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NATIONAL INVENTORY REPORT 2013

**CROATIAN GREENHOUSE GAS INVENTORY
FOR THE PERIOD 1990-2011**





**MINISTRY OF ENVIRONMENTAL
AND NATURE PROTECTION**

**CROATIAN ENVIRONMENT
AGENCY**

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Croatian greenhouse gas inventory for the period 1990-2011

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LIST OF ABBREVIATIONS

AD	- Activity Data
ARKOD	- Land parcel identification system
CBS	- Central Bureau of Statistics
CEM	- Continuous Emission Monitoring
CFC	- Chlorofluorocarbons
CHBC	- Croatian Horse Breeding Centre
CLC	- CORINE Land Cover
CLRTAP	- Convention on Long-range Transboundary Air Pollution
CNG	- Compressed Natural Gas
COP	- Conference of Parties
COPERT	- Computer Programme to Calculate Emissions from Road Transport
CORINAIR	- Core Inventory of Air Emissions in Europe
CORINE	- Coordination Of Information On The Environment
CPS Molve	- Central Gas Station Molve
CRF	- Common Reporting Format
CRONFI	- Croatian National Forest Inventory
EAF	- Electric Arc Furnace
EEA	- European Environment Agency
EF	- Emission Factor
EIHP	- Energy Institute "Hrvoje Požar"
EKONERG	- Energy Research and Environmental Protection Institute
EMEP	- Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe
EOR Project	- Enhanced Oil Recovery Project
EU ETS	- European Union Emissions Trading Scheme
ERT	- Expert Review Team
FAO	- Food and Agriculture Organization of the United Nations
FAOSTAT	- FAO statistical database
FAS	- Forest Advisory Service
FMAP	- Forest Management Area Plan
FSC	- Forest Stewardship Council
GHG	- Greenhouse gas
GIS	- Gas Insulated Switchgear
GWP	- Global Warming Potential
HEP	- Croatian Electricity Utility Company
HEP ODS	- HEP Distribution System Operator; subsidiary company of HEP

HEP OPS	- HEP Transmission System Operator; subsidiary company of HEP
HFC	- Hydrofluorocarbons
HPP	- Hydro Power Plant
HRK	- Croatian currency; kuna
IACS	- Integrated Administration and Control System
IEA	- International Energy Agency
INA	- Croatian Oil and Gas Company
IPCC	- Intergovernmental Panel on Climate Change
ISWA	- International Solid Waste Association
KP-LULUCF	- Kyoto Protocol Land Use, Land Use Change and Forestry
LPG	- Liquefied Petroleum Gas
LRTAP	- Long-range Transboundary Air Pollution
LULUCF	- Land-use, Land Use Change and Forestry
MENP	- Ministry of Environmental and Nature Protection
MSW	- Municipal Solid Waste
NCV	- Net Calorific Values
NGGIP	- National Greenhouse Gas Inventories Programme
NIR	- National Inventory Report
NMVO	- Non-methane Volatile organic Compounds
NPP	- Nuclear Power Plant
ODS	- Ozone Depleting Substances
OG	- Official Gazette
PCP	- Public Cogeneration Plant
PFC	- Perfluorocarbons
PHP	- Public Heating Plant
PRODCOM	- Production statistics database
QA/QC	- Quality Assurance/Quality Control
SF ₆	- Sulphur hexafluoride
TPP	- Thermal Power Plant
UNDP	- United Nations Development Program
UNDP/GEF	- United Nations Development Programme/Global Environment Facility
UNECE	- United Nations Economic Commission for Europe
UNFCCC	- United Nations Framework Convention on Climate Change
WW	- Wastewaters
ZGOS	- Zagreb's Environmental Protection and Waste Management Company
int.	- international
dom.	- domestic

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EXECUTIVE SUMMARY

ES.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) on 17 January 1996 when the Croatian Parliament passed the law on its ratification (Official Gazette, International Treaties No. 2/96). For the Republic of Croatia the Convention came into force on 7 July 1996. As a country undergoing the process of transition to market economy, Croatia has, pursuant to Article 22, paragraph 3 of the Convention, assumed the commitments of countries included in Annex I. By the amendment that came into force on 13 August 1998 Croatia was listed among Parties included in Annex I to the Convention.

The adoption of the Decision 7/CP.12 by the Conference of Parties was acknowledged by the Croatian Parliament which ratified the Kyoto Protocol on 27 April 2007 (Official Gazette, International Treaties No. 5/07). The Kyoto Protocol has entered into force in Croatia on 28 August 2007. Initial Report of the Republic of Croatia under the Kyoto Protocol¹ was submitted in August 2008.

One of the commitments outlined in Article 4, paragraph 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.

Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia (Official Gazette No. 87/12) and Ordinance on Greenhouse Gas Emissions Monitoring in the Republic of Croatia (Official Gazette No. 134/12) prescribe obligation and procedure for emissions monitoring, which comprise estimation and/or reporting of all anthropogenic emissions and removals. Monitoring of GHG gases is stipulated by Article 75 of the Air Protection Act (Official Gazette No. 130/11).

In this NIR, the inventory of the emissions and removals of the greenhouse gases is reported for the period from 1990 to 2011. The NIR is prepared in accordance with the UNFCCC reporting guidelines on annual Inventories

¹ According to decision 13/CMP.1 *Modalities for the accounting of assigned amounts under Article 7, paragraph 4, of the Kyoto Protocol* each Party included in Annex I with a commitment inscribed in Annex B shall submit to the Secretariat, prior to 1 January 2007 or one year after the entry into force of the Kyoto Protocol for that Party, whichever is later, the report referred to in paragraph 6 of the annex of decision 13/CMP.1. Therefore, the Ministry of Environmental and Nature Protection has prepared the Initial Report of the Republic of Croatia in accordance with requirements of paragraph 7 of the annex of decision 13/CMP.1 which specifies the information which shall be provided by the Party.

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 eight reviews so far, in-country review in 2004, 2008 and 2012 and centralized reviews in 2005, 2006, 2009, 2010 and 2011. 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 (CO₂), methane (CH₄), nitrous oxide (N₂O), halogenated carbons (HFCs, PFCs) and sulphur hexafluoride (SF₆) and indirect greenhouse gases: carbon monoxide (CO), oxides of nitrogen (NO_x), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO₂). 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.

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

Institutional arrangement for inventory preparation in Croatia is regulated in Part II of the Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia entitled National system for the estimation and reporting of anthropogenic greenhouse gas emissions by sources and removals by sinks. Institutional arrangements for inventory management and preparation in Croatia could be characterized as decentralized and out-sourced with clear tasks breakdown between participating institutions including Ministry of Environmental and Nature Protection (MENP), Croatian Environment Agency (CEA) and

competent governmental bodies responsible for providing of activity data. The preparation of inventory itself is entrusted to Authorised Institution which is elected for three year period by public tendering.

MENP is a national focal point for the UNFCCC, with overall responsibility for functioning of the National system in a sustainable manner, including:

- mediation and exchange of data on greenhouse gas emissions and removals with international organisations and Parties to the Convention;
- mediation and exchange of data with competent bodies and organisations of the European Union in a manner and within the time limits laid down by legal acts of the European Union;
- control of methodology for emission calculation and greenhouse gas removal in line with good practices and national circumstances;
- consideration and approval of the Greenhouse Gas Inventory Report prior to its formal submission to the Convention Secretariat.

CEA is responsible for the following tasks:

- organisation of greenhouse gas inventory preparation with the aim of meeting the due deadlines referred to in Article 12 of this Regulation;
- collection of activity data referred to in Article 11 the Regulation;
- development of quality assurance and quality control plan (QA/QC plan) related to the greenhouse gas inventory in line with the guidelines on good practices of the Intergovernmental Panel on Climate Change;
- implementation of the quality assurance procedure with regard to the greenhouse gas inventory in line with the quality assurance and quality control plan;
- archiving of activity data on calculation of emissions, emission factors, and of documents used for inventory planning, preparation, quality control and quality assurance;
- maintaining of records and reporting on authorised legal persons participating in the Kyoto Protocol flexible mechanisms;
- selection of Authorised Institution (in Croatian: Ovlaštenik) for preparation of the greenhouse gas inventory.
- provide insight into data and documents for the purpose of technical reviews.

Authorised Institution is responsible for preparation of inventory, which include:

- emission calculation of all anthropogenic emissions from sources and removals by greenhouse gas sinks, and calculation of indirect greenhouse gas emissions, in line with the methodology stipulated by the effective guidelines of the Convention, guidelines of the Intergovernmental Panel on Climate Change, Instructions for reporting on greenhouse gas emissions as published on the Ministry's website, and on the basis of the activities data referred to in Article 11 of this Regulation;

- quantitative estimate of the calculation uncertainty referred to in indent 1 of this Article for each category of source and removal of greenhouse gas emissions, as well as for the inventory as a whole, in line with the guidelines of the Intergovernmental Panel on Climate Change;
- identification of key categories of greenhouse gas emission sources and removals;
- recalculation of greenhouse gas emissions and removals in cases of improvement of methodology, emission factors or activity data, inclusion of new categories of sources and sinks, or application of coordination/adjustment methods;
- calculation of greenhouse gas emissions or removal from mandatory and selected activities in the sector of land use, land-use change and forestry;
- reporting on issuance, holding, transfer, acquisition, cancellation and retirement of emission reduction units, certified emission reduction units, assigned amount units and removal units, and carry-over, into the next commitment period, of emission reduction units, certified emission reduction units and assigned amount units, from the Registry in line with the effective decisions and guidelines of the Convention and supporting international treaties;
- implementation of and reporting on quality control procedures in line with the quality control and quality assessment plan;
- preparation of the greenhouse gas inventory report, including also all additional requirements in line with the Convention and supporting international treaties and decisions;
- cooperation with the Secretariat's ERTs for the purpose of technical review and assessment/evaluation of the inventory submissions.

EKONERG – Energy and Environmental Protection Institute was selected as Authorised Institution for preparation of 2013 inventory submission.

ES.1.2. BACKGROUND INFORMATION ON SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1, OF THE KYOTO PROTOCOL

LULUCF

MENP, as the UNFCCC focal point, initiated intensive and continuous consultation and knowledge sharing with relevant national institutions responsible for the forestry sector in Croatia. The overall goal of this effort was to establish procedural arrangements necessary for streamlined data flow needed for reporting of information related to accounting of LULUCF activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol.

In Croatia, there is a long tradition of forest management and a comprehensive national system for monitoring, data collection and reporting on the condition and activities in forestry sector. In that respect, main effort was directed in harmonization of current system with the KP-LULUCF requirements. In the beginning of 2010, MENP commissioned a preparation of Action plan for implementation of Article 3, paragraphs 3 and 4 of the Kyoto Protocol which should facilitate the process of data collection and preparation of information related to accounting of LULUCF activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol. Terms of reference for this Action plan included harmonization of definitions and their appliance to national circumstances, identification of lands subject to activities under Article 3.3 and elected activity under Article 3.4, data collection for estimation of carbon stock change and non-CO₂ greenhouse gas emissions and uncertainty assessment and verification.

The Ministry of Agriculture and MENP agreed that preparation of the annual GHG Inventory in respect of LULUCF sector should be based on forest management plans. As for the first Croatian National Forest Inventory (CRONFI), it is still not official. Once CRONFI becomes official and published, it could be used to fill the gaps in reporting.

Information on Kyoto units

Until the end of 2012 Croatia did not make any transaction of Kyoto units.

Changes in national system

National system was changed compared to the description given in last inventory submission in May 2012 in part related to legal arrangements where new Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia was enacted in July 2012 and Ordinance on Greenhouse Gas Emissions Monitoring in the Republic of Croatia was enacted in December 2012.

The purpose of these legal documents is to further harmonize national system with requirements of EU mechanisms for monitoring and reporting greenhouse gas emissions stipulated by Decisions 280/2004/EC, 2005/166/EC, 406/2009/EC and draft of new MMR Regulation.

New national Plan for Air Protection, Ozone Layer Protection and Climate Change Mitigation for the period 2012-2016 is under preparation. The plan will stipulate concrete measures to improve performance of national system. It is planned to prepare and carry out two capacity building projects, one related to improvements in emissions estimates in all IPCC sectors and one specifically related to reporting in LULUCF sector.

All other components of national system remain to perform their general and specific functions.

Changes in national registry

There were no changes in national registry.

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 2011. The results are presented as total emissions of all greenhouse gases in CO₂ 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 different contribution to the greenhouse effect, it is necessary to multiply the emission of every gas with proper Global Warming Potential (GWP). The Global Warming Potential is a measure of the impact on greenhouse effect of the certain gas compared to CO₂ 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 (CO₂-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. Global warming potentials for certain gases (100- year time horizon) are presented below.

Gas	Global Warming Potential
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	21
Nitrous oxide (N ₂ O)	310
HFC-23	11700
HFC-32	650
HFC-125	2800
HFC-134a	1300
HFC-143a	3800
HFC-152a	130
HFC-227ea	2900
HFC-236fa	6300
CF ₄	6500
C ₃ F ₈	7000
C ₂ F ₆	9200
SF ₆	23900

ES.2.1. OVERVIEW OF SOURCES AND SINK CATEGORY EMISSION ESTIMATES AND TRENDS

Total emission/removal of greenhouse gases for the period 1990-2011 and their trend in sectors is given in table ES.2-1, while the contribution of the individual gases is given in table ES.2-2.

Table ES.2-1: Emissions/removals of GHG by sectors for the period 1990-2011 (Gg CO₂-eq)

Source	Emissions and removals of GHG (Gg CO ₂ -eq)							
	1990	1995	2000	2005	2008	2009	2010	2011
Energy	22,796	17,263	19,482	22,672	22,903	21,651	21,009	20,715
Industrial Processes	3,789	2,016	2,861	3,295	3,593	2,984	3,211	3,000
Solvent and Other Product Use	117	108	109	195	239	153	152	144
Agriculture	4,381	3,055	3,130	3,478	3,431	3,314	3,193	3,319
Waste	564	619	707	814	1,001	1,057	1,050	1,078
Total emission (excluding net CO₂ from LULUCF)	31,647	23,061	26,290	30,454	31,167	29,159	28,615	28,256
Removals (LULUCF)	-6,411	-9,078	-7,719	-8,151	-7,823	-8,066	-7,872	-7,032
Total emission (including LULUCF)	25,236	13,982	18,571	22,302	23,343	21,093	20,744	21,225

Table ES.2-2: Emissions/removals of GHG by gases for the period 1990-2011 (Gg CO₂-eq)

Source	Emissions and removals of GHG (Gg CO ₂ -eq)							
	1990	1995	2000	2005	2008	2009	2010	2011
Carbon dioxide (CO ₂)	23,339	17,202	20,093	23,485	23,756	21,982	21,289	20,869
Methane (CH ₄)	3,420	2,744	2,729	3,132	3,518	3,522	3,566	3,509
Nitrous oxide (N ₂ O)	3,941	3,054	3,285	3,490	3,456	3,210	3,279	3,392
HFCs, PFCs and SF ₆	948	61	183	347	437	444	482	486
Total emission (excluding net CO₂ from LULUCF)	31,647	23,061	26,290	30,454	31,167	29,159	28,615	28,256
Removals (LULUCF)	-6,431	-9,085	-7,785	-8,159	-7,835	-8,075	-7,881	-7,049
Total emission (including LULUCF)	25,0236	13,982	18,571	22,302	23,343	21,093	20,744	21,225

Table ES.2-1 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 2011 has the Energy Sector with 73.3 percent, followed by Agriculture with 11.7 percent, Industrial Processes with 10.6 percent, Waste with 3.8 percent and Solvent and Other product Use with 0.5 percent. This structure is with minor changes consistent through all the observed period from 1990 to 2011. In the year 2011, the amount of removed emissions of the greenhouse gases by CO₂ from the forestry sector was 19.3 percent.

Energy sector is the largest contributor to greenhouse gas emissions. In the year 2011, the greenhouse gas emission from Energy sector was 1.4 percent lower in relation to 2010. The total energy consumption in 2011 was 0.4 percent lower than in the previous year. The consumption of gaseous fuel decreased (4.5 percent) but consumption of solid fuel increased for 4.8 percent and also consumption of fuel wood and other renewables increased (14.8 percent in relation to 2010). Because of the economic crisis, there was decrease in industrial production and consequently, decrease in fuel consumption (greatest reduction in fuel consumption was in Manufacturing industries and construction sector), and it was contributed to the GHG emission decrease.

Emission of CH₄ and N₂O in the Agricultural sector is conditioned by different agricultural activities. For the emission of CH₄, the most important source is livestock farming (Enteric Fermentation) which makes about 83 percent of sectoral CH₄ emission. The number of cattle showed continuous decrease in the period from 1990 to 2000. As a consequence, this led to CH₄ emission reduction. In the year 2000, the number of cattle has started increasing and this trend was mostly retained until 2006. From 2007 to 2010, cattle number decreased and remained at approximately the same level in 2011. Compared to 2010, in 2011 CH₄ emission decreased by about 0.5 percent. As for Manure management emissions, both CH₄ and N₂O emission decreased in 2010 compared to 2009 by about 0.4 percent and 0.5 percent respectively. Emissions from Agricultural soils decreased after 1990 and during the war due to specific national circumstances and limited agricultural practice at that time. Afterwards, the emission trend is mostly influenced by the changes in the direct soil emissions; thus, emission increase can be noticed in 1997, 2001 and 2002 due to increase in mineral fertilizer consumption and crop production, later on also due to the increase of livestock population. N₂O emission from Agricultural soils increased in 2011 compared to 2010 by about 6 percent. Overall, in 2011 emission from agriculture sector increased by about 3.8 percent compared to 2010.

In Industrial Processes sector, the key emission sources are Cement Production, Lime Production, Ammonia Production, Nitric Acid Production and Consumption of HFCs in Refrigeration and Air Conditioning Equipment, which all together contribute with 96 percent in total sectoral emission in 2011. The iron production in blast furnaces and aluminium production ended in 1992, and ferroalloys production ended in 2003. The cement production in the period 1997-2008 was constantly increasing. After that period, due to reduced economic activities, which influenced the cement production in Croatia, the production dropped by 23 percent in 2009, 26 percent in 2010, and 28 percent in 2011, regarding the year 2008. The manufacturers aim to use the maximum of the existing capacities, which amount to about 3.2 million tons of clinker in total per year, whereas in the year 2011, 2.1 million tons of clinker were produced. The ammonia production in 2011 was 2 percent higher in comparison to the previous year. Nitric acid production in 2011 was 1.2 percent lower in comparison to 2010. The level of emissions from these sub-sectors strongly depends on the consumer's demand for a particular type of mineral fertilizer.

CO₂ emission from Solvent and Other Product Use contributes to the total greenhouse gas emission in 2011 with 0.5 percent.

Waste sector includes waste disposal, waste water management and waste incineration, whereas the waste disposal represents dominant CH₄ emission source from that sector. The emission depends on the amount and composition of municipal solid waste, management practices on-site including implementation of measures for collection and utilization of landfill gas. The First Order Decay (FOD) model was used for CH₄ emission calculation. Although increasing of municipal solid waste amounts as a result of the growth in the living standard, this rise has slightly declined due to economic crisis and effects of measures undertaken to avoid/reduce, separately collect and recycle waste. Priority is given to avoiding and reducing waste generation and reducing its hazardous properties. These objectives, defined by the *Waste Management Strategy* (Official Gazette No. 130/05) and *Waste Management Plan in the Republic of Croatia* (Official Gazette No. 85/07, 126/10, 31/11) include the assumed time-lags with respect to relevant EU legislation. CH₄ that is recovered and burned in a flare or energy recovery device in the period 2004-2011 have been included in emission estimation. It should be emphasized that Solid Waste Disposal on Land contributes with 71.5 percent in total sectoral emission in 2011. Waste sector contributes to total greenhouse gas emissions with 3.8 percent in 2011.

ES.2.1.1. CARBON DIOXIDE EMISSION (CO₂)

Carbon dioxide is the most significant anthropogenic greenhouse gas. As in the majority of countries, the most significant anthropogenic sources of CO₂ emissions in Croatia are the processes of fossil fuel combustion for electricity or/and heat production, transport and industrial processes (cement and ammonia production). The results of the CO₂ emission calculation in Croatia are presented in table ES.2-3.

Table ES.2-3: CO₂ emission/removal by sectors from 1990-2011 (Gg CO₂)

Sector	1990	1995	2000	2005	2008	2009	2010	2011
Energy	21,234	15,904	18,086	21,061	21,155	19,957	19,252	19,052
Industrial processes	2,023	1,224	1,933	2,264	2,395	1,906	1,915	1,710
Solvent and Other Product Use	82	74	74	160	205	119	121	107
LULUCF	-6,431	-9,085	-7,784,7	-8,159	-7,836	-8,076	-7,882	-7,049
Waste	0.04	0.04	0.04	0.03	1.01	0.38	0.13	0.05
Total CO₂ emission	23,339	17,202	20,093	23,485	23,756	21,982	21,289	20,869
Net CO₂ emission	16,907	8,117	12,309	15,327	15,920	13,907	13,407	13,820

ES.2.1.1.1. Energy sector

This sector covers all activities that involve fuel consumption from stationary and mobile sources, 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 73.3 percent in total greenhouse gas emission (presented as equivalent emission of CO₂). CO₂ emission from fuel combustion makes the largest part of CO₂ emission (90.3 percent). Emission by sub-sectors is presented in table ES.2-4.

Table ES.2-4: CO₂ emission by sub-sectors from 1990-2011 (Gg CO₂)

Source	1990	1995	2000	2005	2008	2009	2010	2011
Energy Industries	7,127	5,262	5,877	6,779	6,705	6,373	5,884	6,253
Manufacturing Ind. and Construct.	5,843	3,541	3,617	4,081	4,198	3,379	3,364	3,139
Transport	4,019	3,406	4,464	5,553	6,178	6,182	5,963	5,826
Comm./Inst., Resid., Agr /For./Fish.	3,606	2,826	3,389	3,867	3,415	3,428	3,480	3,257
Fugitive emissions	640	869	739	780	659	595	562	577
Total CO₂ emission	21,234	15,904	18,086	21,061	21,155	19,957	19,253	19,052

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 CO₂ emissions between reference and sectoral approach for Croatia is around 2.5 percent (table ES.2-5).

Table ES.2-5: CO₂ emission comparison due to fuel combustion (Gg)

	1990	1995	2000	2005	2008	2009	2010	2011
Reference approach	20,692.1	15,052.9	17,703.2	20,847.8	21,167.8	19,834.6	19,265.0	18,904.1
Sectoral approach	20,593.8	15,034.4	17,347.1	20,280.6	20,496.0	19,361.9	18,690.4	18,474.8
Relative Diff. (%)	0.48	0.12	2.05	2.93	3.28	2.44	3.07	2.32

The energy most intensive stationary sub-sector is Energy Industries (electricity and heat production, refineries and oil and gas field combustion). In the framework of the sub-sector Manufacturing Industries and Construction, the largest CO₂ emissions are the result of fuel combustion in industry of construction material and petrochemical production, followed by food processing industry, chemical industry, industry of pulp, paper and print, iron and steel industry and non-ferrous metal industry. Furthermore, this sub-sector includes electricity and heat production in manufacturing industry for manufacturing processes.

Transport sector is also one of more important CO₂ emission sources. This sector includes emission from road transport, civil aviation, railways and navigation. In the year 2011, the CO₂ emission from Transport sector contributed with 27.9 percent to the national total CO₂ emission. The largest part of the CO₂ emission from Transport sector arises from road transport (95.1 percent of CO₂ emission from transport sector in 2011) followed by national navigation, domestic civil aviation and railways.

Biomass combustion (fuel wood and waste wood, biodiesel, biogas) also results in greenhouse gas emissions. CO₂ emission from biomass is not included in balance according the Guidelines, due to assumption that life-cycle CO₂ emitted is formerly absorbed for the growth of biomass. Sinks or CO₂ 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.

ES.2.1.1.2. Industrial processes

The greenhouse gas emission is a by-product in various industrial processes, where the raw material is chemically transformed into final product. Industrial processes where the contribution to CO₂ emission is identified as relevant are production of cement, lime, ammonia, as well as use of limestone and soda ash in various industrial activities.

General methodology used for emission calculation from industrial processes, recommended by the Convention, includes multiplying the annual produced or consumed amount of a product or material with the appropriate emission factor per unit of this production or consumption. Annual production or consumption data for particular industrial processes are in most cases collected by a direct survey of manufacturers. The results of the CO₂ emission calculation for industrial processes are shown in table ES.2-6.

Table ES.2-6: CO₂ emission from Industrial Processes for the period from 1990-2011 (Gg CO₂)

Source	1990	1995	2000	2005	2008	2009	2010	2011
Cement production	1,086	629	1,244	1,500	1,527	1,224	1,198	1,050
Lime production	153	83	141	219	269	174	161	89
Limestone and dolomite use	51	17	16	27	26	30	37	42
Soda ash production and use	14	20	17	23	20	20	24	23
Ammonia production	466	439	498	485	530	446	468	476
Ferroalloys production	119	32	12	0	0	0	0	0
Aluminium production	1,048	0	0	0	0	0	0	0
Iron and steel production	21	4	5	11	24	11	27	29
Total CO₂ emission	2,023	1,224	1,933	2,264	2,395	1,906	1,915	1,710

The most significant CO₂ industrial processes emission sources are production of cement, ammonia and lime. In 2011, cement production contributes in total sectoral CO₂ emission with 61.4 percent, lime production with 5.2 percent and ammonia production with 27.8 percent. Generally, CO₂ 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 1996-2008 emissions slightly increased. Production of iron and aluminium was stopped in 1992. A decrease of economic activities after 2008, influenced a reduction in cement, lime, and steel productions. Although ammonia production increased by 2 percent in 2011, overall emissions from industrial processes dropped by 10.7 percent., regarding 2010.

The quantity of the CO₂ emitted during cement production is directly proportional to the lime content of the clinker. Therefore, the CO₂ emissions are calculated using an emission factor, in tonnes of CO₂ released per

tonne of clinker produced, to the annual clinker output corrected with the fraction of clinker that is lost from the kiln in the form of Cement Kiln Dust (CKD). The emission factor and correction factor for CKD is determined according to *Revised 1996 IPCC Guidelines and Good Practice Guidance*. Country-specific emission factors were estimated using data from individual plants. The activity data for clinker production were collected from survey of cement manufacturers and cross-checked with cement production data from Annual PRODCOM results published by Central Bureau of Statistics.

In ammonia production, emission of CO₂ from natural gas used as feedstock is stoichiometrically determined based on carbon content in natural gas. One part of the CO₂ produced in ammonia production is further used as feedstock in urea production, i.e. mineral fertilizer. Emission of intermediately bound CO₂ occurs during the use of urea as a fertilizer in agriculture. However, according to IPCC methodology this approach is not distinguished.

ES.2.1.1.3. CO₂ removals

The *Forest Act* (OG 140/05, 82/06, 129/08, 80/10, 124/10) regulates the growing, protection, usage and management of forests and forest land as a natural resource aimed to maintain biodiversity and ensure management based on principles of economic sustainability, social responsibility and ecological acceptability. Moreover, one of its the most important provisions, in the context of climate protection, is that forests should be managed in conformity with the sustainable management criteria, implying the maintenance and enhancement of forest ecosystems and their contribution to the global carbon cycle. Planning activities in forestry sector in Croatia are also regulated by the *Forest Act* (OG 140/05, 82/06, 129/08, 80/10, 124/10). Forest management plans determine conditions for harmonious usage of forest and forest land and procedures in that area, necessary scope regarding cultivation and forest protection, possible utilization degree and conditions for wildlife management. The Forest Management Area Plan (FMAP) for the Republic of Croatia determines the ecological, economic and social background for forest improvement in terms of biology and for the increase of forest productivity.

According to Forest Management Area Plan of the Republic of Croatia (2006-2015), the forests and the forest land cover 47.5 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. The Plan determines, for 2006, growing stock of about 398 millions of m³ while its yearly increment amounts around 10.5 millions of m³. The most frequent species are Common Beech (*Fagus sylvatica*), Pedunculate Oak (*Quercus robur*), Sessile Oak (*Quercus petraea*), Common Hornbeam (*Carpinus betulus*), Silver Fir (*Abies alba*), Narrow-leaved Ash (*Fraxinus angustifolia*), Spruce (*Picea abies*), Black Alder (*Alnus glutinosa*), Black Locust (*Robinia pseudoacacia*), Turkey Oak (*Quercus cerris*) and other.

For this inventory, data are collected and presented in the CRF database for all other land use categories under LULUCF sector. Interpretation of the collected data are given in this NIR's submission.

The methodology used for CO₂ removal calculation is taken from the IPCC and it is based on data on increment and fellings. The problem of deforestation in Croatia does not exist. According to present data the total forest area has not been reduced in the last 100 years.

Table ES.2-7 shows the CO₂ emission/removal trend in the forestry sector. Emissions arisen in LULUCF sector contribute with 3.4% to the total emissions of CO_{2eq} in Croatia in year 2011.

Table ES.2-7: Emission trends in LULUCF sector from 1990-2011 (Gg CO₂)

	1990	1995	2000	2005	2008	2009	2010	2011
Removals*	-6,431	-9,085	-7,784,7	-8,159	-7,836	-8,076	-7,882	-7,049

*Due to the new methodology applied in emission/removal calculation in category Forest land remaining Forest land, data used for the estimation are under the revision

ES.2.1.2. METHANE EMISSION (CH₄)

The major sources of methane (CH₄) 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.2-8, sectoral and total CH₄ emissions are reported.

Table ES.2-8: CH₄ emission in Croatia in the period from 1990-2011 (Gg CH₄)

Source	1990	1995	2000	2005	2008	2009	2010	2011
Energy	69	61	59	69	78	75	78	74
Agriculture	70	44	41	46	47	47	46	46
LULUCF	0.6	0.1	2.4	0.1	0.2	0.1	0.1	0.3
Waste	23	25	30	34	43	45	45	46
Total CH₄ emission	163	131	132	149	168	168	170	167

Fugitive methane emission is mainly the result of exploration, production, processing, transportation and distribution of natural gas (about 88.8 percent). The fugitive emission from oil and natural gas accounts with 40.1 percent in total methane emission, and venting and flaring of gas/oil production accounts with approximately 1 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. The emission trend depends on the livestock population trend.

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 1.6 million tons of municipal solid waste is produced annually and the average composition of its biodegradable part is: paper and textile (21-22 percent), garden and park waste (18-19 percent), food waste (23-24 percent), wood waste and straw (3 percent). As for the wastewater handling in Croatia, aerobic biological process is used mostly in wastewater treatment. Anaerobic process is applied in some industrial wastewater treatment, which results with CH₄ emissions. 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 CH₄ emissions.

ES.2.1.3. NITROUS OXIDE EMISSION (N₂O)

The most important sources of N₂O emissions in Croatia are agricultural activities, nitric acid production, but as well, the N₂O emissions occur in energy sector and waste management. In table ES.2-9 the N₂O emission is reported according to sectors.

Table ES.2-9: N₂O emission in Croatia for the period from 1990-2011 (Gg N₂O)

Source	1990	1995	2000	2005	2008	2009	2010	2011
Energy	0.3	0.2	0.5	0.5	0.4	0.4	0.4	0.3
Industrial Processes	2.6	2.3	2.4	2.2	2.4	2.0	2.6	2.6
Solvent and Other Product Use	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Agriculture	9.4	6.9	7.3	8.1	7.9	7.5	7.1	7.6
LULUCF	0.02	0.01	0.05	0.02	0.03	0.03	0.03	0.03
Waste	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Total N₂O emission	12.7	9.9	10.6	11.3	11.2	10.4	10.6	11.0

In the Agricultural sector, three N₂O emission sources are determined: direct N₂O emission from agricultural soils, direct N₂O emission from livestock farming and indirect N₂O emission induced by agricultural activities. The largest emission is a result of direct emission from agricultural soils which makes about 55.3 percent of total emission from agricultural soils in 2011. According to IPCC methodology, the mineral nitrogen, nitrogen from organic fertilizers, amount of nitrogen in fixing crops, amount of nitrogen which is released from crop residue mineralization, soil nitrogen mineralization due to cultivation of histosols and amount of nitrogen from the application of sewage sludge in are separately analyzed.

In Industrial Processes sector, the N₂O emission occurs in nitric acid production, which is used as a raw material in nitrogen mineral fertilizers. In the framework of the N₂O reduction measure analysis, the possibility for application of non-selective catalytic reduction device was considered, whereby the nitric acid production influence on N₂O emissions would be practically eliminated.

In Energy sector the emission was calculated on the basis of fuel consumption and adequate emission factors (IPCC). The major sources of N₂O emission in Energy sector is use of three-way catalytic converters in road transport motor vehicles.

N₂O emission from the Waste sector indirectly occurs from human sewage. It is calculated on the basis of the total number of inhabitants and annual protein consumption per inhabitant. Data on the annual per capita Protein Intake Value were obtained by the FAOSTAT Statistical Database. Extrapolation method has been used for calculation of insufficient data.

ES.2.1.4. HALOGENATED CARBONS (HFCs, PFCs) AND SF₆ 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. Ministry of Environmental and Nature Protection (MENP) is responsible for monitoring of consumption of substitutes and mixture of substitutes for gases that deplete the ozone layer. There is no production of HFCs PFCs and SF₆ in Croatia, therefore, all quantities of these gases are imported. Minor quantities of some substances are exported.

Croatia is an Article 5 country, according to the Montreal protocol, and has a longer period for using CFC, HCFC and halons. Because of that, Croatia started using HFCs 10 years later than other Annex I countries.

According to survey carried out among major agents, users and consumers of these gases, information related to consumption of HFCs, PFCs, and SF₆ (provided by the MENP) was used for emission calculation which is presented in Gg of CO₂-eq and showed in Table ES.2-10.

Table ES.2-10: HFCs, PFCs and SF₆ emission in the period from 1990-2011 (Gg CO₂-eq)

	1990	1995	2000	2005	2008	2009	2010	2011
<i>HFC, PFC and SF₆ emission</i>	948	61	183	347	437	444	482	486

ES.3. EMISSION OF INDIRECT GREENHOUSE GASES

The photochemically active gases, carbon monoxide (CO), oxides of nitrogen (NO_x) 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 (SO₂), as a precursor of sulphate and aerosols, is believed to contribute negatively to the greenhouse effect.

Emissions of indirect GHGs have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2011* Submission to the Convention on Long-range Transboundary Air Pollution'.

The calculations of aggregated results for the emissions of indirect gases in the period 1990-2011 are given in table ES.3-1.

Table ES.3-1: Emissions of ozone precursors and SO₂ by different sectors (Gg)

Gas	Emissions (Gg)							
	1990	1995	2000	2005	2008	2009	2010	2011
NO_x Emission	69.9	61.7	69.1	75.6	53.8	47.5	43.8	42.7
Energy Industries	17.5	14.5	13.8	12.2	11.5	11.5	9.5	9.6
Manufacturing Ind. & Construction	16.3	7.6	7.7	10.1	12.7	9.7	10.0	9.4
Transport	16.6	27.9	29.5	30.1	5.0	4.6	4.2	5.0
Other Energy (fuel comb.)	15.0	8.1	12.8	13.1	13.5	13.3	13.2	13.3
Fugitive Em. from Fuels	0.5	0.3	0.3	0.3	0.3	0.3	0.2	0.2
Industrial Processes	2.8	2.6	2.8	8.3	9.2	7.0	5.8	4.1
Agriculture	0.8	0.7	0.9	0.9	0.9	0.8	0.8	0.8
LULUCF	0.4	0.1	1.7	0.0	0.1	0.1	0.0	0.2
CO Emission	366.1	288.7	379.6	287.7	221.2	223.0	225.8	245.8
Energy Industries	2.4	1.6	1.6	1.1	1.5	1.2	1.1	1.2
Manufacturing Ind. & Construction.	37.2	38.1	33.6	33.5	31.4	30.7	31.7	29.4
Transport	19.3	67.6	69.7	44.0	3.5	2.4	2.0	3.0
Other Energy (fuel comb.)	204.0	116.7	146.4	133.0	120.1	126.2	141.8	166.3
Fugitive Em. from Fuels	50.1	34.5	54.1	54.4	41.6	51.9	40.1	32.6
Industrial Processes	41.7	28.4	32.1	19.8	41.8	38.0	12.8	3.4
Agriculture	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	12.7	1.9	51.5	1.1	3.9	1.9	1.3	6.9

Table ES.3-1: Emissions of ozone precursors and SO₂ by different sectors (Gg), cont.

Gas	Emissions (Gg)							
	1990	1995	2000	2005	2008	2009	2010	2011
NMVOC Emission	94.0	82.8	80.4	92.1	96.9	67.3	68.2	65.0
Energy Industries	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.3
Manufacturing Ind. & Construction	1.6	1.3	1.4	1.8	2.1	1.7	1.6	1.5
Transport	16.6	20.2	22.3	8.7	1.4	1.3	1.2	1.3
Other Energy (fuel comb.)	12.1	6.9	9.0	8.3	7.7	8.0	8.8	10.1
Fugitive Em. from Fuels	9.0	7.0	9.1	8.5	7.5	8.0	7.7	7.1
Industrial Processes	24.0	9.3	7.8	8.7	8.3	6.3	5.9	5.3
Solvent and Other Product Use	28.1	25.5	25.3	55.2	64.6	72.1	68.8	40.0
LULUCF	1.3	0.2	5.2	0.1	0.4	0.2	0.1	0.7
SO₂ Emission	173.1	82.8	62.2	63.5	51.2	53.4	40.4	37.3
Energy Industries	99.5	54.0	32.9	32.7	32.0	36.7	19.7	17.9
Manufacturing Ind. & Construction.	39.8	16.7	11.0	9.7	8.2	6.1	12.2	9.7
Transport	5.5	4.6	6.4	9.2	1.5	0.9	0.7	1.3
Other Energy (fuel comb.)	23.9	4.7	6.5	6.8	4.3	4.5	4.2	3.7
Fugitive Em. from Fuels	1.8	1.2	3.1	3.1	2.8	3.3	2.3	3.5
Industrial Processes	2.6	1.6	2.1	2.1	1.9	2.1	2.4	1.8

PART 1: ANNUAL INVENTORY SUBMISSION

1 INTRODUCTION

1.1. BACKGROUND INFORMATION ON GHG INVENTORIES, CLIMATE CHANGE AND SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1, OF THE KYOTO PROTOCOL

1.1.1. 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) on 17 January 1996 when the Croatian Parliament passed the law on its ratification (Official Gazette, International Treaties No. 2/96). For the Republic of Croatia the Convention came into force on 7 July 1996. As a country undergoing the process of transition to market economy, Croatia has, pursuant to Article 22, paragraph 3 of the Convention, assumed the commitments of countries included in Annex I. By the amendment that came into force on 13 August 1998 Croatia was listed among Parties included in Annex I to the Convention.

The adoption of the Decision 7/CP.12 by the Conference of Parties was acknowledged by the Croatian Parliament which ratified the Kyoto Protocol on 27 April 2007 (Official Gazette, International Treaties No. 5/07). The Kyoto Protocol has entered into force in Croatia on 28 August 2007. Initial Report of the Republic of Croatia under the Kyoto Protocol² was submitted in August 2008.

One of the commitments outlined in Article 4, paragraph 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.

Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia (Official Gazette No. 87/12) and Ordinance on Greenhouse Gas Emissions Monitoring in the Republic of Croatia (Official Gazette No. 134/12) prescribe obligation and procedure for emissions monitoring, which comprise estimation and/or reporting of all anthropogenic emissions and removals. Monitoring of GHG gases is stipulated by Article 75 of the Air Protection Act (Official Gazette No. 130/11).

² According to decision 13/CMP.1 *Modalities for the accounting of assigned amounts under Article 7, paragraph 4, of the Kyoto Protocol* each Party included in Annex I with a commitment inscribed in Annex B shall submit to the Secretariat, prior to 1 January 2007 or one year after the entry into force of the Kyoto Protocol for that Party, whichever is later, the report referred to in paragraph 6 of the annex of decision 13/CMP.1. Therefore, the Ministry of Environmental and Nature Protection has prepared the Initial Report of the Republic of Croatia in accordance with requirements of paragraph 7 of the annex of decision 13/CMP.1 which specifies the information which shall be provided by the Party.

In this NIR, the inventory of the emissions and removals of the greenhouse gases is reported for the period from 1990 to 2011. 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 eight reviews so far, in-country review in 2004, 2008 and 2012 and centralized reviews in 2005, 2006, 2009, 2010 and 2011. 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 (CO₂), methane (CH₄), nitrous oxide (N₂O), halogenated carbons (HFCs, PFCs) and sulphur hexafluoride (SF₆) and indirect greenhouse gases: carbon monoxide (CO), oxides of nitrogen (NO_x), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO₂). 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.

1.1.2. BACKGROUND INFORMATION ON SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1, OF THE KYOTO PROTOCOL

LULUCF

MENP, as the UNFCCC focal point, initiated intensive and continuous consultation and knowledge sharing with relevant national institutions responsible for the forestry sector in Croatia. The overall goal of this effort was to establish procedural arrangements necessary for streamlined data flow needed for reporting of

information related to accounting of LULUCF activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol.

In Croatia, there is a long tradition of forest management and a comprehensive national system for monitoring, data collection and reporting on the condition and activities in forestry sector. In that respect, main effort was directed in harmonization of current system with the KP-LULUCF requirements. In the beginning of 2010, MENP commissioned a preparation of Action plan for implementation of Article 3, paragraphs 3 and 4 of the Kyoto Protocol which should facilitate the process of data collection and preparation of information related to accounting of LULUCF activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol. Terms of reference for this Action plan included harmonization of definitions and their appliance to national circumstances, identification of lands subject to activities under Article 3.3 and elected activity under Article 3.4, data collection for estimation of carbon stock change and non-CO₂ greenhouse gas emissions and uncertainty assessment and verification.

The Ministry of Agriculture and MENP agreed that preparation of the annual GHG Inventory in respect of LULUCF sector should be based on forest management plans. As for the first Croatian National Forest Inventory (CRONFI), it is still not official. Once CRONFI becomes official and published, it could be used to fill the gaps in reporting.

Information on Kyoto units

Until the end of 2012 Croatia did not make any transaction of Kyoto units.

Changes in national system

National system was changed compared to the description given in last inventory submission in May 2012 in part related to legal arrangements where new Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia was enacted in July 2012 and Ordinance on Greenhouse Gas Emissions Monitoring in the Republic of Croatia was enacted in December 2012.

The purpose of these legal documents is to further harmonize national system with requirements of EU mechanisms for monitoring and reporting greenhouse gas emissions stipulated by Decisions 280/2004/EC, 2005/166/EC, 406/2009/EC and draft of new MMR Regulation.

New national Plan for Air Protection, Ozone Layer Protection and Climate Change Mitigation for the period 2012-2016 is under preparation. The plan will stipulate concrete measures to improve performance of national system. It is planned to prepare and carry out two capacity building projects, one related to improvements in emissions estimates in all IPCC sectors and one specifically related to reporting in LULUCF sector.

All other components of national system remain to perform their general and specific functions.

Changes in national registry

There were no changes in national registry.

12 BRIEF DESCRIPTION OF THE INSTITUTIONAL ARRANGEMENT FOR INVENTORY PREPARATION

Institutional arrangement for inventory preparation in Croatia is regulated in Part II of the Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia entitled National system for the estimation and reporting of anthropogenic greenhouse gas emissions by sources and removals by sinks. Institutional arrangements for inventory management and preparation in Croatia could be characterized as decentralized and out-sourced with clear tasks breakdown between participating institutions including Ministry of Environmental and Nature Protection (MENP), Croatian Environment Agency (CEA) and competent governmental bodies responsible for providing of activity data. The preparation of inventory itself is entrusted to Authorised Institution which is elected for three year period by public tendering.

MENP is a national focal point for the UNFCCC, with overall responsibility for functioning of the National system in a sustainable manner, including:

- mediation and exchange of data on greenhouse gas emissions and removals with international organisations and Parties to the Convention;
- mediation and exchange of data with competent bodies and organisations of the European Union in a manner and within the time limits laid down by legal acts of the European Union;
- control of methodology for emission calculation and greenhouse gas removal in line with good practices and national circumstances;
- consideration and approval of the Greenhouse Gas Inventory Report prior to its formal submission to the Convention Secretariat.

CEA is responsible for the following tasks:

- organisation of greenhouse gas inventory preparation with the aim of meeting the due deadlines referred to in Article 12 of this Regulation;
- collection of activity data referred to in Article 11 the Regulation;
- development of quality assurance and quality control plan (QA/QC plan) related to the greenhouse gas inventory in line with the guidelines on good practices of the Intergovernmental Panel on Climate Change;
- implementation of the quality assurance procedure with regard to the greenhouse gas inventory in line with the quality assurance and quality control plan;
- archiving of activity data on calculation of emissions, emission factors, and of documents used for inventory planning, preparation, quality control and quality assurance;
- maintaining of records and reporting on authorised legal persons participating in the Kyoto Protocol flexible mechanisms;
- selection of Authorised Institution (in Croatian: Ovlaštenik) for preparation of the greenhouse gas inventory.

- provide insight into data and documents for the purpose of technical reviews.

Authorised Institution is responsible for preparation of inventory, which include:

- emission calculation of all anthropogenic emissions from sources and removals by greenhouse gas sinks, and calculation of indirect greenhouse gas emissions, in line with the methodology stipulated by the effective guidelines of the Convention, guidelines of the Intergovernmental Panel on Climate Change, Instructions for reporting on greenhouse gas emissions as published on the Ministry's website, and on the basis of the activities data referred to in Article 11 of this Regulation;
- quantitative estimate of the calculation uncertainty referred to in indent 1 of this Article for each category of source and removal of greenhouse gas emissions, as well as for the inventory as a whole, in line with the guidelines of the Intergovernmental Panel on Climate Change;
- identification of key categories of greenhouse gas emission sources and removals;
- recalculation of greenhouse gas emissions and removals in cases of improvement of methodology, emission factors or activity data, inclusion of new categories of sources and sinks, or application of coordination/adjustment methods;
- calculation of greenhouse gas emissions or removal from mandatory and selected activities in the sector of land use, land-use change and forestry;
- reporting on issuance, holding, transfer, acquisition, cancellation and retirement of emission reduction units, certified emission reduction units, assigned amount units and removal units, and carry-over, into the next commitment period, of emission reduction units, certified emission reduction units and assigned amount units, from the Registry in line with the effective decisions and guidelines of the Convention and supporting international treaties;
- implementation of and reporting on quality control procedures in line with the quality control and quality assessment plan;
- preparation of the greenhouse gas inventory report, including also all additional requirements in line with the Convention and supporting international treaties and decisions;
- cooperation with the Secretariat's ERTs for the purpose of technical review and assessment/evaluation of the inventory submissions.

EKONERG – Energy and Environmental Protection Institute was selected as Authorised Institution for preparation of 2013 inventory submission.

1.2.1. OVERVIEW OF INSTITUTIONAL, LEGAL AND PROCEDURAL ARRANGEMENTS FOR COMPILING SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1, OF THE KYOTO PROTOCOL

MENP, as the UNFCCC focal point, initiated intensive and continuous consultation and knowledge sharing with relevant national institutions responsible for the forestry sector in Croatia. The overall goal of this effort was to establish procedural arrangements necessary for streamlined data flow needed for reporting of

information related to accounting of LULUCF activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol.

13. BRIEF DESCRIPTION OF THE PROCESS OF INVENTORY PREPARATION

Process of inventory preparation encompasses several steps starting with activity data collection and followed by emissions estimation and recalculations in accordance with the IPCC methodology and recommendations for improvements from the ERT review reports, compilation of inventory including the NIR and the CRF and in parallel implementation of general and source-category specific quality control procedures.

Activity data collection is under responsibility of CEA which represents a hub between governmental and public institutions responsible for providing activity data and Authorised Institution responsible for inventory preparation. The scope and due dates for delivering activity data to CEA are prescribed by the Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia. In addition several operators from energy and industrial sector were directly approached by the CEA and EKONERG for more detailed activity data since higher tier methods have been applied (see table 1.4-1 for details).

After activity data are collected and processed, inventory team performed emission estimations and recalculation in accordance with the IPCC methodology and taking into consideration recommendations for inventory improvements. Results are checked against quality control procedures in order to ensure data integrity, correctness and completeness.

Process of inventory preparation has been improved in recent submissions mainly as a result of activities carried out under the framework of two capacity building projects, i.e.:

- UNDP/GEF regional project “Capacity building for improving the quality of GHG inventories” in which following inventory related documents were prepared:
 - o National GHG Inventory Improvement Strategy
 - o National QA/QC plan
 - o National QA/QC guidance
 - o Manuals of procedures for compiling, archiving, updating and managing GHG Inventory
 - o Description of inventory archives
 - o Description of awareness-raising campaign
 - o Improvement of GHG emission calculation from road transport
 - o Improvement of methane emission calculations from waste disposal
- EC LIFE Third Countries project “Capacity building for implementation of the UNFCCC and the Kyoto Protocol in the Republic of Croatia”

Furthermore, since the introduction of annual technical reviews of the national inventories by experts review teams (ERT), Croatia has undergone seven reviews so far, in-country review in 2004 and 2008 and centralized reviews in 2005, 2006, 2009, 2010 and 2011. Issues recommended by the ERT have been included in this report as far as possible.

14. BRIEF DESCRIPTION OF METHODOLOGIES AND DATA SOURCES USED

The methodologies from *Revised 1996 IPCC Guidelines for National GHG Inventories* and *Good Practice Guidance and Uncertainty Management in National GHG Inventories*, recommended by the UNFCCC were used for emission estimations of greenhouse gases which are result of anthropogenic activities, i.e. CO₂, CH₄, N₂O, HFCs, PFCs, SF₆. Emissions of indirect GHGs have been taken from the emission inventory report 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2011 Submission to the Convention on Long-range Transboundary Air Pollution'.

Carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) 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 (SF₆) 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 (SO₂), as a precursor of sulphate and aerosols, is believed to exacerbate the greenhouse effect because the creation of aerosols removes heat from the environment.

Generally, methodology applied to estimate emissions includes the product of activity data (e.g. fuel consumption, cement production, wood stock increment and so forth) and 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 methodology with default emission factors for different tiers. The emission estimates are divided into following sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Land Use, Land-Use Change and Forestry and Waste. Detailed description of the applied methodologies is described in sector specific chapters of the NIR from 3 to 9 and overview is given in the CRF tables Summary 3s1 - Summary 3s2.

The 2008 reporting cycle represents a transition from voluntary to in principal mandatory activity data collection system stipulated by the Regulation on the Monitoring of Greenhouse Gas Emissions in the Republic of Croatia (Official Gazette No. 01/07). Activity data sources for inventory preparation are presented in the Table 1.4-1, but more detailed information is given in sectoral chapters.

Table 1.4-1: Data sources for GHG inventory preparation

CRF Sector/Sub-sector	Type of data	Source of data
Energy	Energy balance	- Ministry of Economy with assistance of Energy Institute Hrvoje Požar
	Registered motor vehicles database	- Ministry of Interior
	Fuel consumption and fuel characteristic data for thermal power plants	- Pollution Emission Register - Voluntary survey of Power Utility Company
	Fuel characteristic data	- Voluntary survey of Oil and Gas Company
	Natural gas processed (scrubbed), CO ₂ content before scrubbing and CO ₂ emission	- Voluntary survey of Central Gas Station
Industrial Processes	Activity data on production/consumption of material for particular industrial process	- Central Bureau of Statistics, Department of Manufacturing and Mining - Croatian Environment Agency - 'Republic of Croatia <i>Informative Inventory Report for LRTAP Convention for the Year 2011</i> Submission to the Convention on Long-range Transboundary Air Pollution'
	Activity data on production/consumption of halogenated hydrocarbons (PFCs, HFCs) and sulphur hexafluoride (SF ₆)	- Ministry of Environmental and Nature Protection
	Data on consumption and composition of natural gas in ammonia production Data on cement and lime production	- Survey of ammonia manufacturer - Survey of cement and lime manufacturers - Croatian Environment Agency
Solvent and Other Product Use	Activity data on production for particular source category and number of inhabitants	- 'Republic of Croatia <i>Informative Inventory Report for LRTAP Convention for the Year 2011</i> Submission to the Convention on Long-range Transboundary Air Pollution'
Agriculture	Livestock number	- Central Bureau of Statistics - Croatian Horse breeding Centre
	Production of N-fixing crops and non N-fixing crops	- Central Bureau of Statistics
	Area of histosols	- Faculty of Agriculture
	Activity data on mineral fertilisers applied in Croatia	- Voluntary survey of Fertilizer Companies

CRF Sector/Sub-sector	Type of data	Source of data
	Activity data on sewage sludge applied	- Voluntary survey of Food Company
LULUCF	Activity data on areas of different land use categories, annual increment and annual cut, fuel wood and wildfires	- Ministry of Agriculture with assistance of public company "Hrvatske šume"
Waste	Activity data on municipal solid waste disposed to different types of SWDSs	- Ministry of Environmental and Nature Protection - Croatian Environment Agency
	Activity data on wastewater handling	- State company Croatian Water (Hrvatske vode)
	Activity data on waste incineration	- Croatian Environment Agency

15. 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% (Tier 1) or 90% (Tier 2) 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. Results of Key categories analysis are presented in Annex 1, Table A1.2-2 – Table A1.2-18.

Tier 1 level assessment uses emissions and removals from each category directly and Tier 2 level assessment analyzes the emissions and removals of each category, multiplied by the uncertainty (Annex 5, Table A5.2-1, Table A5.2-2). The purpose of trend assessment is to identify categories that may not be large enough to be identified by level assessment, but whose trend is significantly different from the trend of the overall inventory, and should therefore receive particular attention. Tier 2 trend assessment is calculated multiplying the Tier 1 trend assessment with uncertainty of each category (Annex 5, Table A5.2-1, Table A5.2-2).

The analysis is based on the contribution of CO₂ 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.

The results of the Approach 1 Level Assessment including/excluding LULUCF for 1990 and 2011 are shown in Tables A1.2-1 to A1.2-4 respectively, with the key categories shaded.

The results of the Approach 2 Level Assessment including/excluding LULUCF for 1990 and 2011 are shown in Tables A1.2-7 to A1.2-10 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 Approach 1 Trend Assessment including/excluding LULUCF are shown in Tables A1.2-5 to A1.2-6, with the key categories shaded.

The results of the Approach 2 Trend Assessment including/excluding LULUCF are shown in Tables A1.2-11 to A1.2-12, with the key categories shaded.

The key categories are sorted in descending order of magnitude, and the cumulative total is shown in the final column of the table.

The results of the Key Category Analysis including/excluding LULUCF are summarized by sector and gas in Table A1-17 and A1-18 respectively. The tables indicate whether the key category arises from the level assessment or the trend assessment or both level and trend assessment for 1990 and 2011 using Approach 1 and Approach 2.

Key category analysis is used to drive improvements of the inventory. Most efforts were made to collect detailed information on emissions calculation regarding key sources.

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

1.6.1. QA/QC PLAN

According to Article 8, paragraph 1 of the Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia, within the competence of CEA is the preparation of quality assurance and quality control plan regarding greenhouse gas inventory (hereinafter QA/QC plan), implementation of the quality assurance procedures in accordance with the QA/QC plan and archiving activity data for emission calculation, emission factors and documents used for planning, preparing, controlling and assuring Inventory quality. QA/QC plan is a part of quality assurance and quality control system (QA/QC system), stipulated by Decision 19/CMP.1 Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol. Implementation of QA/QC system is based on following documents: QA/QC programme, Quality objectives document, QA/QC plan and Category-specific QC checklist.

QA/QC programme describes: overall responsibilities and roles of institutions involved in inventory planning, preparation and management, general timetable of activities for data collection, inventory preparation, inventory submission, annual review and reporting on GHG registry and general and specific QA/QC procedures.

Quality objectives document defines general and specific short-term (< 1 year) and medium-term (1-3 years) objectives related to the improvement of National system in regard to inventory planning, preparation and management. This document takes into account results of uncertainty analysis, key category analysis and recommendations outlined in the Annual review report. This document is prepared annually.

QA/QC plan follows the proposed cycle of activities and responsibilities:

activity	responsibility
Preparation of QA/QC plan • Making decisions regarding method selection, procedures and/or national system supplements • Documentation revision and supplement	QA/QC coordinator CEA, MENP, Authorized Institution
Approval of QA/QC plan	CEA, MENP
Implementation of QC procedures • Internal audit • Corrective and preventive activities • Reporting on performed internal audit	QA/QC coordinator, Authorized Institution's sectoral experts QA/QC coordinator, Project leader in NIR preparation Authorized Institution's sectoral experts QA/QC coordinator
Reporting on QC procedures	Authorized Institution
Implementation of QA procedures	CEA, MENP - National System Committee

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

- Activity data collection and archiving;
- Preparation of inventory report;
- Submission of inventory report;
- Review activities;
- Reporting on GHG registry.

For the purposes of transparency of the emission calculation and archiving of data, inventory team has continued with the good practice in 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. An example of Inventory Data Record Sheet for 2011 in Waste sector is presented in Annex 6, Table A6-1. All data in the form of Inventory Data Record Sheets are also archived at CEA.

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 by each sector, subsector and corresponding CRF tables.

Finally, before the Authorized Institution submits the NIR to CEA, QA/QC manager carried out an audit which covers selected IPCC source categories, as outlined in the QA/QC plan, with purpose to check which quality

control elements, both general (Tier 1) and specific (Tier 2), 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. CRF tables for each sector are reviewed in accordance with the Quality Management Standard (ISO 9001) and Environmental Management Standard (ISO 14001) implemented within the Agency and the authorized institution. Audit results are registered in control lists as well as performed correction activities.

Quality assurance activities are accomplished in a way that CEA submits complete Inventory and CRF tables to the MENP, which, upon receipt, approves the latter. National System Committee is included in the approval process; its members provide their opinion on certain parts of the Inventory within the frame of their speciality. Members of the National System Committee are nominated by the authorized Ministries upon the request of the MENP. QA/QC coordinator documents all Committee results/findings.

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 CO₂ emissions from fuel combustion calculated using sectoral methods with the IPCC Reference Approach. Further verification checks may be done through 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 CO₂ 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).

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 uncertainties are estimated using Tier 1 and Tier 2 (Monte Carlo analysis) methods described by the IPCC, which provide 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 Tier 1 uncertainty analysis the total uncertainty excluding LULUCF is 16.12 percent, while the total uncertainty including LULUCF is 31.14 percent.

According to the Tier 2 Monte Carlo analysis the total uncertainty excluding LULUCF for all key source activities is estimated to be from -16.48 percent to +16.90 percent.

According to the Tier 2 Monte Carlo analysis the total uncertainty including LULUCF for all key source activities is estimated to be from -32.13 percent to +32.84 percent.

According to the Tier 1, the uncertainty introduced into the trend in total national emissions excluding LULUCF is estimated to be 19.43 percent and including LULUCF 36.30 percent.

According to the Tier 2 Monte Carlo analysis the total uncertainty introduced into the trend for all key source activities excluding LULUCF is estimated to be from -16.28 percent to +19.35 percent.

According to the Tier 2 Monte Carlo analysis the total uncertainty introduced into the trend for all key source activities including LULUCF is estimated to be from -29.35 percent to +38.11 percent.

The results of the Tier 1 approach are shown in Table A5.2-1 and A5.2-2 and results of the Tier 2 approach are shown in Table A5.1-2 and A5.1-3 (Annex 5).

Comparison of result uncertainties in total emission and uncertainty of trend from the Error Propagation model and Monte Carlo model are described and explained in the Annex 5, Chapter A.5.3.

According to 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume I: General Guidance and Reporting, pp 3.58, in trend uncertainty calculation for the tier 1 method a factor of the square root 2 is used only in the case when activity data (AD) and emission factors (Efs) uncertainty is the same in the base year and year t. This is not the case with Croatian inventory.

Explanation on correlation assumptions are provided in the Annex 5. EFs are not correlated between the years for many categories because EFs values and EFs uncertainties are not the same for 1990 and 2011.

The results of the uncertainty analysis are used to drive improvements of the inventory. Most efforts were made to collect detailed information on AD and EFs (especially country-specific EFs) in order to improve accuracy of the emission calculation.

18. GENERAL ASSESSMENT OF THE COMPLETENESS

Croatian inventory consists of the emission estimates for the period from 1990-2011.

The completeness is evaluated following the IPCC methodology and appropriate use of the following notation keys: *NO* (not occurred); *NE* (not estimated); *NA* (not applicable); *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 issues related with lack of activity data are described in sectoral chapters where necessary. The aim of the Croatian inventory is to include all anthropogenic 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 A4-1.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

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

The total GHG emissions in 2011, excluding removals by sinks, amounted to 28.256 mil. t CO₂-eq (equivalent CO₂ emissions), which represents 10.6 percent emission reduction compared to GHG emission in the year 1990.

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 Šibenik, coke plant in Bakar), which was considerably reflected in GHG emissions reduction. Emissions have started to increase in the 1995 at an average rate of 3 percent per year, till 2008. Due to decreasing of economic activity within the period 2009-2011, emission has been reduced by 6.4 percent in 2009, 8.0 in 2010 and 9.3 in 2011, regarding 2008.

The main reasons of GHG emission increase in the period 1995-2008 was Energy (Public electricity and Heat production and Transport), Industrial processes (Cement production, Lime production, Ammonia production, Nitric acid production and Consumption of HFCs) and Waste. Increase in Public electricity and Heat production sector is mostly due to higher consumption of liquid fuels (7.5%). Lately, cement, lime, ammonia and nitric acid producers reached their highest producing capacity which has reflected on emission levels. Waste disposal on land, as well as Wastewater handling, have the greatest impact on emission increase in Waste sector.

The main reasons of GHG emission decrease in 2011 was economic crisis. Namely, because of the economic crisis, there was decrease in industrial production and consequently, decrease in fuel consumption (greatest reduction in fuel consumption was in Manufacturing industries and construction sector and also in transport sector), and it was contributed to the GHG emission decrease.

A decrease of economic activities after 2008 influenced a reduction in cement, lime, and steel productions. Although ammonia production increased by 2 percent in 2011, overall emissions from industrial processes dropped by 6.6 percent., regarding 2010.

2.2 BRIEF 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 2011, the shares of GHG emissions were as follows: 73.9 percent CO₂, 12.4 percent CH₄, 12.0 percent N₂O, 1.7 percent HFCs and 0.04 percent SF₆. The trend of aggregated emissions/removals, divided by gasses, is shown in the Table 2.2-1 and Figure 2.2-1.

Table 2.2-1: Aggregated emissions and removals of GHG by gases (1990-2011)

Gas	Emissions and removals of GHG (Gg CO ₂ -eq)							
	1990	1995	2000	2005	2008	2009	2010	2011
CO ₂	23,339	17,202	20,093	23,485	23,756	21,982	21,289	20,869
CH ₄ as CO ₂ -eq	3,420	2,744	2,729	3,132	3,518	3,522	3,566	3,509
N ₂ O as CO ₂ -eq	3,941	3,054	3,285	3,490	3,456	3,210	3,279	3,392
HFCs as CO ₂ -eq	0	49	171	333	424	436	472	476
PFCs as CO ₂ -eq	937	0	0	0	0	0.2	0.03	0.01
SF ₆ as CO ₂ -eq	11	12	12	14	13	8	9	10
Total GHG emission	31,647	23,061	26,290	30,454	31,167	29,159	28,615	28,256
Removals (CO ₂)	-6,411	-9,078	-7,719	-8,151	-7,823	-8,066	-7,872	-7,032
Total emission (including LULUCF)	25,236	13,982	18,571	22,302	23,343	21,093	20,744	21,225

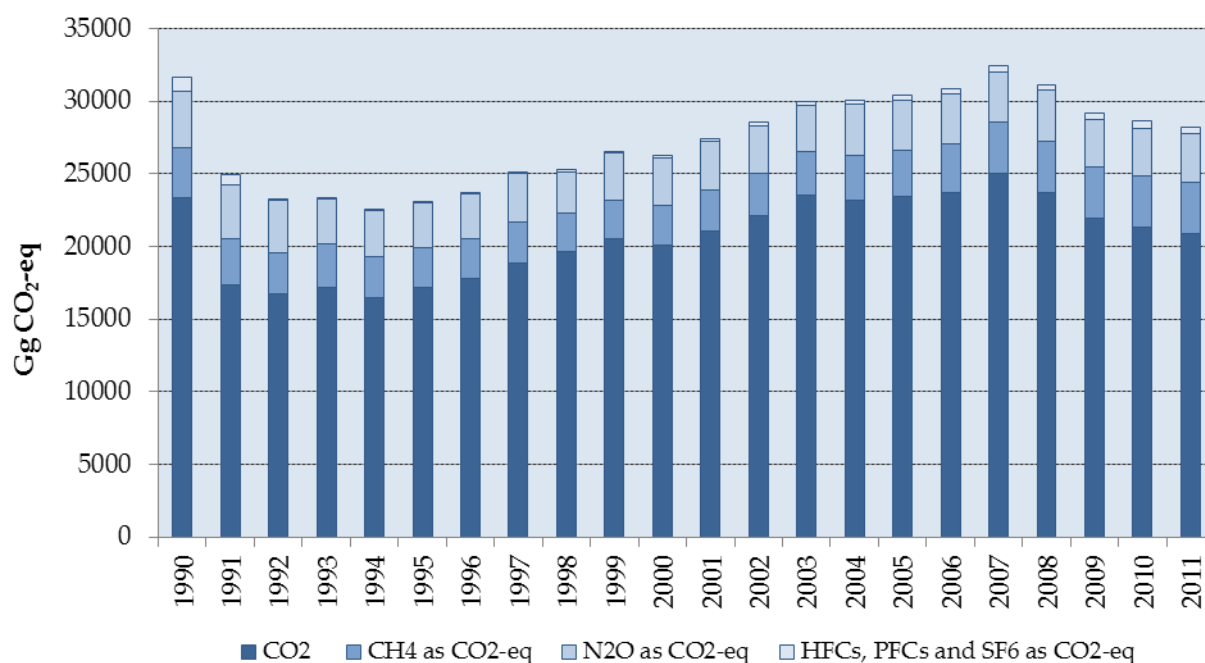


Figure 2.2-1: Trend of GHG emissions, by gases

2.2.1. CARBON DIOXIDE – CO₂

The most significant anthropogenic greenhouse gas is carbon dioxide (CO₂). In 2011, CO₂ emission was 10.6 percent lower than in 1990. The largest CO₂ emission decrease was in Industrial Processes (Metal Production) and Energy (Manufacturing Industries and Construction) sectors. There was a permanent increase in mobility (number of road vehicles) and therefore an increase in motor fuel consumption. The largest CO₂ emission growth is present in Solvent and Other Product use and Waste (Waste Incineration) sectors.

2.2.2. METHANE – CH₄

The CH₄ emission in 2011 was 2.6 percent higher than in 1990, largely due to emission trend in Waste sector.

2.2.3. NITROUS OXIDE – N₂O

The N₂O emission in 2011 was 13.9 percent lower than emission in 1990. A decrease of emission was present in Energy, Solvent and Other Product Use and Agriculture sectors.

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 and PFCs were used as substitutes for cooling gases that deplete the ozone layer, in refrigerating and air-conditioning systems, foam blowing, fire extinguishers and aerosols/metered dose inhalers. According to provided calculations, the contribution of F-gases in total national GHG emission in 2011 was approximately 1.7 percent.

2.2.5. SULPHUR HEXAFLUORIDE SF₆

Total emissions of SF₆ used in GIS application and high voltage circuit-breakers have been estimated using data on total charge of SF₆ contained in the existing stock of equipment and leakage and maintenance losses as a fixed percentage of the total charge. According to provided calculations, the contribution of SF₆ in total national GHG emission in 2011 was approximately 0.03 percent.

2.3. BRIEF 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 and Other Product Use, Agriculture, Land Use, 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 Figure 2.3-1.

Table 2.3-1: Aggregated emissions and removals of GHG by sectors (1990-2011)

Source	Emissions and removals of GHG (Gg CO ₂ -eq)							
	1990	1995	2000	2005	2008	2009	2010	2011
Energy	22,796	17,263	19,482	22,672	22,903	21,651	21,009	20,715
Industrial Processes	3,789	2,016	2,861	3,295	3,592	2,984	3,211	3,000
Solvent and Other Product Use	117	108	109	195	239	153	152	144
Agriculture	4,381	3,055	3,130	3,478	3,431	3,314	3,193	3,319
Waste	564	619	707	814	1,001	1,057	1,050	1,078
Total GHG emission	31,647	23,061	26,290	30,454	31,167	29,159	28,615	28,256
Removals (LULUCF)	-6,411	-9,078	-7,719	-8,151	-7,823	-8,066	-7,872	-7,032
Total emission (including LULUCF)	25,236	13,982	18,571	22,302	23,343	21,093	20,744	21,225

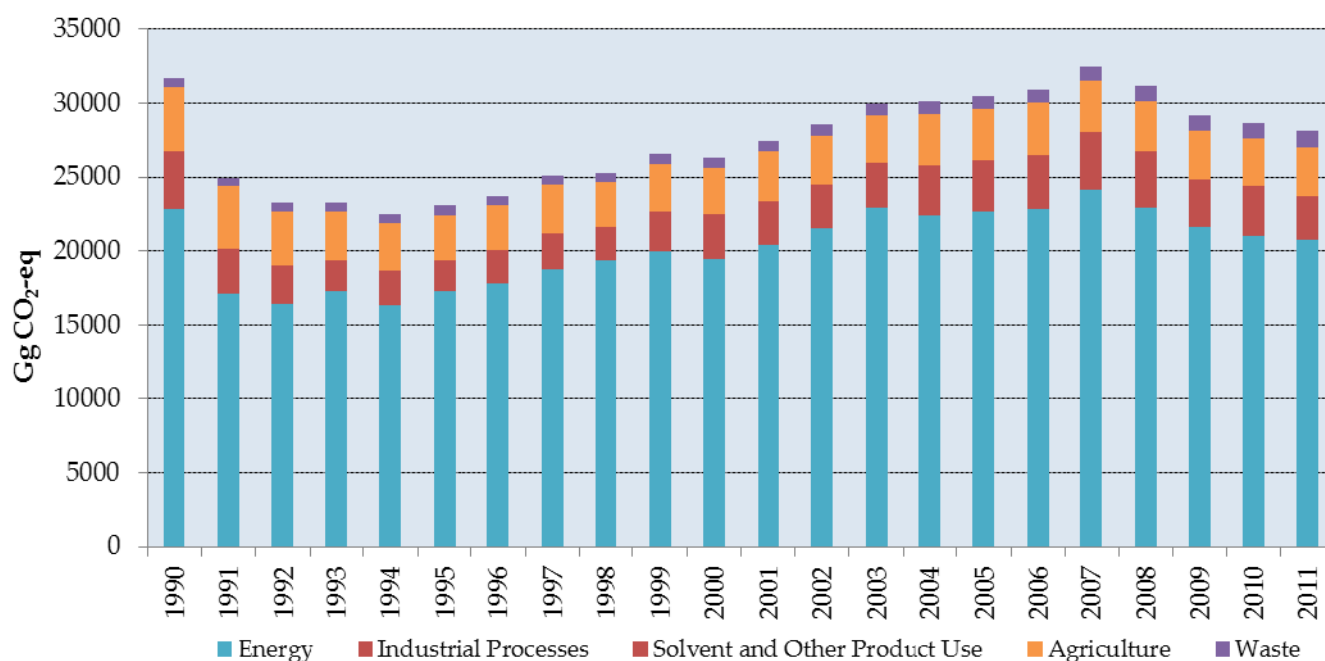


Figure 2.3-1: Trend of GHG emissions, by sectors

2.3.1.ENERGY

The most important IPCC sector in Croatia is Energy sector. The Energy sector accounted for some 73.3 percent of the total national GHG emissions (presented as equivalent emission of CO₂). In 2011, the GHG emission from Energy sector was 1.4 percent lower in relation to 2010 and 9.1 percent smaller than emission in 1990.

The main reasons of GHG emission decrease in 2011 was economic crisis. Namely, because of the economic crisis, there was decrease in industrial production and consequently, decrease in fuel consumption (greatest reduction in fuel consumption was in Manufacturing industries and construction sector and also in transport sector), and it was contributed to the GHG emission decrease.

The total energy consumption in 2011 was 0.4 percent lower than in the previous year. The consumption of gaseous fuel has decreased (4.5 percent) but consumption of solid fuel has increased for 4.8 percent and also consumption of fuel wood and other renewables has increased (14.8 percent in relation to 2010).

In 2011, the total electricity production was 23.2 percent lower than in the former year. Hydro power utilisation has decreased by 45.2 percent because of unfavorable hydrological conditions. Increase in energy consumption from thermal power plants, public and industrial cogeneration plants was 31.1 percent. Electricity production in wind power plants was increased for 44.5 percent in relation to 2010. The import of electricity was about 30 percent of total electricity consumption in Croatia.

2.3.2.INDUSTRIAL PROCESSES

Industrial Processes contributes to total GHG emission with approximately 10 percent, depending on the year. Due to decreasing of economic activity after 2008, which influenced decreasing of cement, lime and ammonia production, in 2011 emissions from this sector have dropped by 16.5 percent, regarding 2008. In 2011, cement production was decreased by 2.6 percent, lime production by 12.9 percent and iron and steel production by 7.3 percent, regarding 2010. On the other side, in 2010 ammonia production increased by 2 percent, regarding 2010. Consequently, in 2011 emissions from industrial processes were decreased by 6.6 percent, regarding 2010.

2.3.3.SOLVENT AND OTHER PRODUCT USE

Solvent and Other Product Use contributes to total GHG emission with some 0.5 percent of the total national GHG emissions (presented as equivalent emission of CO₂). The GHG emission in 2011 was 23 percent larger than emission in 1990 since new activity data, regarding Other use of solvent, were included in the emission calculation.

2.3.4. AGRICULTURE

The GHG emissions from Agriculture have been decreasing from 2006. The GHG emission in 2011 was about 24.2 percent lower in comparison with 1990 emission. According to estimation of Croatian experts for agriculture, approximately 11.75 percent of total GHG emissions belong to Agriculture.

2.3.5. WASTE

Emissions from Waste sector have been constantly increasing in the period 1990-2011. Increasing emissions are a consequence of greater quantities of waste, activities in wastewater handling and waste incineration. Although increasing of municipal solid waste amounts as a result of the growth in the living standard, this rise has slightly declined due to economic crisis and effects of measures undertaken to avoid/reduce, separately collect and recycle waste. Priority is given to avoiding and reducing waste generation and reducing its hazardous properties.

The GHG emission in 2011 was 91 percent larger in comparison with 1990 emission. Contribution of waste sector to the total GHG emission is 3.8 percent.

2.4. BRIEF DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR INDIRECT GREENHOUSE GASSES AND SO₂

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 O₃ as one of the GHGs. Sulphur dioxide (SO₂), as a precursor of sulphate and aerosols, is believed to contribute negatively to the greenhouse effect.

Emissions of indirect GHGs have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2011* Submission to the Convention on Long-range Transboundary Air Pollution'.

The emissions of ozone precursors and SO₂ are shown in the Table 2.4-1.

Table 2.4-1: Emissions of ozone precursors and SO₂ by different sectors (Gg)

Gas	Emissions (Gg)							
	1990	1995	2000	2005	2008	2009	2010	2011
NO_x Emission	69.9	61.7	69.1	75.6	53.8	47.5	43.8	42.7
Energy Industries	17.5	14.5	13.8	12.2	11.5	11.5	9.5	9.6
Manufacturing Ind. & Construction	16.3	7.6	7.7	10.1	12.7	9.7	10.0	9.4
Transport	16.6	27.9	29.5	30.1	5.0	4.6	4.2	5.0
Other Energy (fuel comb.)	15.0	8.1	12.8	13.1	13.5	13.3	13.2	13.3
Fugitive Em. from Fuels	0.5	0.3	0.3	0.3	0.3	0.3	0.2	0.2
Industrial Processes	2.8	2.6	2.8	8.3	9.2	7.0	5.8	4.1
Agriculture	0.8	0.7	0.9	0.9	0.9	0.8	0.8	0.8
LULUCF	0.4	0.1	1.7	0.0	0.1	0.1	0.0	0.2
CO Emission	366.1	288.7	379.6	287.7	221.2	223.0	225.8	245.8
Energy Industries	2.4	1.6	1.6	1.1	1.5	1.2	1.1	1.2
Manufacturing Ind. & Construction	37.2	38.1	33.6	33.5	31.4	30.7	31.7	29.4
Transport	19.3	67.6	69.7	44.0	3.5	2.4	2.0	3.0
Other Energy (fuel comb.)	204.0	116.7	146.4	133.0	120.1	126.2	141.8	166.3
Fugitive Em. from Fuels	50.1	34.5	54.1	54.4	41.6	51.9	40.1	32.6
Industrial Processes	41.7	28.4	32.1	19.8	41.8	38.0	12.8	3.4
Agriculture	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	12.7	1.9	51.5	1.1	3.9	1.9	1.3	6.9
NMVOC Emission	94.0	82.8	80.4	92.1	96.9	67.3	68.2	65.0
Energy Industries	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.3
Manufacturing Ind. & Construction	1.6	1.3	1.4	1.8	2.1	1.7	1.6	1.5
Transport	16.6	20.2	22.3	8.7	1.4	1.3	1.2	1.3
Other Energy (fuel comb.)	12.1	6.9	9.0	8.3	7.7	8.0	8.8	10.1
Fugitive Em. from Fuels	9.0	7.0	9.1	8.5	7.5	8.0	7.7	7.1
Industrial Processes	24.0	9.3	7.8	8.7	8.3	6.3	5.9	5.3
Solvent and Other Product Use	28.1	25.5	25.3	55.2	64.6	72.1	68.8	40.0
LULUCF	1.3	0.2	5.2	0.1	0.4	0.2	0.1	0.7
SO₂ Emission	173.1	82.8	62.2	63.5	51.2	53.4	40.4	37.3
Energy Industries	99.5	54.0	32.9	32.7	32.0	36.7	19.7	17.9
Manufacturing Ind. & Construction	39.8	16.7	11.0	9.7	8.2	6.1	12.2	9.7
Transport	5.5	4.6	6.4	9.2	1.5	0.9	0.7	1.3
Other Energy (fuel comb.)	23.9	4.7	6.5	6.8	4.3	4.5	4.2	3.7
Fugitive Em. from Fuels	1.8	1.2	3.1	3.1	2.8	3.3	2.3	3.5
Industrial Processes	2.6	1.6	2.1	2.1	1.9	2.1	2.4	1.8

3 ENERGY (CRF sector 1)

3.1. OVERVIEW

3.1.1. OVERVIEW OF THE ENERGY SITUATION

Primary sources of energy that are produced in Croatia are fuel wood, crude oil, natural gas, renewables and hydro power. Coal production stopped in 2000. Primary energy production for the 1990, 1995, 2000, 2005 and period from 2008 to 2011 is presented in the Table 3.1-1.

Table 3.1-1: Primary energy production

PJ	1990	1995	2000	2005	2008	2009	2010	2011
Coal and coke	4.21	1.96	0.00	0.00	0.00	0.00	0.00	0.00
Fuel wood	22.68	13.52	15.64	14.77	16.58	17.97	19.96	26.74
Crude oil	104.54	62.81	51.35	40.11	35.42	33.07	30.69	28.37
Natural gas	74.27	69.12	59.4	79.76	94.05	93.50	93.88	85.02
Hydro power	38.55	51.75	56.93	62.40	50.19	65.77	79.71	42.59
Heat	-	-	-	0.61	1.25	1.48	1.71	1.73
Renewables	0.00	0.00	0.00	0.20	1.03	1.34	2.63	2.97
Total	244.25	199.16	183.32	197.24	197.28	211.64	228.57	187.42

Figure 3.1-1 presents the trends in the primary energy production from 1990 to 2011.

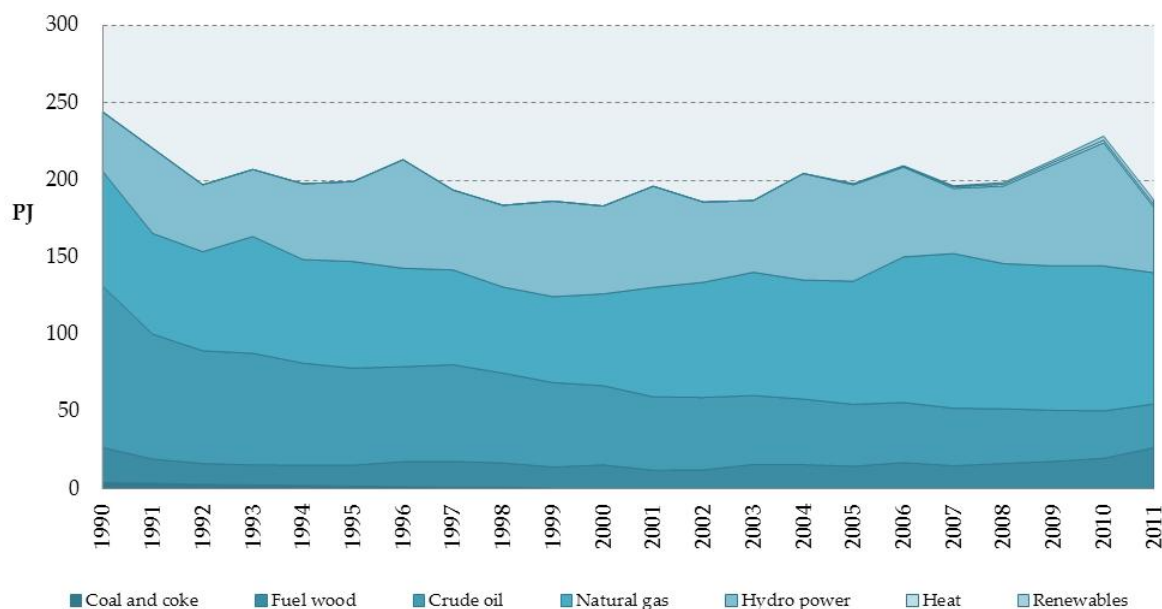


Figure 3.1-1: Trends in primary energy production for the period from 1990 to 2011

In 1990 primary energy production was about 244 PJ, which is 23.3% higher comparing to 2011. In 2011, the total primary energy production decreased by 18% with relation to the 2010. Comparing to 2010, the energy production from renewable sources increased 13% in 2010. The production of natural gas decreased 9.4% as well as production of crude oil by 7.6%, while production of fuel wood increased (34%). Hydro power utilization decreased by 46.6%.

While in 1990 the share of crude oil in primary energy production was the highest one with 42.8%, in 2011 its' share was only 15.1%. In 2011, the share of natural gas (45.4%) was the highest one. It was followed by hydro power with the share of 22.7%. The comparison of shares in primary energy productions for the 1990 and 2011 are presented in Figure 3.1-2.

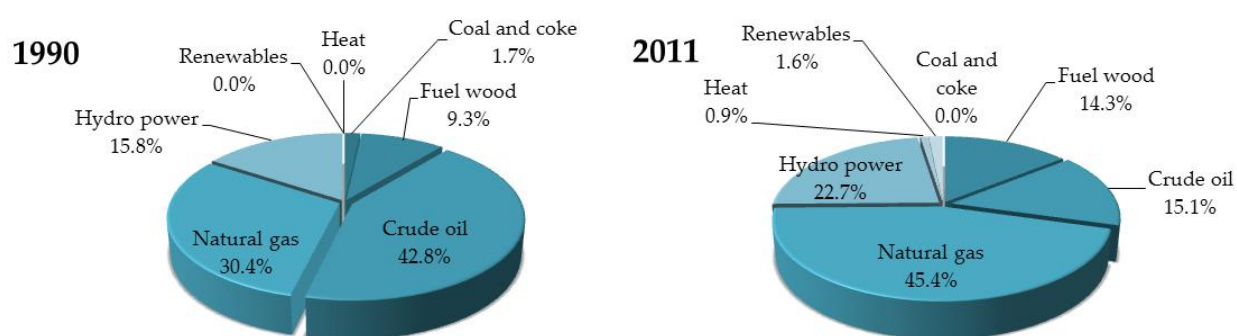


Figure 3.1-2: Shares of individual energy forms in the total production for the 1990 and 2011

Primary energy supply

Total primary energy supply is determined by adding the import and subtracting the export of all primary and transformed energy forms to the total primary energy supply. Primary energy supply for the 1990, 1995, 2000, 2005 and period from 2008 to 2011 is presented in the Table 3.1-2.

Table 3.1-2: Primary energy supply

PJ	1990	1995	2000	2005	2008	2009	2010	2011
Coal and coke	34.07	7.42	17.15	32.95	34.65	24.66	30.92	31.66
Fuel wood	22.68	13.52	15.64	14.77	13.38	14.42	16.05	19.23
Liquid fuels	192.6	146.03	160.52	181.88	180.15	178.04	152.54	149.16
Natural gas	98.22	82.77	94.98	101.06	110.22	102.15	111.37	108.60
Hydro power	38.55	51.75	56.93	62.40	50.19	65.77	79.71	42.59
Electricity	25.42	12.59	14.4	18.41	23.68	20.46	17.15	27.71
Heat				0.61	1.25	1.48	1.71	1.73
Renewables	0.00	0.00	0.00	0.20	0.97	1.43	2.24	2.97
Total	411.54	314.08	359.62	411.67	413.24	406.92	411.69	383.65

Figure 3.1-3 presents the trends in the primary energy supply from 1990 to 2011.

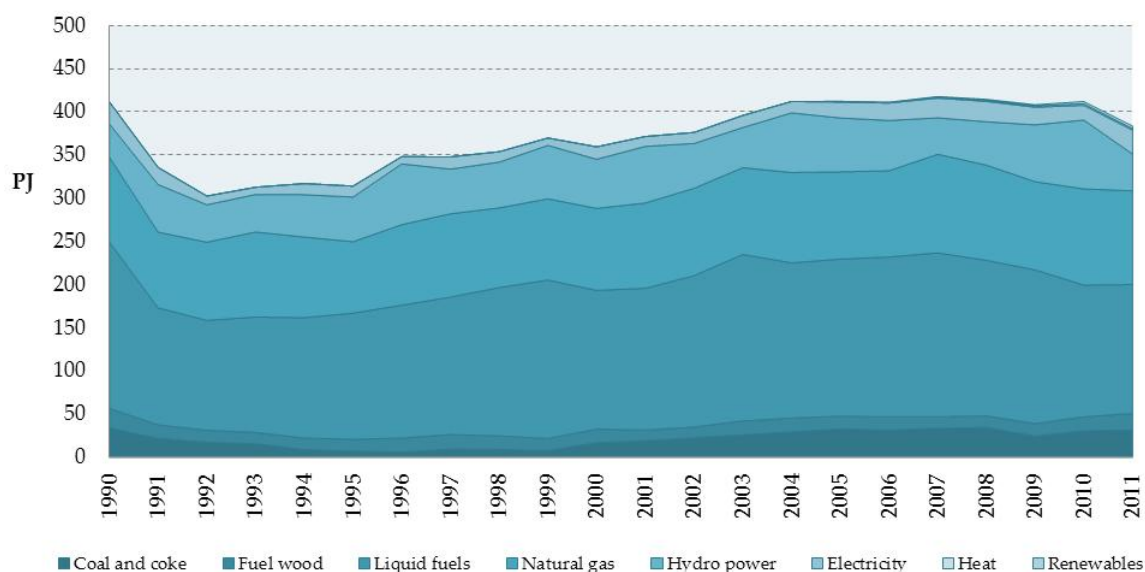


Figure 3.1-3: Trends in primary energy supply for the period from 1990 to 2011

In 1990 primary energy supply was about 412 PJ, which is 6.8% higher comparing to 2011. In 2011, the total primary energy supply increased by 6.9% with relation to the previous year. There was an increase in coal and coke, fuel wood, renewable energy sources, heat and electricity, while consumption of natural gas and liquid fuels decreased. Due to poor hydrology conditions, hydro power energy supply decreased by 46.6% with relation to the 2010. Figure 3.1-4 presents comparison of the shares of individual energy forms in the total primary energy supply for the 1990 and 2011.

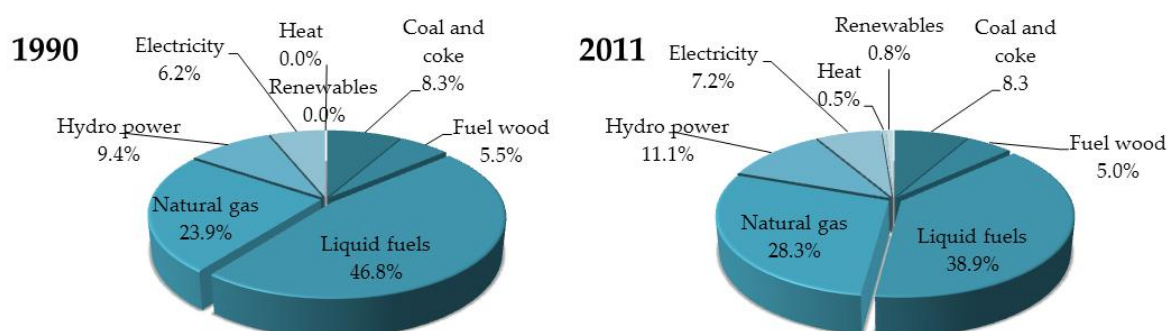


Figure 3.1-4: Comparison of the shares of individual energy forms for the 1990 and 2011

Liquid fuels had the largest share in total primary energy supply in 1990 as well as in 2011 (approximately 39%). It was followed by the natural gas with the share of approximately 28%. The Figure 3.1-5 presents difference between total primary energy production (P) given in Table 3.1-1 and total primary energy supply (S) given in Table 3.1-2.



Figure 3.1-5: Total primary energy supply (S) and production (P)

The difference between the supply and the production presents the balance of energy export and import to Croatia. The relation between the produced and consumed energy constitutes own supply which in 2011 amounted 48.8%. Total hydro power and fuel wood supply were fully covered from the territory of Croatia. The production of solid fuels stopped in 2000, thus all needs for coke and coal were satisfied from export.

The basis for estimating the GHG emissions from Energy sector is the national energy balance. Data on production, imports, exports, stock change and consumption of fuels are reported both in natural units (kg or m³) and energy units (PJ). National energy balance for 2011 is presented in Annex 3.

For easier comparison of data from energy balance the natural units are transformed to energy units using appropriate national net calorific values (Table 3.1-3).

Table 3.1-3: National net calorific values, CO₂ emission factors and oxidation factors for 1990 and 2011

Fuel	Net Caloric Value			Carbon emission factor ³ (t C/TJ)	CO ₂ emission factor (t CO ₂ /TJ) (without OF)	Oxidation factor (OF)
	Unit	1990	2011			
SOLID FUELS						
Anthracite	TJ/Gg	29.29	29.31	26.8	98.27	0.98
Other Bituminous Coal	TJ/Gg	25.14	24.40	25.8	94.60	0.98
Sub-Bituminous Coal	TJ/Gg	16.74	17.10	26.2	96.07	0.98
Lignite	TJ/Gg	10.90	11.60	27.6	101.20	0.98
Brown Coal Briquettes	TJ/Gg	16.74	-	26.6	97.53	0.98
Coke oven Coke	TJ/Gg	29.31	29.31	29.5	108.17	0.98
LIQUID FUELS						
Motor gasoline	TJ/Gg	44.60	44.59	18.9	69.30	0.99
Aviation gasoline	TJ/Gg	44.60	44.59	18.9	69.30	0.99
Jet Kerosene	TJ/Gg	44.00	43.96	19.5	71.50	0.99
Gas/Diesel oil	TJ/Gg	42.71	42.71	20.2	74.07	0.99
Residual Fuel Oil	TJ/Gg	40.19	40.19	21.1	77.37	0.99
Liquefied Petroleum Gases	TJ/Gg	46.89	46.89	17.2	63.07	0.99
Petroleum Coke	TJ/Gg	29.31	31.00	27.5	100.83	0.99
Petroleum	TJ/Gg	44.00	43.96	19.6	71.87	0.99
Lubricants	TJ/Gg	33.57	33.50	20.0	73.33	0.99
GASEOUS FUELS						
Natural Gas	TJ/10 ⁶ m ³	34.00	34.0	15.3	56.10	0.995
Gas Works Gas	TJ/10 ⁶ m ³	15.82	17.20	13.0	47.67	0.995
Coke Oven Gas	TJ/10 ⁶ m ³	17.90	-	13.0	47.67	0.995
BIOMASS FUELS						
Wood biomass	TJ/Gg	-	9.0	29.9	109.63	0.98
Industrial waste	TJ/Gg	-	-	29.9	109.63	0.98

The structure of energy consumption of fossil fuels from 1990 to 2011 is shown in Figure 3.1-6.

³ IPCC default (from "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook")

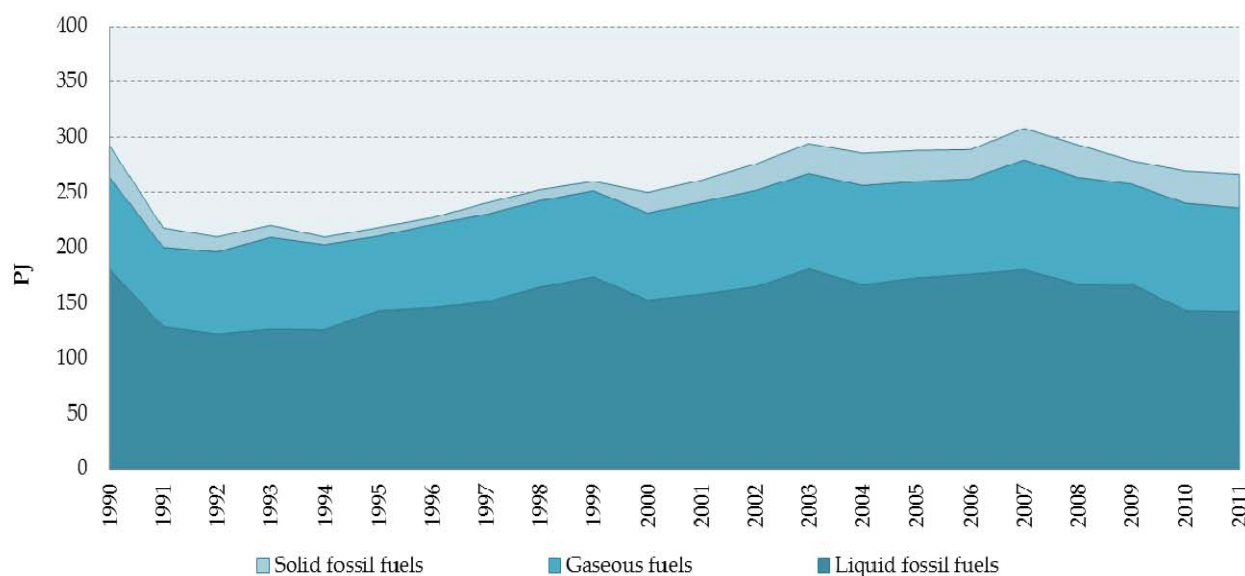


Figure 3.1-6: Structure of energy consumption

Liquid fossil fuels are mainly used with share between 50 to 65 percent, and natural gas with approximately 30 percent, while share of solid fossil fuels is between 3 to 11 percent. Fuel woods and biomass-based fuels are neutral regarding CO₂ emission, therefore are not shown in the Figure 3.1-6.

3.1.2.OVERVIEW OF EMISSIONS

Energy 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 approximately 75 percent of the total emission of all greenhouse gases presented as equivalent emission of CO₂. Looking at its contribution to total emission of carbon dioxide (CO₂), the energy sector accounts for about 90 percent. The contribution of energy in methane (CH₄) emission is substantially smaller (46 percent) while the contribution of energy in nitrous oxide (N₂O) emission is quite small (about 3 percent).

During complete combustion, the carbon contained in fuel oxidizes and transforms into CO₂, while through the incomplete combustion the small amounts of CH₄, CO and NMVOC emissions also appear. The CO₂ is the most important greenhouse gas from fuel combustion. The emission of CO₂ depends on the quantity and type of the fuel used. The specific emission is the highest 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 (CH₄) and nitrous oxide (N₂O), 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 creation and destruction of ozone, which is one of the GHGs. In the framework of the IPCC methodology, the calculation of sulphur dioxide (SO₂) emission is also recommended. The sulphur dioxide as a precursor of sulphate and aerosols has a negative impact on the greenhouse effect because the creation of aerosols removes heat from the atmosphere.

The fuel fugitive emission which is generated during production, transport, processing, storing and distribution of fossil fuels, is also estimated. These activities produce mainly the emission of CH₄, and smaller quantities of CO₂ and N₂O, NMVOC, CO and NO_x.

Emissions from fossil fuel combustion comprise the majority (more than 90 percent) of energy-related emissions. Contribution of individual subsectors to emission of greenhouse gases, for the last estimated year (2011), is presented in the Table 3.1-4 while contribution of individual subsectors to GHG emission for the period 1990-2011 is presented in Figure 3.1-7.

Table 3.1-4: Contribution of individual subsectors to emission of greenhouse gases, for 2011

GHG categories	Gg			Total	
	CO ₂	CH ₄	N ₂ O	CO ₂ -eq (Gg)	%
ENERGY	19,051.98	74.43	0.32	20,715.35	100.00
A. Fuel combustion activities	18,474.82	6.45	0.32	18,710.49	90.32
1. Energy industries	6,252.91	0.22	0.06	6,275.44	30.29
a) Electricity and heat production	4,202.70	0.15	0.04	4,219.27	20.37
b) Petroleum refining	1,753.58	0.07	0.01	1,759.26	8.49
c) Manufacture of solid fuels	296.64	0.01	0.00	296.91	1.43
2. Manufacturing ind. and constr.	3,139.07	0.29	0.03	3,153.34	15.22
3. Transport	5,826.11	0.66	0.16	5,888.70	28.43
a) Civil aviation	89.88	0.00	0.00	89.91	0.43
b) Road transport	5,537.15	0.65	0.16	5,598.91	27.03
c) Railways	82.68	0.01	0.00	83.01	0.40
d) Navigation (domestic)	116.40	0.01	0.00	116.87	0.56
4. Other sectors	3,256.73	5.28	0.08	3,393.01	16.38
5. Other	NO	NO	NO	-	-
B. Fugitive emissions from fuels	577.16	67.98	0.00	2,004.86	9.68
1. Solid fuels	NO	NO	NO	-	-
2. Oil and natural gas	577.16	67.98	0.00	2,004.86	9.68

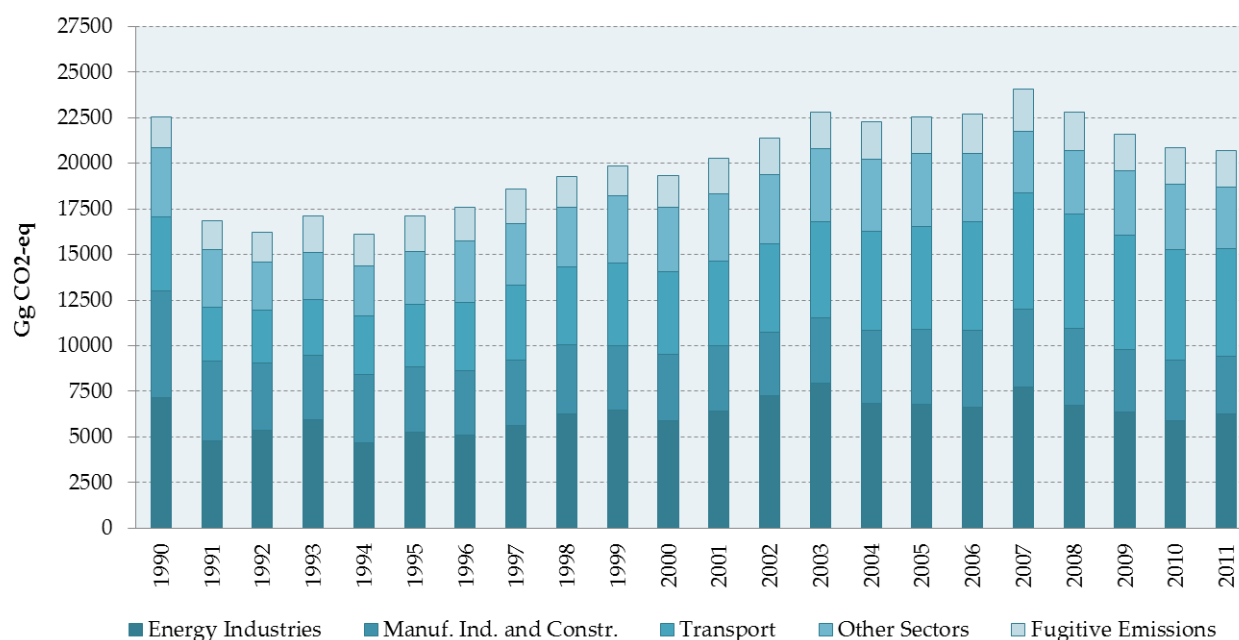


Figure 3.1-7: CO₂-eq emissions from Energy sector by subsectors in 1990-2011

The largest part (30.3 percent) of the emissions are a consequence of fuel combustion in Energy industries, then the combustion in Transport (28.4 percent in 2011) and the combustion in small stationary energy sources, such as Commercial/Institutional, Residential and Agriculture/Forestry/Fishing (16.4 percent in 2011). Manufacturing Industries and Construction contribute to total emission from Energy sector with 15 percent, while Fugitive Emissions from Fuels contribute with about 10 percent. The majority of energy-related GHG emissions belong to CO₂ (91 to 93 percent), then follows CH₄ (6 to 9 percent) and N₂O (less than 1 percent).

