859**									
	Total Uncertainties (Level/Trend)							**14.0869**					**3.4153**

Table A5-2: Tier 1 Uncertainty Calculation and Reporting – including LULUCF (Table 6,1 – IPCC Good Practice Guidance)

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC Source Category	**GHG**	**Base year emissions 1990**	**Year t emissions 2004**	**Activity data uncertainty**	**Emission factor uncertainty**	**Combined uncertainty**	**Combined uncertainty as % of total emissions in year t**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor uncertainty**	**Uncertainty in trend in national emissions introduced by activity data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
			Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%	%	%	%	%	%	%
1A	CO_2 Emissions from Stationary Combustion - Coal	CO_2	3,141.488	2,663.037	5	5	7.07	0.41	-0.01	0.06	-0.05	0.29	0.30
1A	CO_2 Emissions from Stationary Combustion - Oil	CO_2	8,782.686	6,317.157	5	5	7.07	0.98	-0.05	0.14	-0.27	0.69	0.75
1A	CO_2 Emissions from Stationary Combustion - Gas	CO_2	3,764.030	4,648.125	5	5	7.07	0.72	0.02	0.10	0.10	0.51	0.52
1A	Mobile Combustion - Road Vehicles	CO_2	3,475.304	4,987.540	5	5	7.07	0,77	0,03	0,11	0,16	0,55	0,57
1A	Mobile Combustion: Water-borne Navigation	CO_2	132.980	91.130	5	5	7.07	0,01	0,00	0,00	0,00	0,01	0,01
1A	Mobile Combustion: Aircraft	CO_2	295.612	158.951	5	5	7.07	0,02	0,00	0,00	-0,02	0,02	0,02
1A	Mobile Combustion: Railways	CO_2	137.525	92.070	5	5	7.07	0,01	0,00	0,00	-0,01	0,01	0,01
1A	Mobile Combustion - Agriculture/Forestry/Fishing	CO_2	839.186	698.8	5	5	7.07	0.11	0.00	0.02	-0.02	0.08	0.08
1B	CO_2 Emissions from Natural Gas Scrubbing*	CO_2	415.95	710.000	10	3	10.44	0.16	0.01	0.02	0.02	0.16	0.16
2A	CO_2 Emissions from Cement Production	CO_2	1,022.903	1,459.004	3	6	6.71	0.21	0.01	0.03	0.06	0.10	0.11
2A	CO_2 Emissions from Lime Production	CO_2	159.780	174.341	7.5	15	16.77	0.06	0.00	0.00	0.00	0.03	0.03
2A	CO_2 Emissions from Limestone and Dolomite Use	CO_2	43.218	11.515	7.5	30	30,92	43,08	53,03	68,33	86,49	110,23	140,11
2A	CO_2 Emissions from Soda Ash Production and Use	CO_2	25.740	16.526	7.5	30	30.92	0.0112	-0.0002	0.0004	-0.0061	0.0027	0.0067
2C	CO_2 Emissions from Iron and Steel Production	CO_2	0.867	0.394	7.5	30	30.92	0.0003	0.0000	0.0000	-0.0003	0.0001	0.0003
2B	CO_2 Emissions from Ammonia Production	CO_2	491.551	522.576	3	5	5.83	0.0666	0.0006	0.0115	0.0032	0.0344	0.0346
2C	CO_2 Emissions from Ferroalloys Production	CO_2	194.526		7.5	30	30.92	0.0000	-0.0043	0.0000	-0.1286	0.0000	0.1286
2C	Aluminium Production	CO_2	111.372		3	30	30.15	0.0000	-0.0025	0.0000	-0.0736	0.0000	0.0736
5A	Forest land remaining forest land	CO_2	-14,436.821	-16,320.782	45	60	75.00	26.7538	0.0399	0.3582	2.3932	16.1200	16.2967
6C	Emissions from Waste Incineration	CO_2		0.078	10	30	31.62	0.000054	0.000002	0.000002	0.000051	0.000017	0.000054
		CO_2 Total	**8,597.9**	**6,230.4**									
1A	Fuel Combustion - Stationary Sources	CH_4	171.702	104.510	5	20	20.62	0.0471	-0.0015	0.0023	-0.0298	0.0115	0.0319
1A	Mobile Combustion - Road Vehicles	CH_4	15.875	25.364	5	40	40.31	0.0223	0.0002	0.0006	0.0083	0.0028	0.0087
1A	Mobile Combustion: Water-borne Navigation	CH_4	0.190	0.131	5	40	40.31	0.0001	0.0000	0.0000	-0.0001	0.0000	0.0001
1A	Mobile Combustion: Aircraft	CH_4	0.044	0.024	5	40	40.31	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table A5-2: Tier 1 Uncertainty Calculation and Reporting – including LULUCF (Table 6,1 – IPCC Good Practice Guidance) (cont.)