Greenhouse gases are also generated during combustion of biomass and biomass-based fuels. The CO₂ emission from biomass, in line with IPCC guidelines, is not included into the national emission totals because emitted CO₂ had been previously absorbed from the atmosphere for growth and development of biomass. Removal or emission of CO₂ due to the changes in the forest biomass is estimated in the Land Use, Land-use Change and Forestry sector.

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.

In Energy sector, nine source categories represent key source category regardless of LULUCF (detailed in Table 3.1-5).

Table 3.1-5: Key categories in Energy sector based on the level and trend assessment in 2011⁴

IPCC Source Categories	Direct GHG	Criteria for Identification			
		Level		Trend	
		excl. LULUCF	incl. LULUCF	excl. LULUCF	incl. LULUCF
ENERGY SECTOR					
CO ₂ Emissions from Stationary Combustion: Coal	CO ₂	L1e	L1i	T1e, T2e	T1i, T2i
CO ₂ Emissions from Stationary Combustion: Oil	CO ₂	L1e, L2e	L1i	T1e, T2e	T1i, T2i
CO ₂ Emissions from Stationary Combustion: Gas	CO ₂	L1e, L2e	L1i	T1e, T2e	T1i, T2i
Mobile Combustion: Road Vehicles	CO ₂	L1e, L2e	L1i	T1e, T2e	T1i, T2i
Mobile Combustion: Aircraft	CO ₂				T1i, T2i
Combustion: Agriculture/Forestry/Fishing	CO ₂	L1e	L1i		T1i, T2i
Fugitive Emissions from Coal Mining and Handling	CH ₄				T2i
Fugitive Emissions from Oil and Gas Operations	CH ₄	L1e, L2e	L1i, L2i	T1e	T1i
Fugitive Emissions from Oil and Gas Operations	CO ₂	L1e	L1i		

L1e - Level excluding LULUCF Tier 1

L1i - Level including LULUCF Tier 1

T1e - Trend excluding LULUCF Tier 1

T1i - Trend including LULUCF Tier 1

L2e - Level excluding LULUCF Tier 2

L2i - Level including LULUCF Tier 2

T2e - Trend excluding LULUCF Tier 2

T2i - Trend including LULUCF Tier 2

⁴ Data on key categories are taken from Annex 1 Key categories (Tier 1 and Tier 2)

3.2.FUEL COMBUSTION (CRF 1.A)

3.2.1. COMPARISON OF THE SECTORAL APPROACH WITH THE REFERENCE APPROACH

The methodology used for estimating CO₂ emissions follows the *Revised 1996 IPCC Guidelines*. The emission of CO₂ is calculated using two 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 3. The total differences in fuel consumption and CO₂ emissions for chosen years are given in Table 3.2-1.

Table 3.2-1: The fuel consumption and CO₂ emissions from fuel combustion (Reference & Sectoral approach)

	1990	1995	2000	2005	2008	2009	2010	2011
Fuel consumption (PJ)								
Reference approach	299.71	216.44	249.47	290.78	298.61	280.71	273.56	268.04
Sectoral approach	292.77	218.60	250.15	287.97	292.75	278.48	269.94	266.47
Relative Diff. (%)	2.37	-0.99	-0.27	0.98	2.00	0.80	1.34	0.59
CO₂ Emission (Gg)								
Reference approach	20,692.1	15,052.9	17,703.2	20,874.8	21,167.8	19,834.6	19,265.0	18,904.1
Sectoral approach	20,593.8	15,034.4	17,347.1	20,280.6	20,496.0	19,361.9	18,690.4	18,474.8
Relative Diff. (%)	0.48	0.12	2.05	2.93	3.28	2.44	3.07	2.32

The CO₂ emission calculated by Reference approach is higher in comparison to Sectoral approach. The reason is that CO₂ emission from feedstock and non-energy fuel consumption is calculated under Reference approach while it is not accounted under Sectoral approach.

Namely, CO₂ emissions from natural gas which used as fuel in ammonia production is calculated under Manufacturing Industries and Construction, Petrochemical Production (1.A.2.f) while in Croatian national energy balance, is specified as non-energy use in Petrochemical industry. During In country review (2008), this amount of natural gas was relocated in Industry sector, and then difference between Reference approach and Sectoral approach was smaller. But ERT revisers during centralized review (2010) suggested that this amount of fuel should be calculated under Energy sector although in national energy balance this amount of fuel is specified as non-energy fuel.

As recommended by ERT (2012) here are shown both previously mentioned estimations of CO₂ emission for 2008:

-emissions from natural gas used as fuel in ammonia production is calculated under Manufacturing Industries and Construction, Petrochemical Production (1.A.2.f):

FUEL TYPES	REFERENCE APPROACH			SECTORAL APPROACH ⁽¹⁾		DIFFERENCE ⁽²⁾	
	Apparent energy consumption ⁽³⁾ (PJ)	Apparent energy consumption (excluding non-energy use and (PJ)	CO ₂ emissions (Gg)	Energy consumption (PJ)	CO ₂ emissions (Gg)	Energy consumption (%)	CO ₂ emissions (%)
Liquid Fuels (excluding international bunkers)	182,53	169,62	12.549,53	167,21	12.387,09	1,44	1,31
Solid Fuels (excluding international bunkers)	29,24	29,69	2.722,73	29,32	2.729,99	1,26	-0,27
Gaseous Fuels	108,97	99,30	5.895,52	96,22	5.378,92	3,20	9,60
Other ⁽⁵⁾	NO	NO	NO	NO	NO	0,00	0,00
Total ⁽⁵⁾	320,74	298,61	21.167,77	292,75	20.496,00	2,00	3,28

-emissions from natural gas used as fuel in ammonia production is calculated under Ammonia Production (2.B.1):

FUEL TYPES	REFERENCE APPROACH			SECTORAL APPROACH ⁽¹⁾		DIFFERENCE ⁽²⁾	
	Apparent energy consumption ⁽³⁾ (PJ)	Apparent energy consumption (excluding non-energy use and (PJ)	CO ₂ emissions (Gg)	Energy consumption (PJ)	CO ₂ emissions (Gg)	Energy consumption (%)	CO ₂ emissions (%)
Liquid Fuels (excluding international bunkers)	182,53	169,62	12.549,53	167,21	12.387,09	1,44	1,31
Solid Fuels (excluding international bunkers)	29,24	29,69	2.722,73	29,32	2.729,99	1,26	-0,27
Gaseous Fuels	108,97	90,09	5.028,96	88,70	4.949,37	1,57	1,61
Other ⁽⁵⁾	NO	NO	NO	NO	NO		0,00
Total ⁽⁵⁾	320,74	289,40	20.301,22	285,23	20.066,45	1,46	1,17

3.2.2. INTERNATIONAL BUNKER FUELS

The CO₂ 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) and CO₂-eq emissions for International Aviation and Marine Bunkers are shown in the Table 3.2-2.

Table 3.2-2: Fuel consumption and CO₂-eq emissions for International aviation and marine bunkers, from 1990 to 2011

	1990	1995	2000	2005	2008	2009	2010	2011
Fuel combustion (PJ)								
Aviation bunkers	4.85	2.64	2.39	3.19	3.75	3.21	3.42	3.57
Marine bunkers	1.44	1.36	0.76	1.05	0.87	0.28	0.25	0.98
Total bunkers	6.29	4.00	3.15	4.24	4.62	3.49	3.68	4.55
CO₂-eq emission (Gg)								
Aviation bunkers	346.35	188.42	170.91	228.16	270.37	231.31	246.63	256.98
Marine bunkers	108.96	102.40	57.24	79.29	67.05	21.71	19.50	75.47
Total bunkers	455.31	290.82	228.15	307.45	337.42	253.02	266.14	332.45

Total CO₂-eq from the international bunker in 2011 amounted to 332.45 Gg which is 25% higher than in 2010 as a result of higher fuel consumption especially in the Marine bunkers (3.5 times higher than in 2010).

In comparison with 1990, the emission of CO₂-eq in 2011 was for a 27% lower as a result of reduced fuel consumption especially in the Marine bunkers (31.9%), but also in Aviation bunkers (26.4%).

International marine bunkers are included in national energy balance for the period from 1994 to 2011, as separate data. Until the year 1994, international marine bunkers are based on expert estimation.

3.2.3. FEEDSTOCK 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 CO₂ emission because all carbon is bound to the product. The fraction of carbon stored in products is suggested in *Revised 1996 IPCC Guidelines* (Workbook, auxiliary worksheet 1-1, page 1.37).

The CO₂ emissions from natural gas which used as fuel in ammonia production are calculated under Manufacturing Industries and Construction, Petrochemical Production (1.A.2.f), while emissions of CO₂ from natural gas which used as feedstock are calculated under Ammonia production (2.B.1).

In Croatian national energy balance, non-energy use of natural gas is specified in Petrochemical industry. This amount of natural gas was split between natural gas used as fuel and natural gas used as feedstock for ammonia production. Data on consumption of natural gas used as a feedstock were collected by survey of ammonia manufacturer (Fertilizer Company) as described in Chapter 4.3.1.2. Natural gas which used as fuel in ammonia production is defined as the difference between the data on non-energy use of natural gas in energy balance and data on consumption of natural gas used as a feedstock which collected by survey of ammonia manufacturer.

3.2.4. CO₂ CAPTURE FROM FLUE GASES AND SUBSEQUENT CO₂ STORAGE

There are no plants in operation for recovery and storage of CO₂ in Croatia, although there are plans for storage of CO₂ in two oil fields in central part of Croatia as part of EOR project conducted by INA - Oil Company. Natural gas produced in Croatian gas fields contains a large amount of CO₂, more than 15 percent, and before coming to commercial pipeline has to be cleaned (scrubbed), but CO₂ is emitted without capture and storage.

The CO₂ emission from gas scrubbing in Central Gas Station Molve, estimated by material balance method, is described in the Chapter 3.3.2.1.

3.2.5. COUNTRY-SPECIFIC ISSUES

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

- The methodology for estimating CO₂ emission from natural gas scrubbing is not given in the IPCC Guidelines. The CO₂ emission is determined on the base of differences in CO₂ content before and after scrubbing units and quantity of scrubbed natural gas (material balance method). The data for estimating CO₂ emission is given from gas field Molve.
- Country-specific net calorific values (NCV) obtained from national energy balance are used in GHG emission calculation (Annex 2).

3.2.6. ENERGY INDUSTRIES (CRF 1.A.1)

3.2.6.1. Source category description

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 3.2-3 and Figure 3.2-1.

Table 3.2-3: The CO₂-eq emissions (Gg) from Energy Industries

CO ₂ -eq emission (Gg)	1990	1995	2000	2005	2008	2009	2010	2011
Public Electr. and Heat Production	3,693.5	2,988.1	3,809.2	4,640.4	5,039.0	4,307.6	3,971.3	4,219.3
Petroleum Refining	2,574.8	1,892.1	1,792.4	1,810.5	1,441.7	1,706.0	1,479.6	1,759.3
Other Energy Industries	875.5	394.7	293.4	350.7	245.6	378.6	453.8	296.9
Total Energy Industries	7,143.8	5,275.0	5,895.0	6,801.6	6,726.3	6,392.2	5,904.7	6,275.5

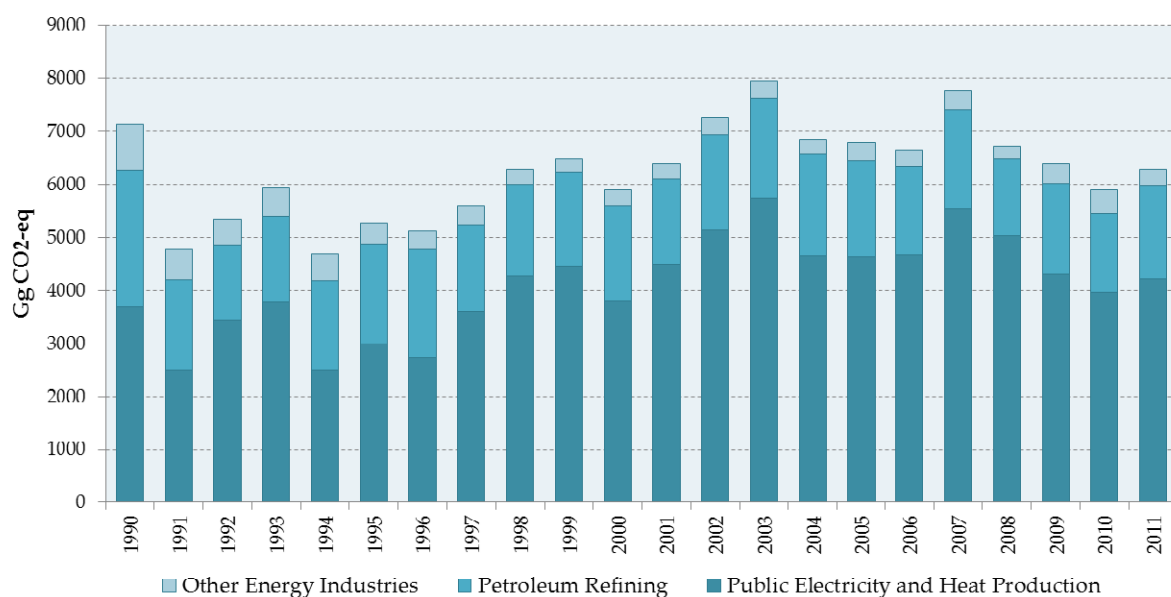


Figure 3.2-1: CO₂-eq emissions from Energy Industries

It should be stressed out that approximately 53 percent of the electricity is generated in hydro power plants; therefore the emission from Energy Industries sector is relatively small, 29-36 percent of emission from total Energy sector. The largest part (51-75 percent) of the emission is a consequence of fuel combustion in thermal power plants, then the combustion in oil refineries 21-40 percent. The remaining combustion in oil and gas fields, coal mines and the coke plant accounts for some 3-12 percent.

Public Electricity and Heat Production (CRF 1.A.1.a)

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 3,817.76 MW (including TPP Plomin and excluding NPP Krško). Total capacities serving the needs of the Croatian electric power system amount to 4,165.76 MW (with 50% of Krško capacities). Out of this amount, 1,681 MW is placed in thermal power plant, 2,136.56 MW in hydro power plant and 348 MW in the nuclear unit Krško (50% of total available capacity). These capacities do not include generating units in other countries from which the Croatian electric power system has the right to withdraw electricity on the basis of capacity lease and share-ownership arrangements. Generating capacities of HPPs, TPPs and NPP Krško are presented in the Table 3.2-4.

Table 3.2-4: Generating capacities of HPPs, TPPs and NPP Krško

	Available Power (MW) Net Output	Fuel
HPPs	2,136.76	-
NPP Krško*	348	uranium oxide (UO ₂)
TPP Plomin 1	110	coal
TPP Plomin 2**	192	coal
TPP Rijeka	303	fuel oil
TPP Sisak	396	fuel oil / natural gas
CHP Zagreb (east)	422	fuel oil / natural gas / extra light oil
CHP Zagreb (west)	90	fuel oil / natural gas / extra light oil
CPP Osijek	90	fuel oil / natural gas / extra light oil
CCGT Jertovec	78	natural gas / extra light oil
Total (HPPs+NPP+TPPs)	4,165.76	

* 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 2011 in Croatia only 14 to 32 percent of Croatian electricity demands were covered by thermal power plants. The largest contribution to electricity production in Croatia had hydro power plants 36 to 69 percent. Nuclear power plant Krško delivered 50 percent of its electricity to Croatian power system until 1998 after which was a four year period of non-delivery. 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 2011, the import of electricity was about 30 percent of total electricity consumption in Croatia. Electricity supply for the period from 1990 to 2011 is presented in Figure 3.2-2.



Figure 3.2-2: Electricity supply for the period from 1990 to 2011

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.

TPP Plomin 2, which started to operate in 2002, has installation for flue gasses cleaning. By-product from process which cleans flue gasses from sulphur (SO_2 scrubbing process) is CO_2 . CO_2 emission is calculated from amount of CaCO_3 used for cleaning. Amounts of produced CaCO_3 as well as emitted CO_2 emission are presented in Industry sector (Limestone and dolomite use).

The CO_2 -eq emission from public electricity and heat production are presented in Figure 3.2-3 for the whole period from 1990 to 2011.

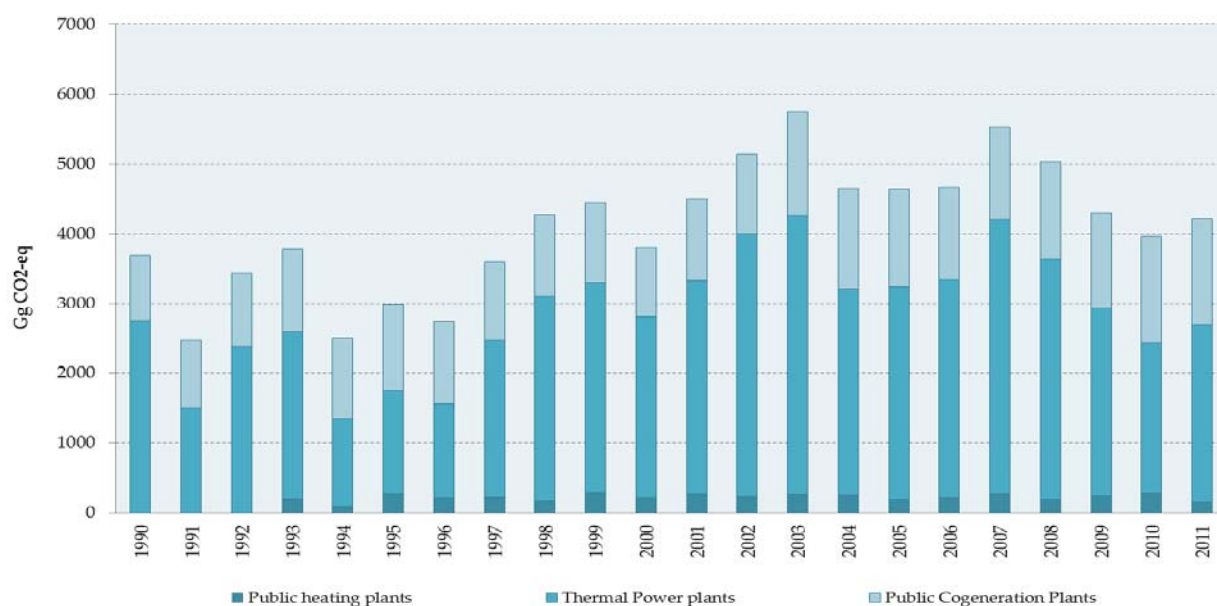


Figure 3.2-3: CO₂-eq emissions from Public Electricity and Heat Production subsector's

Production of electricity has increasing trend through the years, from 8 TWh (1990) to 14 TWh (2010) but CO₂ emission does not follow this trend. Approximately 53 percent of electricity is generated in hydro power plants (HPP), but this percent depends on hydrological conditions during the year. If hydrological conditions are unfavorable the lack of electricity must be supplemented by stronger engagement of thermal power plants, which consequently leads to large GHG emissions. Domestic production of electricity by sources for the period from 1990 to 2011 is presented in Figure 3.2-4. In 2011, the total electricity production was 23.2 percent lower than in the former year. Increase in energy consumption from thermal power plants and public cogeneration plants are mostly due to unfavorable hydrological conditions which led to decrease in electricity production from hydro power by 45.2 percent (Table 3.2-5).

Table 3.2-5: Differences between electricity production in 2010 and 2011

ENERGY BALANCE	Electricity, GWh		Difference 2011-2010	Difference %
	2010	2011		
Production	14,104.9	10,830.3	-3,274.7	-23.2
Hydro power plants	8,435.2	4,620.0	-3,815.2	-45.2
Wind power plants	139.1	201.0	61.9	44.5
Photovoltaic	0.1	0.1	0	0
Thermal power plants	2,494.8	2,876.6	381.8	15.3
Public cogeneration plants	2,589.0	2,620.7	31.7	1.2
Industrial cogeneration plants	446.8	511.9	65.1	14.6
Import	6,682.4	8,729.9	2,047.5	30.6
Export	-1,917.4	-1,032.6	884.8	46.1
Total consumption	18,869.9	18,527.6	-342.4	-1.8

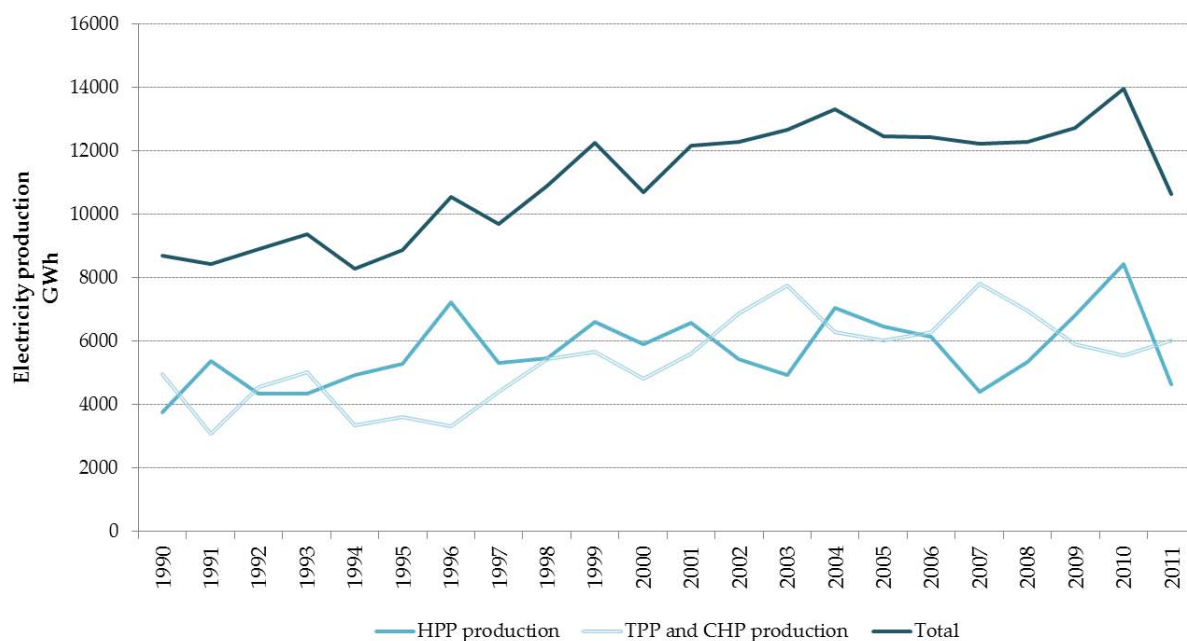


Figure 3.2-4: Domestic production of electricity by sources for the period from 1990 to 2010

Electricity and heat production, fuel consumption and GHG emissions for the years 1990, 2000, 2005 and for period 2008-2011 are presented in Tables A2-1 to A2-2 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. Crude oil is produced from 33 oil fields and gas condensation products from 8 gas-condensations fields, which covers about 35 percent of the total domestic demand. Processing capacities of the Croatian refineries, which belong to INA – oil and gas company, are shown in the Table 3.2-6.

Table 3.2-6: Processing Capacities of Oil and 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
isomerization	250
hydrodesulphurization (HDS)	1040
mild hydrocracking (MHC)	560
hydrocracking	2600
Oil Refinery Sisak	
atmospheric distillation	4000
reforming	680
fluidized-bed catalytic cracking (FCC)	470
coking	270
vacuum distillation	850
bitumen	350
Lube Refinery Zagreb Ltd.	
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. Emissions from both types of fuel combustion were calculated in this sector and presented in Figure 3.2-5.

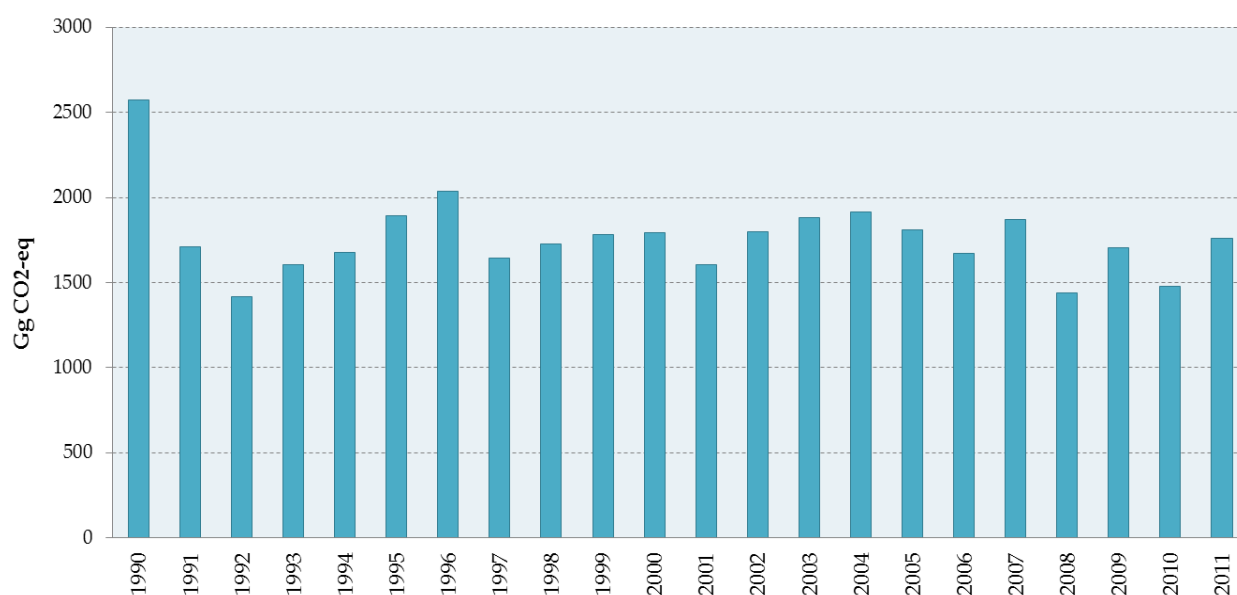


Figure 3.2-5: CO₂-eq emissions from Petroleum Refining subsector for the period from 1990 to 2011

Fuel consumption and GHG emissions from Petroleum Refining are presented in Table A2-5 of the Annex 2.

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

In Croatia the coal production in the period 1990-1998 was rather low. Last coal mines in Istria were closed in 1999. Coke-oven plant in Bakar, nearby Rijeka, was also closed in 1994.

Natural gas is produced from 17 on-shore gas fields and 9 off-shore gas fields, which covers about 68.7 percent of total domestic demand in 2011. The largest share of gas is coming from fields Molve and Kalinovac. They include the units for processing and preparation of gas for transportation – Central Gas Stations (CGS) Molve I, II and III. Their capacities are:

- 1 mill. m³/day for Molve I
- 3 mill. m³/day for Molve II
- 5 mill. m³/day for Molve III

The underground gas storage Okoli was designed with the nominal capacity of 553 million m³. Maximum injection capacity is 3.8 million m³/day and maximal withdrawal capacity is 5.8 million m³/day.

CO₂-eq emissions from this subsector for the whole period from 1990 to 2011 are presented in Figure 3.2-6.

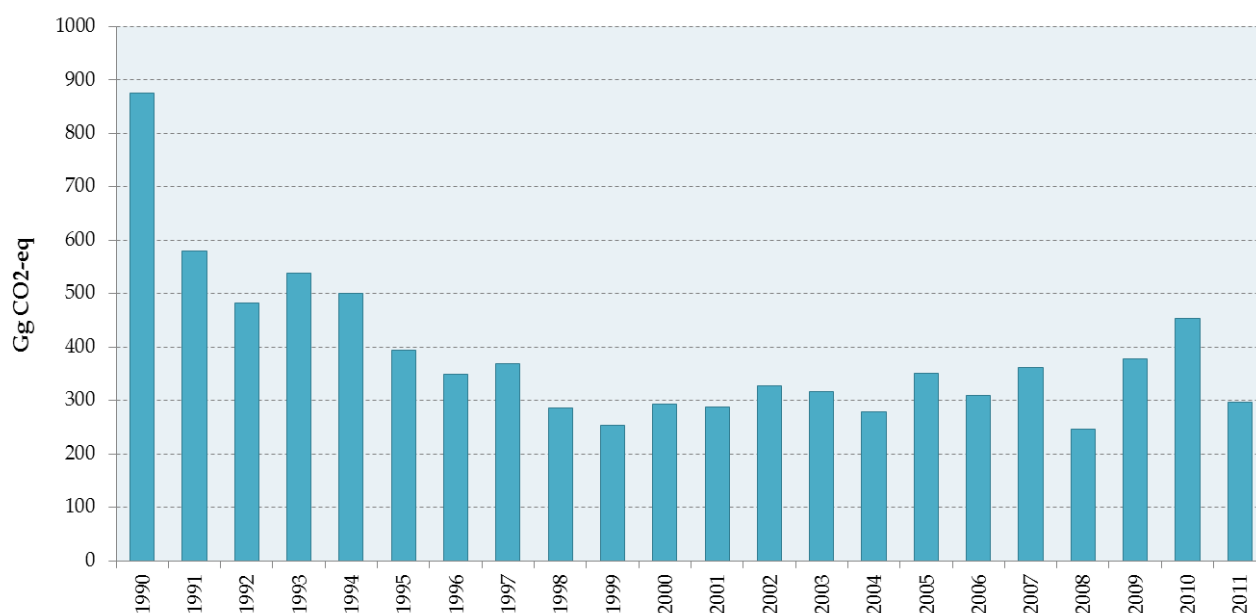


Figure 3.2-6: CO₂-eq emissions from Manufacturing of Solid Fuels and Other Energy Industries for the period from 1990 to 2011

Fuel consumption and GHG emissions from Manufacturing of Solid Fuels and Other Energy Industries are presented in the Table A2-6 of the Annex 2.

3.2.6.2. Methodological issues

The GHG emissions from thermal power plants and public cogeneration plants in the period from 1990-2011, were calculated using more detailed Tier 2 approach while emissions from Petroleum Refining and Other Energy Industries were calculated using Tier 1 approach.

Tier 1 Approach

Tier 1 approach is based on data on the amount of fuel combusted in the source category. Source of data on the amount of fuel combusted is national energy balance. Data from the national energy balance were recalculated from natural units into energy units by means of its 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 *Revised 1996 IPCC Guidelines* as recommended (Workbook, Page 1.8).

Emissions of CH₄ and N₂O 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.

Tier 2 Approach

The GHG emissions from thermal power plants and public cogeneration plants in the period from 1990 to 2011 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 yearly fuel consumption and detailed fuel characteristics data (net calorific value). For estimation of CO₂ emissions, default IPCC emission factors were used, while implied emission factors for CH₄ and N₂O are based on technology type and configuration (Tier 2).

3.2.6.3. Uncertainties and time-series consistency

Uncertainty of CO₂ emissions

The CO₂ emission, from the fossil fuel combustion, depends on amount of fuel consumed (from energy balance), net calorific values (from energy balance), carbon emission factors (IPCC), the fraction of carbon stored (IPCC) and the fraction of carbon oxidised (IPCC).

The national energy balance is based on data from different 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 4 percent.

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

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 CO₂ emission factors for fuels are generally well determined within 5 percent, as they are primarily dependent on the carbon content of the fuel.

Uncertainty of CH₄ and N₂O emissions

Estimates of CH₄ and N₂O 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 CO₂ emissions from the fossil fuel combustion.

The uncertainty of CH₄ emission is estimated to ± 40 percent; while the uncertainty of N₂O 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 approach for estimation of CH₄ and N₂O emissions from thermal power plants and public cogeneration plants lead to certain uncertainty reduction.

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 more detailed approach (Tier 2).

3.2.6.4. Source-specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness, consistency, comparability, recalculation and uncertainty of activity data, emission factors and emission estimates. 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.

Regarding to QC Tier 2 activities, 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 whole period from 1990 to 2011, due to availability of detail information on fuel consumption in the facilities. Activity data from energy balance were compared with data provided by individual facilities. Results of this comparison showed that there is no significant difference between these two sets of data. These bottom up 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. Calorific values from energy balance were compared with data from the IPCC Guidelines. Results of this comparison showed that there is no significant difference between these two sets of data.

3.2.6.5. Source-specific recalculations

There are no recalculations in this sub-sector.

3.2.6.6. Source-specific planned improvements

Inventory team is planning use CO₂ emission factors, which are calculated using fuel characteristics data, specific for every plant. These data were available from the verified annual emission reports of plants.

On long term basis, inventory team is planning apply country-specific carbon content values and oxidation factor values to estimate emissions for the main fuel types.

3.2.7. MANUFACTURING INDUSTRIES AND CONSTRUCTION (CRF 1.A.2)

3.2.7.1. Source category description

Manufacturing Industries and Construction includes 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, petrochemical 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). In national energy balance fuel consumed in industrial heating plants and cogenerations were not divided by appropriate industrial branches, so in addition to national energy balance so called 'Industry analysis balance' was created, but only for the period from 2001 to 2011. The total GHG emission from Manufacturing Industries and Construction is given in the Table 3.2-7 and Figure 3.2-7.

Table 3.2-7: The CO₂-eq emissions (Gg) from Manufacturing Industries and Construction

	1990	1995	2000	2005	2008	2009	2010	2011
Iron and Steel Industry	IE	IE	IE	89	98	79	93	84
Non-Ferrous Metals	IE	IE	IE	21	21	18	14	18
Chemicals	IE	IE	IE	578	568	501	448	417
Pulp, Paper and Print	IE	IE	IE	174	153	148	161	148
Food Proc., Bev. and Tobac.	IE	IE	IE	589	639	490	511	493
Other	IE	IE	IE	2,647	2,736	2,158	2,103	1,993
Total Manuf. Ind. and Cons.	5,872	3,524	3,632	4,098	4,215	3,394	3,330	3,153

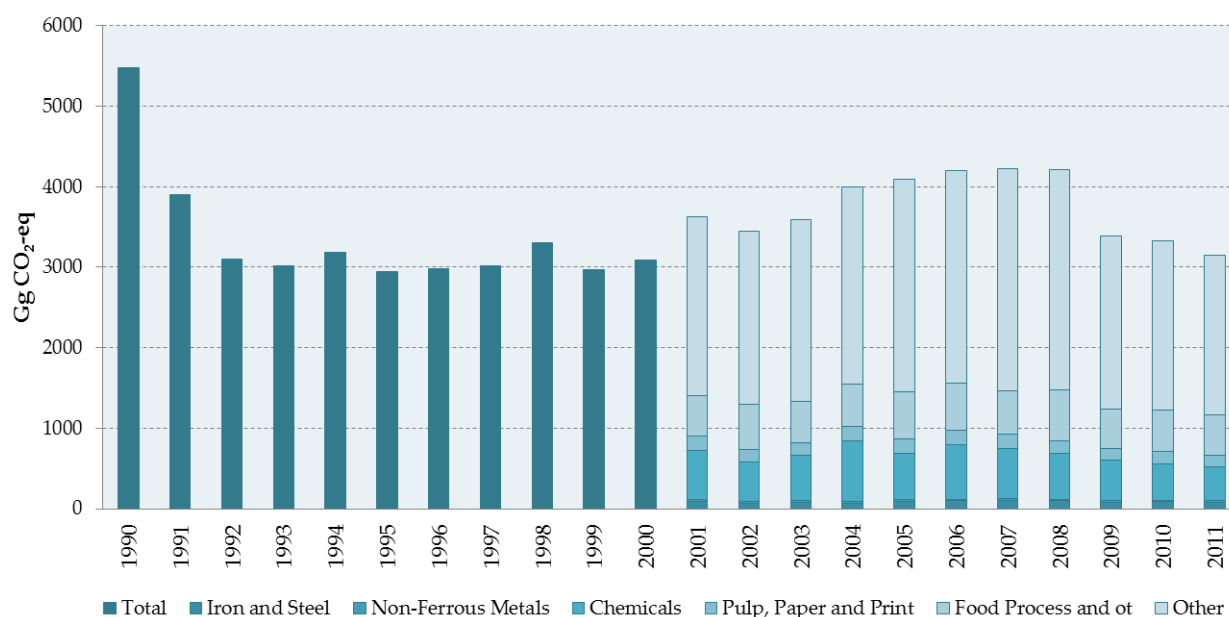


Figure 3.2-7: CO₂-eq emissions from Manufacturing Industries and Construction

The emissions from this subsector contribute 16-27 percent of the total emission from Energy sector. The largest contributor to emissions is fuel combustion in industry of construction materials and petrochemical production (subsector: Other in Figure 3.2-7), followed by food processing industry, chemical industry, paper industry, iron and steel industry and non-ferrous metal industry.

3.2.7.2. Methodological issues

The GHG emissions from this subsector were calculated using Tier 1 approach.

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 for the period 2001-2011 (Industry analysis balance).

Data from the national energy balance were recalculated from natural units into energy units by means of its 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)*.

Values for fraction of carbon oxidizes were taken from *Revised 1996 IPCC Guidelines* as recommended (Workbook, Page 1.8).

The GHG emissions from Manufacturing Industries and Construction by fuels are shown in Tables A2-7, A2-8 and A2-9 of the Annex 2.

3.2.7.3. Uncertainties and time-series consistency

Uncertainty of CO₂ emissions

The CO₂ emission, from the fossil fuel combustion, depends on amount of fuel consumed (from energy balance), net calorific values (from energy balance), carbon emission factors (IPCC), the fraction of carbon stored (IPCC) and the fraction of carbon oxidised (IPCC).

The national energy balance is based on data from different 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 4 percent.

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

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 CO₂ 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 CO₂ estimates. However, these uncertainties are believed to be relatively small.

Overall uncertainty for CO₂ emission estimates from the fossil fuel combustion are considered accurate within 3 percent.

Uncertainty of CH₄ and N₂O emissions

Estimates of CH₄ and N₂O 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 CO₂ emissions from the fossil fuel combustion.

The uncertainty of CH₄ emission is estimated to ± 40 percent; while the uncertainty of N₂O 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.

Time-series consistency

Activity data, emission factors and methodology implied for GHG emission calculation from fuel combustion activities is very consistent for entire period.

3.2.7.4. Source-specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness, consistency, comparability, recalculation and uncertainty of activity data, emission factors and 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.

3.2.7.5. Source-specific recalculations

Recalculation was made for Petrochemical production (1.A.2.f) for 2010 because new activity data have been added.

Differences in emissions before and after recalculation in Manufacturing Industries and Construction sector are:

	2010
CO ₂ , %	1.45
CH ₄ , %	1.37
N ₂ O, %	0.30

3.2.7.6. Source-specific planned improvements

On long term basis, inventory team is planning apply more detailed Tier 2 approach for calculation CO₂ emissions from Manufacturing Industries and Construction. Since 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, petrochemical industries, are in ETS, verified annual emission report of each industrial plant are available. Tier 2 approach is based on bottom-up fuel consumption data from every industrial plant. In verified annual emission reports there are available data about yearly fuel consumption and detailed fuel characteristics data (net calorific value) and plant-specific emission factors.

Also, on long term basis, inventory team is planning apply country-specific carbon content values and oxidation factor values to estimate emissions for the main fuel types.

3.2.8. TRANSPORT (CRF 1.A.3)

3.2.8.1. Source category description

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 3.2-8 and Figure 3.2-8.

Table 3.2-8: The CO₂-eq emissions (Gg) from sector Transport

	1990	1995	2000	2005	2008	2009	2010	2011
Civil Aviation	156.1	79.4	55.4	67.2	89.0	78.1	81.8	89.9
Road Transport	3,634.1	3,151.6	4,327.5	5,373.2	5,948.0	5,954.8	5,748.0	5,598.9
Railways	138.7	106.8	85.8	95.9	101.6	89.6	90.0	83.0
Navigation	133.5	98.7	86.1	100.0	131.3	145.9	115.6	116.9
Total Transport	4,062.4	3,436.4	4,554.8	5,636.3	6,269.9	6,268.4	6,035.4	5,888.7

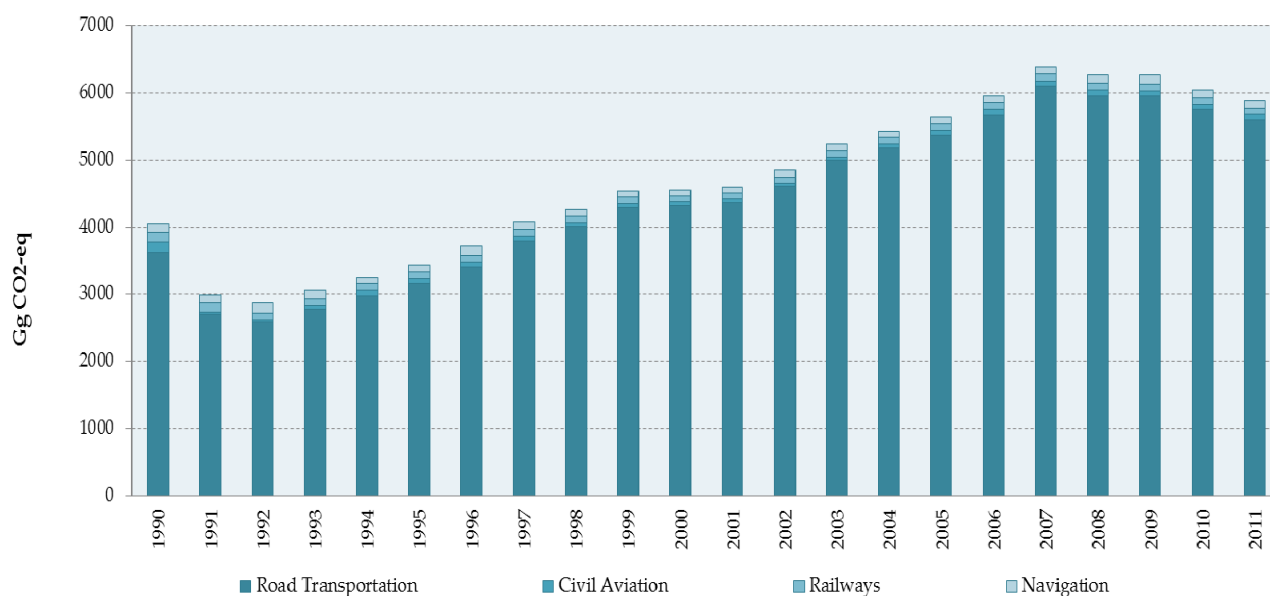


Figure 3.2-8: The CO₂-eq emissions from Transport

The contribution from Transport sector to the total CO₂-eq emissions from Energy sector in 2011 was 28.4%.

CO₂-eq emissions from the transport sector in 2011 amounted to 5,888.7 Gg, which is 2.5% less than in 2010 as a result of less fuel consumption in road transport. Specifically, the emission of CO₂-eq emissions from Road transport sector (CRF 1.A.3.b) was dominant one in the transport sector (CRF 1.A.3) in 2011 and contributed to the CO₂-eq emissions from the transport sector with 95.1%. In 2011, the sector Civil aviation (domestic) was contributed to the CO₂-eq emissions from the transport sector with 1.5%, Railways with 1.4% and Navigation with 2.0% (Figure 2.3-8).

In comparison with 1990, CO₂-eq emissions from the transport sector were increased by 45% as a result of increasing the number of vehicles and also increase of annual millage.

Civil aviation (CRF 1.A.3.a)

The CO₂-eq emission from the sub-sector domestic civil aviation in 2011 was amounted to 89.9 Gg, which is 9.9% higher than in 2010 as a result of increase of fuel jet kerosene consumption. In comparison with 1990, CO₂-eq emission was by 42.4% lower as a result of decrease of fuel consumption.

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

Road transportation includes all types of passenger cars, light-duty vehicles, heavy-duty vehicles, buses, mopeds and motorcycles. These mobile sources use different types of liquid and gaseous fuels, mostly gasoline

and diesel oil, and emit significant amounts of greenhouse gases and air pollutants. The contribution of road transportation to the total greenhouse gas emissions was 19.8 percent in 2011 and 11.6 percent in 1990. In the period from 1990 to 2011 emissions from road transportation rose by 53.0 percent mainly due to increase in the numbers of vehicles (passenger cars mostly) and consumption of diesel oil in all types of vehicles. From 2008 onwards emissions from road transportation have slightly decreased due to lower fuel consumption caused by economic crises in Croatia and increase in retail fuel prices.

Railways (CRF 1.A.3.c)

The CO₂-eq from the sub-sectors Railways in 2011 was amounted to 83.01 Gg, which is 7.4% lower than in 2010 as a result of decrease of fuel diesel consumption. In comparison with 1990, CO₂-eq was decreased by 40.17% as a result of decrease in railways transportation and consequently decreases in fuel consumption.

Navigation (CRF 1.A.3.d)

The CO₂-eq from the sub-sectors Navigation in 2011 was amounted to 116.9 Gg, which is for 1.1% higher than in 2010 as a result of increase in fuel consumption. In comparison with 1990, CO₂-eq was decreased by 12.5% as a result of decrease in navigation traffic and consequently decreases in fuel consumption.

3.2.8.2. Methodological issues

Civil aviation

The GHG emissions from sub-sectors Civil aviation were calculated using Tier 1 approach based on jet fuel consumption and aviation kerosene provided by national energy balance and default IPCC emission factors.

Emissions from domestic aviation estimate by using drivers such as ratio of domestic/international passengers, taking into account average km traveled for passengers on domestic/international routes. So, total jet kerosene consumption from Energy balance was divided to domestic and international aviation according to average km traveled per passenger on domestic/international routes (Table 3.2-9).

Data were obtained from Statistical yearbooks and Energy balance.

Table 3.2-9: Estimation of civil aviation drivers

	1990	1995	2000	2005	2008	2009	2010	2011
Total jet kerosene (10 ³ t)	160.0	85.0	72.0	93.0	112.7	96.9	103.3	109.4
Passangers carried - Total (10 ³)		679	1,072	2,099	2,329	2,053	1,861	2,078
Passangers carried – intern. (10 ³)		346	712	1,633	1,775	1,561	1,418	1,571
Passangers carried – domestic (10 ³)		333	360	466	554	492	443	507
Passangers kilometers- total (10 ⁶)		444.0	763.0	1,989.0	1,945.0	1,636.0	1,510.0	1,591.0
Passangers kilometers-inter. (10 ⁶)		317.0	656.0	1,842.0	1,768.0	1,483.0	1,370.0	1,430.0
Passangers kilometers-dom. (10 ⁶)		127.0	107.0	147.0	177.0	153.0	140.0	161.0
Passangers domestic/km		381.4	297.2	315.5	319.5	311.0	316.0	317.6
Passangers international/km		916.2	921.3	1,128.0	996.1	950.0	966.1	910.2
Passangers intern.+domestic		1,297.6	1,218.1	1,443.4	1,315.6	1,261.0	1,282.2	1,227.8
share domestic	0.311	0.294	0.244	0.219	0.243	0.247	0.246	0.259
Jet kerosene in domestic aviation	49.68	24.98	17.56	20.32	27.37	23.90	25.46	28.29
Jet kerosene in international	110.32	60.02	54.44	72.68	85.33	73.00	77.84	81.11

Data for the period from 1991 to 2006 were obtained from Statistical yearbooks (1994, 1997 and 2008) of Republic of Croatia. Since average km traveled per passenger on domestic/international routes for 1990 is not included in available Croatian statistical publications, this value was estimated using linear extrapolation from the period 1991-2006 (Figure 3.2-9).

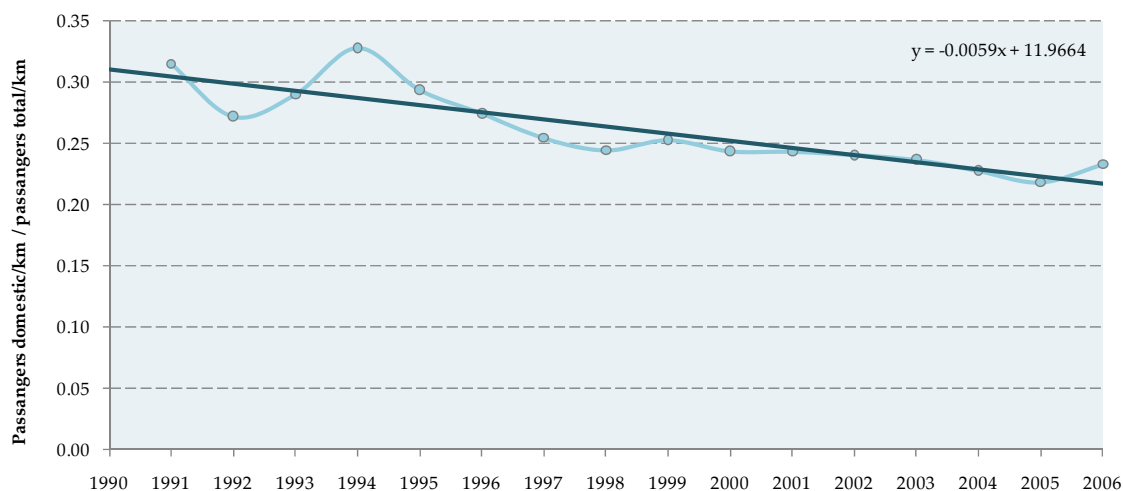


Figure 3.2-9: The average km traveled per passenger on domestic/international routes for the period 1991-2006

Fossil fuel consumption, their net calorific values, appropriate GHG emission factors and GHG emissions for sub-sector Civil aviation for years 1990, 2000, 2005 and for period 2008 - 2011 are shown in Table A2-12 Annex 2.

Road Transport

Emissions of CO₂ from liquid fuels in this inventory submission are calculated on the basis of the amount and type of fuel combusted using tier 1 (top-down) approach which is in line with the IPCC good practice guidance. In the previous submissions CO₂ emissions were calculated using tier 2/3 approach (COPERT 4 model) which led to overestimation of emissions by 1.17 percent in average for entire time series (0.93 percent in 1990 and 0.64 percent in 2010).

Amounts of all types of liquid and gaseous fuels consumed in 2011 were extracted from national energy balance. Emissions factors used for calculating CO₂ emissions from liquid fuels are from Revised 1996 IPCC guidelines, European vehicles, tables 1-36 to 1-42), and equals 73 g/MJ for gasoline (oxidation factor 0.99) and 74 g/MJ for diesel oil (oxidation factor 0.99).

Emissions of CO₂ from gaseous fuels (LPG – liquefied petroleum gas and CNG – compressed natural gas) and biomass (biodiesel) are calculated using bottom-up COPERT 4 model.

Emissions of CH₄ and N₂O are calculated using the COPERT 4 model because emission factors depend on vehicle technology, fuel and operating characteristics (vehicle-kilometres, average trip speed, driving share on urban, rural and highway roads, etc.).

The COPERT 4 model (Tier 2/3 method) requires very detailed set of input activity data, including:

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

Main activity data provider is Ministry of Interior, which is responsible for compilation of national motor vehicle database with detailed information on each registered vehicles in Croatia. Fuel consumption data were taken from national energy balance and average monthly temperatures from statistical yearbooks. Additional data, like highway, rural and urban transport mileage, average speed of different kind of vehicles and different road types, average daily trip distance and beta value (the fraction of the monthly mileage driven before the engine and any exhaust components have reached their nominal operation temperature) are expert judgments or default data from COPERT model.

There were two assumptions/adjustments applied in the COPERT model:

- Gasoline or diesel oil tank-filled abroad and consumed in Croatia is equal to amount of same type of fuels tank-filled in Croatia and consumed abroad (this is due to a large number of tourist destination and transit trips in Croatia), so effect of this consumption pattern in neutral to fuel balance.

- Fuel consumption calculated by COPERT, taking into account number of vehicles and annual average vehicle mileage, should be to a highest possible degree equal to consumption of fuels from the national energy balance (the difference should not be greater than 1%).

The aggregate number of road motor vehicles per each major group (passenger cars, light and heavy duty vehicles, buses, motorcycles and mopeds) for year 1990, 2000, 2005 and for period 2008 – 2011 are presented in the Table A2-10 of the Annex 2. Comparing the total number of vehicles in 2011 with the number of vehicles in 1990 it can be notice the increase by 47.1 percent. The increase was largely the result of increase in the number of passenger cars by 32.1 percent, constituting 81.3 percent of the total number of road vehicles in 2011. Other classes of vehicles were also increased in this period: the number of Light Duty vehicles increased by 2.3 times, Heavy Duty vehicles included buses by 1.1 times, motorcycles and mopeds by 5.9 times. It is important to emphasize that number of registered vehicles gradually decreased in the period 2008-2011 due to economic crisis, where number of passenger cars which have a highest share in total number of vehicles decreased by 3.5 percent.

Amounts of fuels consumed, their net calorific values and appropriate GHG emission factors and GHG emissions in the sub-sector Road transport for the years 1990, 2000, 2005 and for period 2008 - 2011 are shown in Table A2-11 Annex 2.

The CO₂-eq from the sub-sectors Road transport in 2011 amounted to 5,608.83 Gg, which is 2.6 percent less than in 2010 as a result of decrease in fuel consumption. In comparison with 1990, CO₂-eq increased by 52.9% as a result of grow in diesel fuel consumption (by 2.9 times compared to 1990). At the same time gasoline consumption was decreased by 18.1%.

Trends of CO₂-eq emissions for fossil fuel type consumed in road transport for the period from 1990 to 2011 are shown in Figure 3.2-10.

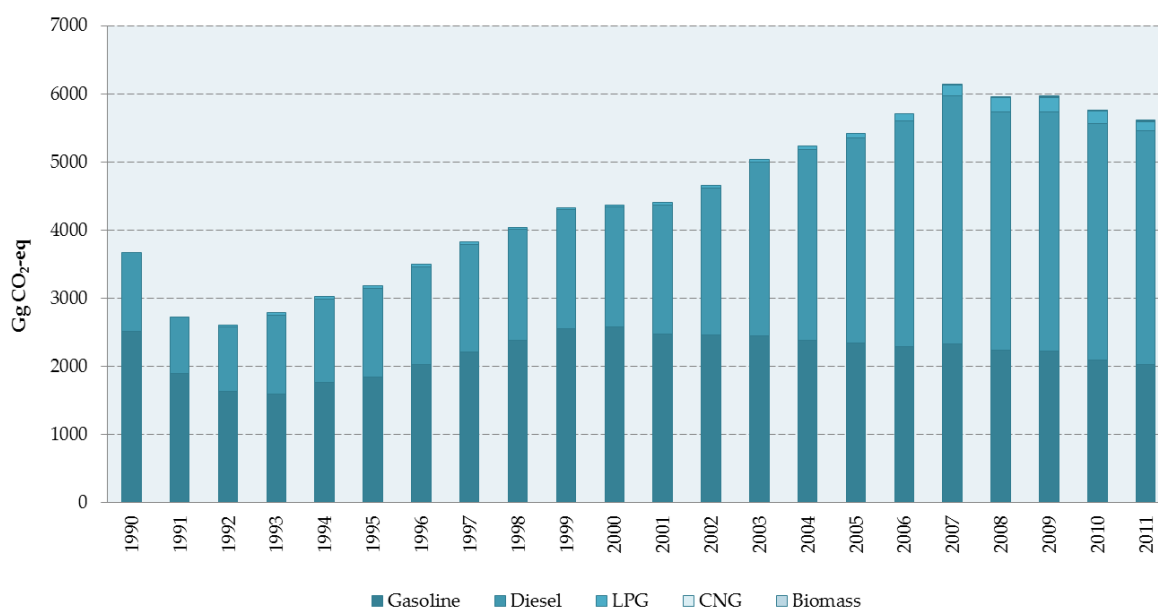


Figure 3.2-10: The CO₂-eq emission from Road transport sub-sector by fossil fuel type for the period from 1990 to 2011

Railways

The GHG emissions from sub-sector Railways were calculated using Tier 1 approach based on fossil fuel consumption data (from national energy balance) and default IPCC emission factors.

Quantities of fossil fuel consumed their net calorific values and appropriate GHG emission factor and GHG emissions in the sub-sector Railways for the years 1990, 2000, 2005 and for period 2008 - 2011 are shown in the Table A2-14 of the Annex 2.

Navigation

The GHG emissions from Navigation sub-sector were calculated using Tier 1 approach, based on fossil fuel consumption data (from national energy balance) and default IPCC emission factors.

Quantities of fossil fuel consumed their net calorific values and appropriate GHG emission factor and GHG emissions in the sub-sector Navigation for the years 1990, 2000, 2005 and for period 2008 - 2011 are shown in the Table A2-13 of the Annex 2.

3.2.8.3. Uncertainties and time-series consistency

Uncertainty of CO₂ emissions

The CO₂ emission, from the fossil fuel combustion, depends on amount of fuel consumed (from energy balance), net calorific values (from energy balance), carbon emission factors (IPCC), the fraction of carbon stored (IPCC) and the fraction of carbon oxidised (IPCC).

The estimated uncertainty of data from energy balance is below 4 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 effect on the accuracy of data of national emission, as marine and aviation transport have relatively small influence. The estimated CO₂ 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 CO₂ emission factors for fuels are generally well determined within 5 percent, as they are primarily dependent on the carbon content of the fuel.

Uncertainty of CH₄ and N₂O emissions

Estimates of CH₄ and N₂O emissions are based on fuel 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.

The uncertainty of CH₄ emission is estimated to ± 40 percent; while the uncertainty of N₂O 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 CH₄ and N₂O emissions from Road transport (CRF 1.A.3.b) lead to certain uncertainty reduction.

Time-series consistency

Activity data, emission factors and methodology implied for GHG emission calculation from fuel combustion activities is very consistent for entire period.

3.2.8.4. Source-specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness, consistency, comparability, recalculation and uncertainty of activity data, emission factors and emission estimates.

Also, inventory team used country-specific fuel net calorific values for emission estimates. Calorific values from energy balance were compared with data from the IPCC Guidelines. Results of this comparison showed that there is no significant difference between these two sets of data.

Source-specific quality check in road transportation included comparison of results of emission calculation obtained independently with Tier 1 (top-down) and Tier 2/3 (COPERT model) approach for CO₂ emissions from liquid fuels. This is in line with recommendation from the IPCC good practice guidance. The difference between these two approaches is 0.57 percent for combined CO₂ emissions from gasoline and diesel oil in 2011, with positive difference for gasoline and negative for diesel oil (3.53 and -1.06 percent respectively) and less than 1 percent difference in fuel balance. For the entire time-series (1990-2011) average difference between Tier 1 and Tier 2/3 approach is 1.15 percent (1.91 percent for gasoline and 0.59 percent for diesel oil). It could be concluded that difference is not significant and that Tier 1 approach yields slightly higher emission estimates than Tier 2/3 approach. Secondly, we can conclude that COPERT model is in general reliable and accurate, and estimates for other greenhouse gases, i.e. CH₄ and N₂O are reliable and accurate as well.

3.2.8.5. Source-specific recalculations

Recalculation was made for sub-sector Civil aviation (1.A.3.a) in 2010:

- Wrong net calorific value for gasoline is used for emission calculation. In this submission error is corrected.

Differences in emissions before and after recalculation in Civil aviation sub-sector are:

	2010
CO ₂ , %	-0.05
CH ₄ , %	-0.05
N ₂ O, %	-0.05

Recalculations were made for sub-sector Road transportation (1.A.3.b):

- emissions of CO₂ from liquid fuels were recalculated for the period 1990-2010 in the course of the in-country review in 2012
- in this submission, emissions from gaseous fuels (CNG – compressed natural gas) were estimated for the period 2009-2011 for the first time
- revised emission factor for liquefied petroleum gas is applied (64.48 t/TJ instead of 78.15 t/TJ) for the entire time-series

Differences in emissions before and after recalculation in Road Transportation sub-sector are:

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO ₂ , %	0.00	0.00	-0.22	-0.29	-0.27	-0.28	-0.26	-0.22	-0.17	-0.14
CH ₄ , %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N ₂ O, %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO ₂ , %	-0.15	-0.19	-0.18	-0.17	-0.21	-0.27	-0.42	-0.54	-0.75
CH ₄ , %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N ₂ O, %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	2009	2010
CO ₂ , %	-0.69	-0.53
CH ₄ , %	0.51	1.06
N ₂ O, %	0.00	0.00

Recalculation was made for sub-sector Railways (1.A.3.c) in 2010:

- Wrong emission factor of CH₄ and N₂O for diesel fuel. In this submission error is corrected.

Differences in emissions before and after recalculation in sub-sector Railways are:

	2010
CH ₄ , %	-16.7
N ₂ O, %	-62.5

3.2.8.6. Source-specific planned improvements

Inventory team is planning to further explore differences between Tier 1 and Tier 2/3 approach with particular focus on emission factors used in COPERT model for CO₂ emissions from gasoline and diesel oil, and reasons for high uncertainties of emission factors for CH₄ and N₂O.

3.2.9. SMALL STATIONARY ENERGY SOURCES (CRF 1.A.4)

3.2.9.1. Source category description

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

The total GHG emissions from abovementioned Small Stationary Energy Sources are shown in the Table 3.2-10 and Figure 3.2-11.

Table 3.2-10: The CO₂-eq emissions (Gg) from Small Stationary Energy Sources

	1990	1995	2000	2005	2008	2009	2010	2011
Commercial/Institutional	775	652	638	786	626	627	669	616
Residential	2,176	1,688	2,008	2,481	2,116	2,166	2,209	2,060
Agricultural/Forestry/Fishing	843	583	861	712	771	738	718	717
Total	3,794	2,923	3,507	3,979	3,513	3,531	3,596	3,393

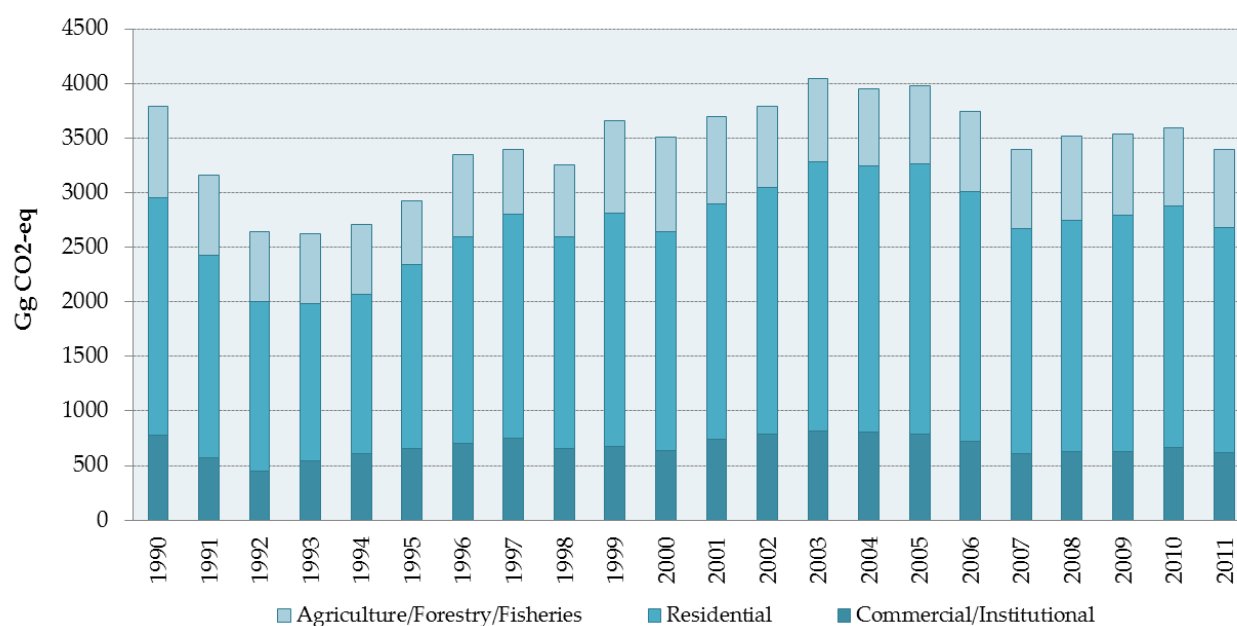


Figure 3.2-11: The CO₂-eq emissions from Small Stationary Energy Sources

The CO₂-eq emissions from these subsectors were about 16-20 percent of the total emissions from Energy sector. The most of the emission comes from small household furnaces and boiler rooms (54-62 percent), then from service sector (17-22 percent), while the combustion of fuel in agriculture, forestry and fishing accounts for 18 to 25 percent.

3.2.9.2. Methodological issues

The GHG emissions from these subsectors were calculated using Tier 1 approach, based on fuel consumption data (national energy balance) and default IPCC emission factors.

Data from the national energy balance were recalculated from natural units into energy units by means of its 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)*. Values for fraction of carbon which oxidizes were taken from *Revised 1996 IPCC Guidelines* as recommended (Workbook, Page 1.8).

The fuel consumption and GHG emissions for Commercial/Institutional, Residential and Agriculture/Forestry/Fishing are presented in Tables A2-15, A2-16 and A2-17 of the Annex 2.

3.2.9.3. Uncertainties and time-series consistency

Uncertainty of CO₂ emissions

The CO₂ emission, from the fossil fuel combustion, depends on amount of fuel consumed (from energy balance), net calorific values (from energy balance), carbon emission factors (IPCC), the fraction of carbon stored (IPCC) and the fraction of carbon oxidised (IPCC).

The estimated uncertainty of data from energy balance is below 4 percent.

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

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 CO₂ emission factors for fuels are generally well determined within 5 percent, as they are primarily dependent on the carbon content of the fuel.

Uncertainty of CH₄ and N₂O emissions

Estimates of CH₄ and N₂O emissions are based on fuel and aggregate emission factors for different sectors. Using the aggregate emission factors for each sector leads to greater the uncertainties associated with estimates of CH₄ and N₂O emissions from the fossil fuel combustion.

The uncertainty of CH₄ emission is estimated to ± 40 percent; while the uncertainty of N₂O emission is estimated to factor 2 (the emission could be twice larger or smaller than the estimated one).

Time-series consistency

Activity data, emission factors and methodology implied for GHG emission calculation from fuel combustion activities is very consistent for entire period.

3.2.9.4. Source-specific QA/QC and verification

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness, consistency and comparability of activity data, emission factors and emission estimates.

Also, inventory team used country-specific fuel net calorific values for emission estimates. Calorific values from energy balance were compared with data from the IPCC Guidelines. Results of this comparison showed that there is no significant difference between these two sets of data.

3.2.9.5. Source-specific recalculations

There are no recalculations in this sub-sector.

3.2.9.6. Source-specific planned improvements

On long term basis, inventory team is planning apply country-specific carbon content values and oxidation factor values to estimate emissions for the main fuel types.

3.2.10. OZONE PRECURSORS AND SO₂ EMISSIONS

3.2.10.1. Source category description

The emissions of indirect greenhouse gases (NO_x, CO and NMVOC) and SO₂ are described in this chapter. Ozone precursors are cause of greenhouse gas - tropospheric ozone, whereas SO₂ 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. Emissions of indirect GHGs for whole time period, from 1990 to 2011 was set up according to the EMEP/CORINAIR methodology. Emissions were obtained from the emission inventory report 'Republic of Croatia Informative Inventory Report for 2011, under Convention on Long-range Transboundary Air Pollution (CLRTAP)' which is Croatia's obligation in the framework of the Long-range Transboundary Air Pollution Convention according to the Act on Air Protection (OG 130/11).

NO_x emissions

The NO_x emission encompasses nitrogen monoxide and nitrogen dioxide emissions. The emissions are expressed as equivalents of NO₂. NO_x is a pollutant that causes acidification and eutrophication. Together with volatile organic compounds and other reactive gases in atmosphere, and in presence of solar radiation, NO_x takes part in ground ozone formation.

The emission of NO_x from Energy sector (Fuel Combustion Activities) in 2011 was 60.2 Gg which is 3.4 percent lower than the year before and 33.0 percent lower compared to 1990. The NO_x emissions from Energy sector contribute with 90.7 percent to national total NO_x emission. The structure of NO_x emission in Energy sector has not changed significantly in the period from 1990 to 2011 (Figure 3.2-12). The main source of NO_x emission is transport (42.1 percent of total emission). Small stationary energy sources accounted for 20 percent to national total NO_x emission and emission from industry sectors accounted for 14 percent to the national total.

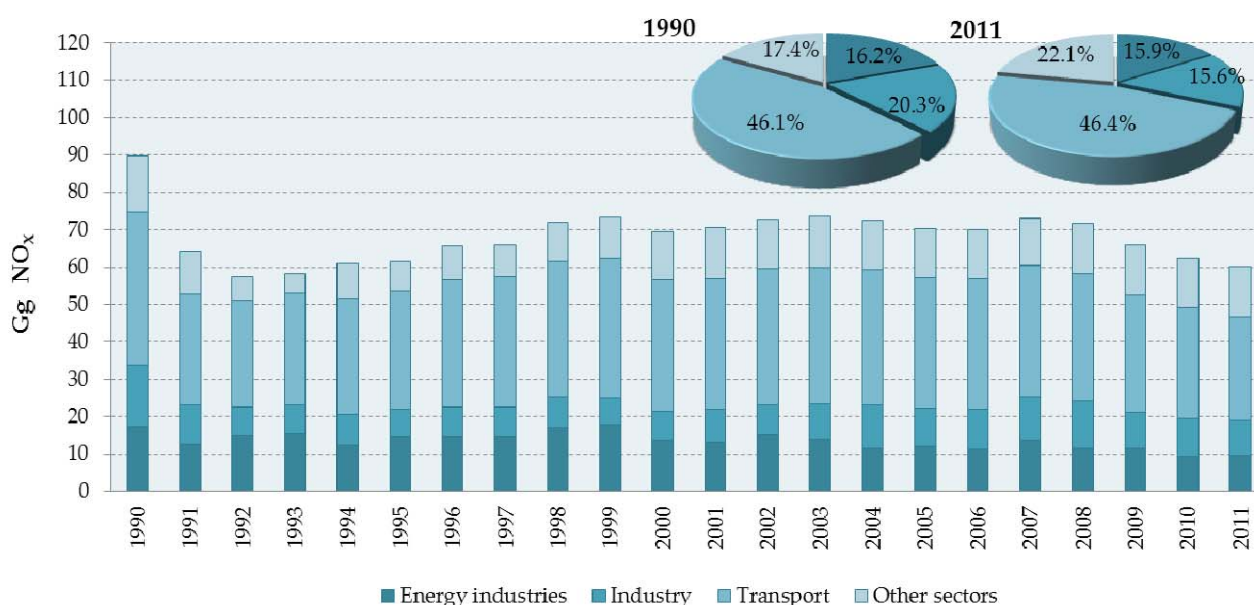


Figure 3.2-12: NO_x emissions from Energy sector in the period 1990-2011

CO emissions

In 2011, the emission of CO from Fuel Combustion Activities was 252.5 Gg which is 6.1 percent higher than in the year before and 47.6 percent lower compared to 1990, the year with maximum emission (481.5 Gg) of CO in the observed period. The CO emissions from Energy sector in 2011 contribute with 87.4 percent to national total CO emission. 19.2 percent of CO emission in Energy sector in 2011 was the result of incomplete fossil fuel combustion in Road transport sector and 57.5 percent in Commercial and Residential sector (Figure 3.2-13).

Large combustion plants have automatic regulation of air throughput and combustion control, so CO emissions are low (about 0.4% of national total emission).

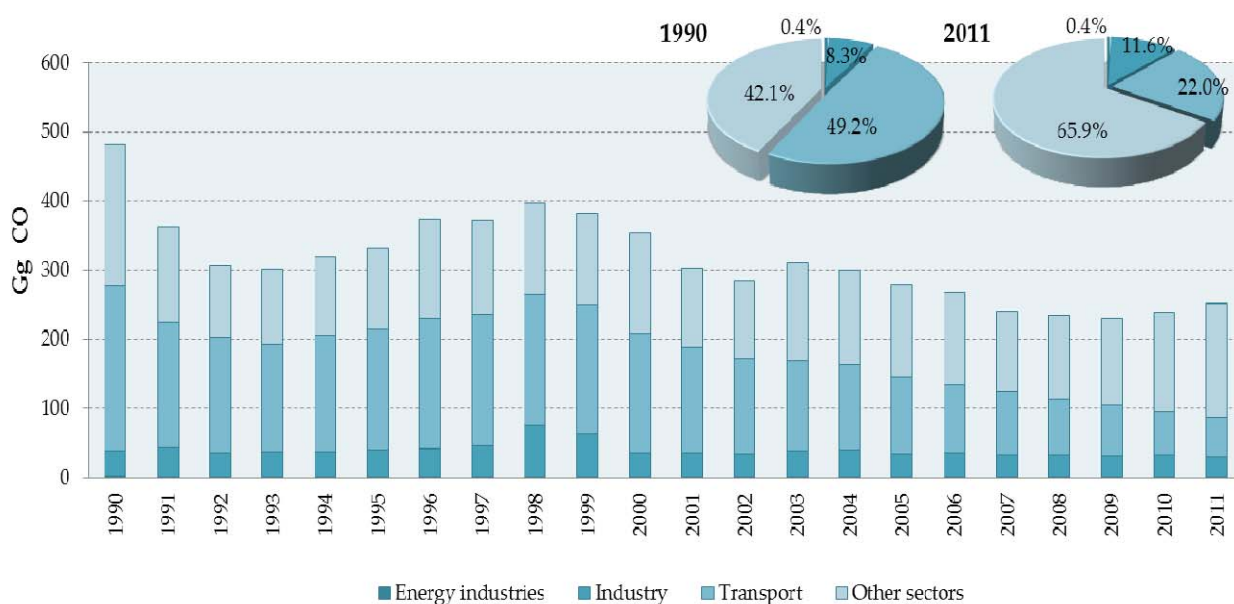


Figure 3.2-13: CO emissions from Energy sector in the period 1990-2011

NMVOC emissions

Non methane volatile organic compounds are important because they are precursors in formation of tropospheric ozone. Some of them may have undesirable ecotoxicological properties, for example benzene and xylene. Anthropogenic NMVOCs emissions from Energy sector (Fuel Combustion Activities) were 22.1 Gg in 2011 which was 0.7 percent higher than the year before and 55.2 percent lower than 1990. The NMVOC emissions from Energy sector contribute with 30.2 percent to national total NMVOC emission.

The structure of NMVOC emission from Energy sector has not changed significantly in the period from 1990 to 2011 (Figure 3.2-14). The main source of NMVOC emission is transport sources sector (46.3 percent of total emission of Energy sector). Emission of NMVOC from stationary combustion sectors accounted with 16.2 percent to the national total, mainly from the Commercial and Residential sector (45.8 percent).

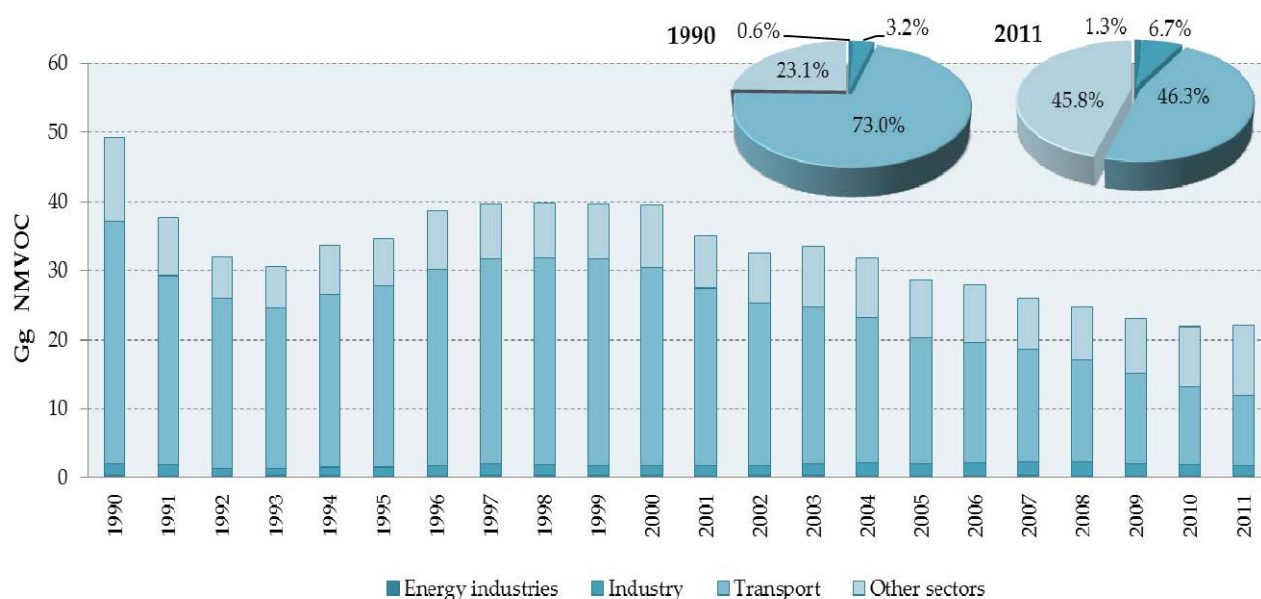


Figure 3.2-14: NMVOC emissions from Energy sector in the period 1990-2011

SO₂ emissions

In accordance with the calculated results, the level of SO₂ emission from Fuel Combustion Activities in 2011 reached 34.0 Gg which is 87.6 percent of total national SO₂ emission. The trend shows that emissions of SO₂ have decreased by 13.3 percent compared to the emission in 2010 and decreased by 79.9 percent since 1990. Since 1990, SO₂ emission has the overall decreasing trend due to consumption of fossil fuel with lower sulphur content. The outstanding high level of SO₂ emission in 1990 is a result of fossil fuel consumption with high sulphur content in Energy Industries and Manufacturing Industries and Construction sectors. In years ahead, emissions from these two sectors were reduced by 50%.

During the period from 1990 to 2011, the decrease of SO₂ emissions was achieved in almost all sectors and the greatest decrease of SO₂ emission was in Energy Industries sector (82.0%). Emission trend for SO₂ in the period of 1990 to 2011 as well as the share of the particular sectors in total emission of SO₂ in Energy sector 1990 and 2011 is presented in Figure 3.2-15.

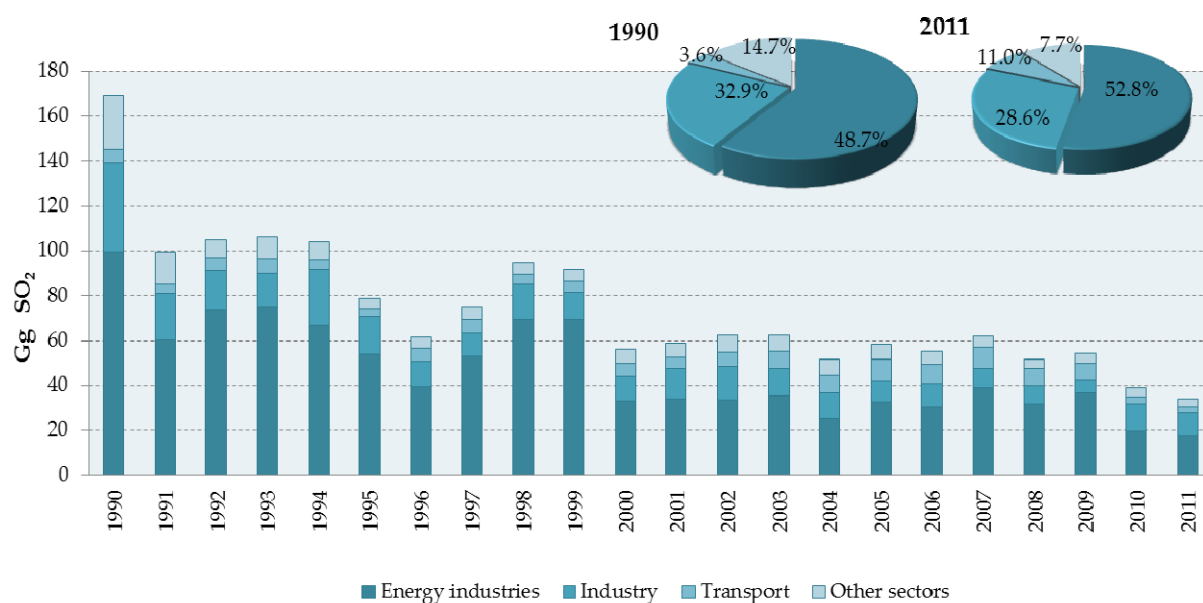


Figure 3.2-15: SO₂ emissions from Energy sector in the period 1990-2011

The emissions of ozone precursors and SO₂ are shown in the Table 3.2-11.

Table 3.2-11: Emissions of ozone precursors and SO₂ from Fuel Combustion sector (Gg)

Emission (Gg)	1990	1995	2000	2005	2008	2009	2010	2011
NO_x Emission	89.872	61.632	69.399	70.268	73.260	66.944	62.903	60.153
Energy Industries	17.534	14.480	13.755	12.188	11.477	11.470	9.484	9.573
Manufact. Ind. and Const.	16.330	7.573	7.732	9.901	13.997	11.084	11.017	9.372
Transport	40.974	31.448	35.066	35.033	34.279	31.103	29.225	27.904
Other Sectors	15.034	8.132	12.846	13.146	13.508	13.286	13.176	13.304
CO Emission	481.453	331.640	354.351	278.918	234.008	230.655	237.459	252.455
Energy Industries	2.395	1.558	1.621	1.149	1.450	1.177	1.068	1.218
Manufact. Ind. and Const.	37.226	38.102	33.564	33.357	31.706	30.918	31.797	29.369
Transport	237.881	175.297	172.776	111.450	80.794	72.409	62.824	55.604
Other Sectors	203.951	116.683	146.389	132.962	120.058	126.151	141.770	166.264
NMVOC Emission	52.081	36.712	42.454	29.254	25.295	23.372	21.896	22.086
Energy Industries	0.352	0.255	0.293	0.263	0.280	0.263	0.249	0.280
Manufact. Ind. and Const.	1.660	1.336	1.398	1.760	2.097	1.733	1.575	1.479
Transport	37.924	28.213	31.753	18.938	15.199	13.368	11.277	10.220
Other Sectors	12.144	6.909	9.011	8.292	7.718	8.009	8.796	10.107
SO₂ Emission	169.040	78.829	56.393	58.037	52.190	53.994	38.209	33.979
Energy Industries	99.526	53.981	32.929	32.732	31.959	36.737	19.668	17.944
Manufact. Ind. and Const.	39.753	16.657	10.986	9.380	8.470	5.957	12.041	9.703
Transport	5.888	3.536	5.974	9.150	7.490	6.785	2.316	2.611
Other Sectors	23.874	4.655	6.505	6.775	4.272	4.514	4.185	3.721

3.2.10.2. Methodological issues

Emissions of indirect GHGs was set up according to the EMEP/CORINAIR methodology. Emissions were obtained from the emission inventory report 'Republic of Croatia Informative Inventory Report for 2011, under Convention on Long-range Transboundary Air Pollution (CLRTAP)' which is Croatia's obligation in the framework of the Long-range Transboundary Air Pollution Convention according to the Act on Air Protection (OG 130/11).

3.2.10.3. Uncertainties and time-series consistency

Estimates of 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 CO₂ emissions from the fossil fuel combustion.

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

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. SOLID FUELS (CRF 1.B.1)

3.3.1.1. Source category description

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 steadily decreasing in the period 1990-1999. 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.

The emissions of methane from mining and post-mining activities are showed in the Figure 3.3-1.

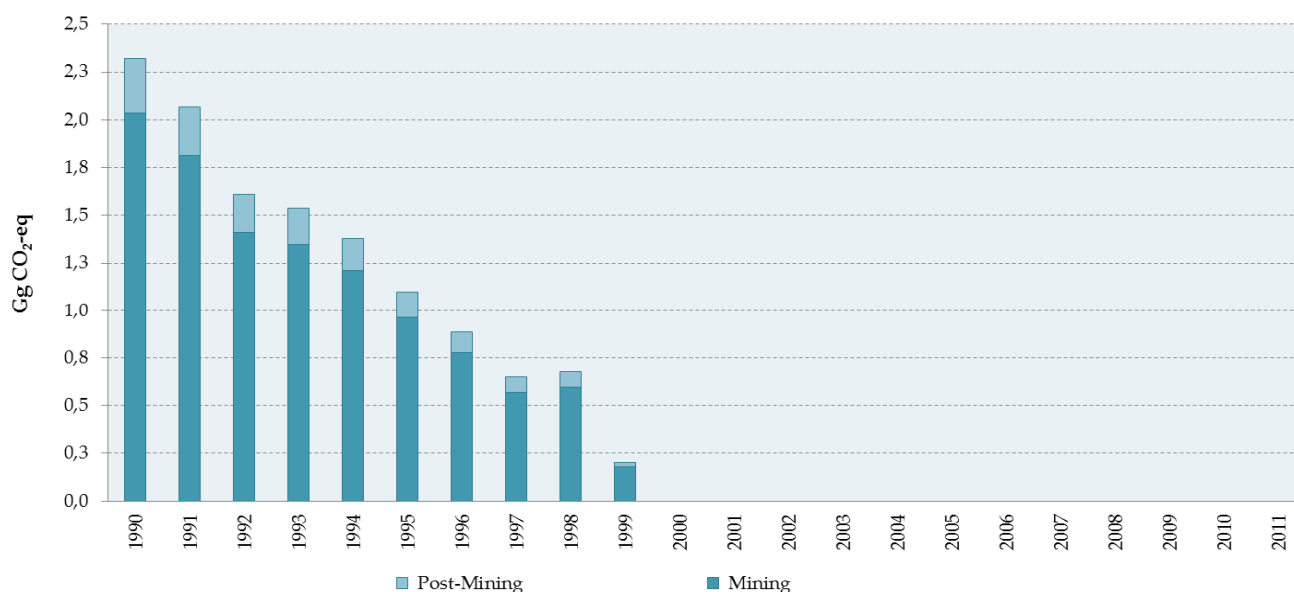


Figure 3.3-1: The fugitive emissions of methane from coal mines

3.3.1.2. Methodological issues

For estimating the fugitive emission from coal the simplest procedure has been used (Tier 1). Emission calculations were based on fuel production data, average IPCC emission factors and IPCC conversion factor.

Data about quantities of the mined coal is taken from the national energy balance.

The emission factors and conversion factor used for calculation are taken from *IPCC Guidelines (Revised 1996 IPCC Guidelines for National GHG Inventories, Workbook, Page 1.26)*.

The coal production data and emissions of methane from mining and post-mining activities are showed in Table A2-18, Annex 2.

3.3.1.3. Uncertainties and time-series consistency

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 Guidelines for the region to which Croatia belongs. The estimated uncertainty of methane emissions, for underground mining may be as high as a factor of 2 and for post-mining activities a factor of 3.

Time-series consistency

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

3.3.1.4. Source-specific QA/AC and verification

In this sub-sector only general (Tier 1) quality control procedures were applied, since the coal production was stop in 1999.

3.3.1.5. Source-specific recalculations

There are no recalculations in this sub-sector.

3.3.1.6. Source-specific planned improvements

On the short term basis, the inventory team is planning revise the calculations of fugitive emissions from coal mining and handling, provide sources for EFs used and improve QA/QC procedures.

3.3.2. OIL AND NATURAL GAS (CRF 1.B.2)

3.3.2.1. Source category description

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 which is the result of incomplete combustion of gas during flaring, and the emission from venting during oil and gas production.

Also, emission of CO₂ from natural gas scrubbing in Central Gas Station Molve, are included in this sub-sector. Namely, natural gas produced in Croatian gas fields (Molve and Kalinovac) contains a large amount of CO₂, more than 15 percent, and before coming to commercial pipeline has to be cleaned (scrubbed). Since the maximum volume content of CO₂ 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 CO₂ emissions, by the material balance method, are presented in Table 3.3-1.

Table 3.3-1: The CO₂ emissions (Gg) from natural gas scrubbing in CGS Molve

CO ₂ emission (Gg)	1990	1995	2000	2005	2008	2009	2010	2011
Central Gas Station MOLVE	416	739	633	691	576	516	487	509

The total GHG fugitive emission from oil and natural gas systems are shown in the Table 3.3-2 and Figure 3.3-2.

Table 3.3-2: The CO₂-eq emissions (Gg) from oil and gas systems

	1990	1995	2000	2005	2008	2009	2010	2011
Oil activities	16.1	11.5	10.9	10.2	8.9	9.4	8.9	7.2
Gas activities	1,577.7	1,852.2	1,712.7	1,983.2	2,059.6	1,945.8	1,971.1	1,897.7
Venting and Flaring	248.9	156.0	128.0	118.7	118.4	113.4	109.3	99.94
Total	1,842.8	2,019.6	1,851.5	2,112.2	2,186.9	2,068.6	2,089.3	2,004.9

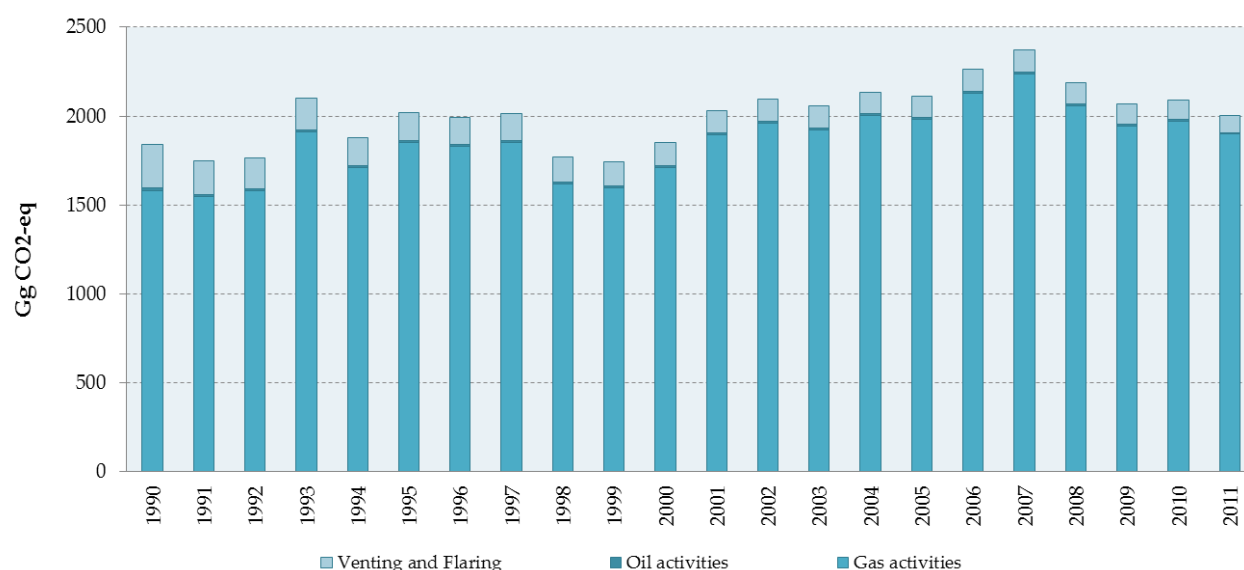


Figure 3.3-2: The fugitive emissions from oil and gas activities

The CO₂-eq emissions from this sub-sector were about 8-12 percent of the total emissions from Energy sector. The most of the emission comes from gas activities (86-95 percent), then from venting and flaring (5-14 percent), while the oil activities accounts for 0.4 to 0.9 percent.

Fugitive emission of ozone precursors and SO₂

Emissions of indirect GHGs for whole time period (1990-2011) was set up according to the EMEP/CORINAIR methodology. Emissions were obtained from the emission inventory report 'Republic of Croatia Informative Inventory Report for 2011, under Convention on Long-range Transboundary Air Pollution (CLRTAP)' which is Croatia's obligation in the framework of the Long-range Transboundary Air Pollution Convention according to the Act on Air Protection (OG 130/11).

A summary of estimated results of the fugitive emissions of CO, NO_x, NMVOC and SO₂ are illustrated in the Table 3.3-3 and Figure 3.3-3.

Table 3.3-3: The fugitive emissions of ozone precursors and SO₂ from oil refining

Emissions (Gg)	1990	1995	2000	2005	2008	2009	2010	2011
CO emission	50.06	34.51	54.07	54.42	41.61	51.91	40.12	32.64
NO _x emission	0.49	0.30	0.30	0.30	0.24	0.29	0.21	0.17
NMVOC emission	8.50	6.73	9.06	8.45	7.47	7.98	7.67	7.06
SO ₂ emission	1.80	1.24	3.11	3.10	2.83	3.27	2.33	3.46

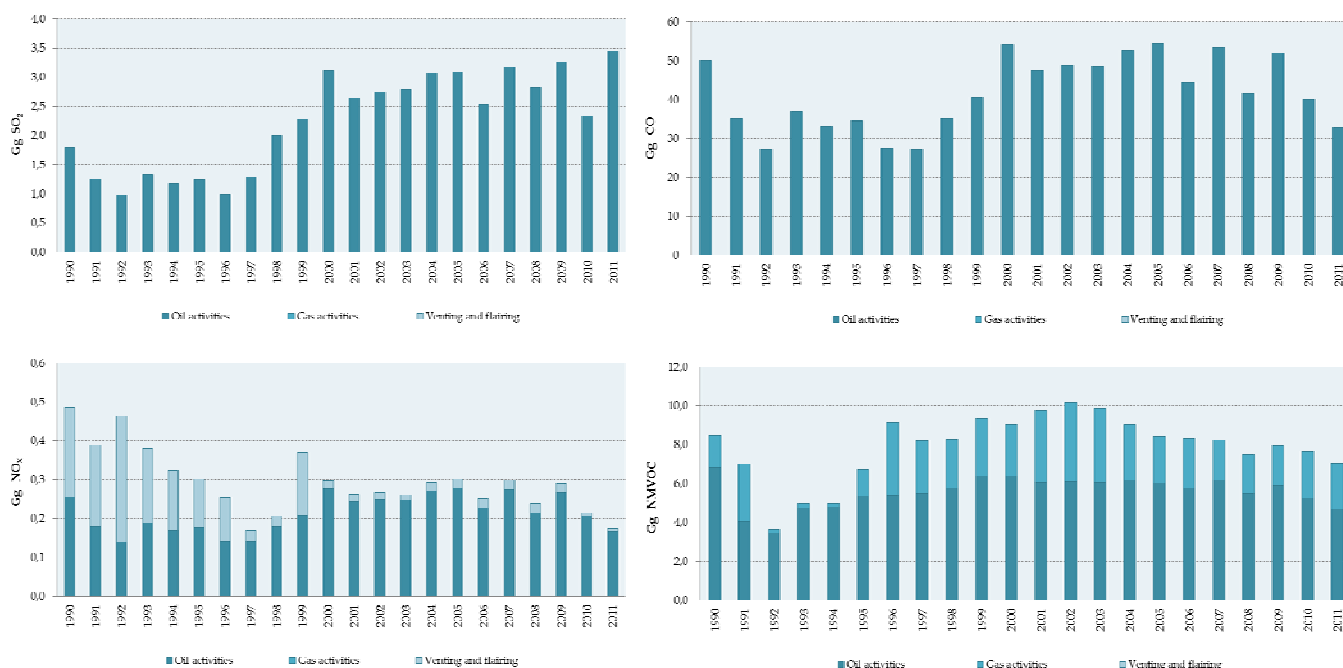


Figure 3.3-3: The fugitive emissions of CO, NO_x, NMVOC and SO₂

3.3.2.2. Methodological issues

Fugitive emission of methane

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

According to the 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 (*Revised 1996 IPCC Guidelines for National GHG Inventories, Workbook*, page 1.30). 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.

Data about quantities of production, unloading, transportation, processing, storing and consumption of oil and gas are taken from the national energy balance.

Fugitive emission of CO₂ and N₂O

For estimating the fugitive emission of CO₂ and N₂O from oil and gas the simplest procedure has been used (Tier 1), which is based on production, unloading, processing and consumption of oil and gas.

Data about quantities of production, unloading, transportation, processing, storing and consumption of oil and gas are taken from the national energy balance. Data about number of active wells are taken from INA – Oil and Gas Company.

The emission factors used for calculation are taken from *IPCC GPG (IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Table 2.16)*.

CO₂ emission from natural gas scrubbing

The methodology for estimating CO₂ emission from natural gas scrubbing is not given in IPCC Guidelines. The CO₂ emission is determined on the base of differences in CO₂ content before and after scrubbing units and quantity of scrubbed natural gas.

The fugitive emissions from oil and gas activities are showed in Table A2-19, Annex 2.

Fugitive emission of ozone precursors and SO₂

A simplified Tier 1 procedure was used for fugitive emission estimates of ozone precursors and SO₂ from oil refineries, for the entire period from 1990 to 2011. The simplified procedure is based on the quantity of crude oil processed in oil refineries. Default emission factors were used for the estimation.

3.3.2.3. Uncertainties and time-series consistency

Uncertainty

The simplest procedure (Tier 1) 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 SO₂ is also very high.

The CO₂ emission from scrubbing of natural gas is also shown here. The calculation is based on material balance which gives much better accuracy (± 10 percent).

Time-series consistency

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

3.3.2.4. Source-specific QA/AC and verification

For fugitive emissions from oil and gas operations a Tier 1 method was applied and emission factor is value proposed in the IPCC Guidelines/ IPCC GPG. The CO₂ emission from natural gas scrubbing in CPS Molve was estimated using country specific methodology since IPCC Guidelines does not provide methodology for this source category.

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness, consistency, comparability, recalculation and uncertainty of activity data, emission factors and emission estimates.

3.3.2.5. Source-specific recalculations

In this sector several recalculations were performed:

- Natural Gas – Transmission (1.B.2.b.iii)
 - New activity data added (lengths of transportation pipelines in the Republic of Croatia).
 - Recalculation of CO₂ emission was performed for the period 1990-2010.
- Natural Gas – Production (1.B.2.b.ii)
 - Typing error. Recalculation of CO₂ emission was performed for year 1991.
- Natural Gas – Production (1.B.2.b.ii)
 - Typing error. Recalculation of CH₄ emission was performed for year 2002.
- Oil – Production (1.B.2.a.ii)
 - Typing error. Recalculation of CH₄ emission was performed for the period 1993-2007.
- Venting – Natural Gas (1.B.2.c.ii)
 - Typing error. Recalculation of CH₄ emission was performed for year 1990, 1996, 1997 and 1999.

The differences in emissions before and after recalculations in Fugitive Emissions from Oil, Natural Gas and Other Source are:

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO ₂ , %	0.006	6.895	0.006	0.004	0.005	0.004	0.004	0.005	0.005	0.005	0.005
CH ₄ , %	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0002	0.0001	0.000	0.000

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CO ₂ , %	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004
CH ₄ , %	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

3.3.2.6. 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 Guidelines*. However, fugitive emission from natural gas is key source and implementation of rigorous source-specific evaluations approach (Tier 3) is necessary.

On long term basis, inventory team is planning apply Tier 3 approach for calculation of fugitive emissions from oil and natural gas operations.

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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 (CO₂), methane (CH₄) or nitrous oxide (N₂O) are released into the atmosphere.

Industrial processes whose contribution to CO₂ emissions was identified as significant are production of cement, lime, ammonia, as well as use of limestone and soda ash in different industrial activities. Nitric acid production is a source of N₂O emissions. Emissions of CH₄ appear in production of other chemicals, as well as carbon black and ethylene.

Consumption of halocarbons (HFCs) and perfluorocarbons (PFCs), which are used as substitution gases in refrigeration and air conditioning systems, foam blowing, fire extinguishers and aerosols/metered dose inhalers, is a source of emissions of fluorinated compounds. SF₆ is used as an insulation medium in electrical equipment. During SF₆ manipulation and equipment testing, leakage and maintenance losses of the total charge can be present.

Some industrial processes, 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 (SO₂). These gases indirectly contribute to the 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 were collected in the way described in the following chapters.

Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia prescribes obligation and procedure for emissions monitoring, which comprise estimation and/or reporting of all anthropogenic emissions and removals. According to the requirement, sources of abovementioned greenhouse gases are responsible to report required activity data for more accurate emissions estimation.

Emission factors used for calculation of emissions are, in most cases, 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. Country-specific emission factors for cement and lime production as well as ammonia and nitric acid production were estimated by collecting the actual data from individual plants.

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, CO₂ emissions from industrial processes declined from 1990 to 1995, due to a decline in industrial activities caused by the war in Croatia, while during the period 1996-2008 emissions slightly increased. Decreasing of economic activity in 2009 influenced a decrease in overall emissions, which are in 2011 still considerably lower than in 2008.

The total annual emissions of GHGs, expressed in Gg CO₂-eq, from Industrial Processes in the period 1990-2011 are presented in the Figure 4.1-1.

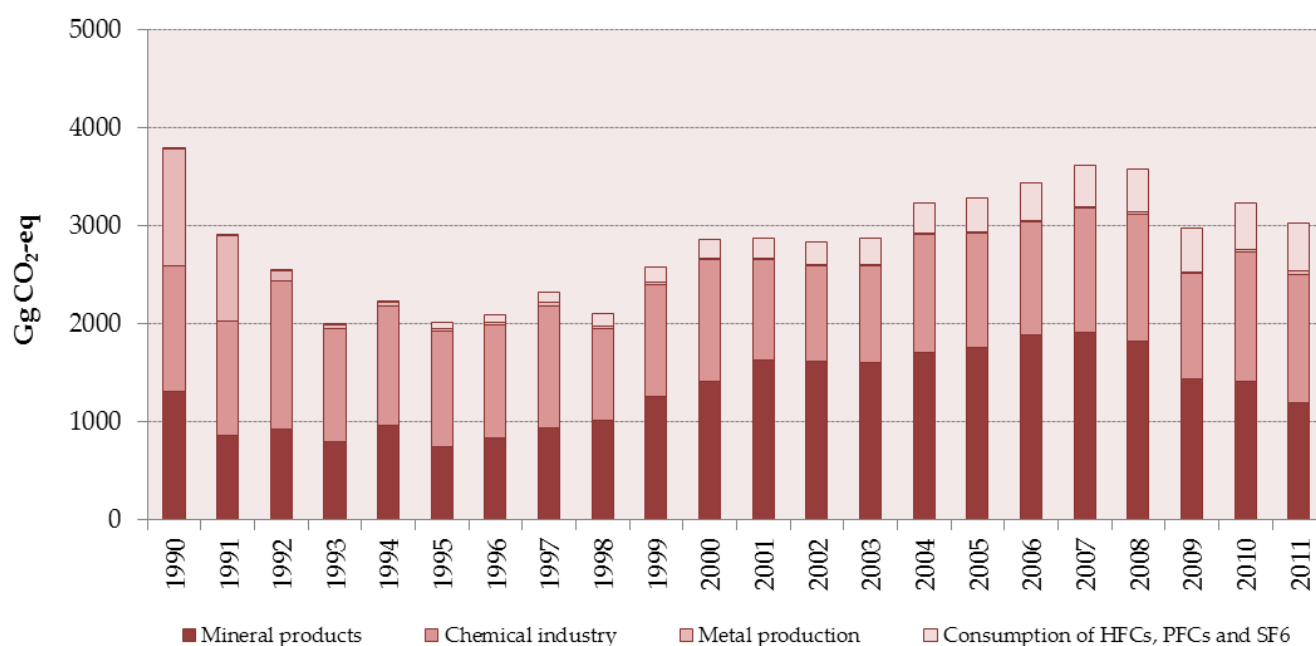


Figure 4.1-1: Emissions of GHGs from Industrial Processes (1990-2011)

In Industrial processes, eight source categories represent key source category regardless of LULUCF (detailed in Table 4.1-1):

Table 4.1-1: Key categories in Industrial processes sector based on the level and trend assessment in 2011⁵

IPCC Source Categories	Direct GHG	Criteria for Identification			
		Level		Trend	
		excl. LULUCF	incl. LULUCF	excl. LULUCF	incl. LULUCF
INDUSTRIAL PROCESSES					
CO ₂ Emissions from Cement Production	CO ₂	L1e	L1i	T1e, T2e	
CO ₂ Emissions from Lime Production	CO ₂				T2i
CO ₂ Emissions from Ammonia Production	CO ₂	L1e	L1i	T1e, T2e	
CO ₂ Emissions from Ferroalloys Production	CO ₂			T1e, T2e	T1i, T2i
CO ₂ Emissions from Aluminium Production	CO ₂			T1e, T2e	T1i, T2i
N ₂ O Emissions from Nitric Acid Production	N ₂ O	L1e, L2e	L1i, L2i	T1e, T2e	T1i, T2i
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC	L1e, L2e	L1i, L2i	T1e, T2e	T1i, T2i
PFC Emissions from Aluminium Production	PFC		T1e, T2e		T1i, T2i

L1e - Level excluding LULUCF Tier 1

L1i - Level including LULUCF Tier 1

T1e - Trend excluding LULUCF Tier 1

T1i - Trend including LULUCF Tier 1

L2e - Level excluding LULUCF Tier 2

L2i - Level including LULUCF Tier 2

T2e - Trend excluding LULUCF Tier 2

T2i - Trend including LULUCF Tier 2

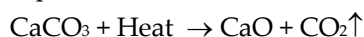
⁵ Data on key categories are taken from Annex 1 Key categories (Tier 1 and Tier 2)

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:



Lime is combined with silica-containing materials (e.g. clay) 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 three manufacturers (five factories) of Portland cement and one manufacturer of Aluminate cement in Croatia. CO_2 emitted during the cement production process represents the most important source of non-energy industrial process of total CO_2 emissions. Different raw 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 raw clay 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*).

Country-specific emission factor for Portland and Aluminate cement was estimated by using data on CaO and MgO content of clinker produced from individual plants. CO_2 from Cement Kiln Dust (CKD) leaving the kiln system was calculated using the default CF_{ckd} (2 percent of the CO_2 calculated for the clinker) due to the absence of plant-specific data for the whole time series.

The activity data for clinker production, data on the CaO and MgO content of the clinker, information on the CKD collection and recycling practices and likewise on the calcination fraction of the CKD were collected by a direct survey of cement manufacturers. The data were cross-checked with cement production data from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining. The data on clinker production and emission factors are presented in Table 4.2-1. The quantity of clinker imported has not been considered in the emission estimations.

Table 4.2-1: Clinker production and emission factors (1990 - 2011)

Year	Clinker production Portland cement (tonnes) ¹	Clinker production Aluminate cement (tonnes) ¹	Actual clinker production (tonnes) ²	Emission factor Portland cement (t CO ₂ /t clinker)	Emission factor Aluminate cement (t CO ₂ /t clinker)
1990	2,017,840	44,585	2,103,674	0.521	0.319
1991	1,296,146	40,974	1,363,862	0.521	0.327
1992	1,538,923	27,378	1,597,627	0.521	0.307
1993	1,264,565	40,511	1,331,178	0.523	0.312
1994	1,548,980	34,702	1,615,356	0.526	0.317
1995	1,148,756	48,854	1,221,562	0.523	0.317
1996	1,245,692	60,570	1,332,387	0.524	0.312
1997	1,470,234	63,541	1,564,451	0.515	0.314
1998	1,571,767	77,344	1,682,093	0.517	0.309
1999	2,063,838	87,175	2,194,033	0.517	0.311
2000	2,308,148	73,999	2,429,790	0.518	0.312
2001	2,645,180	94,065	2,794,030	0.517	0.306
2002	2,627,934	70,667	2,752,573	0.511	0.315
2003	2,609,349	82,741	2,745,932	0.510	0.307
2004	2,764,331	87,911	2,909,287	0.512	0.307
2005	2,827,258	99,320	2,985,110	0.510	0.299
2006	3,007,818	96,549	3,166,454	0.508	0.314
2007	3,046,209	114,311	3,223,730	0.507	0.310
2008	2,883,266	111,787	3,054,954	0.507	0.311
2009	2,355,148	83,911	2,487,840	0.499	0.310
2010	2,229,152	91,332	2,366,894	0.515	0.309
2011	1,965,307	106,353	2,113,093	0.508	0.306

¹ Clinker production according to survey of cement manufacturers² Actual clinker productions calculated as a product of clinker production and CF_{ckd}.

Import/export quantities of clinker are presented in Table 4.2-2.

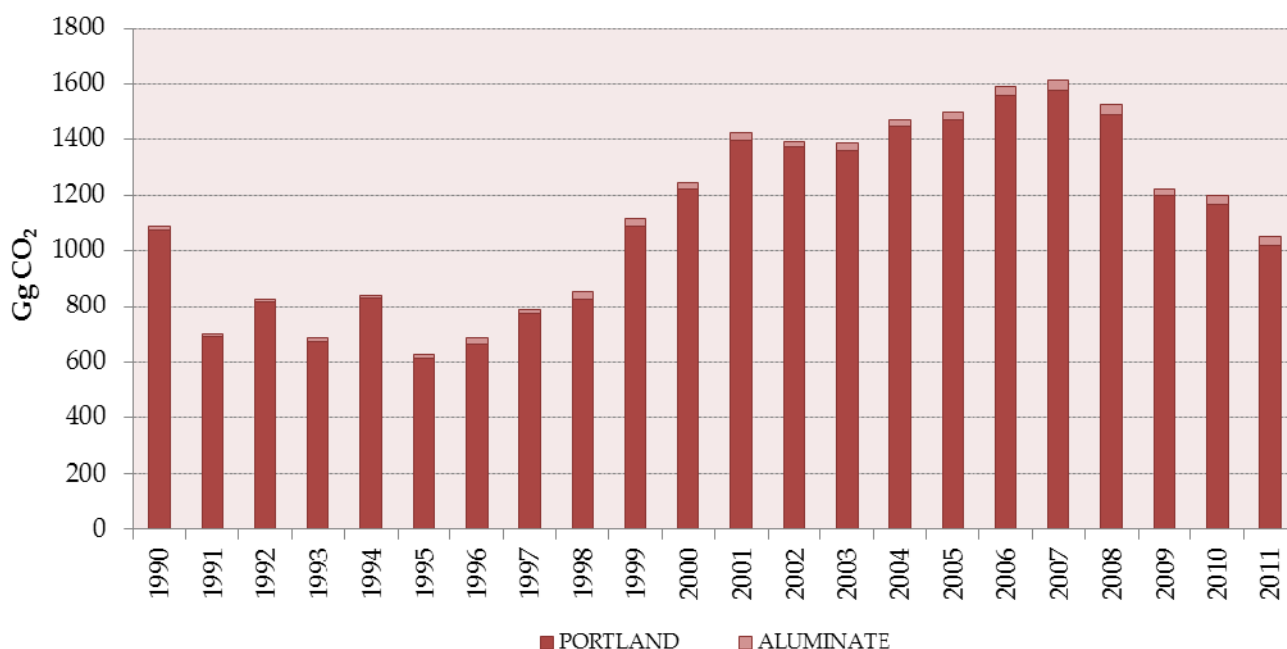
Table 4.2-2: Import/export quantities of clinker (1990 - 2011)

Year	Clinker import / tonnes		Clinker export / tonnes		Change in clinker stocks* / tonnes	
	Portland	Aluminate	Portland	Aluminate	Portland	Aluminate
1990	0	0	0	0	9,484	-113
1991	0	0	0	0	-35,932	7,790
1992	0	0	4,376	0	51,763	-3,154
1993	0	0	0	0	-25,265	-3,616
1994	0	0	0	2,200	-16,847	1,003

Table 4.2-2: Import/export quantities of clinker (1990 - 2011), cont.

Year	Clinker import / tonnes		Clinker export / tonnes		Change in clinker stocks* / tonnes	
	Portland	Aluminate	Portland	Aluminate	Portland	Aluminate
1995	52,500	0	0	5,504	10,313	3,619
1996	0	0	32,715	5,500	10,521	3,416
1997	57,973	0	63,529	5,000	16,034	-824
1998	116,397	0	82,451	14	-22,552	8,827
1999	0	0	114,868	287	-13,736	7,145
2000	0	0	111,226	576	-15,574	-9,775
2001	0	100	131,565	519	47,038	8,999
2002	0	0	5,029	2,987	-12,673	-8,991
2003	112,467	0	0	285	-16,320	690
2004	51,791	0	53,387	157	33,581	-1,643
2005	0	0	195,888	238	-88,696	-1,151
2006	0	0	243,708	438	-32,078	-1,710
2007	24,000	1,632	309,431	1,115	4,442	4,467
2008	0	153	234,849	626	-21,949	2,602
2009	0	0	169,356	536	43,281	958
2010	67	0	124,675	297	-19,944	-2,865
2011	0	0	65,082	388	-49,880	-8

The resulting emissions of CO₂ from Cement Production in the period 1990-2011 are presented in the Figure 4.2-1.

Figure 4.2-1: Emissions of CO₂ from Cement Production (1990-2011)

CO₂ emissions from cement production declined from the year 1990 to 1995, due to the decline in industrial activities caused by the war in Croatia, while from 1996 to 2008 emissions slightly increased. After that period, due to reduced economic activities, which influenced the cement production in Croatia, the production dropped by 23 percent in 2009, 26 percent in 2010, and 28 percent in 2011, while emissions decreased by 20 percent in 2009, 22 percent in 2010 and 31 percent in 2011, regarding the year 2008.

The activity data for cement production (see Table 4.2-3) were collected by survey of cement manufacturers and cross-checked with cement production data from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Table 4.2-3: Cement production (1990-2011)

Year	Cement production / tonnes	
	Portland	Aluminate
1990	2,598,066	44,698
1991	1,702,589	33,184
1992	1,810,780	30,532
1993	1,596,244	36,895
1994	2,049,140	31,499
1995	1,571,415	39,731
1996	1,643,049	51,654
1997	1,906,133	59,365
1998	2,161,827	68,503
1999	2,549,726	79,743
2000	2,909,466	83,388
2001	3,152,805	84,655
2002	3,415,011	76,737
2003	3,607,840	81,860
2004	3,553,985	89,563
2005	3,528,544	100,509
2006	3,657,889	98,041
2007	3,613,548	111,624
2008	3,671,826	108,891
2009	2,847,053	80,945
2010	2,687,535	93,128
2011	2,602,955	104,694

SO₂ 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). SO₂ 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 SO₂ generated in the process is absorbed in the produced alkaline clinker.

Emissions of SO₂, CO, NO_x and NMVOC have been taken from the emission inventory report 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2011 Submission to the Convention on Long-range Transboundary Air Pollution'.

The resulting emissions of SO₂, CO, NO_x and NMVOC from Cement Production in the period 1990-2011 are presented in the review on indirect GHG emissions from non-energy industrial processes.

4.2.1.3. Uncertainties and time-series consistency

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data amounts 3 percent (1 to 5 percent), based on expert judgements. Uncertainty estimate associated with emission factors amounts 3 percent, accordingly to values (1 to 5 percent) reported in *Good Practice Guidance* (detailed in Annex 5, Tables A5-1, A5-2).

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

4.2.1.4. Source-specific QA/QC and verification

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

Cement Production is one of the key source categories in Industrial Processes. Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. CO₂ emissions from cement production were estimated using Tier 2 method which is a *good practice*. Basic activity data from Annual PRODCOM results were compared with data provided by individual plants. Results of this comparison showed that there is no significant difference between these two sets of data. Country-specific emission factors for Portland cement were compared with IPCC default emission factor. Difference between these two data sets is caused by difference in CaO/MgO content in raw materials and clinker.

4.2.1.5. Source-specific recalculations

There are no source-specific recalculations for this subsector.

In previous reports, adjusted value for clinker production with the Cement Kiln Dust (CKD) factor was reported as "activity data". According to ERT recommendation during the in-country review, for this report, non-adjusted activity data was reported in the CRF, for comparability across parties.

4.2.1.6. Source-specific planned improvements

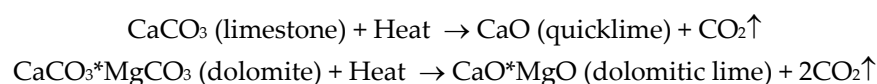
Detailed activity data have been collected from individual plants and there is no need for further improvements regarding data collection.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

4.2.2. LIME PRODUCTION

4.2.2.1. Source category description

The production of lime involves a series of steps which include quarrying the raw material, crushing and sizing, calcination and hydration. CO₂ is generated during the calcination stage, when limestone (CaCO₃) or dolomite (CaCO₃*MgCO₃) are burned at high temperature (900-1,200°C) in a kiln to produce quicklime (CaO) or dolomitic lime (CaO*MgO) and CO₂ which is released in the atmosphere:



There are four manufacturers (five factories) of lime in Croatia, with one of them producing both quicklime and dolomitic lime and the others producing only quicklime. Total seven kilns are used, among four are parallel-flow regenerative shaft kilns, two are annular shaft kilns and one is long rotary kiln.

Emissions from the production of sugar, where a certain amount of quicklime is produced, have been also included in this sub-sector. So far, due to the availability of data, only two sugar factories have been included in the emission calculation. This source needs to be further investigated.

Certain amounts of quicklime were produced in the blast furnace processes during 1990 and 1991.

4.2.2.2. Methodological issues

Calculation of CO₂ emissions from lime production is accomplished by applying an emission factor in tonnes of CO₂ 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.

Country-specific emission factor for quicklime was estimated by using data on CaO content of the lime and stoichiometric ratio between CO₂ and CaO from individual plants. Country-specific emission factor for dolomitic lime was estimated by using data on CaO*MgO content of the lime and stoichiometric ratio between

CO₂ and CaO*MgO from one plant. Vertical shaft kilns, which are mostly used, generate relatively small amounts of Lime Kiln Dust (LKD). It is judged that a correction factor for LKD from vertical shaft kilns would be negligible and do not need to be estimated.

The data for quicklime and dolomitic lime production, data on the CaO and CaO*MgO content of the lime and stoichiometric ratio between CO₂ and CaO and CaO*MgO were collected by survey of lime and sugar manufacturers.

The data for quicklime and dolomitic lime production were cross-checked with lime production data from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining.

A part of the data needed for the calculation of emissions from sugar production have been estimated based on the available data, therefore, for the purpose of additional analysis of reliability and correctness, these data will be checked and more accurate calculations will be performed.

Table 4.2-4: Lime production and emission factors (1990-2011)

Year	Quicklime		Dolomitic lime	
	Production (tonnes)	EF (t CO ₂ /t lime)	Production (tonnes)	EF (t CO ₂ /t lime)
1990	224,830	0.654	7,474	0.869
1991	155,258	0.732	0	-
1992	119,422	0.629	0	-
1993	131,811	0.634	0	-
1994	133,124	0.642	0	-
1995	128,164	0.646	0	-
1996	125,991	0.636	38,070	0.862
1997	119,763	0.634	55,171	0.850
1998	130,386	0.661	53,367	0.874
1999	124,366	0.679	52,704	0.870
2000	118,437	0.675	68,572	0.887
2001	146,369	0.685	84,838	0.887
2002	165,330	0.687	94,378	0.892
2003	146,801	0.687	96,191	0.879
2004	219,774	0.697	56,689	0.895
2005	220,518	0.689	76,351	0.875
2006	248,582	0.686	105,653	0.895
2007	246,545	0.694	115,315	0.899
2008	236,365	0.677	120,680	0.900
2009	150,953	0.654	87,789	0.861
2010	114,025	0.679	92,574	0.903
2011	108,101	0.589	71,761	0.357

The resulting emissions of CO₂ from Lime Production in the period 1990-2011 are presented in the Figure 4.2-2.

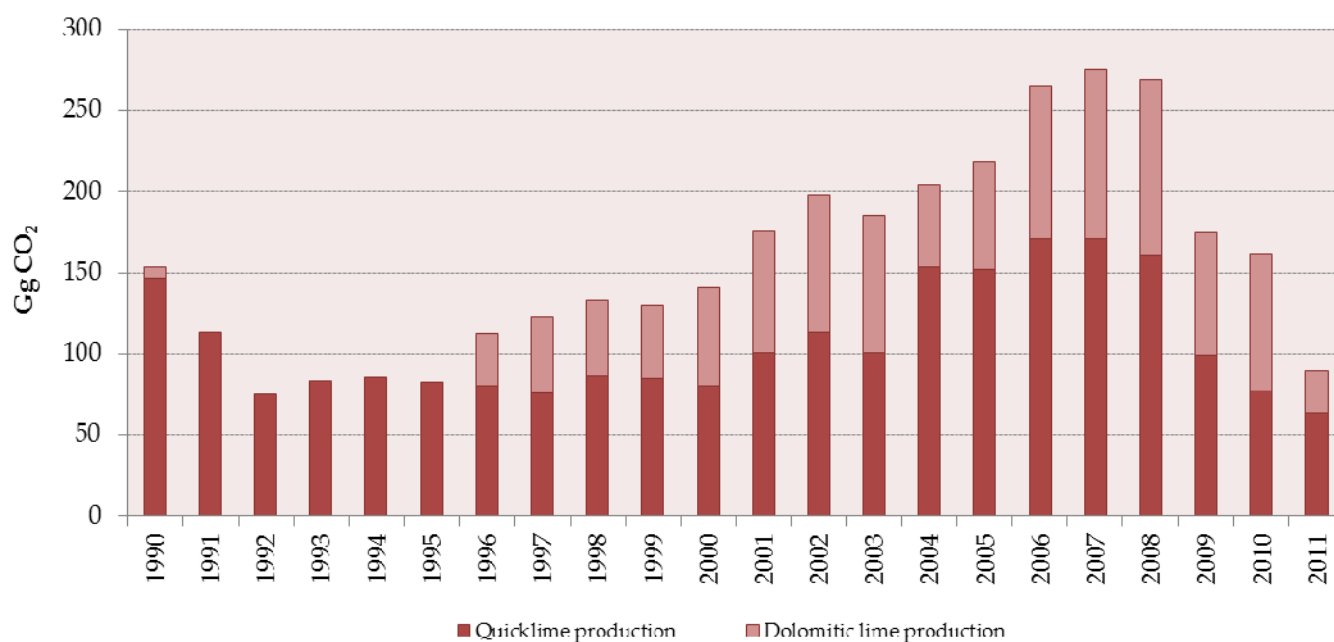


Figure 4.2-2: Emissions of CO₂ from Lime Production (1990-2011)

CO₂ emissions from lime production declined from 1990 to 1995, due to the decline in industrial activities caused by the war in Croatia, while in the period 1996-2007 emissions slightly increased. After that period, due to a decrease of economic activity in Croatia, which influenced lime production, the production started to slightly decrease during 2008 to significantly drop by 34 percent in 2009, by 43 percent in 2010 and by 52 percent in 2011, while emissions were decreased by 36 percent in 2009, 41 percent in 2010 and by 70 percent in 2011, regarding the year 2008.

The methodology for calculation of SO₂ emissions from Lime Production is not available in *Revised 1996 IPCC Guidelines*. Process (non-combustion) SO₂ emissions depend on the sulphur content and mineralogical form of the stone feed, the quality of the lime produced and the type of kiln.

Emissions of CO have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2011* Submission to the Convention on Long-range Transboundary Air Pollution'.

The resulting emissions of CO from Lime Production in the period 1990-2011 are presented in the review on indirect GHG emissions from non-energy industrial processes.

4.2.2.3. Uncertainties and time-series consistency

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data amounts 2.1 percent (1 to 5 percent), based on expert judgements. Uncertainty estimate associated with emission factors amounts 2.2 percent, accordingly to values (1 to 5 percent) reported in *Good Practice Guidance* (detailed in Annex 5, Tables A5-1, A5-2).

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 source specific quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation keys in the CRF tables according to QA/QC plan.

Lime Production is one of the key source categories in Industrial Processes. Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. CO₂ emissions from lime production were estimated using Tier 2 method which is a *good practice*. Basic activity data from Annual PRODCOM results were compared with data provided by individual plants. Results of this comparison showed that there is no significant difference between these two sets of data. Country-specific emission factors for quicklime and dolomitic were compared with IPCC default emission factor. Difference between these two data sets is caused by difference in CaO/CAO*MgO content in lime.

4.2.2.5. Source specific recalculations

New data from one sugar manufacturer were provided. Accordingly, for this resubmission recalculations were made for the period 1999-2011.

4.2.2.6. Source-specific planned improvements

Data received from three sugar manufacturers were collected. Only two manufacturers were included in the emission calculation due to the incompleteness of the data from the third manufacturer. Also, there were some gaps in the reported data from one included manufacturer, which were estimated on the basis of the rest of the time series (for 1990 estimation was based on the data for 1992, since there was no production in 1991; for 1996 data estimation was made by an interpolation and for 2011 emission was calculated by data for 2010). All of the aforementioned will be additionally investigated for the next submission.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

4.2.3. LIMESTONE AND DOLOMITE USE

4.2.3.1. Source category description

Limestone (CaCO_3) and dolomite ($\text{CaCO}_3 \cdot \text{MgCO}_3$) are basic raw materials that have commercial applications in a number of industries, including metal production, glass, brick and ceramics manufacture, refractory materials manufacture, 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 limestone and dolomite in Croatia occurs in glass, brick, ceramics and refractory materials manufacture. Both limestone and dolomite were used in considerable amounts in the pig iron production during 1990 and 1991. Data for the period from 2000-2011 also include significant limestone use in desulphurization process in Thermal Power Plant (TPP) Plomin 2⁶.

Also, emissions from the use of lithium carbonate (Li_2CO_3) in glass production during 2010, have been included in this sub-sector.

4.2.3.2. Methodological issues

Emissions of CO_2 arising from limestone and dolomite use have been calculated by multiplying annual consumption of raw material in processes (limestone/dolomite) by emission factors, which are based on a 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. Emissions from the use of lithium carbonate were calculated by using emission factor which equals 596 kg CO_2 /tonne carbonate⁷. A 100 percent purity of raw material was assumed for the purpose of calculations (*Revised 1996 IPCC Guidelines*).

The activity data for limestone use in the production of pig iron (for the 1990 and 1991), cast iron, glass, brick and ceramics, and for the use in desulphurization process in TPP Plomin 2 were collected by a survey of manufacturers.

The activity data for dolomite use in glass, brick, ceramic and refractory materials manufacture for the period 1990-1996 were extracted from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining. After this period, national classification of activities did not

⁶ TPP Plomin 2 is a thermal power plant that uses hard coal as a fuel, with sulphur content between 0.3 and 1.4%. In Plomin 2, emission of sulphur dioxide is reduced by utilization of wet limestone-based desulphurization process.

⁷ Source: 2007/589/EC: Commission Decision of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council (Annex IX, table 1)

distinguish dolomite use in abovementioned activities and because of that, AD was collected by survey of manufacturers. Some of these activities (from the period 1990-1996) were halted in the meantime.

The activity data for the use of lithium carbonate was collected by a survey of glass manufacturers.

Data for the use of limestone, dolomite and other carbonates are shown in Table 4.2-5.

Table 4.2-5: Limestone, dolomite and other carbonates use (1990-2011)

Year	Limestone use (tonnes)	Dolomite and other carbonates* use (tonnes)
1990	60,618	52,031
1991	30,507	40,452
1992	9,950	21,505
1993	9,589	20,134
1994	13,704	32,504
1995	14,085	23,461
1996	12,947	25,063
1997	11,012	14,762
1998	13,412	19,546
1999	12,160	18,396
2000	18,887	15,992
2001	22,526	18,596
2002	38,212	18,415
2003	31,292	21,928
2004	33,369	24,088
2005	33,281	25,275
2006	30,849	22,350
2007	27,802	20,018
2008	32,768	23,582
2009	30,700	35,544
2010	43,728	36,690
2011	69,000	24,036

* Li_2CO_3 from glass production, used in 2010

The resulting emissions of CO_2 from Limestone and Dolomite Use in the period 1990-2011 are presented in the Figure 4.2-3.

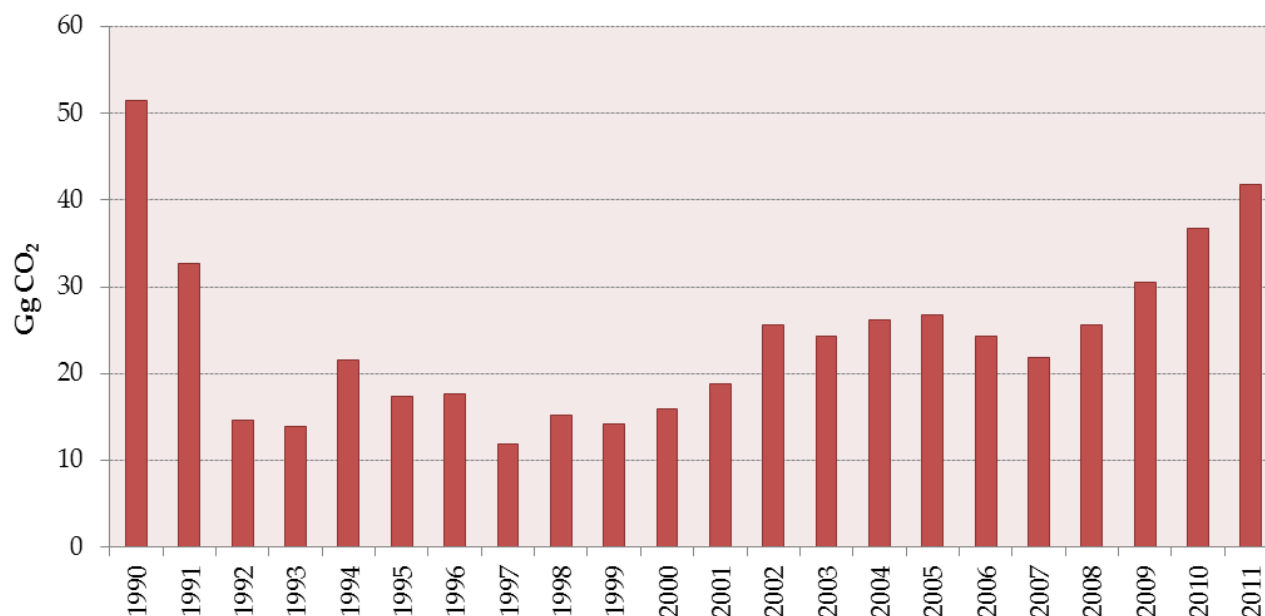


Figure 4.2-3: Emissions of CO₂ from Limestone and Dolomite Use (1990-2011)

CO₂ emissions from limestone and dolomite use considerably declined from 1990 to 1992, due to the fact that the production of pig iron, which utilized considerable amounts of limestone (41,816 t in 1990 and 12,037 t in 1991) and dolomite (12,396 t in 1990 and 7,561 t in 1991) was stopped in 1991. Also, glass production, and consequently, limestone and dolomite use in this production, significantly decreased in 1992 (275.490 t of glass produced in 1990, 252.936 t in 1991 and 143.904 t in 1992). Since 2000, limestone use data include significant amounts used in one thermo power plant. Sets of data for partly 2008, for 2009, 2010 and especially for 2011 include more sources than the rest of the time series. These data were collected from brick, ceramics and refractory material manufacturers, some of which were put into operation in 2008 or later, but some of them might have started their production earlier. All of these new data should be further investigated in order to ensure accurate CO₂ emission calculation for the whole time series.

4.2.3.3. Uncertainties and time-series consistency

Uncertainties in CO₂ 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 activity data amounts 7.5 percent (5 to 10 percent), based on expert judgements. Uncertainty estimate associated with default emission factors amounts 30 percent, based on expert judgements (detailed in Annex 5, Tables A5-1, A5-2).

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 1990-1996 in relation to the period 1997-2011. As abovementioned, in the period 1990-1996 national classification of activities distinguished dolomite use in glass, brick, ceramic and refractory materials manufacture. After this period, national classification of activities did not distinguish dolomite use in abovementioned activities and because of that, AD was collected by survey of manufacturers. Data for 2008, 2009, 2010 and especially for 2011 are more detailed than data for previous years and therefore discrepancy has occurred concerning the whole time-series. So far, detailed data for the entire calculation period have not been collected. Some of the activities (from the period 1990-1996) were halted in the meantime and there is no possibility to collect AD by the same data sets, for entire period.

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 according to QA/QC plan.

Since this source category is not a key source, QA/QC plan does not prescribe source specific quality control procedures.

4.2.3.5. Source specific recalculations

There are no recalculations for this sub-sector.

4.2.3.6. Source-specific planned improvements

More detailed activity data have been collected from individual plants for the period 2008-2011. This particularly refers to data for the year 2011. The improved gathering of data for entire time-series should be performed to avoid potential inconsistency.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

4.2.4. SODA ASH PRODUCTION AND USE

4.2.4.1. Source category description

Soda ash (sodium carbonate, Na_2CO_3) is used as a raw material in a large number of industrial processes including the manufacture of glass, ceramic, soap and detergents, pulp and paper production and water treatment methods.

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 1990-2011. Therefore, only CO₂ emissions arising in soda ash consumption in Croatia have been estimated.

4.2.4.2. Methodological issues

Emissions of CO₂ from the soda ash use have been calculated by multiplying annual consumption of soda ash by emission factor, which is based on a ratio between CO₂ and soda ash used. Default emission factor equals 415 kg CO₂/tonne soda ash has been used (*Revised 1996 IPCC Guidelines*).

Activity data is taken from the report "Foreign trade in goods statistics of the Republic of Croatia". Report is officially published by Croatian Bureau of Statistics, Foreign Trade Statistics department. Data is corresponding with FAO data. Since data for 1990 is missing and data for 1991 was evaluated as insufficient by an expert judgement, values for these two years were estimated by extrapolation (based on the trend from 1992 to 1996).

Table 4.2-6: Soda ash use (1990-2011)

Year	Soda ash use (tonnes)
1990	34,858
1991	37,006
1992	39,781
1993	36,468
1994	47,666
1995	49,170
1996	44,171
1997	38,901
1998	39,455
1999	37,983
2000	40,573
2001	43,881
2002	45,527
2003	48,881
2004	55,435
2005	55,857
2006	52,672
2007	49,190
2008	48,450
2009	48,667
2010	57,196
2011	56,168

The resulting emissions of CO₂ from Soda Ash Use in the period 1990-2011 are presented in the Figure 4.2-4.

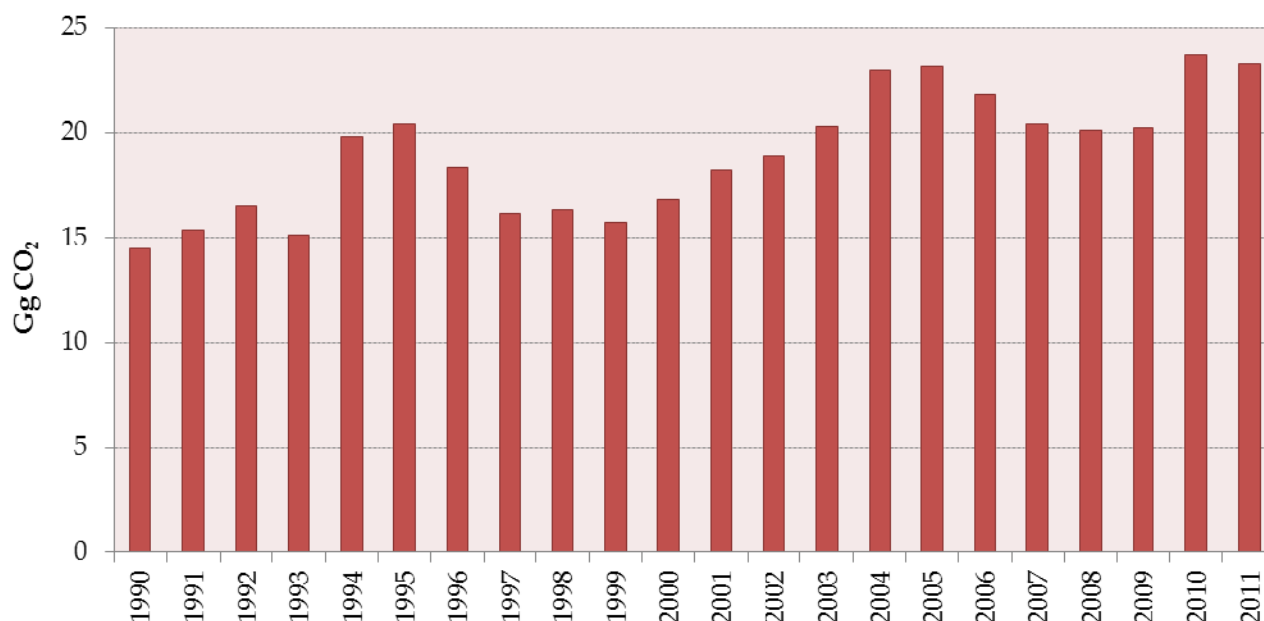


Figure 4.2-4: Emissions of CO₂ from Soda Ash Use (1990-2011)

4.2.4.3. Uncertainties and time-series consistency

Emissions of CO₂ 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 activity data amounts 7.5 percent (5 to 10 percent), based on expert judgements. Uncertainty estimate associated with default emission factors amounts 30 percent, based on expert judgements (detailed in Annex 5, Tables A5-1, A5-2).

Emissions from Soda Ash Use have been calculated using the same method for every year in the time series. The activity data for soda ash use were extracted from statistical database on the import and export quantities of soda ash for the Republic of Croatia. Since data for 1990 is missing and data for 1991 was evaluated as insufficient by an expert judgement, values for these two years were estimated by extrapolation.

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 according to QA/QC plan.

Since this source category is not a key source, QA/QC plan does not prescribe source specific quality control procedures.

4.2.4.5. Source specific recalculations

In previous reports, the activity data used for calculations included data on soda ash use in glass and ceramic manufacture, and in the production of soap and detergents in the period 1990-1996, extracted from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining. For the period 1997-2010, AD was collected by survey of manufacturers of glass, ceramic, soap and detergents. According to ERT recommendation during the in-country review, the activity data for soda ash use were extracted from statistical database on the import and export quantities of soda ash for the Republic of Croatia and thus recalculations were made for the entire period 1990-2010. These new calculations were presented in the "Resubmission of Croatia's 2012 Inventory Submission". Thereupon, CO₂ emissions have been recalculated and presented in CRF tables "Official Resubmission 2012".

There are no additional source-specific recalculations in this report.

4.2.4.6. Source-specific planned improvements

There are no plans for additional improvements of emission calculations. More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

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

CO₂ emissions from the use of carbonate materials in glass production have been included in the emission estimates for the categories limestone and dolomite use and soda ash use.

Emissions of NMVOC and CO have been taken from the emission inventory report 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2011 Submission to the Convention on Long-range Transboundary Air Pollution'.

The resulting emissions of indirect GHGs from Production and Use of Miscellaneous Mineral Products in the period 1990-2011 are presented in the review on indirect GHG emissions from non-energy industrial processes.

4.2.5.3. Uncertainties and time-series consistency

Uncertainties associated with 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 according to QA/QC plan.

Since this source category is not a key source, QA/QC plan does not prescribe source specific quality control procedures.

4.2.5.5. Source specific recalculations

There are no source-specific recalculations because only NMVOC and CO emissions are calculated in abovementioned activities.

4.2.5.6. Source-specific planned improvements

Investigation of specific information related to type of asphalt roofing production processes and type of asphalt as well as amounts of diluents which are used in asphalt production is intended.

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). There is one manufacturer of ammonia in Croatia.

4.3.1.2 Methodological issues

In ammonia production natural gas provides both feedstock and fuel. Emissions of CO_2 from natural gas used as feedstock have been calculated by means of multiplying annual consumption of natural gas by carbon content of natural gas and molecular weight ratio between CO_2 and carbon (Tier 1a, *Revised 1996 IPCC Guidelines*). Emissions of CO_2 from natural gas used as fuel are presented in the Energy sector.

Data on consumption and composition of natural gas (see Table 4.3-1) used as a feedstock were collected by survey of ammonia manufacturer (Fertilizer Company) and cross-checked with ammonia production data from Annual PRODCOM results 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. Measurements were performed at the standard condition (1 atm, 15°C). Therefore, molar volume were corrected ($V = R \cdot T/p = 23.64 \text{ dm}^3$). Natural gas composition is determined by an accredited chromatographic "in house" method COMPOSITION OF NATURAL GAS. CALCULATION OF LOWER CALORIFIC VALUE AND DENSITY. CHROMATOGRAPHIC METHOD NR. 69-08-2-5-9-830/0307. Calculation of lower heating value is done according to norm HRN ISO 6976:2008 Natural gas – Calculation of heating values, density, relative density and Wobbe index from composition.

Table 4.3-1: Consumption and composition of natural gas in Ammonia Production (1990-2011)

Year	Natural gas consumption (m ³)	Carbon content of gas (kg C/m ³)
	Feedstock	
1990	242,905,233	0.5232
1991	230,492,226	0.5289
1992	299,567,927	0.5237
1993	238,269,046	0.5114
1994	239,717,137	0.5120
1995	232,773,362	0.5141
1996	254,116,356	0.5115
1997	277,311,935	0.5093
1998	207,973,360	0.5094
1999	262,772,017	0.5108
2000	266,433,375	0.5097
2001	214,441,408	0.5134
2002	193,045,364	0.5139
2003	216,859,822	0.5148
2004	264,367,950	0.5111
2005	259,004,302	0.5103
2006	253,861,433	0.5128
2007	280,232,850	0.5075
2008	284,633,920	0.5082
2009	238,983,580	0.5086
2010	249,994,075	0.5108
2011	253,619,204	0.5118

The resulting emissions of CO₂ from Ammonia Production in the period 1990-2011 are presented in the Figure 4.3-1.

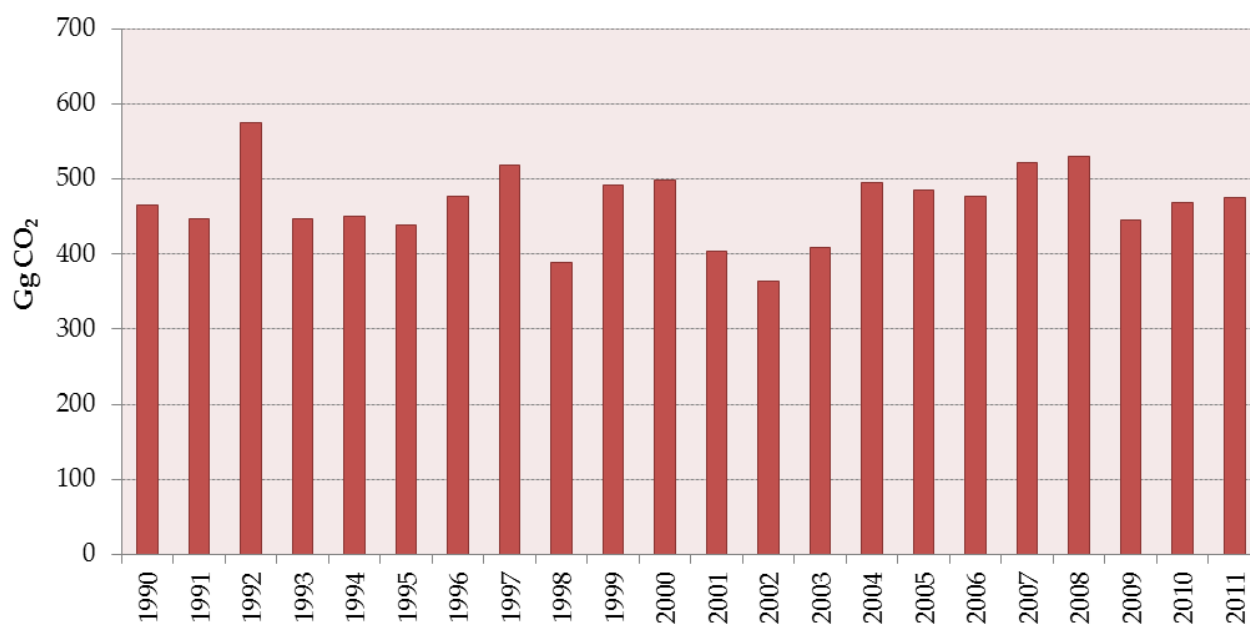


Figure 4.3-1: Emissions of CO₂ from Ammonia Production (1990-2011)

4.3.1.3 Uncertainties and time-series consistency

According to *Revised 1996 IPCC Guidelines*, the most accurate method of emission estimation from natural gas as feedstock is based on the consumption and composition of natural gas in the process. There are some uncertainties concerning the use of CO₂ 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 CO₂ in production of urea, dry ice and fertilizer.

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data amounts 3 percent (1 to 5 percent), based on expert judgements. Uncertainty estimate associated with emission factors amounts 5 percent, accordingly to value recommended in *Good Practice Guidance* (detailed in Annex 5, Tables A5-1, A5-2).

Emissions from Ammonia Production have been calculated using the same methods 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 according to QA/QC plan.

Ammonia Production is one of the key source categories in Industrial Processes. Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. Emissions of CO₂ from consumption of natural gas were estimated using Tier 1a method which could be considered as a *good practice*. Basic activity data from Annual PRODCOM results were compared with data provided by plant. Results of this comparison showed that there is no significant difference between these two sets of data.

4.3.1.5 Source-specific recalculations

New data were provided for 2010 and 2011. Recalculations for this resubmission were made accordingly.

A mistake in data input was made in the previous submission for the year 2009, which was corrected in this resubmission.

4.3.1.6 Source-specific planned improvements

Since Ammonia Production is a key source category, more detailed information about use of CO₂ as a feedstock in downstream manufacturing processes are planned to be investigated.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

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 monoxide 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 oxide 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 fertilizers.

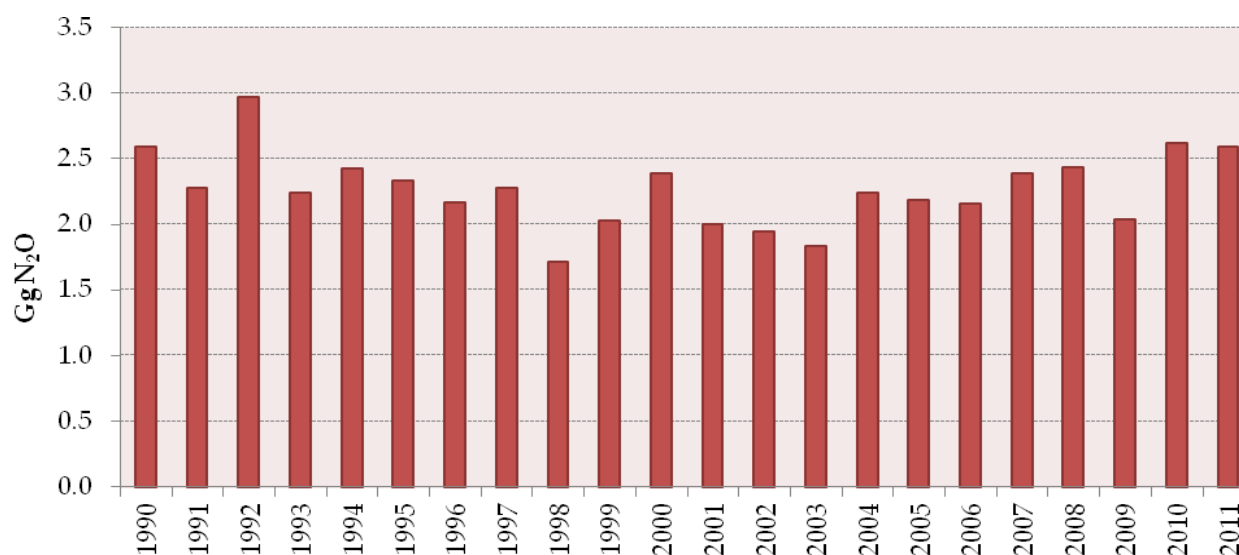
4.3.2.2. Methodological issues

Emissions of N₂O from nitric acid production have been calculated by multiplying annual nitric acid production by plant-specific EF of 7.8 kg N₂O/tonne nitric acid. This plant-specific EF is in accordance with BAT document. Data on nitric acid production (see Table 4.3-3) were collected by survey of nitric acid manufacturer (Fertilizer Company) and cross-checked with nitric acid production data from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Table 4.3-2: Nitric acid production (1990-2011)

Year	Nitric acid production
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
1999	260,198
2000	306,201
2001	257,534
2002	249,992
2003	235,645
2004	287,567
2005	280,746
2006	277,590
2007	306,619
2008	312,928
2009	261,478
2010	336,795
2011	332,713

The resulting emissions of N₂O from Nitric Acid Production in the period 1990-2011 are presented in the Figure 4.3-2.

Figure 4.3-2: Emissions of N₂O from Nitric Acid Production (1990-2011)

4.3.2.3. Uncertainties and time-series consistency

The main uncertainties concerning the emissions of N₂O from nitric acid production are due to applied emission factor. This plant-specific EF does not completely outline the real value, because Fertilizer Company does not continuously measure N₂O emissions. In the future, this company will perform continuously measurement of N₂O emissions.

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data amounts 3 percent (1 to 5 percent), based on expert judgements. Uncertainty estimate associated with default emission factors amounts 30 percent, based on expert judgements (detailed in Annex 5, Tables A5-1, A5-2).

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

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 according to QA/QC plan.

Nitric Acid Production is one of the key source categories in Industrial Processes. Emissions of N₂O from nitric acid production were based on plant-specific emission factor and annual amount of nitric acid production. It is a *good practice* to use direct emission measurement for national emission factor calculation. Basic activity data from Annual PRODCOM results were compared with data provided by individual plant. Results of this comparison showed that there is no significant difference between these two sets of data.

4.3.2.5. Source-specific recalculations

There are no source-specific recalculations in this report.

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 be investigated. 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. In the future, Fertilizer Company will perform continuous measurement of N₂O emissions.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

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, dichloroethylene, styrene) can be sources of CH₄ emissions. Although most CH₄ sources from industrial processes individually are small, collectively they may be significant.

4.3.3.2. Methodological issues

Emissions of CH₄ 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 4.3-4) was extracted from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Emissions of CH₄ from Production of Other Chemicals in the period 1990-2011 are reported in Table 4.3-5.

Table 4.3-3: Production of Other chemicals (1990-2011)

Year	Carbon black (tonnes)	Ethylene (tonnes)	Dichloroethylene (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	24,087	60,148	31,308	0	0
1999	20,627	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	19,416	43,554	0	0	0
2003	21,295	41,252	0	0	0
2004	20,272	49,886	0	0	0
2005	18,498	50,263	0	0	0
2006	26,264	48,824	0	0	0
2007	23,724	45,438	0	0	0
2008	16,904	43,045	0	0	0
2009	3,976	38,797	0	0	0
2010	0	36,271	0	0	0
2011	0	23,323	0	0	0

Table 4.3-4: Emissions of CH₄ from Production of Other Chemicals (1990-2011)

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	0.21
1994	0.24	0.07	0.04	0	0.14
1995	0.30	0.07	0.03	0	0
1996	0.29	0.06	0.02	0	0
1997	0.27	0.06	0.01	0	0
1998	0.26	0.06	0.01	0	0
1999	0.23	0.06	0.02	0	0
2000	0.22	0.04	0.03	0	0
2001	0.23	0.05	0.03	0	0
2002	0.21	0.04	0	0	0
2003	0.23	0.04	0	0	0
2004	0.22	0.05	0	0	0
2005	0.20	0.05	0	0	0
2006	0.29	0.05	0	0	0
2007	0.26	0.05	0	0	0
2008	0.19	0.04	0	0	0
2009	0.04	0.04	0	0	0
2010	0	0.04	0	0	0
2011	0	0,02	0	0	0

The emissions of indirect GHGs from Production of Other Chemicals for the period 1990-2011 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 activity data for CH₄ emissions amounts 7.5 percent (5 to 10 percent), based on expert judgements. Uncertainty estimate associated with default emission factor for CH₄ emissions amounts 30 percent, based on expert judgements (detailed in Annex 5, Tables A5-1, A5-2).

Emissions from Production of 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 according to QA/QC plan.

Since this source category is not a key source, QA/QC plan does not prescribe source specific quality control procedures.

4.3.3.5. Source-specific recalculations

Recalculations of data from production of carbon black were made for periods 1998-1999, 2002-2004 and 2007-2008, for the production of ethylene for the year 1997, and also for the production of styrene for the period 1991-1992, according to the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2011* Submission to the Convention on Long-range Transboundary Air Pollution'.

4.3.3.6. Source-specific planned improvements

For the purpose of accurate emission calculations, specific chemical production processes are planned to be analyzed.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

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 CO₂.

4.4.1.2. Methodological issues

Pig Iron Production

Emissions of CO₂ have been calculated by multiplying annual production of pig iron by the emission factor proposed by *Revised 1996 IPCC Guidelines* (1.6 tonnes CO₂/tonne pig iron produced).

The activity data for pig iron were extracted from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining and cross-checked with iron and steel manufacturer⁸.

The resulting emission of CO₂ from Pig Iron Production in 1990 was amounted 335,000 tonnes. In 1991 about 111,000 tonnes of CO₂ was emitted. CO₂ 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

There are two steel manufacturers in Croatia. In 2009, steel production by one manufacturer was halted. A method based on annual consumption of carbon donors in EAFs has been used for CO₂ emission calculation for each manufacturer. Methodology proposed by the Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC has been used. For 2005-2011 CO₂ emissions have been taken for the inventory.

The same methodology has been used for the entire time series. Calculation of CO₂ emissions is accomplished by applying an emission factor in tonnes of CO₂ released per tonne of carbon donors (input material) to the consumed quantity of the input material. The carbon emission factor is based on carbon loss from carbon donors. Total CO₂ emission has been calculated as follows:

$$\text{CO}_2 \text{ emission (t CO}_2\text{)} = \sum (\text{activity data}_{\text{input}} * \text{emission factor}_{\text{input}}) - \sum (\text{activity data}_{\text{output}} * \text{emission factor}_{\text{output}})$$

The activity data for main carbon donors (scrap iron, steel scrap, EAF carbon electrodes, EAF charge carbon and petroleum coke), which were collected by bottom up analysis from two steel manufacturers, are presented in Table 4.4-1. The other carbon donors were used in minor quantity. Within installations natural gas, diesel oil and liquefied petroleum gases were used as reducing agents (see Table 4.4-2).

⁸ 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: Consumption of main carbon donors (input materials) in EAFs (1990-2011)

Year	Scrap iron (tonnes)	Steel scrap (tonnes)	EAF carbon electrodes (tonnes)	EAF charge carbon (tonnes)	Petroleum coke (tonnes)
1990	2,500	173,588	1,180	121	0
1991	13,221	119,396	982	106	600
1992	17,866	96,221	927	88	327
1993	23,557	60,799	627	63	253
1994	14,892	56,777	550	122	68
1995	10,559	41,661	346	27	0
1996	12,858	38,966	312	12	191
1997	18,233	61,114	468	7	369
1998	31,968	84,281	698	100	246
1999	11,743	72,647	557	78	127
2000	7,845	70,363	462	67	58
2001	7,003	55,100	375	60	118
2002	5,324	29,121	213	292	115
2003	15,934	29,777	223	240	215
2004	20,409	76,594	417	737	274
2005	7,818	77,641	286	745	99
2006	5,510	87,978	331	886	177
2007	4,523	85,054	351	967	97
2008	31,421	130,815	713	1,418	399
2009	25,531	26,293	333	4	376
2010	82,659	38,797	649	283	1,550
2011	83,790	25,331	396	973	1,637

Table 4.4-2: Consumption of other carbon donors (input materials) and reducing fuels in EAFs (1990-2011)

Year	Lime (tonnes)	Other carbon donors* (tonnes)	Natural gas (m³)	Diesel oil (tonnes)	Liquefied petroleum gases (tonnes)
1990	2,970	603	8,470,000	1,624	0
1991	2,095	262	5,310,000	960	0
1992	1,484	256	1,331,000	756	0
1993	2,737	286	1,547,000	379	0
1994	1,530	629	1,242,000	444	0
1995	848	235	687,000	398	0
1996	1,322	496	908,000	252	0
1997	1,729	695	1,119,000	429	0
1998	2,606	1,103	2,032,000	617	0
1999	1,468	518	1,976,000	495	0
2000	861	530	1,146,000	509	0
2001	1,047	449	1,264,000	334	0
2002	670	280	570,000	0	438

Table 4.4-2: Consumption of other carbon donors (input materials) and reducing fuels in EAFs (1990-2011), cont.

Year	Lime (tonnes)	Other carbon donors* (tonnes)	Natural gas (m ³)	Diesel oil (tonnes)	Liquefied petroleum gases (tonnes)
2003	1,226	500	1,505,000	0	371
2004	1,641	564	1,818,000	0	1,221
2005	555	289	1,036,000	0	1,392
2006	592	315	1,446,000	0	1,642
2007	386	180	1,033,000	0	1,661
2008	2,559	366	2,311,000	0	2,041
2009	2,327	317	2,839,000	0	0
2010	5,229	463	4,016,000	0	0
2011	4,891	1188	4,016,000	0	0

* other carbon donors include alloys Fe-Cr, Fe-Mo, Fe-Mn, Fe-V, Fe-Si, Fe-Si-Mn and fluorite

Default emission factors for main carbon donors⁹ (Table 4.4-3) and reducing fuels¹⁰ (Table 4.4-4) have been used.

Table 4.4-3: EF for carbon donors (input materials) in EAFs (1990-2011)

Carbon donors	EF (t CO ₂ /t)
Scrap iron	0.15
Steel scrap	0.008
EAF carbon electrodes	3.00
EAF charge carbon	3.04
Petroleum coke	3.19

Table 4.4-4: EF and net calorific values for reducing fuel in EAFs (1990-2011)

Reducing fuels	EF (t CO ₂ /TJ)	NCV (TJ/Gg)
Natural gas	56.1	34.00
Gas/Diesel oil	74.07	42.71
Liquefied petroleum gases	63.07	46.89

The activity data for steel production (see Table 4.4-5) were collected by bottom up analysis from two steel manufacturers.

Table 4.4-5: Steel production (1990-2011)

Year	Steel production (tonnes)
1990	171,148
1991	119,734
1992	101,944
1993	74,082

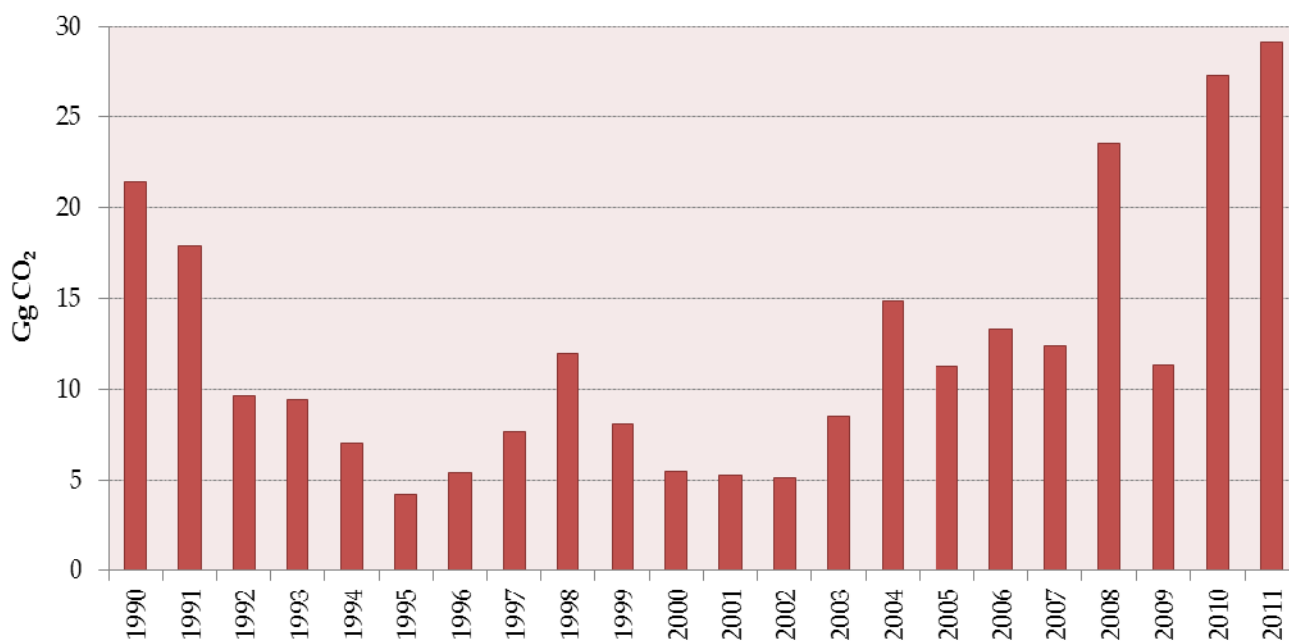
⁹ See 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 4.3 - EF expressed in t C/t multiplied with a CO₂/C conversion factor of 3.664

¹⁰ see Annex 8 (oxidation factor OF = 1 is used)

Table 4.4-5: Steel production (1990-2011), cont.

Year	Steel production (tonnes)
1994	63,355
1995	45,370
1996	45,754
1997	69,895
1998	103,204
1999	75,877
2000	69,641
2001	56,169
2002	32,789
2003	40,942
2004	86,105
2005	73,640
2006	80,517
2007	76,252
2008	138,865
2009	46,264
2010	103,427
2011	95,907

The resulting emissions of CO₂ from Steel Production in the period 1990-2011 are presented in the Figure 4.4-1.

Figure 4.4-1: Emissions of CO₂ from Steel Production (1990-2011)

CO₂ emissions fluctuated over the period. It is mainly a result of discontinuous operation which requires increasing consumption of input materials.

4.4.1.3. Uncertainties and time-series consistency

Uncertainty estimate associated with activity data amounts 7.5 percent (5 to 10 percent), based on expert judgements. The main uncertainties concerning the emission of CO₂ from steel production are due to applied emission factor. Uncertainty estimate associated with emission factors amounts 30 percent, based on expert judgements (detailed in Annex 5, Tables A5-1, A5-2).

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 according to QA/QC plan.

Since this source category is not a key source, QA/QC plan does not prescribe source specific quality control procedures.

4.4.1.5. Source-specific recalculations

There are no recalculations for this sub-sector.

4.4.1.6. Source-specific planned improvements

There is no need for further improvements because steel production is not a key category. More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

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, CO₂ is emitted when metallurgical coke is oxidized during a high-temperature reaction with iron and the selected alloying element. Ferroalloys production was halted in 2003.

4.4.2.2. Methodological issues

A higher tier method based on reducing agents has been used for CO₂ emissions calculation. Applying a higher tier method enables avoiding of possible double counting of CO₂ emissions that are already accounted for in the energy sector. Reducing agents that are not accounted for in the energy sector are included here.

Emissions of CO₂ have been calculated by multiplying annual data on reducing agents (see Table 4.4-6) by default emission factor (3.1 tonne CO₂/tonne coke from coal and 3.6 tonne CO₂/tonne coal electrodes). Reducing agent were collected from statistical database 'Inputs of raw and material in industrial production'. Interpolation method has been used for calculation of insufficient data for coke from coal for the period 1994-1996 and 1999-2001. Ferroalloys production fluctuated over the period. It is mainly a result of discontinuous operation, caused by the war in Croatia. Ferroalloys production was halted in 2003 (see Table 4.4-7).

Table 4.4-6: Reducing agents (1990-2003)

Year	Coke from coal (tonnes)	Coal electrodes (tonnes)
1990	36,216	1,824
1991	41,981	2,533
1992	25,619	1,645
1993	8,519	799
1994	8,566	988
1995	9,529	650
1996	3,860	266
1997	11,867	818
1998	9,529	650
1999	3,860	266
2000	11,867	818
2001	5,166	356
2002	6,054	417
2003	3,624	250
2004	1,195	82
2005	4	0.28
2006	13	0.9

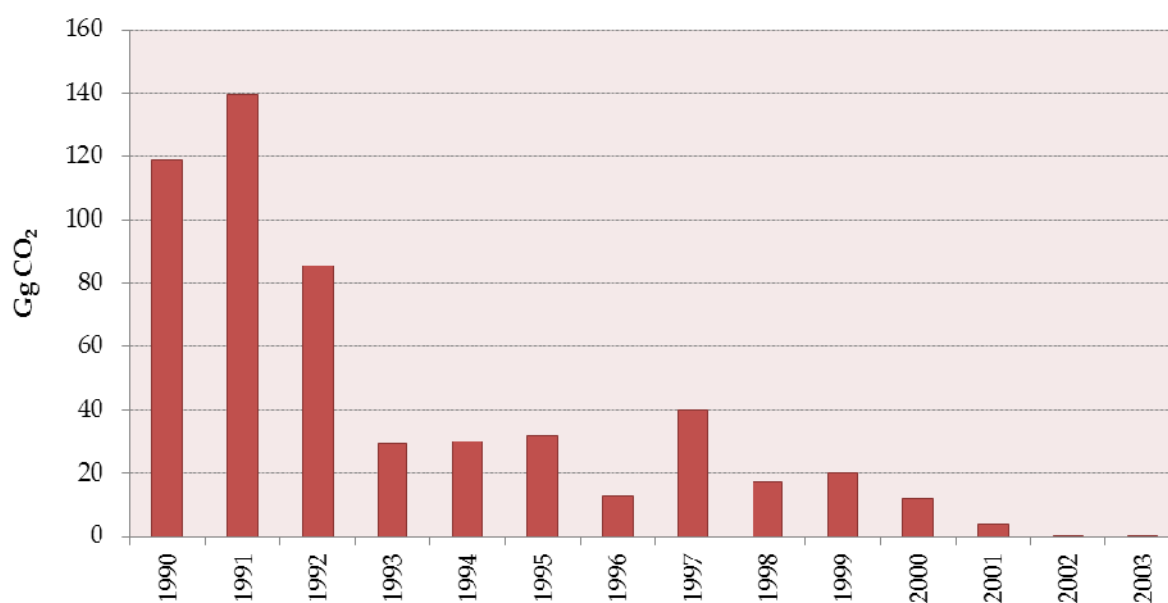
Table 4.4-7: Ferroalloys production (1990-2003)

Year	Ferroalloys production (tonnes)		
	Ferromanganese	Silicon manganese	Ferrochromium
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

Table 4.4-7: Ferroalloys production (1990-2003), cont.

Year	Ferroalloys production (tonnes)		
	Ferromanganese	Silicon manganese	Ferrochromium
1994	562	22,071	31,704
1995	0	0	26,081
1996	0	0	10,559
1997	47	416	24,231
1998	57	697	11,861
1999	64	271	13,807
2000	29	330	15,753
2001	43	297	361
2002	28	190	2
2003	62	660	2

The resulting emissions of CO₂ from Ferroalloys Production in the period 1990-2003 are presented in the Figure 4.4-2.

Figure 4.4-2: Emissions of CO₂ from Ferroalloys Production (1990-2003)

4.4.2.3. Uncertainties and time-series consistency

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data amounts 7.5 percent (5 to 10 percent), based on expert judgements. Uncertainty estimate associated with default emission factors amounts 30 percent, based on expert judgements (detailed in Annex 5, Tables A5-1, A5-2).

Emissions from Ferroalloys Production have been calculated using the same method and data sets for every year in the time series, except insufficient data which were obtained by interpolation method. Fluctuations in ferroalloys production over the period caused high uncertainty of data which was assessed by interpolation.

4.4.2.4. 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 according to QA/QC plan.

Since this source category is not a key source, QA/QC plan does not prescribe source specific quality control procedures.

4.4.2.5. Source-specific recalculations

There are no source-specific recalculations in this report.

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 in Croatia was halted in 1991. There were used two types of furnaces – open and closed type. Open furnaces were older and represent majority of production furnaces. Alusuisse technology was used, with total 208 open furnaces with prebaked anodes, side feed, without computer controlled process. At the end of 1990 (in September) 10 new closed furnaces started to work (Peciney technology), with central feed and computer controlled process.

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 survey of aluminium manufacturer¹¹.

¹¹ It should be noticed that primary aluminium production (electrolysis) were closed at the end of 1991 mainly due to war activities near the location of aluminium plant.

The resulting emission of CO₂ from Aluminium Production in 1990 was amounted about 111 Gg CO₂. In 1991 about 76 Gg CO₂ 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 CF₄ and C₂F₆ 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 CF₄ and 0.17 kg/tonne Al for C₂F₆ (Side Worked Prebaked Anodes). 820 Gg CO₂-eq of CF₄ and 116 Gg CO₂-eq of C₂F₆ were emitted in 1990. 563 Gg CO₂-eq of CF₄ and 80 Gg CO₂-eq of C₂F₆ were emitted in 1991.

Occasionally, sulphur hexafluoride (SF₆) is also used by the aluminium industry as a cover gas for special foundry products. There are no available data on SF₆ consumption in aluminium industry.

4.4.3.3. Uncertainties and time-series consistency

Uncertainties related to calculation of CO₂ emissions are primarily due to applied emission factor. A less uncertain method to calculate CO₂ 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.

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data for CO₂ emissions amounts 3 percent (1 to 5 percent), based on expert judgements. Uncertainty estimate associated with default emission factor for CO₂ emissions amounts 30 percent, based on expert judgements (detailed in Annex 5, Tables A5-1, A5-2).

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. Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis.

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

4.4.3.4. 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 according to QA/QC plan.

Since this source category is not a key source, QA/QC plan does not prescribe source specific quality control procedures.

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 taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2011* Submission to the Convention on Long-range Transboundary Air Pollution'.

The resulting emissions of indirect GHGs from Pulp and Paper in the period 1990-2011 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 emission factors and activity data were not estimated for Pulp and Paper.

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

4.5.1.4. 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 according to QA/QC plan.

Since this source category is not a key source, QA/QC plan does not prescribe source specific quality control procedures.

4.5.1.5. Source specific recalculations

There are no source-specific recalculations because emissions of indirect GHGs are calculated.

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: bread, wine, beer, spirit.

4.5.2.2. Methodological issues

Emissions of NMVOC have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2011* Submission to the Convention on Long-range Transboundary Air Pollution'.

The resulting emissions of NMVOC from Food and Drink in the period 1990-2011 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 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.

4.5.2.4. 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 according to QA/QC plan.

Since this source category is not a key source, QA/QC plan does not prescribe source specific quality control procedures.

4.5.2.5. Source specific recalculations

There are no source-specific recalculations because emissions of indirect GHGs are calculated.

4.6. CONSUMPTION OF HALOCARBONS AND SF₆ (CRF 2.F.)

Ministry of Environmental and Nature Protection is responsible for monitoring of consumption of substitutes and mixture of substitutes for gases that deplete the ozone layer. According to requirement of Regulation on the Greenhouse Gases Emissions Monitoring in the Republic of Croatia (Official Gazette No. 1/07), all sources of HFCs, PFCs and SF₆ emissions should report required activity data. Regulation on controls of ozone-depleting substances (Official Gazette No.120/05) prescribes control of import and export of these gases and providing of register to the Ministry of Environmental and Nature Protection. There is no production of HFCs PFCs and SF₆ in Croatia, therefore, there are no emissions from manufacturing. All quantities of these gases are imported. Minor quantities of some substances are exported.

Due to the relatively short time of use of HFCs PFCs and SF₆ in Croatia, it has been assumed that the disposed amount of these gases is relatively small. Since there are no usable data on these amounts available so far, they have not been taken into consideration when the emission calculation was performed.

Croatia is an Article 5 Country, according to the Montreal protocol on Ozone depleting substances (ODS). Because of that, Croatia has a longer time to use ODS, compared to Article 2 Countries. ODS Phase-out plan for Article 5 countries refers to a complete phase-out in CFCs consumption by the year 2010. According to this obligation, Croatia has adopted:

1) ODS Regulation in January 1999 (Official Gazette 7/1999):

- From 1999 – banned import of CFC equipment;
- From 2010 – banned consumption of CFC refrigerants;
- From 2010 - banned consumption of halons.

2) ODS Regulation in October 2005 (Official Gazette 120/2005):

- From 2006 – banned import of equipment with HCFCs;
- HCFC refrigerants (virgin) are allowed to be used only for servicing and maintenance of the existing equipment till EU accession (July 1st 2013)
- Recovered and reclaimed HCFCs can be used by the end of 2014
- Reporting on HFCs is mandatory since 2005
- Reporting on installed equipment (CFCs, HCFCs and HFCs) to the Ministry of environmental and nature protection

3) New ODS and F-gas Regulation in August 2012 (Official Gazette 92/2012):

- Coordinated with EU legislation (ODS and F-gases)
- Reporting is obligatory for ODS and F-gases.

This subsector comprises emissions of HFCs, PFCs and SF₆ from their use in refrigeration and air conditioning equipment, foam blowing, fire extinguishers, aerosols/metered dose inhalers and electrical equipment. It has been determined that HFCs have not been used as solvents during the period 1990-2011.

Methodology used for calculating emissions from the abovementioned sources is described in the following chapters.

The resulting HFCs, PFCs and SF₆ emissions (Gg CO₂-eq) from Consumption of Halocarbons and SF₆ in the period 1990-2011 are presented in the Figure 4.6-1. Shown are actual emissions of gases HFC-32, HFC-125, HFC-134a and HFC-143a, and potential emissions of gases HFC-23, PFC-14 and PFC-218 used in Refrigeration and Air Conditioning Equipment; actual emissions of gases HFC-125, HFC-227ea and HFC-236fa used in Fire Extinguishers; actual emission of HFC-134a used in Aerosols/Metered Dose Inhalers; potential emission of HFC-152a used in Foam Blowing and actual emission of SF₆ used in Electrical Equipment. Further clarification is given in the subsequent chapters.

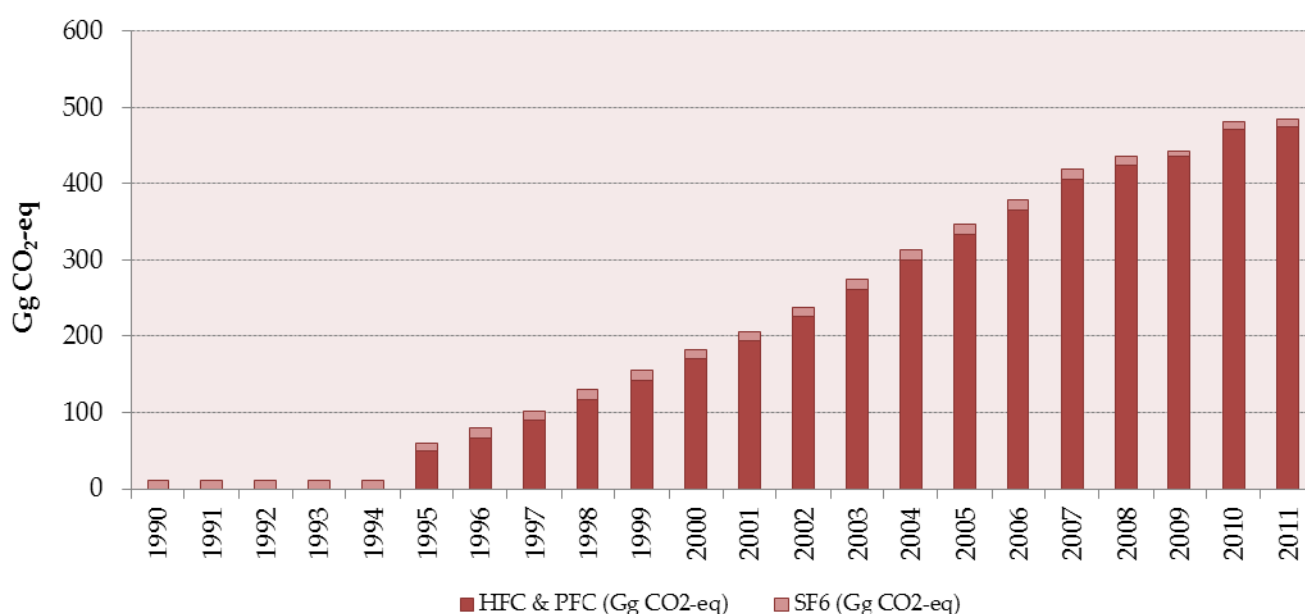


Figure 4.6-1: Emissions of HFCs, PFCs and SF₆ (Gg CO₂-eq) from Consumption of Halocarbons and SF₆ (1990-2011)

4.6.1. REFRIGERATION AND AIR CONDITIONING EQUIPMENT

4.6.1.1. Source category description

Refrigeration and air-conditioning accounts for the majority of emissions in the subsector Consumption of halocarbons and SF₆.

Emissions are released by the consumption of synthetic greenhouse gases, HFCs and PFCs (HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a, PFC-14 and PFC-218), which are used as substitutes for cooling gases in refrigerating and air-conditioning systems that deplete the ozone layer. This category includes the use of these substances in Domestic Refrigeration, Commercial Refrigeration, Transport Refrigeration, Industrial Refrigeration, Stationary Air-Conditioning and Mobile Air-Conditioning.

Refrigerants used are R-23, R-134a, PFC-14, PFC-218, R-404A, R-407C, R-410A, R-413A, R-417A, R-422A, R-422D, R-437A, R-507A and RMO-89.

There are currently no available data on decommissioning and disposal of the refrigeration and air-conditioning equipment. Presumably, there are individual cases of the disposal of this equipment. The Republic of Croatia has established the system of collecting the refrigeration and air conditioning equipment that uses the substances that deplete the ozone layer and fluorinated greenhouse gases. This collection is free for end users, which means that the authorized company collects all devices and transports them to the plant where they are being dismantled and the gas is being collected from the cooling system and the insulating foam (in the refrigeration equipment).

Gas is also being collected from the air conditioners in motor vehicles that are brought to disposal sites. All servicing operators are required to collect gas during servicing and especially after switching off the device from use, and to deliver it to a collection center. Three regional centers for the collection, reuse and recovery of these substances are established. If the recovery is not possible, waste gases are exported to be destroyed.

The correct data on the above mentioned activities is expected to be available for future reports.

4.6.1.2. Methodological issues

Actual and potential emissions of HFCs used in Refrigeration and Air Conditioning Equipment have been calculated for the period 1995-2011, since there was no use of these substances prior to 1995. HFC-143a was introduced in 2005, as a component of the refrigerant R-507A used in Industrial Refrigeration.

Actual emissions that could not be calculated due to the missing data on average annual stocks, were reported by using the values for potential emissions. This refers to gases HFC-23 (used in 2010 and 2011), PFC-14 (used in 2010) and PFC-218 (used in the period 2009-2011).

Actual emissions of HFCs have been calculated based on the data on the amount of HFCs in operating systems (average annual stocks) for Domestic Refrigeration (HFC-134a), Commercial Refrigeration (HFC-125, HFC-134a, HFC-143a), Transport Refrigeration (HFC-134a), Industrial Refrigeration (HFC-23, HFC-32, HFC-125, HFC-134a), Stationary-Air Conditioning (HFC-125, HFC-134a, HFC-32) and Mobile Air-Conditioning (HFC-134a). Default emission factors proposed by *Revised 1996 IPCC Guidelines* have been used for actual emission calculation.

According to available data, decommissioning and disposal have not occurred so far because all of the equipment is still functioning and in use.

Data on import and export of HFCs and PFCs, which were used for calculation of potential emissions, have been compiled by the Ministry of Environmental and Nature Protection. Potential emissions of HFCs and PFCs from Refrigeration and Air Conditioning Equipment were calculated (Tier 1a method, *Revised 1996 IPCC Guidelines*) for the period 1995-2011. Data on total consumption (import minus export) were included in CRF (category *in bulk*). There are no data for CRF category *in product* for each gas. Accordingly, total consumption was presented in CRF category *in bulk* for each gas.

Cluster analysis of countries with similar circumstances was used for the period 1990-1994 (HFCs and PFCs emissions are identified as not occurred).

Actual emissions of HFCs used in Refrigeration and Air Conditioning Equipment in the period 1995-2011 are reported in Table 4.6-1.

Table 4.6-1: Actual emissions of HFCs (Gg CO₂-eq) (1990 – 2011)

Source/Gas	1995	1996	1997	1998	1999	2000	2001	2002
2.F.1. Refrigeration and Air Conditioning Equipment								
Domestic Refrigeration								
HFC-134a	0.03	0.06	0.14	0.18	0.20	0.23	0.27	0.29
Commercial Refrigeration								
HFC-125	1.41	2.38	2.90	4.31	4.58	5.28	5.54	6.60
HFC-134a	0.13	0.22	0.26	0.39	0.42	0.48	0.50	0.60
HFC-143a	1.66	2.81	3.43	5.10	5.41	6.24	6.55	7.80
Transport Refrigeration								
HFC-134a	24.38	26.33	29.90	32.50	39.00	44.85	55.58	66.95
Industrial Refrigeration								
HFC-125	0.56	0.68	0.92	1.24	1.52	2.00	2.32	2.48
HFC-134a	0.33	0.42	0.58	0.92	1.00	1.16	1.66	1.83
HFC-32	0.55	0.66	0.90	1.20	1.48	1.96	2.26	2.41
HFC-143a	NO	NO	NO	NO	NO	NO	NO	NO
Stationary Air-Conditioning								
HFC-125	0.31	0.51	0.99	1.28	1.71	2.08	2.40	2.56
HFC-134a	0.29	0.44	0.81	0.99	1.22	1.51	1.82	1.90
HFC-32	0.30	0.50	0.96	1.24	1.67	2.02	2.33	2.49
Mobile Air-Conditioning								
HFC-134a	2.40	8.40	16.80	25.05	33.60	42.60	45.30	51.15

Table 4.6-1: Actual emissions of HFCs (Gg CO₂-eq) (1990 – 2011), cont.

Source/Gas	2003	2004	2005	2006	2007	2008	2009	2010	2011
2.F.1. Refrigeration and Air Conditioning Equipment									
Domestic Refrigeration									
HFC-134a	0.33	0.42	0.45	0.41	0.32	0.30	0.29	0.29	0.29
Commercial Refrigeration									
HFC-125	7.13	8.18	8.80	9.33	10.38	10.56	10.65	11.62	13.73
HFC-134a	0.65	0.74	0.80	0.85	0.94	0.96	0.97	1.06	1.25
HFC-143a	8.42	9.67	10.40	11.02	12.27	12.48	12.58	13.73	16.22
Transport Refrigeration									
HFC-134a	80.93	93.93	105.30	113.75	124.80	133.25	134.88	144.30	143.33
Industrial Refrigeration									
HFC-125	2.60	3.08	3.69	3.96	4.14	4.27	4.56	4.92	4.92
HFC-134a	1.91	2.25	2.66	2.83	2.83	2.91	3.00	3.41	3.41
HFC-32	2.53	2.99	3.58	3.81	3.97	4.09	4.36	4.71	4.71
HFC-143a	NO	NO	0.01	0.04	0.06	0.07	0.08	0.08	0.08
Stationary Air-Conditioning									
HFC-125	2.80	3.23	3.60	3.94	4.20	4.31	4.34	4.45	4.23
HFC-134a	2.18	2.39	2.55	2.73	2.86	2.99	2.99	3.12	3.02
HFC-32	2.72	3.13	3.50	3.83	4.09	4.20	4.22	4.33	4.11
Mobile Air-Conditioning									
HFC-134a	54.90	61.50	68.40	80.85	89.25	97.20	97.50	107.40	106.35

Comparison of actual and potential emissions of gases HFC-23, HFC-32, HFC-125, HFC-134a and HFC-143a used in Refrigeration and Air Conditioning Equipment in the period 1990-2011 is reported in Table 4.6-2 and Figure 4.6-2.

Table 4.6-2: Actual (A) and potential (P) emissions of HFCs in Refrigeration and Air Conditioning Equipment (Gg CO₂-eq) (1990 – 2011)

Year	HFC-23		HFC-32		HFC-125		HFC-134a		HFC-143a		Total (Gg CO ₂ -eq)	
	A	P	A	P	A	P	A	P	A	P	A	P
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	0.55	1.42	6.39	21.08	35.99	14.35	6.32	23.71	49.25	60.57
1996	NO	NO	0.75	3.32	9.99	34.41	46.79	19.86	10.67	31.62	68.20	89.21
1997	NO	NO	1.21	3.47	13.47	38.81	63.04	24.60	13.04	37.54	90.76	104.4
1998	NO	NO	1.59	4.27	19.12	48.47	78.01	26.83	19.36	47.42	118.0	126.9
1999	NO	NO	2.05	4.12	21.86	51.46	98.04	28.91	20.55	53.35	142.5	137.8

Table 4.6-2: Actual (A) and potential (P) emissions of HFCs in Refrigeration and Air Conditioning Equipment (Gg CO₂-eq) (1990 – 2011), cont.

Year	HFC-23		HFC-32		HFC-125		HFC-134a		HFC-143a		Total (Gg CO ₂ -eq)	
	A	P	A	P	A	P	A	P	A	P	A	P
2000	NO	NO	2.58	5.22	26.19	60.06	118.0	33.70	23.71	59.28	170.5	158.2
2001	NO	NO	2.98	4.24	28.74	57.09	136.6	40.25	24.90	61.26	193.2	162.8
2002	NO	NO	3.18	5.54	32.60	63.92	159.5	44.20	29.64	63.23	224.9	176.9
2003	NO	NO	3.41	7.27	35.08	80.25	183.1	51.84	32.01	77.06	253.6	216.4
2004	NO	NO	3.98	8.37	40.57	92.54	209.7	60.68	36.75	88.92	291.0	250.5
2005	NO	NO	4.60	5.74	45.04	117.0	234.0	110.2	39.52	145.5	323.1	378.5
2006	NO	NO	4.97	7.34	48.22	125.6	261.9	101.3	41.89	148.4	357.0	382.7
2007	NO	NO	5.24	9.04	52.42	140.7	287.3	106.3	46.63	160.5	391.6	416.6
2008	NO	NO	5.39	14.83	53.60	183.1	308.6	131.8	47.42	187.4	415.0	517.2
2009	NO	NO	5.58	13.23	54.73	183.5	311.5	134.0	47.82	198.4	419.6	529.4
2010	0.77	0.77	5.88	7.65	58.76	155.9	337.4	121.8	52.17	191.7	455.0	477.9
2011	0.42	0.42	5.73	11.92	64.04	193.3	334.9	155.0	61.96	225.2	467.0	586.0

National Classification of Activities used by Central Bureau of Statistics, does not particularly mark HFCs and PFCs. Customs Departments Tariff Number does not precisely distinguish these compounds from other fluorinated chemicals which are controlled by Montreal Protocol.

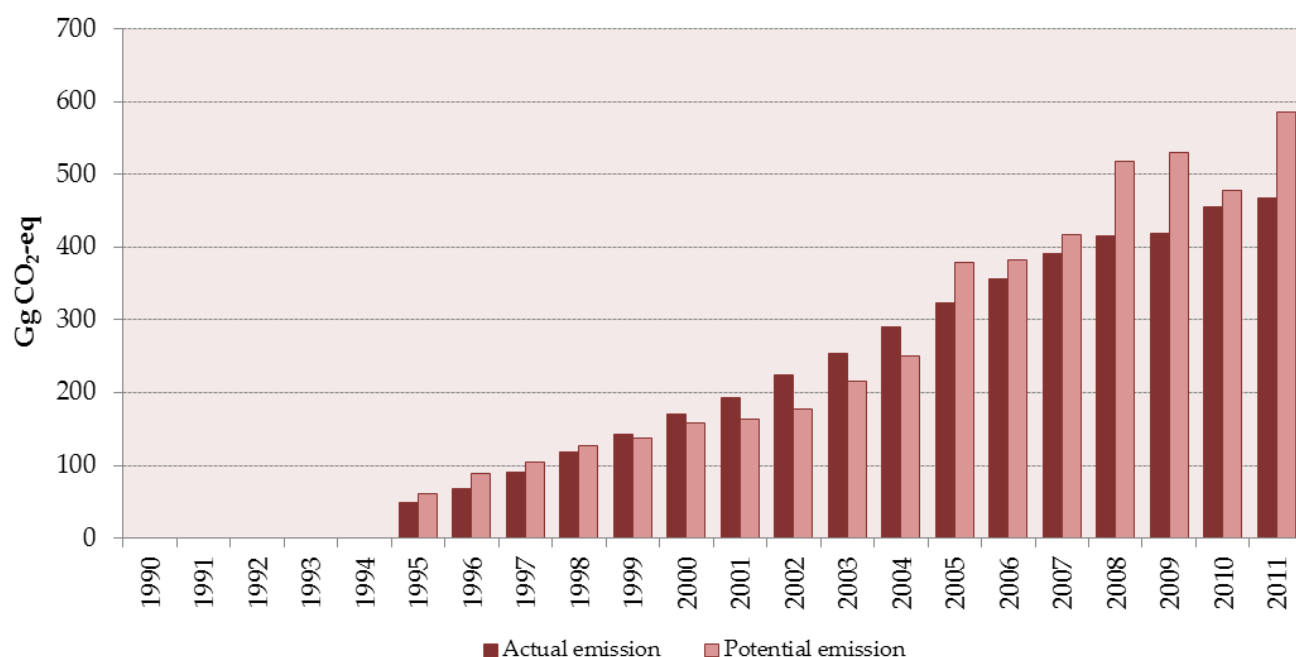


Figure 4.6-2: Actual and potential emission of HFCs in Refrigeration and Air Conditioning Equipment (Gg CO₂-eq) (1990-2011)

4.6.1.3. Uncertainties and time-series consistency

Activity data and emission factor uncertainties were calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with estimation of actual emissions of HFC-23, HFC-32, HFC-125, HFC-134a and HFC-143a amounts 50 percent for activity data and 50 percent for emission factor, based on expert judgements (detailed in Annex 5, Tables A5-1, A5-2).

Emissions (actual and potential) from Consumption of HFCs in Refrigeration and Air Conditioning Equipment have been calculated using the same methods and data sets for every year in the time series.

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 according to QA/QC plan.

Consumption of HFCs and PFCs in Refrigeration and Air Conditioning Equipment is one of the key source categories in Industrial Processes. Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. Due to incompleteness of data set, QA/QC plan does not prescribes source specific quality control procedures at this moment, but it recommends improvements which should be implemented in short-term period (see Chapter 4.6.1.6).

4.6.1.5. Source-specific recalculations

According to ERT recommendation during the in-country review, actual emissions that could not be calculated due to the missing data on average annual stocks were updated by using the values for potential emissions (HFC-23). Accordingly, recalculations were made for 2010.

Also, new data were provided for R-507A used in Industrial refrigeration. Recalculations were made for the period 2005-2010.

4.6.1.6. Source-specific planned improvements

For the purpose of accurate emission calculations it is essential to adjust National Classification of Activities used by Central Bureau of Statistics in order to particularly mark HFCs, PFCs and SF₆ and Customs Departments Tariff Number to distinguish these compounds from other fluorinated chemicals which are controlled with Montreal Protocol.

Actual and potential emissions of HFCs and PFCs were estimated on the basis of data compiled by the Ministry of Environmental and Nature Protection. Actual emissions were calculated by using data on annual stocks of

HFCs in operating systems. Information on decommissioning and disposal have not been available so far. This needs to be investigated for the future submissions.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

4.6.2. OTHER CONSUMPTION OF HFCs, PFCs AND SF₆

4.6.2.1. Source category description

This category encompasses consumption of HFCs in foam blowing (HFC-152a), fire extinguishers (HFC-125, HFC-227ea and HFC-236fa), aerosols/metered dose inhalers (HFC-134a) and SF₆ in electrical equipment. All data on HFCs, PFCs and SF₆ have been compiled by the Ministry of Environmental and Nature Protection.

According to the available data, the use of HFCs and SF₆ in the aforementioned activities was present in Croatia as follows:

- in Fire Extinguishers
 - HFC-227ea (1995-2011)
 - HFC-125 (2003-2010)
 - HFC-236fa (2006- 2011)
- in Foam Blowing
 - HFC-152a (2006-2010)
- in Aerosols/Metered Dose Inhalers
 - HFC-134a¹² (2003-2011)
- in Electrical Equipment
 - SF₆ (1990-2011)

4.6.2.2. Methodological issues

Actual emissions of HFCs have been calculated using data on the amount of HFCs in operating systems (average annual stocks) for Fire Extinguishers and Aerosols/Metered Dose Inhalers. Data on HFC-152a used in Foam Blowing, which are needed for calculation of actual emissions are not available, thus only potential emissions of this gas were calculated. According to ERT recommendation during the in-country review, actual emissions that could not be calculated due to the missing data on average annual stocks were reported by using the values for potential emissions.

For actual emission calculation, default emission factors proposed by *Revised 1996 IPCC Guidelines* were used.

¹² Fluticasone propionate, salmeterol/fluticasone propionate, salmeterol and salbutamol

According to available data, decommissioning and disposal have not been occurring so far because all of the equipment is still in use and functioning. This needs to be investigated for the future submissions.

Potential emissions (Tier 1a method, *Revised 1996 IPCC Guidelines*) from Foam Blowing and Fire Extinguishers have been calculated for the period 2006-2011 (according to available data). Insufficient data on HFC-152a used in Foam Blowing for 2007 are assessed according to data for 2006. Insufficient data on HFC-227ea used in Fire Extinguishers for 2007 and 2008 been assessed by interpolation method. Data on the consumption of HFC-125 used in Fire Extinguishers are so far available only for 2006. Potential emissions from Aerosols/Metered Dose Inhalers have been calculated for the period 2003-2011.

Actual emissions of HFCs used in Fire Extinguishers and Aerosols/Metered Dose Inhalers in the period 1995-2011 are reported in Table 4.6-3.

Table 4.6-3: Actual emissions of HFCs used Fire Extinguishers and Aerosols/Metered Dose Inhalers, by gas (Gg CO₂-eq) (1990 – 2011)

Source/Gas	1995	1996	1997	1998	1999	2000	2001	2002
2.F.2 Foam Blowing								
HFC-152a	NO	NO	NO	NO	NO	NO	NO	NO
2.F.3 Fire Extinguishers								
HFC-227ea	0.12	0.12	0.12	0.12	0.12	0.12	0.17	0.17
HFC-125	NO	NO	NO	NO	NO	NO	NO	NO
HFC-236fa	NO	NO	NO	NO	NO	NO	NO	NO
2.F.4 Aerosols/Metered Dose Inhalers								
HFC-134a	NO	NO	NO	NO	NO	NO	NO	NO

Table 4.6-3: Actual emissions of HFCs used Fire Extinguishers and Aerosols/Metered Dose Inhalers, by gas (Gg CO₂-eq) (1990 – 2011), cont.

Source/Gas	2003	2004	2005	2006	2007	2008	2009	2010	2011
2.F.2 Foam Blowing									
HFC-152a	NO	NO	NO	0.0001	0.0001	0.0001	6.41	5.05	NO
2.F.3 Fire Extinguishers									
HFC-227ea	0.17	0.17	0.20	0.44	0.93	0.21	1.38	1.62	0.58
HFC-125	0.022	0.022	0.022	0.022	0.022	0.022	0.056	0.112	NO
HFC-236fa	NO	NO	NO	0.25	0.50	0.50	NO	NO	0.30
2.F.4 Aerosols/Metered Dose Inhalers									
HFC-134a	9.17	8.89	10.06	7.61	12.65	7.16	7.89	10.15	7.97

A certain amount of SF₆ is contained in electrical equipment used in Croatian National Electricity (HEP) and KONCAR Electrical Industries Inc. Total quantity of SF₆ is imported and used as an insulation medium in high and medium voltage electrical equipment – gas insulated switchgear (GIS) and circuit-breakers.

Actual emissions of SF₆ have been calculated using data on total charge of SF₆ contained in the existing stock of equipment and leakage and maintenance losses as a fixed percentage of the total charge provided by Croatian Electricity Utility Company (Hrvatska elektroprivreda, HEP) and Končar – Electrical Industries Inc.

Data on total charge of SF₆ contained in the gas insulated switchgear and circuit-breakers and leakage/maintenance losses of the total charge, as well as losses during SF₆ manipulation and testing of high voltage circuit-breakers and apparatus before delivery, have been provided by:

- HEP Proizvodnja (limited liability company licensed to perform electricity production for tariff customers;
- HEP OPS (Transmission System Operator licensed to carry out electricity transmission as a public service – a member of HEP Group);
- HEP ODS (Distribution System Operator licensed to carry out the activity of electricity distribution and the electricity supply for tariff customers - a member of HEP Group);
- Končar Group (High Voltage Apparatus and Switchgear and Medium Voltage Apparatus and Switchgear)

Potential emissions of SF₆ used in electronic equipment have been calculated only for the period 2006-2011, because data for potential emission calculation for the previous period are not available. Data on the amount of consumed gas for the period 2006-2011 have been compiled by the Ministry of Environmental and Nature Protection.

Actual emissions of SF₆ expressed in Gg CO₂-eq for the period 1990-2011 are presented in the Table 4.6-5.

Table 4.6-4: Emissions of SF₆ (Gg CO₂-eq) (1990 – 2011)

Year	Emission of SF ₆ (Gg CO ₂ -eq)
1990	10.95
1991	10.83
1992	10.92
1993	11.04
1994	11.16
1995	11.66
1996	12.13
1997	11.98
1998	12.57
1999	12.57
2000	12.18
2001	12.26
2002	12.59
2003	12.87
2004	13.17
2005	13.66
2006	13.64
2007	13.68
2008	12.55
2009	8.39
2010	9.32
2011	9.82

4.6.2.3. Uncertainties and time-series consistency

The main uncertainties of HFCs and SF₆ emissions calculation is related to activity data. Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with estimation of actual and potential emissions of HFC-152a, HFC-125, HFC-227ea, HFC-236fa and SF₆ amounts 50 percent for activity data and 50 percent for emission factor, based on expert judgements (detailed in Annex 5, Tables A5-1, A5-2).