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC Source Category	**GHG**	**Base year emissions 1990**	**Year t emissions 2004**	**Activity data uncertainty**	**Emission factor uncertainty**	**Combined uncertainty**	**Combined uncertainty as % of total emissions in year t**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor uncertainty**	**Uncertainty in trend in national emissions introduced by activity data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
			Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%	%	%	%	%	%	%
1A	Mobile Combustion: Railways	CH_4	0.213	0.132	5	40	40.31	0.0001	0.0000	0.0000	-0.0001	0.0000	0.0001
1A	Mobile Combustion – Agriculture/Forestry/Fishing	CH_4	1.299	1.1	5	40	40.31	0.0009	0.0000	0.0000	-0.0002	0.0001	0.0002
1B	Fugitive Emissions from Coal Mining and Handling	CH_4	48.757		5	250	250.05	0.0000	-0.0011	0.0000	-0.2687	0.0000	0.2687
1B	Fugitive Emissions from Oil and Gas Operations	CH_4	1,186.258	1331.00	5	300	300.04	8.7286	0.0031	0.0292	0.9199	0.1461	0.9314
2B	Production of Other Chemicals	CH_4	15.798	5.890	7.5	30	30.92	0.0040	-0.0002	0.0001	-0.0066	0.0010	0.0066
4A	CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	1,343.853	815.640	30	40	50.00	0.8914	-0.0117	0.0179	-0.4686	0.5371	0.7128
4B	CH_4 Emissions from Manure Management	CH_4	227.409	180.547	30	40	50.00	0.1973	-0.0010	0.0040	-0.0420	0.1189	0.1261
4F	Agricultural Residue Burning	CH_4					0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6A	Solid Waste Disposal Sites	CH_4	221.208	486.807	50	50	70.71	0.7524	0.0058	0.0107	0.2904	0.5342	0.6081
6B	Emissions from Waste Water Handling	CH_4		63.650	10	30	31.62	0.0440	0.0014	0.0014	0.0419	0.0140	0.0442
		CH_4 Total	**3,232.6**	**3,014.8**									
1A	Fuel Combustion – Stationary Sources	N_2O	65.307	50.253	5	200	200.06	0.2197	-0.0003	0.0011	-0.0673	0.0055	0.0675
1A	Mobile Combustion – Road Vehicles	N_2O	9.221	167.400	5	200	200.06	0.7320	0.0035	0.0037	0.6942	0.0184	0.6944
1A	Mobile Combustion: Water-borne Navigation	N_2O	0.337	0.231	5	200	200.06	0.0010	0.0000	0.0000	-0.0005	0.0000	0.0005
1A	Mobile Combustion: Aircraft	N_2O	2.589	1.393	5	200	200.06	0.0061	0.0000	0.0000	-0.0053	0.0002	0.0053
1A	Mobile Combustion: Railways	N_2O	0.390	0.234	5	200	200.06	0.0010	0.0000	0.0000	-0.0007	0.0000	0.0007
1A	Mobile Combustion – Agriculture/Forestry/Fishing	N_2O	2.038	1.7	5	200	200.06	0.0075	0.0000	0.0000	-0.0015	0.0002	0.0015
2B	Nitric Acid Production	N_2O	927.561	802.311	3	30	30.15	0.5287	-0.0028	0.0176	-0.0850	0.0528	0.1001
4B	N_2O Emissions from Manure Management	N_2O	376.710	235.194	30	60	50.00	0.2570	-0.0031	0.0052	-0.1884	0.1549	0.2439
4B	Direct N_2O Emissions from Agricultural Soils	N_2O	1,334.723	1,266.466	30	40	50.00	1.3840	-0.0016	0.0278	-0.0649	0.8339	0.8364
4D	N_2O Emissions from Pasture, Range and Paddock Manure	N_2O	223.323	216.527	30	40	50.00	0.2366	-0.0002	0.0048	-0.0068	0.1426	0.1427
4F	Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O	900.332	844.003	30	60	67.08	1.2375	-0.0013	0.0185	-0.0792	0.5557	0.5614
6C	Emissions from Waste Incineration	N_2O		0.078	10	30	31.62	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001
6B	Emissions from Waste Water Handling	N_2O	77.117	91.272	10	30	31.62	0.0631	0.0003	0.0020	0.0091	0.0200	0.0220
		N_2O Total	**3919.6**	**3677.1**									