Emissions from Consumption of HFCs in Fire Extinguishers and Aerosols/Metered Dose Inhalers have been calculated using the same methods for every year in the time series. Emissions from consumption of SF₆ have been calculated using the same method and data sets for every year in the time series.

4.6.2.4. 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 according to QA/QC plan.

Since this source category is not a key source, QA/QC plan does not prescribes source specific quality control procedures.

4.6.2.5. Source-specific recalculations

According to ERT recommendation during the in-country review, actual emissions that could not be calculated due to the missing data on average annual stocks (for HFC-152a used in Foam Blowing) were updated by using the values for potential emissions. These new calculations were presented in the "Resubmission of Croatia's 2012 Inventory Submission". Thereupon, emissions for HFC-152a used in Foam Blowing have been recalculated for the period 2006-2010 and presented in CRF tables "Official Resubmission 2012".

New data were provided for HFC-236fa used in Fire Extinguishers. Recalculations were made for the period 2006-2010.

Also, new data were provided regarding potential emissions of HFC-134a from Aerosols/Metered Dose Inhalers for the year 2010. Recalculation was made for this year.

More detailed data for SF₆ emission calculation have been provided for the period 2000-2010. Accordingly, recalculations were made for this period.

In this resubmission, new data for SF₆ emission calculation from Medium Voltage Apparatus and Switchgear have been provided for 2010 and 2011. Accordingly, recalculations were made for 2010 and 2011.

4.6.2.6. Source-specific planned improvements

For the purpose of accurate emission calculations it is essential to adjust National Classification of Activities used by Central Bureau of Statistics in order to particularly mark HFCs, PFCs and SF₆ and Customs Departments Tariff Number to distinguish these compounds from other fluorinated chemicals which are controlled with Montreal Protocol.

Actual and potential emissions of HFCs and PFCs were calculated on the basis of data compiled by the Ministry of Environmental and Nature Protection. Actual emissions were calculated by using data on annual stocks of HFCs and SF₆ in operating systems. Actual emission trend needs to be additionally investigated. This particularly refers to SF₆ emission trend, since the latest received data to a greater extent differ from previously used data, which may indicate a high level of uncertainty.

Potential emissions from Foam Blowing and Fire Extinguishers for the period 1995-2005 were not calculated due to the lack of required data. There are insufficient data for the period 2007-2011 for HFC-125 used in Fire Extinguishers. All compiled data have high uncertainty. Accordingly, potential emission trend needs to be additionally investigated.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

4.7. NON - ENERGY USE (CRF 2.G.)

4.7.1. SOURCE CATEGORY DESCRIPTION

Non-energy fuel consumptions (fuels used as feedstock) cause 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. The feedstock use of energy carriers occurs in chemical industry (naphtha, lubricants, ethane and other), construction industry (bitumen production), and other products such as motor oil, industrial oil, grease etc.

4.7.2. METHODOLOGICAL ISSUES

According to ERT recommendation during the in-country review, CO₂ emissions from non-energy use of naphtha, lubricants, ethane and other have been removed from inventory, because there is no available information or supporting documentation on the oxidation or use of these substances.

4.8. EMISSION OVERVIEW

4.8.1. GHG EMISSIONS

Emissions of GHGs from Industrial Processes in the period 1990-2011 are presented in Table 4.8-1.

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2011)

Source	Year	GHG	Emission (Gg)	GWP ¹	Emission (Gg CO ₂ -eq)	Percent in Industrial Processes	Percent in Total Country Emission
Cement production	1990	CO ₂	1,085.79	1	1,085.79	28.65	3.43
	1991		702.56		702.56	24.10	2.82
	1992		826.23		826.23	32.45	3.56
	1993		687.13		687.13	34.31	2.95
	1994		841.87		841.87	37.76	3.75
	1995		628.67		628.67	31.16	2.73
	1996		684.69		684.69	32.75	2.89
	1997		792.26		792.26	34.05	3.15
	1998		852.93		852.93	40.50	3.37
	1999		1,115.06		1,115.06	43.26	4.20
	2000		1,243.59		1,243.59	43.52	4.73
	2001		1,423.55		1,423.55	49.50	5.19
	2002		1,392.12		1,392.12	49.02	4.88
	2003		1,383.62		1,383.62	48.13	4.62
	2004		1,470.38		1,470.38	45.45	4.89
	2005		1,499.86		1,499.86	45.69	4.93
	2006		1,588.04		1,588.04	46.26	5.14
	2007		1,611.88		1,611.88	44.58	4.95
	2008		1,526.87		1,526.87	42.66	4.89
	2009		1,224.17		1,224.17	41.16	4.19
	2010		1,198.26		1,198.26	37.04	4.17
	2011		1,050.36		1,050.36	34.75	3.71
Lime production	1990	CO ₂	153.44	1	153.44	4.05	0.48
	1991		113.60		113.60	3.90	0.46
	1992		75.12		75.12	2.95	0.32
	1993		83.60		83.60	4.17	0.36
	1994		85.49		85.49	3.83	0.38
	1995		82.79		82.79	4.10	0.36
	1996		112.92		112.92	5.40	0.48
	1997		122.85		122.85	5.28	0.49
	1998		132.79		132.79	6.31	0.53
	1999		130.27		130.27	4.70	0.46
	2000		140.76		140.76	4.77	0.52
	2001		175.51		175.51	5.83	0.61
	2002		197.73		197.73	6.57	0.65
	2003		185.43		185.43	6.17	0.59

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2011), cont.

Source	Year	GHG	Emission (Gg)	GWP ¹	Emission (Gg CO ₂ -eq)	Percent in Industrial Processes	Percent in Total Country Emission
Lime production	2004	CO ₂	203.83	1	203.83	5.91	0.64
	2005		218.66		218.66	6.27	0.68
	2006		265.02		265.02	7.30	0.81
	2007		274.81		274.81	7.21	0.80
	2008		268.62		268.62	7.15	0.82
	2009		174.32		174.32	5.53	0.56
	2010		161.01		161.01	4.68	0.53
	2011		89.24		89.24	2.52	0.27
Limestone and dolomite use	1990	CO ₂	51.49	1	51.49	1.36	0.16
	1991		32.72		32.72	1.12	0.13
	1992		14.64		14.64	0.57	0.06
	1993		13.82		13.82	0.69	0.06
	1994		21.53		21.53	0.97	0.10
	1995		17.39		17.39	0.86	0.08
	1996		17.65		17.65	0.84	0.07
	1997		11.89		11.89	0.51	0.05
	1998		15.22		15.22	0.72	0.06
	1999		14.13		14.13	0.55	0.05
	2000		15.94		15.94	0.56	0.06
	2001		18.78		18.78	0.65	0.07
	2002		25.60		25.60	0.90	0.09
	2003		24.23		24.23	0.84	0.08
	2004		26.17		26.17	0.81	0.09
	2005		26.70		26.70	0.81	0.09
	2006		24.23		24.23	0.71	0.08
	2007		21.78		21.78	0.60	0.07
	2008		25.67		25.67	0.72	0.08
	2009		30.46		30.46	1.02	0.10
	2010		36.76		36.76	1.14	0.13
	2011		41.83		41.83	1.38	0.15
Soda ash production and use	1990	CO ₂	14.47	1	14.47	0.38	0.05
	1991		15.36		15.36	0.53	0.06
	1992		16.51		16.51	0.65	0.07
	1993		15.13		15.13	0.76	0.06
	1994		19.78		19.78	0.89	0.09
	1995		20.41		20.41	1.01	0.09
	1996		18.33		18.33	0.88	0.08
	1997		16.14		16.14	0.69	0.06
	1998		16.37		16.37	0.78	0.06
	1999		15.76		15.76	0.61	0.06
	2000		16.84		16.84	0.59	0.06
	2001		18.21		18.21	0.63	0.07
	2002		18.89		18.89	0.67	0.07

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2011), cont.

Source	Year	GHG	Emission (Gg)	GWP ¹	Emission (Gg CO ₂ -eq)	Percent in Industrial Processes	Percent in Total Country Emission
Soda ash production and use	2003	CO ₂	20.29	1	20.29	0.71	0.07
	2004		23.01		23.01	0.71	0.08
	2005		23.18		23.18	0.71	0.08
	2006		21.86		21.86	0.64	0.07
	2007		20.41		20.41	0.56	0.06
	2008		20.11		20.11	0.56	0.06
	2009		20.20		20.20	0.68	0.07
	2010		23.74		23.74	0.73	0.08
	2011		23.31		23.31	0.77	0.08
Ammonia production	1990	CO ₂	466.01	1	466.01	12.30	1.47
	1991		447.00		447.00	15.33	1.79
	1992		575.22		575.22	22.59	2.48
	1993		446.83		446.83	22.31	1.92
	1994		450.03		450.03	20.18	2.00
	1995		438.77		438.77	21.75	1.90
	1996		476.59		476.59	22.80	2.01
	1997		517.83		517.83	22.26	2.06
	1998		388.43		388.43	18.44	1.54
	1999		492.14		492.14	19.10	1.85
	2000		497.96		497.96	17.43	1.89
	2001		403.70		403.70	14.04	1.47
	2002		363.78		363.78	12.81	1.27
	2003		409.38		409.38	14.24	1.37
	2004		495.43		495.43	15.31	1.65
	2005		484.65		484.65	14.76	1.59
	2006		477.34		477.34	13.91	1.55
	2007		521.51		521.51	14.42	1.60
	2008		530.39		530.39	14.82	1.70
	2009		445.63		445.63	14.97	1.52
	2010		468.22		468.22	15.50	1.75
	2011		475.94		475.94	16.92	1.81
Nitric acid production	1990	N ₂ O	2.59	310	803.89	21.21	2.54
	1991		2.28		706.05	24.22	2.83
	1992		2.98		923.19	36.25	3.97
	1993		2.24		695.91	34.75	2.99
	1994		2.43		752.57	33.75	3.35
	1995		2.33		723.70	35.88	3.14
	1996		2.17		673.86	32.23	2.84
	1997		2.28		708.21	30.44	2.82
	1998		1.72		533.19	25.32	2.11
	1999		2.03		629.16	24.41	2.37
	2000		2.39		740.39	25.91	2.82
	2001		2.01		622.72	21.65	2.27

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2011), cont.

Source	Year	GHG	Emission (Gg)	GWP ¹	Emission (Gg CO ₂ -eq)	Percent in Industrial Processes	Percent in Total Country Emission
Nitric acid production	2002	N ₂ O	1.95	310	604.48	21.29	2.12
	2003		1.84		569.79	19.82	1.90
	2004		2.24		695.34	21.49	2.31
	2005		2.19		678.84	20.68	2.23
	2006		2.17		671.21	19.55	2.17
	2007		2.39		741.40	20.50	2.28
	2008		2.44		756.66	21.14	2.42
	2009		2.04		632.25	21.26	2.17
	2010		2.63		814.37	25.17	2.84
	2011		2.60		804.50	26.62	2.84
Production of other chemicals	1990	CH ₄	0.75	21	15.80	0.42	0.05
	1991		0.52		10.95	0.38	0.05
	1992		0.46		9.62	0.38	0.04
	1993		0.50		10.48	0.52	0.05
	1994		0.48		10.06	0.45	0.05
	1995		0.40		8.41	0.42	0.04
	1996		0.38		7.94	0.38	0.03
	1997		0.34		7.15	0.31	0.03
	1998		0.34		7.09	0.34	0.03
	1999		0.31		6.43	0.25	0.02
	2000		0.29		6.04	0.21	0.02
	2001		0.31		6.41	0.22	0.02
	2002		0.26		5.40	0.19	0.02
	2003		0.28		5.79	0.20	0.02
	2004		0.27		5.73	0.18	0.02
	2005		0.25		5.33	0.16	0.02
	2006		0.34		7.09	0.21	0.02
	2007		0.31		6.43	0.18	0.02
	2008		0.23		4.81	0.13	0.02
	2009		0.08		1.73	0.06	0.01
	2010		0.04		0.76	0.02	0.003
	2011		0.02		0.49	0.02	0.002
Steel production	1990	CO ₂	21.45	1	21.45	0.57	0.07
	1991		17.86		17.86	0.61	0.07
	1992		9.65		9.65	0.38	0.04
	1993		9.46		9.46	0.47	0.04
	1994		7.06		7.06	0.32	0.03
	1995		4.24		4.24	0.21	0.02
	1996		5.36		5.36	0.26	0.02
	1997		7.64		7.64	0.33	0.03
	1998		11.96		11.96	0.57	0.05
	1999		8.06		8.06	0.31	0.03
	2000		5.43		5.43	0.19	0.02

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2011), cont.

Source	Year	GHG	Emission (Gg)	GWP ¹	Emission (Gg CO ₂ -eq)	Percent in Industrial Processes	Percent in Total Country Emission
Steel production	2001	CO ₂	5.27	1	5.27	0.18	0.02
	2002		5.14		5.14	0.18	0.02
	2003		8.47		8.47	0.29	0.03
	2004		14.89		14.89	0.46	0.05
	2005		11.24		11.24	0.34	0.04
	2006		13.25		13.25	0.39	0.04
	2007		12.42		12.42	0.34	0.04
	2008		23.51		23.51	0.66	0.08
	2009		11.30		11.30	0.38	0.04
	2010		27.27		27.27	0.84	0.09
	2011		29.18		29.18	0.97	0.10
Ferroalloys production	1990	CO ₂	118.84	1	118.84	3.14	0.38
	1991		139.26		139.26	4.78	0.56
	1992		85.34		85.34	3.35	0.37
	1993		29.29		29.29	1.46	0.13
	1994		30.11		30.11	1.35	0.14
	1995		31.88		31.88	1.58	0.14
	1996		12.92		12.92	0.62	0.05
	1997		36.79		36.79	1.71	0.16
	1998		16.01		16.01	0.82	0.07
	1999		18.77		18.77	0.79	0.08
	2000		11.24		11.24	0.42	0.05
	2001		3.70		3.70	0.14	0.01
	2002		0.01		0.01	0.00	0.00005
	2003		0.04		0.04	0.00	0.00015
	2004-2011		-		-	-	-
	Aluminium production		1990		CO ₂	111.37	1
1991		76.40	76.40	2.61		0.31	
1992-2011		-	-	-		-	
1990		CF ₄	0.13	6500	820.44	21.58	2.61
1991			0.09		562.79	19.26	2.27
1992-2011			-		-	-	-
1990		C ₂ F ₆	0.013	9200	116.12	3.05	0.37
1991			0.009		79.66	2.73	0.32
1992-2011			-		-	-	-
Consumption of HFCs, PFCs and SF ₆	1990	HFC	2	2	10.95	0.29	0.03
	1991	PFC			10.83	0.37	0.04
	1992	SF ₆			10.92	0.43	0.05
	1993				11.04	0.55	0.05

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2011), cont.

Source	Year	GHG	Emission (Gg)	GWP ¹	Emission (Gg CO ₂ -eq)	Percent in Industrial Processes	Percent in Total Country Emission
Consumption of HFCs, PFCs and SF ₆	1994	HFC	2	2	11.16	0.50	0.05
	1995	PFC			61.02	3.03	0.26
	1996	SF ₆			80.45	3.85	0.34
	1997				102.85	4.42	0.41
	1998				130.76	6.21	0.52
	1999				155.19	6.02	0.58
	2000				182.86	6.40	0.70
	2001				205.67	7.15	0.75
	2002				237.70	8.37	0.83
	2003				275.90	9.60	0.92
	2004				313.28	9.68	1.04
	2005				347.10	10.57	1.14
	2006				378.95	11.04	1.23
	2007				419.41	11.60	1.29
	2008				435.51	12.17	1.40
	2009				443.97	14.93	1.52
	2010				481.29	14.87	1.68
	2011				485.77	16.06	1.72

¹ Time horizon chosen for GWP values is 100 years

³ HFC-23 (GWP=11,700); HFC-32 (GWP=650); HFC-125 (GWP=2,800); HFC-134a (GWP=1,300); HFC-143a (GWP=3,800); HFC-152a (GWP=130); HFC-227ea (GWP=2,900); HFC-236fa (GWP=6,300); PFC-218 (GWP=7000); PFC-14 (GWP=6500); SF₆ (GWP=23,900)

4.8.2. 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 (SO₂) (see Table 4.8-2).

Emissions of indirect GHGs have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2011* Submission to the Convention on Long-range Transboundary Air Pollution'.

Table 4.8-2: 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 1990-2011 are reported in table 4.8-3.

Table 4.8-3: Emissions of indirect GHGs from Industrial Processes (1990-2011)

Year	SO ₂ (Gg)	NO _x (Gg)	CO (Gg)	NMVOC (Gg)
1990	2.57	2.76	41.71	24.01
1991	1.75	2.42	26.30	20.85
1992	1.54	2.82	14.87	13.21
1993	1.42	2.32	18.35	11.92
1994	1.82	2.48	22.94	9.00
1995	1.63	2.62	28.35	9.32
1996	1.58	2.53	27.98	10.56
1997	1.65	2.64	25.67	8.89
1998	1.48	2.24	25.76	8.41
1999	1.87	2.44	22.48	8.41
2000	2.05	2.78	32.10	7.78
2001	2.04	2.09	26.26	6.95
2002	2.17	2.17	29.17	7.62
2003	1.86	2.41	30.96	7.23
2004	2.07	2.77	20.35	7.79
2005	2.07	8.30	19.79	8.74
2006	1.90	9.49	41.81	8.35
2007	2.05	10.05	37.99	6.26

Table 4.8-3: Emissions of indirect GHGs from Industrial Processes (1990-2011), cont.

Year	SO ₂ (Gg)	NO _x (Gg)	CO (Gg)	NMVOC (Gg)
2008	2.41	9.21	12.75	5.95
2009	1.77	6.96	2.34	5.27
2010	1.30	5.76	3.42	5.42
2011	1.14	4.14	3.48	5.96

4.9. REFERENCES

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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 use of solvents is the cause of less than 15 percent of anthropogenic national emissions of non-methane volatile organic compounds (NMVOCs). 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.

NMVOC emissions oxidize in the atmosphere and CO₂ emissions are generated as a consequence of this oxidation.

N₂O emissions are caused by medical uses of N₂O (for anaesthesia) and other possible sources emissions (aerosol cans).

NMVOC, CO₂ and N₂O emissions are included in emissions estimates in this sector.

5.1.2. METHODOLOGICAL ISSUES

NMVOC emissions

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. Emissions of NMVOC have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2011* Submission to the Convention on Long-range Transboundary Air Pollution'. The NMVOC emissions 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 population data. The activity data for the other sources were extracted from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Activity data and average emission factors are shown in the Table 5.1-1.

Table 5.1-1: Activity data for NMVOC emissions from Solvent and Other Product Use (1990-2011)

Source and Sink Categories	Activity Data, t (1000 capita*)								EF, kg/t (cap)
	1990	1995	2000	2005	2008	2009	2010	2011	1990-2011
Paint application									
Decorative coating application	7,318	3,694	5,036	5,464	6,572	5,062	5,465	5,539	150
Industrial coating application	7,318	3,694	5,036	5,464	6,572	5,062	5,465	5,539	400
Other coating application	7,318	3,694	5,036	5,464	6,572	5,062	5,465	5,539	200
Degreasing, dry cleaning and electronics									
Metal degreasing *	4,778	4,669	4,381	4,442	4,434	4,429	4,417	4,403	0.85
Dry cleaning *	4,778	4,669	4,381	4,442	4,434	4,429	4,417	4,403	0.25
Chemical products manufacturing or processing									
Polyester	6,047	2,225	12,848	10,886	16,548	13,989	7,268	7,070	50
Polyvinylchloride	30,718	5,346	1,462	9,396	9,341	6,815	4,670	3,832	40
Polyurethane	3,763	2,909	1,860	2,919	1,873	1,026	780	615	15
Polystyrene	7,844	6,449	3,654	1,684	16,226	11,053	10,130	581	60
Rubber	5,739	2,285	21	4	0	0	0	0	15
Pharmaceutical products manufac.*	4,778	4,669	4,381	4,442	4,434	4,429	4,418	4,403	0.014
Paints manufacturing	21,956	10,773	15,107	16,393	19,716	15,186	16,394	16,618	15
Inks manufacturing	4,713	1,417	924	669	935	616	345	421	30
Glues manufacturing	5,139	10,076	10,355	56,573	77,701	33,821	35,507	28,722	20
Other use of solvents and related activities									
Printing industry	4,672	1,367	916	665	929	612	341	417	800
Application of glues and adhesives	5,139	10,076	10,355	56,573	77,701	33,849	35,507	28,722	600
Domestic solvent use*	4,778	4,669	4,381	4,442	4,434	4,429	4,418	4,403	2

* Activity data is number of inhabitants in Croatia (1,000 capita)

The contribution of group of activities to NMVOC emissions is given in the Figure 5.1-1.

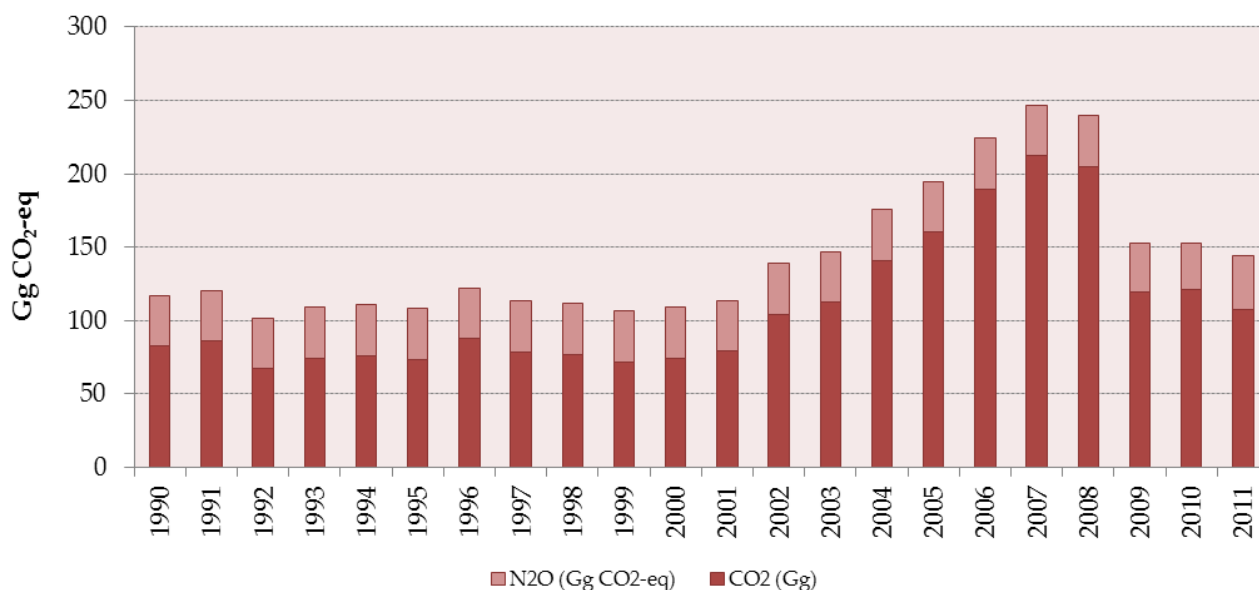


Figure 5.1-1: Emissions of NMVOC from Solvent and Other Product Use (1990-2011)

CO₂ emissions

IPCC Guidelines do not provide methodology for calculation of CO₂ emissions from Solvent and Other Product Use. CO₂ emissions are calculated using conversion factor which contains ratio C/NMVOC = 0.8 and recalculation ratio of C to CO₂ equal to 44/12. The overall conversion factor has value of 2.93.

C/NMVOC conversion factor has been assessed using cluster analysis. The results of investigations performed in other countries were used. Investigation of conversion factor C/NMVOC in Croatia need to be performed during the next period (long-term goals), with purpose of accurate CO₂ emission calculation.

N₂O emissions

N₂O emissions have been calculated by multiplying annual quantity of N₂O used for anaesthesia and aerosol cans and default emission factor. Activity data were obtained by producers and distributors of N₂O in Croatia.

It is assumed that none of the N₂O is chemically changed by the body or reacted during the process and all of the N₂O is emitted to the atmosphere, which resulting in an emission factor of 1.0 for these sources.

The resulting emissions of CO₂ and N₂O (Gg CO₂-eq) from Solvent and Other Product Use in the period 1990-2011 are presented in the Figure 5.1-2.

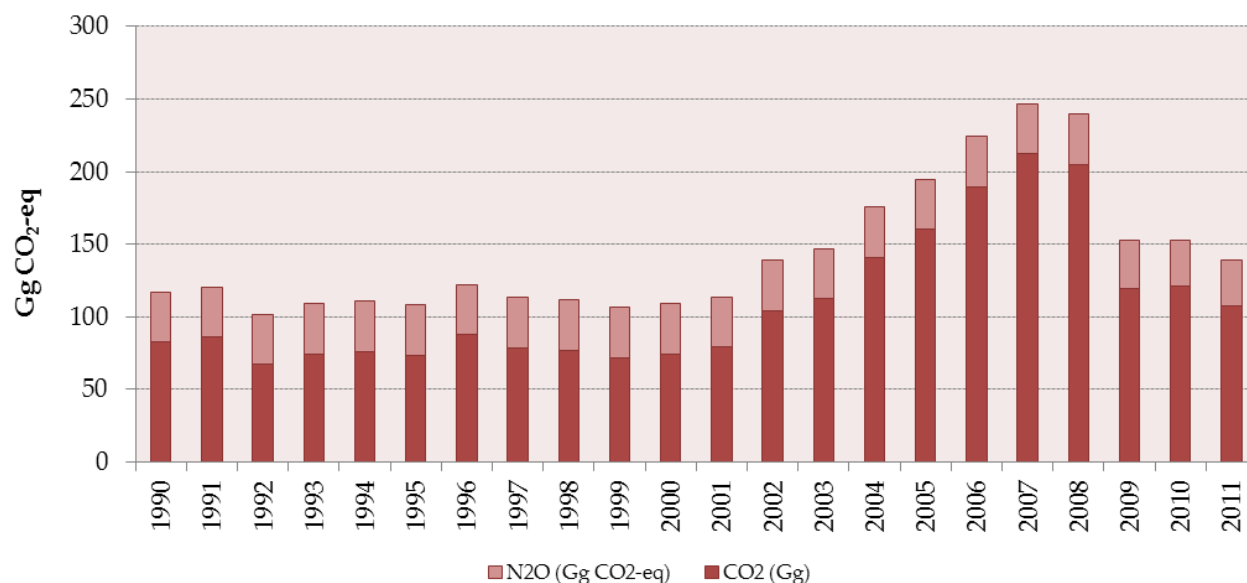


Figure 5.1-2: Emissions of CO₂ and N₂O from Solvent and Other Product Use (1990-2011)

5.1.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties in CO₂ emissions estimates are mainly due to the accuracy of used conversion factor (C/NMVOC) and reliability of calculation is very low. Uncertainties in N₂O emissions estimates are caused by relatively high uncertainties of activity data.

Uncertainty estimates are based on expert judgement. Uncertainty estimate associated with activity data amounts 50 percent. Uncertainty estimate associated with emission factors amounts 50 percent (detailed in Annex 5, Tables A5-1, A5-2).

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 according to QA/QC plan.

Since this source category is not a key source, QA/QC plan does not prescribes source specific quality control procedures.

5.1.5. SOURCE-SPECIFIC RECALCULATIONS

Activity data for NMVOC emission calculation for the whole period 1990-2010 have been updated according to the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2011* Submission to the Convention on Long-range Transboundary Air Pollution'. Therefore, CO₂ emissions have been recalculated for the period 1990-2010 in this report.

In this resubmission, new data for N₂O emission calculation from one additional source have been provided for 2011. Accordingly, recalculations were made for this year.

5.1.6. SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Investigation of conversion factor C/NMVOC needs to be performed during the next period (long-term goals), with a purpose of accurate CO₂ emission calculation.

According to the requirement of Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia, each source of CO₂ emissions from Solvent and Other Product Use should report required activity data for more accurate emissions estimation.

N₂O emissions from medical uses and other possible sources are estimated using constant value for activity data, which is an assessment of producer and distributor of N₂O in Croatia. More detailed data are needed for an accurate emission calculation.

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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 emission in 2011 caused by agricultural activities was 3,318.52Gg CO_2 -eq, which represents about 11.75 percent of the total inventory emission. 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, dairy cattle are the largest source of methane (CH_4) emission. The result of agricultural soil management, manure management and agricultural engineering in cultivation of some crops are relatively high emission of nitrous oxide (N_2O). Emission generated by burning agricultural residues was not included in the calculation because this activity is prohibited by Croatian regulations. There are no ecosystems in the Republic of Croatia that could be considered natural savannas or rice fields; therefore, no greenhouse gas emissions exist for this sub-category.

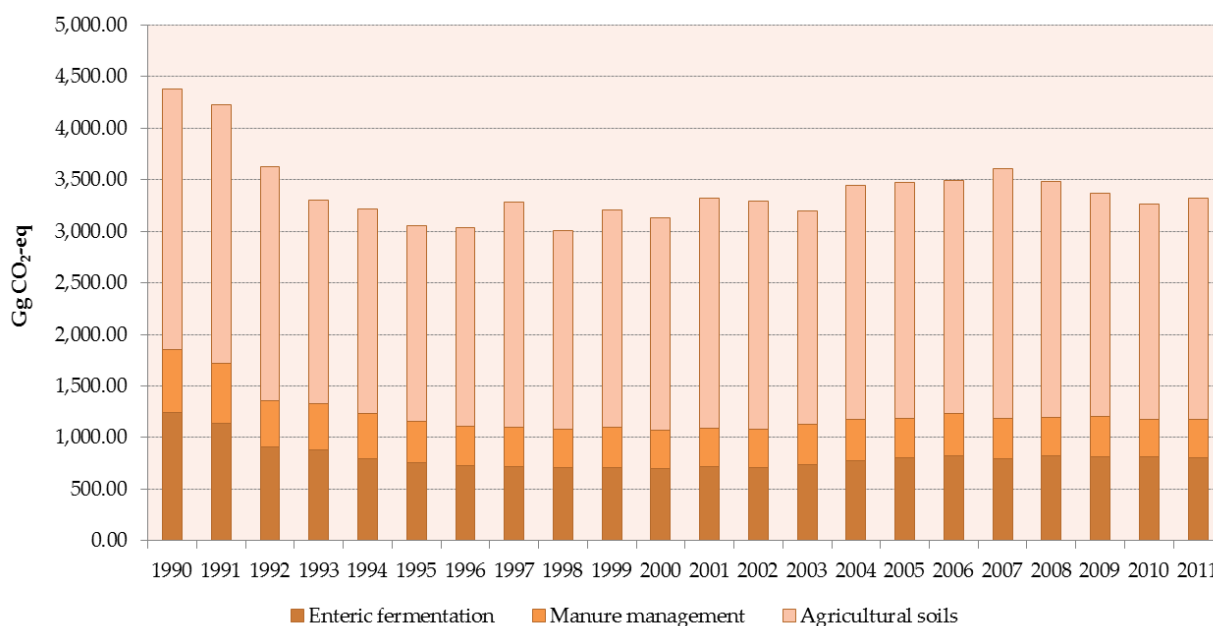


Figure 6.1-1: Agriculture emission trend

Greenhouse gas emission decreased from 1990-1996 due to the war which highly influenced the animal population, crop production, consumption of mineral fertilizers and the overall agricultural practice in Croatia. Afterwards, the sector began to revitalize and emission slightly increased due to better national circumstances

for agricultural production. Table 6.1-1 and Table 6.1-2 show the total emission from Agriculture by gases and by emission sources for the period 1990-2011.

Table 6.1-1: Emission of greenhouse gases from agriculture

Year	Methane emission / Gg CH ₄			Nitrous oxide emission / Gg N ₂ O		
	Enteric fermentation	Manure management	Total	Manure management	Agricultural soils	Total
1990	59.14	10.89	70.03	1.23	8.16	9.39
1991	54.23	10.69	64.92	1.15	8.09	9.23
1992	43.08	8.09	51.17	0.91	7.32	8.23
1993	41.96	8.32	50.27	0.89	6.34	7.23
1994	37.94	8.35	46.29	0.83	6.42	7.25
1995	36.20	7.50	43.70	0.78	6.11	6.89
1996	34.50	7.39	41.89	0.73	6.23	6.96
1997	34.35	7.26	41.61	0.72	7.04	7.76
1998	33.93	7.15	41.08	0.70	6.21	6.91
1999	33.82	7.93	41.75	0.72	6.80	7.52
2000	33.28	7.37	40.65	0.70	6.65	7.34
2001	34.13	7.41	41.54	0.70	7.20	7.90
2002	33.72	7.52	41.25	0.69	7.14	7.83
2003	35.28	7.89	43.16	0.72	6.69	7.40
2004	36.70	8.50	45.20	0.73	7.31	8.05
2005	38.36	7.41	45.77	0.72	7.40	8.12
2006	39.10	8.57	47.66	0.75	7.31	8.05
2007	38.00	7.95	45.95	0.72	7.29	8.02
2008	39.26	7.61	46.86	0.68	7.22	7.90
2009	38.81	8.21	47.02	0.68	6.82	7.51
2010	38.48	7.96	46.45	0.66	6.50	7.15
2011	38.28	7.99	46.27	0.66	6.91	7.57

Table 6.1-2: Emission of greenhouse gases from agriculture

Year	Methane emission / Gg CO ₂ -eq			Nitrous oxide emission / Gg CO ₂ -eq			Gg CO ₂ -eq
	Enteric fermentation	Manure management	Total	Manure management	Agricultural soils	Total	TOTAL EMISSION
1990	1,241.92	228.62	1,470.54	381.84	2,528.33	2,910.18	4,380.72
1991	1,138.74	224.57	1,363.31	354.98	2,507.64	2,862.62	4,225.93
1992	904.73	169.82	1,074.54	282.53	2,269.23	2,551.75	3,626.30
1993	881.07	174.68	1,055.75	276.21	1,966.50	2,242.72	3,298.47
1994	796.64	175.38	972.03	257.44	1,989.65	2,247.09	3,219.12
1995	760.22	157.43	917.65	241.97	1,895.21	2,137.18	3,054.84
1996	724.43	155.26	879.69	227.56	1,930.88	2,158.43	3,038.12
1997	721.36	152.50	873.86	223.66	2,181.14	2,404.80	3,278.66
1998	712.46	150.25	862.71	217.88	1,925.14	2,143.02	3,005.73
1999	710.19	166.61	876.80	222.78	2,107.08	2,329.87	3,206.66
2000	698.87	154.73	853.60	216.04	2,060.53	2,276.56	3,130.16
2001	716.79	155.59	872.37	218.27	2,231.23	2,449.50	3,321.87
2002	708.14	158.02	866.16	212.82	2,213.25	2,426.07	3,292.23
2003	740.85	165.62	906.46	222.75	2,072.50	2,295.26	3,201.72
2004	770.70	178.60	949.30	227.71	2,266.96	2,494.67	3,443.97
2005	805.58	155.57	961.15	224.02	2,292.53	2,516.55	3,477.70
2006	821.00	179.88	1,000.88	231.79	2,265.10	2,496.89	3,497.77
2007	798.02	166.87	964.89	224.37	2,260.43	2,484.80	3,449.69
2008	824.43	159.74	984.16	211.27	2,237.96	2,449.23	3,433.39
2009	815.09	172.35	987.44	212.23	2,114.45	2,326.68	3,314.12
2010	808.18	167.17	975.35	203.53	2,014.24	2,217.78	3,193.13
2011	803.80	167.79	971.59	204.59	2,142.35	2,346.93	3,318.52

Overview of the greenhouse gas emission calculation according to previously stated sources is presented in the following subchapters.

In Agriculture, five source categories represent key source category regardless of LULUCF (detailed in Table 6.1-3):

Table 6.1-3: Key categories in agriculture sector based on the level and trend assessment in 2011¹³

IPCC Source Categories	Direct GHG	Criteria for Identification			
		Level		Trend	
		excl. LULUCF	incl. LULUCF	excl. LULUCF	incl. LULUCF
AGRICULTURE SECTOR					
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	L1e, L2e	L1i	T1e, T2e	T1i, T2i
N ₂ O Emissions from Manure Management	N ₂ O	L1e	L1i	T1e, T2e	T1i, T2i
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	L1e, L2e	L1i, L2i		T1i, T2i
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	L1e, L2e			T1i, T2i
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	L1e, L2e	L1i, L2i	T1e	T1i, T2i

L1e - Level excluding LULUCF Tier1

L1i - Level including LULUCF Tier1

T1e - Trend excluding LULUCF Tier1

T1i - Trend including LULUCF Tier1

L2e - Level excluding LULUCF Tier 2

L2i - Level including LULUCF Tier 2

T2e - Trend excluding LULUCF Tier2

T2i - Trend including LULUCF Tier2

¹³ Data on key categories are taken from Annex 1 Key Categories.

6.2. CH₄ EMISSIONS FROM ENTERIC FERMENTATION IN DOMESTIC LIVESTOCK (CRF 4.A.)

6.2.1. SOURCE CATEGORY DESCRIPTION

Methane is a direct product of animal metabolism generated during the digestion process. The greatest producers of methane are ruminants (cows, other 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. Estimates in the inventory include only emissions in farm animals. Buffalo, camels, and lamas 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. Dairy cattle is the single major source of emissions representing about 50% of total CH₄ emission from Enteric fermentation in 2011, followed by non dairy cattle representing about 30%. Jointly, cattle are responsible for around 80% of total CH₄ emission from Enteric fermentation. No methodology for calculating CH₄ emission from poultry is available in Revised 1996 IPCC Guidelines.

Figure 6.2-1 shows emission of methane from Enteric fermentation for the period from 1990-2011. The emission trend follows the trend of animal population which significantly decreased during the war period in the early 1990s (up to 1996). The decrease is recorded for each animal category (see Table 6.2.2).

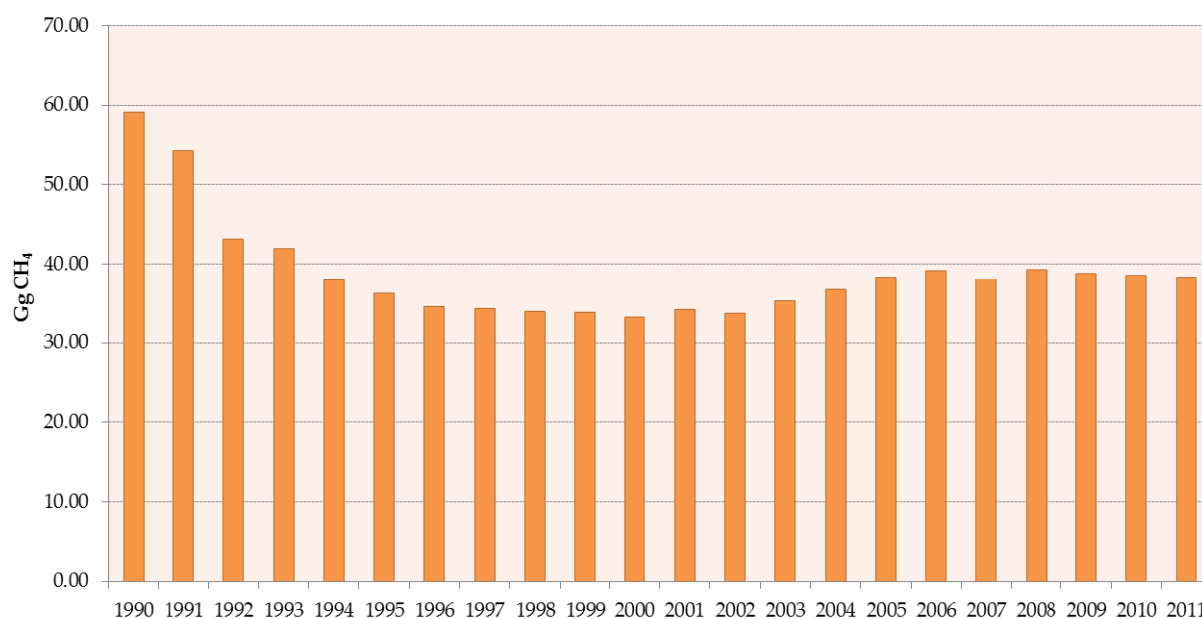


Figure 6.2-1: CH₄ emission from Enteric fermentation

6.2.2. METHODOLOGICAL ISSUES

The IPCC methodology has been used to calculate methane emission from enteric fermentation. For cattle, Tier 2 method was used and for other animals a simplified, Tier 1, method.

The main two sources regarding the animal population are the Central Bureau of Statistics (CBS) and FAO database. More detailed data on horses and mules/asses was provided by Croatian Horse breeding Centre (CHBC). See Table 6.2-1 for detailed information. National data (provided by Croatian CBS and CHBC) are considered to be the most accurate source. For animal categories where national data was not available, FAO data was considered an adequate replacement source. Due to the by Croatian Horse breeding Centre gap for the horses in year 1996, interpolation was performed instead of usage of FAO database data to maintain a more correct trend for the entire period 1995-2011.

Table 6.2-1: Sources of activity data regarding animal population

Animal category	CBS	FAO	Croatian Horse breeding Centre	Interpolation
Cattle	1990-2011			
Sheep	1990-2011			
Goats	1990-1991; 1999-2011	1992-1998		
Horses	1990-2004		1995; 1997-2010	1996
Mules/asses	1990-1991	1992-1999	2000-2011	
Swine	1990-2011			
Poultry	1990-2011			

The number of livestock is reported in Table 6.2-2.

Table 6.2-2: Livestock population in the period from 1990 – 2011

Year	Animal number / 1000 heads							
	Dairy cattle	Non-dairy cattle	Sheep	Goats	Horses	Mules/asses	Swine	Poultry
1990	460	370	751	172	39	17	1573	17102
1991	422	335	753	133	36	13	1621	16512
1992	369	221	539	114	26	13	1182	13142
1993	333	256	525	105	22	12	1262	12697
1994	328	191	444	108	21	7	1347	12503
1995	308	185	453	107	2	4	1175	12024
1996	283	178	427	105	3	4	1197	10993
1997	279	172	453	100	3	4	1176	10945

1998	270	173	427	84	4	4	1166	9959
1999	268	170	488	78	4	4	1362	10871
2000	262	164	529	79	5	1	1234	11256
2001	254	184	539	93	5	1	1234	11747
2002	247	170	580	97	6	1	1286	11665
2003	252	192	587	86	7	1	1347	11778
2004	226	240	722	126	9	1	1489	11185
2005	235	236	796	134	10	1	1205	10641
2006	233	250	680	103	12	1	1488	10088
2007	236	232	646	92	14	1	1348	10053
2008	220	234	643	84	16	2	1104	10015
2009	212	235	619	76	17	2	1250	10787
2010	182	262	629	75	19	2	1231	9469
2011	184	263	639	70	20	3	1233	9523

The overall livestock population decreased significantly in the war period (1991-1995) compared to 1990. Dairy cattle maintained the decreasing trend over the entire period from 1990-2011. The population of other animal categories fluctuates through the period concerned but the explanation for the latter requires more detailed information which requires additional research. Croatian Horse breeding Centre provided detailed national data for the population numbers of horses (1995; 1997-2010) and mules/asses (2000-2010). CBS data was used for horse and FAOSTAT numbers for mules/asses population were used for the period 1990-1994 and 1990-1999, respectively, due to current unavailability of national data. Since these numbers are not consistent with the new trend, more investigation into the accuracy of source data is required.

Cattle classification for Tier 2 is as follows:

- Mature dairy cattle – mature dairy cows
- Mature non dairy cattle – mature females and mature males (other cows, heifers, bullocks, oxen)
- Young cattle - calves

Cattle activity data and subcategorization into distinct cattle subcategories was provided by CBS. Since the methodology for the subcategorization (more specifically, category names) of cattle in the statistical data has changed slightly over the years, Table 6.2-3 contains information on how CBS categories were reclassified into the appropriate IPPC categories. Over time, it is expected that this CBS categorization will be uniform across the dataset.

Table 6.2-3: Cattle classification into IPPC categories

IPPC categories	CBS categories		
	1990-1999	2000-2006	2007-2011
mature dairy	Dairy cows	Dairy cows	Dairy cows
mature non-dairy	- Heifers - Other cows - Other (bull, ox)	- Other cows - Other (bull, ox) - Pregnant heifers - Calves over 2 years old	- Heifers over 2 years old - Cows (female bovine animals that have calved)* - Other bovine animals over 2 years old
young	Bovine animals aged under 2 years	- Calves under 3 months - Calves 3 month – 1 year of age - Calves 1-2 years of age	- Bovine animals less than 1 year old (includes calves for slaughter and other young males, male and female) - Bovine animals aged between 1 and 2 years (male and female animals for slaughter and breeding)

For the calculation of emission factor for dairy cattle, mature non dairy cattle and the young, default factors were used (see Table 6.2-4).

Table 6.2-4: Default data used in emission factor calculation for cattle

Animal	weight (kg)	Cfi	Ca	WG (kg/day)	fat (%)	C _{pregnancy}	DE (%)	Ym
mature dairy	550.00	0.335	0.00	0.00	4.00	0.10	60.00	0.060
mature non-dairy	600.00	0.322	0.17	0.00			60.00	0.065
young	230.00	0.322	0.17	0.40			60.00	0.060

Milk yield per cow per day for the period from 1990-2011 is presented in Table 6.2-5.

Table 6.2-5: Milk yield per cow

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Milk yield (kg/day)	5.47	5.03	5.28	5.12	5.03	5.26	5.77	6.12	6.45	6.37

Table 6.2-5: Milk yield per cow, cont.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Milk yield (kg/day)	6.54	7.08	7.44	7.67	7.90	9.08	9.94	10.04	10.34	10.66	11.95	12.05

Other parameters are calculated as follows:

- net energy required by the animal for maintenance (NEm) – Equation 4.1
- net energy for animal activity (NEa) – Equation 4.2a
- net energy needed for growth (NEg) – Equation 3 (IPCC Guidelines)
- net energy for lactation (NEl) – Equation 4.5a
- net energy required for pregnancy (NEp) – Equation 4.8
- ratio of net energy available for growth in a diet to digestible energy consumed (NEga/DE) – Equation 4.10
- gross energy (GE) – Equation 4.11

Finally, emission factors for dairy and non-dairy cattle are calculated upon the following equation (IPCC Guidelines - equation 14):

$$\text{Emission factor (kg/yr)} = [\text{Intake (MJ/day)} \times Y_m \times (365 \text{ days/yr})] / 55.65 \text{ MJ/kg of methane}$$

Emission factor for mature non-dairy cattle and young cattle is about 66 kg CH₄/head/yr and 41 kg CH₄/head/yr respectively while the emission factor used for dairy cattle is presented in Figure 6.2-2.

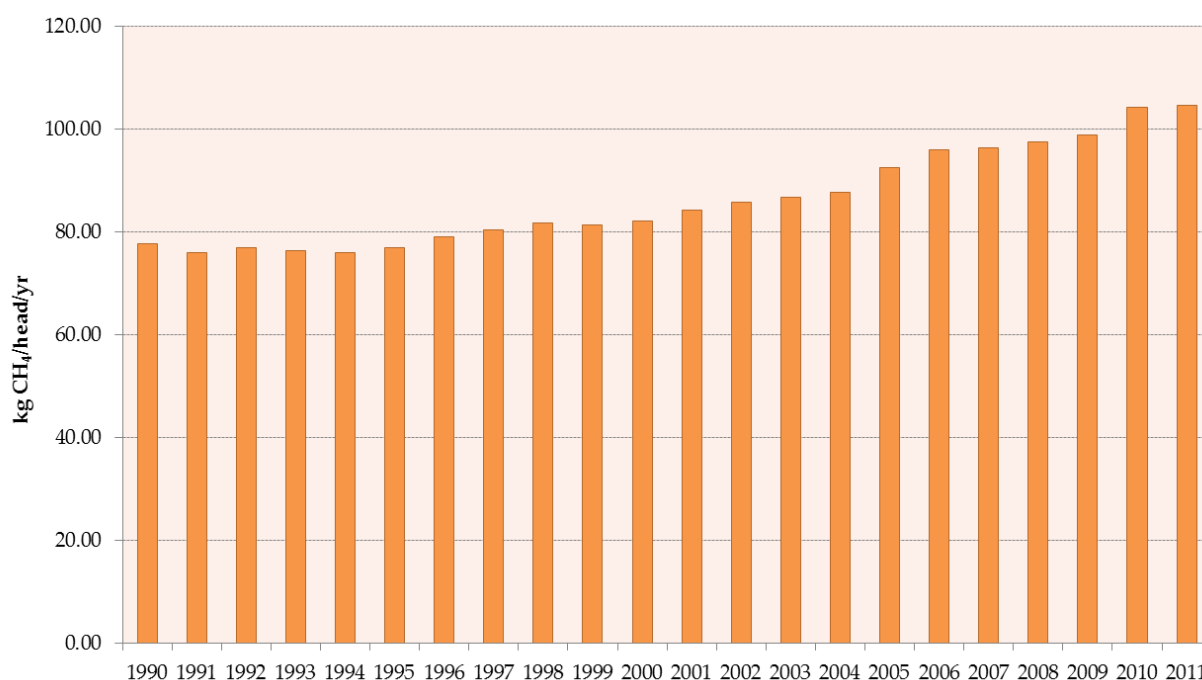


Figure 6.2-2: Enteric fermentation emission factors used for dairy cattle

For other animals (sheep, goats, horses, mules/asses, swine), Tier 1 has been used as well as default EF for developing countries (from 1990-2007) and default EF for developed countries (2008-2011). The only difference is therefore related to sheep and swine since default emission factors for other animal categories are the same for developing and developed countries. Abovementioned is presented in Table 6.2-6.

Table 6.2-6: Default enteric fermentation emission factors for each animal category (except cattle)

Animal Category	EF / kg per head per year	
	1990-2007 (developing countries)	2008-2011 (developed countries)
Sheep	5	8
Goats	5	5
Horses	18	18
Mules/asses	10	10
Swine	1.0	1.5
Poultry	Not estimated	Not estimated

6.2.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data amounts to minimal $\pm 10\%$ and maximum of $\pm 30\%$, based on expert judgements. The expert judgement used for the uncertainty of the AD is based on the authority of the AD source (10% for high authority CBS source, 30% for FAO and other data), observing annual variation in AD and of periodic revisions of the AD.

Uncertainty estimate associated with emission factors amounts to 20% for Tier2 (cattle) and 30% for Tier (all other) animal categories according to information provided in the *IPCC Guidelines* (detailed in Annex 5, Tables A5-1, A5-2).

CH₄ emissions from Enteric Fermentation have been calculated using the same method and data sets for every year in the time series.

6.2.4. CATEGORY-SPECIFIC QA/QC AND VERIFICATION

During the preparation of inventory submission, activity data regarding animal population for the entire time series were checked and revised if found necessary. Therefore, activities related to quality control were focused on completeness and consistency of emission estimates and also on the proper use of notation keys in the CRF tables. After a final draft of this chapter was prepared, 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 inventory preparation, despite the fact that formal QC procedures were not prepared.

Regarding Tier 2 activities, emission factors and activity data were checked for key source categories.

6.2.5. SOURCE SPECIFIC RECALCULATIONS

Methane emissions from Enteric fermentation were recalculated for the years 2007 and 2008 due to changes in activity data (number of dairy cows) and changes in CBS methodology for the cattle subcategorization (Table 6.2-3). This reclassification of older data accounts for a slight change in the number of cattle within individual Tier II categories.

6.2.6. SOURCE SPECIFIC PLANNED IMPROVEMENT

At this point, several areas for improvements have been recognized and accordingly short and mid-term goals have been set. These planned improvements also cover the issues and questions raised during the in-country review in 2012.

Short term goals (1 year) are as follows:

- Improvements and investigation of activity data (livestock population numbers) with the purpose of more detailed explanation of the activity data trends and verification of source data.
- Collecting relevant data from the Central Bureau of Statistic and other national institutions in order to provide additional detail on sourcing of AD and improve transparency.
- Reconciliation of the discrepancy regarding the usage of IPPC default EFs for developing countries for the period 1990-2007 and default EFs for developed countries for the period 2009-2011 for the estimation of emissions from enteric fermentation (sheep, goats, horses, mules and assess, swine and poultry).

Planned improvements which are assumed to be mid-term or long-term goals (over 1 year) are:

- The development of national emission factors for the calculation of CH₄ emission.
- Collecting appropriate country specific data on cattle live weights and milk fat percentage to replace default values used in Tier2 method of emission estimates.
- Investigation of the difference in statistical data of mineral fertilizer usage that is possibly leading to the overestimation of direct N₂O emissions from the Agricultural Soils .
- Continued improvements and investigation of activity data with the purpose of more detailed explanation of the activity data trends and further verification of source data.

6.3. MANURE MANAGEMENT – CH₄ EMISSIONS (CRF 4.B.)

6.3.1. SOURCE CATEGORY DESCRIPTION

Management of livestock manure produces both methane (CH₄) and nitrous oxide (N₂O) emissions. Methane is generated under the conditions of anaerobic decomposition of manure. Manure storing methods, in which 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. Methane emission from Manure management for the period from 1990 to 2011 is presented in Figure 6.3-1. The emission trend depends on the animal population trend.

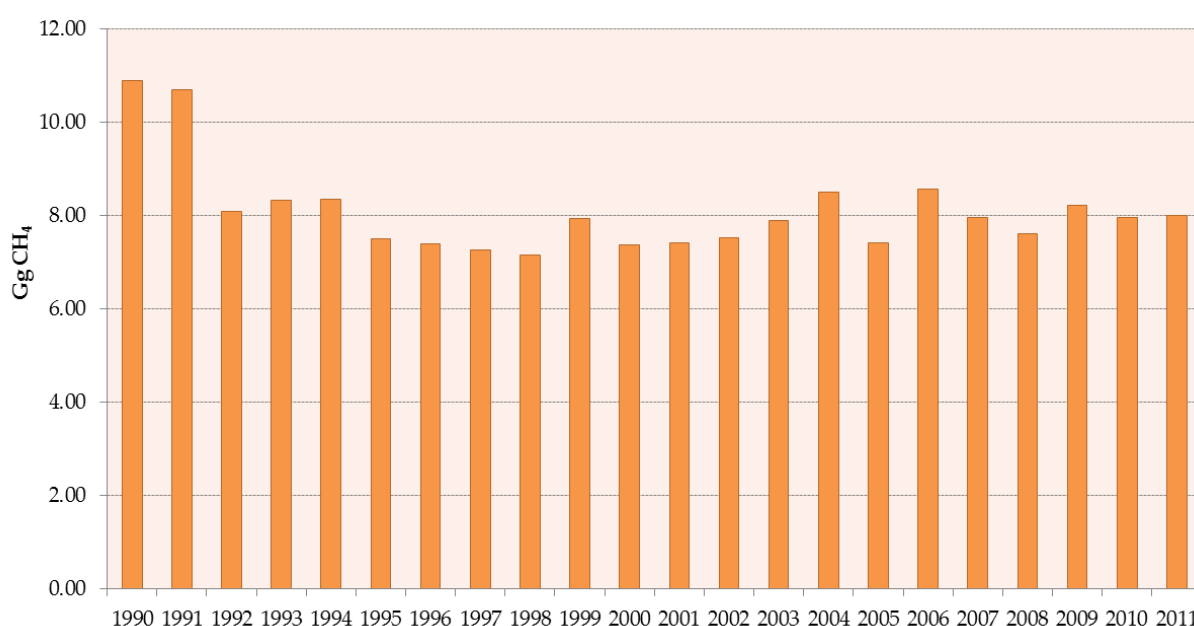


Figure 6.3-1: CH₄ emission from Manure management

6.3.2. METHODOLOGICAL ISSUES

The IPCC methodology (Tier 1) has been used to calculate methane emission from Manure Management. The same activity data as in Enteric fermentation have been used in emission calculation, thus referring to Table 6.2-2. Default emission factors were used for emission calculation according to IPCC Guidelines for National Greenhouse Gas Inventories Reference Manual. They are specified for the animal type, climate region (cool), geographic region and/or the degree of region development. For cattle and swine, emission factors for Eastern Europe have been used. For the period from 1990-2007, these default EFs refer to those of developing countries for sheep, goats, horses, mules/asses and poultry while for the emission calculation for the period 2008-2011 EFs of developed countries have been used. Abovementioned is presented in Table 6.3-1.

Table 6.3-1: Default manure management emission factors for each animal category except cattle

Animal Category	EF / kg per head per year	
	1990-2007 (developing countries)	2008-2011 (developed countries)
Sheep	0.19	0.10
Goats	0.12	0.11
Horses	1.4	1.1
Mules/asses	0.76	0.60
Poultry	0.078	0.012

6.3.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis (detailed in Annex 5, Tables A5-1, A5-2). Uncertainty estimate associated with activity data amounts to minimal $\pm 10\%$ and maximum of $\pm 30\%$, based on expert judgements. The expert judgement used for the uncertainty of the AD is based on the authority of the AD source (10% for high authority CBS source, 30% for FAO and other data), observing annual variation in AD and of periodic revisions of the AD. Uncertainty estimate associated with emission factors amounts to 40% based on expert judgement and usage of default emission factors.

6.3.4. CATEGORY-SPECIFIC QA/QC AND VERIFICATION

During the preparation of inventory submission, activity data regarding animal population for the entire time series were checked and revised if found necessary. Therefore, activities related to quality control were focused on completeness and consistency of emission estimates and also on the proper use of notation keys in the CRF tables. After a final draft of this chapter was prepared, 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 inventory preparation, despite the fact that formal QC procedures were not prepared.

6.3.5. SOURCE SPECIFIC RECALCULATIONS

Methane emissions from Enteric fermentation were recalculated for the years 2007 and 2008 due to changes in activity data (number of dairy cows) and changes in CBS methodology for the cattle subcategorization (Table 6.2-3). This reclassification of older data accounts for a slight change in number cattle within individual Tier II categories.

6.4. N₂O EMISSIONS FROM MANURE MANAGEMENT (CRF 4.B.)

6.4.1. SOURCE CATEGORY DESCRIPTION

Emissions of nitrous oxide (N₂O) from all animal waste management systems are estimated. 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. Emissions of N₂O from pasture range and paddock are reported under Agricultural soils. Farm animals emit very little nitrous oxide directly and this has not been considered in estimation of GHG emissions. In the Republic of Croatia, manure is not used as fuel.

6.4.2. METHODOLOGICAL ISSUES

The IPCC methodology (Tier 1) has been used. Emission factors are taken from the 1996 IPCC Reference Manual. Nitrous oxide (N₂O) emission is calculated according to the following equations:

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

where

$Nex_{(AWMS)}$	stands for	N excretion per Animal Waste Management System
$N_{(T)}$	stands for	number of animals by type
$Nex_{(T)}$	stands for	N excretion of animals by type
$AMWS_{(T)}$	stands for	fraction of $Nex_{(T)}$ that is managed in one of the different distinguished animal waste management systems
T	stands for	type of animal category

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

where

$N_2O_{(AWMS)}$	stands for	N ₂ O emissions from all Animal Waste Management Systems (kg N/yr)
$Nex_{(AWMS)}$	stands for	N excretion per Animal Waste Management System (kg/yr)
EF_3	stands for	emission factor

Nitrous oxide (N₂O) emissions from Manure management for the period from 1990 to 2011 are presented in Figure 6.4-1. The emission trend depends on the animal population trend.

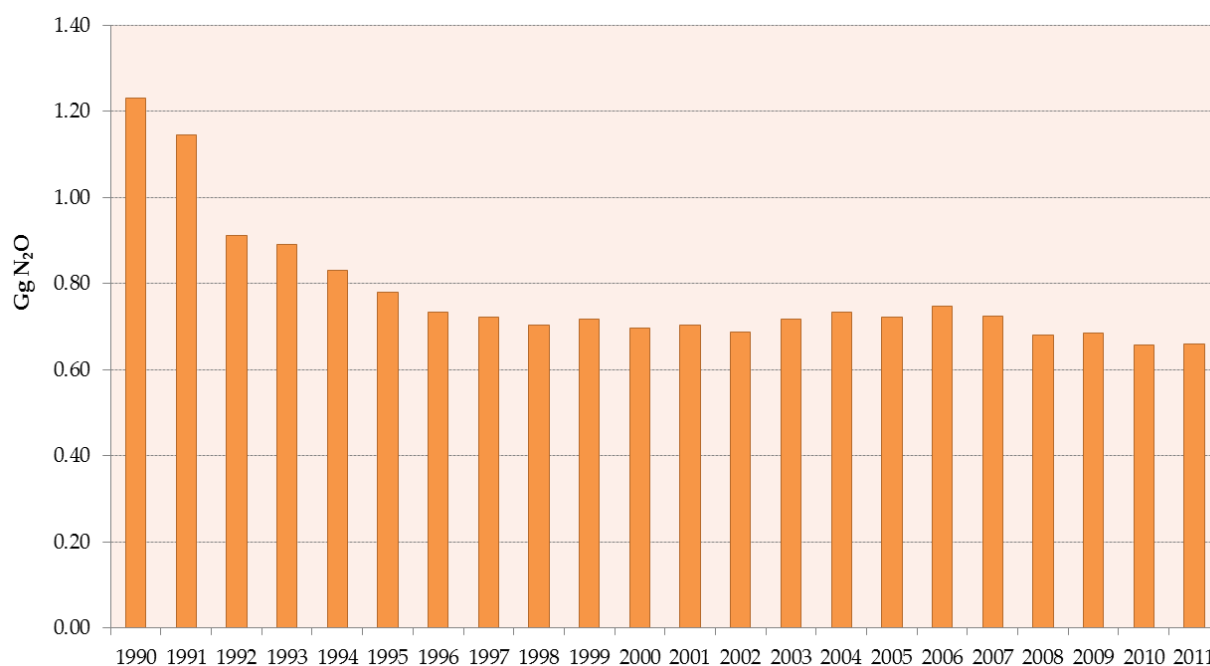


Figure 6.4-1: N₂O Emissions from Manure management

Activity data regarding livestock population are the same as for the calculation of CH₄ emission from Enteric fermentation and Manure management. Nitrogen excretion per each manure management system and emission factors were taken from the 1996 IPCC Reference Manual, and presented in Table 6.4-1.

Table 6.4-1: Manure management emission factors for each animal category and AWMS

Livestock Type	Nitrogen Excretion Nex kg/head/(yr)	Fraction of Manure Nitrogen per AWMS (%/100)					
		Anaerobic lagoon	Liquid system	Daily spread	Solid storage and drylot	Pasture range and paddock	Other systems
Non-dairy Cattle	50	8%	39%	52%	0%	0%	1%
Dairy Cattle	70	0	18%	68%	1%	13%	0%
Poultry	0.6	0	28%	0%	0%	1%	71%
Sheep	16	0	0	0	0	73%	27%
Swine	20	0	29%	0%	0%	27%	45%
Goats	25	0	0	0	0	92%	8%
Horses and Mules/Asses	25	0	0	0	0	92%	8%

6.4.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis (detailed in Annex 5, Tables A5-1, A5-2). Uncertainty estimate associated with livestock activity data is based on the

authority of the AD source ($\pm 10\%$ for high authority CBS source, $\pm 30\%$ for FAO and other data), observing annual variation in AD and of periodic revisions of the AD. Uncertainty for N excretion rates is default IPPC value of $\pm 50\%$. Uncertainty of emission factors is within the range -50% to $+100\%$.

6.4.4. CATEGORY-SPECIFIC QA/QC AND VERIFICATION

During the preparation of inventory submission, activity data regarding animal population for the entire time series were checked and revised if found necessary. Therefore, activities related to quality control were focused on completeness and consistency of emission estimates and also on the proper use of notation keys in the CRF tables. After a final draft of this chapter was prepared, 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 inventory preparation, despite the fact that formal QC procedures were not prepared.

6.4.5. SOURCE SPECIFIC RECALCULATIONS

Methane emissions from Enteric fermentation were recalculated for the years 2007 and 2008 due to changes in activity data (number of dairy cows) and changes in CBS methodology for the cattle subcategorization (Table 6.2-3). This reclassification of older data accounts for a slight change in the number of cattle within individual Tier II categories.

6.4.6. SOURCE SPECIFIC PLANNED IMPROVEMENT

Short term goals (1 year) are as follows:

- Reconciliation of the discrepancy regarding the usage of IPPC default EFs for developing countries for the period 1990-2007 and default EFs for developed countries for the period 2009-2011 for the estimation of emissions from manure management (sheep, goats, horses, mules and asses, swine and poultry).

Planned improvements which are assumed to be mid-term or long-term goals (over 1 year) are:

- The development of national emission factors for the calculation of CH_4 emission from manure management.
- Development of Tier 2 estimates for the emission calculation for cattle and swine.
- Continued improvements and investigation of activity data (mineral fertilizer, crop production, livestock population numbers) with the purpose of more detailed explanation of the activity data trends and further verification of source data.

6.5. RICE CULTIVATION (CRF 4.C.)

6.5.1. SOURCE CATEGORY DESCRIPTION

Anaerobic decomposition of organic material in flooded rice fields produces methane (CH₄) which escapes into the atmosphere by diffusive transport through the plants during the growing season.

Rice cultivation does not occur in Croatia, so there is no possible emissions from this source.

6.6. 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 N₂O emitted.

Three sources of nitrous oxide emissions are distinguished:

- Direct emissions of N₂O from agricultural soils (CRF 4.D.1.)
- Direct N₂O emission from pasture, range and paddock manure (CRF 4.D.2.)
- Indirect N₂O Emissions from Nitrogen Used in Agriculture (CRF 4.D.3.)

Major part of emission comes directly from 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), nitrogen from agricultural residues and the treatment of histosols. Emissions of nitrous oxide (N₂O) from Agricultural soils for the period from 1990 to 2011 are presented in Figure 6.6-1. Emissions from Agricultural soils decreased after 1990 and during the war due to specific national circumstances and limited agricultural practice at that time. Afterwards, the emission trend is mostly influenced by the changes in the direct soil emissions. In 1997, 2001 and 2002 direct soil emissions increased due to the increase in mineral fertilizer consumption (1997, 2001) and also due to the increase in crop production (2002). In the period from 2004-2008, emission increased in comparison to 2003 due to increases in mineral fertilizer consumption, number of animals and crop production. Emissions for the years 2009 and 2010 continue on a declining trend, mostly related to economic recession, while the year 2011 shows a slight increase again, due to increase in mineral fertilizer consumption.

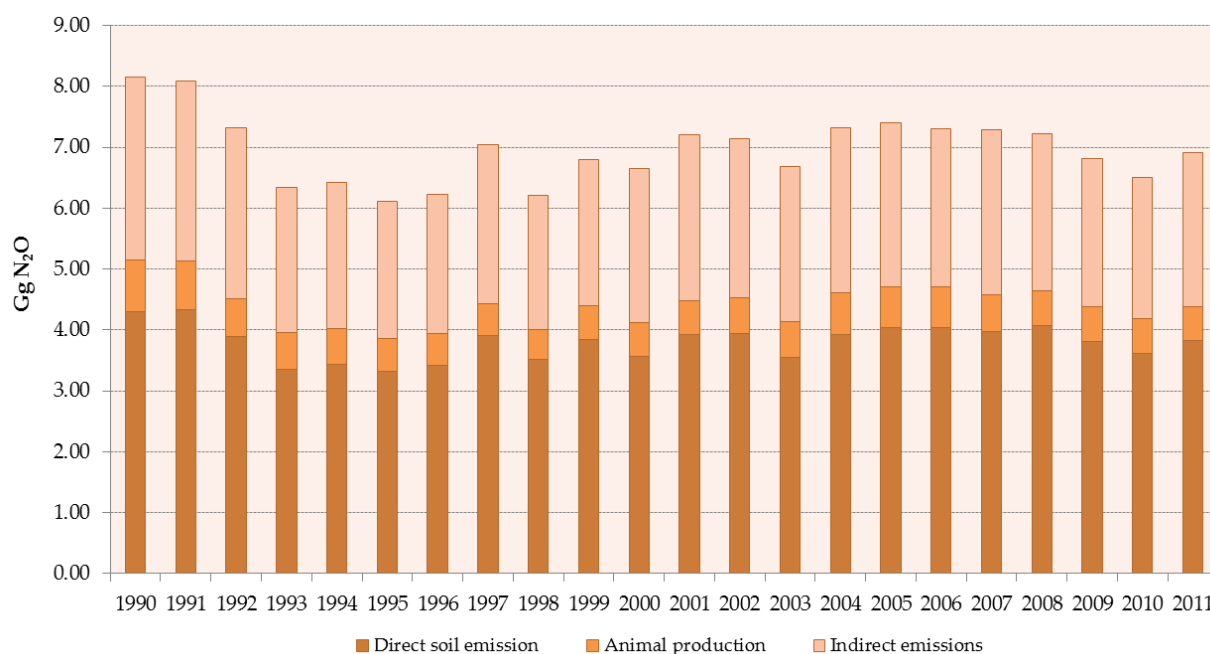


Figure 6.6-1: Total N₂O emissions from Agricultural soils

6.6.1. DIRECT EMISSION FROM AGRICULTURAL SOILS (CRF 4.D.1.)

6.6.1.1. Source category description

Direct N₂O emissions from agricultural soils include total amount of nitrogen applied to soils through cropping practices. These practices include application of synthetic fertilizer, nitrogen from animal waste, production of nitrogen – fixing crops, nitrogen from crop residue mineralization, soil nitrogen mineralization due to cultivation of histosols and nitrogen from sludge applied to soils. Input data required for this part of the calculation are the following:

- annual amount of the synthetic fertilizer applied
- the amount of organic fertilizer applied
- the head of animals by category
- the biomass of leguminous plants and soyabean
- the area of histosols
- annual amount of sludge applied

Direct emission from agricultural soils is calculated by the following equation:

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

where

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

Direct Emissions of N_2O from Agricultural soils for the period from 1990 to 2011 are shown in Figure 6.6-2. Emission trend is also dependent on mineral fertilizer consumption, number of animals and crop production which is already explained in related chapters where activity data trends are provided.

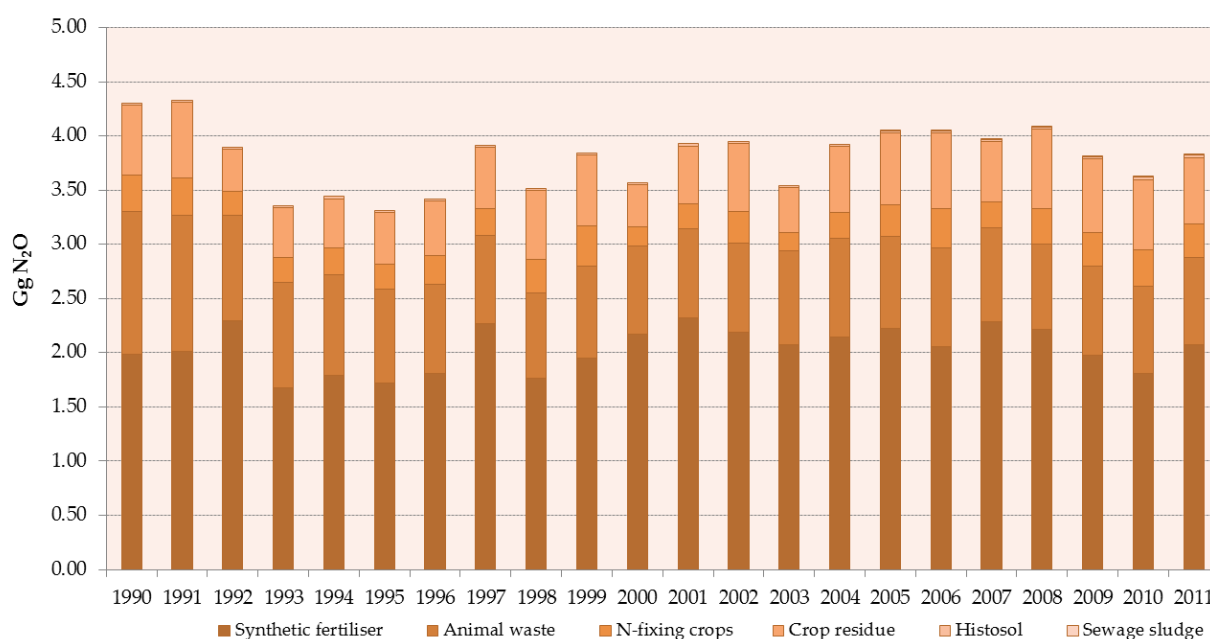


Figure 6.6-2: Direct N_2O emissions from Agricultural soils

6.6.1.2. Methodological issues

In order to calculate emission from Agricultural Soils, the IPCC methodology (Tier 1) has been used. Emission factors were taken from the *Revised 1996 IPCC Reference Manual and IPCC Good Practice Guidance 2000*.

Nitrous oxide from mineral fertilisers

This estimate is based on the amount of N in mineral fertiliser that is annually consumed in the Republic of Croatia. Data on the consumption of mineral fertilisers that are produced and applied in Croatia were obtained from companies that produces synthetic fertilizers for the time period 1992-2011. Data on mineral fertilizers produced and applied in Croatia in 1990 and 1991 have been estimated by extrapolation method using pattern from 1992 to 2006. Data on import before the year 2000 are negligible due to tariffs which were eliminated in 2000. Activity data on amounts of different mineral fertilizer types applied to soils for the entire period from 1990-2011 is presented in Figure 6.6-3 while the nitrogen applied in the same period is shown in Table 6.6-1. Nitrogen dispersed into the atmosphere in the form of NH_3 and NO_x was subtracted from the total estimated quantity of emitted nitrogen N.

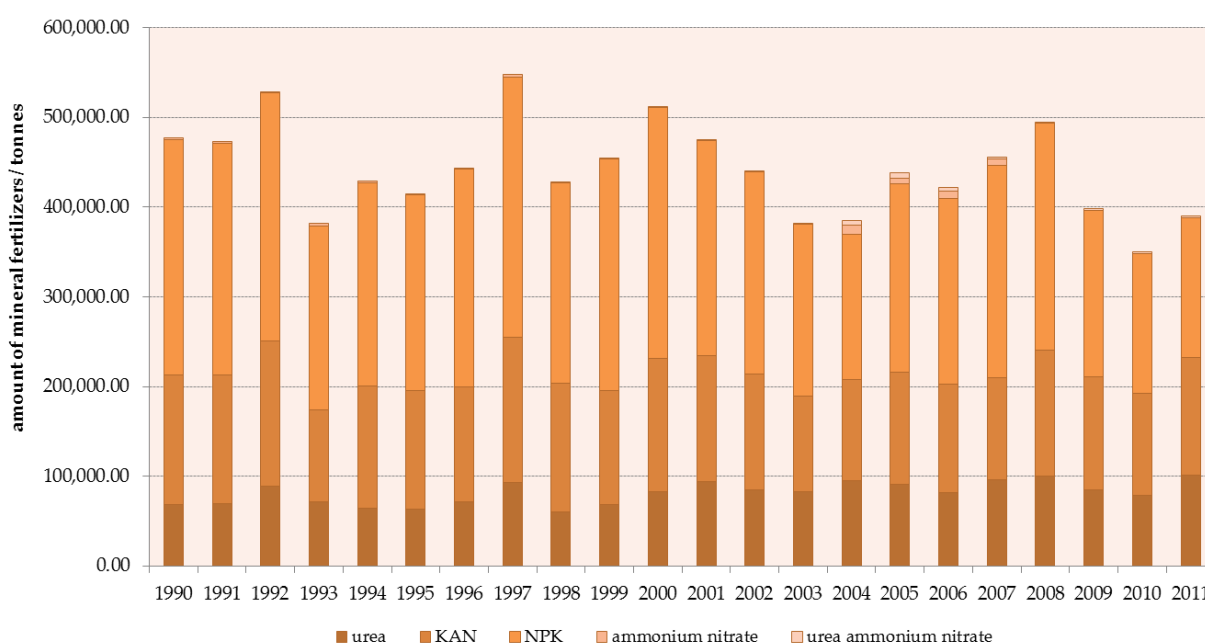


Figure 6.6-3: Mineral fertilizers applied to soil in the period from 1990-2010

Over the years, the consumption of mineral fertilizers fluctuates depending on the prices of the agricultural products. The consumption refers to the amounts produced and sold within the country and imported amounts. Regarding the domestic production for domestic consumption, low consumption in 1993 is recorded due to the war which obstructed the agricultural practice around the country while in 2009 it was caused by the drastic decrease of prices related to agricultural products. Only calcium ammonium nitrate (KAN) stayed at the same level (being the cheapest fertilizer). The consumption trend of this type of mineral fertilizer is decreasing in the period from 1992-2009 although from 2000 onwards is almost stationary. As for urea, its consumption increased from 1998-2008, then started fluctuating but on a overall higher level. NPK has the highest decreasing trend in the period from 2000-2004 which is a reflection of the economic position of agricultural producers. Recent drop of NPK usage is in correlation with the overall state of economic recession. The consumption of mineral fertilizers peaked in 2007 and was high in 2008 up to the last quarter and was characterized with high

prices of agricultural products. The imported amounts were the highest in 2004 because at that time the fertilizer prices decreased in the region while the lowest imported amounts were recorded for 2008.

Table 6.6-1: Nitrogen applied in the period from 1990-2011

Year	Nitrogen applied / tonnes					
	Urea	Calcium ammonium nitrate	NPK	Ammonium nitrate	Urea ammonium nitrate	TOTAL
1990	31,376	39,030	36,286	721	0	107,413
1991	31,957	38,643	37,442	672	0	108,715
1992	41,094	43,521	39,921	282	0	124,818
1993	32,706	27,744	29,856	1,054	0	91,359
1994	29,839	36,708	29,815	549	0	96,911
1995	29,039	35,701	28,396	280	0	93,416
1996	32,894	34,645	30,769	82	0	98,389
1997	42,898	43,609	35,924	921	0	123,352
1998	27,756	38,791	28,359	341	0	95,246
1999	31,669	34,221	39,496	235	0	105,621
2000	38,180	39,922	39,862	42	0	118,005
2001	57,769	37,933	32,341	300	0	128,343
2002	50,656	38,066	31,651	97	0	120,469
2003	42,176	31,017	33,361	5,203	1,863	113,621
2004	45,109	32,070	33,626	5,126	1,647	117,579
2005	41,940	36,265	36,439	4,983	1,683	121,309
2006	37,505	36,121	34,055	2,730	1,390	111,802
2007	44,424	37,701	38,343	3,416	777	124,661
2008	46,659	39,456	34,110	333	590	121,148
2009	39,667	36,486	31,102	19	737	108,011
2010	40,999	34,812	23,197	21	498	99,526
2011	51,675	35,651	26,631	18	604	114,579

Data on the fraction of synthetic fertilizer nitrogen applied to soils that volatilises as NH_3 and NO_x were obtained from EMEP/EEA Emission Inventory Guidebook (2007) for each fertilizer type (see Table 6.6-2).

Table 6.6-2: Nitrogen fraction emitted as NH_3 and NO_x

Fertilizer type	Fraction of N emitted as NH_3 and NO_x
Urea	0.15
calcium ammonium nitrate (KAN)	0.02
NPK	0.02
Ammonium nitrate	0.02
Urea ammonium nitrate	0.08

The emission of nitrous oxide was then calculated by multiplying the quantity of the remaining N with emission factor 0.0125 kg N₂O-N/kg N (Revised 1996 IPCC Guidelines).

Nitrous oxide from animal manure and liquid/slurry

The estimate is based on the amount of N in solid and liquid manure/slurry which is annually used for crop fertilization. Of the total estimated quantity of emitted nitrogen, the N that is emitted on pasture (Frac_{GRAZ}) and N that is dispersed into the atmosphere in the form of NH₃ and NO_x (Frac_{GASM}) was subtracted. For Frac_{GASM}, default value of 20% was used from Table 4-19 in the IPCC Reference Manual for the entire period. As for the Frac_{GRAZ}, the values were calculated as ratios of N excreted during grazing and total N excretion. The latter is as follows:

Year	Frac _{GRAZ}
1990	0.242597
1991	0.243235
1992	0.242183
1993	0.237468
1994	0.239793
1995	0.238328
1996	0.241126
1997	0.244305
1998	0.240604
1999	0.246151
2000	0.250735
2001	0.251589
2002	0.260838
2003	0.254671
2004	0.273151
2005	0.283515
2006	0.264639
2007	0.2620236
2008	0.261985
2009	0.25744
2010	0.260452
2011	0.2600051

Emission of nitrous oxide was then calculated by multiplying the quantity of the remaining N with emission factor 0.0125 kg N₂O-N/kg N (Revised 1996 IPCC Guidelines).

Nitrous oxide from biological fixation of N

Tier 1b method was used in calculation of nitrous oxide emission due to biological fixation of N. The estimate is based on the amount of N-fixing crops produced in the country as dry biomass. The data on the production were obtained from the Central Bureau of Statistics, FAO database and for certain years by extrapolation (see Table 6.6-3). National data (provided by Croatian CBS) are considered to be the most accurate source and was always used when available. For crops where national data was not available, FAO data was considered an adequate replacement source. Where only a part of the national dataset was missing for a specific crop, trend of FAO data was found to be inline with the national data trends and was used for the missing years rather than interpolation. Extrapolation was used only where no national or FAO data was available.

Table 6.6-3: Data sources regarding N-fixing crop production

Crop	CBS	FAO	Extrapolation*
Soyabeans	1990-2011		
Beans, dry	1990-2011		
Cow peas, dry	2008-2011	1992-2007	1990-1991
Lentils		1992-2009	1990-1991
Peas, dry	2008-2011	1992-2007	1990-1991
Vetches		1992-2009	1990-1991
Clover	1990-2011		
Alfaalfa	1990-2011		

*Extrapolation was based on data for the period 1992-1995.

Activity data related to production of N-fixing crops is presented in Table 6.6-4.

Table 6.6-4: Production of N-fixing crops in the period from 1990 – 2011

Year	Production of N-fixing crops / tonnes			
	Soyabeans	Beans, dry	Cow peas, dry	Lentils
1990	55,461	18,437	1,790	219
1991	56,365	21,949	1,521	199
1992	46,129	15,961	895	155
1993	49,456	17,588	1,651	180
1994	44,127	20,596	441	167
1995	34,319	21,844	400	92
1996	35,896	20,221	368	123
1997	39,469	20,527	373	135
1998	77,458	21,003	384	139
1999	115,853	22,291	400	148
2000	65,299	2,657	300	143
2001	91,841	4,421	400	130
2002	129,470	5,163	400	152

2003	82,591	4,967	400	105
2004	97,923	4,459	400	106
2005	119,602	6,041	338	108
2006	174,214	4,058	400	140
2007	90,637	2,503	400	100
2008	107,558	3,263	1,149	41
2009	115,159	2,460	1,468	74
2010	153,580	1,641	1,197	29
2011	147,271	1,059	1,939	82

Table 6.6-4: Production of N-fixing crops in the period from 1990 – 2011 (cont.)

Year	Production of N-fixing crops / tonnes			
	Peas, dry	Vetches	Clover	Alfaalfa
1990	535	1,888	225,466	252,563
1991	554	2,005	226,546	251,486
1992	812	2,125	129,747	142,613
1993	337	2,160	136,012	137,225
1994	400	2,509	155,087	162,457
1995	853	2,400	143,910	158,557
1996	611	2,207	165,973	188,462
1997	577	2,237	157,559	179,669
1998	746	2,305	158,516	201,778
1999	824	2,400	167,266	223,387
2000	650	2,400	100,179	85,575
2001	739	2,300	115,709	98,305
2002	886	2,690	131,103	107,815
2003	1,335	1,851	51,890	72,056
2004	1,100	1,840	124,813	103,555
2005	893	1,363	125,460	147,272
2006	715	2,400	121,411	162,694
2007	670	2,300	111,675	137,291
2008	870	2,996	176,089	196,244
2009	955	2,000	147,763	174,274
2010	340	1,838	119,968	177,652
2011	696	1,636	105,075	153,240

By comparing all trends, highest fluctuations can be noticed in regard to dry cow peas, dry peas and soyabeans. Production of dry cow peas and dry peas is obtained from several different sources which resulted in aforementioned fluctuation. Years 2000 and 2003 were very hot and dry which had a negative effect on soyabeans production along with the changes in seed market. Related fluctuations between 2006 and 2007 are caused by changes in harvested area and yield per hectare.

Data on dry matter fraction, residue/crop ratio and N fraction used in emission calculation as well as their sources are presented in the Table 6.6-5.

Main sources of data on dry matter fraction, residue/crop ratio and N fraction were

- Default GPG values
- Slovenian NIR – selected due to high similarities of growing conditions

Table 6.6-5: Dry matter fraction, residue/crop ratio and N fraction for N-fixing crops

Crop	dry matter fraction	residue/crop ratio	N fraction
Soyabeans	0.86	2.10	0.023
Beans, dry	0.895	2.10	0.03
Cow peas, dry	0.85	1.50	0.014
Lentils	0.85	1.00	0.03
Peas, dry	0.87	1.50	0.0142
Vetches	0.85	1.00	0.03
Clover	0.85	0.00	0.03
Alfaalfa	0.85	0.00	0.03

 GPG and Guidelines default values

 Values from Slovenian NIR

Emission of nitrous oxide was then calculated by multiplying the quantity of the remaining N with emission factor 0.0125 kg N₂O-N/kg N (Revised 1996 IPCC Guidelines).

Emissions of nitrous oxide from crop residue

The estimate is based on a more accurate methodology recommended by the GPG 2000. The basic step in the process is to estimate the amount of crop residue nitrogen that is incorporated in soils for both non-nitrogen-fixing crops and N-fixing crops. In order to do so, a modified approach is used (Tier 1b).

Data on the production of non N-fixing crops were obtained from the Central Bureau of Statistics and/or FAO database. National data (provided by Croatian CBS) are considered to be the most accurate source and was always used when available. For crops where national data was not available, FAO data was considered an adequate replacement source. Where only a part of the national dataset was missing for a specific crop, trend of FAO data was found to be inline with the national data trends and was used for the missing years rather than interpolation. See Table 6.6-6 for details.

As for additional uses of crop residues, in Croatia alfalfa and clover are used as fodder. Field burning of crop residues is prohibited by law; therefore fraction of crop residue burnt is set as NO.

Table 6.6-6: Data sources regarding non N-fixing crop production

Crop	CBS	FAO
Wheat	1990-2011	
Maize	1990-2011	
Potatoes	1990-2011	
Sugar beets	1990-2011	
Tobacco	1990-2011	
Sunflowers	1990-2011	
Rape seed	1990-2011	
Tomatoes	1990-2011	
Barley	1990-2011	
Oats	1990-1991; 2000-2011	1992-1999
Cabbages and other brassicas	1990-2011	
Garlic**	1990-2011	
Onions**	1990-2011	
Rye	1990-2011	
Sorghum	1990-1997*	1998-2011
Watermelons	1990-2011	

*CBS stopped obtaining sorghum production data after 1997

**CBS provides aggregated data for garlic & onions. FAO data was used to calculate yearly ratios of garlic and onions in the total, aggregated number.

Activity data related to production of non N-fixing crops is presented in Table 6.6-7.

Table 6.6-7: Production of non N-fixing crops in the period from 1990 – 2011

Year	Production of non N-fixing crops / tonnes				
	Wheat	Maize	Potatoes	Sugar beets	Tobacco
1990	1,602,435	1,950,011	610,236	1,205,928	12,394
1991	1,495,625	2,387,533	658,687	1,244,439	10,460
1992	658,019	1,357,663	480,079	525,189	11,651
1993	886,921	1,671,819	507,898	537,196	9,585
1994	750,330	1,686,922	563,285	591,819	8,613
1995	876,507	1,735,854	692,216	690,707	8,548
1996	741,235	1,885,515	666,020	906,246	11,272
1997	833,508	2,183,144	620,032	931,186	11,339
1998	1,020,045	1,982,545	664,753	1,233,322	12,133
1999	558,217	2,135,452	728,646	1,113,969	10,051
2000	865,260	1,190,238	198,243	482,211	9,714
2001	811,674	1,733,003	242,709	964,880	10,502
2002	822,650	1,956,418	266,055	1,183,445	10,905

2003	506,212	1,279,617	164,051	677,569	9,680
2004	801,424	1,931,627	247,057	1,260,444	10,293
2005	601,748	2,206,729	273,409	1,337,750	9,579
2006	804,601	1,934,517	274,529	1,559,737	10,851
2007	812,347	1,424,599	296,302	1,582,606	12,639
2008	858,333	2,504,940	255,554	1,269,536	12,866
2009	936,076	2,182,521	270,251	1,217,041	13,348
2010	681,017	2,067,815	178,611	1,249,151	8,491
2011	782,499	1,733,664	167,524	1,168,015	10,643

Table 6.6-7: Production of non N-fixing crops in the period from 1990 – 2011 (cont.)

Year	Production of non N-fixing crops / tonnes				
	Sunflowers	Rape seed	Tomatoes	Barley	Oats
1990	52,982	33,200	54,742	196,554	62,287
1991	46,430	22,816	48,601	185,695	53,851
1992	40,413	24,183	35,262	106,811	45,262
1993	42,723	28,665	39,771	125,671	41,074
1994	26,474	28,341	46,276	107,810	42,425
1995	37,066	24,472	46,958	103,281	38,237
1996	28,526	11,661	49,019	88,091	39,529
1997	36,138	11,181	48,085	108,496	46,796
1998	62,206	21,967	62,003	143,510	56,110
1999	72,374	32,581	70,816	124,890	56,823
2000	53,956	29,436	26,081	179,652	61,604
2001	42,985	22,456	27,272	192,067	71,632
2002	62,965	25,585	25,988	206,478	74,187
2003	69,253	28,596	22,942	160,203	53,025
2004	68,973	31,392	25,938	237,603	73,462
2005	78,006	41,275	28,930	162,530	49,470
2006	81,614	19,996	29,027	215,262	66,630
2007	54,303	39,330	48,040	225,265	56,150
2008	119,872	62,942	32,358	279,106	65,328
2009	82,098	80,424	37,419	243,609	62,297
2010	61,789	33,047	33,648	172,359	48,190
2011	84,960	49,483	35,798	193,961	77,223

Table 6.6-7: Production of non N-fixing crops in the period from 1990 – 2011 (cont.)

Year	Production of non N-fixing crops / tonnes					
	Cabbages and other brassicas	Garlic	Onions	Rye	Sorghum	Watermelons
1990	135,637	11,830	40,309	15,840	2,185	20,938
1991	129,437	10,471	38,488	14,069	1,858	17,941
1992	75,981	6,744	28,717	6,069	633	8,062
1993	88,933	7,345	31,081	6,273	678	8,014
1994	104,178	9,346	40,896	7,146	618	16,045
1995	125,874	9,384	43,010	5,051	559	21,384
1996	131,563	8,967	39,274	5,517	466	26,901
1997	143,549	9,002	43,776	5,009	547	25,450
1998	144,298	10,624	51,662	5,530	540	60,243
1999	160,170	10,277	55,633	6,246	485	53,437
2000	36,887	2,553	14,166	7,236	466	25,802
2001	35,570	3,069	18,000	10,796	571	25,837
2002	40,357	2,908	17,385	9,207	626	28,210
2003	38,814	2,609	15,393	5,967	396	16,988
2004	36,127	2,888	17,523	8,994	527	24,237
2005	53,399	3,741	22,059	4,737	600	28,852
2006	52,851	3,445	20,381	5,487	800	26,549
2007	43,582	5,250	31,097	4,364	1,200	30,193
2008	62,820	5,100	30,601	4,079	760	35,608
2009	77,004	5,105	30,529	2,860	1,130	44,175
2010	45,654	3,659	26,704	2,507	1000	23,313
2011	36,877	2,728	19,569	2,949	1,280	19,902

Higher fluctuations in trend have been noticed for sunflower, tomato and rape seed. The latter is primarily caused by changes in harvested area and in some cases changes in yield per hectare.

Tier 1b includes crop specific data on the ratio of aboveground biomass to crop product mass (residue/crop ratio), dry matter fraction and N fraction (see Tables 6.6-5 and 6.6-8). Dry matter fraction needed to be incorporated so that adjustments for moisture contents could be made. Moreover, Crop_{BF} should represent all N-fixing crops not just the seed yield of pulses and soybeans.

Main sources of data on dry matter fraction, residue/crop ratio and N fraction were

- Default GPG values
- Slovenian, Portuguese and Hungarian NIR – selected due to the similarities and comparability of growing conditions
- Values based on the expert judgement of the Faculty of Agriculture

Table 6.6-8: Dry matter fraction, residue/crop ratio and N fraction for non N-fixing crops

Crop	dry matter fraction	residue/crop ratio	N fraction
Wheat	0.86	1.30	0.0028
Maize	0.86	1.00	0.0081
Potatoes	0.30	0.40	0.011
Sugar beets	0.25	1.40	0.015
Tobacco	0.89	1.00	0.015
Sunflowers	0.92	1.30	0.015
Rape seed	0.90	1.00	0.015
Tomatoes	0.063	1.00	0.015
Barley	0.86	1.20	0.0043
Oats	0.92	1.30	0.007
Cabbages and other brassicas	0.135	0.10	0.0027
Garlic	0.354	1.00	0.0150
Onions, dry	0.142	1.00	0.0150
Rye	0.900	1.60	0.0048
Sorghum	0.910	1.40	0.0108
Watermelons and melons	0.850	0.40	0.0110

 GPG default values

 Values based on expert judgement (Faculty of Agriculture)

 Values from Slovenian NIR

 Values from Portuguese NIR

 Values from Hungarian NIR

N in crop residues returned to soils (F_{CR}) is calculated according to equation 4.29 from GPG 2000. Furthermore, emission of nitrous oxide was calculated by multiplying the quantity of the remaining N with emission factor 0.0125 kg N_2O -N/kg N (Revised 1996 IPCC Guidelines - no change in the GPG 2000).

Emissions of nitrous oxide due to cultivation of organic soils

Cultivation of soils with high content of organic material causes the release of a long term bounded N. New activity data regarding the area of histosols in the Republic of Croatia have been obtained from the Croatian Environment Agency based on the results of a project performed in cooperation with experts from the Faculty of Agronomy, University of Zagreb. The distribution of histosols was revised based on pedological maps (scale 1:50000) and CORINE Land Cover database (CLC). Pedological maps were used to obtain information on total national histosol area, and CLC data was then overlayed in order to obtain area of histosol that is under cultivation. Resulting total histosol area relating to agricultural land is 1.473,8 ha. Based on Faculty of Agronomy expert judgment this value is accurate on a national level and can be used for each year in the entire

period from 1990-2011 since no land use change in CLC database has occurred over histosol area from 1980 to 2006.

Emission of nitrous oxide, due to cultivation of histosols, was then calculated by multiplying the area of histosols with the emission factor 8 kg N/ha/yr. The emission factor represents an updated default value for mid-latitude organic soils (GPG 2000).

Emissions of nitrous oxide due to application of sewage sludge

Emissions of nitrous oxide from sludge input were included for the first time in NIR 2012. Sufficient activity data was provided for the period 2005-2011, while for the period 1990-2004 no data was provided or could be estimated. The current AD set is limited to one company that started to operate in the year 2005 and the resulting sludge is the result of their production process, there is no driver that can be used to obtain relevant data prior to that year. Sewage sludge nitrogen was included and calculated according to direct N₂O emissions from agricultural soils equation 4.20 (GPG 2000).

Table 6.6-10: Amount of sludge and nitrogen percentage applied

Year	Amount of sludge applied (tons dry matter)	Nitrogen percentage (N % in dry matter mass)
2005	3	0.11
2006	6	0.11
2007	7	0.11
2008	16	0.11
2009	24	0.11
2010	30.5	0.11
2011	28.4	0.11

6.6.1.3. Uncertainties and time-series consistency

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis (detailed in Annex 5, Tables A5-1, A5-2). Uncertainty estimates are based on expert judgement. Uncertainty of activity data is within the range from -30% to 0% for mineral fertilizers, $\pm 10\%$ for animal manure, N-fixing crops and crop residues while for histosols it is $\pm 20\%$. The expert judgement used for the uncertainty of the AD is based on the authority of the AD source (lower uncertainty for high authority CBS source, higher for FAO and other data), observing annual variation in AD and of periodic revisions of the AD. Uncertainty of emission factors amounts $\pm 80\%$ for mineral fertilizers, animal manure, N-fixing crops and crop residues while for histosols it is $\pm 60\%$. Direct N₂O emissions from agricultural soils have been calculated using the same method and data sets for every year in the time series.

6.6.1.4. Category-specific QA/QC and verification

During the preparation of inventory submission, activity data for the entire time series were checked and revised if found necessary, including the FAO data. National Inventory Reports of countries with similar climate and soil conditions were consulted and checked for values on dry matter fraction, residue/crop ratio and N fraction for non N-fixing crops. Therefore, activities related to quality control were focused on completeness and consistency of emission estimates. After a final draft of this chapter was prepared, 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 inventory preparation, despite the fact that formal QC procedures were not prepared.

6.6.1.5. Source specific recalculations

N₂O emissions originating from mineral fertilizers

During a consultation meeting that included representatives of fertilizer producers, a minor mistake was found in the activity data for the time period 2004-2010 regarding the percentage of nitrogen in several complex (NPK) fertilizer formulations. In addition, a mistake in activity data was found in the data given by one of the fertilizer producers. Data on NPK fertilizer production for the period 2006 - 2010 was given in kilograms instead of required tonnes, resulting in 1000 times larger numbers.

Corrections that were performed resulted in different N percentage values and amount of total nitrogen applied, thus recalculation of N₂O emissions from mineral fertilizers was performed for the aforementioned time period.

N₂O emissions originating from biological fixation of nitrogen and crop residue

Recalculations were performed in the year 2010 due to the change in activity data for the vetches and sorghum crops.

6.6.1.6. Source specific planned improvement

Short term goals (1 year) are as follows:

- Improvements and investigation of activity data (mineral fertilizer, crop production) with the purpose of more detailed explanation of the activity data trends and verification of source data.
- Collecting relevant data from the Central Bureau of Statistic and other national institutions in order to provide additional detail on sourcing of AD and improve transparency.

Planned improvements which are assumed to be mid-term or long-term goals (over 1 year) are:

- Investigation of the difference in statistical data of mineral fertilizer usage that is leading to the possible overestimation of direct N₂O emissions from the Agricultural Soils .
- Continued improvements and investigation of activity data (mineral fertilizer, crop production) with the purpose of more detailed explanation of the activity data trends and further verification of source data.

Note regarding direct N₂O emissions from agricultural soils from the usage of sewage sludge:

During the in-country ERT review in the year 2012, it was recommended to attempt to get the missing AD values for the period 1990-2004 using drivers. However, since the current AD set is limited to one company that started to operate in the year 2005 and the resulting sludge is the result of their production process, there is no driver that can be used to obtain relevant data prior to the year 2005. Both short and long term improvements regarding the emission for this source are continued improvements and investigation of activity data in order to provide a correct estimate for the period 1990-2004.

6.6.2. DIRECT N₂O EMISSION FROM PASTURE, RANGE AND PADDOCK MANURE (CRF 4.D.2.)

6.6.2.1. Methodological issues

Estimates of N₂O emissions from animals were based on animal waste deposited directly on soils by animals on pasture, range and paddock. N₂O emissions from animals can be calculated as follows:

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

where

N ₂ O _{animals}	stands for	N ₂ O emissions from animal production (kg N/yr)
N ₂ O _(AWMS)	stands for	N ₂ O emissions from Animal Waste Management Systems (kg N/yr)
N _(T)	stands for	number of animals of type T
Nex _(T)	stands for	N excretion of animals of type T (kg N/animal/yr)
AWMS _(T)	stands for	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)}	stands for	emission factor

The same emission factor (0.02 kg N₂O-N/kg of emitted N), recommended by the Revised 1996 IPCC Guidelines, was used for all grazing animals regardless of their species and climatic conditions. Direct N₂O emissions from Pasture, range and paddock manure for the period from 1990 to 2010 are shown in the Figure 6.6-4. The emission trend follows the animal population trend.

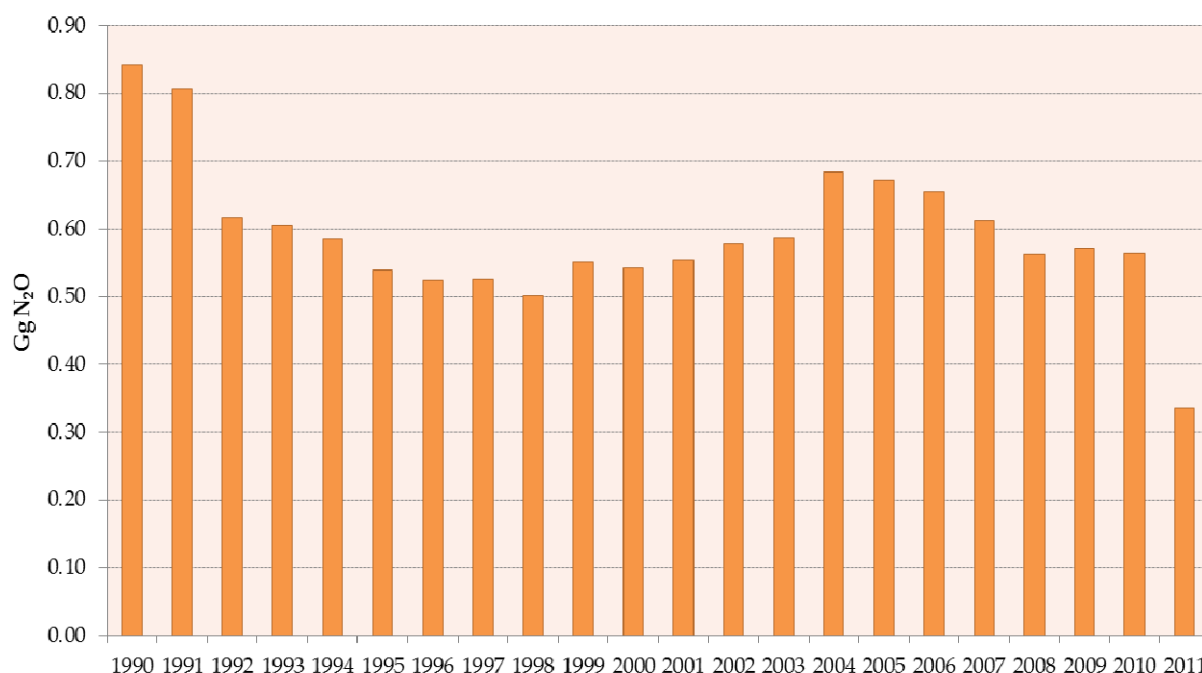


Figure 6.6-4: Direct N₂O emissions from animal production

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data amounts ± 10 to ± 30 percent, based on expert judgements. The expert judgement used for the uncertainty of the AD is based on the authority of the AD source (lower uncertainty for high authority CBS source, higher for FAO and other data), observing annual variation in AD and of periodic revisions of the AD. Uncertainty of emission factors is within the range of -75% to +50%.

Direct N₂O emissions from Pasture, Range and Paddock Manure have been calculated using the same method and data sets for every year in the time series.

6.6.2.2. Uncertainties and time-series consistency

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis (detailed in Annex 5, Tables A5-1, A5-2). Uncertainty estimates are based on expert judgement. Uncertainty of activity data is within the range from -30% to 0% for mineral fertilizers, $\pm 10\%$ for animal manure, N-fixing crops and crop residues while for histosols it is $\pm 20\%$. The expert judgement used for the uncertainty of the AD is based on the authority of the AD source (lower uncertainty for high authority CBS source, higher for FAO and other data), observing annual variation in AD and of periodic revisions of the AD. Uncertainty of emission factors amounts $\pm 80\%$ for mineral fertilizers, animal manure, N-fixing crops and crop residues while for histosols it is $\pm 60\%$. Direct N₂O emissions from agricultural soils have been calculated using the same method and data sets for every year in the time series.

6.6.2.3. Category-specific QA/QC and verification

There is no category-specific information, QA/QC for this category is shared and presented in the 4.B. *Emissions from Manure Management* category (Chapter 6.3.4).

6.6.2.4. Source specific recalculations

No recalculations were performed.

6.6.2.5. Source specific planned improvement

Goals of the planned improvements in this category are shared with the planned improvements for the 4.A. *Emission from Enteric Fermentation* (Chapter 6.2.5) and 4.B. *Emissions from Manure Management* (Chapter 6.4.5)

6.6.3. INDIRECT N₂O EMISSIONS FROM NITROGEN USED IN AGRICULTURE (CRF 4.D.1.)

6.6.3.1. Source category description

Calculations of indirect N₂O emission from nitrogen used in agriculture are based on two pathways. These are: volatilization and subsequent atmospheric deposition of NH₃ and NO_x (originating from the application of fertilizers and animal manure) and leaching and runoff of the nitrogen that is applied to or deposited on soils. These two indirect emission pathways are treated separately, although activity data used are identical. The indirect emission of N₂O from the agriculture is calculated using the following equation:

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

where

N ₂ O _{indirect}	stands for	indirect N ₂ O emissions (kg N/yr)
N ₂ O _(g)	stands for	N ₂ O emissions due to atmospheric deposition of NH ₃ and NO _x (kg N/yr)
N ₂ O _(L)	stands for	N ₂ O emissions due to nitrogen leaching and runoff (kg N/yr)

Emissions of N₂O produced from the discharge of human sewage N into rivers are reported under the sector waste.

Indirect emission of N₂O from agriculture sector for the period from 1990 to 2011 is shown in Figure 6.6-5. The emission trend is influenced by the mineral fertilizer consumption and animal population altogether.

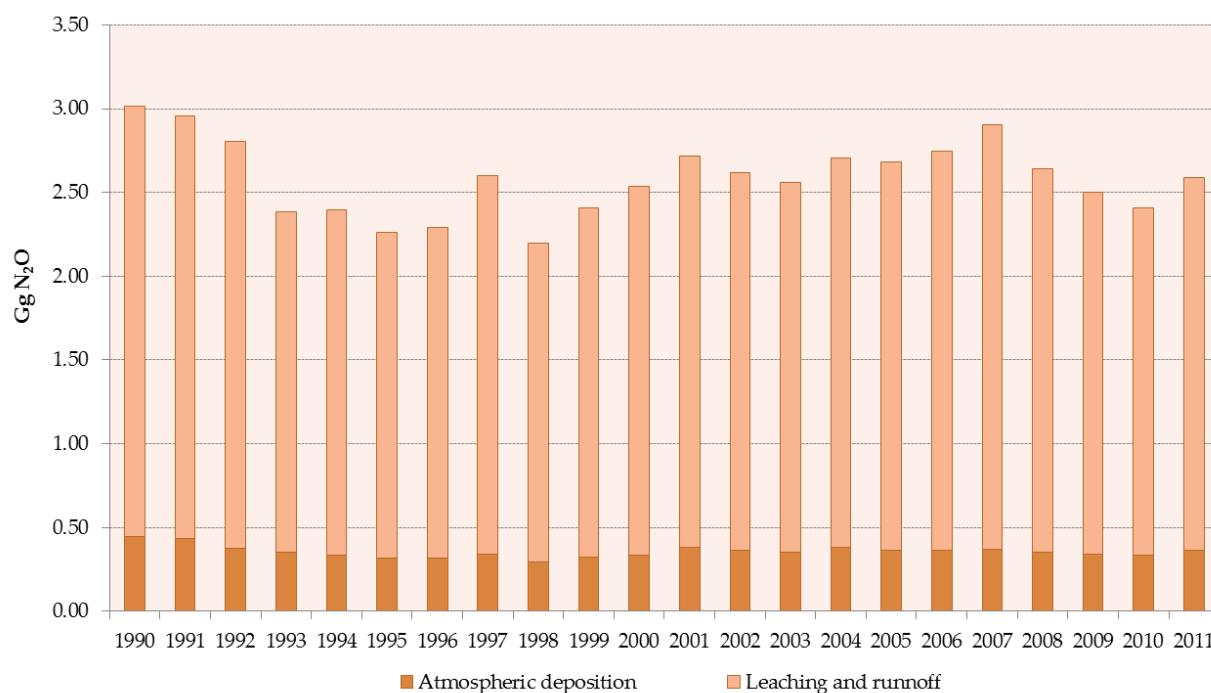


Figure 6.6-5: Indirect N₂O emissions from Agriculture

6.6.3.2. Methodological issues

Nitrous oxide arising due to volatilization of ammonia (NH₃) and nitrogen oxides (NO_x)

While fertilizing agricultural soils with nitrogen fertilizers, some N volatilises in form of ammonia (NH₃) and nitrogen oxides (NO_x). This nitrogen is deposited by precipitation and particulate matter on agricultural soil, in forests and waters and thus indirectly contributes to emissions of N₂O. Emissions are attributed to the place of origin of ammonia and NO_x, not to the place where N is re-deposited, causing N₂O 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 fertilization. The amount of volatilised N depends very strongly on the type of fertilizer as well as on weather conditions and the manner of application. Detailed data on fraction of synthetic fertilizer nitrogen applied to soils that volatilises as NH₃ and NO_x were obtained from Croatian documents reporting to the LRTAP Convention for each fertilizer type (see Table 3.5-1). For calculation of indirect emissions of nitrous oxide, the emission factor 0.01 kg N₂O-N/kg NH₃ and NO_x-N has been used (Revised 1996 IPCC Guidelines).

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 emission factor (20%, Revised 1996 IPCC Guidelines) 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 N₂O-N/kg NH₃-N and NO_x-N (Revised 1996 IPCC Guidelines).

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

Surface runoff and leaching of N into groundwater, surface waters, and watercourses due to mineral fertilisers

It has been considered that 30% of N from mineral fertilizers is lost through surface runoff and leaching into the groundwater and watercourses. For calculation of emissions of nitrous oxide, it has been considered that, for every kg of leached/run-off nitrogen, 0.025 kg of N₂O-N is emitted (Revised 1996 IPCC Guidelines).

Nitrogen leaching and runoff into groundwater, surface waters, and watercourses due to animal manure

It has been considered that, for every kg of N excreted by farm animals, 0.3 kg of N is lost through surface runoff to watercourses and groundwater (Revised 1996 IPCC Guidelines). For calculation of emissions of nitrous oxide, the same emission factors have been considered, as in the case of nitrogen leaching/runoff due to mineral fertilizer (0.025 kg N₂O-N/kg of leached/run-off N).

6.6.3.3. Uncertainty and time-series consistency

The uncertainty of the calculation is conditioned by the use of emission factors recommended by the methodology and the input data unreliability. According to the bibliography, uncertainty of the recommended emission factors is high.

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data amounts 40 percent, based on expert judgements. Uncertainty estimate associated with emission factors amounts 200 percent, according to information provided in the *IPCC Guidelines* (detailed in Annex 5, Tables A5-1, A5-2). Indirect N₂O emissions have been calculated using the same method and data sets for every year in the time series.

6.6.3.4. Category-specific QA/QC and verification

There is no category-specific information, QA/QC for this category is shared and presented in the *4.B. Emissions from Manure Management* category (Chapter 6.3.4). and *4.D.1. Direct emission from agricultural soil* (Chapter 6.6.1.4)

6.6.3.5. Source specific recalculations

Since direct N₂O emissions from synthetic fertilizers applications were recalculated due to the changes in activity data for synthetic fertilizers, recalculations of indirect N₂O emissions were performed for the same time period. For detailed explanation, see Chapter 6.6.1.5.

6.6.3.6. Source specific planned improvement

Planned improvements in this category are shared with the planned improvements for the *4.A. Emission from Enteric Fermentation* (Chapter 6.2.5), *4.B. Emissions from Manure Management* (Chapter 6.4.5) and *4.D.1. Direct emission from agricultural soils* (Chapter 6.6.1.5).

6.7. PRESCRIBED BURNING OF SAVANNAS (CRF 4.E.)

6.7.1. SOURCE CATEGORY DESCRIPTION

The term savannah refers to tropical and subtropical vegetation formations with predominantly continuous grass cover with an occasional tree or shrub interruption of the grass matrix. Large scale burning takes place primarily in the humid savannas since dry savannas lack sufficient grass cover to sustain fire. Savannas are intentionally burned during the dry season for agricultural purposes, mostly to encourage new grass growth for animal grazing. There are no ecosystems in the Republic of Croatia that could be considered natural savannas and no intentional burning of savannas occurs; no greenhouse gas emissions exist for this sub-category.

6.8. FIELD BURNING OF AGRICULTURAL RESIDUES (CRF 4.F.)

6.8.1. SOURCE CATEGORY DESCRIPTION

Burning of agricultural wastes (e.g., woody crop and cereal residues, crop processing residues) in the fields is common practice in developing countries and is present in some developed countries.

This activity is strictly prohibited by Croatian legislative regulations („Ordinance on good agricultural and environmental conditions“, Official Gazette of the Republic of Croatia 89/11); the emission generated by burning agricultural residues was not included in the calculation.

6.9. REFERENCES

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

7.1 OVERVIEW OF LULUCF

According to the methodology prescribed by the IPCC Good Practice Guidance for LULUCF (GPG 2003), the land use categories relevant for the greenhouse gas (GHG) reporting are:

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

In accordance with the IPCC GPG, emissions and removals are reported in subcategory land remaining in the same category and land converted to another land use category. All land use changes are traced down and reported for a transition period of 20 years after which they are reported in the respective categories. Also in accordance with the IPCC GPG, emissions/removals in the categories Wetlands remaining Wetlands, Settlement remaining Settlement and Other land remaining Other land are not estimated.

In LULUCF sector only Forest land remaining Forest land category is key category according to Trend Tier 1 and Tier 2 assessment and according to Tier 1 and Tier 2 Level assessment. Details are presented in Table 7.1-1.

Table 7.1-1: Key category analyze for LULUCF sector based on the level and trend assessment for 2011

IPCC Categories	Direct GHG	Criteria for Identification			
		Level		Trend	
		excl. LULUCF	incl. LULUCF	excl. LULUCF	incl. LULUCF
FOREST LAND					
<i>Forest land remaining forest land</i>	CO ₂		L1i, L2i		T1i, T2i
<i>Land converted to Forest land</i>	CO ₂		L2i		T1i, T2i
<i>Cropland remaining Cropland</i>	CO ₂		L2i		T1i, T2i
<i>Land converted to Cropland</i>	CO ₂		L2i		
<i>Land converted to Grassland</i>	CO ₂		L2i		T1i, T2i
<i>Land converted to Settlements</i>	CO ₂		L1i, L2i		T1i, T2i

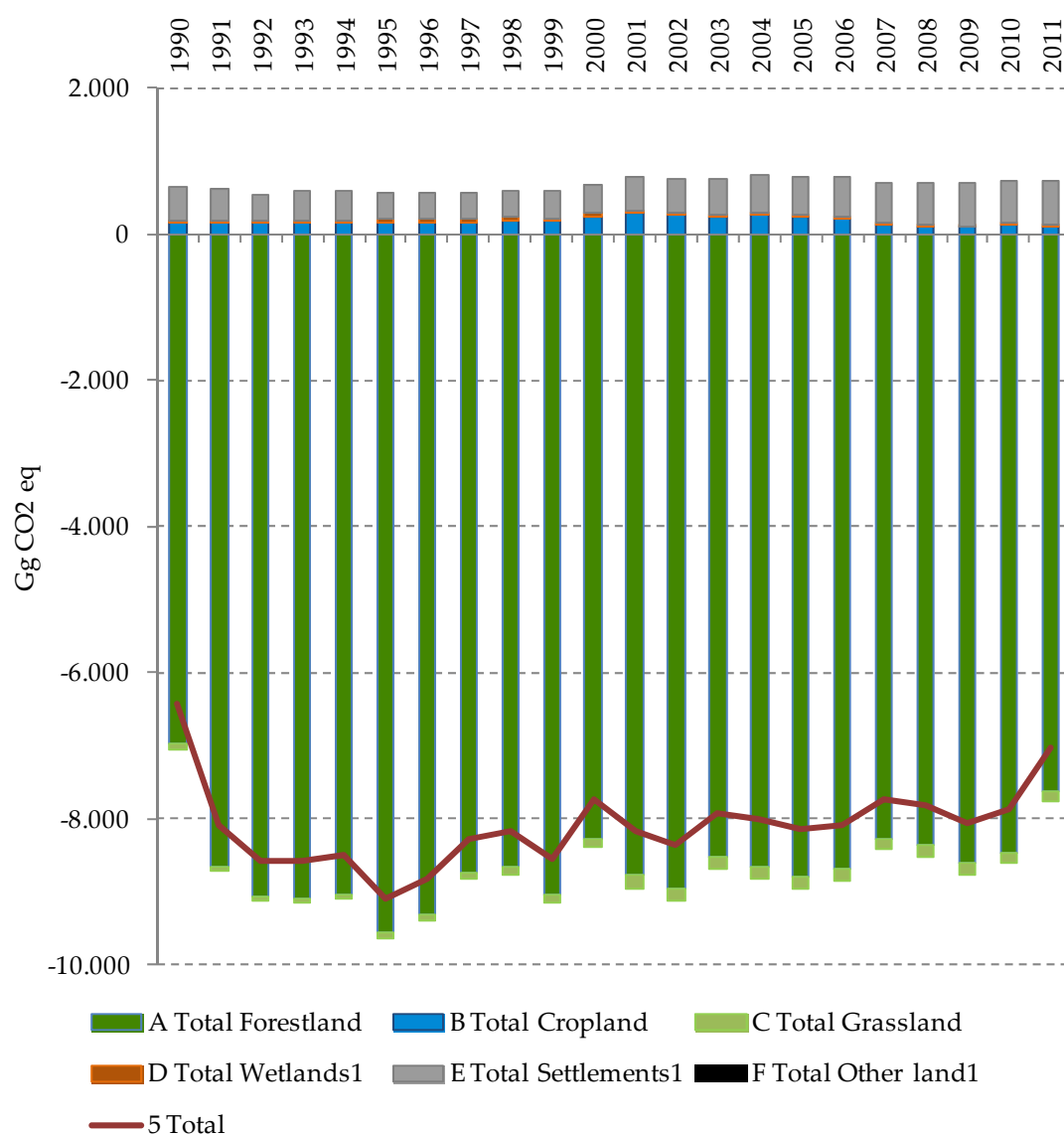
The completeness of the estimated emissions/removals is presented in Table 7.1-2.

Table 7.1-2: Reported LULUCF categories - status of emission estimates

LAND USE CATEGORIES	Net CO ₂ emissions/removals	CH ₄	N ₂ O
A. Forest land	x	x	x
1.Forest land remaining forest land	x	x	x
2.Land converted to Forest Land	x	NO	NO
B. Cropland	x	NO	x
1.Cropland remaining Cropland	x	NO	NO
2.Land converted to Cropland	x	NO	x
C. Grassland	x	NO	NO
1.Grassland remaining Grassland	NO	NO	NO
2.Land converted to Grassland	x	NO	NO
D. Wetlands	x	NO	NO
1.Wetlands remaining Wetlands	NE	NO	NO
2.Land converted to Wetlands	x	NO	NO
E. Settlements	x	NO	NO
1.Settlements remaining Settlements	NE	NO	NO
2.Land converted to Settlements	x	NO	NO
F. Other land	x	NO	NO
1.Other land remaining Other land	NE	NO	NO
2.Land converted to Other land	NO	NO	NO

7.1.1 EMISSION TRENDS

As it can be concluded from the above reported figures and Figure 7.1-1, the LULUCF sector in Croatia presents a sink of greenhouse gases. Two of the land use categories, *Forest land* and *Grassland*, are categories with CO₂ removals, while every other category represents an emission source.



¹ Refers to the Land converted to Wetlands, Settlements and Other land
 Figure 7.1-1. Emission/removal trend for LULUCF

7.1.2 METHODOLOGY

Data on the total area of forest for the separate years, as well as the relative share of the coniferous and deciduous and the forests out of yield were obtained from the *Croatian Forest Ltd.* company which is pursuant to the relevant legislation¹⁴ obliged to manage all the forests in Croatia.

¹⁴ Forest Act (OG 140/05, 82/06, 129/08, 80/10, 124/10)

Information on areas of the wetlands, grassland and settlements for the single years (1980, 1990, 2000 and 2006) were obtained from the Corine Land Cover database.

Information on areas of the cropland was extracted from the national Statistical Yearbooks and from the Corine Land Cover database. For the purpose of this report the Croatian Bureau of Statistics (CBS) data from the time series 1960-2000 were used. A deviation in the CBS data series 1992-1997 was adjusted with linear interpolation. Changes in the CBS data collection approach and significant data deviation in the period after 2000 were corrected using the data from the CLC database.

By expert judgment certain land use changes were considered not to occur in Croatia:

- wetlands, settlements or other land converted to cropland or grassland
- cropland or settlements converted to wetlands
- wetlands converted to settlements

The area of other land is reported in accordance with the IPCC GPG. It was interpreted as the difference of the area of all other categories and the whole area of Croatia. Within the reporting period, a decrease in area of other land was observed with simultaneous increase of the forest area. Based on the analysis of land use changes in each land category and available information from *Croatian Forest Ltd.*, it was concluded that the increase of the forest land was coming from grassland and the other land category.

All the information were merged and based on annual land use changes, a matrix for LUC transition period over 20 years was developed (Table 7.1-4).

The remaining area was then calculated as the difference between the total area of a land use category and the land use changes to each category. Detailed descriptions of the methodology of area information are given in corresponding chapters of the report. The table 7.1-3 presents land use data and land use changes in the reporting period.

Table 7.1-3: Land use and LUC for Croatia for the years 1990-2011

area in kha	1990	2011	2011-1990
5. A Forest land - Total	2,053	2,327	274
5 A 1. Forest land remaining forest land	2,019	2,043	24
5A1a Forest land remaining forest land -coniferous	190	181	-9
5A1b Forest land remaining forest land -deciduous	1,574	1,470	-104
5A1c Forest land remaining forest land -out of yield	254	391	137
5 A2. LUC in Forest land	34	284	250
A2.1a Annual cropland in forest land	0	0	0
5A2.1b Perennial cropland in forest land	0	0	0

5A2.2 Grassland in forest land	28	20	-8
5A2.3 Wetlands in forest land	0	0	0
5A2.4 Settlement in forest land	0	0	0
5A2.5 Other land in forest land	7	264	257
5.B Cropland - Total	1,624	1,544	-80
Cropland annual	1,479	1,407	-72
Cropland perennial	145	137	-8
5B1. Cropland remaining cropland	1,616	1,531	-85
5B1a annual cropland remaining annual cropland	1,472	1,394	-78
5B1b perennial cropland remaining perennial cropland	143	136	-7
5B1c LUC perennial cropland in annual cropland	0	0	0
5B1d LUC annual cropland in perennial cropland	1	0	-1
5B2 LUC in cropland	7	13	6
5B2.1a Forest land in annual cropland	0	0	0
5B2.1b Forest land in perennial cropland	0	0	0
5B2.2a Grassland in annual cropland	6	12	6
5B2.2b Grassland in perennial cropland	1	1	0
5B2.3a Wetlands in annual cropland	0	0	0
5B2.3b Wetlands in perennial cropland	0	0	0
5B2.4a Settlements in annual cropland	0	0	0
5B2.4b Settlements in perennial cropland	0	0	0
5B2.5a Other land in annual cropland	0	0	0
5B2.5b Other land in perennial cropland	0	0	0
5. C Grassland	1,211	1,218	7
5C1. Grassland remaining grassland	1,178	1,165	-13
5C2. LUC in grassland	33	53	20
5C2.1 Forest land in grassland	0	0	0
5C2.2a Annual cropland in grassland	30	48	18
5C2.2b Perennial cropland in grassland	3	5	2
5C2.3 wetlands in grassland	0	0	0
5C2.4 Settlements in grassland	0	0	0
5C2.5 Other land in grassland	0	0	0
5. D Wetlands	72	74	2
5D1. Wetlands remaining wetlands	70	73	3
5D2. LUC in wetlands	2	2	0
5D2.1 Forest land in wetlands	0	0	0
5D2.2a Annual cropland in wetlands	2	2	0
5D2.2b Perennial cropland in wetlands	0	0	0
5D2.3 Grassland in wetlands	2	2	0

5D2.4 Settlements in wetlands	0	0	0
5D2.5 Other land in wetlands	0	0	0
5. E Settlements	220	261	0
5E1. Settlements remaining Settlements	198	221	0
5E2. LUC in Settlements	22	41	41
5E2.1 Forest land in Settlements	18	11	23
5E2.2a Annual cropland in Settlements	2	13	19
5E2.2b Perennial cropland in Settlements	0	1	-7
5E2.3 grassland in Settlements	1	15	11
5E2.4 wetlands in Settlements	0	0	1
5E2.5 Other land in Settlements	0	0	14
5. F Other land	479	236	-243
5F1. Other land remaining other land	479	236	-243
5F2. LUC in Other land	0	0	0
5F2.1 Forest land in Other land	0	0	0
5F2.2a Annual cropland in Other land	0	0	0
5F2.2b Perennial cropland in Other land	0	0	0
5F2.3 grassland in Other land	0	0	0
5F2.3 wetlands in Other land	0	0	0
5F2.5 Settlements in other land	0	0	0
Total area Croatia	5,659	5,659	

Table 7.1-4 Land use matrixes

		Area in 1990 (kha)						Initial sum
		FL	CL	GL	WL	SL	OL	
		2,053	1,624	1,211	72	220	479	5,659
Area in 1991 (kha)	FL	2,021	NO	NO	NO	18	NO	2,038
	CL	NO	1,600	34	2	3	NO	1,639
	GL	27	7	1,178	NO	2	NO	1,214
	WL	NO	NO	NO	70	NO	NO	70
	SL	NO	NO	NO	NO	199	NO	199
	OL	7	NO	NO	NO	NO	492	498
	Final sum	2,054	1,607	1,213	73	221	492	5,659

		Area in 1991 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,054	1,607	1,213	73	221	492	5,659
Area in 1992 (kha)	FL	2,022	NO	NO	NO	17	NO	2,039
	CL	NO	1,597	36	3	3	NO	1,640
	GL	27	7	1,178	NO	2	NO	1,214
	WL	NO	NO	NO	70	NO	NO	70
	SL	NO	NO	NO	NO	200	NO	200
	OL	6	NO	NO	NO	NO	490	497
	Final sum	2,055	1,604	1,215	73	222	490	5,659

		Area in 1992 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,055	1,604	1,215	73	222	490	5,659
Area in 1993 (kha)	FL	2,022	NO	NO	NO	18	NO	2,040
	CL	NO	1,595	39	3	3	NO	1,639
	GL	27	7	1,178	NO	2	NO	1,214
	WL	NO	NO	NO	70	NO	NO	70
	SL	NO	NO	NO	NO	200	NO	200
	OL	7	NO	NO	NO	NO	489	496
	Final sum	2,056	1,601	1,217	73	223	489	5,659

		Area in 1993 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,056	1,601	1,217	73	223	489	5,659
Area in 1994 (kha)	FL	2,022	NO	NO	NO	19	NO	2,040
	CL	NO	1,592	41	3	3	NO	1,639
	GL	28	6	1,178	NO	2	NO	1,214
	WL	NO	NO	NO	70	NO	NO	70
	SL	NO	NO	NO	NO	201	NO	201
	OL	7	NO	NO	NO	NO	488	495
	Final sum	2,057	1,598	1,219	73	225	488	5,659

		Area in 1994 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,057	1,598	1,219	73	225	488	5,659
Area in 1995 (kha)	FL	2,023	NO	NO	NO	18	NO	2,041
	CL	NO	1,590	43	3	3	NO	1,639
	GL	28	6	1,178	NO	2	NO	1,214
	WL	NO	NO	NO	70	NO	NO	70
	SL	NO	NO	NO	NO	203	NO	203
	OL	7	NO	NO	NO	NO	486	493
	Final sum	2,057	1,596	1,221	73	226	486	5,659

		Area in 1995 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,057	1,596	1,221	73	226	486	5,659
Area in 1996 (kha)	FL	2,024	NO	NO	NO	18	NO	2,042
	CL	NO	1,587	45	3	3	NO	1,638
	GL	27	6	1,179	NO	2	NO	1,214
	WL	NO	NO	NO	70	NO	NO	70
	SL	NO	NO	NO	NO	204	NO	204
	OL	7	NO	NO	NO	NO	485	491
	Final sum	2,058	1,593	1,223	73	227	485	5,659

		Area in 1996 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,058	1,593	1,223	73	227	485	5,659
Area in 1997 (kha)	FL	2,026	NO	NO	NO	17	NO	2,043
	CL	NO	1,584	47	4	3	NO	1,638
	GL	27	5	1,178	NO	2	NO	1,213
	WL	NO	NO	NO	70	NO	NO	70
	SL	NO	NO	NO	NO	205	NO	205
	OL	29	NO	NO	NO	NO	461	490
	Final sum	2,082	1,590	1,225	74	228	461	5,659

		Area in 1997 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,082	1,590	1,225	74	228	461	5,659
Area in 1998 (kha)	FL	2,027	NO	NO	NO	17	NO	2,044
	CL	NO	1,582	49	4	3	NO	1,638
	GL	27	5	1,179	NO	3	NO	1,213
	WL	NO	NO	NO	70	NO	NO	70
	SL	NO	NO	NO	NO	206	NO	206
	OL	51	NO	NO	NO	NO	437	488
	Final sum	2,105	1,587	1,227	74	229	437	5,659

		Area in 1998 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,105	1,587	1,227	74	229	437	5,659
Area in 1999 (kha)	FL	2,028	NO	NO	NO	16	NO	2,044
	CL	NO	1,585	51	4	4	NO	1,644
	GL	26	5	1,179	NO	3	NO	1,213
	WL	NO	NO	NO	70	NO	NO	70
	SL	NO	NO	NO	NO	208	NO	208
	OL	74	NO	NO	NO	NO	407	481
	Final sum	2,128	1,590	1,230	74	230	407	5,659

		Area in 1999 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,128	1,590	1,230	74	230	407	5,659
Area in 2000 (kha)	FL	2,029	NO	NO	NO	16	NO	2,045
	CL	NO	1,587	52	4	4	NO	1,647
	GL	26	5	1,178	NO	3	NO	1,213
	WL	NO	NO	NO	70	NO	NO	70
	SL	NO	NO	NO	NO	209	NO	209
	OL	96	NO	NO	NO	NO	379	475
	Final sum	2,152	1,592	1,232	74	231	379	5,659

		Area in 2000 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,152	1,592	1,232	74	231	379	5,659
Area in 2001 (kha)	FL	2,031	NO	NO	NO	15	NO	2,046
	CL	NO	1,582	52	4	5	NO	1,643
	GL	25	5	1,178	NO	4	NO	1,212
	WL	NO	NO	NO	70	NO	NO	70
	SL	NO	NO	NO	NO	210	NO	210
	OL	120	NO	NO	NO	NO	358	478
	Final sum	2,175	1,587	1,230	74	234	358	5,659

		Area in 2001 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,175	1,587	1,230	74	234	358	5,659
Area in 2002 (kha)	FL	2,032	NO	NO	NO	15	NO	2,047
	CL	NO	1,577	52	4	6	NO	1,638
	GL	24	6	1,177	NO	5	NO	1,212
	WL	NO	NO	NO	71	NO	NO	71
	SL	NO	NO	NO	NO	211	NO	211
	OL	142	NO	NO	NO	NO	338	480
	Final sum	2,198	1,583	1,229	74	237	338	5,659

		Area in 2002 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,198	1,583	1,229	74	237	338	5,659
Area in 2003 (kha)	FL	2,033	NO	NO	NO	15	NO	2,048
	CL	NO	1,572	53	4	7	NO	1,635
	GL	24	7	1,175	NO	6	NO	1,212
	WL	NO	NO	NO	71	NO	NO	71
	SL	NO	NO	NO	NO	212	NO	212
	OL	165	NO	NO	NO	NO	317	482
	Final sum	2,222	1,579	1,228	74	240	317	5,659

		Area in 2003 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,222	1,579	1,228	74	240	317	5,659
Area in 2004 (kha)	FL	2,034	NO	NO	NO	15	NO	2,048
	CL	NO	1,567	52	3	7	NO	1,629
	GL	23	8	1,175	0	7	NO	1,212
	WL	NO	NO	NO	71	NO	NO	71
	SL	NO	NO	NO	NO	213	NO	213
	OL	188	NO	NO	NO	NO	297	485
	Final sum	2,245	1,574	1,227	74	242	297	5,659

		Area in 2004 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,245	1,574	1,227	74	242	297	5,659
Area in 2005 (kha)	FL	2,035	NO	NO	NO	14	NO	2,049
	CL	NO	1,562	52	3	8	NO	1,625
	GL	22	9	1,173	NO	8	NO	1,212
	WL	NO	NO	NO	71	NO	NO	71
	SL	NO	NO	NO	NO	214	NO	214
	OL	211	NO	NO	NO	NO	276	487
	Final sum	2,268	1,570	1,226	74	245	276	5,659

		Area in 2005 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,268	1,570	1,226	74	245	276	5,659
Area in 2006 (kha)	FL	2,036	NO	NO	NO	14	NO	2,050
	CL	NO	1,556	52	3	9	NO	1,621
	GL	21	9	1,172	NO	9	NO	1,212
	WL	NO	NO	NO	71	NO	NO	71
	SL	NO	NO	NO	NO	216	NO	216
	OL	234	NO	NO	NO	NO	256	490
	Final sum	2,292	1,566	1,224	74	248	256	5,659

		Area in 2006 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,292	1,566	1,224	74	248	256	5,659
Area in 2007 (kha)	FL	2,038	NO	NO	NO	13	NO	2,051
	CL	NO	1,551	52	3	10	NO	1,616
	GL	20	10	1,171	NO	10	NO	1,212
	WL	NO	NO	NO	72	NO	NO	72
	SL	NO	NO	NO	NO	217	NO	217
	OL	238	NO	NO	NO	NO	254	492
	Final sum	2,296	1,561	1,223	74	250	254	5,659

		Area in 2007 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,296	1,561	1,223	74	250	254	5,659
Area in 2008 (kha)	FL	2,039	NO	NO	NO	12	NO	2,052
	CL	NO	1,546	52	2	12	NO	1,612
	GL	19	11	1,170	NO	12	NO	1,211
	WL	NO	NO	NO	72	NO	NO	72
	SL	NO	NO	NO	NO	218	NO	218
	OL	247	NO	NO	NO	NO	248	495
	Final sum	2,305	1,557	1,222	74	253	248	5,659

		Area in 2008 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,305	1,557	1,222	74	253	248	5,659
Area in 2009 (kha)	FL	2,041	NO	NO	NO	12	NO	2,053
	CL	NO	1,541	52	2	13	NO	1,608
	GL	18	12	1,169	NO	13	NO	1,211
	WL	NO	NO	NO	72	NO	NO	72
	SL	NO	NO	NO	NO	219	NO	219
	OL	254	NO	NO	NO	NO	243	497
	Final sum	2,312	1,553	1,221	74	256	243	5,659

		Area in 2009 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,312	1,553	1,221	74	256	243	5,659
Area in 2010 (kha)	FL	2,042	NO	NO	NO	12	NO	2,053
	CL	NO	1,536	53	2	14	NO	1,605
	GL	18	12	1,167	NO	14	NO	1,211
	WL	NO	NO	NO	72	NO	NO	72
	SL	NO	NO	NO	NO	220	NO	220
	OL	260	NO	NO	NO	NO	239	499
	Final sum	2,320	1,548	1,219	74	259	239	5,659

		Area in 2010 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,320	1,548	1,219	74	259	239	5,659
Area in 2011 (kha)	FL	2,043	NO	NO	NO	11	NO	2,054
	CL	NO	1,531	52	1	15	NO	1,598
	GL	20	13	1,165	NO	15	NO	1,213
	WL	NO	NO	NO	73	NO	NO	73
	SL	NO	NO	NO	NO	221	NO	221
	OL	264	NO	NO	NO	NO	236	500
	Final sum	2,327	1,544	1,217	74	261	236	5,659

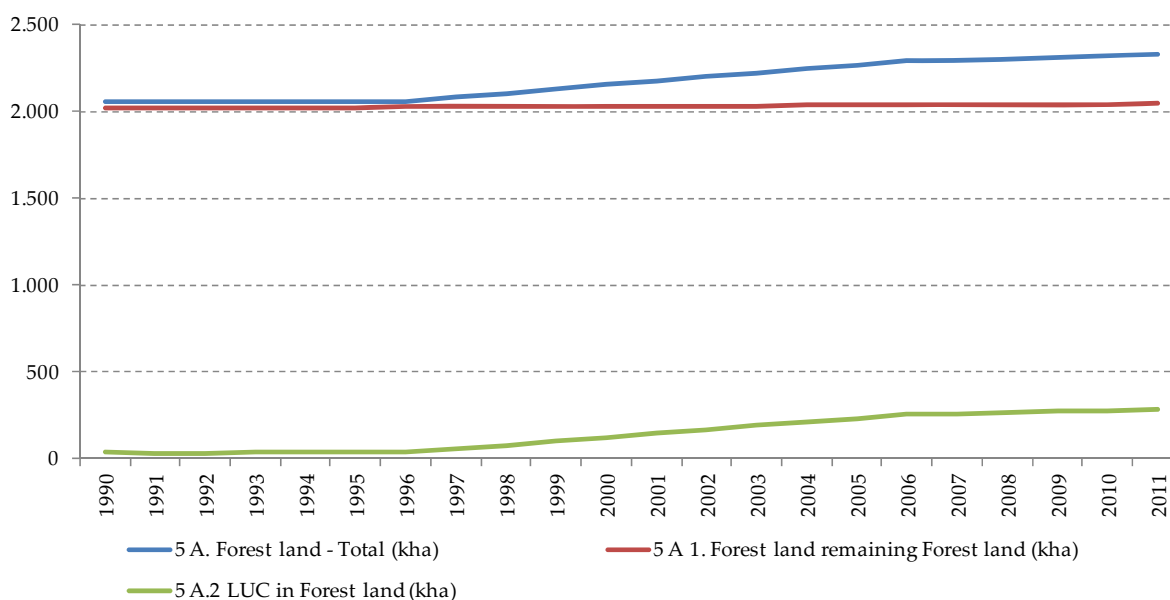
Table 7.1.-4 Land use change matrix (1990-2011)

		Area in 1990 (kha)						
		FL	CL	GL	WL	SL	OL	Initial sum
		2,053	1,624	1,211	72	220	479	5,659
Area in 2011 (kha)	FL	2,043	NO	NO	NO	11	NO	2,054
	CL	NO	1,531	53	2	14	NO	1,599
	GL	20	13	1,165	0	14	NO	1,212
	WL	NO	NO	NO	73	NO	NO	73
	SL	NO	NO	NO	NO	221	NO	221
	OL	264	NO	NO	NO	NO	236	500
	Final sum	2,327	1,544	1,218	74	260	236	5,659
	Net change	273	-80	8	2	40	-244	

7.2 FOREST LAND (5.A)

7.2.1 DESCRIPTION

Under this land category, CO₂ emissions/removals from soil and living biomass¹⁵ from the *Forest land remaining forest land* and from *Land converted to forest land* have been reported. For C stock changes in dead organic matter and in soil of *Forest land remaining forest land* the IPCC GPG tier 1 approach is used which assumes no C stock changes in these pools. Non-CO₂ emissions due to wildfires are also reported but only for the *Forest land remaining forest land* because, currently, the area burnt cannot be differentiated between the *Forest land remaining forest land* and *Land converted to forest land* (Table 7.2-2). Figure 7.2-1 represents the trend of forest area and LUC area to forest land in conversion period of 20 years.



* forest land area including forests out of yield

Figure 7.2.-1: Trend of forest land and LUC to forest land in conversion period of 20 years (1990-2011) in kha*

CO₂ removals from forest land remaining forest land in 2011 are -7,530.7 Gg CO₂ and from Land converted to Forest land -175.0 Gg CO₂. Therefore, the share of removals from land conversion in total Forest land removals makes only 2.3%. Annual emissions/removals from each land use category to forest land are presented in Table 7.2-1.

¹⁵ Below ground biomass is combined with the above ground and thus the notation key IE is used for below ground biomass.

Table 7.2.-1 Emissions/Removals of CO₂ in Forest land category (Gg CO₂)

Year	5 A Forest land - Total	5 A 1. Forest land remaining Forest land	5 A 2. Land converted to Forest land	5 A 2.1 Cropland converted to Forest land	5 A 2.2 Grassland converted to Forest land	5 A 2.3 Wetland converted to Forest land	5 A 2.4 Settlement converted to Forest land	5 A 2.5 Other land converted to Forest land
1990	-7,120.7	-6,848.1	-272.6	NO	-272.6	NO	NO	NE
1991	-8,787.6	-8,511.6	-276.0	NO	-276.0	NO	NO	NE
1992	-9,105.3	-8,840.6	-264.8	NO	-264.8	NO	NO	NE
1993	-9,366.6	-9,101.6	-265.0	NO	-265.0	NO	NO	NE
1994	-9,169.1	-8,905.8	-263.2	NO	-263.2	NO	NO	NE
1995	-9,580.3	-9,307.5	-272.8	NO	-272.8	NO	NO	NE
1996	-9,383.5	-9,108.6	-274.9	NO	-274.9	NO	NO	NE
1997	-8,880.1	-8,613.7	-266.5	NO	-266.5	NO	NO	NE
1998	-8,910.9	-8,644.3	-266.6	NO	-266.6	NO	NO	NE
1999	-9,047.9	-8,786.4	-261.5	NO	-261.5	NO	NO	NE
2000	-8,855.6	-8,594.4	-261.2	NO	-261.2	NO	NO	NE
2001	-8,890.3	-8,633.7	-256.6	NO	-256.6	NO	NO	NE
2002	-9,022.0	-8,781.2	-240.9	NO	-240.9	NO	NO	NE
2003	-8,807.7	-8,572.7	-235.0	NO	-235.0	NO	NO	NE
2004	-8,665.3	-8,431.3	-234.0	NO	-234.0	NO	NO	NE
2005	-8,795.0	-8,573.9	-221.1	NO	-221.1	NO	NO	NE
2006	-8,696.5	-8,483.2	-213.3	NO	-213.3	NO	NO	NE
2007	-8,320.8	-8,117.4	-203.4	NO	-203.4	NO	NO	NE
2008	-8,411.4	-8,218.1	-193.2	NO	-193.2	NO	NO	NE
2009	-8,622.2	-8,439.9	-182.4	NO	-182.4	NO	NO	NE
2010	-8,481.3	-8,313.7	-167.6	NO	-167.6	NO	NO	NE
2011	-7,705.6	-7,530.7	-175.0	NO	-175.0	NO	NO	NE

Table 7.2.-2 CO₂ emissions from wildfires

Year	Area burnt (ha)	CO ₂ emission CO ₂ equivalent (Gg)	CH ₄ emission CO ₂ equivalent (Gg)	N ₂ O emission CO ₂ equivalent (Gg)
1990	4,234	128.34	12.50	2.86
1991	4,234	128.34	12.50	2.86
1992	964	29.22	2.85	0.65
1993	8,196	248.45	24.20	5.53
1994	3,723	112.86	10.99	2.51
1995	633	19.19	1.87	0.43
1996	2,550	77.30	7.53	1.72
1997	4,026	122.03	11.88	2.72
1998	7,551	228.91	22.29	5.10
1999	472	14.31	1.39	0.32
2000	17,174	520.62	50.70	11.60
2001	3,514	106.52	10.37	2.37
2002	1,769	53.63	5.22	1.19
2003	8,271	250.73	24.42	5.58
2004	355	10.76	1.05	0.24
2005	381	11.55	1.13	0.26
2006	507	15.37	1.50	0.34
2007	1,698	51.47	5.01	1.15
2008	1,299	39.38	3.84	0.88
2009	646	19.58	1.91	0.44
2010	446	13.52	1.32	0.30
2011	2,309	69.99	6.81	1.56

7.2.2 INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USE DATABASES USED FOR THE INVENTORY PREPARATION

For the purposes of this reporting, data obtained by the *Croatian Forest Ltd* were used for presenting the forest land areas.

The *Forest Act* (OG 140/05, 82/06, 129/08, 80/10, 124/10) regulates the activities in forestry sector in Croatia. The forest management plans determine conditions for harmonious usage of forests and forest land and procedures in that area, necessary scope regarding the cultivation and forest protection, possible utilization degree and conditions for wildlife management. The forest management plans are as follows:

- Forest Management Area Plan for the Republic of Croatia (FMAP)
- Forest Management Plan for management units
- Programmes for management of management units on karst
- Programmes for management of private forests
- Programmes for forest renewal and protection in specially endangered area
- Programmes for management of forest with special purpose
- Annual forest management plans
- Annual operative plans

All forest management plans, their renewal and revision are under supervision of the Ministry of Agriculture.

The FMAP, among the other, appoints activities which will be performed in the forests for the next 10 years but also, to some extent, describes the former management (management in the previous 10-year period) and the status of forests at the beginning of the new 10-year period. So far, three FMAPs have been prepared:

- FMAP encompassing the period from 1986-1995 (FMAP 1986-1995)
- FMAP encompassing the period from 1996-2005 (FMAP 1996-2005)
- FMAP encompassing the period from 2006-2015 (FMAP 2006-2015)

Summarized, the total forest land in Croatia constitutes of one forest management area which is established in order to ensure the unique and sustainable management of the forest land. Therefore, according to the national criteria, both forest land with and without tree cover is sustainably managed regardless of their ownership, purpose, forest stand etc.

Based on the forest management type, according to the *Ordinance¹⁶ on Forest Management* (OG 111/06, 141/08), forest stands are managed either as even-aged or uneven-aged. Even-aged forest stands make regular forests which cover about 83% of forest land with tree cover (excluding maquis, shrub, garigue and scrub). Uneven-aged forests make about 17 % of forest land with tree cover (excluding maquis, shrub, garigue and scrub).

State forests are managed either by "Croatian Forests Ltd." or by other legal bodies. As regarding the private forests, the Forest Advisory Service (FAS) was established in 2006 (began working in 2007). Its function was to assist private forest owners in management and improvement of private forests' condition. This service was merged with the *Croatian Forests Ltd* in 2010.

Furthermore, detailed information on the system within state forests managed by "Croatian Forests" is provided. It should be emphasized that the management system of "Croatian Forests" has the international FSC certification (Forest Stewardship Council A.C.) proving that state forests are managed sustainable.

¹⁶ Ordinance on Forest Management (OG 111/06, 141/08)

The system is divided in 16 organizational and territorial units – forest districts (Figure 7.2-7). This division was established in 1996.

Districts consist of forest units and today Croatian area is divided into 170 forest units. The forest unit is the basic organizational unit for performing all expert and technical activities in forest management and they are directly supervised by the District. Forest management in forest units is based upon forest management plans for individual management units approved by the Ministry of Agriculture. An example of one district divided into 11 forest units is presented in Figure 7.2-8.

Each forest unit manages a certain number of management units. The division of forest management area on management units is performed to facilitate the implementation of forest management plans. The area of a management unit is usually between 1,000 and 3,000 ha. The area of management units is determined by the Forest Management Area Plan and, usually, they are not changed (now there is about 653 management units). The number of management units governed by a certain forest unit is variable. Figure 7.2-9 shows forest unit “Cerna” divided into three management units.

Management unit is divided into compartments and sub-compartments. Compartment is considered as the permanent, basic unit regarding the management forest division. They are established in order to facilitate the management, inspection and field orientation. The compartment area, except for first age class, shrub, scrubs, maquia, garigue and barren wooded land, in general can not be larger than 60 ha. Figure 7.2-10 shows the division of the management unit “Krivsko ostrvo” on 33 compartments.

Compartments are divided into smaller areas (sub-compartments), and a sub-compartment is the smallest variable, basic area regarding the management division of forests which is specially managed as a stand. Stands are included in sub-compartments depending on their stand origin, stand form, development stage, tree specie, age, management goal, mixture ratio and tree coverage. The smallest area of a sub-compartment is 1 ha except in private forests and separated forest area when it can be even smaller, and the largest sub-compartment area is determined by the compartment size. However, the sampling is performed within the sub-compartment on a 0.05 ha grid. Figure 7.2-11 shows that compartment 7 of the management unit “Krivsko ostrvo” is divided into 3 sub-compartments.

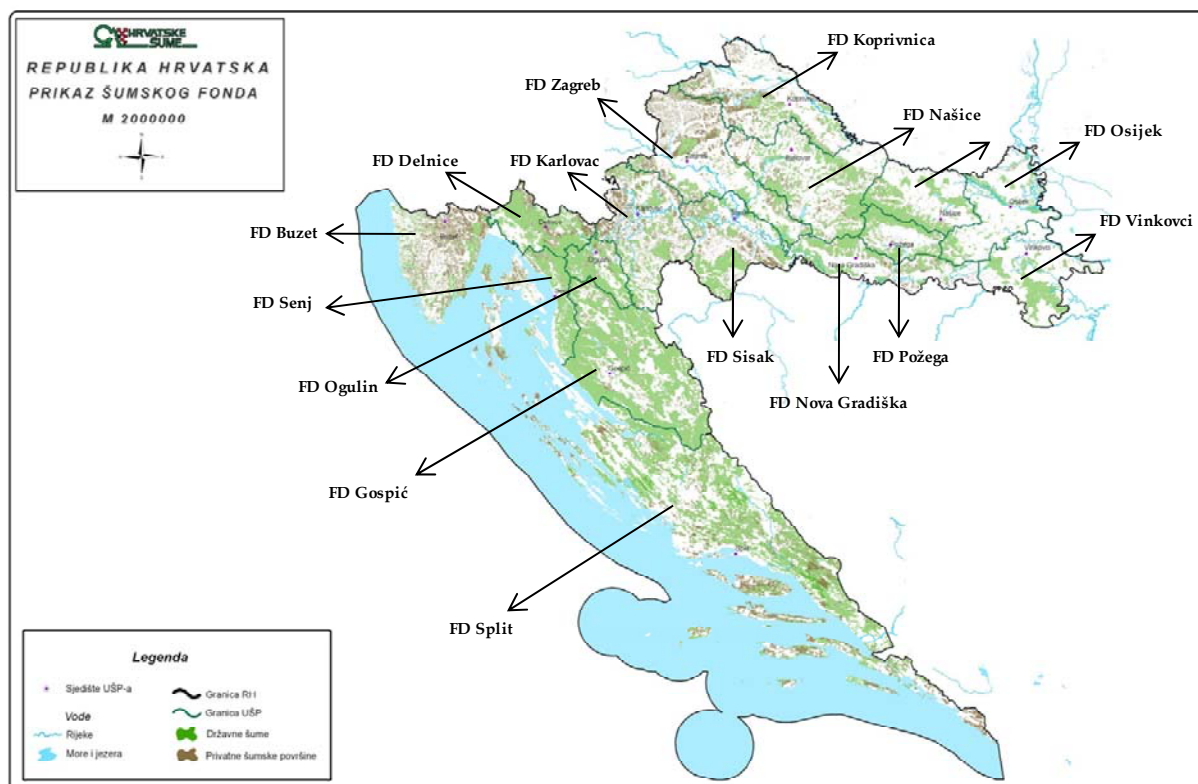


Figure 7.2-2: Spatial division of the Republic of Croatia on forest districts

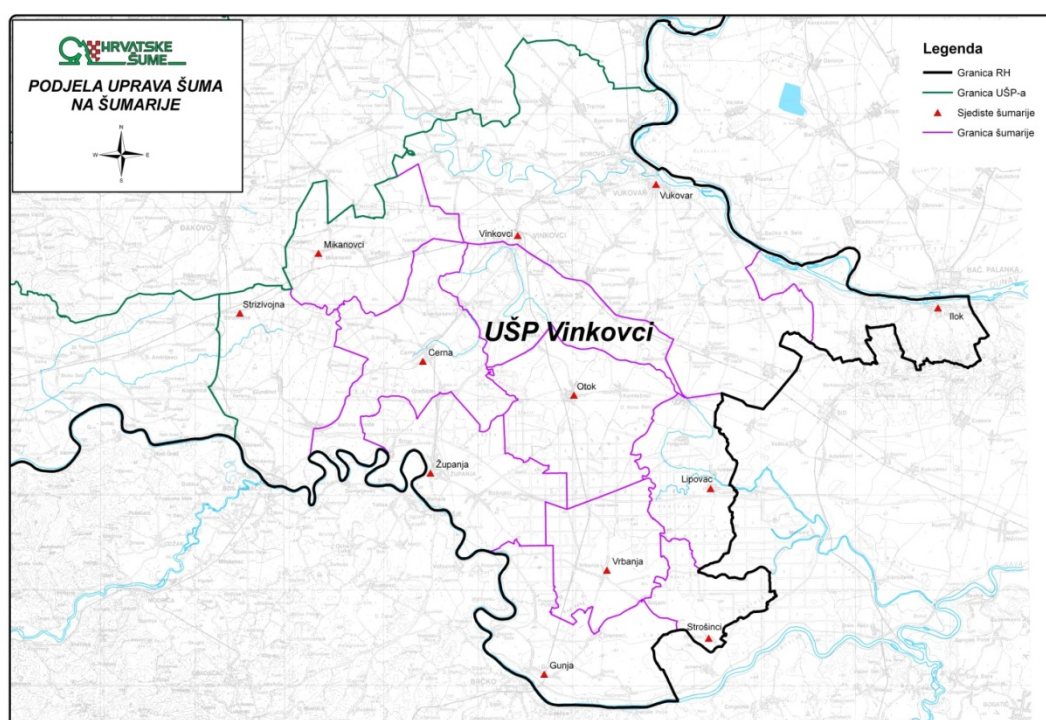


Figure 7.2-3: Division of forest district "Vinkovci" on related forest units (example, UŠP refers to FD)

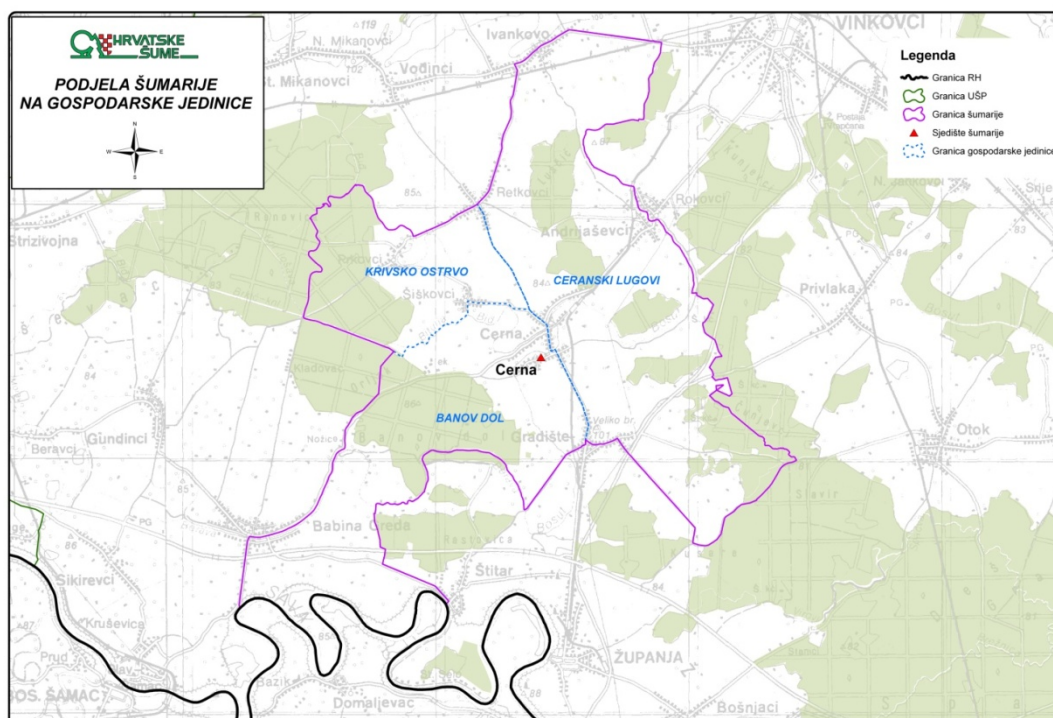


Figure 7.2-4: Area of a forest unit “Cerna” with the spatial division on related management units (example)

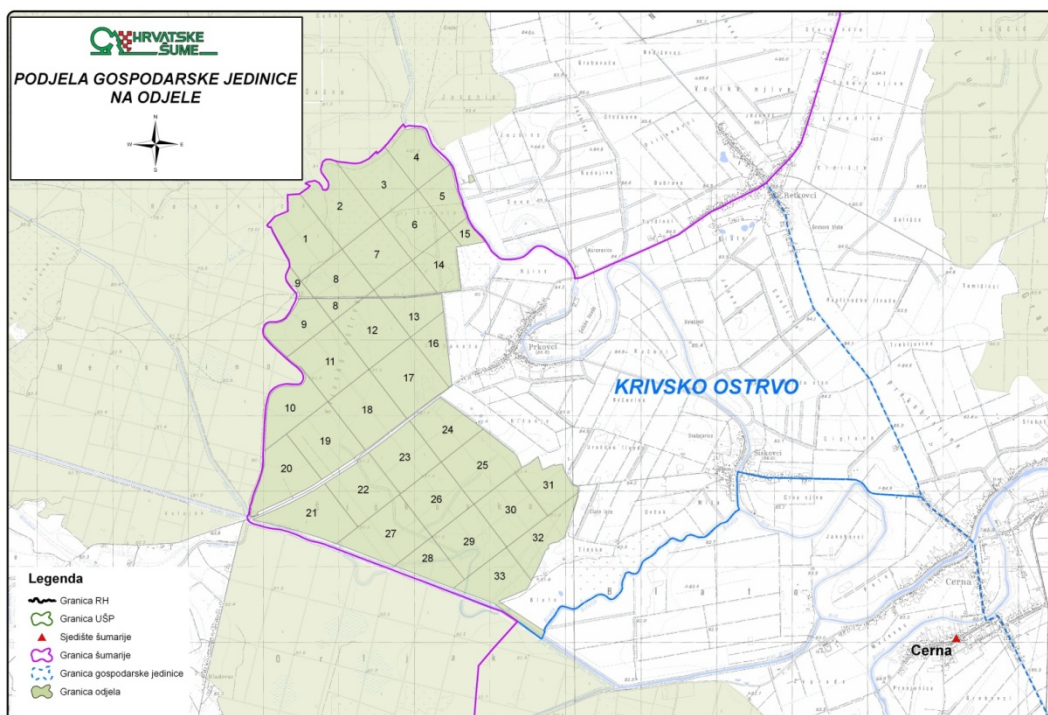


Figure 7.2-5: Area of a management unit “Krivsko ostrvo” divided into compartments (example)

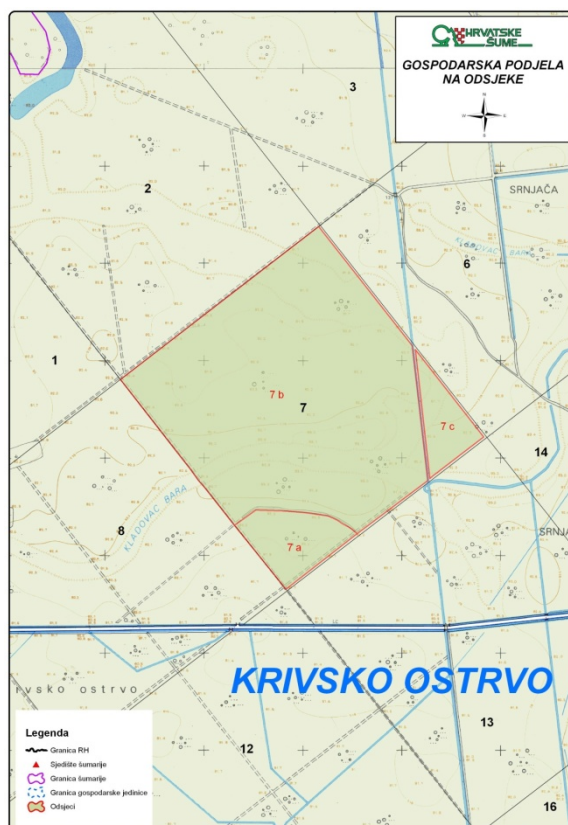


Figure 7.2-6: Compartment area divided into sub-compartments (example)

Short scheme of the system's structure is presented in Figure 7.2-12.

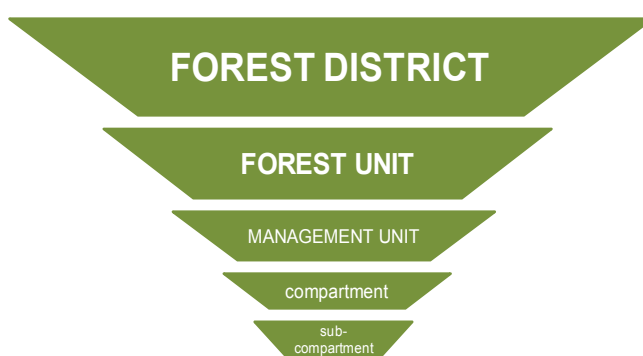


Figure 7.2-7: The scheme of the national system's structure

Therefore, it should be emphasized again that the basic unit for forest management in Croatia is the sub-compartment for which, based on field measurements on a 0.05 ha grid and the analysis of the related results, data on area, land category, growing stock and increment on diameter class (above 10 cm in diameter at 130 cm above ground, classes by 5 cm), age, ecological and management type, crown cover, height above sea level, the

level of fire vulnerability, tree species and related number of trees etc. are determined. Furthermore, for each sub-compartment, a felling and silvicultural treatment rule is prepared which is recorded each year.

Forest land

The *Forest Act* regulates the growing, protection, usage and management of forest land as a natural resource aimed to maintain biodiversity and ensure management based on principles of economic sustainability, social responsibility and ecological acceptability. It prohibits the renewal of forests by clear cutting, thus natural rejuvenation is the principal method for renewal of all natural forests.

The following figures are based on data for 2006 provided in the Forest Management Area Plan for the period 2006-2015 (FMAP 2006-2015).

Based on the forest stands, forest land with tree cover is divided as follows:

- high forests
- plantations
- forest cultures
- coppice
- maquia
- shrub
- garigue
- scrub

Their share in the forest land with tree cover is shown in Figure 7.2-2.

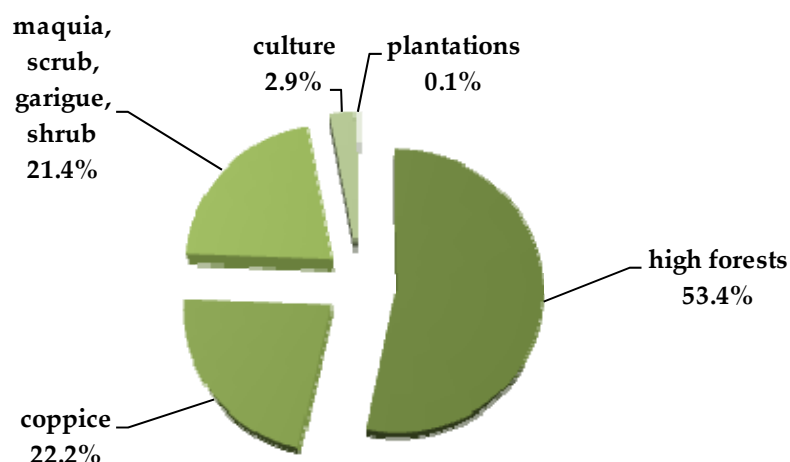


Figure 7.2-8: The share of each forest stand in forest land with tree cover, year 2006

According to the *Forest Act* forests are classified in three categories:

- management forests (which made about 90% of total forest area in 2006)
- protection forests (which made about 6% of total forest area in 2006)
- forests with special purpose (which made about 4% of total forest area in 2006)

Based on the ownership, there are two types of forests in Croatia:

a) State forests owned by the state and managed by

- the public enterprise "Hrvatske šume d.o.o." (*Croatian Forests Ltd.*)
- legal bodies owned by the state (e.g. national parks, Faculty of Forestry, Ministry of Defence, "Croatian Waters" etc.)

b) Private forests

State forests make about 78% of total forest area, while the remaining 22% are privately owned (Figure 7.2-3).

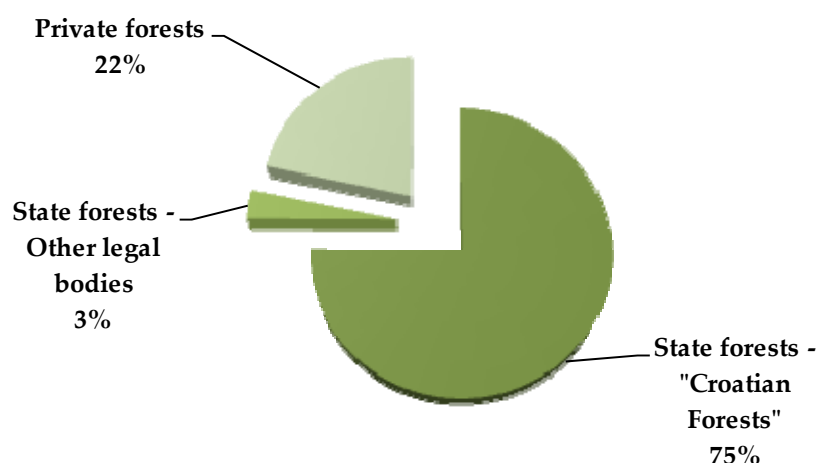


Figure 7.2-9: The ownership structure of forest area in Croatia, year 2006.

The area of forests is determined based on all available cadastral maps in various scales. However, while preparing the FMAP 2006-2015, it was noticed that cadastral data on forest area did not match real conditions – private forests were larger than those presented in the cadastre. Since private forests are highly fragmented and scattered over the entire Croatian territory, most precise determination of their area and their spatial position was accomplished by applying the remote sensing methods for the forest area extraction and field work to determine forests' condition. The forest area was extracted in three ways: 1. by using the ortophoto (scale 1:5,000), 2. by using the satellite images (scale 1: 1,000,000), 3. by using the CORINE data.

The current FMAP 2006-2015 determines total growing stock of about 398 mil. m³ in 2006 by calculation based on the following measured data:

- diameters at breast height and
- height of living trees above the taxation level (10 cm in breast height diameter)

The growing stock is not measured for the first age class of even-aged forests, maquia, shrub, garigue and scrub and this is why carbon stock changes in these forests are not taken into consideration in the report. It should be noted that there is no wood harvest in maquia, shrub, garigue and scrub. So, in line with IPCC GPG approaches is assumed that there is no human-induced C stock change.

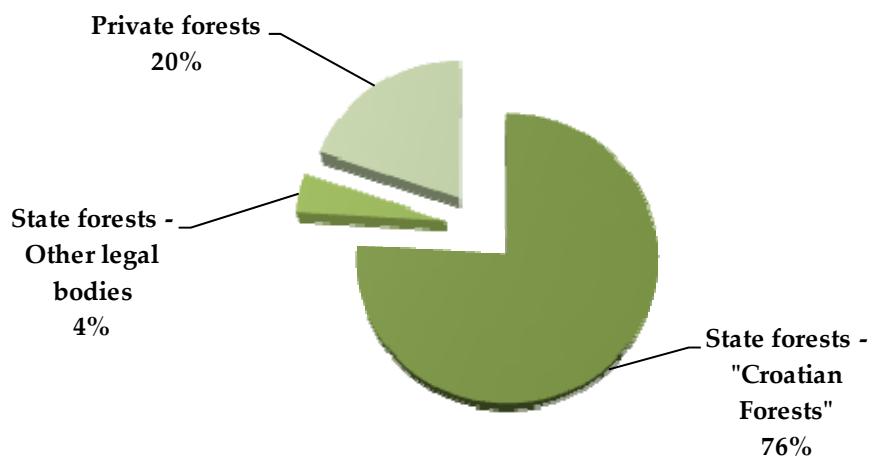


Figure 7.2-10: The share of growing stock in state and private forests, year 2006

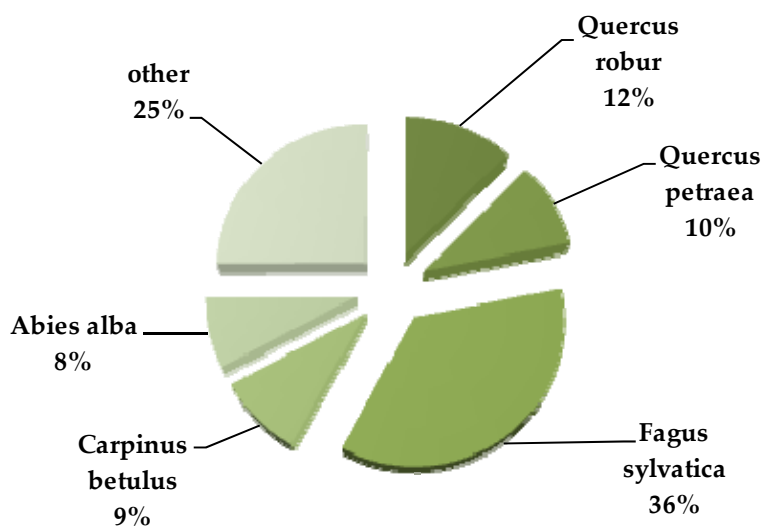


Figure 7.2-11: Share of main species in total growing stock, year 2006

Diameters at breast height are measured at sample plots taken from the total sub-compartment area:

- At least 2% in even-aged stands of the second age class regarding the high forests in area that is subject of FMAP, forests with limited management, coppices, protection forests and private forests
- At least 5% in even-aged stands of high forests (age classes above the second age class) in area that is subject of FMAP and in uneven-aged forests

For example, planned work normative for state forests managed by „Croatian Forests“ for the year 2010 included:

- Extracting the sub-compartment at 143,000 ha
- Measurements of breast diameters at 69,000 sample plots of the 5% sample trees
- Measurements of breast diameters at 25,000 sample plots of the 2% sample trees
- Measurements of breast diameters of all trees at 6,000 ha
- Measurements of 123,000 tree heights
- Taking 43,000 bores

Based on the legislation¹⁷, when preparing the FMAPs, the increment value is determined based on the volume tables and measured diameter increment. Measuring of the diameter increment has been performed for the main tree species. In even-aged stands, samples for diameter increment measuring are grouped for each tree species according to their origin and stand quality and age, and in uneven-aged stands on management classes and stand quality. In case of coppice forests only mean total increment of growing stock has to be determined. The increment cores are taken at breast height (1.30 m) with Pressler's borer.

The share of increment in state and private forests is presented in Figure 7.2-6.

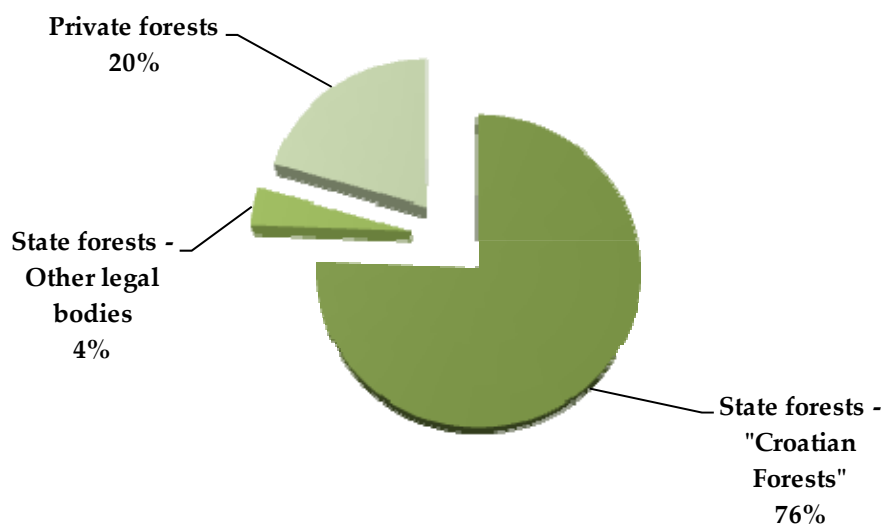


Figure 7.2-12: The share of increment in state and private forests, year 2006

¹⁷ Ibid. Reference No 2

Representation of the Forest land in this report is based on the definitions provided in the following chapter (Chapter 7.2.3.). The related data have been obtained from the FMAPs. The forests in Croatia are presented by forest type as broadleaved and coniferous forests and out of yield forests (maquies and shrub forests).

7.2.3 LAND-USE DEFINITIONS AND CLASSIFICATION SYSTEMS USED AND THEIR CORRESPONDENCE TO THE LULUCF CATEGORIES

Definitions applied within this inventory regarding the Forest land are consistent with the GPG 2003 and also with the KP reporting requirements in order for both UNFCCC and KP reporting frame to be completely harmonized, transparent and comparable. Therefore, *Forest land remaining forest land* is represented in KP reporting within Article 3.4 (Forest Management) and *Land converted to forest land* refers to afforestation activities under the Article 3.3 activities while *Forest land converted to Settlements* refers to deforestation activities under the Article 3.3. All definitions applied for KP are the same as applied for the UNFCCC reporting (see KP Chapters 11.1.1. *Definition of forest and any other criteria* and 5.1.3. *Description of how the definitions of each activity under article 3.3 and each elected activity under article 3.4 have been implemented and applied consistently over time*).

The Forest land is composed of the *Forest land remaining forest land* and *Land converted to forest land*. The *Forest land remaining forest land* is forest land with tree cover (national frame) but with forest defined as the land spanning more than 0.1 hectares with trees higher than 2 meters and canopy cover more than 10 percent, or trees able to reach these thresholds *in situ* (KP definition). Based on this definition, the forest stands that fall within these thresholds are high forests, plantations, cultures, coppice, maquia and scrub. **However, since a complete dataset required for emission/removal calculation is not available for maquia and shrub, the estimation of carbon stock change for the related forest stands is not performed. It should be noted that there is no wood harvest in maquia, shrub, garigue and scrub.** So, in line with IPCC GPG approaches is assumed that there is no human-induced C stock change. Thus, these areas are excluded from the estimates of C stock changes.

Therefore, the *Forest land remaining forest land* is forest land covered with high forests, plantations, cultures and coppice.

According to the *Ordinance*¹⁸ total forest land in Croatia is divided in two main categories with several subcategories. The latter is as follows:

I. Forest land with tree cover

II. Land under forest management (forest land without tree cover):

- Productive forest land without tree cover (e.g. clearings, grasslands)
- Non-productive forest land without tree cover (e.g. fire lanes, landings)

¹⁸ Ibid. Reference No 2

- Barren wooded land (e.g. forest roads wider than 3 meters, quarries)

Therefore, based on the aforementioned, within the national frames, there exists land without tree cover in Croatia under forest management plans, which represents grassland according to the IPCC definition. The latter indicates for example that afforestation does not necessarily mean land conversion for Croatia in the administrative national frame. According to the IPCC GPG definitions of land use categories, land under the forest management plans on which afforestation is performed in Croatia, falls under the Grassland category. Therefore, this afforestation land (though always “forest land” in the Croatian administrative understanding) represents a LUC land from grassland to forest land according to IPCC GPG and is reported as such. The Croatian reporting of lands and LUCs follows the IPCC GPG definitions. To present land under the forest management (without tree cover) previously it was used Other land category. Since 2012 report this has been changed and this land was reported under the Grassland category.

7.2.4 METHODOLOGICAL ISSUES

7.2.4.1 Forest land remaining forest land (5.A.1)

A) Changes in the carbon stock in the living biomass

The dataset required for presenting the biomass carbon stock change encompasses the entire period from 1990-2011 and the main data source is the Forest Management Area Plans (FMAPs). Data are divided based on the ownership and forest type upon which the related emission/removal calculation was performed using primarily Tier 1. However, data are presented in CRF in aggregated form as coniferous, deciduous and out of yield forests (maquies and shrub). The calculation refers only to living biomass. The C stock changes of the other pools (dead wood, litter, soil) are reported according to IPCC GPG tier 1, no C stock change is assumed. Shortly, the calculation can be presented as follows:

$$\Delta C_{FFLB} = (\Delta CFFG_{CFj} - \Delta CFFL_{CFj}) + (\Delta CFFG_{Otherj} - \Delta CFFL_{Otherj}) + (\Delta CFFG_{Privatej} - \Delta CFFL_{Privatej})$$

Where:

ΔC_{FFLB} = annual change in carbon stocks in living biomass (includes above and below ground biomass) in the *Forest land remaining forest land*, Cyr^{-1}

$\Delta CFFG_{CFj}$
 $\Delta CFFG_{Otherj}$
 $\Delta CFFG_{Privatej}$ = annual increase in carbon stocks due to biomass growth, in state forests managed by “Croatian Forests” (CF), other state forests (Other) and private forests (Private), by forest types ($j=1,2$), Cyr^{-1}

$\Delta CFFL_{CFj}$ = annual decrease in carbon stocks due to biomass loss, in state forests

$\Delta\text{CFFL}_{\text{Other } j}$ managed by "Croatian Forests" (CF), other state forests (Other) and
 $\Delta\text{CFFL}_{\text{Private } j}$ private forests (Private), by forest types ($j=1,2$), Cyr^{-1}

Where $j =$
 1 - broadleaved
 2 - coniferous

The activity data for CO₂ emission/removal calculation includes data on forest area, increment and fellings. Methodological issues are explained in detail below.

Forest area

Data on forest area are in line with the relevant definitions and therefore exclude afforested area. Figure 7.2-3 shows forest area by ownership for all forests that meet Kyoto definition of forests (maquies and shrub included) for the period 1990-2011.

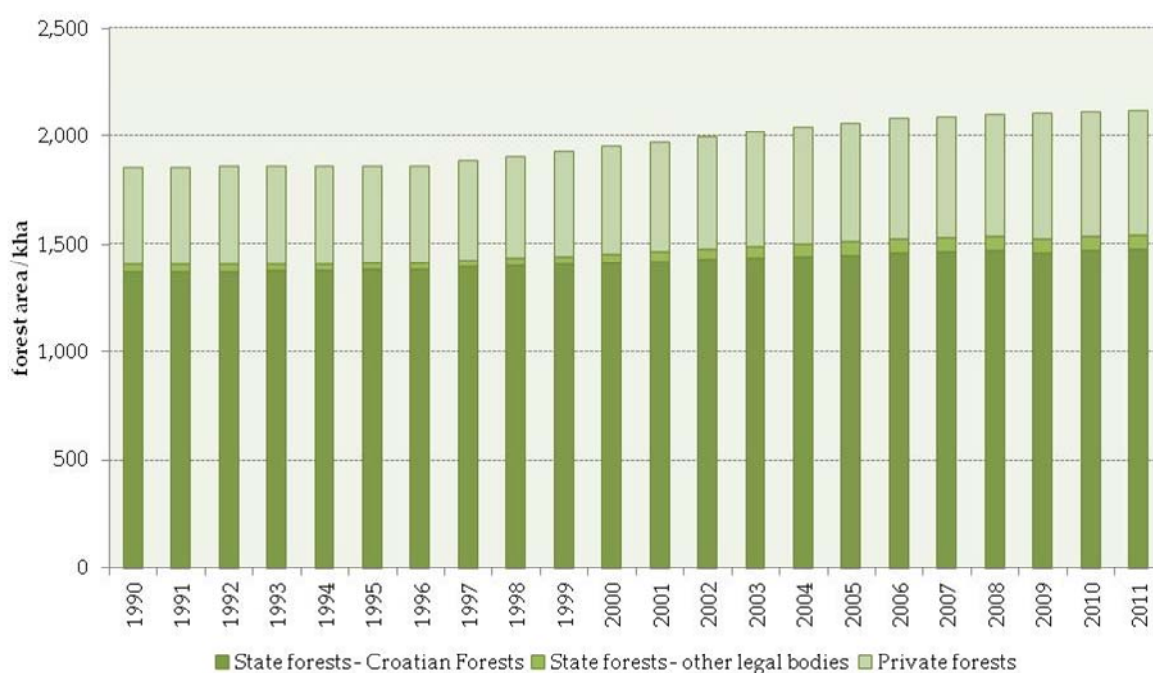


Figure 7.2-13: Forest area by ownership

Increment

For this year submission, following recommendation given by ERT during the in county review Croatia decided to apply same approach to calculate carbon gains in increments for all forests regardless the ownership structure. For this year reporting, Croatian forests delivered data about increment presented as per ha value for all types of forests ownership. Increment is presented per broadleaved and coniferous species for all type of

forest ownerships. Data are presented in CRF tables for coniferous and deciduous species without previously used disaggregation on forest ownerships although emissions/removals in this category of land are calculated for each category of ownerships separately.

Since the War period, in Croatia there is an active process of returning previously confiscated forests to private owners¹⁹ which makes difficult to follow difference in area based on ownership structure.

The carbon loss due to fellings is calculated using Tier 2 and **equation 3.2.7 from GPG 2003**.

For this year submission Croatia estimated national values for wood densities for coniferous and deciduous species based on the scientific papers and published data.

Since fellings already include the volume cut after natural disturbances, carbon losses due to natural disturbances are allocated within the carbon losses due to fellings. Therefore, notation key IE was used in the CRF tables.

Data used in the CO₂ emission/removal calculation are presented in Table 7.2-3.

Table 7.2-3: Data used in the CO₂ emission/removal calculation

	tonnes d.m.m ⁻³	dimensionless	dimensionless	dimensionless	(tonnes d.m.) ⁻¹
	D	BEF1	R	BEF2	CF
Broadleaved	0.56	1.2	0.24	1.4	0.5
Coniferous	0.39	1.15	0.23	1.3	

For this year report, national values for wood densities are used in the greenhouse gas estimation in the sector. Based on the wood density values available through the nationally conducted scientific investigations²⁰ and share of species in total growing stock in Croatia²¹, it is estimated that wood density in deciduous species is 0.558 t d.m./ha and 0.395 t d.m./ha in case of coniferous species. For these estimations, wood densities of absolute dry wood per fresh volume (m_0/V_{WET}) were used except in case of hornbeam wood density where value for wood density in absolute dry were used and corrected by the shrinkage factor of 17.1%²².

In case of fir it was concluded that wood density is highly dependable on geological basis and amounts of 0.37 t d.m./m³ or 0.405 t d.m./m³ depending on whether fir appears on silicate or limestone²³. Since there is no exact data about area of fir on silicate and limestone, mean value of 0.387 t d.m./m³ was used when calculating contribution of fir wood density to the wood density of coniferous species in general.

¹⁹ Draft strategy for management and disposal of property of the Republic of Croatia 2013-2017.

²⁰ Scientific papers of Badjun, Horvat, Sinković, Govorčin, Štajduhar. See list of References

²¹ Forest Management Area Plan of the Republic of Croatia 2006-2015

²² Scientific paper of Sinković, Govorčin and Sedlar. See list of References

²³ Scientific paper of Horvat. See list of References

The detailed overview of the approach is shown below:

$$\begin{aligned}\Delta C_{FFLB} &= \Delta CFFG_{CFj} - \Delta CFFL_{CFj} \\ \Delta CFFG_{CF} &= \sum_j (I_{t1CFj} \times D_j \times BEF1_j \times (1+R_j) \times CF)\end{aligned}$$

Where:

$$\Delta CFFG_{CFj} = \text{annual increase in carbon stocks due to biomass growth by forest types (j=1,2), } \text{Cyr}^{-1}$$

$$\Delta CFFL_{CFj} = \text{annual decrease in carbon stocks due to biomass losses by forest types (j=1,2), } \text{Cyr}^{-1}$$

$$I_{t1CFj} = \text{Increment in forests managed at time } t_1, \text{ by forest types (j=1,2), } \text{m}^3$$

$$H_{t1CFj} = \text{gross volume felled at time } t_1 \text{ (all losses), by forest types (j=1,2), } \text{m}^3$$

$$D_j = \text{basic wood density, by forest types (j=1,2), tonnes d.m.m}^{-3}$$

$$BEF1_j = \text{biomass expansion factor for conversion of annual net increment (including bark) to above ground tree biomass increment, by forest types (j=1,2), dimensionless}$$

$$R_j = \text{Root-to-shoot ratio appropriate to increments, by forest types (j=1,2), dimensionless}$$

$$CF = \text{carbon fraction of dry matter, (tonnes d.m.)}^{-1}$$

$$\Delta CFFL_{CF} = L_{felling} + L_{fuelwood} + L_{other losses}$$

$$L_{felling} = \sum_j H_{t1CFj} \times D_j \times BEF2_j \times CF$$

$$H_{t1CFj} = \text{gross volume felled in forests at time } t_1, \text{ by forest types (j=1,2), } \text{m}^3$$

$$BEF2_j = \text{biomass expansion factor for conversion of merchantable volume to above ground tree biomass increment, by forest types (j=1,2), dimensionless}$$

L_{fuelwood}	=	fuelwood gathering assumed as negligible
$L_{\text{other losses}}$	=	no other losses, already included in volume felled

Non-CO₂ greenhouse gas emissions

The controlled burning of managed forest is not carried out in Croatia. The emissions of CO₂ are reported in the sector *Forest land remaining Forest land*. Estimates of non-CO₂ greenhouse gas emissions (CH₄, CO, N₂O and NO_x) released in wildfires were estimated according to Tier 1, equation 3.2.20, IPCC GPG 2003:

$$L_{\text{fire}} (\text{tGHG}) = A \times B \times C \times D \times 10^{-6}$$

Where:

A = area burnt (ha)

B = mass of available fuel (kg d.m./ha)

C = combustion efficiency, dimensionless

D = emission factor (g/kg dm)

Activity data related to area burnt were obtained from the *Croatian Forests Ltd.* Since the data for 1990 and 1991 were not available, average area burnt in the period from 1996-2006 (which is one of the 10-year periods encompassed by the FMAPs) was used. The area destroyed by fires ranges between 446 and 17 174 ha. It should be emphasized that the area burnt on the *Forest land remaining forest land* and area burnt on the *Land converted to forest land* cannot be differentiated for now. Therefore, all non-CO₂ emissions of wildfires are reported only under the subcategory *Forest land remaining Forest land*.

According to the references in the IPCC GPG in calculation a mean value of 19.8 t/ha biomass consumption was applied (BxC). The IPCC GPG 2003 emission factors (D) prescribed in table 3.A.1.16 for CO₂ (1531), CH₄ (7.1) and N₂O (0.11) were used.

The amount of CH₄ and N₂O emissions ranged between 0.24 and 50.70 GgCO₂ equivalent in the reporting period.

A) Changes in the carbon stock in the dead organic matter – dead wood

As regarding the calculation of carbon stock change in this pool, Croatia uses IPCC GPG Tier 1 approach assuming that there are no changes in the dead wood stock in all managed forests.

B) Changes in the carbon stock in the dead organic matter - litter

As regarding the calculation of carbon stock change in this pool, Croatia uses IPCC GPG Tier 1 approach assuming that there are no changes in the litter stock in all managed forests.

C) Soil

There was no change regarding the forest management in the past 20 years. Because of that it is assumed that the average carbon stock in Croatian soils is stable following the approach of the IPCC GPG 2003 Tier 1 methodology.

7.2.4.2 Land Converted to Forest Land (5 A 2)

Emission/removals from land conversion activities have been calculated using the IPCC GPG Tier 2 method for living biomass and soil for the entire period from 1990-2010.

The related definition of *Land Converted to forest land* is provided in Chapter 7.2.3. As stated before, *Land Converted to forest land* refers to *Afforestation* within the KP reporting, but takes the different time frames for both reporting obligations into account (since 1.1.1990 and permanence of AR lands for KP vs. transition period of 20 years for UN-FCCC).

The basic input data for the emission/removal estimates is the area afforested, which refers to the area of state owned forests managed by *Croatian Forests*. For the period before 1990 (transition period of 20 years), the mean afforestation area 1990-1994 was used. A further share of LUC area to forests results due to area consistency reasons (to cover the full increase in forest area across the time series). By expert judgement it was assumed that this remaining increase in forest area comes from LUC from "other land". For the moment, emissions/removals are only estimated for the LUC area from grassland to forest land, but not for the LUC area from other land to forest land. For the subcategory other land to forest land an assessment is carried out if this land-use change is naturally or human induced, managed or unmanaged land and for the exact year of LUC (description of a survey that needs to be conducted is presented in Chapter 11.2.2). Based on the outcome of the survey a decision will be taken whether or not emission/removal estimates of these LUC lands need to be carried out. The assessment needs to be carried out until submission 2014.

According to the IPCC GPG afforestation implies "*The direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources*". In case of afforestation in private forests generated through planting and seeding measures, it should be mentioned that according to the Ordinance²⁴ that prescribes rules for entitlement to funding for work performed in private forests and Article 9 of the Ordinance on the Register of forest owners²⁵, funds can be obtained by private owners only for works performed on area that is registered in cadastre as forest or land

²⁴ Regulations on the procedure for granting funds from fees for the use of beneficial functions of forests for work performed in private forests (OG 66/2006)

²⁵ Ordinance on amendments to the Ordinance on the Register of forest owners (OG 84/2008)

under the forest management. Comparison between national definition of land under the forest management and IPCC definitions of categories of land shows that partially the IPCC category of Grasslands falls under the definition of land under the forest management according to the national definition. Potentially, this means that some of afforestation work could have occurred on grasslands owned by private owners. However, according to the expert judgement, there has not been afforestation works in case of private forests that has been executed on land under the forest management that has not been forested for a period of at least 50 years. The type of land that is under the private forest management plans and without real forest cover is mainly present in karst region in Croatia. Based on the facts that afforestation works in karst region are very demanding, expensive and require to be performed by adequate species which are mostly economically less valid, it is understandable that afforestation in private forests in karst region on land that has not been forested for a period of at least 50 years is not likely.

For the same reasons the same assumption is found valid in case of Other state forests afforestation.

In case of a forest area increase beyond the traced afforestations from grassland to forest land that (as an intermediate solution – was counted as LUC from other land to forest land) Croatia is going to conduct a special survey to determine reasons for the forest area increase which will include forests of all type of ownerships. It is assumed that increase in area of Private and Others state forests is caused by human-induced promotion of natural seed sources, and survey on these forests will be done as it is described in Chapter 11.2.2.

Area afforested in Croatia through planting and seeding measures on yearly bases is presented in Table 7.2-4

Table 7.2-4: Land converted to forest land each year (ha)

Year	Afforested area (grassland to forests)	LUC area from other land to forests
1990	1,373	122.3
1991	695.4	207.6
1992	1,433	0
1993	1,472	1,139
1994	1,983	248.3
1995	1,334	22.4
1996	814.9	321.2
1997	1,265	22,530.3
1998	992.7	22,769
1999	1,148	22,724
2000	715.0	23,184
2001	227.3	23,620
2002	882.3	23,128
2003	969.9	22,863
2004	311.2	23,877
2005	584.8	23,197
2006	443.8	23,460
2007	427.4	4,214
2008	415.0	8,710

2009	516.6	7,317
2010	1,617	6,203
2011	2,082	4,790

The largest part of the forest area in Croatia is managed in a sustainable manner and little is intensively managed. Extensive forest management as such, does not exist in Croatia. According to the forest experts' judgement, the area of land converted to intensively managed forest (in our case plantations) is very small. Since these data were not provided in this form, the calculation was based on the assumption that afforestation resulted in the area of land converted to sustainable managed forest.

As for wildfires, area caught by fire cannot be differentiated between FF and LF area. Nevertheless, all volume burnt is included in the total amount of fellings and thus CO₂ emissions are reported within the *Forest land remaining forest land*. Therefore, CO₂ and non-CO₂ emissions for the *Land converted to forest land* are reported within the subcategory *Forest land remaining forest land* (notation key IE is used in the relevant CRF tables)

A) Biomass

In order to determine the changes in biomass carbon stock in afforested areas in Croatia, the following assumptions and steps were applied:

- During the reporting period, only coniferous species are used for the afforestation since afforestation has been conducted in Croatia primarily in karst region in a way and by dynamics prescribed within official programmes for management of management units on karst. A special attention is required when selecting species for afforestation purposes. Due attention needs to be given to soil type, environmental conditions at the site of afforestation (i.e. exposition, inclination, altitude) and meteorological conditions. All of this contributes to the fact that afforestation on karst in Croatia is done mainly with the coniferous species that have biological characteristics more suitable for karst conditions (i.e. black pine). For these reasons parameters for coniferous forest type only were selected in the report.
- Average annual increment from the IPCC GPG 2003 was used for the aboveground biomass in natural regeneration.
- Values for the temperate forest, coniferous species in age class less and equal to 20 years and ≥ 20 years were applied. The applied value is the same for both age classes (3 t dm/ha annually)
- Mean value of the average Root-to-Shoot ratio for coniferous species was used (IPCC GPG 2003, value of 0.46) IPCC GPG default value of the Carbon fraction (0.5 tC/ t dm) was used

Based on the above mentioned factors, average biomass growth was calculated to be 2.19 tC/ha annually.

In order to calculate the carbon stock losses as a result of grassland conversion to forestland, the nationally determined value for grassland category of 4.3 tC/ ha annually was used.

B) Soil

These soil data were analyzed and it was concluded that the median values determined for each land use category need to be taken into calculation, because they are less influenced by outliers.

For the purposes of this year reporting, additional analyze has been conducted using the dry combustion method²⁶ for the soil carbon content determination since this method has been found more accurate than previously used wet combustion method. For the estimation national value for C/N ratio (10) was used in case of Grassland mineral soils that are converted to Cropland. Due to the new applied methodology soil carbon content in each LULUCF category of land differ than soil content reported in NIR 2012.

The estimates of the soil carbon stock changes at land converted to forest land (afforestation) follow the equation below:

$$\Delta C_{L\text{FMineral}} = [(SOC_{\text{ref}} - SOC_{\text{Non Forest Land}}) \times A_{\text{Aff}}] / T_{\text{Aff}}$$

where:

$\Delta C_{L\text{FMineral}}$ = annual change in carbon stock in mineral soils for inventory year

SOC_{ref} = reference carbon stock

$SOC_{\text{Non Forest Land}}$ = stable soil organic carbon on previous land use

T_{Aff} = duration of the transition from $SOC_{\text{Non Forest Land}}$ to SOC_{ref} (20 years)

A_{Aff} = total afforested/reforested area after conversion

The median values of soil carbon stock for the soil depth of 0-20 cm determined through the national scientific soil survey were used in order to present the carbon stock changes in soil (see chapter 7.3.4.1). It should be noted that the forest land soil C stock includes also the C stock of the litter layer (humus layer), the C stock change of the litter layer is therefore reported as IE (covered by the soil C stock changes). Conversion that happens in Croatian case refers to grassland converted to forestland only with the following values:

- Grassland: 70.6 tC/ha
- Forestland: 84.5 tC/ha

Emission factor determined in this case is 0.7 t C/ha annually.

Table 7.2-5 provides information on annual change in carbon stock in living biomass and soil for the Land converted to forest land. Since 1990 the conversion from other land use categories to the forest land results in CO₂ removal.

Table 7.2-5: Annual change in carbon stock in living biomass and soil for Land converted to forest land

Year	Gg C				Total
	Biomass carbon stocks gains	Biomass carbon stocks losses	Biomass net carbon stock change	Net soil carbon stock change	
1990	60.92	-5.90	55.02	19.33	74.36
1991	59.40	-2.99	56.41	18.85	75.26
1992	59.49	-6.16	53.33	18.88	72.21
1993	59.67	-6.32	53.34	18.93	72.28
1994	60.96	-8.52	52.44	19.35	71.79
1995	60.84	-5.73	55.10	19.31	74.41
1996	59.57	-3.50	56.07	18.91	74.98
1997	59.30	-5.44	53.86	18.82	72.68
1998	58.42	-4.26	54.16	18.54	72.70
1999	57.89	-4.93	52.96	18.37	71.33
2000	56.41	-3.07	53.34	17.90	71.24
2001	53.86	-0.98	52.88	17.09	69.97
2002	52.74	-3.79	48.95	16.74	65.69
2003	51.82	-4.17	47.65	16.44	64.10
2004	49.45	-1.34	48.11	15.69	63.81
2005	47.68	-2.51	45.17	15.13	60.30
2006	45.61	-1.91	43.70	14.47	58.18
2007	43.50	-1.84	41.66	13.80	55.46
2008	41.36	-1.78	39.57	13.12	52.70
2009	39.44	-2.22	37.22	12.52	49.74
2010	39.97	-6.95	33.03	12.69	45.71
2011	43.01	-8.94	34.07	13.65	47.72

7.2.5 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

For the purpose of defining uncertainties in LULUCF sector in Croatia, special questionnaire was developed and several different experts from several Croatian institutions were consulted. This work was supported with the expert help secured through the EU project “Assistance to Member States for effective implementation of the reporting requirements under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC)”.

²⁶ Work performed by Croatian Geological Institute. See list of References

The input uncertainties, associated with the different emission factors and the activity data as well as the sources of information (default values, empirical data or expert judgment) are presented in Tables 7.2-7 and 7.2-6. Some of the uncertainty values defined by experts are determined comparing two different statistics and were influenced with the fact that Croatia presented some of its area using the CLC data with its low resolution. The highest uncertainties defined by the experts refer to LUC to and from Cropland area caused due to the major change in official methodology used by CBS since 2005 and its data gathering and presentation. In this category, uncertainty was determined based on land use change area in certain time periods and applying more pessimistic values in case of more options (conservative estimation).