Table A5-2: Tier 1 Uncertainty Calculation and Reporting – including LULUCF (Table 6.1 – IPCC Good Practice Guidance) (cont.)

	A	B	C	D	E	F	G	H	I	J	K	L	M
	IPCC Source Category	**GHG**	**Base year emissions 1990**	**Year t emissions 2004**	**Activity data uncertainty**	**Emission factor uncertainty**	**Combined uncertainty**	**Combined uncertainty as % of total emissions in year t**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor uncertainty**	**Uncertainty in trend in national emissions introduced by activity data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
			Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%	%	%	%	%	%	%
2F	HFC Emissions from Consumption of HFCs, PFCs and SF_6	HFC		188.871	70		70.00	0.2890	0.0041	0.0041	0.0000	0.2902	0.2902
2C	PFC Emissions from Aluminium production	PFC	936.564		30	50	58.31	0.0000	-0.0206	0.0000	-1.0320	0.0000	1.0320
	HFC/PFC/SF_6 Total		**936.6**	**188.9**									
	Total GHG Emissions	**CO_2-eq**	**16,686.71**	**13,111.077**									
	Total Uncertainties (Level/Trend)							**28.2469**					**16.4373**

ANNEX 6

QA/QC FRAMEWORK PLAN

Table A6-1: The framework of the Croatian QA/QC Plan

Item	Check/Review			Corrective actions		Comments
	Individual (first initial, last name)	Delivery date	Date of performance	Individual (first initial, last name)	Final date	
A. DATA GATHERING, INPUT, AND HANDLING ACTIVITIES: QUALITY CHECKS						
1. Check a sample of input data for transcription errors (Energy)						
2. Check a sample of input data for transcription errors (Industry+Solvents)						
3. Check a sample of input data for transcription errors (Agriculture+LULUCF)						
4. Check a sample of input data for transcription errors (Waste)						
5. Check a sample of input data for transcription errors (All sources)						
6. Identify spreadsheet modifications that could provide additional controls or checks on quality (Energy-Fugitive emission)						
7. Identify spreadsheet modifications that could provide additional controls or checks on quality (Energy)						
B. DATA DOCUMENTATION: QUALITY CHECKS						
8 Check project file for completeness						
9. Confirm that bibliographical data references are included (in spreadsheet) for every primary data element						
10. Check that all appropriate citations from the spreadsheets appear in the Inventory Report						
11. Check that all citations in spreadsheets and inventory are complete (i.e., include all relevant information)						
12. Check that assumptions and criteria for selection of activity data and emission factors are documented (Waste)						
13. Check that changes in data or methodology are documented (Energy-Fugitive)						
14. Check that changes in data or methodology are documented (Industries)						
15. Check that changes in data or methodology are documented (Waste)						
C. CALCULATING EMISSIONS AND CHECKING CALCULATIONS						
16. Check that all emission calculations are included (i.e., emissions are not hard-wired)						
17. Check whether emission units, parameters, and conversion factors are inappropriately hardwired						
18. Check if units are properly labeled and correctly carried through from beginning to end of calculation						
19. Check that conversion factors are correct						
20. Check that temporal and spatial adjustment factors are used correctly						
21. Check the data relationships (comparability) and data processing steps (e.g., equations) in the spreadsheets						
22. Check a representative sample of calculations, by hand or electronically						
23. Check some calculations with abbreviated calculations						
24. Check the aggregation of data within a source category						
25. When methods or data have changed, check consistency of time series inputs and calculations						
26. Check for consistency with IPCC inventory guidelines and good practices, particularly if changes occur						