Table 7.2-6 Uncertainties of the emissions factors and the activity data and sources of information

Inputs	Uncertainty	Source of information
Area of Forest land	10%	Expert judgment
Increment	7%	Expert judgment
Fellings	5%	Expert judgment
Afforestation area	2%	Expert judgment
Deforestation area	2%	Expert judgment
Wood density	30%	Default, IPCC GPG 2003
R/S (Root to Shoot ratio) for coniferous in Forestland	Range 0.12-0.49	Default, IPCC GPG 2003
R/S (Root to Shoot ratio) for deciduous in Forestland	Range 0.17-0.30	Default, IPCC GPG 2003
R/S (Root to Shoot ratio) for coniferous in afforested areas	42%	Default, IPCC GPG 2003
BEF 1 for coniferous	Range 1-1.3	Default, IPCC GPG 2003
BEF 1 for deciduous	Range 1.1-1.3	Default, IPCC GPG 2003
BEF 2 for coniferous	Range 1.15-4.2	Default, IPCC GPG 2003
BEF 2 for deciduous	Range 1.15-3.2	Default, IPCC GPG 2003
CF factor	3%	Expert judgment
Soil C stock in Forestland	92%	Empirical data
Area of Cropland	12%	Expert judgment
aCL area	12%	Expert judgment
pCL area	9%	Expert judgment
LUC area aCL-pCL	500%	Expert judgment
LUC area pCL-aCL	500%	Expert judgment
LUC area GL - aCL	100%	Expert judgment
LUC area GL - pCL	500%	Expert judgment
Yield biomass at LUC areas to and from aCL	156%	Expert judgment
Other aboveground biomass at LUC areas	156%	Expert judgment

to and from aCL		
Belowground biomass at LUC areas to and from aCL	75%	Default, IPCC GPG 2003
pCL aboveground biomass	75%	Default, IPCC GPG 2003
Organic soil area	12%	Expert judgment
Soil C stock in annual Cropland	57.1%	Empirical data
Soil C stock in perennial Cropland	76.3%	Empirical data
Emission factor for organic Grassland soils	90%	Default, IPCC GPG 2003
Emission factor for organic Cropland soils	90%	Default, IPCC GPG 2003
Area of Grassland	30%	Expert judgment
LUC area aCL-GL	100%	Expert judgment
LUC area pCL-GL	100%	Expert judgment
R/S factor in Grassland	95%	Default, IPCC GPG 2003
Organic soil area	30%	Expert judgment
Soil C stock in Grassland	61.2%	Empirical data
Emission factor for organic Grassland soils	90%	Default, IPCC GPG 2003
C/N ratio grassland soils	10.6%	Empirical data
Yield biomass at LUC areas to and from Grassland	75%	Default, IPCC GPG 2003
Area of Wetland	1%	Expert judgment
LUC area aCL-WL	300%	Expert judgment
LUC area pCL-WL	300%	Expert judgment
Soil C stock in Wetlands	67%	Empirical data
Area of Settlement	30%	Expert judgment
LUC area FL-SL	2%	Expert judgment
LUC area aCL-SL	300%	Expert judgment
LUC area pCL-SL	300%	Expert judgment
LUC area GL-SL	200%	Expert judgment
Biomass growth in pCL-SL	50%	Expert judgment
Soil C stock in Settlements	65.4%	Empirical data

Table 7.2-7 Uncertainties of the emissions factors and the activity data and sources of information from emissions from forest fires

Inputs	Uncertainty (%)	Source of information
Area destroyed by fire (A)	30%	Default, IPCC GPG
Quantity of wood burnt down*Burning efficiency (B*C)	75%	Default, IPCC GPG 2003
Emission factor for CO ₂ (D)	75%	Default, IPCC GPG 2003
Emission factor for CH ₄ (D)	75%	Default, IPCC GPG 2003
Emission factor for N ₂ O (D)	75%	Default, IPCC GPG 2003

For all categories of land, uncertainty was performed using the Tier 1 and Tier 2 method.

When performing Tier 2 method, based on Monte Carlo simulation technique, normal distribution has been assumed for the most of the inputs. The number of the applied iterations was 10000. For each category of land, uncertainty is determined by subcategories and by gases. Relative value uncertainties in LULUCF sector was used when estimating uncertainty of all sectors. When presenting the totals for the uncertainty forest fire emissions were added to the totals of Forest land and remaining Forest land and N₂O emissions from LUC to Cropland were added to the totals of Cropland remaining Cropland. Relative uncertainty for the whole LULUCF sector ranges between $\pm 41\%$ and $\pm 79\%$.

As regarding the *Forest land remaining forest land*, the relative uncertainty of CO₂equivalent emission/removal ranges between ± 44 and $\pm 62\%$ and it is calculated using the uncertainties for emission factors and area presented in Tables 7.2-6 and 7.2-7. In case of LUC to Forest land uncertainty of CO₂equivalent is calculated to ranges between -147 and +173%.

In regards to N₂O emission uncertainty it is calculated to ranges between ± 160 and $\pm 164\%$.

In case of *Grassland converted to forest land*, the uncertainty of CO₂ emission/removal calculation is calculated as range of ± 148 to $\pm 173\%$.

Up to now, Grassland category was included in uncertainty estimates under the land converted to Forest land until investigation on LUC to Forest land arising from Other land category will be conducted.

7.2.6 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

During the preparation of inventory submission, all activity data were checked. The emission calculation was performed by one person and afterwards independently checked by another person within the institution that prepared the inventory. Institution that leads the technical work has approval of the Ministry of Environmental and Nature protection for carrying out the GHG calculations. Activities related to quality control were also focused on completeness and consistency of emission estimates and also on the proper use of notation keys in the CRF tables.

The input data, estimates and results were checked as follows:

1) Bottom-up check

1.1. Input data

- Check for the plausibility of the activity data and their trend
- Check for plausibility of the emission factors as well as the related input data and their trends
- Check of input data for completeness

1.2. Estimations

- Check of the correctness of all equations in the estimate files
- Check of the correctness of all interim results
- Check of the plausibility of the results and their trends
- Check of the correctness of all data and results transfer

2) Top-down check

During the preparation of inventory, experts from all relevant fields were included. All input data were checked by the experts. The definitions, factors and methods applied in the report were agreed with the experts in relevant fields, ensuring in that way consistency and completeness of input data. The final calculated data were sent to the experts for their approval. The used activity data and emission factors were also compared with the data from other data sources (e.g. from literature, results in NIRs of other comparable regions, IPCC default values).

7.2.7 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations made since the last year of reporting:

- For this submission Croatia applied national values for wood densities for deciduous and coniferous species
- Conservative estimates in case of deforestation areas in private forests (pre-2006 year) and state forests that are managed by other legal bodies were applied. Corresponding changes in land use matrix has been performed
- New data aggregation was applied for the estimation and presentation of data in CRF
- Unique approach to carbon gains estimation in increment was introduced for all type of forests ownerships
- Based on new scientific investigation, new values for carbon stock in soils were used²⁷

Recalculations made since the NIR 2012 submission:

- Corrected error due to wrong data entry in CRF (GgCO₂ instead of GgC) in case of carbon losses in the category Forest land converted to Settlements (error made in version for NIR 2012 submission)
- Correction in use of C/N ratio in case of Cropland mineral soils (instead of value defined by the GPG, national value was used)

²⁷ Ibid. See Reference No 13

7.2.8 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

- Disaggregation of data based on the forest ownership was found as not the most suitable for the purposes of this reporting and needed to be reviewed. Introduction of the new data presentation as coniferous, deciduous and out of yield forests needs to be further investigate
- Further stratification (e.g. on species level) in order to improve the overall calculation and to be able to apply more country-specific BEFs
- Growing stock in maquis and shrub forests needs to be estimated/identified in order to attain the dataset required for emission/removal calculation since this vegetation is also within the Kyoto forest definition
- For the subcategory other land to forest land an assessment need to be carried out if this land-use change is naturally or human induced, managed or unmanaged land and for the exact year of LUC. Depending on the outcome estimates for the related emissions/removals will be carried out.
- Attaining required data on forest fires separately for the *Forest land remaining forest land* and *Land converted to forest land* with the purpose of improving the reporting of CO₂ and the non-CO₂ emissions

Improvements are to be implemented in timeframe as it is presented in Chapter 10.3.

The Croatian National Forest Inventory (CRONFI) is still under consideration among the forestry society and has no official character. In that respect, the Ministry of Agriculture and the Ministry of Environmental and Nature Protection agree that preparation of the annual GHG Inventory in respect of LULUCF sector should be based on the forest management plans. Once CRONFI becomes official, it could be used to fill the gaps in reporting.

By taking into consideration the consistency requirements for this reporting, it should be mentioned that the forest management in Croatia from its beginning relies on the forest management plans while CRONFI was conducted for the first time.

7.3 CROPLAND 5.B

DESCRIPTION

In this category emissions/removals from cropland management (Cropland Remaining Cropland and Land Converted to Cropland) were considered.

Cropland area ranged from 1,541 kha to 1,624 kha in the period 1990-2011. Emissions from the change in carbon stock in biomass and soil ranged from 90.55 to 280.52 GgCO₂ for the period 1990-2011.

Annual LUCs to Cropland occurs from the Grassland category.

Tables 7.3-1 and 7.3-2 present the land use change and removals/emissions from land use change to cropland in the period 1990-2011.

Table 7.3-1: Activity Data of Cropland from 1990 to 2011 in kha*

Year	5 B Cropland - Total	5B1 Cropland remaining cropland - total	5B1a annual cropland remaining annual cropland	5B1b perennial cropland remaining perennial cropland	5B1C perennial Cropland converted to annual cropland	5B1D annual Cropland converted to perennial Cropland	5B2 Land converted to Cropland	5B2.2 a Grassland converted to annual cropland	5B2.2b Grassland converted to perennial cropland
1990	1,623.8	1,616.4	1,472.1	143.1	0.4	0.9	7.3	6.7	0.6
1991	1,607.1	1,600.0	1,457.8	140.9	0.4	0.9	7.1	6.5	0.6
1992	1,604.2	1,597.4	1,457.0	139.1	0.4	0.8	6.8	6.3	0.5
1993	1,601.3	1,594.8	1,456.3	137.3	0.4	0.8	6.5	6.0	0.5
1994	1,598.5	1,592.2	1,455.5	135.5	0.4	0.8	6.3	5.8	0.5
1995	1,595.6	1,589.6	1,454.8	133.7	0.4	0.8	6.0	5.6	0.5
1996	1,592.8	1,587.0	1,454.0	131.9	0.4	0.7	5.7	5.3	0.4
1997	1,589.9	1,584.4	1,453.2	130.0	0.4	0.7	5.5	5.1	0.4
1998	1,587.0	1,581.8	1,452.5	128.2	0.4	0.7	5.2	4.8	0.4
1999	1,590.2	1,585.3	1,455.8	128.4	0.4	0.7	5.0	4.6	0.3
2000	1,591.8	1,587.1	1,466.7	119.4	0.4	0.6	4.7	4.4	0.3
2001	1,587.5	1,582.0	1,463.6	117.5	0.4	0.6	5.5	5.1	0.4
2002	1,583.1	1,576.9	1,458.0	118.0	0.4	0.5	6.2	5.8	0.4
2003	1,578.8	1,571.8	1,453.4	117.6	0.3	0.5	7.0	6.5	0.5
2004	1,574.5	1,566.7	1,446.4	119.5	0.3	0.5	7.8	7.3	0.5
2005	1,570.1	1,561.6	1,441.3	119.5	0.3	0.4	8.5	8.0	0.6
2006	1,565.8	1,556.5	1,432.3	123.5	0.3	0.4	9.3	8.7	0.6
2007	1,561.5	1,551.4	1,418.1	132.7	0.3	0.3	10.1	9.4	0.7
2008	1,557.1	1,546.3	1,407.5	138.2	0.3	0.3	10.8	10.1	0.7
2009	1,552.8	1,541.2	1,399.8	140.8	0.2	0.3	11.6	10.9	0.7
2010	1,548.5	1,536.1	1,401.2	134.4	0.2	0.2	12.4	11.6	0.8
2011	1,544.1	1,530.7	1,394.4	135.9	0.2	0.2	13.4	12.5	0.9

*(LUCs from other categories than Grassland do not occur)

Table 7.3-2: Emissions (+) / removals (-) of CO₂ in Cropland from 1990 to 2011 (Gg CO₂ equivalent)

	5 B Total Cropland	5.B.1 Cropland remaining cropland	5.B.2 Land converted to cropland	5.B.2.1 Forestland converted to cropland	5.B.2.2 Grassland converted to cropland	5.B.2.3 Wetlands converted to cropland	5.B.2.4 Settlements converted to cropland	5.B.2.5 Other land converted to cropland	N2O in CO2 equiv
1990	164,8	136.5	28.3	0.0	23.5	NO	NO	NO	4.9
1991	151.4	123.2	28.1	0.0	23.4	NO	NO	NO	4.7
1992	142.0	114.8	27.1	0.0	22.6	NO	NO	NO	4.5
1993	144.8	118.7	26.2	0.0	21.8	NO	NO	NO	4.3
1994	147.5	122.3	25.2	0.0	21.0	NO	NO	NO	4.2
1995	166.6	142.5	24.2	0.0	20.2	NO	NO	NO	4.0
1996	161.1	137.9	23.2	0.0	19.4	NO	NO	NO	3.8
1997	164.0	141.8	22.2	0.0	18.5	NO	NO	NO	3.7
1998	183.2	161.0	21.2	0.0	17.7	NO	NO	NO	3.5
1999	171.7	151.5	20.2	0.0	16.9	NO	NO	NO	3.3
2000	248.6	229.3	19.3	0.0	16.1	NO	NO	NO	3.2
2001	281.8	262.9	18.9	0.0	15.2	NO	NO	NO	3.7
2002	258.6	236.4	22.2	0.0	18.0	NO	NO	NO	4.2
2003	244.3	218.8	25.5	0.0	20.8	NO	NO	NO	4.7
2004	254.3	225.5	28.8	0.0	23.6	NO	NO	NO	5.3
2005	235.8	203.7	32.2	0.0	26.4	NO	NO	NO	5.8
2006	214.3	178.8	35.5	0.0	29.2	NO	NO	NO	6.3
2007	139.7	100.9	38.8	0.0	32.0	NO	NO	NO	6.8
2008	106.3	64.2	42.1	0.0	34.8	NO	NO	NO	7.4
2009	93.2	47.8	45.4	0.0	37.5	NO	NO	NO	7.9
2010	127.1	78.4	48.7	0.0	40.3	NO	NO	NO	8.4
2011	103.1	50,0	53.0	0.0	43.9	NO	NO	NO	9.1

7.3.2 INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USE DATABASES USED FOR THE INVENTORY PREPARATION

To present cropland area in Croatia data from the Croatian Bureau of Statistics (CBS), CORINE LAND COVER ('Coordination of Information on the Environment' Land Cover, CLC) database (years 1980, 1990, 2000 and 2006) and ARKOD database were reviewed. Significant changes among data obtained from these databases were observed, requiring data adjustments for certain time periods.

CLC database has been established in 1985 as the European program with the aim of a computerized inventory on land cover of the EC member states and other European countries, at an original scale of 1: 100 000. It uses 44

classes of the 3-level Corine nomenclature of which each describes a different land cover. The minimum mapping unit is 25 ha for land cover and 5 ha for mapping land cover changes since year 2000.

In 2002 Croatia joined the program and first CLC database for Croatia was established. At the moment within this database Croatia has information about land cover for years: 1980, 1990, 2000 and 2006. During the CLC 2000 development process 39 of 44 CLC classes were detected in Croatia while developing the CLC 2006 40 classes were detected. Also, continuing to participate in this EU program, Croatia managed to develop following databases on land cover changes: CLC change 1980-1990, CLC change 1980-2000, CLC change 1990-2000 and CLC change 2000-2006.²⁸

ARKOD presents a national system of identification of land parcels and use of agricultural land in Croatia. It is based on digital ortho-photo maps at a scale of 1:5000, which serve as a basis for interpreting and determining the area of agricultural land farms.

The Ministry of Agriculture and the Paying Agency for Agriculture, Fisheries and Rural Development established this system in 2009 as part of the Croatian alignment with EU requirements. ARKOD makes an integral part of the Integrated Administration and Control System (IACS) by which EU member countries allocate, monitor and control direct EU payments to farmers. Full ARKOD application starts with the Croatian membership to the EU. Since 2011 this system has been used to track the payments of nationally paid subsidies. At the moment ARKOD is not complete. It contains data for only about 1 million ha of agricultural land in Croatia and needs to be gradually completed. The majority of ARKOD data was taken over from the Farm Register established in Croatia in 2003 for the purpose of granting subsidies to farmers. This Register is based on cadastral data.

Based on the fact that ARKOD contains data (approximately for about 60% of all agricultural land) only on agricultural land under the incentive system, it is not complete and could not be used for the purpose of this report.

For future reporting purposes, this database should be taken into consideration, in particular after the entry of Croatia into the EU when the ARKOD will have to contain information on all farms in Croatia.

For the purpose of this report the CBS data from the time series 1960-2000 were used. Although these CBS data are consistent during the period 1960-2000, a deviation in data series 1992-1997 due to War influences was recorded. In order to adjust this period, linear interpolation of the CBS data from the period 1991-1998 was used.

The CBS data in the period after 2000 needed to be adjusted due to significant changes in cropland area compared to data from previous periods and data obtained from other data sources. The adjustment was done using the relative trend of the CLC.

The significant changes in cropland and grassland area in the period after 2000 were caused by difference in the CBS data collection and application of new EUROSTAT methodology, as follows: *"In 2005, the Croatian Bureau of*

²⁸ Croatian Environment Agency, Corine Land Cover database

Statistics gathered for the first time crop production statistics data concerning private family farms by using the interview method on a selected sample with the help of interviewers. This meant abandoning a long lasting method of collecting data by using the estimation method done by agricultural estimators on the basis of cadastre data. The sample for agricultural households was selected from the 2003 Agricultural Census data basis and was completely random: the only condition was that at least three households were situated in the same settlement. The sample size was conditioned by inimical means allotted from the State Budget of the Republic of Croatia. As much as 11 000 households were selected in the sample. The criterion for the sample selection was based on seven sizes: the total used agricultural land area, size of arable land, size of garden area, size of meadow area, size of pasture area, size of orchard area and size of vineyard area. All obtained data were expanded, compared to data from previous years, to data from the 2003 Agricultural Census and available administrative sources (the Register of Agricultural Holdings of the Ministry of Agriculture, Fisheries and Rural Development). If necessary, corrections have been made on the basis of all available data.

Due to abandoning of a long-standing method of compiling data through estimates done by agricultural estimators on the basis of cadastral data, there emerged significant differences in data on land areas of some crops, vineyards and orchards. They mostly relate to the reduction of land areas, which could have been caused by the tardiness of the cadastre.

Data on area for the period from 2000 to 2004 were revised according to the Agricultural Census 2003 data. Since there were Agricultural Census data and estimates of statistical experts available for 2003, that year was selected as the most suitable to be used for the recalculation of data on areas. The data for the period from 2000 to 2004 were recalculated by multiplying the 2003 data by indices of annual changes derived from expert estimates.

The main purpose of this revision was the methodological harmonisation of data and methods of estimating data for the mentioned period. The methodology is fully harmonised with the EUROSTAT recommendations²⁹.

Applying the new EUROSTAT methodology and the interview method on private family farms in its statistical work after 2005, the CBS needed to focus only on categories of utilized agricultural area that was used for production in a year in question and actually utilized arable land in a year in question. Collecting data in such a way, the CBS completely omitted records on the traditionally less managed or unmanaged areas in Croatia that were not used in year of question (mostly grassland areas such as meadows and pastures). Before the new methodology was applied, these areas were recorded as unutilized agricultural land (and were traced based on the cadastral data), subcategory that does not exist within the new methodology. Comparison between data gathered using official definitions in CBS work before and after 2005 shows difference of more than 1.0 million ha in grassland areas and explains the difference between the CBS data series for the period 1990-1999 and the period 2000-2010.

The area data adjustment after 2000 for the necessity of this report due to the changes in the CBS data collection approach and application of new EUROSTAT methodology is presented in Figure 7.3-1.

²⁹ Statistical Yearbook of the Republic of Croatia 2012

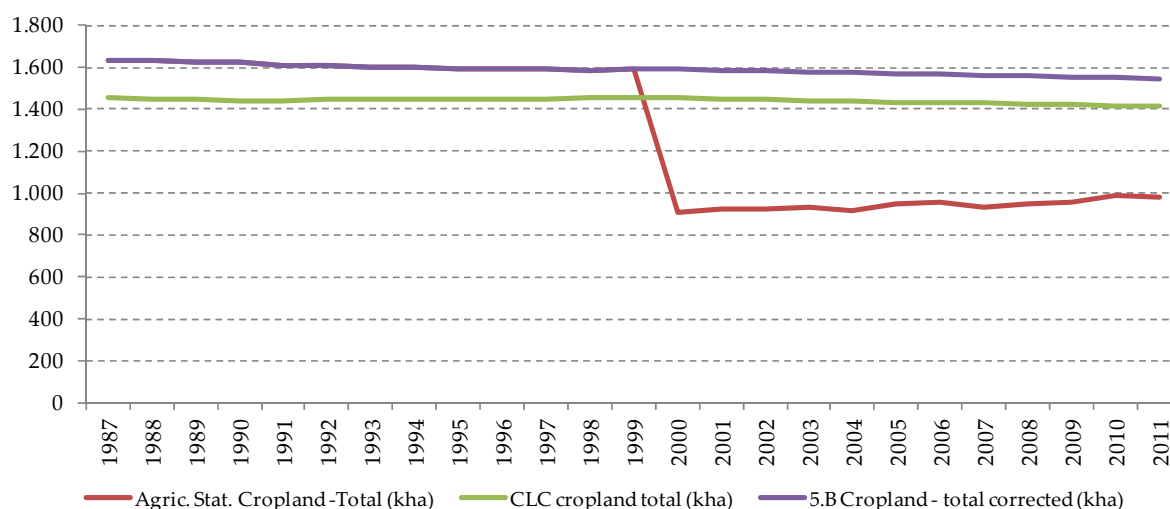


Figure 7.3-1: Total Cropland Area Corrected, kha

The share of perennial cropland in the adjusted total cropland area since 2000 has been estimated based on the relative shares of perennial cropland according to CBS data from the 2000ies. For the years before 2000 the CBS data on annual and perennial cropland area were used. The relative shares of perennial and annual cropland are rather consistent across the whole time series (0.1 vs. 0.9).

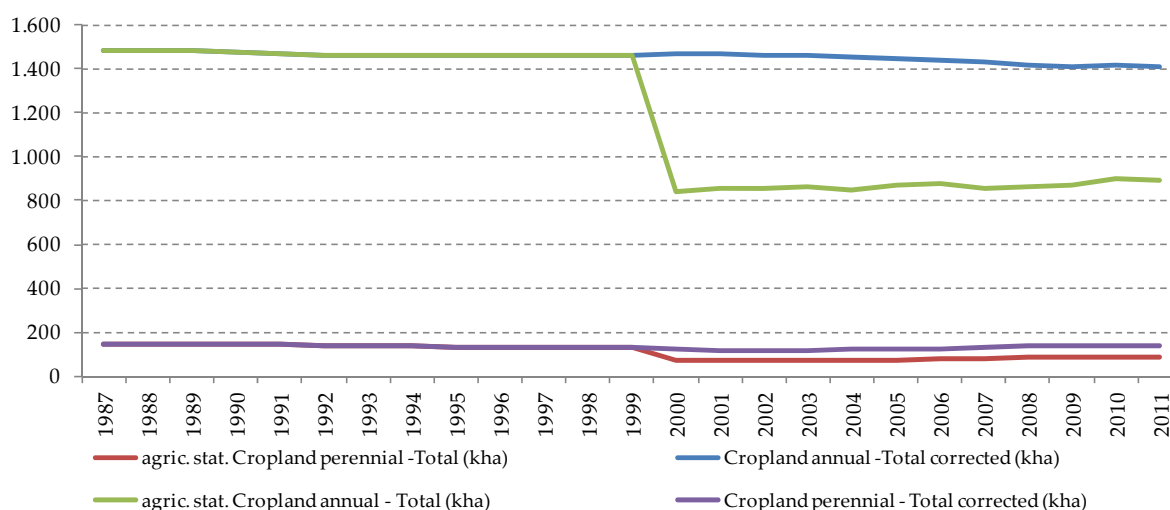


Figure 7.3-2: Area of annual and perennial cropland in Croatia after adjustment of CBS data, kha

For the comparison in this figure the CLC results are based on linear interpolation between the single CLC assessment years (1980–1990, 1981–1989, 1990–2000 and 2000–2006). For the years after 2006 extrapolation of the CLC trend 2000–2006 was applied.

7.3.3 LAND-USE DEFINITIONS AND CLASSIFICATION SYSTEM USED AND THEIR CORRESPONDENCE TO THE LULUCF CATEGORIES

Based on the IPCC GPG definition of the cropland category the area under the following classification of the CBS nomenclature was included in this report:

- Arable Land and Gardens
- Nurseries
- Osier Willows
- Orchards
- Olive groves
- Vineyards

After the year 2000 the area under the CBS nomenclature was compared and data were adjusted with the below presented CLC nomenclature:

- Non-irrigated arable land
- Permanently irrigated arable land
- Vineyards
- Fruit trees and berry plantations
- Olive groves
- Annual crops associated with permanent crops (Complex cultivation patterns)
- Annual crops associated with permanent crops (Complex cultivation patterns)

7.3.4 METHODOLOGICAL ISSUES

7.3.4.1 Cropland Remaining Cropland (5.B.1)

This section provides information about emissions/removals from soil and biomass in the cropland category and comprises the following:

1. annual remaining annual and perennial remaining perennial cropland
2. annual cropland converted to perennial cropland
3. perennial cropland converted to annual cropland

According to the IPCC GPG foreseen method for land use changes within the cropland category, the soil and biomass gains/or losses of annual cropland due to land use changes to/from annual cropland were presented in this report. This approach was applied following the fact that annual cropland has a completely different carbon

stock and accumulation rate than perennial cropland and following the examples of some other countries (Austria, Bulgaria, Luxemburg³⁰) presenting carbon stock changes in this land use category.

A) Biomass

Since the biomass of annual cropland is harvested on an annual basis, there is no long term carbon storage, thus changes in carbon stocks in biomass are not considered in this estimation under the subcategory “annual cropland remaining annual cropland”.

For the subcategory “perennial cropland remaining perennial cropland” the carbon stock changes were estimated using the Tier 1 method. According to this IPCC GPG method the perennial cropland accumulates biomass over the first 30 years, and on an annual basis 3.33% of perennial crops are removed causing the emissions.

- For calculating the carbon stock change of living biomass on perennial cropland remaining perennial cropland, the following IPCC GPG Tier 1 equation was used:

$$\text{Annual change in biomass} = (\text{area of perennial cropland remaining perennial cropland} \times \text{carbon accumulation rate}) - (\text{area of perennial cropland 30 years}^1 \text{ ago} \times 0.033 \times \text{biomass carbon stock at harvest})$$

¹ Excluding perennial cropland areas lost due to land use changes

For the annual carbon accumulation rate in perennial cropland the IPCC GPG default value of 2.1 tC/ha annually was used.

For the aboveground biomass carbon stock at harvest, the IPCC GPG default value of 63 tC/ha annually was used.

- To calculate the annual change in carbon stock of annual cropland living biomass converted to perennial cropland an approach following the IPCC GPG Tier 1 method for LUCs with partly country specific EFs and equation 3.3.8 was applied:

$$\text{Annual change in carbon stock in biomass} = \text{conversion area for a transition period of 20 years} \times \Delta C_{\text{Growth}} + \text{annual area of currently converted land} \times L_{\text{Conversion}}$$

where:

$$L_{\text{Conversion}} = C_{\text{After}} - C_{\text{Before}}$$

$$\Delta C_{\text{Growth}} = \text{Carbon accumulation rate of perennial cropland} = 2.1 \text{ t C/ha annually (IPCC GPG)}$$

³⁰ Bulgaria's National Inventory Report for 2012; Austria's National Inventory Report 2012; Luxembourg's National Inventory Report 2012

default value)

C_{Before} = biomass carbon stock of annual cropland before conversion is: 5.67 tC/ha annually

C_{After} = carbon stock immediately after conversion = 0 t C/ ha (IPCC GPG default value)

For annual cropland biomass losses in the year of LUC from annual to perennial cropland the county specific average biomass stock in annual cropland was used. The source of information for the annual cropland aboveground biomass was the CBS Statistical Yearbooks with published data for the yield biomass of annual crops (i.e. wheat, maize, oats, rye, triticale etc.) in the period 2000-2010. For all annual crops mentioned in the Statistical Yearbooks, the absolute dry weight had to be determined. Due to the fact that there were no nationally available absolute dry weight factors for this purpose, approaches used by other countries were followed (Austria, Bulgaria³¹), as well as expansion factors from the Austrian Expert Panel for Soil Fertility³². The related biomass of strew, leaves or other aboveground plant parts has been determined using the expansion factor from Austria also.

In order to provide an estimate of the belowground biomass the estimated aboveground biomass in annual cropland was multiplied with the root/shoot ratio. Root/shoot ratios of the United States Department of Agriculture were applied for this purpose following examples from other countries. The explanation for the use of this root/shoot ratio was found fitting for Croatia too (all the mentioned countries belong to the temperate region).

For each year from the period 2000-2010 the weighted mean value of the total biomass per ha was calculated on the basis of yields of individual crops and the corresponding areas. From the results thus obtained the average annual carbon stock in annual cropland biomass for Croatia (5.67 tC/ha) was determined.

- To calculate the annual change in carbon stock of perennial cropland living biomass converted to annual cropland an approach following the IPCC GPG Tier 1 method for LUCs with partly country specific EFs and equation 3.3.8 was applied:

$$\text{Annual change in carbon stock in biomass} = \text{Annual area of converted land} \times (L_{\text{Conversion}} + \Delta C_{\text{Growth}})$$

where:

$$L_{\text{Conversion}} = C_{\text{After}} - C_{\text{Before}}$$

ΔC_{Growth} = annual cropland carbon accumulation rate: **1)** 5.7 tC/ha for annual cropland

C_{Before} = carbon stock of perennial cropland biomass before conversion: 63 tC/ha (IPCC GPG default value) (accounted only for the year of LUC)

C_{After} = carbon stock immediately after conversion is 0 t C/ ha (IPCC GPG default value)

³¹ Ibid. Reference No 17

³² Ibid. Reference No 17

According to the IPCC GPG the gains of the annual cropland biomass during land use changes to annual cropland are accounted only once, in the year of LUC to annual cropland.

The area of Cropland Remaining Cropland in 2011 was 1,530 kha.

B) Soil

For the purpose of this report and presenting the soil carbon stock changes the results of the scientific research program named "Geological Maps of Croatia" were used. The work performed in the period 1997-2003 presents a continuation of former researches in this field in Croatia and has a perennial character.

In that period the whole of Croatian territory was covered by setting samples sites in a grid of 5x5 km. Soil samples were collected at depths of 0 to 20 cm (surface horizon A0-20) in such a way that the whole humus layer was included. By this method 2521 soil samples were taken in different land use categories. Each sample was composed of five sub-samples, thus reducing the probability of random errors which appear mainly as a result of local enrichment/depletion of a certain chemical element. The samples were dried, sieved to the fraction of <0.063 mm, homogenized and analyzed on a set of 41 chemical elements. During the evaluation process of carbon content the contribution of rock fragments to the soil's total carbon content was not considered.

The performed statistical analysis included all samples with basic statistical parameters about 27 chemical elements. For the construction of geochemical maps scientists used: 5th, 10th, 25 th (lower quartile), 50th (median), 75th (upper quartile), 90th and 98th percentile.

These soil data were analyzed and it was concluded that the median values determined for each land use category need to be taken into calculation, because they are less influenced by outliers.

For the needs of future reports the results of this scientific research need to be compared with the results of other studies on similar issues (see Chapter 7.9).

According to expert judgment there was no change in the relative stock change factors (tillage factor FMG; land use factor FLU, input factor FI) during the past 20 years; these factors are set by default to 1. Thus there was no change in carbon stocks in soils of annual cropland remaining annual cropland and perennial cropland remaining perennial cropland due to management.

For the purposes of this year reporting, additional analyze has been conducted using the dry combustion method³³ for the soil carbon content determination since this method has been found more accurate than previously used wet combustion method. For the estimation national value for C/N ratio (10) was used in case of Grassland mineral soils that are converted to Cropland. Due to the new applied methodology soil carbon content in each LULUCF category of land differ than soil content reported in NIR 2012.

³³ See Reference No 13

- The land use change area from annual cropland converted to perennial cropland in the conversion status of 20 years changed from 0.2 kha to 0.9 kha from 1990 to 2011.

Following the IPCC GPG (Tier 1) approach, the annual change in carbon stock of mineral soils of annual cropland converted to perennial cropland is calculated as follows:

Annual change in carbon stock in soil = conversion area for a transition period of 20 years × ΔSOC

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = 1.57 \text{ tC/ha annually}$$

where:

ΔSOC = annual change in carbon stock soil

SOC_{0-T} = Croatian soil organic carbon stock in the inventory year = 77.81 tC/ha for perennial cropland

SOC_T = Croatian soil organic carbon stock *T* years prior to the inventory = 46.35 tC/ha for annual cropland

T = Assessment period (20 years)

- Emission/removals due to changes of carbon stock in soils of perennial cropland converted to annual cropland were calculated using the same national figures for the soil carbon content in perennial cropland as in annual cropland. The equation used for this purposes is the same as above:

Annual change in carbon stock in soil = conversion area for a transition period of 20 years × ΔSOC

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = -1.57 \text{ tC/ha annually}$$

ORGANIC SOILS

By expert judgment the area of cultivated organic soils is determined to be 1.18 kha (based on data published in Basic pedology Map of Croatia), with emissions of 3.22 GgCO₂ annually.

For estimating CO₂ emissions from organic soils in the Cropland Remaining Cropland category the IPCC GPG 3.3.5 equation was applied:

$$\Delta C_{CC \text{ Organic}} = A \times EF$$

Where:

ΔC_{CC Organic} = CO₂ emissions from cultivated organic soils (tC/year)

A = land area of organic soils (ha)

EF = emission factor for warm temperate climate = 10 t C/ha annually (IPCC GPG default value)

C) Liming

The application of lime to agricultural soils has yet to be estimated in Croatia. At the time of preparing this report no national data about lime application were available.

However, based on the fact that more than 1.5 million ha of the Croatian soils are acid (Designated Soil Map, Bogunović & et al. 1997), it can be assumed that lime application still occurs in Croatia. For this year's report it was not possible to estimate the amounts of lime used in soils, because the application of lime depends on the general economic situation and the situation in the agricultural sector in particular.

Investigation on this issue needs to be conducted in due time until submission in 2014. See Chapter 7.3.8

7.3.4.2 LAND USE CHANGE TO CROPLAND (5.B.2)

7.3.4.2.1 Forest Land Converted to Cropland (5.B.2.1)

There has been no conversion from forestland to cropland in the last decades.

7.3.4.2.2 Grassland Converted to Cropland (5.B.2.2)

A) Changes in Carbon Stocks in Biomass

Based on the CLC results, the LUCs to cropland category occur on basis of grassland. The area coming from grassland also had to be divided into LUCs to annual cropland and LUCs to perennial cropland which was done directly on basis of specific CLC subcategories representing annual or perennial cropland or according to the share of these land uses in total cropland (0.9 vs 0.1) for mixed CLC categories which include both, annual and perennial cropland in one CLC category.

Representing a LUC transition period of 20 years, 12,5 kha of grassland area were converted to cropland in 2011. The changes of carbon stocks during the conversion from one category to another vary from year to year. In 1990 LUC in this category resulted in emissions of 23.48 Gg CO₂ and in 2011 in emissions of 43.94 GgCO₂.

For the calculation of carbon stock in living biomass of grassland national data were used. The source of information for the grassland aboveground biomass was the CBS Statistical Yearbooks with published data for hay yield. Based on data available for the period 2000-2010 the mean value of hay biomass was calculated (2.5 t dm/ha annually). The total biomass was calculated (4.29 tC/ha) by adding the aboveground stubble biomass (1.6 t dm/ha, IPCC GPG default value) and the appropriate IPCC GPG root to shoot ratio (2.8) and converting it to t C.

The approach used to determine the accumulation of carbon stock in the biomass of annual cropland in the first year after the conversion is presented in Chapter 7.3.4.1

To calculate the annual change in carbon stock of grassland living biomass converted to annual and perennial cropland the IPCC GPG Tier 1 equation 3.3.8 was applied, as follows:

$$\text{Annual change in carbon stock in biomass} = \text{annual area of converted land} \times (L_{\text{Conversion}} + \Delta C_{\text{Growth}})$$

where:

$$L_{\text{Conversion}} = C_{\text{After}} - C_{\text{Before}}$$

ΔC_{Growth} = carbon accumulation rate which amounts to:

- 1) 5.7 tC/ha for annual cropland
- 2) 2.1 t C/ ha for perennial cropland = (IPCC GPG default value)

C_{Before} = carbon stock of grassland biomass before conversion = 4.3 tC/ha

C_{After} = carbon stock immediately after conversion = 0 t C/ ha

B) Changes in Carbon Stocks in Soil

For the calculation of the average annual change in carbon stock of mineral soils of grassland converted to cropland, specific data for the country were used and the IPCC GPG Tier 1 equation was applied, as follows:

$$\Delta \text{SOC} = (\text{SOC}_0 - \text{SOC}_{0-T})/20$$

ΔSOC = annual change in carbon stock soil

SOC_{0-T} = soil organic carbon stock in the inventory year, which amounts to:

- 1) 46.35 tC/ha for annual cropland
- 2) 77.81 tC/ha for perennial cropland

SOC_T = soil organic carbon stock T years prior to the inventory, which equals 70.64 tC/ha

T = Assessment period (20 years)

The change in carbon stock in soils of grassland converted to annual and perennial cropland was further calculated by multiplying the emission factor by the area of converted territory in a transition period of 20 years. The emission factor for grassland converted to annual cropland was calculated to be -1.21 tC/ha annually, and 0.36 tC/ha annually for the area of grassland converted to perennial cropland.

The net soil carbon stock changes resulted in removals in the range of 0,12 to 0,31 GgCO₂ in case of grassland converted to perennial cropland and in emissions in case of grassland converted to annual cropland in the range of 5,31 to 15,24 GgCO₂ for the period 1990-2011.

7.3.4.2.3 N₂O Emissions in Soils of Land Converted to Cropland

The annual release of N₂O due to the conversion of grassland to cropland was calculated using the IPCC default value (Tier 1) and equations 3.3.14 and 3.3.15:

$$N_2O_{\text{net-min}} - N = EF_1 \times \Delta C_{\text{LCmineral}} \times 1/(C/N \text{ ratio})$$

where:

EF₁ = the emission factor for calculating emissions of N₂O from N in the soil = 0.0125 kg N₂O-N/kg N (IPCC GPG default value)

ΔC_{LCmineral} = change in the carbon stock in mineral soils in grassland converted to cropland

C/N = ratio by mass of C to N in the soil organic matter = 10

7.3.5 UNCERTAINTIES AND TIME SERIES CONSISTENCY

According to the Tier 2 method uncertainty for the CO₂ eq total in Cropland category ranges between ± 353 and ± 1157%. The uncertainty values for total CO₂ eq in category Land converted to Cropland ranges from ± 429 to ± 500% using uncertainties for emission factors and area as it is presented in table 7.2-6. In regards to Cropland remaining Cropland, uncertainty for total CO₂ eq ranges between ± 366% and ± 2057%.

In Annex 5 comparison between the uncertainties calculated using Tier 1 and Tier 2 methods by categories and carbon pools is presented.

The cropland category has been included into the key category analysis. The analysis using Tier 1 and Tier 2 Trend methods and Tier 1 and Tier 2 level assessment defined cropland remaining cropland as a key category.

7.3.6 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

The calculation of data for the category 5.B was included in the overall QA/QC system of the Croatian GHG inventory.

7.3.7 CATEGORY-SPECIFIC RECALCULATIONS

- Based on new scientific investigation, new values for carbon stock in soils were used³⁴
- National value for C/N ratio in Cropland mineral soils was used³⁵

Consequently estimation in this category of land differ that estimation in NIR 2012.

7.3.8 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

³⁴ Ibid. See Reference No 13

³⁵ Ibid. See Reference No 13

Data on liming application are still missing and needs to be collected. Organic soil area was determined based on expert judgement. At least a further investigation of specific researches on the subject needs to be conducted. Improvements are planned to be executed until submission 2014.

7.4 GRASSLAND 5.C

7.4.1 DESCRIPTION

In this category only emissions/removals from the grassland management (Grassland Remaining Grassland and Land Converted to Grassland) were considered. For the purpose of this report a combination of the IPCC GPG Tier 1 and Tier 2 approach was used to calculate the carbon stock changes.

The grassland area ranged from 1,210.53 kha to 1,231.71 kha in the period 1990-2011. Removals from the change in carbon stock in biomass and soil ranges from 85.19 GgCO₂ to 173.86 GgCO₂ in period 1990-2011.

Annual LUCs to grassland occurred from the cropland category (annual and perennial) only.

Some management practices, such as burning of stubble-fields, are forbidden in Croatia.

Dead wood and litter pools do not exist in the grassland category, so they are not subject to this report.

Tables 7.4-1 and 7.4-2 show the land use change and removals/emissions from LUC to grassland in the period from 1990 to 2011.

Table 7.4-1: Activity Data of Grassland in the period 1990-2011 in kha

Year	5.C Grassland Total	5.C.1 Grassland remaining Grassland	5.C.2 Land converted to Grassland	5.C.2.1 Forest land converted to Grassland	5.C.2.2 Cropland converted to Grassland	5.C.2.2 annual Cropland land converted to Grassland	5.C.2.2 perennial Cropland converted to Grassland	5.C.2.3 Wetlands converted to Grassland	5.C.2.4 Settlements converted to Grassland	5.C.2.5 Other land converted to Grassland
1990	1,210.53	1,177.79	32.74	NO	32.74	29.90	2.84	NO	NO	NO
1991	1,212.64	1,178.40	34.24	NO	34.24	31.26	2.99	NO	NO	NO
1992	1,214.76	1,178.28	36.48	NO	36.48	33.28	3.20	NO	NO	NO
1993	1,216.88	1,178.34	38.54	NO	38.54	35.15	3.39	NO	NO	NO
1994	1,219.00	1,177.89	41.11	NO	41.11	37.48	3.63	NO	NO	NO
1995	1,221.12	1,178.08	43.03	NO	43.03	39.22	3.81	NO	NO	NO

1996	1,223.24	1,178.56	44.67	NO	44.67	40.70	3.97	NO	NO	NO
1997	1,225.35	1,178.48	46.87	NO	46.87	42.70	4.18	NO	NO	NO
1998	1,227.47	1,178.65	48.82	NO	48.82	44.46	4.36	NO	NO	NO
1999	1,229.59	1,178.72	50.87	NO	50.87	46.31	4.56	NO	NO	NO
2000	1,231.71	1,179.24	52.47	NO	52.47	47.76	4.71	NO	NO	NO
2001	1,230.47	1,178.40	52.08	NO	52.08	47.39	4.68	NO	NO	NO
2002	1,229.23	1,176.98	52.25	NO	52.25	47.54	4.71	NO	NO	NO
2003	1,227.99	1,175.38	52.61	NO	52.61	47.86	4.75	NO	NO	NO
2004	1,226.75	1,174.63	52.13	NO	52.13	47.41	4.72	NO	NO	NO
2005	1,225.52	1,173.39	52.12	NO	52.12	47.40	4.73	NO	NO	NO
2006	1,224.28	1,172.36	51.92	NO	51.92	47.20	4.72	NO	NO	NO
2007	1,223.04	1,171.15	51.88	NO	51.88	47.16	4.72	NO	NO	NO
2008	1,221.80	1,170.08	51.72	NO	51.72	47.00	4.72	NO	NO	NO
2009	1,220.56	1,168.85	51.71	NO	51.71	46.98	4.73	NO	NO	NO
2010	1,219.32	1,166.67	52.65	NO	52.65	47.84	4.81	NO	NO	NO
2011	1,218.08	1,165.31	52.77	NO	52.77	47.95	4.82	NO	NO	NO

Table 7.4-2: Emissions (+) / removals (-) of CO₂ in Grassland 1990-2011 (Gg CO₂ equivalent)

Year	5.C Grassland Total	5.C.1 Grassland remaining Grassland	5.C.2 Land converted to Grassland	5.C.2.1 Forest land converted to Grassland	5.C.2.2 Cropland converted to Grassland	5.C.2.3 Wetlands converted to Grassland	5.C.2.4 Settlements converted to Grassland	5.C.2.5 Other land converted to Grassland
1990	-85.19	2.67	-87.86	0.00	-87.86	0.00	0.00	0.00
1991	-56.59	2.67	-59.26	0.00	-59.26	0.00	0.00	0.00
1992	-47.84	2.67	-50.51	0.00	-50.51	0.00	0.00	0.00
1993	-60.10	2.67	-62.78	0.00	-62.78	0.00	0.00	0.00
1994	-57.91	2.67	-60.59	0.00	-60.59	0.00	0.00	0.00
1995	-80.97	2.67	-83.65	0.00	-83.65	0.00	0.00	0.00
1996	-94.19	2.67	-96.87	0.00	-96.87	0.00	0.00	0.00
1997	-89.27	2.67	-91.95	0.00	-91.95	0.00	0.00	0.00
1998	-103.01	2.67	-105.68	0.00	-105.68	0.00	0.00	0.00
1999	-108.60	2.67	-111.28	0.00	-111.28	0.00	0.00	0.00
2000	-125.55	2.67	-128.22	0.00	-128.22	0.00	0.00	0.00
2001	-171.74	2.67	-174.42	0.00	-174.42	0.00	0.00	0.00

2002	-158.65	2.67	-161.33	0.00	-161.33	0.00	0.00	0.00
2003	-155.77	2.67	-158.45	0.00	-158.45	0.00	0.00	0.00
2004	-173.86	2.67	-176.54	0.00	-176.54	0.00	0.00	0.00
2005	-162.37	2.67	-165.05	0.00	-165.05	0.00	0.00	0.00
2006	-166.34	2.67	-169.02	0.00	-169.02	0.00	0.00	0.00
2007	-162.02	2.67	-164.70	0.00	-164.70	0.00	0.00	0.00
2008	-164.52	2.67	-167.19	0.00	-167.19	0.00	0.00	0.00
2009	-160.58	2.67	-163.26	0.00	-163.26	0.00	0.00	0.00
2010	-139.91	2.67	-142.59	0.00	-142.59	0.00	0.00	0.00
2011	-125.67	2.67	-128.35	0.00	-128.35	0.00	0.00	0.00

7.4.2 INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USE DATABASES USED FOR THE INVENTORY PREPARATION

For the presentation of grassland area in Croatia data from the Croatian Bureau of Statistics (CBS) and the CLC databases (years 1980, 1990, 2000 and 2006) were reviewed. Significant changes were observed requiring data adjustments for the whole time series.

The complete examination of CBS data demonstrated its inadequateness related to the total area of Croatia. The adjustment of CBS data with CLC data for the time series since 2000 had the same results, leading to the exceedance of the total area of Croatia. At the same time, self-standing CLC data fitted adequately to the Croatian area and were used in this report for this reason.

Data from the CBS are the result of the Croatian statistical surveys in the field of agriculture. Since 2005 the CBS has been applying in its work a new methodology defined by EUROSTAT in year 2000.

Before the year 2005 the CBS recorded data on private family farms were collected separately using the estimation method by agricultural estimators on the basis of cadastre data. Data gathered on private family farms using the new methodology showed significant reduction of the grassland area in Croatia in the period 1992-1995 compared to the previous as well as the following years (i.e. in 1987 the area was 1.56 million ha, while in 1995 it was 1.10 million ha). The main reason for this difference was the Croatian Homeland War, because of which investigation could not be carried out on the whole of Croatian territory. A separate and additional problem was areas contaminated with mines. On this land, forest vegetation was gradually taking over due to the stop of grassland management at these lands. More information about present and previously methodology used by CBS for area presentation are given Chapter 7.3.2.

To analyze the CBS data for the purpose of this report, linear interpolation of trend 1991-1996 of the CBS data were used in order to adjust the data for the years with partial data in the period 1992-1995 (Figure 7.4-1).

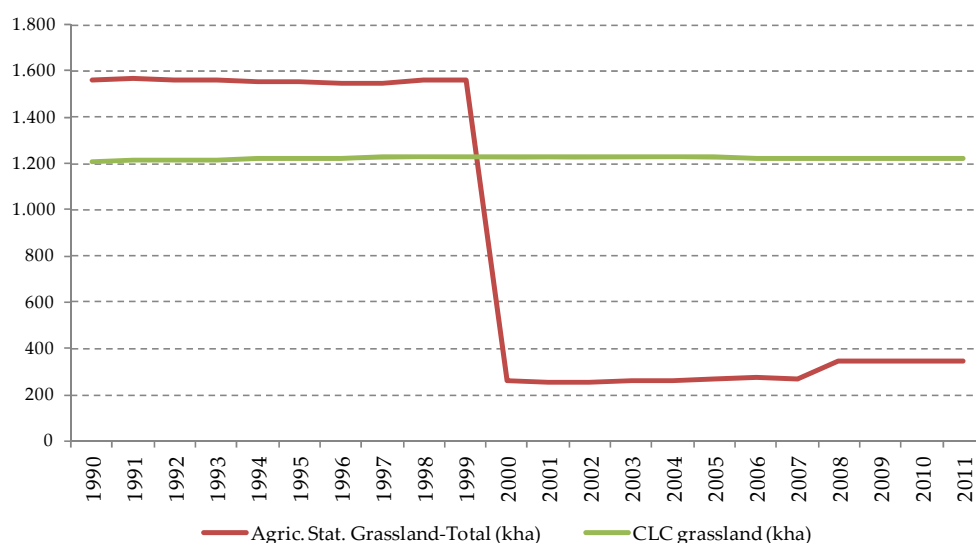


Figure 7.4-1: Total grassland area in Croatia according to the CBS data and CLC database, kha

In this report CLC data were used to present cropland area in Croatia in the years 1980, 1990, 2000 and 2006. Linear interpolation of the CLC trend between these CLC assessment years was carried out. Extrapolation of the CLC trend 2000-2006 was applied for the years after 2006.

According to the CLC trends, the grassland increased in the period 1990-2000 by 2.1 kha annually, and decreased in the period 2001-2011 by 1.2 kha annually.

7.4.3 LAND-USE DEFINITIONS AND CLASSIFICATION SYSTEM USED AND THEIR CORRESPONDENCE TO THE LULUCF CATEGORIES

Based on the IPCC GPG definition of the grassland category the following classes of the CLC database nomenclature are included in this report:

- Pastures
- Land principally occupied by agriculture, with significant areas of natural vegetation
- Natural grasslands
- Moors and heathland
- Sclerophyllous vegetation

7.4.4 METHODOLOGICAL ISSUES

Emissions arisen as the result of LUC were estimated by applying country specific values for the average annual growth in grassland biomass (4.29 t C/ha annually).

7.4.4.1 Grassland Remaining Grassland (5.C.1)

Since the biomass of grassland is harvested on an annual basis, there is no long-term carbon storage; thus changes in carbon stocks in biomass were not considered in the estimation (IPCC GPG 2003).

The area of grassland remaining grassland in 2011 amounts to 1,165.31 kha.

According to the IPCC GPG Tier 1 there was no carbon stock change in soil in the category Grassland Remaining Grassland, since - based on expert judgment - there have been no changes in management practices for grassland in the past 20 years.

The area of organic soils in the grassland category in Croatia was estimated to be 0.29 kha (expert judgment based on data published in Basic pedology Map of Croatia).

The emissions from organic soils were calculated using the IPCC GPG default emission factor (Tier 1) for organic grassland soils in warm temperate climates (2.5 t C/ ha annually). The emissions from organic soils were determined in the value of 2.76 GgCO₂ annually for the period 1990-2011.

According to expert judgment liming does not occur in the grassland category.

7.4.4.2 Land use change to Grassland (5.C.2)

7.4.4.2.1 Forest land converted to Grassland (5.C.2.1)

There has not been conversion from the Forestland to Grassland in the last decades.

7.4.4.2.2 Cropland converted to Grassland (5.C.2.2)

A) Changes in carbon stocks in biomass

According to the CLC results it is concluded that the LUCs into Grassland come from the Cropland area. The area coming from this category of land needed to be also divided into annual Cropland and perennial Cropland. This was done directly on basis of specific CLC subcategories representing annual or perennial cropland or according to the share of these land uses in total cropland (0.9 vs 0.1) for mixed CLC categories which include both, annual and perennial cropland in one CLC category.

With respect to the LUC transition period of 20 years, 52.77 kha of Cropland area were converted into Grassland in year 2011. The changes of carbon stocks during the conversion from one category to another vary between years. In year 1990 LUCs in this category resulted in emissions of 87.86 Gg CO₂ and in year 2011 in emissions of 128.35 GgCO₂.

For the calculation of carbon stock in living biomass of Grassland, national data were used. Source of information for the Grassland aboveground biomass were CBS Statistical Yearbooks with the published data for the hay yield. Based on the available data for period 2000-2010 the mean value of the hay biomass was calculated (2.5 t dm/ha annually). The total biomass was calculated (4.29 tC/ha) by adding of the aboveground stubble biomass (1.6 t dm/ha, IPCC GPG value) and using the IPCC GPG root to shoot ratio (2.8) and the conversion factor to t C.

To calculate annual change in carbon stock of the living biomass of Cropland converted to Grassland the IPCC GPG Tier 1 equation 3.3.8 was applied:

$$\text{Annual change in carbon stock in biomass} = \text{Annual area of converted land} \times (L_{\text{Conversion}} + \Delta C_{\text{Growth}})$$

where:

$$L_{\text{Conversion}} = C_{\text{After}} - C_{\text{Before}}$$

$$\Delta C_{\text{Growth}} = \text{Carbon accumulation rate in Grasslands in Croatia} = 4.29 \text{ t C/ha}$$

$$C_{\text{Before}} = \text{Carbon stock of Cropland biomass before conversion is: 1) } 5.7 \text{ t C/ha for annual Cropland and 2) } 63 \text{ t C/ha for perennial Cropland (IPCC GPG value)}$$

$$C_{\text{After}} = \text{Carbon stock immediately after conversion} = 0 \text{ t C/ha (IPCC GPG value)}$$

B) Changes in carbon stocks in soil

For the calculation of average annual change in carbon stock of mineral soils of Cropland converted to Grassland specific data for the country were used and IPCC GPG Tier 1 equation was applied, as follows:

$$\Delta \text{SOC} = (\text{SOC}_0 - \text{SOC}_{0-T})/20$$

$$\Delta \text{SOC} = \text{annual change in carbon stock soil}$$

$$\text{SOC}_0 = \text{soil organic carbon stock in the inventory year, which is: 1) } 46.4 \text{ tC/ha for annual Cropland 2) } 77.8 \text{ tC/ha for perennial Cropland}$$

$$\text{SOC}_{0-T} = \text{soil organic carbon stock } T \text{ years prior to the inventory, which is } 70.6 \text{ tC/ha for grassland}$$

The change in carbon stock in soils of annual and perennial Cropland converted to Grassland was further calculated by multiplying the emission factor by the area of the converted territory in transition of 20 years. Soil emission factor for the annual Cropland converted to grassland in Croatia is calculated to be 1.21 tC/ha annually, and -0.36 tC/ha annually for the perennial Cropland converted to grassland.

Net carbon stock change is resulting in removals in range of 36.31 to 58.23 GgCO₂ in annual Cropland converted to Grassland and in emissions in case of perennial Cropland converted to Grassland in range of 1.07 to 1.73 GgCO₂ in period 1990-2011.

7.4.5 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

According to the Tier 2 method uncertainty for the total Grassland category ranges between -287 and +756%. The uncertainty values for total CO₂ eq in category Land converted to Cropland ranges from -282 to +716% using uncertainties for emission factors and area as it is presented in table 7.2-6. In regards to Grassland remaining Grassland, uncertainty for total CO₂ eq ranges between -96% and +97%.

In Annex 5 comparison between the uncertainties calculated using Tier 1 and Tier 2 methods by categories and carbon pools is presented.

The grassland category has been included into the key category analysis. The analysis using Tier 2 Level method confirmed land converted to grassland as a key category; however every other method applied excluded this category as the key category.

7.4.6 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

The calculation of the data for category 5.C was included in overall QA/QC system of the Croatian GHG inventory.

7.4.7 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations performed under this category of land are connected with use of new values for carbon stock in soils based on new scientific investigation³⁶.

7.4.8 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Organic soil area was determined based on the expert judgment. At least a further investigation of scientific researches on the subject needs to be conducted. The work is to be performed until NIR 2014 submission.

7.5 WETLANDS 5.D

7.5.1 DESCRIPTION

In this category only emissions/removals from the sub-categories "Land Converted to Wetland" were considered.

Due to lack of information it was assumed that the carbon stock in biomass, dead organic matter and soil of surface waters was 0.

³⁶ Ibid. See reference No 13

Peat extraction does not occur in Croatia.

The wetland area ranged from 72,320 ha in 1990 to 74,358 ha in 2011.

The land use change and removals/emissions from the IPCC land use categories to wetland in the period 1990-2011 are presented in Tables 7.5-1 and 7.5-2.

Table 7.5-1: Activity data of wetland in the period 1990-2011 in ha

Year	5 D Total wetland	5 D 1 Wetland remaining Wetland	5 D 2 Land converted to Wetland	5 D 2.1 Forest land converted to Wetland	5 D 2.2 Cropland converted to Wetlands	5 D 2.3 Grassland converted to Wetlands	5 D 2.4 Settlements converted to Wetlands	5 D 2.5 Other land converted to Wetlands
1990	72,320	70,057	2,263	NO	2,263	NO	NO	NO
1991	72,509	70,057	2,452	NO	2,452	NO	NO	NO
1992	72,699	70,057	2,642	NO	2,642	NO	NO	NO
1993	72,888	70,057	2,831	NO	2,831	NO	NO	NO
1994	73,077	70,057	3,020	NO	3,020	NO	NO	NO
1995	73,267	70,057	3,210	NO	3,210	NO	NO	NO
1996	73,456	70,057	3,399	NO	3,399	NO	NO	NO
1997	73,645	70,057	3,588	NO	3,588	NO	NO	NO
1998	73,834	70,057	3,777	NO	3,777	NO	NO	NO
1999	74,024	70,057	3,967	NO	3,967	NO	NO	NO
2000	74,213	70,057	4,156	NO	4,156	NO	NO	NO
2001	74,226	70,283	3,943	NO	3,943	NO	NO	NO
2002	74,239	70,510	3,730	NO	3,730	NO	NO	NO
2003	74,253	70,736	3,517	NO	3,517	NO	NO	NO
2004	74,266	70,962	3,303	NO	3,303	NO	NO	NO
2005	74,279	71,189	3,090	NO	3,090	NO	NO	NO
2006	74,292	71,415	2,877	NO	2,877	NO	NO	NO
2007	74,305	71,641	2,664	NO	2,664	NO	NO	NO
2008	74,318	71,867	2,451	NO	2,451	NO	NO	NO
2009	74,332	72,094	2,238	NO	2,238	NO	NO	NO
2010	74,345	72,320	2,025	NO	2,025	NO	NO	NO
2011	74,358	72,509	1,849	NO	1,849	NO	NO	NO

Table 7.5-2: Emissions of wetland in the period 1990-2011 in Gg CO₂

Year	5 D Total wetland	5 D 1 Wetland remaining Wetland	5 D 2 Land converted to Wetland	5 D 2.1 Forest land converted to Wetland	5 D 2.2 Cropland converted to Wetlands	5 D 2.3 Grassland converted to Wetlands	5 D 2.4 Settlements converted to Wetlands	5 D 2.5 Other land converted to Wetlands
1990	30.00	NE	30.00	0	30.00	0	0	0
1991	30.17	NE	30.17	0	30.17	0	0	0
1992	31.89	NE	31.89	0	31.89	0	0	0
1993	33.60	NE	33.60	0	33.60	0	0	0
1994	35.32	NE	35.32	0	35.32	0	0	0
1995	37.04	NE	37.04	0	37.04	0	0	0
1996	38.76	NE	38.76	0	38.76	0	0	0
1997	40.47	NE	40.47	0	40.47	0	0	0
1998	42.19	NE	42.19	0	42.19	0	0	0
1999	43.91	NE	43.91	0	43.91	0	0	0
2000	45.63	NE	45.63	0	45.63	0	0	0
2001	36.33	NE	36.33	0	36.33	0	0	0
2002	34.40	NE	34.40	0	34.40	0	0	0
2003	32.46	NE	32.46	0	32.46	0	0	0
2004	30.53	NE	30.53	0	30.53	0	0	0
2005	28.59	NE	28.59	0	28.59	0	0	0
2006	26.66	NE	26.66	0	26.66	0	0	0
2007	24.72	NE	24.72	0	24.72	0	0	0
2008	22.79	NE	22.79	0	22.79	0	0	0
2009	20.86	NE	20.86	0	20.86	0	0	0
2010	18.92	NE	18.92	0	18.92	0	0	0
2011	17.32	NE	17.32	0	17.32	0	0	0

7.5.2 INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USE DATABASES USED FOR THE INVENTORY PREPARATION

In order to present the wetland area in Croatia data presented in the Corine Land Cover databases (years 1980, 1990, 2000 and 2006) and the GIS database on the distribution of habitat types in Croatia were compared. A habitat map was built in a scale of 1:100.000, with a minimum mapping unit of 9 hectares, also containing data on wetlands in Croatia protected under the Ramsar Convention. The primary mapping method was the analysis of Landsat ETM+ satellite images, in combination with other data sources (air photos, literature data) and field

work. Habitats throughout the Croatian territory were mapped. No significant differences between the wetland areas according to these databases were found and it was decided that CLC data would be used for the wetlands area presentation.

Linear interpolation of the CLC trend between the CLC assessment years was carried out. For the years after 2006 extrapolation of the CLC trend 2000-2006 was applied.

According to CLC trends the wetland area increased 226 ha per year in the period 1980-1990, 189 ha per year in the period 1991-2000 and 13 ha per year in the period 2001-2010. The LUC from cropland to wetland was divided into annual and perennial cropland according to the share of these land uses in total cropland (0.9 vs 0.1).

An assessment of the land use changes according to CLC suggested that the observed wetland area increase comes only from the cropland area in Croatia.

7.5.3 LAND-USE DEFINITIONS AND CLASSIFICATION SYSTEM USED AND THEIR CORRESPONDENCE TO THE LULUCF CATEGORIES

Two levels of the first classes under the CLC nomenclature (Wetlands and Water Bodies) were examined; the below presented classes were included into the wetland area:

- inland marshes
- salt marshes
- salines
- intertidal flats
- water courses
- water bodies
- coastal lagoons

7.5.4 METHODOLOGICAL ISSUES

7.5.4.1 Land Use Change to Wetland (5.D.2)

Based on analyzed data it was concluded that no conversion occurred from other land use categories to wetland except from cropland.

7.5.4.1.1 Cropland Converted to Wetland (5.D.2.2)

Changes in Carbon stocks in Biomass of Cropland Converted to Wetland

For the calculation of the annual change in carbon stocks of living biomass in cropland converted to wetland the GPG equation 3.5.6 was applied.

The annual change in carbon stocks of living biomass in cropland converted to wetland (t C/a):

$$\Delta C_{LW\ flood} = \sum A_i \times (B_{after} - B_{before})_i$$

A_i = area of land converted annually to flooded land from original land use i , ha yr⁻¹

B_{before} = living biomass in land immediately before conversion to wetland:

1) for annual cropland 5.7 t C / ha a and 2) for perennial cropland 63 t C / ha (IPCC GPG default value)

B_{after} = living biomass in land immediately before conversion to wetland (default = 0 t C/ha a)

Changes in carbon stocks in soil of cropland converted to wetland

$$\Delta C_{LW\ flood} = \sum A_i \times (B_{after} - B_{before})_i / 20$$

A_i = area of land converted to flooded land for a transition period of 20 years, ha

B_{before} = carbon stock in soil immediately before conversion to wetland:

1) for annual cropland 46.4 t C / ha a, and 2) for perennial cropland 77.8 t C / ha a (See Chapter 7.2.1.)

B_{after} = carbon stock in soil immediately after conversion to wetland (default = 0 t C/ha a)

7.5.5 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

According to the Tier 2 method uncertainty for the total CO₂ eq in category Land converted Wetland ranges between ± 294 and ± 343%. Uncertainties for emission factors and areas used in this estimation are presented in table 7.2-6. In Annex 5 comparison between the uncertainties calculated using Tier 1 and Tier 2 methods by categories and carbon pools is presented.

The wetland category has been included into the key category analysis. The analysis using Tier 1 and Tier 2 Level and Trend methods excluded wetland as a key category.

7.5.6 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

The calculation of the data for category 5.D was included in overall QA/QC system of the Croatian GHG inventory.

7.5.7 CATEGORY-SPECIFIC RECALCULATIONS

- Based on new scientific investigation, new values for carbon stock in soils were used³⁷

7.5.8 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

NA

7.6 SETTLEMENTS 5.E

7.6.1 DESCRIPTION

In this category only emissions/removals from sub-categories "Land converted to Settlements" were considered.

It was assumed that dead wood and litter do not occur in the settlements area.

The settlements area ranges from 220, 002 ha in 1990 to 261, 370 ha in 2011. Emissions from the change in the carbon stock in biomass and soil ranges from 432 to 840 Gg CO₂.

Annual LUCs to Settlements occur from the subcategories Forest Land, Cropland (annual and perennial) and Grassland.

Tables 7.6-1 and 7.6-2 show the land use change and removals/emissions from LUC to Settlements in the period 1990 to 2011.

Table 7.6-1: Activity data of Settlements for 1990-2011 in ha

Year	Total Settlement	5 E 1 Settlement remaining settlement	5 E 2 Land converted to Settlement	5 E 2 1 Forest land converted to Settlement	5 E 2 2 Cropland converted to Settlement	5 E 2 3 Grassland converted to Settlement	5 E 2 4 wetland converted to Settlement	5 E 2 5 Other land converted to Settlement
1990	220,002	197,711	22,291	18,301	2,623	1,367	NO	NO
1991	221,142	198,847	22,295	17,725	2,877	1,692	NO	NO
1992	222,282	199,983	22,298	17,166	3,124	2,008	NO	NO
1993	223,422	200,456	22,966	18,043	2,985	1,938	NO	NO
1994	224,562	201,308	23,253	18,540	2,845	1,869	NO	NO
1995	225,701	203,035	22,666	18,162	2,706	1,799	NO	NO
1996	226,841	204,172	22,670	17,562	2,972	2,135	NO	NO

³⁷ Ibid. See reference No 13

1997	227,981	205,308	22,674	17,077	3,182	2,415	NO	NO
1998	229,121	206,444	22,677	16,558	3,408	2,711	NO	NO
1999	230,261	207,580	22,681	16,150	3,579	2,952	NO	NO
2000	231,401	208,717	22,685	15,768	3,737	3,179	NO	NO
2001	234,126	209,853	24,273	15,335	4,713	4,225	NO	NO
2002	236,850	210,989	25,861	15,064	5,608	5,189	NO	NO
2003	239,575	212,125	27,449	14,617	6,591	6,242	NO	NO
2004	242,299	213,261	29,038	14,524	7,396	7,117	NO	NO
2005	245,023	214,398	30,626	14,026	8,405	8,195	NO	NO
2006	247,748	215,534	32,214	13,649	9,352	9,213	NO	NO
2007	250,472	216,670	33,802	12,895	10,489	10,419	NO	NO
2008	253,197	217,806	35,390	12,383	11,503	11,503	NO	NO
2009	255,921	218,873	37,048	11,754	12,647	12,647	NO	NO
2010	258,645	219,645	39,000	11,529	13,735	13,735	NO	NO
2011	261,370	220,785	40,585	11,344	14,620	14,620	NO	NO

Table 7.6-2: Emissions of Settlements 1990-2011 in Gg CO₂

Year	Total Settlement	5.E.1 Settlement remaining settlement	5.E.2 Land converted to Settlement	5.E.2.1 Forest land converted to Settlement	5.E.2.2 Cropland converted to Settlement	5.E.2.3 Grassland converted to Settlement	5.E.2.4 Wetland converted to Settlement	5.E.2.5 Other land converted to Settlement
1990	448	NE	448	406	24	18	NO	NO
1991	426	NE	426	359	41	27	NO	NO
1992	364	NE	364	290	43	31	NO	NO
1993	400	NE	400	351	25	24	NO	NO
1994	414	NE	414	366	24	23	NO	NO
1995	348	NE	348	303	23	22	NO	NO
1996	365	NE	365	290	42	33	NO	NO
1997	363	NE	363	286	41	35	NO	NO
1998	366	NE	366	283	44	39	NO	NO
1999	372	NE	372	288	43	41	NO	NO
2000	384	NE	384	296	44	44	NO	NO
2001	452	NE	452	297	86	69	NO	NO
2002	459	NE	459	289	90	80	NO	NO
2003	472	NE	472	275	102	94	NO	NO
2004	535	NE	535	331	102	103	NO	NO
2005	529	NE	529	291	119	119	NO	NO
2006	530	NE	530	275	124	131	NO	NO
2007	536	NE	536	246	142	148	NO	NO
2008	579	NE	579	273	146	160	NO	NO
2009	581	NE	581	248	158	175	NO	NO
2010	588	NE	588	237	164	187	NO	NO
2011	603	NE	603	225	177	201	NO	NO

7.6.2 INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USE DATABASES USED FOR THE INVENTORY PREPARATION

In order to present the settlements area in Croatia data presented in the Corine Land Cover databases (years 1980, 1990, 2000 and 2006) and the State Geodetic Administration's Register of spatial units were found useful for this report.

Although the Register contains information on state, county, city of Zagreb, town, municipality, settlements, protected areas, cadastral municipality, statistical range etc, it turned out that the data presentation was not in

line with the requirements of this report (i.e. build-up areas are not presented in the Register). This is why expert judgment recommended to use data from the CLC databases.

Comparing CLC data under the settlements category with the same data in other countries (Austria and Luxemburg), it was observed that the total CLC settlement area in Croatia represents only 2.9 % of total land while in other countries it is significantly higher. Furthermore, it has been observed that roads and railroads within the Croatian CLC settlements category were represented only with 1.5%. Detailed Austrian and Luxembourgian data report that 45 to 50 % of the settlement area is composed of roads and railroad lines.

It was expert judgment that the difference between Croatian CLC settlements area and Austrian and Luxembourgian area were most likely due to the fact that the roads and railroads area outside of the settlements in Croatia was not covered by the CLC database due to the area resolution of CLC and the insignificant narrow areas represented by these traffic lines in the CLC assessment units. Because of that, Croatian CLC settlements data needed to be adjusted for these uncovered countryside traffic areas. The data adjustment for the years 1980, 1990, 2000 and 2006 was done using the correction factor which is estimated to be:

$$((1/(1-0.45+0.015))-(0.029 \times 0.45 \times \text{total area of Croatia}))$$

This correction factor is multiplied with the CLC settlement area to estimate the adjusted settlement area. The term $1/(1-0.45+0.015)$ expands the settlement area for traffic lines (45 % of the settlement area are assumed to be traffic lines, of which only 1.5 % are covered by the CLC results and need to be added to avoid an overestimate). In a next step of this correction factor estimate $-(0.029 \times 0.45 \times \text{total area of Croatia})$ those 45% area share of traffic lines that fall within the detected CLC settlement areas (2.9 % of total area of Croatia) but which are also assessed as other settlement categories than traffic lines due to the area dominance of other categories (e.g. urban fabric) have to be subtracted to avoid traffic area double accounting.

After that linear interpolation of the CLC trend between the assessment years was carried out. For the years after 2006 extrapolation of the CLC trend 2000-2006 was applied.

Based on the CLC data on LUC areas and the information from Croatian Forests Ltd. on deforestation areas it was concluded that LUCs in settlements come from the Forest Land, Grassland and Cropland category. According to the CLC 1990-2000 and CLC 2000-2006 half of the settlements area increase on basis of agricultural land comes from cropland and half from grassland subcategories. The area coming from cropland was divided into annual cropland and perennial cropland according to the share of these land uses in total cropland (0.9 vs 0.1).

The annual increase in the settlements area coming from forest land was recorded based on the data delivered by the Croatian Forests Ltd..

For the years before 1990 the mean LUC areas of the years 1990-1994 were used as LUCs into settlements.

7.6.3 LAND-USE DEFINITIONS AND THE CLASSIFICATION SYSTEMS USED AND THEIR CORRESPONDENCE TO THE LULUCF CATEGORIES

Based on the LULUCF definition of the settlement category the following classes of the CLC database nomenclature were included in this report:

- continuous and discontinuous urban fabric area
- industrial or commercial units
- road and rail networks and associated land
- port areas
- airports
- mineral extraction sites
- dump sites
- construction sites
- green urban areas
- sport and leisure facilities

7.6.4 METHODOLOGICAL ISSUES

7.6.4.1 Land Use Change to Settlements (5.E.2)

A) Biomass

For the calculation of the annual change in carbon stocks of living biomass of the IPCC land use categories converted to settlements the IPCC Tier 2 approach was used. The approach follows exactly the method in the other LUC categories. Country specific biomass data for grassland and annual plants of cropland were used. Based on expert judgment the biomass carbon stocks of annual plants in unsealed areas of settlements was estimated to be the same as the grassland biomass (4.29 t C/ha), corrected as per the relative share of the unsealed areas of settlements in Croatia. According to the CLC database the average share of unsealed areas in the settlements category was 4.5%. Carbon stocks of sealed areas were set to be zero.

The biomass carbon stock growth rates of perennial plants at unsealed settlement areas were determined based on the data from Cadastre of Greens of City of Zagreb. Based on this Cadastre in region of City of Zagreb there is 23251 coniferous trees and 143203 deciduous trees in unsealed area of City of Zagreb. Default annual carbon accumulation rate from the IPCC GPG (Table 3A.4.1) for mixed hardwood species (0,0100 tC/ha annually) was taken to calculate total annual carbon accumulation for deciduous trees in Zagreb.

In case of coniferous species, the mean value of annual carbon accumulation rate for pine and spruce was taken (0,00895 tC/year) from the IPCC GPG (Table 3A.4.1).

The resulting total annual carbon accumulation for trees in City of Zagreb was then divided by the related unsealed area of City of Zagreb to get per ha value. This resulted in an annual growth of trees at unsealed area of City of Zagreb of 0,03 tC/ha annually.

The average annual carbon stock in annual plants of cropland before the LUC was determined to be 5.7 t C/ha. The GPG default value of 63 t C/ha for perennial cropland was used to calculate the biomass carbon stock change in perennial cropland converted to settlements.

For the calculation of the annual change in carbon stocks of living biomass of forest land converted to settlements, specific harvest data for these deforestation areas delivered by the Croatian Forests Ltd were used.

B) Soil

The approach follows exactly the method in the other LUC categories. The calculation of emissions from soil carbon stock changes due to land use changes from other subcategories refer to a soil depth of 0-25 cm. Research on carbon stock in Croatian soils was done so that the skeleton and whole humus layers were included into the soil analysis. The calculation of the emissions from soils as a result of the conversion of other subcategories to settlements was made using national data for carbon stocks in the soils of the land use categories involved in the LUCs (forest land, annual and perennial cropland, grassland, settlement). The soil carbon stocks in unsealed areas of settlements were assessed by this soil survey to be on average 55.0 t C/ha, corrected as per the relative share of the unsealed areas of settlements in Croatia. By expert judgment the median value of the carbon stock was used, because it is less influenced by outliers (see Chapter 7.2.3.1). The used soil C stocks of the previous land uses are the same as represented in the other LUC chapters.

According to GPG the carbon stock change calculation in the litter pool was to be done including the whole humus layer. Consequently, in case of Croatia the carbon stock change in litter is included in the soil C stock change results because the soil C stock of forest land used for the estimates includes also the C stock of the litter layer.

7.6.4.1.1 Forest Land Converted to Settlements (5.E.2.1)

The area in conversion status from forest land to settlements for the time period of 20 years ranged from 9,290 ha to 13,565 ha.

Changes in Carbon Stocks in Biomass of Forest Land Converted to Settlements

Annual net emission rates due to loss of forest biomass and increase of biomass in the settlements area ranged from 27.14 to 132.72 GgCO₂ in the period 1990-2011.

Changes in Carbon Stocks in Soil and Dead Wood of Forest Land Converted to Settlements

The calculation of the emissions from soils as a result of the conversion of forest land to settlements was made by using national data for carbon stocks in soils in forest land (84.7 t C/ha) and carbon stocks in soils of settlements (55.04 t C/ha for the unsealed settlement area or 2.5 t C/ha for the total settlement area).

Annual net emission rates due to carbon stock changes in soil ranged from 46.6 to 76.1 GgCO₂ in the period 1990 to 2011.

The average annual carbon stock change in dead wood in forest land deforested in Croatia is included in the stem wood loss of deforestation areas and therefore included in the biomass results.

7.6.4.1.2 Cropland Converted to Settlements (5.E.2.2)

The area in conversion status from cropland to settlements for the time period of 20 years ranged from 2,623 ha to 14,620 ha in the years 1990-2011.

Changes in Carbon Stocks in Biomass of Cropland Converted to Settlements

Annual net emission rates due to loss of cropland biomass and increase of biomass in settlements area ranged from -6.05 to 0.07 GgCO₂ in annual cropland and -8.00 to 0.01 GgCO₂ in perennial cropland converted to settlements in the years 1990-2011.

Changes in Carbon Stocks in Soil of Cropland Converted to Settlements

The calculation of the emissions from soils as a result of the conversion of cropland to settlements was made by using national data for carbon stocks in soils in annual cropland (46.4 t C/ha) and perennial cropland (77.8 t C/ha), as well as carbon stocks in soils of settlements (55.0 t C/ha for the unsealed settlement area or 2.5 t C/ha for the total settlement area).

Annual net emission rates due to carbon stock changes in soil ranged from 5.3 to 28.9 GgCO₂ in annual cropland and 5.5 to 1.0 Gg CO₂ in perennial cropland converted to settlements in the years 1990-2011.

7.6.4.1.3 Grassland Converted to Settlements (5.E.2.3)

The area in conversion status from grassland to settlements for the time period of 20 years ranged from 1,367 ha to 14,620 ha.

Changes in Carbon Stocks in Biomass of Grassland Converted to Settlements

Annual net emission rates due to loss of grassland biomass and increase of biomass in settlements area ranged from 19 to 0 GgCO₂ during the period 1990-2010.

Changes in Carbon Stocks in Soil of Grassland Converted to Settlements

The calculation of emissions from soils as a result of conversion of grassland to settlements was made by using national data for carbon stocks in soils in grassland (70.6 t C/ha) and carbon stocks in soils of settlements (55.0 t C/ha for the unsealed settlement area or 2.5 t C/ha for the total settlement area).

Annual net emission rates due to carbon stock changes in soil ranged from 5.8 to 49.8 GgCO₂ in the period 1990-2011.

7.6.5 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

According to the Tier 2 method relative uncertainty for the total CO₂ eq in category Land converted to Settlements ranges between ± 89 and $\pm 156\%$. In Annex 5 comparison between the uncertainties calculated using Tier 1 and Tier 2 methods by categories and carbon pools is presented.

The Settlement category has been included into the key category analysis. The analysis using Tier 1 and Tier 2 Level and Trend methods confirmed land converted to Settlement as a key category.

7.6.6 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

The calculation of the data for category 5.E was included in overall QA/QC system of the Croatian GHG inventory.

7.6.7 CATEGORY-SPECIFIC RECALCULATIONS

Based on the recommendations given by the ERT, Croatia applied conservative estimate for the purposes of determining deforestation areas in private forests pre-2006 years and deforestation areas in state forests managed by other legal bodies. In these cases worse case scenarios were applied assuming that the biggest recorded deforested area in both types of ownerships were deforested in years without exact data. Consequently, deforested areas in Croatia are bigger than previously reported.

Based on new scientific investigation, new values for carbon stock in soils were used³⁸.

³⁸ Ibid. See Reference No 13

7.6.8 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Further investigation on deforested areas in private forests pre-2006 years and in state forests managed by other legal bodies in order to secure that emissions on these areas are neither underestimated nor overestimated is planned to be conducted until NIR 2014 submission.

7.7 OTHER LAND 5.F

In this category only the total area of land was considered. There was no conversion from other land use categories to other land.

7.7.1 DESCRIPTION

Table 7.7-1: Activity Data for Other Land, kha

Year	5.E Total Other land	5.E.1 Other land remaining other land	5.E.2 Land converted to Other land	5.E.2.1 Forest and converted to Other land	5.E.2.2 Cropland converted to Other land	5.E.2.3 Cropland converted to Other land	5.E.2.4 wetland converted to Other land	5.E.2.5 Settlement converted to Other land
1990	479.45	479.45	NO	NO	NO	NO	NO	NO
1991	491.89	491.89	NO	NO	NO	NO	NO	NO
1992	490.50	490.50	NO	NO	NO	NO	NO	NO
1993	489.10	489.10	NO	NO	NO	NO	NO	NO
1994	487.71	487.71	NO	NO	NO	NO	NO	NO
1995	486.32	486.32	NO	NO	NO	NO	NO	NO
1996	484.93	484.93	NO	NO	NO	NO	NO	NO
1997	460.99	460.99	NO	NO	NO	NO	NO	NO
1998	437.05	437.05	NO	NO	NO	NO	NO	NO
1999	407.05	407.05	NO	NO	NO	NO	NO	NO
2000	378.67	378.67	NO	NO	NO	NO	NO	NO
2001	358.15	358.15	NO	NO	NO	NO	NO	NO
2002	337.63	337.63	NO	NO	NO	NO	NO	NO
2003	317.11	317.11	NO	NO	NO	NO	NO	NO
2004	296.59	296.59	NO	NO	NO	NO	NO	NO
2005	276.07	276.07	NO	NO	NO	NO	NO	NO
2006	255.55	255.55	NO	NO	NO	NO	NO	NO

2007	253.92	253.92	NO	NO	NO	NO	NO	NO
2008	248.04	248.04	NO	NO	NO	NO	NO	NO
2009	243.34	243.34	NO	NO	NO	NO	NO	NO
2010	238.82	238.82	NO	NO	NO	NO	NO	NO
2011	235.95	235.95	NO	NO	NO	NO	NO	NO

7.7.2 INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USE DATABASES USED FOR THE INVENTORY PREPARATION

In order to present the category of other land area in Croatia data presented in CLC the database (years 1980, 1990, 2000 and 2006) were examined.

According to the definition of CLC classes, the following areas were included into this land use category:

- Beaches, dunes, sands
- Bare rocks
- Sparsely vegetated areas
- Burnt areas

According to CLC the total other land category ranged between 79 and 71 kha in the period 1990-2010, which does not match the available area of the total area of Croatia. The difference between the CLC other land area and available area under the total area ranged between 168 and 413 kha in the reporting period.

This is why the total area of other land is reported according to the IPCC GPG 2003 as the difference between the area of all land use categories except other land and the total area of Croatia, which ranges between 240.11 and 491.19 kha.

Table 7.7-1 presents calculated other-land areas. As can be seen, there are annual decreases of the area of other land. These areas are assumed to change completely to Forest land due to the unfavorable conditions of other land for other land uses.

The other land category has been included into the key category analysis for the first time. The analysis using Tier 1 and Tier 2 Level and Trend methods excluded other land as a key category. The uncertainty of this subcategory has not been defined.

The calculation of data for category 5.F was included in the overall QA/QC system of the Croatian GHG inventory.

The uncertainty assessment model applied in Croatia does not include the other land category into the calculation. When investigation about other land converted to Forest land will be performed, and more accurate data on other land area will be available, uncertainty will be defined for this category of land.

7.8 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 solid waste (MSW) and wastewaters (WW) handling as well as waste incineration, can produce emissions of GHGs including methane (CH₄), carbon dioxide (CO₂) and nitrous oxide (N₂O).

CH₄ emissions as a result of disposal and treatment of MSW, CH₄ emissions from treatment of wastewater (disposal of domestic and commercial wastewater in septic tanks), indirect N₂O emissions from human sewage and CO₂ emissions resulting from incineration of waste (without energy recovery) are included in emissions estimates in this sector.

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 not organized and implemented completely results in the lack and inconsistency of data. However, the improvements of quality and quantity of data are visible in last couple of years. Effort was done in order to evaluate and compile data coming from different sources and adjust them to recommended IPCC methodology which is used for GHGs emissions estimation.

Implementation and establishment of the integral waste management system in Croatia are ensured by applying and fulfilling the objectives defined by the Waste Act³⁹, Strategy⁴⁰ and Plan⁴¹. The main act regulating waste management issues in the Republic of Croatia is the Waste Act. There are a number of ordinances that have been adopted according to Waste Act, some of them regulating certain waste management operations, some regulating management of specific waste types. The transposition of the Acquis in the area of waste management into the Croatian legislation has been completed except for the new Waste Framework Directive⁴². This Directive is to be transposed by the new Waste Act which is under preparation.

Management of the different types of waste is arranged by the Strategy and Plan, which are harmonised by objectives of the hierarchical concept of waste management. Three phases of the hierarchical concept, avoiding/reduction - reuse/recovery - disposal, are ordered according to importance. Avoiding and reducing of waste generation has the highest priority and results in reduction of quantity and adversity of produced waste which enters into the next phase. Reuse/recovery of produced waste has the purpose to use material and energy potentials of waste, in the framework of technical, ecological and economic possibilities. Disposal of remaining inert waste at the managed controlled landfills has the lowest rank in the waste management hierarchy.

³⁹ Waste Act (OG 178/04, 111/06, 60/08, 87/09)

⁴⁰ Waste Management Strategy of the Republic of Croatia (OG 130/05)

⁴¹ Waste Management Plan of the Republic of Croatia for 2007 - 2015 (OG 85/07, 126/10, 31/11)

⁴² Waste Framework Directive 2008/98/EC

According to the Plan, waste management system in Croatia will be organized as integral unit of all subjects at the national, regional and local level by predicted establishment of regional and counties' waste management centres.

Regulation on the Greenhouse Gases Emissions Monitoring, Policy and Measures for Climate Change Mitigation in the Republic of Croatia (Official Gazette No. 87/12) prescribes obligation and procedure for emissions monitoring, which comprise estimation and/or reporting of all anthropogenic emissions and removals. According to requirement, sources of abovementioned greenhouse gases should report required activity data for more accurate emissions estimation.

The total annual emissions of GHGs, expressed in Gg CO₂-eq, from waste management in the period 1990-2011 are presented in the Figure 8.1-1.

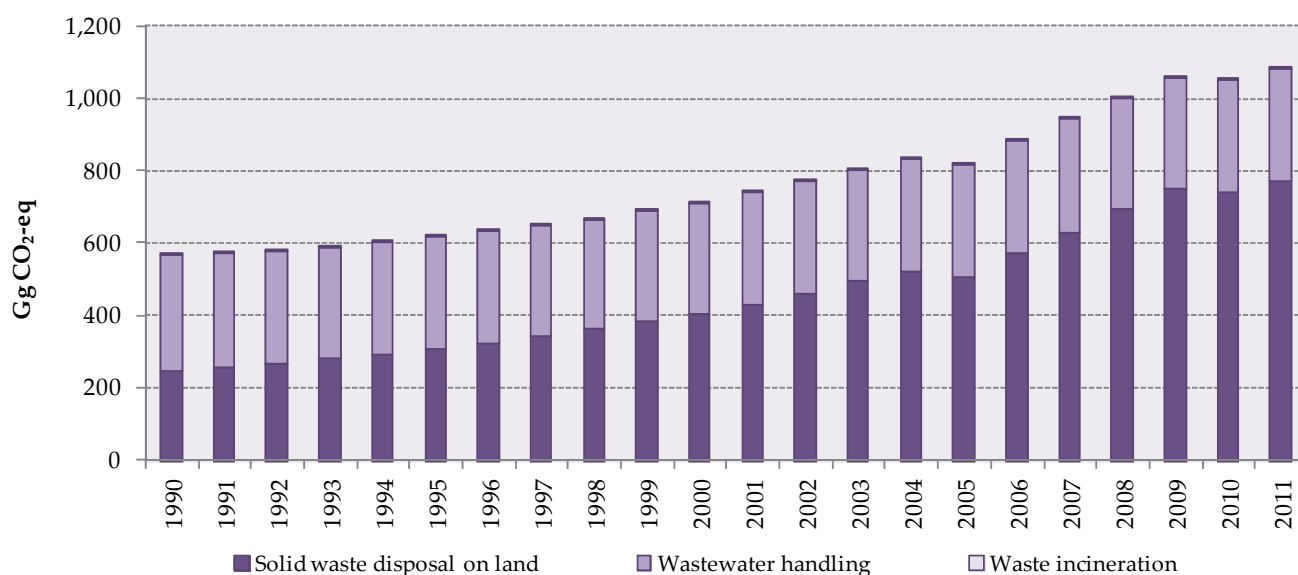


Figure 8.1-1: Emissions of GHGs from Waste (1990-2011)

In Waste sector, two source categories represent key source category regardless of LULUCF (detailed in Table 8.1-1):

Table 8.1-1: Key categories in Waste sector based on the level and trend assessment in 2011⁴³

IPCC Source Categories	Direct GHG	Criteria for Identification			
		Level		Trend	
		excl. LULUCF	incl. LULUCF	excl. LULUCF	incl. LULUCF
WASTE					
CH ₄ Emissions from Solid Waste Disposal Sites	CH ₄	L1e, L2e	L1i	T1e, T2e	T1i, T2i
CH ₄ Emissions from Waste Water Handling	CH ₄	L1e, L2e	L1i		

L1e - Level excluding LULUCF Tier 1

L1i - Level including LULUCF Tier 1

T1e - Trend excluding LULUCF Tier 1

T1i - Trend including LULUCF Tier 1

L2e - Level excluding LULUCF Tier 2

L2i - Level including LULUCF Tier 2

T2e - Trend excluding LULUCF Tier 2

T2i - Trend including LULUCF Tier 2

⁴³ Data on key categories are taken from Annex 1 Key categories (Tier 1 and Tier 2)

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

8.2.1. SOURCE CATEGORY DESCRIPTION

Generation of MSW per capita has registered significant increasing trend until 2008. After 2008 there is a decrease in quantities registered, caused primarily by economic crisis but also other factors regarding to effects of measures undertaken to avoid/reduce and recycle waste. Priority is given according avoiding and reducing waste generation and reducing its hazardous properties. If waste generation can neither be avoided nor reduced, waste must be re-used-recycled and/or recovered; reasonably unusable waste must be permanently deposited in an environmentally friendly way. These objectives, defined by Strategy and Plan, include the assumed time-lags with respect to relevant EU legislation.

The total amount of municipal waste generated in Croatia in 2011 was 1.64 million tonnes, which is in average 371 kg per capita. The amounts of separately collected fractions from municipal waste are gradually increasing. Since 2006, collection schemes have been developed for management of six special waste categories - packaging waste, waste oils, end-of-life vehicles, waste electrical and electronic equipment, waste tires, batteries and accumulators. This resulted in increased quantities of collection and recovery of those waste streams.

There has been no systematic monitoring of the composition of municipal waste, but results of individual research in some areas are available. Apart from certain amount of waste being separately collected, most of municipal waste quantities are still sent to landfills and disposed without previous treatment. The infrastructure currently available for the management of municipal waste and environment protection measures on landfills are still of inadequate standard. However, efforts are being made to reduce possible adverse effects that landfills can have on environment by laying down stringent technical requirements by adopting the Ordinance on the methods and conditions for the landfill of waste, categories and operational requirements for waste landfills, which is in line with the European Directive on the landfill of waste.

The investment level regarding environment protection has been significantly increased for the activities of remediation of existing municipal waste landfills, remediation of illegal dumpsites and establishment of waste management centres. For a total of 300 official landfills registered in the Republic of Croatia in 2005, remediation processes for all the locations are either in planning phase, ongoing or completed. In the period from 2005 to 2011, remediation of 107 official landfills has been completed and the waste removed completely from 66 of them. For 750 wild dumpsites remediation was also conducted, by waste removal. In 2011, the waste is still actively landfilled at 148 official sites.

During the period until 2018, remediation and closure of the existing landfills or their conversion into transfer stations or recycling yards will continue in parallel with the construction of the new waste management centres (implementing mechanical-biological treatment), complying with the requirements of the Landfill Directive. Three of these centres are in the phase of construction. For the City of Zagreb, a waste to energy incineration

plant is planned. This activities combined with planned increase of primary separation, will further lead to the considerable reduction of biodegradable municipal waste on landfills.

8.2.2. METHODOLOGICAL ISSUES

A method used to calculate CH₄ emissions according to *Revised 1996 IPCC Guidelines* is First Order Decay (FOD) method. The quantity of disposed MSW is taken into account from 1955 onwards, which is in line with *IPCC Good Practice Guidance*.

8.2.2.1. Activity data and data sources description

Main data supplier for activity data in Waste sector is CEA. According to the Waste Act, CEA is responsible for maintaining the Waste Management Information System. The CEA is collecting and processing waste data, among other the data reported to Environmental Pollution Register; data on waste management permits and certificates, and data for Landfill Inventory. By the Ordinance on the Environmental Pollution Register (OG No. 35/08), adopted according to Environment Protection Act, the CEA is collecting data on the quantities and types of waste produced, collected, recovered or disposed. Data on quantities are available for each waste code (based on European LoW- List of Waste) and NACE activity. Four forms are available for data delivery (for waste producer, waste collector of municipal waste, waste collector for industrial waste and operator of waste treatment facility). Waste data are reported by operators electronically, using internet based application, on annual basis. Validation and verification of data is done first by county offices (with appropriate support from the environment protection inspectors), and then by the CEA. CEA is cooperating with competent offices in counties and with companies collecting MSW or operating landfills, in order to strengthen data quality. Data is checked for completeness, correctness and consistency in time-series. In cases that collected or disposed waste is not reported, quantities are determined on the basis of previous year report or calculation on the basis of average MSW production per capita. Quality of municipal data is gradually improving as scales are installed at landfills, but still large amount of municipal waste is not being weighted, which usually lead to overestimation of collected and disposed quantities.

Main source for activity data on MSW is Environmental Pollution Register database and Landfill Inventory database, operated by CEA from 2005 onwards.

Historical data for the total amount of generated and disposed MSW for the period 1955-1989 have been estimated based on assumptions on national waste generation rate. Waste generation data have been assessed for the following years: 1955 (0.34 kg/capita/day), 1960 (0.39 kg/capita/day), 1970 (0.46 kg/capita/day), 1980 (0.55 kg/capita/day). Interpolation method has been used to obtain insufficient data for the years between 1955-1960, 1960-1970, 1970-1980 and 1980-1990.

Total annual MSW generated in 1955, 1960, 1970 and 1980 (MSW_T) and fractions of MSW disposed at SWDS (MSW_F) are reported in the Table 8.2-1.

Table 8.2-1: MSW_T and MSW_F in 1955, 1960, 1970 and 1980

Year	MSW_T (Gg)	MSW_F (fraction)
1955	492	0.27
1960	594	0.32
1970	740	0.41
1980	920	0.50

Total annual MSW disposed to SWDS 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. Insufficient 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 and Nature Protection. Data for the quantity of disposed MSW in 2005 were obtained from *Waste Management Plan in the Republic of Croatia*. Taking into account the pattern over 2000 and 2005, quantity of disposed MSW for the period 2001 to 2004 were assessed by interpolation method. Data for the quantity of disposed MSW for the period 2006-2009 was obtained from the Environmental Pollution Register. Due to low quality of data provided by operators of landfills, the data was taken from the reports of companies collecting the MSW (reporting destination of MSW). Data on the quantity of disposed MSW for the years 2010 and 2011 was obtained from the Environmental Pollution Register - reports delivered by the operators of active landfills.

Landfill Inventory contains various data on landfills, such as implementation of technical measures (e.g. fence, scale, flares...) or environment protection measures (e.g. degassing, compacting, aligning, monitoring...). Database also contains data on the status of remediation of landfills (in preparation/ongoing/finished) and status of operation (active/closed). Data collection is not regulated by legislation, but the data forms are periodically sent to landfill operators by CEA (last in 2009) or the update is done upon receiving the information on individual landfill from other sources. Data on remediation status is requested by CEA once a year from the Environment Protection and Energy Efficiency Fund which is cofinancing remediation of all official landfills.

SWDS in Croatia are classified into several categories, according to applied waste management activities, legality, volume and status. In the past the classification was made to "Official" and "Unofficial" SWDS. "Official" SWDS do not necessarily fall under managed SWDS category as defined by IPCC (site management activities carried out in "Official" SWDS in some cases do not meet requirements to be characterized as managed). "Unofficial" SWDS 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 SWDS classification it was proposed that "Unofficial" SWDS fall under unmanaged shallow and deep IPCC categories, whereas "Official" SWDS fall under all three IPCC categories depending on management activities and dimensions of waste disposal sites. In the process of adjustment the country-specific to IPCC SWDS

classification, some assumptions have been made. It has been assumed that MSW was disposed on unmanaged shallow SDWSs in the period 1955-1979 (according to recommendation for developing countries provided by IPCC Good Practice Guidance). It has been assumed that MSW was disposed on uncategorised SWDS in the period 1980-1989. Proportion of waste (by weight) in each type of site (managed, unmanaged deep and unmanaged shallow) have been assessed for the period 1990-1998 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. Due to fact that data for 1999 are not available, proportion of waste in each type of site (managed, unmanaged deep and unmanaged shallow) has been assessed by interpolation method. Information on proportion of waste (by weight) disposed on “Official” and “Unofficial” site in 2000 was obtained from *Report of Environment Condition*, Ministry of Environmental and Nature Protection. Distribution of quantity of MSW disposed on all three IPCC categories (managed, unmanaged deep and unmanaged shallow) has been made by applying a factor of increasing disposed MSW on managed and unmanaged deep SWDS in the amount of 25 % compared to 1998 (according to expert judgement). Distribution of quantity of MSW disposed on managed, unmanaged deep and unmanaged shallow SWDS for 2005 and 2006 has been made by information provided in *Waste Management Plan in the Republic of Croatia*. Taking into account the pattern over 2000 and 2005, quantity of MSW disposed on managed, unmanaged deep and unmanaged shallow SWDS for the period 2001 to 2004 has been assessed by interpolation method. In the process of defining managed and unmanaged landfills for 2010 and 2011 (adjustment the country-specific to IPCC SWDS classification), the set of criteria was defined by working group, using the data available in Landfill inventory and Environmental Emission Register. Landfills on which remediation activities were reported as finished have been selected as managed. Landfills which reported having fully surrounding landfill fences and implemented at least one operation among aligning, compacting or covering, have been selected as managed. Other landfills have been selected as unmanaged and classified as unmanaged deep (≥ 5 m) or unmanaged shallow (< 5 m). Taking into account the pattern over 2005/2006 and 2010/2011, quantities of MSW disposed on managed, unmanaged deep and unmanaged shallow SWDS for the period 2007 to 2009 have been assessed by interpolation method.

The total annual generated and disposed MSW on different types of SWDS in the period 1990-2011 are reported in the Table 8.2-2.

Table 8.2-2: The total annual generated and disposed MSW on different types of SWDS (1990-2011)

Year	MMSW _T (Gg)	MSW _F (fraction)	MSW disposed on managed SWDS (Gg)	MSW disposed on unmanaged SWDS (≥ 5 m) (Gg)	MSW disposed on unmanaged SWDS (< 5 m) (Gg)
1990	1,000	0.59	18	277	295
1991	980	0.61	19	280	300
1992	970	0.63	20	284	309
1993	985	0.65	22	297	324
1994	1,005	0.67	26	322	329

Table 8.2-2: The total annual generated and disposed MSW on different types of SWDS (1990-2011), cont.

Year	MMSW _T (Gg)	MSW _F (fraction)	MSW disposed on managed SWDS (Gg)	MSW disposed on unmanaged SWDS (≥5m) (Gg)	MSW disposed on unmanaged SWDS (<5m) (Gg)
1995	1,060	0.70	31	364	342
1996	1,100	0.72	35	392	361
1997	1,150	0.74	40	433	375
1998	1,205	0.76	45	470	398
1999	1,253	0.78	54	538	383
2000	1,173	0.80	60	618	260
2001	1,259	0.80	131	627	250
2002	1,346	0.80	202	635	240
2003	1,434	0.80	273	644	230
2004	1,439	0.85	344	652	220
2005	1,449	0.89	415	661	210
2006	1,627	0.89	528	720	200
2007	1,683	0.96	822	612	175
2008	1,788	0.97	1,011	564	156
2009	1,743	1.02*	1,126	516	136
2010	1,630	0.97	1,023	456	109
2011	1,645	0.95	1,040	421	102

* quantity of waste removed from remediated landfills is added

8.2.2.2. Parameters description

Data for 3-5 year half-lives for the waste deposited at the SWDS is included in order to achieve accurate emission estimate. IPCC default value for methane generation rate constant ($k = 0.05$), proposed by *IPCC Good Practice Guidance*, has been used in CH₄ emission calculation.

Default methane correction factor (MCF) for unmanaged shallow SDWS of 0.4 has been used for the period 1955-1979. Default MCF for uncategorised SWDS of 0.6 has been used for the period 1980-1989. Weighted average MCF for each type of SWDS (managed, unmanaged deep and unmanaged shallow) has been assessed for the period 1990-2011. Proportion of waste (by weight) for each type of SDWS are multiplied by corresponding default MCF proposed by *IPCC Good Practice Guidance*.

The total weighted average MCF, that is obtained by summing of weighted average MCF for each type of SWDS, for the period 1990-2011, are reported in the Table 8.2-3.

Table 8.2-3: Total weighted average MCF (1990-2011)

Year	MCF (fraction)
1990	0.606
1991	0.606
1992	0.605
1993	0.606
1994	0.613
1995	0.623
1996	0.625
1997	0.632
1998	0.636
1999	0.654
2000	0.702
2001	0.727
2002	0.748
2003	0.767
2004	0.784
2005	0.799
2006	0.818
2007	0.859
2008	0.881
2009	0.896
2010	0.902
2011	0.907

The quantity of CH₄ 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. Only small numbers of municipalities/cities implement the analysis of the composition of mixed municipal waste sent to landfills. There is no obligation to send the result of analysis to competent body, but is available on request only. 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.

DOC has been calculated using default carbon content values proposed by IPCC Good Practice Guidance:

$$\text{Percent DOC (by weight)} = 0.4 (A) + 0.17 (B) + 0.15 (C) + 0.30 (D)$$

A - fraction of MSW that is paper and textiles

B - fraction of MSW that is garden waste, park waste or other non-food organic putrescibles

C - fraction of MSW that is food waste

D - fraction of MSW that is wood or straw

Composition of waste and DOC calculated using default carbon content values are presented in the Table 8.2-4.

Table 8.2-4: Composition of waste and DOC

Waste stream	Percent in the MSW (1955-1997)	Percent in the MSW (1998-2004)	2005-2011
Paper and textiles	22	22	
Garden and park waste	17	19	
Food waste	22	24	
Wood and straw waste	4	3	
DOC	16.99	16.53	15.70*

* objectives defined by Waste Management Strategy and Waste Management Plan, include the assumed time-lags with respect to relevant EU legislation

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 *IPCC Good Practice Guidance* approximately 50-60 percent of total DOC actually degrades⁴⁴ and converts to landfill gas. A mean value for DOC_F , i.e. 55 percent, was taken into account for the purpose of CH_4 emissions estimation from SWDS.

The CH_4 fraction (F) is taken to be 0.5, according to proposed value by *IPCC Good Practice Guidance*.

Collection of data on the quantity of landfill gas captured/flared/recovered was done on the basis of request from CEA sent by letter to operators of landfills which reported gas capture to Landfill Inventory. CH_4 that is recovered and burned in a flare or energy recovery device in the period 2004-2011 have been included in emission estimation and subtracted from generated CH_4 . Information on recovered CH_4 in the period 2004-2011 is presented in the table 8.2-5.

Table 8.2-5: Recovered CH_4 (2004-2011)

Year	Recovered CH_4 (Gg)
2004	0.242
2005	2.723
2006	1.615
2007	1.370
2008	1.123
2009	1.234
2010	3.814
2011	4.397

⁴⁴ 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.

The most of managed SWDS are not covered with aerated material and because of that default value for oxidation factor (OX), which equals zero, has been used.

The resulting annual emissions of CH₄ from land disposal of MSW in the period 1990-2011 are presented in the Figure 8.2-1.

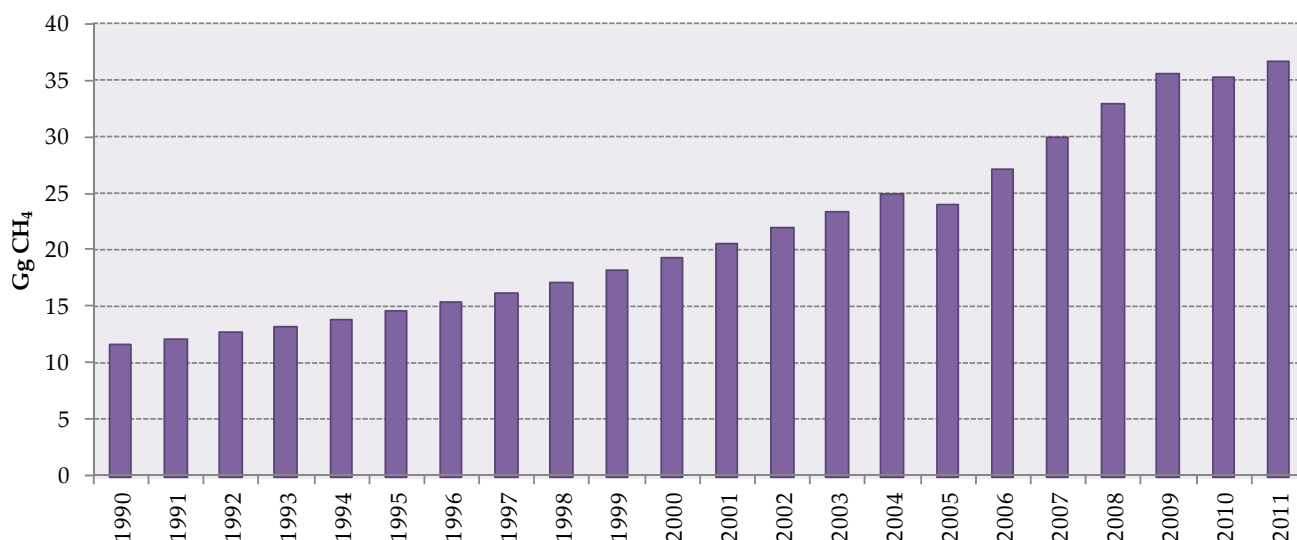


Figure 8.2-1: Emissions of CH₄ from Solid Waste Disposal on Land (1990-2011)

8.2.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainties contained in CH₄ emissions estimates are related primarily to assessment of historical data for quantity of MSW disposed to different types of SWDS and the main characteristic of SWDS as well as the usage of default IPCC methane generation rate constant ($k=0.05$).

In addition, SWDS in Croatia are classified into several categories, according to applied waste management activities, legality, volume and status. In the process of defining managed and unmanaged landfills for entire time series assessments have been performed using the data available in relevant documents, Landfill inventory and Environmental Emission Register. It is obvious that adjustment the country-specific to IPCC SWDS classification 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 several sorting of waste in Croatia, and in consequence of that these results were compared and adjust to relevant data in similar countries.

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data amounts 50 percent, based on expert judgements. Uncertainty estimate

associated with emission factor amounts 50 percent, according to the provided uncertainty assessment in *Good Practice Guidance* (detailed in Annex 5, Tables A5-1, A5-2).

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 according to QA/QC plan.

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. CH₄ 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. Basic country-specific activity data for CH₄ emission calculation were compared with data set from similar countries. Results of this comparison showed that there is no significant difference between these two sets of data.

8.2.5. SOURCE SPECIFIC RECALCULATIONS

According to ERT recommendation during the in-country review, correct MCF value for 2010 has been included in the calculation. These new calculations were presented in the "Resubmission of Croatia's 2012 Inventory Submission". Correct CH₄ emission for 2010 is presented in CRF tables "Official Resubmission 2012".

However, after the resubmission, activity data for the quantity of disposed MSW on different types of SWDS in the period 2007-2010 and data for recovered CH₄ for the period 2004-2010 have been corrected, according to more detailed data provided by CEA. Therefore additional recalculation of CH₄ emission was performed for the period 2004-2010.

8.2.6. SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

- more accurate determination on waste quantities disposed to different types of SWDS (managed, unmanaged deep and unmanaged shallow) – based on measurement/weighing or more accurate estimation

- providing methodology to determine country-specific MSW composition and periodic analysis of waste composition at major landfills according to provided methodology;
- modification of Environmental Pollution Register and Landfill Inventory database regarding to MSW with additional information (provided on regular basis) on technical and environmental protection measures implemented at landfills, waste quantities disposed to different types of SWDS (managed, unmanaged deep and unmanaged shallow) and waste composition.

For the purposes of emission inventory improvement it is necessary to adjust country-specific to IPCC SWDS classification for entire time series, in order to accurately estimate the MCF. Due to lack of adequate information, interpolation/extrapolation method has been applied for estimation of waste and landfills characteristics over a long period of time. It is necessary to improve the quality of existing data and to reconstruct historical data.

According to ERT recommendation, more detailed background information related to the sources of AD and EFs are necessary in order to improve transparency. More information for uncertainty estimation is required. Furthermore, research should be conducted in order to develop country-specific parameters for the first order decay method to increase the accuracy of the emission estimates.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

8.3. WASTEWATER HANDLING (CRF 6.B.)

8.3.1. SOURCE CATEGORY DESCRIPTION

Aerobic biological process is used mostly in wastewater treatment. 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 CH₄ emissions. Anaerobic process is applied in some industrial wastewater treatment but CH₄ emissions have not been estimated because data for calculation of degradable organic component in kg COD/year are not available in appropriate form. Submitted data on sludge treatment show that aerobic processes are used, which mean that no methane emission.

According to the Article 20 of Ordinance on the establishment of the pollutant emission register (Official Gazette No. 35/08) the completed forms should be submitted for the previous calendar year not later than 1 March of the current year. According to the article 21 of the Ordinance the competent authority (administrative department of the county and the City of Zagreb) in collaboration with the environmental inspection ensures the checking of data submitted in terms of their completeness, consistency and credibility. The CEA coordinates activities relating to data quality assurance and control.

CH₄ emissions from treatment of domestic and commercial wastewater and indirect N₂O emissions from human sewage are included in emission estimates for the period 1990-2011.

8.3.2. METHODOLOGICAL ISSUES

8.3.2.1. Domestic and commercial wastewater

Methane emissions from domestic and commercial wastewater (disposal particularly in rural areas where systems such as septic tanks are used) have been calculated using the IPCC Tier 1 methodology.

Data for population with individual system of drainage and data for calculation of degradable organic component in kg BOD/1000 person/yr have been obtained by state company Croatian Water (Hrvatske vode) for 1990, 1995, 2000 and for the period 2003-2010. Insufficient data have been assessed by interpolation method. Data for 2011 have not been provided and it assessed according to data for 2010. Submitted data on sludge treatment show that aerobic processes are used. Fraction of DOC removed as sludge is reported to be zero.

Data for CH₄ emission calculation for the period 1990-2011 are presented in the Table 8.3.1.

Table 8.3-1: Data for CH₄ emission calculation from Domestic and Commercial Wastewater (1990-2011)

Year	DOC (kg BOD/1000persons/yr)	Population*	Total organic product (Gg DC/yr)
1990	21,899.86	2,866,000	62.77
1991	21,899.55	2,842,800	62.26
1992	21,899.58	2,819,600	61.75
1993	21,899.60	2,796,400	61.24
1994	21,899.63	2,773,200	60.73
1995	21,900.00	2,750,000	60.23
1996	21,900.00	2,732,000	59.83
1997	21,900.00	2,714,000	59.44
1998	21,900.00	2,696,000	59.04
1999	21,900.00	2,678,000	58.65
2000	21,900.00	2,660,000	58.25
2001	21,899.65	2,630,333	57.60
2002	21,899.70	2,601,666	56.98
2003	21,900.16	2,574,000	56.37
2004	21,900.00	2,560,000	56.06
2005	21,900.01	2,541,460	55.66
2006	21,900.17	2,525,460	55.31
2007	21,899.89	2,514,488	55.07
2008	21,900.13	2,478,889	54.29
2009	21,900.13	2,459,300	53.86
2010	21,983.27	2,450,000	53.86
2011	21,983.27	2,450,000	53.86

* data for population with individual system of drainage

According to expert judgement provided by Croatian Water in 2006, fraction of treated wastewater has been estimated to be 0.3. Water consumption in rural areas was estimated to be 120 liters/person/day and 70 % of this amount is returned to the drainage system (overflows in septic tanks). Due to fact that information on fraction of treated wastewater is not available for entire period, proposed values of 30 % have been used for emission calculation for entire period 1990-2011.

No country-specific data are available for methane conversion factor. Default value for anaerobic systems (MCF=1), proposed by *Revised 1996 IPCC Guidelines*, has been used for emission calculation for entire period 1990-2011.

Default value for maximum methane producing capacity (Bo) of 0.6 kg CH₄/kg BOD, proposed by *2000 IPCC Good Practice Guidance*, has been used for emission calculation for entire period 1990-2011.

No data are available for amount of methane recovered or flared. Default value of zero, proposed by *Revised 1996 IPCC Guidelines*, has been used for emission calculation for entire period 1990-2011.

The resulting annual emissions of CH₄ from Domestic and Commercial Wastewater in the period 1990-2011 are presented in the Figure 8.3-1.



Figure 8.3-1: Emissions of CH₄ from Domestic and Commercial Wastewater (1990-2011)

8.3.2.2. Industrial wastewater

CH₄ emissions from industrial wastewater have not been estimated because data for calculation of degradable organic component in kg COD/year are not available in appropriate form.

Only available information, provided by CEA, refers to data for the year 2011 on the total amount of produced wastes from waste water treatment plants not otherwise specified (group 19 08 from Waste catalogue), which has been based on validated PL-PPO forms – Registration form for industrial waste producer/holder.

8.3.2.3. Human sewage

Indirect nitrous oxide (N₂O) 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 which equals 0.16 (proposed by *Revised 1996 IPCC Guidelines*), number of people in country and default emission factor which equals 0.01 kg N₂O-N/kg sewage N produced (proposed by *Revised 1996 IPCC Guidelines*).

The population estimate of the Republic of Croatia for the period 1990-2011 were taken from Statistical Yearbook. Croatian data on the annual per capita Protein intake value (PIV), for the period 1992-2010, were obtained by the FAOSTAT Statistical Database. Extrapolation method 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 data in 1990 and 1991. The pattern over three years from 2007 to 2009 has been used for calculation of insufficient data for 2010 and 2011.

Data for N₂O emission calculation from Human Sewage for the period 1990-2011 are presented in the Table 8.3.2.

Table 8.3-2: Data for N₂O emission calculation from Human Sewage (1990-2011)

Year	Protein intake (kg/person/yr)	Population
1990	22.71	4,778,000
1991	22.43	4,513,000
1992	22.52	4,470,000
1993	21.46	4,641,000
1994	21.97	4,649,000
1995	23.54	4,669,000
1996	23.18	4,494,000
1997	22.89	4,572,000
1998	22.67	4,501,000
1999	24.05	4,554,000
2000	24.05	4,426,000
2001	25.81	4,440,000
2002	27.41	4,440,000
2003	27.63	4,440,000
2004	27.63	4,439,000
2005	28.84	4,442,000
2006	29.93	4,440,000
2007	30.44	4,436,000
2008	30.40	4,434,000
2009	30.84	4,429,000
2010	30.87	4,418,000
2011	31.07	4,284,889

The resulting annual emissions of N₂O from Human Sewage in the period 1990-2011 are presented in the Figure 8.3-2.

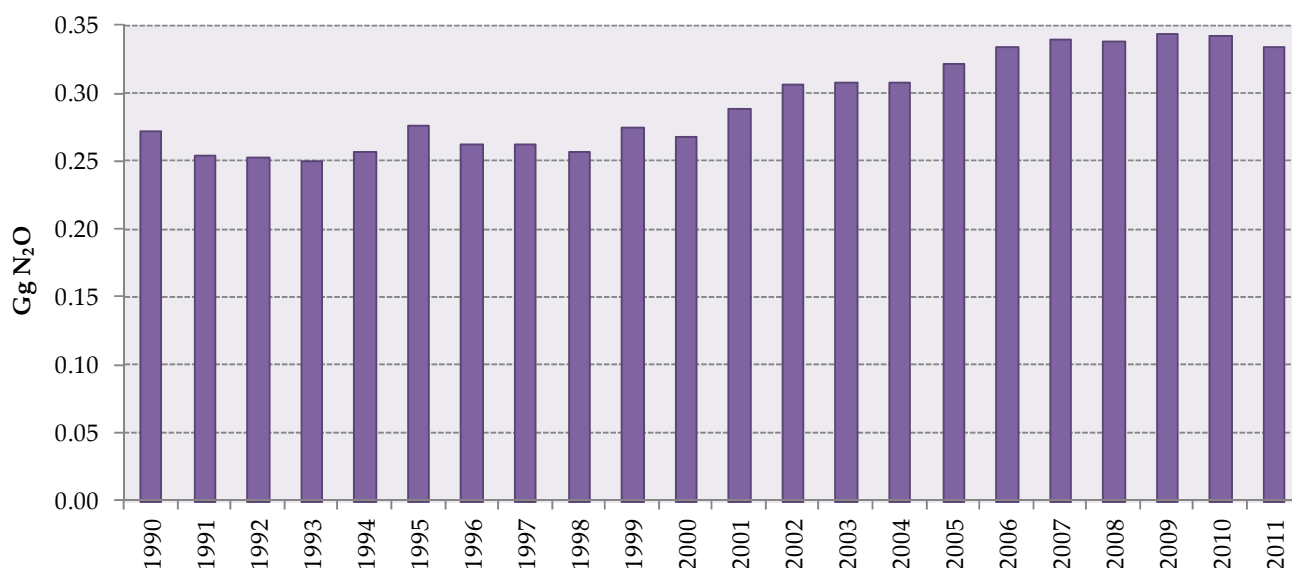


Figure 8.3-2: Emissions of N₂O from Human Sewage (1990-2011)

8.3.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainties contained in CH₄ emissions estimates from Domestic and Commercial Wastewater are related primarily to applied default emission factor and assessed values for degradable organic component. Data have been assessed based on information from different sources and consequently have high uncertainty. Also, insufficient data have been assessed by interpolation, which represents additional uncertainty in the estimations.

The uncertainties contained in N₂O emissions estimates are related primarily to applied default emission factor and extrapolated values for protein intake.

Activity data and emission factor uncertainty for CH₄ emission from Domestic and Commercial Wastewater was calculated in detail using Monte-Carlo analysis.

Uncertainty estimate associated with activity data for CH₄ and N₂O emission calculation amounts 50 percent, based on expert judgements. Uncertainty estimate associated with CH₄ and N₂O emission factor amounts 30 percent, accordingly to provided uncertainty assessment in *Good Practice Guidance* (detailed in Annex 5, Tables A5-1, A5-2).

Emissions from Domestic and Commercial Wastewater and Human Sewage have been calculated using the same method for every year in the time series. Different source of information were used for data sets.

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 according to QA/QC plan.

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. Wastewater handling represent key source category in Waste sector. CH₄ emissions from wastewater handling estimated using Tier 1 method. The uncertainty is very high due to assessment of insufficient data and applied default emission factors. Investigation will be performed with a view to collect more accurate data.

8.3.5. SOURCE SPECIFIC RECALCULATIONS

The Bo value of 0.6 kg CH₄/kg BOD from 2000 *IPCC Good Practice Guidance* has been used in CH₄ emission calculation from Domestic and Commercial Wastewater, instead of 0.25 kg CH₄/kg BOD which is specified in the *Revised 1996 IPCC Guidelines*. Thereupon, CH₄ emissions have been recalculated for the period 1990-2010.

During the in-country review ERT has recommended correction of activity data for CH₄ emission calculation from Industrial Wastewater in order to accurate calculation of degradable organic component in kg COD/year. According to ERT recommendation, total amount of wastewater produced by industries with the largest potential for CH₄ emission should be replaced by tonnes of product produced. However, CH₄ emissions have not been estimated in this report because data for tonnes of product produced are not available in appropriate form. Thereupon, notation key "NE" has been used for the entire period 1990-2011.

New data for Protein intake value which are used for indirect nitrous oxide (N₂O) emissions from human sewage, have been provided at the FAOSTAT Food Balance Sheet (version 29 June 2012). Data for 1992, 1994, 1998, 2000, 2003-2009 have been corrected. Thereupon, N₂O emissions have been recalculated for 1990-1992, 1994, 1998, 2000 and 2003-2010.

8.3.6. SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Improvements in the sub-sectors Domestic and Commercial Wastewater and Industrial Wastewater related primarily to establishment of effectively *Water Information System* with base for systematic gathering/provision of insufficient data needed for CH₄ emission calculation:

- tonnes of product produced by industries with the largest potential for CH₄ emission, in order to accurate calculation of degradable organic component in kg COD/yr

- investigation whether DOC removed as sludge for industrial and domestic/commercial wastewater are there
- assumptions of parameters which default values are used
 - wastewater treated ratio for industrial and domestic/commercial wastewater
 - methane conversion factor for industrial and domestic/commercial wastewater
 - maximum methane producing capacity for industrial and domestic/commercial wastewater
 - DOC in kg COD/m³ wastewater of industries with the largest potential for CH₄ emission
 - wastewater produced in m³/tonne product for industries with the largest potential for CH₄ emission

According to ERT recommendation, more detailed background information related to the sources of AD and EFs are necessary in order to improve transparency. It is necessary to improve quantity and quality of data on sludges produced and data on management of sludges which are to be reported to Environmental Pollution Register.

Insufficient data for CH₄ emission calculation in the domestic and commercial wastewater subcategory (population with individual system of drainage and data for calculation of degradable organic component in kg BOD/1000 person/yr) for 2011 must be submitted.

Recalculation of CH₄ emissions from the industrial wastewater subcategory must be carried out in order to correct the error in the emission estimates. Since data for calculation of degradable organic component in kg COD/year are not available in appropriate form, these data need to be collected in short-term period.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

8.4. WASTE INCINERATION (CRF 6.C.)

8.4.1. SOURCE CATEGORY DESCRIPTION

Incineration of waste produces emissions of CO₂, CH₄ and N₂O. According to *Revised 1996 IPCC Guidelines* only CO₂ 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.

The official source of activity data for waste incineration is CEA that collects data from emission point sources in the Environmental Pollution Register database. According to the Article 20 of Ordinance on the establishment of the pollutant emission register (Official Gazette No. 35/08) the completed forms should be submitted for the previous calendar year not later than 1 March of the current year. According to the article 21 of the Ordinance the competent authority (administrative department of the county and the City of Zagreb) in collaboration with the environmental inspection ensures the checking of data submitted in terms of their completeness, consistency and credibility. The CEA coordinates activities relating to data quality assurance and control.

Data for the period 2008 - 2011 on the total amount of incinerated waste by operation D10 (Incineration on land) and R1 (Use principally as a fuel or other means to generate energy) has been based on validated PL-OPKO forms - Registration form for entities carrying out the municipal and/or industrial waste recovery/disposal.

CO₂ emissions from incineration of clinical waste are included in emission estimates for the period 1990-2011. CO₂ emissions from incineration of hazardous waste have not been estimated for entire period because data for categorisation of waste types is lacking. An incinerator of hazardous waste was functioning in Croatia between 1998 and 2002. By means of more detailed collected data in the Environmental Pollution Register database, data for CO₂ emission calculation from incineration of hazardous waste are used for the period 2007-2010 and data for CO₂ emission calculation from incineration of plastic are used for the period 2007-2009.

In regard to N₂O emissions from waste incineration, rotating treatment plants are used only in the cement clinker production, i.e. energy is recovering in this process and these kilns are used for co-incineration of waste and emissions are reported in Energy sector. Due to a fact that information on other types of incineration technology of hazardous waste is not available in the Environmental Pollution Register database, N₂O emissions have not been estimated.

8.4.2. METHODOLOGICAL ISSUES

CO₂ emissions from incineration of waste have been calculated using the methodology proposed by *Revised 1996 IPCC Guidelines*, by multiplying the total incinerated waste with default values for fraction of carbon content, fraction of fossil carbon and burn out efficiency of combustion.

Data for quantity of incinerated hospital waste for the period 2004-2010 were obtained by CEA. Insufficient data for the period 1990-2003 have been assessed using population data as reference. Default values for fraction of carbon content (0.6), fraction of fossil carbon (0.4) and burn out efficiency of combustion (0.95), proposed by *IPCC Good Practice Guidance*, have been used for emission calculation for entire period 1990-2011.

Data on incineration of hazardous waste for the period 2007-2011 have been provided by CEA. Insufficient data for 2009 have been assessed according to data for 2008. Default values for fraction of carbon content (0.5), fraction of fossil carbon (0.9) and burn out efficiency of combustion (0.995), proposed by *IPCC Good Practice Guidance*, have been used for emission calculation for the period 2007-2010. There was no incineration of hazardous waste without energy recovery in 2011.

Data on incineration of plastics for the period 2007-2009 have been provided by CEA. Insufficient data for 2009 have been assessed according to data for 2008. Default values for fraction of carbon content (0.8), fraction of fossil carbon (1.0) and burn out efficiency of combustion (0.995), proposed by *IPCC Good Practice Guidance*, have been used for emission calculation for the period 2007-2009. There was no incineration of plastics without energy recovery in 2010 and 2011.

Data for CO₂ emission calculation from Waste Incineration for the period 1990-2011 are presented in the Table 8.4-1.

Table 8.4-1: Incinerated waste (1990-2011)

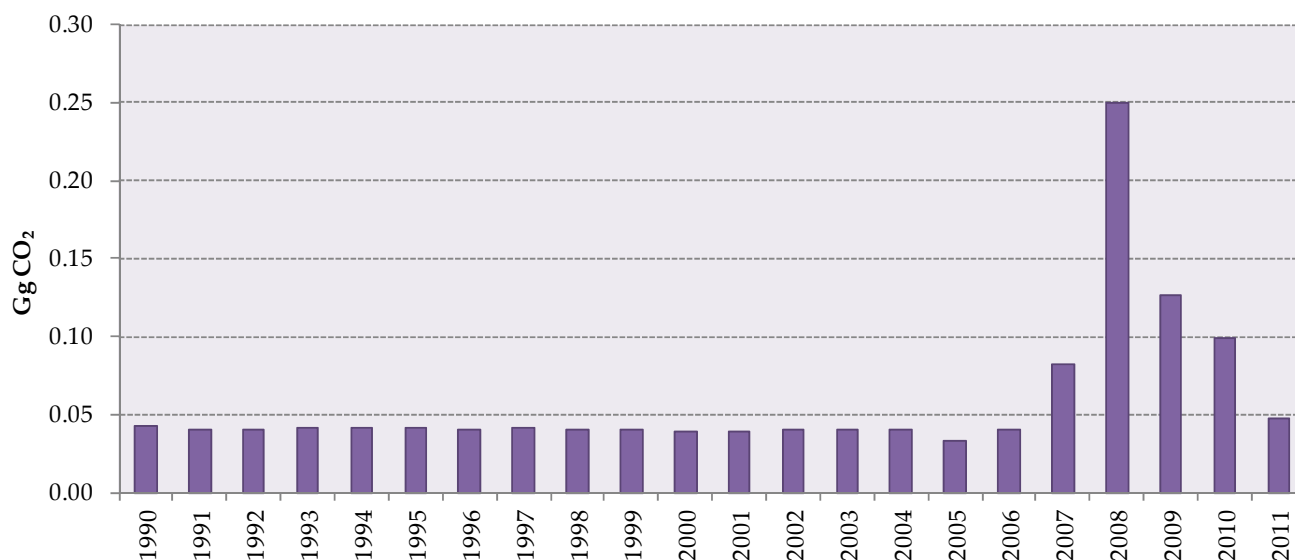
Year	Incinerated waste (tonnes)		
	Hospital waste	Hazardous waste	Plastics
1990	51.70	Information on categorisation of waste type is not available	Data are not available
1991	48.83		
1992	48.37		
1993	50.22		
1994	50.31		
1995	50.52		
1996	48.63		
1997	49.47		
1998	48.71		
1999	49.28		
2000	47.41		
2001	48.01		
2002	48.08		
2003	48.07		
2004	49.20		
2005	40.23		
2006	48.05		
2007	14.03	37.36	3.35
2008	196.64	28.64	13.23

Table 8.4-1: Incinerated waste (1990-2011), cont.

Year	Incinerated waste (tonnes)		
	Hospital waste	Hazardous waste	Plastics
2009	49.19	28.64	13.23
2010	54.40	32.60	0.00
2011	57.45	0.00	0.00

Quantities of incinerated waste without energy recovery were not increased significantly in 2007, but CO₂ emission increased. The reason is accessibility of more detailed data on types of incinerated waste. CO₂ emissions from incineration of hazardous waste for the period 1990-2006 have not been estimated because data for categorisation of waste types is lacking. Quantities of incinerated waste without energy recovery were increased significantly in 2008. The latter is due to larger quantity of hospital waste which was incinerated without energy recovery in 2008. In the previous period, as well as in the period 2009- 2011, larger quantities of hospital waste have been incinerated with energy recovery. The total quantity of hazardous waste has been incinerated with energy recovery in 2011. Also, the total quantity of plastics has been incinerated with energy recovery in 2010 and 2011.

The resulting annual emissions of CO₂ from Waste Incineration in the period 1990-2011 are presented in the Figure 8.3-4.

Figure 8.4-1: Emissions of CO₂ from Waste Incineration (1990-2011)

8.4.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainties contained in CO₂ emissions estimates from incineration of waste are related primarily to assess activity data and applied default emission factors.

Uncertainty estimate associated with activity data amounts 50 percent, based on expert judgements. Uncertainty estimate associated with emission factor amounts 30 percent, according to the provided uncertainty assessment in *Good Practice Guidance* (detailed in Annex 5, Tables A5-1, A5-2).

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 according to QA/QC plan.

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. Since this source category is not a key source, QA/QC plan does not prescribes source specific quality control procedures.

8.4.5. SOURCE SPECIFIC RECALCULATIONS

There are no source-specific recalculations in this report.

8.4.6. SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Improvements in the sub-sector Waste Incineration are related primarily to aggregation of accurate data for CO₂ emission calculations from incineration of different types of waste.

According to ERT recommendation, research and identification of the technologies applied in the incineration of hazardous waste should be performed in short-term period.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

8.5. EMISSION OVERVIEW

Emissions of GHGs from Waste in the period 1990-2011 are presented in Table 8.5-1.

Table 8.5-1: Emissions from Waste (1990-2011)

Source	Year	GHG	Emission (Gg)	GWP ¹	Emission (Gg CO ₂ -eq)	Percent in Waste	Percentage in Total Country Emission
Solid Waste Disposal on Land	1990	CH ₄	11.55	21	242.62	42.98	0.77
	1991		12.09		253.95	44.69	1.02
	1992		12.63		265.23	45.96	1.14
	1993		13.20		277.15	47.27	1.19
	1994		13.82		290.13	48.41	1.29
	1995		14.54		305.26	49.34	1.32
	1996		15.32		321.80	51.15	1.36
	1997		16.20		340.30	52.63	1.35
	1998		17.13		359.75	54.30	1.42
	1999		18.18		381.84	55.42	1.44
	2000		19.24		404.11	57.13	1.54
	2001		20.47		429.83	58.33	1.57
	2002		21.85		458.90	59.66	1.61
	2003		23.39		491.15	61.40	1.64
	2004		24.82		521.32	62.89	1.73
	2005		24.01		504.14	61.90	1.66
	2006		27.14		569.87	64.57	1.85
	2007		29.86		627.08	66.67	1.93
	2008		32.87		690.17	68.97	2.21
	2009		35.57		746.97	70.66	2.56
	2010		35.21		739.50	70.46	2.58
	2011		36.71		770.89	71.49	2.73
Domestic and Commercial Wastewater	1990	CH ₄	11.30	21	237.25	42.03	0.75
	1991		11.21		235.33	41.41	0.94
	1992		11.11		233.41	40.44	1.00
	1993		11.02		231.49	39.48	0.99
	1994		10.93		229.57	38.30	1.02
	1995		10.84		227.65	36.80	0.99
	1996		10.77		226.16	35.94	0.95
	1997		10.70		224.67	34.75	0.89
	1998		10.63		223.18	33.69	0.88
	1999		10.56		221.69	32.18	0.83
	2000		10.49		220.20	31.13	0.84
	2001		10.37		217.74	29.55	0.79
	2002		10.26		215.37	28.00	0.75
	2003		10.15		213.08	26.64	0.71
	2004		10.09		211.92	25.57	0.70
	2005		10.02		210.39	25.83	0.69
	2006		9.96		209.06	23.69	0.68
	2007		9.91		208.15	22.13	0.64
	2008		9.77		205.21	20.51	0.66
	2009		9.69		203.59	19.26	0.70
	2010		9.69		203.59	19.40	0.71
	2011		9.69		203.59	18.88	0.72

Table 8.5-1: Emissions from Waste (1990-2011), cont.

Source	Year	GHG	Emission (Gg)	GWP ¹	Emission (Gg CO ₂ -eq)	Percent in Waste	Percentage in Total Country Emission
Industrial Wastewater	1990	CH ₄	NE	21	NE	NE	NE
	1991		NE		NE	NE	NE
	1992		NE		NE	NE	NE
	1993		NE		NE	NE	NE
	1994		NE		NE	NE	NE
	1995		NE		NE	NE	NE
	1996		NE		NE	NE	NE
	1997		NE		NE	NE	NE
	1998		NE		NE	NE	NE
	1999		NE		NE	NE	NE
	2000		NE		NE	NE	NE
	2001		NE		NE	NE	NE
	2002		NE		NE	NE	NE
	2003		NE		NE	NE	NE
	2004		NE		NE	NE	NE
	2005		NE		NE	NE	NE
	2006		NE		NE	NE	NE
	2007		NE		NE	NE	NE
	2008		NE		NE	NE	NE
	2009		NE		NE	NE	NE
	2010		NE		NE	NE	NE
	2011		NE		NE	NE	NE
Human Sewage	1990	N ₂ O	0.27	310	84.57	14.98	0.27
	1991		0.25		78.91	13.89	0.32
	1992		0.25		78.46	13.59	0.34
	1993		0.25		77.64	13.24	0.33
	1994		0.26		79.62	13.28	0.35
	1995		0.28		85.67	13.85	0.37
	1996		0.26		81.19	12.90	0.34
	1997		0.26		81.55	12.61	0.32
	1998		0.26		79.52	12.00	0.31
	1999		0.28		85.38	12.39	0.32
	2000		0.27		82.98	11.73	0.32
	2001		0.29		89.30	12.12	0.33
	2002		0.31		94.86	12.33	0.33
	2003		0.31		95.62	11.95	0.32
	2004		0.31		95.60	11.53	0.32
	2005		0.32		99.83	12.26	0.33
	2006		0.33		103.58	11.74	0.34
	2007		0.34		105.25	11.19	0.32
	2008		0.34		105.08	10.50	0.34
	2009		0.34		106.47	10.07	0.36
	2010		0.34		106.29	10.13	0.37
	2011		0.33		103.76	9.62	0.37

Table 8.5-1: Emissions from Waste (1990-2011), cont.

Source	Year	GHG	Emission (Gg)	GWP ¹	Emission (Gg CO ₂ -eq)	Percent in Waste	Percentage in Total Country Emission
Waste Incineration	1990	CO ₂	0.043	1	0.043	0.008	0.0001
	1991		0.041		0.041	0.007	0.0002
	1992		0.040		0.040	0.007	0.0002
	1993		0.042		0.042	0.007	0.0002
	1994		0.042		0.042	0.007	0.0002
	1995		0.042		0.042	0.007	0.0002
	1996		0.041		0.041	0.006	0.0002
	1997		0.041		0.041	0.006	0.0002
	1998		0.041		0.041	0.006	0.0002
	1999		0.041		0.041	0.006	0.0002
	2000		0.040		0.040	0.006	0.0002
	2001		0.040		0.040	0.005	0.0001
	2002		0.040		0.040	0.005	0.0001
	2003		0.040		0.040	0.005	0.0001
	2004		0.041		0.041	0.005	0.0001
	2005		0.034		0.034	0.004	0.0001
	2006		0.040		0.040	0.005	0.0001
	2007		0.083		0.083	0.009	0.0003
	2008		0.250		0.250	0.025	0.0008
	2009		0.127		0.127	0.012	0.0004
	2010		0.099		0.099	0.009	0.0003
	2011		0.048		0.048	0.004	0.0002

¹ Time horizon chosen for GWP values is 100 years

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Potočnik, V. (2000) *Report: The basis for methane emission estimation in Croatia 1990-1998, B. Data on Municipal Solid Waste in Croatia 1990-1998, Zagreb*

9 OTHER (CRF sector 7)

At present, no greenhouse gas emissions are calculated for Croatia which cannot be allocated to one of the existing source categories.

10 RECALCULATIONS AND IMPROVEMENTS

The key differences between the previous and latest submission of CRF tables for the time series 1990-2010 are outlined in this chapter. Detailed description and explanations for recalculations are shown in recalculation sections in the sector chapters (Chapters 3 to 8).

10.1 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 (suggestions reported in "DRAFT Report of the individual review of the greenhouse gas inventory of Croatia submitted in 2012")

Recalculations are performed in the following sectors:

- Energy
 - o Feedstock and non-energy use
 - o Reference Approach
 - o Civil aviation
 - o Railways
 - o Road transport
 - o Manufacturing Industries and Construction – Petrochemical production
 - o Fugitive emissions from oil, natural gas and other sources
- Industrial Processes
 - o Lime production
 - o Soda Ash Production and Use
 - o Ammonia production
 - o Production of Other Chemicals
 - o Consumption of Halocarbons and SF₆
- Solvent and Other Product Use
- Agriculture
 - o CH₄ emissions from Enteric fermentation in domestic livestock
 - o CH₄ emissions from Manure management,
 - o N₂O emissions from Manure management
 - o N₂O emissions from Agricultural soils
 - o Indirect N₂O emissions from nitrogen used in agriculture
- LULUCF
 - o Emissions/removals from Forest land remaining forest land and Land converted to Forest land
 - o Emissions/removals from Cropland remaining Cropland and Land converted to Cropland

- o Emissions/removals from Grassland remaining Grassland and Land converted to Grassland
- o Emissions/removals from Land converted to Wetlands
- o Emissions/removals from Land converted to Settlements
- Waste
 - o Solid Waste Disposal on Land
 - o Wastewater Handling

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 10.1.1.)
- Correction of errors (Chapter 10.1.2.)

10.1.1 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.

10.1.1.1 Changes in available data

Energy sector

Feedstock and non-energy use of fuels (1.A.d)

- CO₂ emission from natural gas which used as a feedstock in ammonia production.
- Recalculation was made because new activity data added. Recalculation was performed for year 2010.
- This recalculation has no influence to total national GHG emission.

Manufacturing Industries and Construction - Petrochemical production (1.A.2.f)

- CO₂ emission from Petrochemical Production (ammonia production)
- Recalculation was made because new activity data added. Recalculation was performed for year 2010.

Road transportation (1.A.3.b)

- Recalculations were made for the period 2009-2010 because new activity data added (CNG – compressed natural gas).

Fugitive emissions from oil, natural gas and other sources (1.B.2.b)

- Recalculations were made because new activity data added (lengths of transportation pipelines in the Republic of Croatia). Recalculations were performed for the period 1990-2010.

Industrial processes**Mineral Products (2.A.); Lime Production (2.A.2.)**

New data from one sugar manufacturer were provided. Accordingly, for this resubmission recalculations were made for the period 1999-2011.

Mineral Products (2.A.); Soda Ash Production and Use (2.A.4.)

In previous reports, the activity data used for calculations included data on soda ash use in glass and ceramic manufacture, and in the production of soap and detergents in the period 1990-1996, extracted from Annual Industrial Reports published by Central Bureau of Statistics, Department of Manufacturing and Mining. For the period 1997-2010, AD was collected by survey of manufacturers of glass, ceramic, soap and detergents. According to ERT recommendation during the in-country review, the activity data for soda ash use were extracted from statistical database on the import and export quantities of soda ash for the Republic of Croatia and thus recalculations were made for the entire period 1990-2010. These new calculations were presented in the "Resubmission of Croatia's 2012 Inventory Submission". Thereupon, CO₂ emissions have been recalculated and presented in CRF tables "Official Resubmission 2012".

Chemical Industry (2.B.); Ammonia Production (2.B.1.)

New data were provided for 2010 and 2011. Recalculations for this resubmission were made accordingly.

Chemical Industry (2.B.); Production of Other Chemicals (2.B.5.a)

Recalculations of data from production of carbon black were made for periods 1998-1999, 2002-2004 and 2007-2008, for the production of ethylene for the year 1997, and also for the production of styrene for the period 1991-1992, according to the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2011* Submission to the Convention on Long-range Transboundary Air Pollution'.

Consumption of Halocarbons and SF₆ (2.F.); Refrigeration and Air Conditioning Equipment (2.F.1.)

According to ERT recommendation during the in-country review, actual emissions that could not be calculated due to the missing data on average annual stocks were updated by using the values for potential emissions (HFC-23). Accordingly, recalculations were made for 2010.

Also, new data were provided for R-507A used in Industrial refrigeration. Recalculations were made for the period 2005-2010.

Consumption of Halocarbons and SF₆ (2.F.); Foam Blowing (2.F.2.)

According to ERT recommendation during the in-country review, actual emissions that could not be calculated due to the missing data on average annual stocks (for HFC-152a used in Foam Blowing) were updated by using the values for potential emissions. These new calculations were presented in the "Resubmission of Croatia's 2012 Inventory Submission". Thereupon, emissions for HFC-152a used in Foam Blowing have been recalculated for the period 2006-2010 and presented in CRF tables "Official Resubmission 2012".

Consumption of Halocarbons and SF₆ (2.F.); Fire Extinguishers (2.F.3.)

New data were provided for HFC-236fa used in Fire Extinguishers. Recalculations were made for the period 2006-2010.

Consumption of Halocarbons and SF₆ (2.F.); Aerosols/Metered Dose Inhalers (2.F.4.)

Also, new data were provided regarding potential emissions of HFC-134a from Aerosols/Metered Dose Inhalers for the year 2010. Recalculation was made for this year.

Consumption of Halocarbons and SF₆ (2.F.); Electrical equipment (2.F.7.)

More detailed data for SF₆ emission calculation have been provided for the period 2000-2010. Accordingly, recalculations were made for this period.

In this resubmission, new data for SF₆ emission calculation from Medium Voltage Apparatus and Switchgear have been provided for 2010 and 2011. Accordingly, recalculations were made for 2010 and 2011.

Solvent and Other Product Use

Solvent and Other Product Use (3.B.C.D.)

Activity data for NMVOC emission calculation for the whole period 1990-2010 has been updated according to the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2011* Submission to the Convention on Long-range Transboundary Air Pollution'. Therefore, CO₂ emissions have been recalculated for the period 1990-2010 in this report.

In this resubmission, new data for N₂O emission calculation from one additional source have been provided for 2011. Accordingly, recalculations were made for this year.

Agriculture

CH₄ Emissions from Enteric Fermentation in Domestic Livestock (4.A.)

Methane emissions from Enteric fermentation were recalculated for the years 2007 and 2008 due to changes in activity data (number of dairy cows) and changes in CBS methodology for the cattle subcategorization (Table 6.2-3). This reclassification of older data accounts for a slight change in the number of cattle within individual Tier II categories.

Manure management (4.B.)

Methane emissions from Enteric fermentation were recalculated for the years 2007 and 2008 due to changes in activity data (number of dairy cows) and changes in CBS methodology for the cattle subcategorization (Table 6.2-3). This reclassification of older data accounts for a slight change in the number of cattle within individual Tier II categories.

Agricultural soils (4.D.)

Direct emission from Agricultural soils (4.D.1.)

N₂O emissions originating from mineral fertilizers

During a consultation meeting that included representatives of fertilizer producers, a minor mistake was found in the activity data for the time period 2004 - 2010 regarding the percentage of nitrogen in several complex (NPK) fertilizer formulations. In addition, a mistake in activity data was found in the data given by one of the fertilizer producers. Data on NPK fertilizer production for the period 2006 - 2010 was given in kilograms instead of required tonnes, resulting in 1000 times larger numbers.

Corrections that were performed resulted in different N percentage values and amount of total nitrogen applied, thus recalculation of N₂O emissions from mineral fertilizers was performed for the aforementioned time period.

N₂O emissions originating from biological fixation of nitrogen and crop residue

Recalculations were performed in the year 2010 due to the change in activity data for the vetch and sorghum crops.

Indirect N₂O emission from nitrogen used in agriculture (4.D.3.)

Atmospheric Deposition and Nitrogen Leaching and Run-off

Since direct N₂O emissions from synthetic fertilizers applications were recalculated due to the changes in activity data for synthetic fertilizers, recalculations of indirect N₂O emissions were performed for the same time period.

LULUCF

CO₂ emissions/removals in Forest land remaining Forest land (5 A 1)

Based on the recommendations given by the ERT during the In country review in 2012, in this submission Croatia applied same methodology to estimations of carbon gains due to the increment instead of previously used method dependable on forest ownership. Also, for this submission Croatia applied national values for wood densities for deciduous and coniferous species. New data aggregation was applied for the estimation and presentation of data in CRF. Based on new scientific investigation, new values for carbon stock in soils were used.

CO₂ emissions/removals in Land converted to Forest land (5 A 2)

Conservative estimates in case of deforestation areas in private forests (pre-2006 year) and state forests that are managed by other legal bodies were applied. New values for carbon stock in soils were applied.

CO₂ emissions/removals in Cropland remaining Cropland (5 B 1) and Land converted to Cropland (5 B 2)

New values for carbon stock in soils were applied.

CO₂ emissions/removals in Grassland remaining Grassland (5 C 1) and Land converted to Grassland (5 C 2)

New values for carbon stock in soils were applied.

CO₂ emissions/removals in Land converted to Wetlands (5 D 2)

New values for carbon stock in soils were applied.

CO₂ emissions/removals in Land converted to Settlements (5 E 2)

New values for carbon stock in soils were applied.

Due to conservative estimate conducted in deforested areas of private forests and state forests managed by other legal bodies, corrections in Land use change matrix were done.

Waste

Solid Waste Disposal on Land (6.A.)

According to ERT recommendation during the in-country review, correct MCF value for 2010 has been included in the calculation. These new calculations were presented in the "Resubmission of Croatia's 2012 Inventory Submission". Correct CH₄ emission for 2010 is presented in CRF tables "Official Resubmission 2012".

However, after the resubmission, activity data for the quantity of disposed MSW on different types of SWDS in the period 2007-2010 and data for recovered CH₄ for the period 2004-2010 have been corrected, according to more detailed data provided by CEA. Therefore additional recalculation of CH₄ emission was performed for the period 2004-2010.

Wastewater Handling (6.B.)

The Bo value of 0.6 kg CH₄/kg BOD from 2000 *IPCC Good Practice Guidance* has been used in CH₄ emission calculation from Domestic and Commercial Wastewater, instead of 0.25 kg CH₄/kg BOD which is specified in the *Revised 1996 IPCC Guidelines*. Thereupon, CH₄ emissions have been recalculated for the period 1990-2010.

During the in-country review ERT has recommended correction of activity data for CH₄ emission calculation from Industrial Wastewater in order to accurate calculation of degradable organic component in kg COD/year. According to ERT recommendation, total amount of wastewater produced by industries with the largest potential for CH₄ emission should be replaced by tonnes of product produced. However, CH₄ emissions have not been estimated in this report because data for tonnes of product produced are not available in appropriate form. Thereupon, notation key "NE" has been used for the entire period 1990-2011.

New data for Protein intake value which are used for indirect nitrous oxide (N₂O) emissions from human sewage, have been provided at the FAOSTAT Food Balance Sheet (version 29 June 2012). Data for 1992, 1994, 1998, 2000, 2003-2009 have been corrected. Thereupon, N₂O emissions have been recalculated for 1990-1992, 1994, 1998, 2000 and 2003-2010.

10.1.1.2 Consistency with good practice guidance

Energy

Reference approach (1.A.b)

- Coke Oven Gas is excluded from the production column of the Reference Approach. This recalculation was carried out as recommended by ERT (2012), for the period from 1990 to 1994.
- This recalculation has no influence to total national GHG emission.

Road transportation (1.A.3.b)

- Emissions of CO₂ from liquid fuels were recalculated for the period 1990-2010 in the course of the In-country review in 2012.
- Revised emission factor for liquefied petroleum gas is applied (64.48 t/TJ instead of 78.15 t/TJ) for the entire time-series.

10.1.1.3 New methods

LULUCF

For this year submission, following recommendation given by the ERT during the in county review Croatia decided to apply same method for estimating carbon gains due to increment in all forests regardless the ownership structure. For the first time, the increment is calculated based on the difference in growing stock in two points in time and annual fellings using per ha values for the growing stocks and annual fellings. Both growing stock and fellings are divided as broadleaved and coniferous.

For this submission, data used in estimations in form of per ha value are under the revision and full report about carbon stock changes will be given in NIR 2013 resubmission.

10.1.2 CORRECTION OF ERRORS

This chapter presents corrected errors noticed after the resubmission. Necessary recalculations were mostly due to typing errors. The latter are explained only in this report.

Energy

Reference approach (1.A.b)

- GHG emissions from jet kerosene were recalculated for period 1990-2006 due to a typing error of jet kerosene consumption. In this submission error is corrected.
- GHG emissions from gas/diesel oil were recalculated only for the year 2004 due to a typing error of gas/diesel oil consumption and stock change. In this submission error is corrected.
- GHG emissions from lubricants were recalculated only for the year 2010 due to a typing error of lubricants stock change. In this submission error is corrected.

Civil aviation (1.A.3.a)

- GHG emissions from gasoline were recalculated only for the year 2010 due to a typing error of net calorific value for gasoline. In this submission error is corrected.

Railways (1.A.3.c)

- CH₄ and N₂O emissions from diesel fuel were recalculated only for the year 2010 due to a typing error of CH₄ and N₂O emission factors for diesel fuel. In this submission error is corrected.

Fugitive emissions from oil, natural gas and other sources (1.B.2)

- In this sector several recalculations were performed:
 - Natural Gas – Production (1.B.2.b.ii)
 - Typing error. Recalculation of CO₂ emission was performed for year 1991.

- Natural Gas – Production (1.B.2.b.ii)
 - Typing error. Recalculation of CH₄ emission was performed for year 2002.
- Oil – Production (1.B.2.a.ii)
 - Typing error. Recalculation of CH₄ emission was performed for the period 1993-2007.
- Venting – Natural Gas (1.B.2.c.ii)
 - Typing error. Recalculation of CH₄ emission was performed for year 1990, 1996, 1997 and 1999.

Industrial processes

Chemical Industry (2.B.); Ammonia Production (2.B.1.)

A mistake in data input was made in the previous submission for the year 2009, which was corrected in this resubmission.

Consumption of Halocarbons and SF₆ (2.F.); Refrigeration and Air Conditioning Equipment (2.F.1.)

A mistake was detected in the calculation of potential emissions of gas HFC-125 for the year 2004 and gas HFC-143a for 1998. These mistakes were corrected for this report.

Consumption of Halocarbons and SF₆ (2.F.); Other Consumption of HFCs, PFCs and SF₆ (2.F.2. Foam Blowing, 2.F.3. Fire Extinguishers, 2.F.4. Aerosols/Metered Dose Inhalers, 2.F.8. Electrical Equipment)

A mistake in data input made in the previous report regarding potential emissions of HFC-227a from Fire Extinguishers for 2007 and 2008 was corrected.

A mistake was noticed in calculation of actual emissions of SF₆ for 2008 and was corrected in this report.

Agriculture

CH₄ Emissions from Manure management (4.B.)

Within the CRF table 4.B(a) submitted in October 2010 (CRF v3.1), a mistake was noticed in regard to implied emission factors for horses, mules/asses and poultry for the period from 1990-2008. The mistake refers to 1000 times lower IEF than the normal one which resulted in 1000 times lower CH₄ emission from manure management of these animal categories. The mistake was generated by using Gg instead of tonnes. Aforementioned was corrected.

In the previous submission, regarding dairy cattle and its nitrogen excretion in solid storage and dry lot, mistakenly 9,972,018.70 kg N for 2008 was reported while the correct value was and is still now 10,120,854.80 kg

N. The latter is corrected but it did not influence the reported N₂O emission (correct emission value was reported); thus, emission recalculation was not required.

A mistake regarding allocation of mature dairy cattle is also corrected in the CRF and now the sum of allocation values amounts 100%.

Agricultural soils (4.D.)

Direct emission from Agricultural soils

Recalculations of N₂O emissions from mineral fertilisers were made due to a mistake noticed regarding the fraction of N emitted as NH₃ and NO_x - for urea ammonium nitrate a fraction of 0.02 was used instead of 0.08. Recalculation was performed for all years in which the mentioned fertilizer was applied; thus referring to the period from 2003 – 2008. In years prior to this period, this type of fertilizer was not used.

Indirect N₂O emissions from nitrogen used in agriculture

Since direct N₂O emissions from mineral fertilizers were recalculated due to correction of N-fraction emitted as NH₃ or NO_x, recalculations of indirect N₂O emissions from nitrogen used in agriculture were also necessary for the same reason and for the same period. The latter refers to indirect N₂O emissions arising from volatilization of ammonia (NH₃) and nitrogen oxides (NO_x) due to application of mineral fertilizers and indirect N₂O emissions from leaching and runoff of nitrogen compounds into surface waters, groundwater and watercourses (due to mineral fertilisers).

LULUCF

Forest land remaining Forest land (5 A) - biomass burning

For this year submission, correction in reported emissions of CH₄ and N₂O due to biomass burning was performed. In last year submission mistake was done putting the CH₄ and N₂O emissions in CRF in Gg CO₂ eq.

10.2 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 10.2-1 shows the differences between NIR 2012 (Resubmission, v3.4) and current submission (NIR 2013), on the level of the different greenhouse gases.

Table 10.2-1: Differences between NIR 2012 (Resubmission, v3.4) and NIR 2013, for 1990-2010 due to recalculations

Source		1990	1991	1992	1993	1994	1995	1996	1997
CO ₂ (Gg) Incl. LULUCF	NIR 2012	16,593.1	10,661.7	9,932.5	10,632.3	9,807.1	10,371.7	11,457.9	12,348.4
	NIR 2013	16,907.3	9,248.0	8,125.6	8,570.4	7,978.0	8,116.8	8,997.3	10,579.8
	Difference %	1.9	-13.3	-18.2	-19.4	-18.7	-21.7	-21.5	-14.3
CO ₂ (Gg) Excl. LULUCF	NIR 2012	23,338.8	17,312.3	16,714.8	17,174.4	16,499.1	17,211.4	17,844.2	18,869.6
	NIR 2013	23,338.7	17,352.5	16,708.1	17,165.2	16,490.3	17,201.7	17,834.3	18,861.4
	Difference %	0.0	0.2	0.0	-0.1	-0.1	-0.1	-0.1	0.0
CH ₄ (Gg CO ₂ -eq)	NIR 2012	3,484.0	3,218.8	2,902.7	3,022.3	2,719.6	2,888.8	2,846.0	2,831.8
	NIR 2013	3,420.2	3,168.2	2,861.7	2,983.9	2,777.1	2,743.9	2,734.6	2,809.4
	Difference %	-1.8	-1.6	-1.4	-1.3	2.1	-5.0	-3.9	-0.8
N ₂ O (Gg CO ₂ -eq)	NIR 2012	3,946.4	3,762.1	3,654.8	3,125.8	3,190.3	3,054.1	3,053.0	3,345.1
	NIR 2013	3,940.8	3,756.7	3,654.9	3,125.8	3,190.4	3,054.1	3,053.0	3,345.1
	Difference %	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
HFCs (Gg CO ₂ -eq)	NIR 2012	0.0	NO	NO	NO	NO	49.4	68.3	90.9
	NIR 2013	0.0	NO	NO	NO	NO	49.4	68.3	90.9
	Difference %	NO	NO	NO	NO	NO	0.0	0.0	0.0
PFCs (Gg CO ₂ -eq)	NIR 2012	936.6	642.4	NO	NO	NO	NO	NO	NO
	NIR 2013	936.6	642.4	NO	NO	NO	NO	NO	NO
	Difference %	0.0	0.0	NO	NO	NO	NO	NO	NO
SF ₆ (Gg CO ₂ -eq)	NIR 2012	11.0	10.8	10.9	11.0	11.2	11.7	12.1	12.0
	NIR 2013	11.0	10.8	10.9	11.0	11.2	11.7	12.1	12.0
	Difference %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total (Gg CO ₂ -eq) Incl. LULUCF	NIR 2012	26,124.4	19,449.1	16,766.9	19,019.3	16,742.4	16,551.2	18,132.9	19,723.9
	NIR 2013	26,014.7	19,353.0	17,315.8	17,751.4	16,775.1	17,011.3	17,653.3	17,546.6
	Difference %	-0.4	-0.5	3.3	-6.7	0.2	2.8	-2.6	-11.0
Total (Gg CO ₂ -eq) Excl. LULUCF	NIR 2012	31,716.8	24,946.4	23,283.3	23,333.6	22,420.2	23,215.2	23,823.6	25,149.3
	NIR 2013	31,647.2	24,930.7	23,235.6	23,285.9	22,469.0	23,060.7	23,702.2	25,118.7
	Difference %	-0.2	-0.1	-0.2	-0.2	0.2	-0.7	-0.5	-0.1

Table 10.2-1: Differences between NIR 2012 (Resubmission, v3.4) and NIR 2013 for 1990-2010 due to recalculations, cont.

Source		1998	1999	2000	2001	2002	2003	2004	2005
CO ₂ (Gg) Incl. LULUCF	NIR 2012	13,064.4	13,595.2	13,556.6	13,960.1	14,832.8	16,278.9	15,537.6	15,716.3
	NIR 2013	11,427.3	11,978.9	12,308.5	12,845.5	13,729.4	15,559.5	15,138.5	15,326.6
	Difference %	-12.5	-11.9	-9.2	-8.0	-7.4	-4.4	-2.6	-2.5
CO ₂ (Gg) Excl. LULUCF	NIR 2012	19,630.9	20,533.3	20,094.7	21,035.6	22,107.0	23,530.8	23,151.4	23,488.0
	NIR 2013	19,623.6	20,535.3	20,093.2	21,034.0	22,108.0	23,528.7	23,152.4	23,485.2
	Difference %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CH ₄ (Gg CO ₂ -eq)	NIR 2012	2,621.1	2,633.2	2,692.0	2,866.0	2,884.8	3,150.3	3,164.6	3,076.5
	NIR 2013	2,654.6	2,664.0	2,729.1	2,877.2	2,948.8	3,050.8	3,146.8	3,131.9
	Difference %	1.3	1.2	1.4	0.4	2.2	-3.2	-0.6	1.8
N ₂ O (Gg CO ₂ -eq)	NIR 2012	2,883.0	3,217.4	3,285.1	3,337.9	3,263.0	3,107.3	3,483.7	3,485.7
	NIR 2013	2,882.9	3,217.4	3,285.0	3,337.9	3,263.0	3,107.5	3,477.4	3,489.6
	Difference %	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.1
HFCs (Gg CO ₂ -eq)	NIR 2012	118.2	142.6	170.7	193.4	225.1	263.0	300.1	333.4
	NIR 2013	118.2	142.6	170.7	193.4	225.1	263.0	300.1	333.5
	Difference %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PFCs (Gg CO ₂ -eq)	NIR 2012	NO	NO	NO	NO	NO	NO	NO	NA,NO
	NIR 2013	NO	NO	NO	NO	NO	NO	NO	NA,NO
	Difference %	NO	NO	NO	NO	NO	NO	NO	NO
SF ₆ (Gg CO ₂ -eq)	NIR 2012	12.6	12.6	12.2	12.3	12.6	12.9	13.2	13.7
	NIR 2013	12.6	12.6	12.2	12.3	12.6	12.9	13.2	13.7
	Difference %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total (Gg CO ₂ -eq) Incl. LULUCF	NIR 2012	20,751.4	19,732.4	24,379.1	21,326.6	21,702.5	25,061.0	22,600.7	22,734.6
	NIR 2013	17,836.1	18,950.2	18,571.0	19,282.8	20,189.5	22,028.4	22,082.5	22,302.4
	Difference %	-14.0	-4.0	-23.8	-9.6	-7.0	-12.1	-2.3	-1.9
Total (Gg CO ₂ -eq) Excl. LULUCF	NIR 2012	25,265.8	26,539.1	26,254.7	27,445.2	28,492.5	30,064.3	30,112.9	30,397.3
	NIR 2013	25,291.9	26,562.7	26,290.2	27,454.8	28,557.6	29,962.8	30,089.8	30,453.8
	Difference %	0.1	0.1	0.1	0.0	0.2	-0.3	-0.1	0.2

Table 10.2-1: Differences between NIR 2012 (Resubmission, v3.4) and NIR 2013 for 1990-2010 due to recalculations, cont.

Source		2006	2007	2008	2009	2010
CO ₂ (Gg) Incl. LULUCF	NIR 2012	15,830.2	16,820.3	15,456.7	14,074.9	12,879.4
	NIR 2013	15,633.8	17,261.8	15,920.1	13,906.6	13,407.1
	Difference %	-1.2	2.6	3.0	-1.2	4.1
CO ₂ (Gg) Excl. LULUCF	NIR 2012	23,725.6	25,017.1	23,783.9	22,010.8	21,292.2
	NIR 2013	23,716.5	24,999.1	23,755.7	21,982.5	21,288.8
	Difference %	0.0	-0.1	-0.1	-0.1	0.0
CH ₄ (Gg CO ₂ -eq)	NIR 2012	3,381.7	3,497.0	3,447.6	3,465.3	3,595.9
	NIR 2013	3,378.9	3,531.1	3,518.0	3,521.8	3,566.0
	Difference %	-0.1	1.0	2.0	1.6	-0.8
N ₂ O (Gg CO ₂ -eq)	NIR 2012	3,418.2	3,635.0	3,505.4	3,257.7	3,349.0
	NIR 2013	3,421.5	3,480.3	3,456.2	3,210.1	3,279.1
	Difference %	0.1	-4.3	-1.4	-1.5	-2.1
HFCs (Gg CO ₂ -eq)	NIR 2012	365.0	405.1	423.2	435.1	471.0
	NIR 2013	365.5	405.9	424.2	435.7	472.3
	Difference %	0.1	0.2	0.2	0.1	0.3
PFCs (Gg CO ₂ -eq)	NIR 2012	NA,NO	NA,NO	NA,NO	0.2	0.0
	NIR 2013	NA,NO	NA,NO	NA,NO	0.2	0.0
	Difference %	NO	NO	NO	NO	NO
SF ₆ (Gg CO ₂ -eq)	NIR 2012	13.6	13.7	12.6	8.4	9.3
	NIR 2013	13.6	13.7	12.6	8.4	9.3
	Difference %	0.0	0.0	0.0	0.0	0.0
Total (Gg CO ₂ -eq) Incl. LULUCF	NIR 2012	23,152.4	24,838.5	23,206.3	21,430.5	20,438.7
	NIR 2013	22,821.4	24,705.8	23,343.2	21,093.0	20,743.8
	Difference %	-1.4	-0.5	0.6	-1.6	1.5
Total (Gg CO ₂ -eq) Excl. LULUCF	NIR 2012	30,904.0	32,567.8	31,173.8	29,183.2	28,722.2
	NIR 2013	30,896.1	32,430.1	31,166.7	29,158.7	28,615.5
	Difference %	0.0	-0.4	0.0	-0.1	-0.4

The change in the 1990-2010 trend for the greenhouse gas emissions compared to the NIR 2012 (Resubmission, v3.4) is presented in Table 10.2-2. It can be concluded that the trend in the total national emissions increased by 9.44 percent including LULUCF and decreased by 1.2 percent excluding LULUCF comparing NIR 2012 (Resubmission, v3.4) and NIR 2013. The largest absolute changes in emission trends are recorded for CO₂, HFC and total CO₂-eq, described in Table 10.2-2.

Table 10.2-2: Differences between NIR 2012 (Resubmission, v3.4) and NIR 2013 for the emission trends 1990-2010

Gas	Trend (absolute)		
CO ₂ -eq (Gg)	NIR 2012	NIR 2013	Difference
CO ₂ emissions including net CO ₂ from LULUCF	-3713.68	-3087.27	-626.42
CO ₂ emissions excluding net CO ₂ from LULUCF	-2046.63	-2469.43	422.81
CH ₄	111.95	88.90	23.05
N ₂ O	-597.45	-548.47	-48.98
HFCs	470.96	0.00	470.96
PFCs	0.00	0.00	0.00
SF ₆	0.00	-1.14	1.14
Total (including LULUCF)	-5685.67	-4790.07	-895.60
Total (excluding LULUCF)	-2994.54	-3390.75	396.21

Table 10.2-2: Differences between NIR 2012 (Resubmission, v3.4) and NIR 2013 for the emission trends 1990-2010, cont.

Gas	Trend (percent)		
CO ₂ -eq (Gg)	NIR 2012	NIR 2013	Difference
CO ₂ emissions including net CO ₂ from LULUCF	-22.38	-12.88	-9.50
CO ₂ emissions excluding net CO ₂ from LULUCF	-8.77	-10.49	1.72
CH ₄	3.21	2.60	0.61
N ₂ O	-15.14	-13.92	-1.22
HFCs	100.00	100.00	0.00
PFCs	-100.00	-100.00	0.00
SF ₆	28.82	-12.55	41.37
Total (including LULUCF)	-21.76	-12.32	-9.44
Total (excluding LULUCF)	-9.44	-10.64	1.20

10.3 PLANNED IMPROVEMENTS TO THE INVENTORY

Croatian National system, as required by Decision 19/CMP.1, was established in 2007 on the basis of Air Protection Act and Regulation on the Greenhouse Gas Emissions Monitoring in the Republic of Croatia. In 2012 new Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia was enacted with purpose to harmonize national system with requirements of EU mechanisms for monitoring and reporting greenhouse gas emissions stipulated by Decisions 280/2004/EC, 2005/166/EC, 406/2009/EC and draft of new MMR Regulation. According to the latest annual review report (ARR) Croatian National System continues to perform its general and specific functions.

Inventory development process in general encompasses inventory planning, preparation and management and each of these components have to be periodically assessed and improved. Basis for planning of improvements to the inventory are: QA/QC programme, QA/QC plan, recommendations identified by Committee for inter-sectorial coordination for national system and recommendations identified by the expert review teams in the course of inventory review process.

Cross-cutting and general planned improvements

In regard to inventory planning phase more attention will be given to the effectiveness of activity data collection particularly in cases when deadlines for submission of activity data by different data providers are not fully met and/or activity data are missing in case higher IPCC methodology tiers are planned to be implemented for emission estimations.

Since inventory preparation is according to national regulation out-sourced to external authorized institution it is critical to follow the timetable established by the regulatory framework and QA/QC programme and Programme for annual activity data collection. In that respect written protocols for activity data submission and adjustments per sectors will be prepared to envisage potential bottlenecks and actions to resolve them. Focus of the protocols will be on providing eligible and robust adjustment techniques, technical corrections and recalculations performed by Agency and/or authorized institution if activity data are missing for entire time series and/or data providers are not in position to make such adjustments. It is planned to draft these protocols by the end of the second quarter of 2013.

Secondly, Committee for inter-sectorial coordination for national system will perform more active role in streamlining activity data collection according to the agreed timetable, provide recommendations for inventory improvement and in official consideration and approval of the inventory.

Still, annual review process carried out by the UNFCCC Expert Review Teams will continue to be the key driver for changes, prioritization and improvements of the inventory. In that regard recommendations from the latest ARR are presented in tables below with indication on timeline of their implementation.

In inventory preparation phase it is decided to strengthen implementation of source-category specific QC procedures (tier 2) for key source categories and to explore possibilities to utilize bottom-up annual GHG emission reports prepared by operators or owners of installations and verified by authorized/accredited bodies which fall under the EU ETS Directive in order to harmonize GHG emissions reported under different monitoring and reporting regimes. If emission calculations prepared by bottom-up installation specific approach (tier 3) could be reconciled with existing tier 1 or tier 2 approach then inventory team will apply higher tier approach. This will be performed in 2014 reporting cycle.

Since certain differences regarding information from installations and those from Environmental Pollution Register database are noticed, in order to minimize mentioned differences a meeting with county officials, Croatian Environmental Agency, Environmental Inspection and this Ministry is planned in autumn 2013.

For inventory management, it is decided to improve existing archiving system, particularly Inventory Data Record Sheets (IDRS), by means of developing database solution for archiving information contained in IDRS in order to allow better and more user-friendly search and analysis since amount of data have grown substantially. This will be done in 2014 reporting cycle. Better coordination among stakeholders will be applied in responding to requests for clarifying inventory information resulting from the different stages of the review process of the inventory information, and information on the national system in a timely manner.

In the tables below recommendations from the latest ARR are addressed with indication of feasible timeline for their accomplishment (long-term indicates period which lasts more than 2 years in order to apply specific recommendation). This plan will be embedded in annual QA/QC plan and approved by competent authorities.

General

Category	Recommendation	NIR 2013	NIR 2014	Long-term
Completeness	Provide estimates of all LULUCF categories and pools.		•	
KC analysis	Include explanations in the NIR on how the key category analysis is used to drive improvements of the inventory.	•	•	
KC analysis	Provide in the NIR a description of the KP-LULUCF key categories, together with the rationale for their identification as key.		•	
Uncertainty	Develop a full set of uncertainty values for the LULUCF sector.	•		
Uncertainty/ QA/QC	Improve quality checks, in order to prevent the presentation of different values of the uncertainty of the inventory in different sections of the NIR.	•	•	
Uncertainty	Provide more details and justify the correlation assumptions for each category in the uncertainty calculation.		•	
Uncertainty	Improve the QC checks on the uncertainty calculations in order to prevent mistakes.	•	•	
Uncertainty	Provide information in the NIR on how the Party uses the results of the uncertainty analysis in the prioritization of future inventory improvements.	•	•	
TS consistency	Recalculate the entire time series for CH ₄ emissions from enteric fermentation and manure management using EFs for developed countries to maintain the time-series consistency.		•	
QA/QC	Include more information on the QC procedures and the relevant information of the QA/QC plan related to planned improvements and follow-up to the previous review reports in the NIR.	•	•	
Archiving	Ensure that all information related to the inventory preparation is archived under the full control of the national system in a permanent way.	•	•	
Adjustments	Include in the NIR a description of the steps taken to improve estimates in areas that were previously adjusted.	•		

Sector-specific planned improvements*Energy*

Category	Recommendation	NIR 2013	NIR 2014	Long-term
Fugitive emissions	Transparently document the AD and methodology used for the calculations of revised estimates.	•		
Transparency	Provide more information on AD and EFs and explanations on trends, especially for the CO ₂ and N ₂ O emissions from road transportation, CO ₂ emissions from civil aviation and CO ₂ emissions from stationary fuel combustion in different categories.	•	•	
Comparability	Follow the Revised 1996 IPCC Guidelines for reporting in its next annual submission and ensure, as far as possible, the separate reporting of categories, or if not possible use the correct notation keys and provide clear explanations on where these emissions are allocated.	•		
Follow-up	Strengthen efforts to implement the previous review report recommendations.	•	•	
Reference approach	Conduct more detailed analysis of factors that may result in discrepancies between the reference and the sectoral approaches and provide the numerical data obtained as a result of such an analysis; make efforts to reconcile the differences between the two approaches for future annual submissions or provide more explanation of the reasons for the differences between the two approaches.	•	•	
Reference approach	Exclude emissions from coke oven gas production from the emissions calculations using the reference approach.	•		

Energy cont.

Category	Recommendation	NIR 2013	NIR 2014	Long-term
Reference approach	Investigate the reasons for the discrepancies between the data reported in the CRF tables and the IEA data (e.g. natural gas stock changes for 1993; coal extracted from mines for the years prior to 2000; and exports and imports of crude oil for the years prior to 1997) and provide information on the results in the NIR.		•	•
Bunker fuels	Improve the description of the approach used to derive the domestic navigation fuel consumption.		•	
Bunker fuels	Correct reporting errors in the CRF tables for fuel consumption in bunkers.	•		
Feedstocks and non-energy use	Provide information on the allocation of feedstocks and non-energy use of fuels to improve the transparency of its reporting of feedstocks and non-energy use of fuels.	•		
Stationary combustion	Apply country-specific carbon content values and oxidation factor values to estimate emissions for main fuel types.			•
Road transportation	Document the methodology used for the recalculations that were conducted during the review.	•		
Fugitive emissions	Revise the calculations of fugitive emissions from coal mining and handling, provide sources for EFs used and improve QA/QC procedures.		•	
Fugitive emissions	Estimate emissions for each stage of oil and gas operations using a higher-tier method, or, if that is not applicable, use disaggregated EFs following the corresponding methods in the IPCC good practice guidance.	•		
Fugitive emissions	Provide more detailed explanations of the approach used for the emission estimations and provide numerical data on the amount of natural gas processed and the natural gas composition before and after processing.	•		

Energy cont.

Category	Recommendation	NIR 2013	NIR 2014	Long-term
Fugitive emissions	Provide more detailed explanations of the approach used for the emission estimations and numerical data on the amount of natural gas processed and the natural gas composition before and after processing			•
Mobile fuel combustion (military)	Use the correct notation key for the reporting of mobile fuel combustion (military) and provide a clear explanation of where these emissions are allocated.		•	

Industrial Processes and Solvent use

Category	Recommendation	NIR 2013	NIR 2014	Long-term
Transparency	Include the time-series data for the amount of ferroalloys production, in addition to the currently provided data on reducing agents, to provide better background information for the changes in the IEF. Improve the descriptions in the NIR be more consistent (e.g. clarify that there is no production of F-gases in Croatia) and clearer (e.g. provide an explanation that the AD coverage for electrical equipment is complete). Add descriptions in the CRF background tables on AD for all categories. Report non-adjusted values for AD of cement production instead of pre-adjusted with the cement kiln dust factor.	•		
Glass production	Correct the notation key.	•		
QA/QC	Continue to refine the AD for all categories in this sector, by conducting more thorough checks against international statistics, general economic trends, and domestic regulation change, such as bans on the use of certain equipment, that may affect trends.		•	

Industrial Processes and Solvent use cont.

Category	Recommendation	NIR 2013	NIR 2014	Long-term
Ammonia production	Provide more general information about the survey of the ammonia manufacturers that provide the data, but also more specifically with regard to the approach used for the split between natural gas used as fuel and natural gas used as feedstock.		•	
Ammonia production	Clearly distinguish in both the CRF tables and the NIR between the energy and the industrial processes sectors with regard to fuel and feedstock issues.	•		
Consumption of halocarbons and SF6	Correct the description in the NIR on the aggregation of potential emissions of PFCs.	•		
Consumption of halocarbons and SF6	Document transparently the methodology used for the estimates of emissions from foam blowing and complete the sectoral background table of the CRF for the foam blowing emissions.		•	
Soda ash use	Document transparently in the next NIR the AD used for the calculations.	•		

Agriculture

Category	Recommendation	NIR 2013	NIR 2014	Long-term
Transparency	Provide more information in the NIR, particularly on the sources of AD.	•		
Transparency	Include information on the annual average Nex rates for livestock and the fractions of Nex that are managed for each animal waste management system for each animal type and the source of information for these data; the reasons for the choice of parameters for different sources; an explanation of how time-series consistency is ensured; information on how each of the four sources of information (page 165 of the NIR) were used to establish the dry matter content of crop residues and specifically linking the four sources of information to the specific activity; information on the residue to crop product mass ratio; information on the N content for N-fixing crops; and an explanation of which data information sources are used for the same parameters for non-N-fixing crops; the drivers and explanations of trends; how and where references in the reference section are used in the NIR; and the logical basis for expert judgement such as the area of organic soils.	•		
Uncertainty	Provide information on the logical basis supporting the expert judgement used for the uncertainty of the AD. Include information on QA/QC and planned improvements under the subsections, and include subsection headings for rice cultivation, crop residue burning and prescribed burning of savannahs with explanations as to why the activities are not occurring	•		
Time-series consistency and comparability	Improve the time-series consistency and comparability with other Parties and use the developed country EFs for the entire time series for livestock data; and for future annual submissions, develop tier 2 methods where data and methods are available.		•	
Field burning of agricultural residues	Complete CRF table 4F "field burning of agricultural residues" with information on crop production, residue crop ratios, dry matter fractions and the crop fraction burned in fields.	•		

Agriculture cont.

Category	Recommendation	NIR 2013	NIR 2014	Long-term
Enteric fermentation	Use country-specific data for cattle live weights and milk fat percentages where country-specific values exist.		•	
Manure management	Develop tier 2 estimates with country-specific EFs for the most significant animal types, namely cattle (based on the gross energy intake associated with the relevant EF used for enteric fermentation) and swine.			•
Manure management	Develop country-specific values for the annual average Nex per head of species and for the fraction of total annual Nex for each livestock species that is managed for every manure management systems, and report these values and information sources in the NIR.			•
Agricultural soils	Report data on crop production in CRF table 4F.	•		
Agricultural soils	Consider options such as the trend extrapolation or a surrogate method to estimate AD and emissions from the application of sewerage sludge to agricultural land for 1990.1994.	•		
Agricultural soils	Continue efforts with the FAO and either reconcile or document the reasons for differences in the values of N reported by the FAO and used in the CRF tables.			•
Agricultural soils	Use the country-specific data which are available on waste management systems for Nex rates for each manure management system.			•

LULUCF and KP-LULUCF

Category	Recommendation	NIR 2013	NIR 2014	Long-term
Completeness	Provide complete estimates for all land-use categories and pools in line with IPCC good practice guidance for LULUCF		•	
Completeness	Provide complete land-use change matrices for all years since 1990, and include land areas for all land-use categories in the CRF tables and provide complete uncertainty estimates.	•		
Transparency	Improve the transparency of the reporting, in particular to explain the forest types covered, and explain the reason for the changes in coverage and corrections to the CBS data, the basis for expert judgements and the source of reference materials.	•		
QA/QC	Review the use of notation keys and other information contained in the CRF tables and improve the QC of the CRF tables; and report the QC checks undertaken to compare country-specific soil data with that for other countries.	•		
FL remaining FL	Report emissions and removals for all forest types and carbon pools.		•	
FL remaining FL	Determine the area of fires on maquia and scrub, and estimate emission/removals from loss and subsequent regrowth of biomass and DOM.		•	
FL remaining FL	Work towards implementing country-specific data and estimate stock changes in all pools; and also (as a minimum) test the validity of the IPCC defaults against countries with similar conditions and country-specific data.		•	
FL remaining FL	Review and, if necessary, revise the methods used to estimate the increment for .other state. and private forests to ensure biomass is neither over- nor underestimated.	•		

LULUCF and KP-LULUCF cont.

Category	Recommendation	NIR 2013	NIR 2014	Long-term
FL remaining FL	Make efforts to advance consideration of the Croatian National Forest Inventory.			•
Land converted to FL	Undertake an investigation to verify whether the conversion from other land to forest land is a real land-use change or a data anomaly.		•	
Land converted to FL	Estimate emissions and removals associated with the conversion of other land to forest land, if occurring on managed lands, and if occurring on unmanaged lands, these land areas should be explicitly reported, as such in the CRF tables, in order to be consistent with the IPCC good practice guidance for LULUCF.		•	
Land converted to SET	Develop methods for determining whether maquia and scrub, "other state" and private forest (pre-2006) are being converted to settlements (or other land categories) and report the associated emissions and removals.	•		
–	Include in the NIR maps showing the geographic location of the boundaries of the areas that encompass the land units.	•		
–	Implement the planned improvements to afforestation, reforestation and deforestation and provide the additional information provided during the review in the NIR.	•		
Aforestation and reforestation	Estimate afforestation for all land areas, using the methods proposed by Croatia during the review.		•	
Deforestation	Develop AD on deforestation of "other state" forests, "private" forests (pre-2006) and maquia and scrub and estimate emissions and removals.	•		

LULUCF and KP-LULUCF cont.

Category	Recommendation	NIR 2013	NIR 2014	Long-term
Forest management	Review and correct the KP-LULUCF land transition matrices and the areas reported for forest management; and provide explanations for the difference in forest areas between forest management and forest land remaining forest land.	•		
Forest management	Estimate emissions/removals for all managed forest types.		•	

Waste

Category	Recommendation	NIR 2013	NIR 2014	Long-term
QA/QC	Ensure that the QA/QC procedures are properly implemented to avoid inconsistencies between the NIR and the CRF tables.	•		
SWDL	Improve transparency by reporting the relevant background information including the sources of EFs and AD.		•	
WWH	Improve the transparency regarding sources of AD and the selection of EFs.		•	
WWH	Recalculate CH ₄ emissions from the industrial wastewater subcategory, correcting the error in the current estimates.		•	
WWH	Correct the notation key for emissions from wastewater sludge.	•		
Waste incineration	Correct the notation key for incineration of sewage sludge.	•		
Waste incineration	Research and identify the technologies applied in the incineration of hazardous waste.		•	

PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11 KP-LULUCF

11.1 GENERAL INFORMATION

Upon the establishment of the National system in 2007 required under the Decision 19/CMP.1, the Ministry of Environmental and Nature Protection undertakes different activities in order to streamline and strengthen flow of data and information relevant for accounting of LULUCF activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol. This includes development of *Action plan for implementation of Article 3, paragraphs 3 and 4 of the Kyoto Protocol*, use of the EU short-term technical assistance and involvement on regular bases of all relevant stakeholders in this subject.

This year's submission follows the previously agreed procedure between the Ministry of Agriculture and the Ministry of Environmental and Nature Protection that preparation of the annual GHG Inventory, in respect of LULUCF sector, should be based on forest management plans. The results of conducted national forest inventory (CRONFI) still have no official status and consequently cannot be used for purposes of this reporting.

The UNFCCC and the KP reporting are harmonized as presented in Table 11.1-1; thus, the same data division was used in emission/removal calculation. Therefore, all stated for the UNFCCC is valid also for the KP (definitions, methodology, etc.). The issue of other land converted to forest land still deserves an examination as it represents AR-lands according to the KP and related definitions. For that reason emissions/removals were not yet estimated.

Table 11.1-1: The relationship between KP activities and reported UNFCCC land categories

UNFCCC			KP	
Land use category	Subcategories		Article	Activities
Forest Land				
	Land converted to Forest land	Grassland converted to Forest land Other land converted to Forest land	3.3	Afforestation
Settlements	Land converted to Settlements	Forest land converted to Settlements		Deforestation

11.1.1 DEFINITION OF FOREST AND ANY OTHER CRITERIA

Definition of forest:

Forest is a land spanning more than 0.1 hectares with trees higher than 2 meters and canopy cover more than 10 percent, or trees able to reach these thresholds *in situ* (Table 11.1-2).

Table 11.1-2: Thresholds in defining forest

Parameter	Range	Selected value
<i>Minimum land area</i>	0.05 - 1 ha	0.1 ha
<i>Minimum crown cover</i>	10 - 30 %	10 %
<i>Minimum tree height</i>	2- 5 m	2 m

Based on the selected values for KP reporting, forest includes the following forest stands: high forests, plantations, forest cultures, coppice, maquia and shrub. However, it is important to emphasize that the entire dataset required for emission/removal calculation is not completely available for maquia and shrub because some parameters (e.g. growing stock) are not measured within the national system. Thus, for now, estimates for these forest types are excluded and estimates for forests are carried out for the following types (see also subchapters 7.2-3 and 7.2.2.1.):

- high forests
- forest cultures
- plantations
- coppice

Based on the *Forest Act*, forests represent also forest nurseries and seed orchards that are an integral part of the forest; forest infrastructure; fire breaks and other less open areas within forests; forests in protected areas under a special regulation; forests of special ecological, scientific, historical or cultural interest; windshields and buffer zones in area larger than 10 acres and a width greater than 20 m.

A separate group of forest trees in the area up to 10 acres, forest nurseries and seed orchards, which are not part of the forest, windbreaks and buffer zones - protective tree belt area of less than 10 acres and a width of less than 20 m, tree rows and parks in urban areas do not present forest.

11.1.2 ELECTED ACTIVITIES UNDER ARTICLE 3, PARAGRAPH 4, OF THE KYOTO PROTOCOL

Croatia has chosen to elect Forest Management (FM) as an activity under Article 3.4 for inclusion in the accounting for the first commitment period in accordance with Paragraph 6 of the Annex to Decision 16/CMP.1. Credits from Forest Management are capped in the first commitment period. Following the Decision 22/CP.9, the cap is equal to 0.265 Mt C (0.972 Mt CO₂) per year, or to 1.325 Mt C (4.858 Mt CO₂) for the whole

commitment period. For 2011, the cap presents about 12% of the estimated removal resulted from Forest Management.

11.1.3 DESCRIPTION OF HOW THE DEFINITIONS OF EACH ACTIVITY UNDER ARTICLE 3.3 AND EACH ELECTED ACTIVITY UNDER ARTICLE 3.4 HAVE BEEN IMPLEMENTED AND APPLIED CONSISTENTLY OVER TIME

The time consistency is achieved because the data were collected for the entire period from 1990–2011 based on definitions presented further in this subchapter. Applied definitions are as follows:

Afforestation/Reforestation

Afforestation in national circumstances is the activity within the biological forest renewal and it refers to afforestation of non-forest land and establishing plantations of fast growing species. Biological forest renewal is part of the FMAPs and thus afforestation is clearly human induced. Reforestation, as defined by Kyoto, does not exist in Croatia due to strict legal provisions. See explanation given under *Forest Management*.

Deforestation

According to the Croatian *Forest Act* (OG 140/05, 82/06, 129/08, 80/10, 124/10), deforestation is clear cutting of forest for land use change to other culture and it is performed in accordance with the spatial planning documents. Therefore, for an activity to be referred as deforestation, certain forest area must be excluded from the national forest management area which is strictly regulated by the Act (Articles 35 and 51). Based on the latter, land use changes from forest to other land use categories are allowed in very limited circumstances (e.g. for important infrastructure projects etc.). The national definition is in line with the KP definition.

Forest Management

Based on the Croatian *Forest Act* (OG 140/05, 82/06, 129/08, 80/10, 124/10), national definition of forest management is in accordance with the Kyoto definition of FM. According to national criteria, forest land with and without tree cover constitutes one forest management area which is sustainably managed based on the FMAPs regardless of the ownership, purpose, forest stand etc. (see Chapter 7.2.2.1. for detail explanation). Therefore, the area under Forest Management according to the KP is not identical to forest management area in the national frame since KP refers only to one part of the forest land (the one with tree cover) which is in line with the Kyoto definition of forest (Table 11.1-2). Therefore, the Croatian area reported under forest management for the KP reporting refers to the area of high forests, cultures, plantations and coppice, excluding at this moment estimates of the C stock changes of maquia and shrub due to unavailability of complete dataset. The latter is illustrated in Figure 11.1-1.

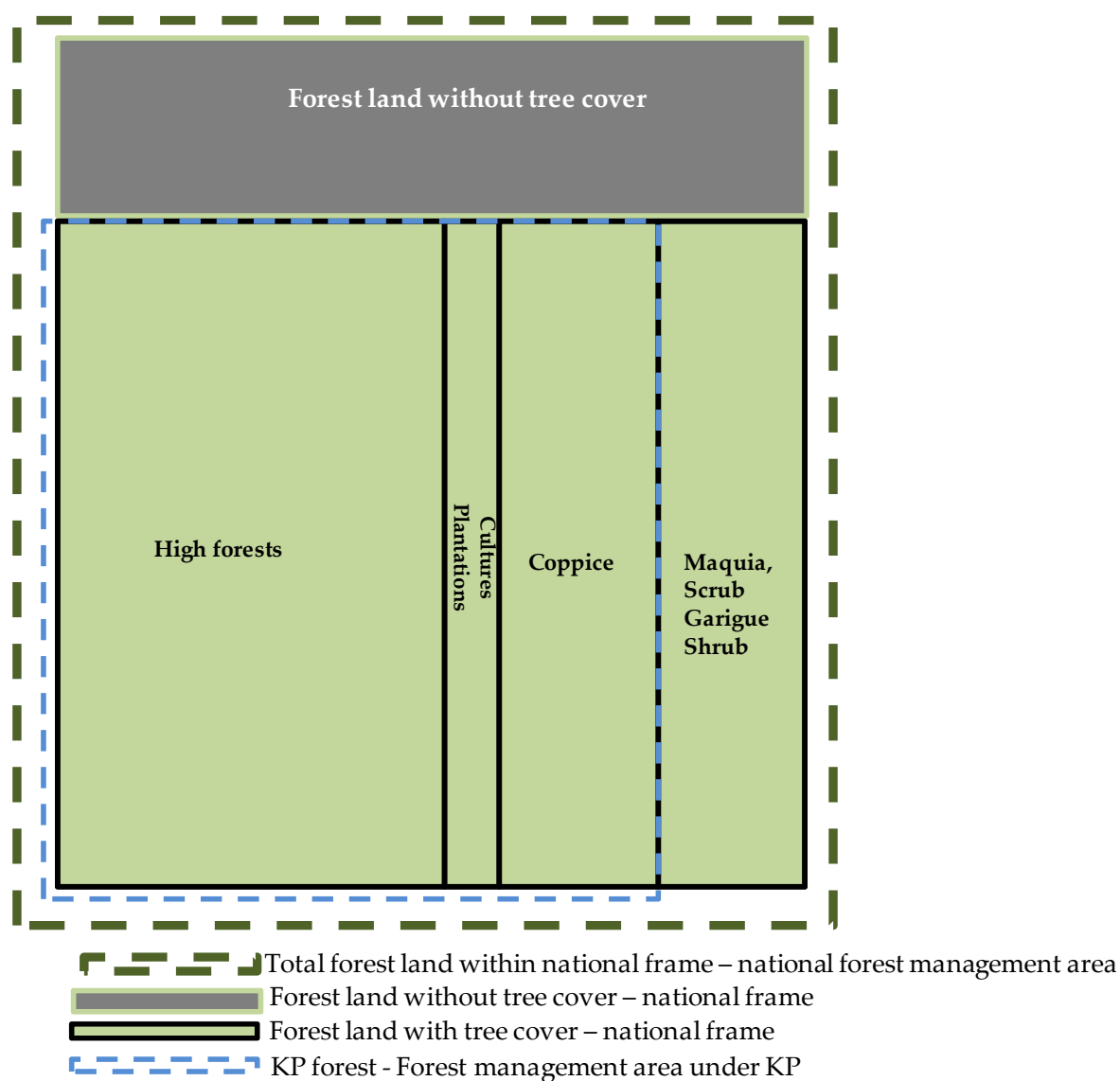


Figure 11.1-1: Forest management area under KP and within the national frame

11.1.4 DESCRIPTION OF PRECEDENCE CONDITIONS AND/OR HIERARCHY AMONG ARTICLE 3.4 ACTIVITIES, AND HOW THEY HAVE BEEN CONSISTENTLY APPLIED IN DETERMINING HOW LAND WAS CLASSIFIED

As Croatia has elected only the *forest management* under Article 3.4 activities, there is no need to develop a hierarchy between *forest management* and other Article 3.4 activities.

11.2 LAND-RELATED INFORMATION

11.2.1 SPATIAL ASSESSMENT UNIT USED FOR DETERMINING THE AREA OF THE UNITS OF LAND UNDER ARTICLE 3.3

The spatial assessment unit to determine the area of units of land under Article 3.3 is 0.1 ha, which is the same as the minimum area of forest. Considering the fact that Croatia is a country of small area, and that all forests in Croatia make one unique area and that all data about forest sector are available at the same company (*Croatian Forests Ltd*) there is no need for further stratification than based on forest type (coniferous, deciduous and out of yield forests).

11.2.2 METHODOLOGY USED TO DEVELOP THE LAND TRANSITION MATRIX

Activity matrices are presented for 2011, 2010, 2009 and 2008 (Tables 11.2-1, 11.2-2, 11.2-3, 11.2-4).

Corrections have been made in comparison to matrix presented in previous reports. The matrix was developed by adding and subtracting the conversion areas to and from land use category areas using the data from different databases available in Croatia (i.e. Croatian Forests Ltd., Croatian Bureau of Statistics, Corine Land Cover). Detailed information on approaches used to define the land use change area of each IPCC Land use category are given in parts 7.2-7.7 of the report.

Annual figures for the forest land area, and consequently for *afforestation/reforestation* areas were derived from the *Croatian Forests Ltd* official database. Based on the *Forest Act* and *Forest Ordinance* (OG 111/06, OG 141/08) afforestation works have to be prescribed by the *Forest Management Plan for management units* (FMAP). *Deforestation* data were derived also from the *Croatian Forest* database. According to the *Forest Act* deforestation is strictly regulated and allowed in very limited circumstances.

The data for the total forest area for the single years as well as the relative share of coniferous and deciduous and forests out of yield (maquies and shrub) are fully assessed in high resolution (0.05 ha grid) through measurements by the Croatian forests and described in the forest management plans in detail for the management subunits. Based on the legislative act⁴⁵, maps of silvicultural works make integral part of the programs. This also applies to the works on the ARD areas in Croatia since afforestations of new areas make a part of the silvicultural works in Croatia.

The forest management system is organized in a way that complete Croatian territory is divided into 16 forest districts (organizational and territorial units). This division was established in 1996. Districts consist of forest units, currently of 170 units altogether. The single forest unit is the basic organizational unit for performing all expert and technical activities in the forest management (see Chapter 7.2.2).

Within the reporting period, an increase of forest area was noticed. Based on the FMAPs total area of forest land in Croatia is known. Also, based on the strict national legislation, forestland converted to settlements category is well known. Also, the grassland area converted to forestland is well known due to the fact that afforestation in

Croatia has been done strictly on land under the forest management plans (without tree cover) which belongs to the grassland category according to the IPCC GPG. At the same time, categories that were facing with area decrease during the reporting period were grassland and other land categories.

Since the conversion of grassland to forestland is known, and a remaining grassland area decrease to account for the total observed forest land increase was not available, it was for the moment assumed that increase of forest area can be only due to conversion of other land to forest land. This can be happened for instance as a result of poor forest management in areas of some forest districts during the War period in Croatia. Since the War is a human induced activity, a more thorough investigation on these LUC lands from other land to forests needs to be conducted in Croatia until submission 2014 before they are estimated and accounted as AR lands.

Under KP-reporting these areas are so far not counted as AR lands but under the FM area (which represents the reason that the FM area is higher than the area of FL remaining FL and increase across the KP period). To solve this problem Croatia will make a survey through a representative subset of forest management plans for the country. On basis of the areas information there-in from the maps and tables the reasons of the forest area increase will be identified as type and year of LUC, previous land use, direct human induced or not and before 1990 or not and, as a consequence, how it should be reported (under KP Art. 3.3 or Art. 3.4). It will be distinguished into:

1. Forest area increase on basis of afforestations that happened before 1.1.1990 (e.g. in 1993 a regulation⁴⁵ by the Croatian law gave the obligation to Croatian Forests to take over all existing forest land covered under previous forest management plan and also from other enterprises). The background for this law was that all forest area in Croatia should be under forest management plans. As a result of this law also mature forests were for the first time counted as forest land under the new forest management plans). Croatia intends to count these lands under Art. 3.4 FM.
2. Afforestation and the former land use after 1.1.1990 and direct human induced LUC. These areas will be counted under Art. 3.3 AR
3. Afforestation not direct human induced. These lands will be counted under Art. 3.4. FM (having in mind the fact that all Croatian forests are managed forests per definition of the Forest law provisions).

The results of this representative subset will be extrapolated to the whole country in line with the allowed use of statistical methods for the identification of lands, land uses and land use changes according to the IPCC GPG. The lack of identification of these additional new forest lands so far is not related to the forest ownership status (state forests, other state forests, private forests) because all forest areas are assessed with the same system. The only reason for the lack of specified reporting of these areas so far is the considerable amount of work that is needed to measure these lands out of the forest management plans. This planned improvement will therefore also cover the identification of the AR areas in private and Other State forests.

⁴⁵ Ordinance on Forest Management (OG 111/06 (Article 63), OG 141/08)

⁴⁶ The Regulation on amendments to the Law on Forests (OG 14/93, Article 18) and Law on amendments to the Law on Forests (OG 76/93, Article 22)

Table 11.2-1: Land transition matrix for year 2008, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL
		A/R	D	FM	CM	GM	RV		2008
3.3 activities	A/R	17.08							17.08
	D		11.04						11.04
Article 3.4 activities	FM		0.42	2,304.9					2,305.3
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		0.42	0.00	0.00	0.00	0.00	0.00	3,325.5	3,325.9
TOTAL (end of 2008)		17.49	11.46	2,304.9	0.00	0.00	0.00	3,325.5	5,659.4

Table 11.2-2: Land transition matrix for year 2009, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL
		A/R	D	FM	CM	GM	RV		2009
3.3 activities	A/R	17.49							17.49
	D		11.46						11.46
Article 3.4 activities	FM		0.3	2,312.4					2,312.7
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		0.52	0.00	0.00	0.00	0.00	0.00	3,317.2	3,317.7
TOTAL (end of 2009)		18.01	11.76	2,312.4	0.00	0.00	0.00	3,317.2	5,659.4

Table 11.2-3: Land transition matrix for year 2010, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL
		A/R	D	FM	CM	GM	RV		2010
3.3 activities	A/R	18.01							18.01
	D		11.75						11.75
Article 3.4 activities	FM		0.46	2,319.8					2,320.3
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		1.62	0.00	0.00	0.00	0.00	0.00	3,307.7	3,309.3
TOTAL (end of 2010)		19.63	12.22	2,319.8	0.00	0.00	0.00	3,307.7	5,659.4

Table 11.2-4: Land transition matrix for year 2011, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL
		A/R	D	FM	CM	GM	RV		2011
3.3 activities	A/R	19.63							19.63
	D		12.22						12.22
Article 3.4 activities	FM		0.17	2,326.5					2,326.6
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		2.08	0.00	0.00	0.00	0.00	0.00	3,298.8	3,300.8
TOTAL (end of 2011)		21.71	12.38	2,326.5	0.00	0.00	0.00	3,298.8	5,659.4

11.2.3 MAPS AND/OR DATABASE TO IDENTIFY THE GEOGRAPHICAL LOCATIONS, AND THE SYSTEM OF IDENTIFICATION CODES FOR THE GEOGRAPHICAL LOCATIONS

All forest lands are assessed with the forest land assessment system by Croatian Forests. It is the duty of Croatian Forests to assess the area of the forest land of total Croatia every ten years. So the reported total forest area and its change over time is complete and covers all Croatia irrespective of ownership and forest type (e.g. also maquis and shrub lands).

Geographical units used for reporting are basically related to the ownership (state and private forests). The annex to FMAP 2006-2015 is composed of certain thematic maps, map on the forest ownership being one of them. The map is prepared by connecting digital spatial data with HS-Fond database, scale 1:100,000. Therefore, the ownership is also spatially located (See Chapter 7.2.2).

Forests maps that are prescribed by article 54 of the Ordinance⁴⁷ as part of the FMAP are:

- Geological map
- Phytocoenological map
- Soil Map detecting erosion and floodplains, rivers and water bodies
- Forest ownership overview map
- General maps of the spatial distribution of forests at the forest management unit especially for state-owned forests (showing boundaries of management units, forest offices, the Forest Administration, counties, specifically designated karst) and private forests (showing boundaries of cadastral municipalities or economic units, municipalities, counties, with specially designated karst).
- Forest map according to their purpose (commercial, protective, special purpose)
- Forest map by way of origin and the management methods (even-aged, uneven-aged forests)
- Main tree species overview forest map
- Map of forest infrastructure with marked existing and planned forest infrastructure
- Misk forest fire map
- Beneficial function forest map with detected larger settlements, industrial plants, agricultural areas, transport corridors

The maps are made in scale 1:300.000 and produced every 10 years at FMAP regular revision or its renewal and during the FMAP's additional, intermediate audits if required, except geological, soil and phytocoenological map which were produced during the development of first FMAP.

Also the reported ARD areas are geographically explicitly determined (Figure 11.2-1 and Figure 11.2-2) and maps on these areas exist for the State Forests. In case of private and other state forests and to subunits addressed as further ARD lands and new forests that are responsible for the forest area increase on basis of the forest area maps in the forest management plans, these subunits are also covered by the Croatian forest land assessment system. Therefore their location is also – in a geographical sense – assessed (included in the total forest area of the forest management plan). However, for the clear geographical identification and its traceability a further assessment of the measured area data is needed. Such an assessment was not done so far, but it is planned to be carried out until submission 2014. The investigation that needs to be conducted refers primarily to deforested area on private and other state forests. In case of geographical identification on afforested areas in private and other state forests and its traceability it should be emphasized that this work refers only to the area increase due to promotion of natural seed resources while afforestation through planting and seeding measures do not occur in these forests (explanation provided under the Chapter 7.2.4.2).

⁴⁷ Article 54 of Ordinance on Forest Management (OG 111/06 and 141/08)

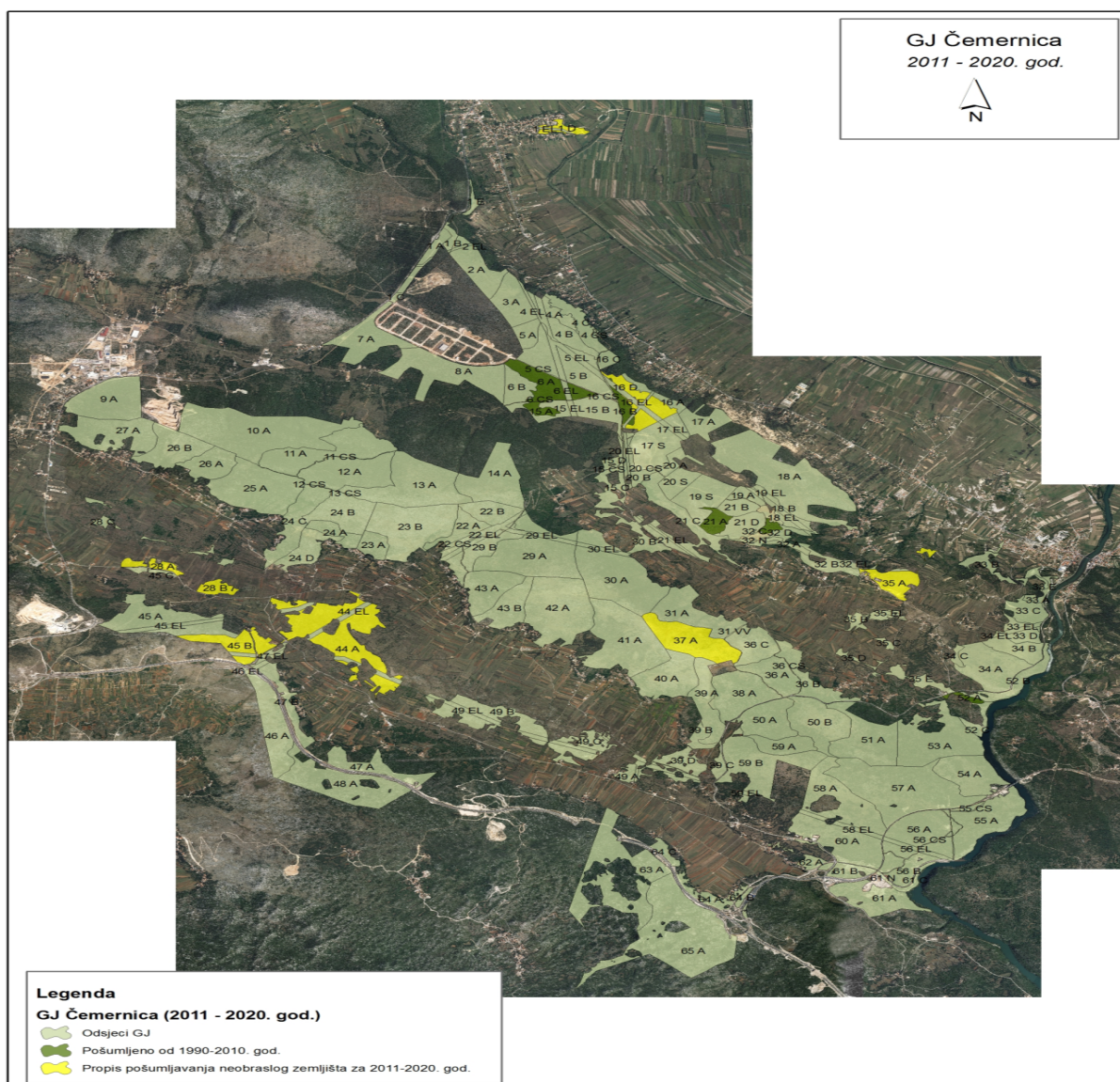


Figure 11.2-1 A map of one forest district in Croatia presenting areas that are afforested in period 1990-2010 (marked green) and areas that are foreseen for the afforestation in period 2011-2020 (marked yellow)

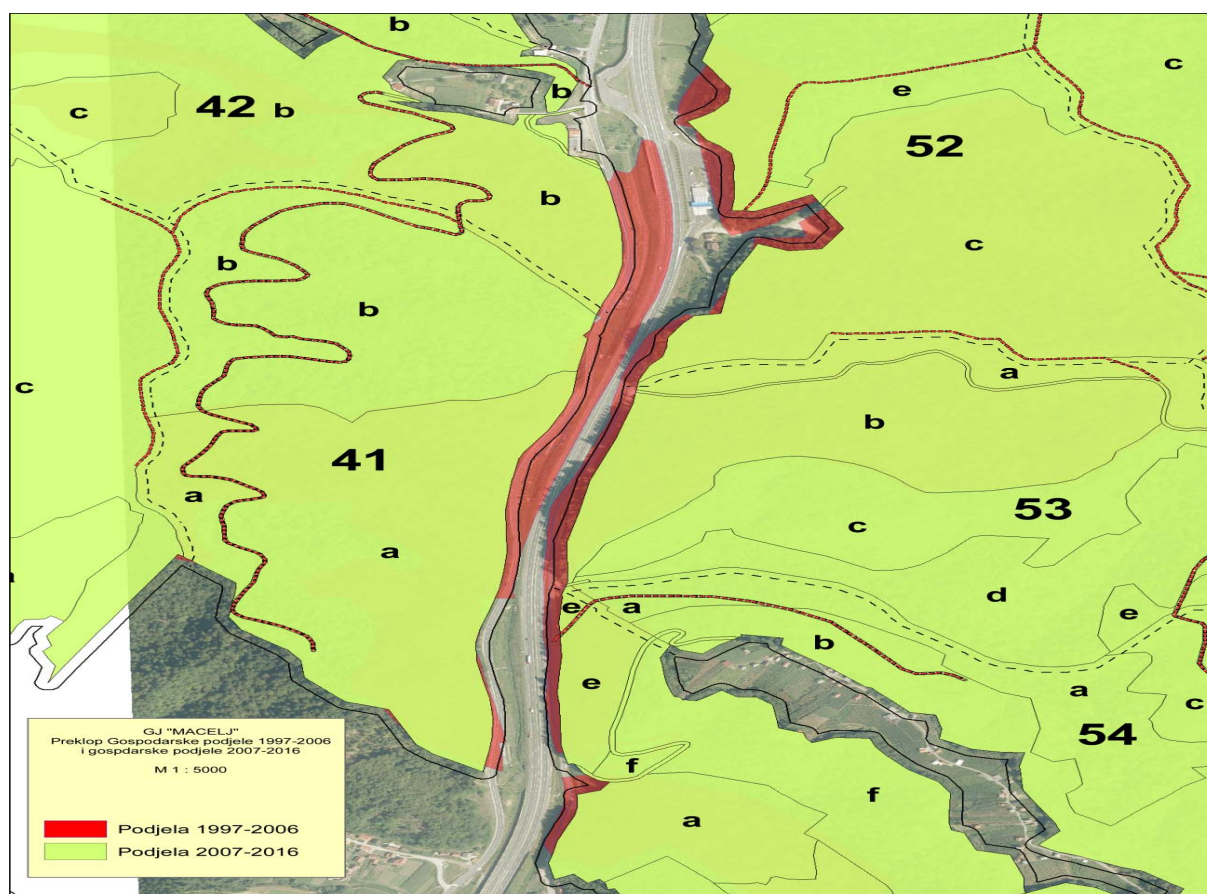


Figure 11.2-2 A map of the area with traced changes in the territory (area which was excluded from forest land in period 1997-2006 presented in red and situation in FMAP 2006-2015 presented in green)

11.3 ACTIVITY-SPECIFIC INFORMATION

Data used in the calculations are attained from FMAPs. The data were divided based on forest ownerships and forest type and reported as broadleaved and coniferous and out of yield forests (maquies and shrub). This disaggregation of data was used for presenting the carbon stock in living biomass. Data on carbon stocks in soil are presented in aggregated way without division by type of forests.

11.3.1 METHODS FOR CARBON STOCK CHANGE AND GHG EMISSION AND REMOVAL ESTIMATES

11.3.1.1. DESCRIPTION OF THE METHODOLOGIES AND THE UNDERLYING ASSUMPTIONS USED

1) ARD activities

Emissions and removals from ARD activities have been calculated using Tier 1 method for biomass gains and Tier 2 method for biomass losses and for soil and litter (GPG 2003) and Level 1 and Level 2 activity data disaggregation. The activity data obtained refer to living biomass and soil as follows:

- For afforestation – afforested area
- For deforestation – deforested area and related volume felled

In case of deforestation areas in state forests managed by *Croatian forests* Ltd all data are well recorded. In case of missing data conservative estimates of deforestation areas in private forests (pre-2006 year) and state forests that are managed by other legal bodies were applied based on data delivered from Croatian forests for these ownership types.

As regarding the afforestation, all units of land were not harvested since the beginning of the commitment period and related emission/removals have been reported. With respect to ensuring determination of harvesting or future deforestation of afforested land, country wide forest management plans secure that all forest management activities – also those at the AR lands – are prescribed and therefore known. These plans as part of officially prescribed method for preparation of forest management plans, prescribe all activities and works on A areas including the harvesting (in case of first age class forests in AR areas, pre-commercial thinning is defined as one of the activities). Each of these programs defines all measures and activities for the period of its validity (10 years), and it also gives a description of the measures that will be required in the following 10 years period. Based on the legislation⁴⁸ execution of each activity prescribed under the programs must be recorded and it should be reported about it. In case of AR areas this means that thinning and harvesting (after the first age class) on these areas is known and can be reported separately.

A) Biomass

To determine the changes in biomass carbon stock in afforested areas in Croatia, following assumptions and steps were applied:

1. During the reporting period, only coniferous species were used for the afforestation (explanation provided under Chapter 7.2.4.2)
2. Average annual increment from the IPCC GPG 2003 was used for the aboveground biomass in natural regeneration.
3. Values for the temperate forest, coniferous species in age class less and equal to 20 years and ≥ 20 years were applied.
4. The applied value is the same for both age classes (3 t dm/ha annually)
5. Mean value of the average Root to Shoot ratio for coniferous species was used (IPCC GPG 2003, value of 0.46)
6. IPCC GPG default value of the Carbon fraction (0.5 tC/ t dm) was used

Based on the above mentioned factors, average biomass growth was calculated to be 2.19 tC/ha annually. This constant value was used for all afforested areas of the first age class and multiplied by the total AR area of the first age class. The estimates for the second age class (AR areas that have been changed into second age class

⁴⁸ Law on Forests, Articles 64 and 65

since 1990) were calculated by multiplying the average biomass stock of the second age class by the area of the second age class.

In order to calculate the biomass carbon stock losses as a result of grassland conversion to the forestland, the nationally determined value for grassland category of 4.3 tC/ha annually was used.

As regarding D areas, the losses in living tree biomass per ha in the year of D are calculated using national information and also IPCC GPG 2003 values as follows:

- Harvested stemwood volumes at the D areas according to the information by Croatian Forests Ltd.
- Wood densities (national value of 0.56 t dm/m³ for deciduous and 0.39 t dm/m³ for coniferous were used)
- Carbon content of dry matter (0.5 tC/t dm according to IPCC GPG)
- Biomass expansion factor (1.40 for deciduous and 1.30 for coniferous according to IPCC GPG)

As regarding the biomass growth of deforested area, the country specific value of 0.19 tC/ha annually for settlements was used following the fact that deforestation in Croatia occurs only due to conversion to the settlement. Description of the underlying methods and assumptions can be found in related part of the report (Chapter 7.6.4.1)

B) Dead wood

Dead wood occurs only in forest lands. Therefore, this pool would represent a sink at AR lands if estimated or data were available. For D lands, the data of extracted stem volume at these lands according to Croatian Forests Ltd. also account for dead wood. Therefore, the emissions from the dead wood pool at the D lands are included in the emissions from the biomass pool in the D lands and IE is reported for the dead wood pool.

C) Litter

It should be noted that the used soil C stocks of forest land according to the national scientific investigation also include the C stock of the litter (humus layer). Therefore, the changes of the C stocks of the litter layer at ARD lands are included in the C stock changes of the soil pool and IE is reported for the litter pool.

D) Soil

The estimates of the soil carbon stock changes at ARD areas follow the equation below:

$$\Delta C_{L\text{Mineral}} = [(\text{SOC}_{\text{ref}} - \text{SOC}_{\text{before ARD}}) \times A_{\text{ARD}}] / T_{\text{ARD}}$$

where:

$\Delta C_{LFMineral}$ = annual change in carbon stock in mineral soils for inventory year

SOC_{ref} = reference carbon stock

$SOC_{before\ ARD}$ = stable soil organic carbon on previous land use

T_{ARD} = duration of the transition from $SOC_{before\ ARD}$ to SOC_{ref} (20 years)

A_{ARD} = total AR or D area after conversion still in SOC transition of 20 years

The values of soil carbon stock determined through national scientific investigation were used in order to estimate the carbon stock changes in soil. Conversion that happens in the Croatian case refers to grassland converted to forestland only with following soil C stocks:

- Grassland: 70.6 tC/ha
- Forestland: 84.5 tC/ha

Soil emission factor determined in this case is 0.14 tC/ha annually.

For determination of soil carbon stock changes in deforested areas the used values of soil carbon stocks are presented below, and emission factor was calculated to be -5.37 tC/ha annually.

- Settlements: 2.5 tC/ha
- Forestland: 84.5 tC/ha

Detailed description of the methodologies and the underlying assumptions used are presented in Chapter 7.2.4. *Methodological issues* and Chapter 7.6.4.1.1 *Forest Land Converted to Settlements*.

2) FM activities

Emissions and removals from FM were calculated based on the GPG 2003 and related equations were used covering estimates for the biomass carbon pool.

The entire calculation and description of the methodological approach are presented in Chapter 7.2.4.

The estimates under forest management for the KP reporting refer to high forests, cultures, plantations and coppice. At this moment estimates of the C stock changes of maquia and shrub are not carried out due to the unavailability of a complete dataset. However, it should be noted that there is no biomass harvest in maquia and shrub lands. Therefore, for these lands in accordance with the IPCC GPG no human induced C stock decreases are assumed (no source statement – see below).

Based on the ERT recommendations given in 2012 during the *In country review*, CO₂ emissions/removals in 2008, 2009, 2010, and 2011 are estimated using the per ha values for increment and harvest for all types of forest ownerships. This unified approach to the emission/removal estimation in all type of ownership is a main reason

that removals for this year reporting differs that removals reported in NIR 2012. Increment and harvest data are divided per broadleaved and coniferous species.

11.3.1.1 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

Omitting GHG emissions/removals

Table 5(KP-I)A.1.2 Article 3.3 activities: Afforestation and Reforestation. Units of land harvested since the beginning of the commitment period

Since fellings are not performed on afforested area due to the young age of the forests and the Croatian way of forest management, Croatia uses the notation key NO.

Table 5(KP-I)A.2.1 Article 3.3 activities: Deforestation. Units of land otherwise subject to elected activities under Article 3.4 (information item)

Only forest management has been elected under Article 3.4. As Deforestation is a permanent loss of forest cover, any unit of land that has been deforested under Article 3.3 cannot also be subject to the forest management under Article 3.4.

Table 5(KP-II)1. Direct N₂O emissions from N fertilization

N fertilization of forests is not performed in Croatia, so emissions are reported as not occurring.

Table 5(KP-II)2. N₂O emissions from drainage of soils

Drainage of soils does not occur in Croatia.

Table 5(KP-II)3. N₂O emissions from disturbance associated with land use conversion to cropland.

Deforestation to Cropland is not occurring in Croatia, as total deforested area was transition into settlements.

Table 5(KP-II)4. Carbon emissions from lime application

No lime is applied to forests, so emissions are reported as not occurring.

Controlled biomass burning

Controlled biomass burning does not occur in Croatia. All fires can be addressed as wildfires.

Wildfire

Currently, there are no data available presenting wildfires on AR and FM area separately. Therefore, all emissions of wildfires are reported under FM and IE is reported in the corresponding ARD tables. Due attention will be given to report separately about forest fires on ARD areas from FM area for NIR 2014 submission.

Omitting carbon pools

Croatia estimated the aboveground and belowground biomass, dead wood, litter and soil for Article 3.3 and the aboveground and belowground biomass for 3.4 activities. As for other carbon pools, based on the forest management practices and the legal framework within which the latter is performed, it is concluded that these pools do not represent emission sources. The background information in this regard is as follows:

ARD activities

As for afforestation areas and the dead wood carbon pool, it is considered that conversion of Grassland to Forestland cannot generate carbon stock changes in terms of losses of dead wood, especially in the long-term. Generally, afforestation is performed on the land under forest management that is without tree cover. Based on the IPCC GPG land use category definitions, this type of land falls under the Grassland category. Since there is no dead wood stock in Grassland area, conversion of this type of land to the Forest land contributes to an increase in the dead wood pool and is not a source of emissions.

As regarding the deforestation and reporting of carbon stock changes in dead wood, it is included in the figures of extracted stemwood and therefore included in the C stock losses of the biomass pool.

Based on the applied methodology during the scientific research on soil carbon stock in land use categories in Croatia (see Chapter 7.3.4.1), soil carbon stock measurement was performed including the litter pool. Therefore, the litter carbon stock changes at ARD lands are included in the reported soil C stock changes.

FM activities

a) Pools in maquis and shrub forests

Maquis and shrub forest type in Croatia has been formed from typical Sub-mediterranean and Eu-mediterranean species in these zones such as Holly oak and Pubescent oak (and with them naturally associated species) as well as significantly pines (i.e. Aleppo pine) that appear in the smaller areas or as a number of trees created through afforestation or natural means (fires) that due to its dispersion cannot be classified as coniferous culture.

According to the forest law and prescribed management plans, these forests are primarily left to the natural development supported through the specific management measures such as: fire protection measures, building of firebreak lines, afforestation (using primarily pioneer tree species) and sporadic activities with the purpose of converting these degraded forests to the form of high forests (i.e. according to the FMAP 2006-2015 conversion from degraded forests to high form of forests and reconstruction of maquis and . forests is prescribed to be executed on more than 10 000 ha in 10 year period).

As one of the measures for maquies and shrub forests preservation, ban of goat keeping in these forests was introduced by Croatian law on forest during the fifties. This measure supported spreading of pioneer tree species and its role in maquies and shrub forests and helped return of native vegetation.

Additionally, given in these forests prevail species of small dbh, their exploitation for firewood consumption requires more time and resources than the exploitation of wood in the high forests, it makes them less interesting for firewood extraction. At the same time vicinity of Lika region with high quality forest species of firewood, contributes to the preservation of maquies and shrub forests. Depopulation of rural areas and the increase of population in urban areas further contributes to the reduction of firewood consumption since electrical heating during the winter period dominates in most urban areas in Dalmatia.

According to the measures in energy sector adopted by the Croatian Government and Parliament⁴⁹ (i.e. completion of gas pipelines for Dalmatia and supporting measures to the production of electricity that originates from wind farms and solar panels both of which are most suitable for this region), it cannot be expected that consumption of wood originating from maquies and shrub forests will be changed in a near future.

Therefore, for these lands in accordance with the IPCC GPG no C stock decrease are assumed. So, by omitting to calculate emissions/removals in this forest type Croatia actually underestimates its removals under Article 3.4 of the Protocol and LULUCF corresponding categories of land.

a) Dead wood

According to FRA 2005⁵⁰, carbon stock in this pool for forest land has increased in Croatia from 1990-2005:

FRA 2005	1990	2000	2005
dead wood / Mt C	20.8	26	27

The latter clearly indicates that this pool is not an emission source.

Data on wood removal from FRA reports (for 1990 FRA 2005 and for 2000 and 2005 FRA 2010) were compared to NIR data on fellings. The comparison indicated that not all wood was removed from the forest and that certain percentage (about 10-15%) was left in the forest; thus contributing to a C input in other carbon pools. Reporting on wood removals under the FRA fits adequately to the wood removals practices conducted in Croatia that is performed in a way that harvest residues and wood less than 7 cm in diameter are left in the forest. Within the KP Forest management reporting, total gross fellings (i.e. including branches and bark) are reported. Considering the latter, there are no underestimations in regard to dead wood.

⁴⁹Energy Development Strategy of the Republic of Croatia (OG 130/2009); Law on Energy (OG 120/12); Tariff system for the production of electricity from renewable energy sources and cogeneration (OG 33/07); Amendments to the plan of development, construction and modernization of gas transportation system in the Republic of Croatia from 2002 to 2011 - The second investment cycle 2007 – 2011

Furthermore, there is a steady increase in the standing stocks in Croatia while the forest management methods remain the same. Under such circumstances and due to the fact that mortality is correlated with stand density also an increase in dead wood stocks as indicated by the FRA results is very likely.

Also, it should be mentioned that the forest management practice is governed by the strict legal framework which prohibits for example cutting the branches or their parts (unless it is provided by the forest management plans), collecting and removing leaf litter, moss etc. (*Forest Act*, Article 32, OG 140/05, 82/06, 129/08, 80/10, 124/10).

So, from all this facts we assume that the dead wood pool in the Croatian forests represents a C sink.

b) Litter

Following the legal framework mentioned above that prohibits the removal of peat, litter and humus from the forest and herein reported data that clearly indicate increase of biomass stock and increment and harvest, it can be concluded that a decrease in the carbon stocks of the litter pool is unlikely. In addition to this, based on the Forest act, exceptionally and under strict conditions, the usage of humus can be allowed but only if it is in accordance with the forest management plans and special legal regulations. By taking the latter into account and evidence for a rise in the C input into litter/soil due to the increase in biomass standing stock and in harvest causing an increase in the input of harvest residues, it can be concluded that the litter pool of the Croatian forests is not an emission source.

c) Soil

Within the reporting period, there was no change in the forest management. Based on this fact and explanations provided under *the dead wood* and *litter* pools, it can be concluded that also the soil carbon stock under forest management is not a source of emissions because the increase in biomass stock and harvest is correlated with a higher litter input to the soil and consequently with an increase of carbon stock in litter and soil.

11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

Croatia has not factored out removals from elevated carbon dioxide concentrations, indirect nitrogen deposition or the dynamic effects of age structure resulting from activities prior to 1 January 1990, considering also that GPG gives no methods for factoring out. For the first commitment period, the effect of indirect and natural removals will be considered through the cap under Article 3.4 credits from the *Forest management*. For Croatia the cap is 0.265 Mt C per year.

⁵⁰ Forest Resources Assessment Croatia 2005 (FRA 2005)

11.3.1.4. Changes in data and methods since the previous submission (recalculations)

Recalculation made since last report:

1. Changed methodology applied to the estimation of carbon gains due to increment. For the first time Croatia applied same methodology in this estimation in all forests regardless the forest ownership structure
2. Conservative estimate in case of deforested areas in private and state forest managed by other legal bodies was done
3. New values for soil carbon stocks were used

11.3.1.5 Uncertainty estimates

For the purpose of defining uncertainties in LULUCF sector in Croatia, special questionnaire was developed and several different experts from several Croatian institutions were consulted. This work was supported with the expert help secured through the EU project **“Assistance to Member States for effective implementation of the reporting requirements under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC)”**.

The input uncertainties, associated with the different emission factors and the activity data as well as the sources of information (default values, empirical data or expert judgment) are presented in Tables 7.2-6 and 7.2-7.

When performing Tier 2 method, based on Monte Carlo simulation technique, normal distribution has been assumed for the most of the inputs. The number of the applied iterations was 10000.

In case of Article 3.3 using the Tier 2 method uncertainty of total CO₂ eq emissions for ARD activities are determined in range of ± 247 to $\pm 681\%$ in period 2008-2011. In the same period uncertainty of total CO₂ eq emissions for AR activities are determined in range of ± 151 to $\pm 158\%$ and in case of D activities range is between ± 190 and $\pm 197\%$. In regards to FM, uncertainty was determined to ranges between ± 65 and $\pm 66\%$.

The same approach and methodology were applied for both the UNFCCC and the KP reporting frame as already presented in Chapter 7.2.5.

11.3.1.6 Information on other methodological issues

No information on other methodological issues.

11.3.1.7 The year of the onset of an activity, if after 2008

For 2008-2011, Croatia reports afforestation, deforestation and Forest management activities.

11.4 ARTICLE 3.3

In the period 1990-2011, afforestation activities resulted in net removals while deforestation presented a net source. The data are presented in Table 11.4-1. The difference between these data and data in NIR 2012 is caused with the fact that for submission 2013, Croatia performed improved analysis⁵¹ of soil carbon content and its changes. Also, based on the ERT recommendation conservative estimation of deforestation areas and related emissions in private forests (pre-2006 year) and state forests that are managed by other legal bodies were applied.

Table 11.4-1: Emissions/removals of Article 3.3 activities [Gg CO₂]

	Article 3.3 - Total	AR Biomass (Aboveground + belowground)	AR Dead wood	AR Litter	AR Soil	D Biomass (Aboveground + belowground)	D Dead wood	D Litter	D Soil
2008	81.12	-133.93	NO	IE	-44.58	87.21	IE	IE	172.42
2009	65.87	-136.48	NO	IE	-45.89	71.35	IE	IE	176.89
2010	58.59	-132.13	NO	IE	-46.51	63.72	IE	IE	173.51
2011	32.93	-141.53	NO	IE	-50.05	53.79	IE	IE	170.72

In each year, mentioned activities altogether resulted in emissions.

11.4.1 INFORMATION DEMONSTRATING THAT ACTIVITIES UNDER ARTICLE 3.3 BEGAN ON OR AFTER 1 JANUARY 1990 AND BEFORE 31 DECEMBER 2012 AND ARE DIRECTLY HUMAN-INDUCED

All data regarding the Article 3.3 activities were attained from HS database related to FMAPs. As mentioned previously, there are three main FMAPs. The first FMAP in this sense is the FMAP encompassing the period from 1986-1995 thus including 1990.

As stated earlier, *afforestation in national circumstances is the activity within the biological forest renewal and it refers to afforestation of non-forest land and establishing plantations of fast growing species*. This activity mentioned is laid down in forest management plans with a clear indication of the time when it is carried out; thus is human induced and not a result of natural succession.

Deforestation requires land use change and relies on a strict legal frame. It is mainly performed due to large infrastructure projects.

Therefore, all activities reported under Article 3.3 (afforestation and deforestation) began on or after 1 January 1990 and are human induced.

⁵¹ Work performed by Croatian Geological Institute. See list of references

11.4.2 INFORMATION ON HOW HARVESTING OR FOREST DISTURBANCE THAT IS FOLLOWED BY THE RE-ESTABLISHMENT OF FOREST IS DISTINGUISHED FROM DEFORESTATION

The main criteria for distinguishing the harvesting or forest disturbance followed by the re-establishment of forest from deforestation is whether or not the land use has changed, which is strictly regulated by the legal framework. More detailed information is provided below.

While comparing and interpreting definitions within the IPCC framework and within the national legislation, it was concluded that deforestation in national circumstances referred to clear cutting intended for land use change of forest land in accordance with the spatial planning documents. However, this activity is forbidden except in very specific cases which are regulated by the *Forest Act*, Article 35 and 51 (OG 140/05, 82/06, 129/08, 80/10, 124/10). Since all forest land in Croatia can be considered managed, if a certain forest land area is permanently removed from the forest management area (in specific circumstances, e.g. for road construction), then this event should be reported as deforestation.

The re-establishment of forest on harvested areas or areas affected by forest disturbance is also regulated by the *Forest Act* (Article 10 and 28) and the *Regulation on Forest Management* (OG 111/06, 141/08).

The FMAPs make a clear distinction between areas that are deforested and areas that are cleared for forest management purposes, all consistent with the provisions of the Forest Act. By that, both activities can be easily distinguished.

11.4.3 INFORMATION ON THE SIZE AND GEOGRAPHICAL LOCATION OF FOREST AREAS THAT HAVE LOST FOREST COVER BUT WHICH HAVE NOT YET BEEN CLASSIFIED AS DEFORESTED

Generally, forest cover can be lost through harvesting or forest disturbance which represent a temporary loss. Permanent loss of forest cover includes land use change. Therefore, there are no forest areas that have permanently lost forest cover but which have not yet been classified as deforested.

11.5 ARTICLE 3.4

11.5.1 INFORMATION THAT DEMONSTRATE THAT ACTIVITIES UNDER ARTICLE 3.4 HAVE OCCURRED SINCE 1 JANUARY 1990 AND ARE HUMAN-INDUCED

Croatia has a very long tradition in the forest management. As stated before, all data have been obtained from FMAPs, the first covering the period from 1986-1995 (thus including 1990). Since forest management area under the KP is all managed based on the FMAPs, if human induced is assumed equivalent with the managed, then it is demonstrated that the forest management as an activity under Article 3.4 of the KP is human induced. Croatia has stock and harvest data in an annual resolution. Therefore, an easy assessment of the year of activity is possible.

11.5.2 INFORMATION RELATING TO CROPLAND MANAGEMENT, GRAZING LAND MANAGEMENT AND REVEGETATION, IF ELECTED, FOR THE BASE YEAR

Croatia has not elected these activities for the first commitment period.

11.5.3 INFORMATION RELATED TO THE FOREST MANAGEMENT

As stated before, all forest management area within the national frame is managed based on the FMAP and is even wider than the forest management area under the KP because it includes, for example, afforested area and also "forest land" (in Croatian sense) that is covered with vegetation which does not reach the selected thresholds for the KP definition of forest (all land under FMAPs, see Figure 11.1-1).

Forest management resulted in net removals in all years within the reporting period. Carbon stock changes in living biomass resulted in removals presented in Table 11.5-1.

Table 11.5-1: Emissions/removals of Article 3.4 activity

Activity	Emissions/removals / Gg CO ₂			
	2008	2009	2010	2011
Forest management	-8.218,13	-8.439,86	-8.313,69	-7.532,51

11.6 OTHER INFORMATION

There is no other information.

11.6.1 KEY CATEGORY ANALYSIS FOR ARTICLE 3.3 ACTIVITIES AND ANY ELECTED ACTIVITIES UNDER ARTICLE 3.4

Figure 11.6-1 shows that only Forest management is considered as a key category.

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS ⁽³⁾
		Associated category in UNFCCC inventory ⁽¹⁾ is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory ^{(1), (4)} (including LULUCF)	Other ⁽²⁾	
Specify key categories according to the national level of disaggregation used ⁽¹⁾					
Forest Management	CO ₂	Forest land remaining forest land	Yes	No other criteria	No

Figure 11.6-1 Summary overview of key categories for LULUCF activities under the Kyoto Protocol (CRF – NIR 3 table).

11.7 INFORMATION RELATING TO ARTICLE 6

Croatia is not participating in any project under Article 6.

12. INFORMATION ON ACCOUNTING OF KYOTO UNITS

Information on accounting of Kyoto units is presented in Table 12.1-1.

Table 12.1-1: Information on accounting of Kyoto units

Annual Submission Item	HR report
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	The Standard Electronic Format report for 2012 has been submitted to the UNFCCC Secretariat electronically and the contents of the report can also be found in annex 6 of this document.
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	No discrepant transactions occurred in 2012.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2012.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2012.
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2012.
15/CMP.1 annex I.E paragraph 17: Actions and changes to address discrepancies	No actions were taken or changes made to address discrepancies for the period under review.
15/CMP.1 annex I.E Publicly accessible information	The public website of Croatian National registry can be found at http://www.azo.hr/RegistarUnije on Croatian language and at http://www.azo.hr/GHGRegistry on english language. Croatian national registry was in "reconciliation mode only" until 28.2.2013. From 1.3.2013. Croatian registry is in operational status with ITL. The web site and the Registry user interface is bilingual: Croatian and English. Registry user interface is publically available through the Internet from 17.1.2013. https://ets-registry.webgate.ec.europa.eu/euregistry/HR/index.xhtml In February 2012 Croatia made only one transaction - issuance of 148,778,503 AAUs. Croatia was obliged to join to the EU Emission Trading Scheme (ETS) form 1.1.3013. because of the accession to the European Union.

Annual Submission Item	HR report
	From 17.1.2013. Croatia is connected to EUTL and part of Union Registry.
15/CMP.1 annex I.E paragraph 18 CPR Calculation	CPR = 90%AAU= 133,900,653

13. INFORMATION ON CHANGES IN NATIONAL SYSTEM

National system was changed compared to the description given in last inventory submission in May 2012 in part related to legal arrangements where new Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia (OG 87/12) was enacted in July 2012 and Ordinance on Greenhouse Gas Emissions Monitoring in the Republic of Croatia (OG 134/12) was enacted in December 2012.

The purpose of these legal documents is to further harmonize national system with requirements of EU mechanisms for monitoring and reporting greenhouse gas emissions stipulated by Decisions 280/2004/EC, 2005/166/EC, 406/2009/EC and draft of new MMR Regulation.

The main improvements are stipulated by the Article 77 of the Air Protection Act (Official Gazette No. 130/11) that regulates timeliness and completeness of requirements given for certain tier by prescribing that the state administration bodies and other public bodies competent for activities pertaining to environmental protection, the economy, agriculture, forestry, water management, sea, transport, official statistics, as well as the companies Hrvatske šume d.o.o. (Croatian Forests) and Hrvatska kontrola zračne plovidbe (Croatia Control Ltd.), which collect and/or hold data on activities according to sectors, in which greenhouse gas emissions are emitted or removed, and which data are required for producing this report should deliver such data to the Agency. The data should be delivered yearly free of charge, taking in consider deadlines prescribed by this Act and the scope and format published by the Ministry on its website .

Futhermore data required for producing this report should be delivered to the Agency by 30 June of the current year for the previous calendar year.

Also, the above mentioned bodies are obligated to participate each year in all phases of data preparation and data submission, report review and revision carried out by the UNFCCC Secretariat.

New national Plan for Air Protection, Ozone Layer Protection and Climate Change Mitigation for the period 2012-2016 is under preparation. The plan will stipulate concrete measures to improve performance of national system. It is planned to prepare and carry out two capacity building projects, one related to improvements in emissions estimates in all IPCC sectors and one specifically related to reporting in LULUCF sector.

All other components of national system remain to perform their general and specific functions.

14. INFORMATION ON CHANGES IN NATIONAL REGISTRY

Information on changes in National Registry is presented in Table 14.1-1.

Table 14.1-1: Information on changes in National Registry

Annual Submission Item	HR report
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	Mr. David Dobrinic Registry system administrator deputy Croatian Environment Agency Trg marsala Tita 8 10 000 Zagreb Tel: +3851 5581 660 Fax: +3851 4886 840 E mail: david.dobrinic@azo.hr
15/CMP.1 annex II.E paragraph 32.(b) Change of cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database or the capacity of national registry	No change to the database or to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change of conformance to technical standards	No change in the registry's conformance to technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change of discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change of security	No change of security measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(g) Change of list of publicly available information	No change to the list of publically available information occurred during the reporting period 2012. Web site is updated with publicly available documents after 1.1.2013. because Croatia became part of Union Registry.

Annual Submission Item	HR report
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry Internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change of data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change of test results	No change of test results occurred during the reporting period.
The previous Annual Review recommendations	1.IAR/2011/HRV/2/2 P2.2.1. 7. SIAR recommends that the party promptly make available all required public information pursuant paragraph 44 to 48 of the annex to decision 13/CMP.1. Croatian registry made only one transaction- issuance of AAUs in February 2012 and had open only national accounts (300 retirement account, 411 tCER replacement account for expiry, 421 ICER replacement account for expiry, 422 ICER replacement account for reversal in carbon storage, 423 ICER replacement account for failure to submit certification report, 210 net source cancellation account, 220 non-compliance cancellation account and 250 mandatory cancellation account). Information required by the paragraph 45 of the annex to decision 13/CMP.1. cannot be publicly accessible because Registry do not have open accounts except national accounts. Information required by the paragraph 47 of the annex to decision 13/CMP.1. cannot be publicly accessible because Registry do not have any ERUs, CERs, RMUs on the accounts. Information required by the paragraph 48 of the annex to decision 13/CMP.1. cannot be publicly accessible because Registry do not have open any accounts. 2.FCCC/ARR/2012/HRV Paragraph 132. Make the required information publicly available, as soon its registry has performed a Kyoto unit transaction. Only performed transaction is AAUs issuance on February 2012.

15. INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3.14.

Policy context

Parties included in Annex I are required to provide information relating to how it is striving under Article 3.14 to implement its commitments mentioned in Article 3.1. This section should provide an overview of its commitments under Article 3, paragraph 1, and how these are to be implemented to minimize adverse social, environmental and economic impacts on developing countries.

The underlying policy drivers for taking actions in climate change mitigation in Croatia are commitment under the Kyoto Protocol to reduce greenhouse gas emissions by 5 percent in the period 2008-2012 in comparison to base year emissions and harmonization with European Union climate and energy legal framework. EU membership term is agreed and it is expected that Croatia will join EU on 1 July 2013 after ratification of Accession agreement by all Member States.

It should be emphasized that in the last five years Croatian economy had suffered from recession and that economic stagnation continued in 2013 with increase in unemployment rate, public deficit and debt. These conditions have caused downturn in industrial activities and energy production and consumption and consequently decrease in greenhouse gas emissions.

Policies and measures related to climate change mitigation are stipulated by Air Protection Act and supporting regulatory framework which covers large emission sources including aviation under emissions trading regime, small and medium emission sources through energy efficiency and emissions standards, fuel quality, flexible mechanisms under the Kyoto Protocol and mechanisms for monitoring and reporting.

In respect of fulfillment of the GHG emission reduction obligations, preparation of Croatia's low carbon strategy is underway. With the aim to discuss low carbon developments meetings with stakeholders in energy, industry, waste management, forestry, agriculture, energy efficiency in buildings, tourism and transportation sectors were held during September and October 2012.

5-year Plan for Air Protection, Ozone Layer Protection and Climate Change Mitigation is a key operative document on national level which further enforces actions and measures to reduce greenhouse gas emissions. Plan for the period 2012-2016 is under preparation and will be adopted in the second quarter of 2013.

In regard to long-term planning Croatia is in the process of adopting framework Low-Emission Development Strategy which is sponsored by the UNDP Croatia. This document should represent a roadmap for transition to low-carbon society till 2050.

Croatia is finalizing its transposition of EU Directive 2009/31/EC on the geological storage of carbon dioxide. Since Croatia has potential for carbon capture and storage it is in future period necessary to assess if there is a need for this technology and also if use of these resources is of national interest.

Key instruments for climate change mitigation in Croatia

One of the most important financial instruments for climate change mitigation in Croatia is Environmental protection and energy efficiency fund which collects charges based on polluter pays principle and co-finance the programmes or projects related to environmental protection, energy efficiency and renewable energy. In the period 2004-2009 total revenues were 4,603 million HRK (approximately 613 million EUR), and of that amount 161 million was from charges on CO₂ emissions (approximately 21.5 million EUR).

Another market instrument which was implemented in Croatia in 2013 is emissions trading system as part of broader phase 3 European Union Emissions Trading System (EU ETS). Installations which fall under this system contribute approximately 1/3 of total greenhouse gas emissions in Croatia. These installations will be required to compensate their annual emissions with emission allowances which will be auctioned on primary market or purchased on secondary market through financial institutions or intermediaries. Revenues raised by auctions will be earmarked to full extent to projects related to climate change mitigation and adaptation in Croatia.

State of play in energy sector

Energy sector is the largest contributor to greenhouse gas emissions in Croatia with more than 70 percent in average in the period 1990-2011 and measures to reduce emissions in this sector, including improving energy efficiency and renewable energy sources, are recognized as priorities at national level. The key indicators in energy sector related to primary energy production, energy import, energy supply, renewable energy sources and energy efficiency are concisely presented below⁵².

During the six year period from 2006 to 2011 primary energy production in Croatia was decreasing at an average annual rate of 2.2 percent. This trend was recorded in the production of crude oil and natural gas as well as in hydro power utilization. The production of crude oil and natural gas was decreasing annually by average 6.1 percent and 2 percent respectively. Hydrological conditions in 2010 were unfavorable, whereupon hydro power had a negative growth of average 6 percent per year.

The fastest growing production was that of renewable energy with average annual growing rate of 65.8 percent. The production of energy from fuel wood, industrial wood waste, wood pellets, and briquettes and energy from charcoal increased by 34 percent in relation to 2010. The energy from other renewable sources includes

⁵² Annual Energy Report, Energy in Croatia 2011, Ministry of Economy

wind energy, solar energy, geothermal energy, biodiesel, and biogas. Installed capacity for production of biofuels is 64,000 tonnes/year although only 7,551 tonnes of biodiesel was produced in 2011 where 66 percent of the production was exported. Total renewable energy production in 2011 grew by 13.3 percent in comparison to 2010.

In 2011, total energy import in Croatia decreased by 5.2 percent from the previous year. In terms of specific energy forms, the import of crude oil, natural gas, and of coal and coke decreased while the import of electricity, petroleum products and fuel wood and biomass increased. The import of crude oil fell by 19.5 percent, of natural gas by 18.1 percent and of coal and coke by 3.6 percent. The import of electricity increased by 30.6 percent, of petroleum products by 26.5 percent and of fuel wood and biomass by 18.5 percent. During the period from 2006 to 2011 the Croatian energy import was decreasing by average 2.7 percent per year.

In the period from 2006 to 2011, total primary energy supply was decreasing at an average annual rate of 1.4 percent. In this period the decrease was recorded in hydro power utilization and liquid fuels consumption, while consumption of other energy forms which made primary energy supply was increasing. Hydro power utilization was decreasing by 6 percent annually, and the consumption of liquid fuels by 4.2 percent annually. Consumption of renewables had a fast growing trend with an average rate of 64.2 percent annually. The consumption of heat energy from heat pumps also grew at a rather high average rate of 21.9 percent annually. The consumption of other energy products was growing at a slower pace: the consumption of imported electricity grew at 6.5 percent annually in average, of wood and biomass at 4.4 percent annually and of natural gas at 1.7 percent annually. The consumption of coal and coke was almost stagnating, with an average annual rate of only 0.03 percent.

Despite difficult economic circumstances Croatian government has continued to support investments in improving energy efficiency and renewable energy sources which are indicated as key cost-effective measures for greenhouse gas emissions reduction in Croatia. As indicated before, the fastest growing production in energy sector was that of renewable energy with average annual growing rate of 65.8 percent.

Feed-in tariff system for electricity and heat production from renewable energy sources and high-efficient cogeneration is implemented in Croatia in 2007 and is still in effect. Total incentive amount paid to all eligible producers in Croatia which delivered electricity and/or heat to the grid equals 223.8 million HRK (approximately 30 million EUR, VAT included) in 2011.

In regard to energy efficiency, the energy efficiency index ODEX (weighted average of the specific consumption index for selected branches of energy consumers) shows a decrease in the economy as a whole for 15.6 percent in the period 1995-2011 which means that economy is less energy intensive and that energy efficiency has improved in general. However, some sectors such as transport and services show higher energy intensity in the observed period.

The national framework objective of energy savings in final consumption is defined in the NAPEnU (National Action Plan for Energy Efficiency) in accordance with the methodology set out in the Directive 2006/32/EC on energy efficiency and energy services. In its absolute amount, it corresponds to 9% of referent final consumption of energy, which is defined as average energy consumption in the period 2001 – 2005.

Slow drop in final energy consumption in buildings sector has been registered in 2011. by 1,0 percent compared to 2010. Final energy consumption in buildings was 111.4 PJ for 2011, representing 42.5 percent of total energy consumption in 2011 totaling 259.2 PJ. Total energy consumption in other sectors in 2011 was 127,3 PJ. Lower energy consumption in industry and transportation is obvious, affecting total drop in consumption by 2.5 percent compared to 2010, but the buildings remain single largest energy consumer.

Considering the fact that largest energy savings can be reached in buildings, it is necessary to direct all the activities in energy efficiency towards upgrade of existing buildings and construction of nearly zero energy new buildings. Energy certification of the buildings, or appraisal and classification of the buildings according to energy use is mandatory for all buildings in the real estate market in Croatia. Energy certification produces transparent information on energy consumption in buildings. Energy certification is becoming strong marketing and differentiation tool for the buildings even in the design process. Amended Directive 2010/31/EU of energy performance of the buildings - EPBD II - is implemented through changes in legal framework and mandatory energy certification for all new buildings and buildings being sold or leased at the market.

Energy audits of the buildings has been extended to: public sector for the public buildings and public lighting; large consumers for the buildings used for their activities; other users funded by the Environmental protection and energy efficiency fund when the energy audits have been stipulated by Funds regulations.

It is assumed that the energy renovations of the buildings will be based primarily on the buildings built before 1987, with average consumption of thermal energy for heating of 200-250 kWh/m². Assuming that each year 3% or about 5 million m² of the buildings' surface is renovated, and that the average annual consumption of thermal energy for heating is decreased from the average 200-250 kWh/m² down to 25-50 kWh/m², and with an annual addition of 10 percent of newly-built surface in nearly zero-energy standard; with more rigorous legislation, the effective savings of final energy would amount to about 20.60 PJ in 2020. With this, we would get closer to the national objective of energy savings of 22.76 PJ in 2020. The targets that are set up are very ambitious and not easily achievable without a systematic and continual approach to the implementation and without putting in place strong financing mechanisms.

The transport sector in Croatia is one of the most significant consumers of energy nowadays and in the near future a fastest-growing trend in consumption can be expected in this sector. In the period between 1991 and 2011 the share of transport sector consumption in the final consumption rose from 21% to 33%, indicating great potential for implementing energy efficiency measures.

The potentials for an energy efficiency increase in this sector are to be found mostly in optimization of modal structure (share of different transport modes), in greater capacity utilization (load factor increase) and in implementation of more energy efficient engines and vehicles, as well as appropriate driving regimes.

Cross-border cooperation and assistance to developing countries

Croatia is actively assisting developing countries in the region in building their capacities to harmonize their national systems to the UNFCCC and the Kyoto Protocol requirements as well as requirements of EU regulation since all of them are in the approximation process to EU however with different starting points. This assistance is organized through projects financed by the European Commission: Regional Environmental Network for Accession – RENA and follow-up project ECRAN.

Conclusion and changes compared to the previous submission

It could be concluded that due to Croatia's size, share in international trade and GHG footprint, policies and measures implemented in Croatia do not have any significant adverse economic, social and environmental impacts on developing countries nor will in the future. All major projects are under obligatory strategic or environmental impact assessment and environmental permitting system including public participation and consultation process and cross-border notification process in case facilities are located on or near borders. Croatia is putting much effort to revive its economy and build sustainable, diverse and competitive energy system which could create environment for investments in more environmentally friendly technologies.

While there have been no significant changes in policies and measures to minimize adverse impact in accordance with Article 3.14 this chapter was largely revised in order to provide more detailed and transparent information on actions undertaken by Croatia in mitigating climate change.

ANNEX 1

KEY CATEGORIES

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

Key categories according to the IPCC Good Practice Guidance (IPCC, 2000) are those found in the accumulative 95% (Tier 1) or 90% (Tier 2) 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 identify key categories for the LULUCF. Therefore, the key category analysis was determined using both approaches:

- excluding LULUCF
- including LULUCF

Following the *Good Practice Guidelines*, Croatia undertook a key category analysis using Tier 1 and Tier 2 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 A1.1-1. Additionally, other sources of direct greenhouse gas emissions not listed in above mentioned guidance were added to the list, e.g. CO₂ Emissions from Solvent and Other Product Use.

Level assessment

Level assessment involves an identification of categories as a key by calculating the proportion of emissions and removals in each category to the total emissions and removals. The calculated values of proportion are added from the category that accounts for the largest proportion, until the sum reaches 95% for Tier 1, 90% for Tier 2. Tier 1 level assessment uses emissions and removals from each category directly and Tier 2 level assessment analyzes the emissions and removals of each category, multiplied by the uncertainty (which is calculated in uncertainty analysis chapter) of each category.

Trend Assessment

The purpose of the trend assessment is to identify categories that may not be large enough to be identified by the level assessment, but whose trend is significantly different from the trend of the overall inventory and should therefore receive particular attention.

The difference between the rate of change in emissions and removals in a category and the rate of change in total emissions and removals is calculated. The trend assessment is calculated by multiplying this value by the ratio of contribution of the relevant category to total emissions and removals. The calculated results, regarded as trend assessment values, are added from the category of which the proportion to the total of trend assessment values is the largest, until the total reaches 95% for Tier 1, 90% for Tier 2. At this point, these

categories are defined as the key categories. Tier 2 trend assessment is calculated multiplying the tier 1 trend assessment with uncertainty of each category (Table A5.2-1, Table A5.2-2).

Table A1.1-1: 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 ₂ O	
Mobile Combustion - Road Vehicles	CO ₂	
Mobile Combustion - Road Vehicles	CH ₄	
Mobile Combustion - Road Vehicles	N ₂ O	
Mobile Combustion: Water-borne Navigation	CO ₂	
Mobile Combustion: Water-borne Navigation	CH ₄	
Mobile Combustion: Water-borne Navigation	N ₂ O	
Mobile Combustion: Aircraft	CO ₂	
Mobile Combustion: Aircraft	CH ₄	
Mobile Combustion: Aircraft	N ₂ O	
Combustion - Agriculture/Forestry/Fishing	CO ₂	
Combustion - Agriculture/Forestry/Fishing	CH ₄	
Combustion - Agriculture/Forestry/Fishing	N ₂ O	
Fugitive Emissions from Coal Mining and Handling	CH ₄	
Fugitive Emissions from Oil and Gas Operations	CO ₂	
Fugitive Emissions from Oil and Gas Operations	CH ₄	
Fugitive Emissions from Oil and Gas Operations	N ₂ O	
INDUSTRIAL SECTOR		
CO ₂ Emissions from Cement Production	CO ₂	
CO ₂ Emissions from Lime Production	CO ₂	
CO ₂ Emissions from Limestone and Dolomite Use	CO ₂	
CO ₂ Emissions from Soda Ash Production and Use	CO ₂	
CO ₂ Emissions from Ammonia Production	CO ₂	
N ₂ O Emissions from Nitric Acid Production	N ₂ O	
CO ₂ Emissions from Iron and Steel Production	CO ₂	
CO ₂ Emissions from Ferroalloys Production	CO ₂	
CO ₂ Emissions from Aluminium production	CO ₂	
PFC Emissions from Aluminium production	PFC	
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	
HFC and PFC Emissions from Other Consumption	HFC/PFC	
SF ₆ Emissions from Other Consumption	SF ₆	
SOLVENT AND OTHER PRODUCT USE		
CO ₂ Emissions from Solvent and Other Product Use	CO ₂	
N ₂ O Emissions from Solvent and Other Product Use	N ₂ O	

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

Source Categories Assessed in Key Source Category Analysis	Direct GHG	Special Considerations
AGRICULTURE SECTOR		
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	
CH ₄ Emissions from Manure Management	CH ₄	
N ₂ O Emissions from Manure Management	N ₂ O	
CH ₄ and N ₂ O Emissions from Agricultural Residue Burning	CH ₄ /N ₂ O	
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	
LULUCF		
Forestland remaining Forestland	CO ₂	
Forestland remaining Forestland	CH ₄	
Forestland remaining Forestland	N ₂ O	
Cropland remaining Cropland	CO ₂	
Grassland remaining Grassland	CO ₂	
Land converted to Forestland	CO ₂	
Land converted to Cropland	CO ₂	
Land Converted to Grassland	CO ₂	
Land converted to Wetlands	CO ₂	
Land converted to Settlements	CO ₂	
Grassland converted to Cropland: mineral soils	N ₂ O	
WASTE SECTOR		
CH ₄ Emissions from Solid Waste Disposal Sites	CH ₄	
CH ₄ Emissions from Waste Water Handling	CH ₄	
N ₂ O Emissions from Waste Water Handling	N ₂ O	
CO ₂ Emissions from Waste Incineration	CO ₂	
N ₂ O Emissions from Waste Incineration	N ₂ O	

The reference to the summary overview for Key Categories 2011 in CRF tables is the Excel file HRV-2013-2011-v2.1, 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 additionally, with the LULUCF category following the *Good Practice Guidance for Land Use, Land-Use Change and Forestry*.

Approach 2 has been done in defining and calculating key categories.

Comments relating to the Approach 2:

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 CO₂ emissions from the fossil fuel combustion.

Uncertainty of N₂O emission is estimated to factor 2 (the emission could be twice larger or smaller than the estimated one).

Because of the high uncertainties (200%) for categories Fuel Combustion - Stationary Sources (N₂O) and Mobile Combustion - Road Vehicles (N₂O), they were calculated as key categories.

(Table A1.2-7: Level Assessment - Tier 2 (Excluding LULUCF)-1990), (Table A1.2-9: Key categories analysis – Trend Assessment - Tier 2 (Excluding LULUCF)-2011), (Table A1.2-11: Key categories analysis – Level Assessment - Tier 2 (Excluding LULUCF)-2011), (Table A1.2-8: Key categories analysis – Level Assessment - Tier 2 (Including LULUCF)-1990) and (Table A1.2-12: Key categories analysis – Trend Assessment - Tier 2 (Including LULUCF)-2011).

A1.2. TABLES 7.A1-7.A3 OF THE IPCC GOOD PRACTICE GUIDANCE

Table A1.2-1: Key categories analysis – Level Assessment - Tier 1(Excluding LULUCF)-1990

Tier 1 Analysis - Level Assessment - Excluding LULUCF				
IPCC Source Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO2)	Level Assessment	Cumulative Total (%)
CO2 Emissions from Stationary Combustion - Oil	CO2	8,497.044	0.268	27%
CO2 Emissions from Stationary Combustion - Gas	CO2	4,458.539	0.141	41%
Mobile Combustion - Road Vehicles	CO2	3,592.693	0.114	52%
CO2 Emissions from Stationary Combustion - Coal	CO2	2,780.447	0.088	61%
Direct N2O Emissions from Agricultural Soils	N2O	1,333.134	0.042	65%
CH4 Emissions from Enteric Fermentation in Domestic Livestock	CH4	1,241.920	0.039	69%
Fugitive Emissions from Oil and Gas Operations	CH4	1,202.278	0.038	73%
CO2 Emissions from Cement Production	CO2	1,085.790	0.034	76%
PFC Emissions from Aluminium production	PFC	936.564	0.030	79%
Indirect N2O Emissions from Nitrogen Used in Agriculture	N2O	934.066	0.030	82%
Combustion - Agriculture/Forestry/Fishing	CO2	839.186	0.027	85%
Nitric Acid Production	N2O	803.886	0.025	88%
Fugitive Emissions from Oil and Gas Operations	CO2	639.818	0.020	90%
CO2 Emissions from Ammonia Production	CO2	466.009	0.015	91%
N2O Emissions from Manure Management	N2O	381.844	0.012	92%
N2O Emissions from Pasture, Range and Paddock Manure	N2O	261.130	0.008	93%
Solid Waste Disposal Sites	CH4	242.623	0.008	94%
Emissions from Waste Water Handling	CH4	237.252	0.007	95%
CH4 Emissions from Manure Management	CH4	228.623	0.007	95%
Fuel Combustion - Stationary Sources	CH4	168.641	0.005	96%
Mobile Combustion: Domestic Aviation	CO2	154.724	0.005	96%
CO2 Emissions from Lime Production	CO2	153.440	0.005	97%
Mobile Combustion: Railways	CO2	138.142	0.004	97%
Mobile Combustion: Water-borne Navigation	CO2	132.980	0.004	98%
CO2 Emissions from Ferroalloys Production	CO2	118.836	0.004	98%
Aluminium Production	CO2	111.372	0.004	98%
Emissions from Waste Water Handling	N2O	84.567	0.003	99%
Total Solvent and Other Product Use	CO2	82.256	0.003	99%
Fuel Combustion - Stationary Sources	N2O	62.365	0.002	99%
CO2 Emissions from Limestone and Dolomite Use	CO2	51.490	0.002	99%
Fugitive Emissions from Coal Mining and Handling	CH4	48.757	0.002	99%
Mobile Combustion - Road Vehicles	N2O	40.247	0.001	100%
Total Solvent and Other Product Use	N2O	34.720	0.001	100%
Mobile Combustion - Road Vehicles	CH4	34.117	0.001	100%
CO2 Emissions from Iron and Steel Production	CO2	21.447	0.001	100%
CO2 Emissions from Soda Ash Production and Use	CO2	14.466	0.000	100%
Production of Chemicals	CH4	14.273	0.000	100%
SF6 Emissions from Other Consumption	SF6	10.954	0.000	100%
Combustion - Agriculture/Forestry/Fishing	N2O	2.038	0.000	100%
Mobile Combustion: Aircraft	N2O	1.355	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH4	1.299	0.000	100%
Fugitive Emissions from Oil and Gas Operations	N2O	0.668	0.000	100%
Mobile Combustion: Railways	N2O	0.392	0.000	100%
Mobile Combustion: Water-borne Navigation	N2O	0.337	0.000	100%

Mobile Combustion: Railways	CH4	0.214	0.000	100%
Mobile Combustion: Water-borne Navigation	CH4	0.190	0.000	100%
Emissions from Waste Incineration	CO2	0.043	0.000	100%
Mobile Combustion: Aircraft	CH4	0.023	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	100%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	0.000	100%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	0.000	100%
TOTAL		31,647.199		

Table A1.2-2: Key categories analysis – Level Assessment - Tier 1(Including LULUCF)-1990

Tier 1 Analysis - Level Assessment - Including LULUCF				
IPCC Source/Sink Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO2)	Level Assessment	Cumulative Total (%)
CO2 Emissions from Stationary Combustion - Oil	CO2	8,497.044	0.216	22%
Forestland remaining Forestland	CO2	6,711.706	0.170	39%
CO2 Emissions from Stationary Combustion - Gas	CO2	4,458.539	0.113	50%
Mobile Combustion - Road Vehicles	CO2	3,592.693	0.091	59%
CO2 Emissions from Stationary Combustion - Coal	CO2	2,780.447	0.071	66%
Direct N2O Emissions from Agricultural Soils	N2O	1,333.134	0.034	70%
CH4 Emissions from Enteric Fermentation in Domestic Livestock	CH4	1,241.920	0.032	73%
Fugitive Emissions from Oil and Gas Operations	CH4	1,202.278	0.031	76%
CO2 Emissions from Cement Production	CO2	1,085.790	0.028	78%
PFC Emissions from Aluminium production	PFC	936.564	0.024	81%
Indirect N2O Emissions from Nitrogen Used in Agriculture	N2O	934.066	0.024	83%
Combustion - Agriculture/Forestry/Fishing	CO2	839.186	0.021	85%
Nitric Acid Production	N2O	803.886	0.020	87%
Fugitive Emissions from Oil and Gas Operations	CO2	639.818	0.016	89%
CO2 Emissions from Ammonia Production	CO2	466.009	0.012	90%
Land converted to Settlements	CO2	448.146	0.011	91%
N2O Emissions from Manure Management	N2O	381.844	0.010	92%
Land converted to Forestland	CO2	272.638	0.007	93%
N2O Emissions from Pasture, Range and Paddock Manure	N2O	261.130	0.007	94%
Solid Waste Disposal Sites	CH4	242.623	0.006	94%
Emissions from Waste Water Handling	CH4	237.252	0.006	95%
CH4 Emissions from Manure Management	CH4	228.623	0.006	95%
Fuel Combustion - Stationary Sources	CH4	168.641	0.004	96%
Mobile Combustion: Domestic Aviation	CO2	154.724	0.004	96%
CO2 Emissions from Lime Production	CO2	153.440	0.004	97%
Mobile Combustion: Railways	CO2	138.142	0.004	97%
Cropland remaining Cropland	CO2	136.483	0.003	97%
Mobile Combustion: Water-borne Navigation	CO2	132.980	0.003	98%
CO2 Emissions from Ferroalloys Production	CO2	118.836	0.003	98%
Aluminium Production	CO2	111.372	0.003	98%
Land converted to Grassland	CO2	87.861	0.002	99%
Emissions from Waste Water Handling	N2O	84.567	0.002	99%
Total Solvent and Other Product Use	CO2	82.256	0.002	99%
Fuel Combustion - Stationary Sources	N2O	62.365	0.002	99%
CO2 Emissions from Limestone and Dolomite Use	CO2	51.490	0.001	99%
Fugitive Emissions from Coal Mining and Handling	CH4	48.757	0.001	99%
Mobile Combustion - Road Vehicles	N2O	40.247	0.001	99%
Total Solvent and Other Product Use	N2O	34.720	0.001	100%
Mobile Combustion - Road Vehicles	CH4	34.117	0.001	100%
Land converted to Wetlands	CO2	29.997	0.001	100%
Land converted to Cropland	CO2	23.477	0.001	100%
CO2 Emissions from Iron and Steel Production	CO2	21.447	0.001	100%
CO2 Emissions from Soda Ash Production and Use	CO2	14.466	0.000	100%
Production of Other Chemicals	CH4	14.273	0.000	100%
Forestland remaining Forestland	CH4	12.499	0.000	100%
SF6 Emissions from Other Consumption	SF6	10.954	0.000	100%
Grassland converted to Cropland: mineral soils	N2O	4.855	0.000	100%

Forestland remaining Forestland	N2O	2.858	0.000	100%
Grassland remaining Grassland	CO2	2.675	0.000	100%
Combustion - Agriculture/Forestry/Fishing	N2O	2.038	0.000	100%
Mobile Combustion: Aircraft	N2O	1.355	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH4	1.299	0.000	100%
Fugitive Emissions from Oil and Gas Operations	N2O	0.668	0.000	100%
Mobile Combustion: Railways	N2O	0.392	0.000	100%
Mobile Combustion: Water-borne Navigation	N2O	0.337	0.000	100%
Mobile Combustion: Railways	CH4	0.214	0.000	100%
Mobile Combustion: Water-borne Navigation	CH4	0.190	0.000	100%
Emissions from Waste Incineration	CO2	0.043	0.000	100%
Mobile Combustion: Aircraft	CH4	0.023	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	100%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	0.000	100%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	0.000	100%
TOTAL		39,380.393		

Table A1.2-3: Key categories analysis – Level Assessment - Tier 1(Excluding LULUCF)-2011

Tier 1 Analysis - Level Assessment - Excluding LULUCF					
IPCC Source Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO ₂)	Last Year (2011) Estimate (Gg eq-CO ₂)	Level Assessment	Cumulative Total (%)
Mobile Combustion - Road Vehicles	CO ₂	3,592.693	5,537.150	0.196	20%
CO ₂ Emissions from Stationary Combustion - Gas	CO ₂	4,458.539	5,183.028	0.183	38%
CO ₂ Emissions from Stationary Combustion - Oil	CO ₂	8,497.044	3,926.128	0.139	52%
CO ₂ Emissions from Stationary Combustion - Coal	CO ₂	2,780.447	2,825.237	0.100	62%
Fugitive Emissions from Oil and Gas Operations	CH ₄	1,202.278	1,427.492	0.051	67%
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	1,333.134	1,184.327	0.042	71%
CO ₂ Emissions from Cement Production	CO ₂	1,085.790	1,050.361	0.037	75%
Nitric Acid Production	N ₂ O	803.886	804.500	0.028	78%
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	1,241.920	803.798	0.028	80%
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.066	782.797	0.028	83%
Solid Waste Disposal Sites	CH ₄	242.623	770.889	0.027	86%
Combustion - Agriculture/Forestry/Fishing	CO ₂	839.186	714.315	0.025	89%
Fugitive Emissions from Oil and Gas Operations	CO ₂	639.818	577.155	0.020	91%
CO ₂ Emissions from Ammonia Production	CO ₂	466.009	475.942	0.017	92%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	467.095	0.017	94%
N ₂ O Emissions from Manure Management	N ₂ O	381.844	204.588	0.007	95%
Emissions from Waste Water Handling	CH ₄	237.252	203.587	0.007	95%
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	261.130	175.222	0.006	96%
CH ₄ Emissions from Manure Management	CH ₄	228.623	167.790	0.006	97%
Fuel Combustion - Stationary Sources	CH ₄	168.641	120.535	0.004	97%
Mobile Combustion: Water-borne Navigation	CO ₂	132.980	116.405	0.004	97%
Total Solvent and Other Product Use	CO ₂	82.256	107.407	0.004	98%
Emissions from Waste Water Handling	N ₂ O	84.567	103.759	0.004	98%
Mobile Combustion: Domestic Aviation	CO ₂	154.724	89.881	0.003	98%
CO ₂ Emissions from Lime Production	CO ₂	153.440	89.243	0.003	99%
Mobile Combustion: Railways	CO ₂	138.142	82.678	0.003	99%
Fuel Combustion - Stationary Sources	N ₂ O	62.365	49.736	0.002	99%
Mobile Combustion - Road Vehicles	N ₂ O	40.247	48.112	0.002	99%
CO ₂ Emissions from Limestone and Dolomite Use	CO ₂	51.490	41.825	0.001	100%
Total Solvent and Other Product Use	N ₂ O	34.720	36.756	0.001	100%
CO ₂ Emissions from Iron and Steel Production	CO ₂	21.447	29.177	0.001	100%
CO ₂ Emissions from Soda Ash Production and Use	CO ₂	14.466	23.310	0.001	100%
Mobile Combustion - Road Vehicles	CH ₄	34.117	13.652	0.000	100%
SF ₆ Emissions from Other Consumption	SF ₆	10.954	9.817	0.000	100%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	8.857	0.000	100%
Combustion - Agriculture/Forestry/Fishing	N ₂ O	2.038	1.738	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH ₄	1.299	1.077	0.000	100%
Mobile Combustion: Water-borne Navigation	N ₂ O	0.337	0.295	0.000	100%
Fugitive Emissions from Oil and Gas Operations	N ₂ O	0.668	0.211	0.000	100%
Mobile Combustion: Railways	N ₂ O	0.392	0.210	0.000	100%
Mobile Combustion: Water-borne Navigation	CH ₄	0.190	0.166	0.000	100%
Mobile Combustion: Railways	CH ₄	0.214	0.118	0.000	100%
Emissions from Waste Incineration	CO ₂	0.043	0.048	0.000	100%
Mobile Combustion: Aircraft	N ₂ O	1.355	0.033	0.000	100%

Mobile Combustion: Aircraft	CH4	0.023	0.001	0.000	100%
Production of Chemicals	CH4	14.273	0.000	0.000	100%
CO2 Emissions from Ferroalloys Production	CO2	118.836	0.000	0.000	100%
Aluminium Production	CO2	111.372	0.000	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	0.000	100%
Fugitive Emissions from Coal Mining and Handling	CH4	48.757	0.000	0.000	100%
PFC Emissions from Aluminium production	PFC	936.564	0.000	0.000	100%
TOTAL		31,647.199	28,256.448		

Table A1.2-4: Key categories analysis – Level Assessment - Tier 1 (Including LULUCF)-2011

Tier 1 Analysis - Level Assessment - Including LULUCF					
IPCC Source/Sink Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO ₂)	Last Year (2011) Estimate (Gg eq-CO ₂)	Level Assessment	Cumulative Total (%)
Forestland remaining Forestland	CO ₂	6,711.706	7,462.514	0.203	20%
Mobile Combustion - Road Vehicles	CO ₂	3,592.693	5,537.150	0.151	35%
CO ₂ Emissions from Stationary Combustion - Gas	CO ₂	4,458.539	5,183.028	0.141	49%
CO ₂ Emissions from Stationary Combustion - Oil	CO ₂	8,497.044	3,926.128	0.107	60%
CO ₂ Emissions from Stationary Combustion - Coal	CO ₂	2,780.447	2,825.237	0.077	68%
Fugitive Emissions from Oil and Gas Operations	CH ₄	1,202.278	1,427.492	0.039	72%
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	1,333.134	1,184.327	0.032	75%
CO ₂ Emissions from Cement Production	CO ₂	1,085.790	1,050.361	0.029	78%
Nitric Acid Production	N ₂ O	803.886	804.500	0.022	80%
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	1,241.920	803.798	0.022	82%
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.066	782.797	0.021	84%
Solid Waste Disposal Sites	CH ₄	242.623	770.889	0.021	86%
Combustion - Agriculture/Forestry/Fishing	CO ₂	839.186	714.315	0.019	88%
Land converted to Settlements	CO ₂	448.146	602.576	0.016	90%
Fugitive Emissions from Oil and Gas Operations	CO ₂	639.818	577.155	0.016	92%
CO ₂ Emissions from Ammonia Production	CO ₂	466.009	475.942	0.013	93%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	467.095	0.013	94%
N ₂ O Emissions from Manure Management	N ₂ O	381.844	204.588	0.006	95%
Emissions from Waste Water Handling	CH ₄	237.252	203.587	0.006	95%
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	261.130	175.222	0.005	96%
Land converted to Forestland	CO ₂	272.638	174.962	0.005	96%
CH ₄ Emissions from Manure Management	CH ₄	228.623	167.790	0.005	97%
Land converted to Grassland	CO ₂	87.861	128.347	0.003	97%
Fuel Combustion - Stationary Sources	CH ₄	168.641	120.535	0.003	97%
Mobile Combustion: Water-borne Navigation	CO ₂	132.980	116.405	0.003	98%
Total Solvent and Other Product Use	CO ₂	82.256	107.407	0.003	98%
Emissions from Waste Water Handling	N ₂ O	84.567	103.759	0.003	98%
Mobile Combustion: Domestic Aviation	CO ₂	154.724	89.881	0.002	98%
CO ₂ Emissions from Lime Production	CO ₂	153.440	89.243	0.002	99%
Mobile Combustion: Railways	CO ₂	138.142	82.678	0.002	99%
Cropland remaining Cropland	CO ₂	136.483	50.042	0.001	99%
Fuel Combustion - Stationary Sources	N ₂ O	62.365	49.736	0.001	99%
Mobile Combustion - Road Vehicles	N ₂ O	40.247	48.112	0.001	99%
Land converted to Cropland	CO ₂	23.477	43.943	0.001	99%
CO ₂ Emissions from Limestone and Dolomite Use	CO ₂	51.490	41.825	0.001	100%
Total Solvent and Other Product Use	N ₂ O	34.720	36.756	0.001	100%
CO ₂ Emissions from Iron and Steel Production	CO ₂	21.447	29.177	0.001	100%
CO ₂ Emissions from Soda Ash Production and Use	CO ₂	14.466	23.310	0.001	100%
Land converted to Wetlands	CO ₂	29.997	17.325	0.000	100%
Mobile Combustion - Road Vehicles	CH ₄	34.117	13.652	0.000	100%
SF ₆ Emissions from Other Consumption	SF ₆	10.954	9.817	0.000	100%
Grassland converted to Cropland: mineral soils	N ₂ O	4.855	9.091	0.000	100%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	8.857	0.000	100%
Forestland remaining Forestland	CH ₄	12.499	6.817	0.000	100%

Grassland remaining Grassland	CO2	2.675	2.675	0.000	100%
Combustion - Agriculture/Forestry/Fishing	N2O	2.038	1.738	0.000	100%
Forestland remaining Forestland	N2O	2.858	1.559	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH4	1.299	1.077	0.000	100%
Mobile Combustion: Water-borne Navigation	N2O	0.337	0.295	0.000	100%
Fugitive Emissions from Oil and Gas Operations	N2O	0.668	0.211	0.000	100%
Mobile Combustion: Railways	N2O	0.392	0.210	0.000	100%
Mobile Combustion: Water-borne Navigation	CH4	0.190	0.166	0.000	100%
Mobile Combustion: Railways	CH4	0.214	0.118	0.000	100%
Emissions from Waste Incineration	CO2	0.043	0.048	0.000	100%
Mobile Combustion: Aircraft	N2O	1.355	0.033	0.000	100%
Mobile Combustion: Aircraft	CH4	0.023	0.001	0.000	100%
Production of Other Chemicals	CH4	14.273	0.000	0.000	100%
CO2 Emissions from Ferroalloys Production	CO2	118.836	0.000	0.000	100%
Aluminium Production	CO2	111.372	0.000	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	0.000	100%
Fugitive Emissions from Coal Mining and Handling	CH4	48.757	0.000	0.000	100%
PFC Emissions from Aluminium production	PFC	936.564	0.000	0.000	100%
TOTAL		39,380.393	36,756.299		

Table A1.2-5: Key categories analysis – Trend Assessment - Tier 1 (Excluding LULUCF)-2011

Tier 1 Analysis - Trend Assessment - Excluding LULUCF						
IPCC Source Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO ₂)	Last Year (2011) Estimate (Gg eq-CO ₂)	Trend Assessment	% Contribution to trend	Cumulative Total (%)
CO ₂ Emissions from Stationary Combustion - Oil	CO ₂	8497.044	3926.128	0.145	0.327	33%
Mobile Combustion - Road Vehicles	CO ₂	3592.693	5537.150	0.092	0.208	54%
CO ₂ Emissions from Stationary Combustion - Gas	CO ₂	4458.539	5183.028	0.048	0.107	64%
PFC Emissions from Aluminium production	PFC	936.564	0.000	0.033	0.075	72%
Solid Waste Disposal Sites	CH ₄	242.623	770.889	0.022	0.050	77%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	467.095	0.019	0.042	81%
Fugitive Emissions from Oil and Gas Operations	CH ₄	1202.278	1427.492	0.014	0.032	84%
CO ₂ Emissions from Stationary Combustion - Coal	CO ₂	2780.447	2825.237	0.014	0.031	87%
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	1241.920	803.798	0.012	0.027	90%
N ₂ O Emissions from Manure Management	N ₂ O	381.844	204.588	0.005	0.012	91%
CO ₂ Emissions from Ferroalloys Production	CO ₂	118.836	0.000	0.004	0.009	92%
Aluminium Production	CO ₂	111.372	0.000	0.004	0.009	93%
Nitric Acid Production	N ₂ O	803.886	804.500	0.003	0.008	94%
CO ₂ Emissions from Cement Production	CO ₂	1085.790	1050.361	0.003	0.007	94%
CO ₂ Emissions from Ammonia Production	CO ₂	466.009	475.942	0.002	0.005	95%
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	261.130	175.222	0.002	0.005	95%
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.066	782.797	0.002	0.005	96%
Mobile Combustion: Domestic Aviation	CO ₂	154.724	89.881	0.002	0.004	96%
CO ₂ Emissions from Lime Production	CO ₂	153.440	89.243	0.002	0.004	97%
Fugitive Emissions from Coal Mining and Handling	CH ₄	48.757	0.000	0.002	0.004	97%
Mobile Combustion: Railways	CO ₂	138.142	82.678	0.002	0.004	98%
CH ₄ Emissions from Manure Management	CH ₄	228.623	167.790	0.001	0.003	98%
Combustion - Agriculture/Forestry/Fishing	CO ₂	839.186	714.315	0.001	0.003	98%
Total Solvent and Other Product Use	CO ₂	82.256	107.407	0.001	0.003	98%
Fuel Combustion - Stationary Sources	CH ₄	168.641	120.535	0.001	0.003	99%
Emissions from Waste Water Handling	N ₂ O	84.567	103.759	0.001	0.003	99%
Mobile Combustion - Road Vehicles	CH ₄	34.117	13.652	0.001	0.002	99%
Production of Chemicals	CH ₄	14.273	0.000	0.001	0.001	99%
Mobile Combustion - Road Vehicles	N ₂ O	40.247	48.112	0.000	0.001	99%
CO ₂ Emissions from Soda Ash Production and Use	CO ₂	14.466	23.310	0.000	0.001	99%
CO ₂ Emissions from Iron and Steel Production	CO ₂	21.447	29.177	0.000	0.001	100%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	8.857	0.000	0.001	100%
Emissions from Waste Water Handling	CH ₄	237.252	203.587	0.000	0.001	100%
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	1333.134	1184.327	0.000	0.001	100%
Fuel Combustion - Stationary Sources	N ₂ O	62.365	49.736	0.000	0.001	100%
Fugitive Emissions from Oil and Gas Operations	CO ₂	639.818	577.155	0.000	0.001	100%
Total Solvent and Other Product Use	N ₂ O	34.720	36.756	0.000	0.001	100%
CO ₂ Emissions from Limestone and Dolomite Use	CO ₂	51.490	41.825	0.000	0.000	100%
Mobile Combustion: Water-borne Navigation	CO ₂	132.980	116.405	0.000	0.000	100%
Mobile Combustion: Aircraft	N ₂ O	1.355	0.033	0.000	0.000	100%

Fugitive Emissions from Oil and Gas Operations	N2O	0.668	0.211	0.000	0.000	100%
Mobile Combustion: Railways	N2O	0.392	0.210	0.000	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH4	1.299	1.077	0.000	0.000	100%
Combustion - Agriculture/Forestry/Fishing	N2O	2.038	1.738	0.000	0.000	100%
Mobile Combustion: Railways	CH4	0.214	0.118	0.000	0.000	100%
SF6 Emissions from Other Consumption	SF6	10.954	9.817	0.000	0.000	100%
Mobile Combustion: Aircraft	CH4	0.023	0.001	0.000	0.000	100%
Emissions from Waste Incineration	CO2	0.043	0.048	0.000	0.000	100%
Mobile Combustion: Water-borne Navigation	N2O	0.337	0.295	0.000	0.000	100%
Mobile Combustion: Water-borne Navigation	CH4	0.190	0.166	0.000	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	0.000	0.000	100%
TOTAL		31,647.199	28,256.448			

Table A1.2-6: Key categories analysis – Trend Assessment - Tier 1 (Including LULUCF)-2011

Tier 1 Analysis - Trend Assessment - Including LULUCF						
IPCC Source/Sink Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO ₂)	Last Year (2011) Estimate (Gg eq-CO ₂)	Trend Assessment	% Contribution to trend	Cumulative Total (%)
CO ₂ Emissions from Stationary Combustion - Oil	CO ₂	8,497.044	3,926.128	0.117	0.311	31%
Mobile Combustion - Road Vehicles	CO ₂	3,592.693	5,537.150	0.064	0.170	48%
Forestland remaining Forestland	CO ₂	6,711.706	7,462.514	0.035	0.093	57%
CO ₂ Emissions from Stationary Combustion - Gas	CO ₂	4,458.539	5,183.028	0.030	0.079	65%
PFC Emissions from Aluminium production	PFC	936.564	0.000	0.025	0.068	72%
Solid Waste Disposal Sites	CH ₄	242.623	770.889	0.016	0.042	76%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	467.095	0.014	0.036	80%
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	1,241.920	803.798	0.010	0.028	83%
Fugitive Emissions from Oil and Gas Operations	CH ₄	1,202.278	1,427.492	0.009	0.024	85%
CO ₂ Emissions from Stationary Combustion - Coal	CO ₂	2,780.447	2,825.237	0.007	0.018	87%
Land converted to Settlements	CO ₂	448.146	602.576	0.005	0.014	88%
N ₂ O Emissions from Manure Management	N ₂ O	381.844	204.588	0.004	0.012	89%
CO ₂ Emissions from Ferroalloys Production	CO ₂	118.836	0.000	0.003	0.009	90%
Aluminium Production	CO ₂	111.372	0.000	0.003	0.008	91%
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.066	782.797	0.003	0.007	92%
Land converted to Forestland	CO ₂	272.638	174.962	0.002	0.006	92%
Cropland remaining Cropland	CO ₂	136.483	50.042	0.002	0.006	93%
Combustion - Agriculture/Forestry/Fishing	CO ₂	839.186	714.315	0.002	0.005	94%
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	261.130	175.222	0.002	0.005	94%
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	1,333.134	1,184.327	0.002	0.005	95%
Mobile Combustion: Domestic Aviation	CO ₂	154.724	89.881	0.002	0.004	95%
Nitric Acid Production	N ₂ O	803.886	804.500	0.002	0.004	95%
CO ₂ Emissions from Lime Production	CO ₂	153.440	89.243	0.002	0.004	96%
Land converted to Grassland	CO ₂	87.861	128.347	0.001	0.004	96%
Mobile Combustion: Railways	CO ₂	138.142	82.678	0.001	0.004	97%
CH ₄ Emissions from Manure Management	CH ₄	228.623	167.790	0.001	0.004	97%
Fugitive Emissions from Coal Mining and Handling	CH ₄	48.757	0.000	0.001	0.004	97%
CO ₂ Emissions from Ammonia Production	CO ₂	466.009	475.942	0.001	0.003	98%
CO ₂ Emissions from Cement Production	CO ₂	1,085.790	1,050.361	0.001	0.003	98%
Fuel Combustion - Stationary Sources	CH ₄	168.641	120.535	0.001	0.003	98%
Total Solvent and Other Product Use	CO ₂	82.256	107.407	0.001	0.002	98%
Emissions from Waste Water Handling	N ₂ O	84.567	103.759	0.001	0.002	99%
Land converted to Cropland	CO ₂	23.477	43.943	0.001	0.002	99%
Fugitive Emissions from Oil and Gas Operations	CO ₂	639.818	577.155	0.001	0.002	99%
Mobile Combustion - Road Vehicles	CH ₄	34.117	13.652	0.001	0.001	99%
Emissions from Waste Water Handling	CH ₄	237.252	203.587	0.001	0.001	99%
Production of Other Chemicals	CH ₄	14.273	0.000	0.000	0.001	99%
Land converted to Wetlands	CO ₂	29.997	17.325	0.000	0.001	99%
Mobile Combustion - Road Vehicles	N ₂ O	40.247	48.112	0.000	0.001	99%
CO ₂ Emissions from Soda Ash Production and Use	CO ₂	14.466	23.310	0.000	0.001	100%

CO2 Emissions from Iron and Steel Production	CO2	21.447	29.177	0.000	0.001	100%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	8.857	0.000	0.001	100%
Fuel Combustion - Stationary Sources	N2O	62.365	49.736	0.000	0.001	100%
Mobile Combustion: Water-borne Navigation	CO2	132.980	116.405	0.000	0.001	100%
CO2 Emissions from Limestone and Dolomite Use	CO2	51.490	41.825	0.000	0.000	100%
Forestland remaining Forestland	CH4	12.499	6.817	0.000	0.000	100%
Grassland converted to Cropland: mineral soils	N2O	4.855	9.091	0.000	0.000	100%
Total Solvent and Other Product Use	N2O	34.720	36.756	0.000	0.000	100%
Mobile Combustion: Aircraft	N2O	1.355	0.033	0.000	0.000	100%
Forestland remaining Forestland	N2O	2.858	1.559	0.000	0.000	100%
Fugitive Emissions from Oil and Gas Operations	N2O	0.668	0.211	0.000	0.000	100%
SF6 Emissions from Other Consumption	SF6	10.954	9.817	0.000	0.000	100%
Grassland remaining Grassland	CO2	2.675	2.675	0.000	0.000	100%
Combustion - Agriculture/Forestry/Fishing	N2O	2.038	1.738	0.000	0.000	100%
Mobile Combustion: Railways	N2O	0.392	0.210	0.000	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH4	1.299	1.077	0.000	0.000	100%
Mobile Combustion: Railways	CH4	0.214	0.118	0.000	0.000	100%
Mobile Combustion: Aircraft	CH4	0.023	0.001	0.000	0.000	100%
Mobile Combustion: Water-borne Navigation	N2O	0.337	0.295	0.000	0.000	100%
Mobile Combustion: Water-borne Navigation	CH4	0.190	0.166	0.000	0.000	100%
Emissions from Waste Incineration	CO2	0.043	0.048	0.000	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	0.000	0.000	100%
TOTAL		39,380.393	36,756.299			

Table A1.2-7: Key categories analysis – Level Assessment - Tier 2 (Excluding LULUCF)-1990

Tier 2 Analysis - Level Assessment - Excluding LULUCF				
IPCC Source Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO2)	Level Assessment Tier 2	Cumulative Total (%)
Fugitive Emissions from Oil and Gas Operations	CH4	1,202.278	0.433	43%
Indirect N2O Emissions from Nitrogen Used in Agriculture	N2O	934.066	0.167	60%
Direct N2O Emissions from Agricultural Soils	N2O	1,333.134	0.083	68%
CO2 Emissions from Stationary Combustion - Oil	CO2	8,497.044	0.030	71%
PFC Emissions from Aluminium production	PFC	936.564	0.030	74%
Nitric Acid Production	N2O	803.886	0.029	77%
CH4 Emissions from Enteric Fermentation in Domestic Livestock	CH4	1,241.920	0.022	79%
Emissions from Waste Water Handling	CH4	237.252	0.017	81%
CO2 Emissions from Stationary Combustion - Gas	CO2	4,458.539	0.016	83%
N2O Emissions from Manure Management	N2O	381.844	0.015	84%
Solid Waste Disposal Sites	CH4	242.623	0.015	86%
Fuel Combustion - Stationary Sources	N2O	62.365	0.015	87%
Fugitive Emissions from Coal Mining and Handling	CH4	48.757	0.015	89%
Mobile Combustion - Road Vehicles	CO2	3,592.693	0.014	90%
CO2 Emissions from Stationary Combustion - Coal	CO2	2,780.447	0.012	91%
N2O Emissions from Pasture, Range and Paddock Manure	N2O	261.130	0.011	92%
Fuel Combustion - Stationary Sources	CH4	168.641	0.010	93%
Mobile Combustion - Road Vehicles	N2O	40.247	0.010	94%
Fugitive Emissions from Oil and Gas Operations	CO2	639.818	0.008	95%
CO2 Emissions from Cement Production	CO2	1,085.790	0.005	96%
Total Solvent and Other Product Use	CO2	82.256	0.005	96%
CH4 Emissions from Manure Management	CH4	228.623	0.005	97%
CO2 Emissions from Ferroalloys Production	CO2	118.836	0.004	97%
Aluminium Production	CO2	111.372	0.004	98%
CO2 Emissions from Ammonia Production	CO2	466.009	0.003	98%
Emissions from Waste Water Handling	N2O	84.567	0.003	98%
Combustion - Agriculture/Forestry/Fishing	CO2	839.186	0.003	99%
Total Solvent and Other Product Use	N2O	34.720	0.003	99%
CO2 Emissions from Limestone and Dolomite Use	CO2	51.490	0.002	99%
Mobile Combustion - Road Vehicles	CH4	34.117	0.002	99%
Mobile Combustion: Railways	CO2	138.142	0.001	99%
Mobile Combustion: Water-borne Navigation	CO2	132.980	0.001	99%
SF6 Emissions from Other Consumption	SF6	10.954	0.001	100%
CO2 Emissions from Iron and Steel Production	CO2	21.447	0.001	100%
Mobile Combustion: Domestic Aviation	CO2	154.724	0.001	100%
CO2 Emissions from Lime Production	CO2	153.440	0.001	100%
CO2 Emissions from Soda Ash Production and Use	CO2	14.466	0.001	100%
Combustion - Agriculture/Forestry/Fishing	N2O	2.038	0.000	100%
Mobile Combustion: Aircraft	N2O	1.355	0.000	100%
Production of Chemicals	CH4	14.273	0.000	100%
Fugitive Emissions from Oil and Gas Operations	N2O	0.668	0.000	100%
Mobile Combustion: Railways	N2O	0.392	0.000	100%
Mobile Combustion: Water-borne Navigation	N2O	0.337	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH4	1.299	0.000	100%
Mobile Combustion: Railways	CH4	0.214	0.000	100%
Mobile Combustion: Water-borne Navigation	CH4	0.190	0.000	100%
Emissions from Waste Incineration	CO2	0.043	0.000	100%

Mobile Combustion: Aircraft	CH4	0.023	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	100%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	0.000	100%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	0.000	100%
TOTAL		31,647.199		

Table A1.2-8: Key categories analysis – Level Assessment - Tier 2 (Including LULUCF)-1990

Tier 2 Analysis - Level Assessment - Including LULUCF				
IPCC Source/Sink Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO ₂)	Level Assessment Tier 2	Cumulative Total (%)
Forestland remaining Forestland	CO ₂	6,711.706	0.262	26%
Fugitive Emissions from Oil and Gas Operations	CH ₄	1,202.278	0.227	49%
Cropland remaining Cropland	CO ₂	136.483	0.101	59%
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.066	0.088	68%
Land converted to Settlements	CO ₂	448.146	0.044	72%
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	1,333.134	0.043	77%
Land converted to Forestland	CO ₂	272.638	0.030	80%
Land converted to Grassland	CO ₂	87.861	0.022	82%
CO ₂ Emissions from Stationary Combustion - Oil	CO ₂	8,497.044	0.016	83%
PFC Emissions from Aluminium production	PFC	936.564	0.016	85%
Nitric Acid Production	N ₂ O	803.886	0.015	86%
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	1,241.920	0.012	88%
Emissions from Waste Water Handling	CH ₄	237.252	0.009	88%
CO ₂ Emissions from Stationary Combustion - Gas	CO ₂	4,458.539	0.008	89%
N ₂ O Emissions from Manure Management	N ₂ O	381.844	0.008	90%
Solid Waste Disposal Sites	CH ₄	242.623	0.008	91%
Fuel Combustion - Stationary Sources	N ₂ O	62.365	0.008	92%
Fugitive Emissions from Coal Mining and Handling	CH ₄	48.757	0.008	93%
Mobile Combustion - Road Vehicles	CO ₂	3,592.693	0.007	93%
Land converted to Cropland	CO ₂	23.477	0.007	94%
CO ₂ Emissions from Stationary Combustion - Coal	CO ₂	2,780.447	0.007	95%
Land converted to Wetlands	CO ₂	29.997	0.006	95%
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	261.130	0.006	96%
Fuel Combustion - Stationary Sources	CH ₄	168.641	0.005	96%
Mobile Combustion - Road Vehicles	N ₂ O	40.247	0.005	97%
Fugitive Emissions from Oil and Gas Operations	CO ₂	639.818	0.004	97%
CO ₂ Emissions from Cement Production	CO ₂	1,085.790	0.003	97%
Total Solvent and Other Product Use	CO ₂	82.256	0.003	98%
CH ₄ Emissions from Manure Management	CH ₄	228.623	0.003	98%
CO ₂ Emissions from Ferroalloys Production	CO ₂	118.836	0.002	98%
Aluminium Production	CO ₂	111.372	0.002	98%
CO ₂ Emissions from Ammonia Production	CO ₂	466.009	0.002	99%
Emissions from Waste Water Handling	N ₂ O	84.567	0.002	99%
Combustion - Agriculture/Forestry/Fishing	CO ₂	839.186	0.002	99%
Total Solvent and Other Product Use	N ₂ O	34.720	0.002	99%
Forestland remaining Forestland	CH ₄	12.499	0.001	99%
Grassland converted to Cropland: mineral soils	N ₂ O	4.855	0.001	99%
CO ₂ Emissions from Limestone and Dolomite Use	CO ₂	51.490	0.001	99%
Mobile Combustion - Road Vehicles	CH ₄	34.117	0.001	100%
Mobile Combustion: Railways	CO ₂	138.142	0.001	100%
Mobile Combustion: Water-borne Navigation	CO ₂	132.980	0.001	100%
SF ₆ Emissions from Other Consumption	SF ₆	10.954	0.000	100%
CO ₂ Emissions from Iron and Steel Production	CO ₂	21.447	0.000	100%
Mobile Combustion: Domestic Aviation	CO ₂	154.724	0.000	100%
CO ₂ Emissions from Lime Production	CO ₂	153.440	0.000	100%
Forestland remaining Forestland	N ₂ O	2.858	0.000	100%
CO ₂ Emissions from Soda Ash Production and Use	CO ₂	14.466	0.000	100%

Combustion - Agriculture/Forestry/Fishing	N2O	2.038	0.000	100%
Mobile Combustion: Aircraft	N2O	1.355	0.000	100%
Production of Other Chemicals	CH4	14.273	0.000	100%
Grassland remaining Grassland	CO2	2.675	0.000	100%
Fugitive Emissions from Oil and Gas Operations	N2O	0.668	0.000	100%
Mobile Combustion: Railways	N2O	0.392	0.000	100%
Mobile Combustion: Water-borne Navigation	N2O	0.337	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH4	1.299	0.000	100%
Mobile Combustion: Railways	CH4	0.214	0.000	100%
Mobile Combustion: Water-borne Navigation	CH4	0.190	0.000	100%
Emissions from Waste Incineration	CO2	0.043	0.000	100%
Mobile Combustion: Aircraft	CH4	0.023	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	100%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	0.000	100%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	0.000	100%
TOTAL		39,380.393		

Table A1.2-9: Key categories analysis – Level Assessment - Tier 2 (Excluding LULUCF)-2011

Tier 2 Analysis - Level Assessment - Excluding LULUCF					
IPCC Source Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO ₂)	Last Year (2011) Estimate (Gg eq-CO ₂)	Level Assessment Tier 2	Cumulative Total (%)
Fugitive Emissions from Oil and Gas Operations	CH ₄	1,202.278	1,427.492	0.497	50%
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.066	782.797	0.144	64%
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	1,333.134	1,184.327	0.071	71%
Solid Waste Disposal Sites	CH ₄	242.623	770.889	0.051	76%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	467.095	0.038	80%
Nitric Acid Production	N ₂ O	803.886	804.500	0.028	83%
Mobile Combustion - Road Vehicles	CO ₂	3,592.693	5,537.150	0.017	85%
CO ₂ Emissions from Stationary Combustion - Gas	CO ₂	4,458.539	5,183.028	0.016	86%
Emissions from Waste Water Handling	CH ₄	237.252	203.587	0.014	88%
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	1,241.920	803.798	0.013	89%
CO ₂ Emissions from Stationary Combustion - Oil	CO ₂	8,497.044	3,926.128	0.013	90%
Fuel Combustion - Stationary Sources	N ₂ O	62.365	49.736	0.012	92%
Mobile Combustion - Road Vehicles	N ₂ O	40.247	48.112	0.011	93%
N ₂ O Emissions from Manure Management	N ₂ O	381.844	204.588	0.009	93%
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	261.130	175.222	0.008	94%
CO ₂ Emissions from Stationary Combustion - Coal	CO ₂	2,780.447	2,825.237	0.007	95%
Fuel Combustion - Stationary Sources	CH ₄	168.641	120.535	0.007	96%
Fugitive Emissions from Oil and Gas Operations	CO ₂	639.818	577.155	0.007	96%
Total Solvent and Other Product Use	CO ₂	82.256	107.407	0.007	97%
CO ₂ Emissions from Cement Production	CO ₂	1,085.790	1,050.361	0.005	98%
Emissions from Waste Water Handling	N ₂ O	84.567	103.759	0.004	98%
CH ₄ Emissions from Manure Management	CH ₄	228.623	167.790	0.003	98%
CO ₂ Emissions from Ammonia Production	CO ₂	466.009	475.942	0.003	99%
Total Solvent and Other Product Use	N ₂ O	34.720	36.756	0.003	99%
Combustion - Agriculture/Forestry/Fishing	CO ₂	839.186	714.315	0.003	99%
CO ₂ Emissions from Limestone and Dolomite Use	CO ₂	51.490	41.825	0.002	99%
CO ₂ Emissions from Iron and Steel Production	CO ₂	21.447	29.177	0.001	99%
Mobile Combustion: Water-borne Navigation	CO ₂	132.980	116.405	0.001	99%
CO ₂ Emissions from Soda Ash Production and Use	CO ₂	14.466	23.310	0.001	100%
SF ₆ Emissions from Other Consumption	SF ₆	10.954	9.817	0.001	100%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	8.857	0.001	100%
Mobile Combustion: Railways	CO ₂	138.142	82.678	0.001	100%
Mobile Combustion - Road Vehicles	CH ₄	34.117	13.652	0.001	100%
Mobile Combustion: Domestic Aviation	CO ₂	154.724	89.881	0.000	100%
Combustion - Agriculture/Forestry/Fishing	N ₂ O	2.038	1.738	0.000	100%
CO ₂ Emissions from Lime Production	CO ₂	153.440	89.243	0.000	100%
Fugitive Emissions from Oil and Gas Operations	N ₂ O	0.668	0.211	0.000	100%
Mobile Combustion: Water-borne Navigation	N ₂ O	0.337	0.295	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH ₄	1.299	1.077	0.000	100%
Mobile Combustion: Railways	N ₂ O	0.392	0.210	0.000	100%
Mobile Combustion: Water-borne Navigation	CH ₄	0.190	0.166	0.000	100%
Mobile Combustion: Aircraft	N ₂ O	1.355	0.033	0.000	100%
Mobile Combustion: Railways	CH ₄	0.214	0.118	0.000	100%
Emissions from Waste Incineration	CO ₂	0.043	0.048	0.000	100%

Mobile Combustion: Aircraft	CH4	0.023	0.001	0.000	100%
CO2 Emissions from Ferroalloys Production	CO2	118.836	0.000	0.000	100%
Aluminium Production	CO2	111.372	0.000	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	0.000	100%
Fugitive Emissions from Coal Mining and Handling	CH4	48.757	0.000	0.000	100%
Production of Chemicals	CH4	14.273	0.000	0.000	100%
PFC Emissions from Aluminium production	PFC	936.564	0.000	0.000	100%
TOTAL		31,647.199	28,256.448		

Table A1.2-10: Key categories analysis – Level Assessment - Tier 2 (Including LULUCF)-2011

Tier 2 Analysis - Level Assessment - Including LULUCF					
IPCC Source/Sink Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO ₂)	Last Year (2011) Estimate (Gg eq-CO ₂)	Level Assessment Tier 2	Cumulative Total (%)
Forestland remaining Forestland	CO ₂	6,711.706	7,462.514	0.291	29%
Fugitive Emissions from Oil and Gas Operations	CH ₄	1,202.278	1,427.492	0.270	56%
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.066	782.797	0.078	64%
Land converted to Settlements	CO ₂	448.146	602.576	0.059	70%
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	1,333.134	1,184.327	0.038	74%
Cropland remaining Cropland	CO ₂	136.483	50.042	0.037	77%
Land converted to Grassland	CO ₂	87.861	128.347	0.032	81%
Solid Waste Disposal Sites	CH ₄	242.623	770.889	0.028	83%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	467.095	0.021	85%
Land converted to Forestland	CO ₂	272.638	174.962	0.019	87%
Nitric Acid Production	N ₂ O	803.886	804.500	0.015	89%
Land converted to Cropland	CO ₂	23.477	43.943	0.012	90%
Mobile Combustion - Road Vehicles	CO ₂	3,592.693	5,537.150	0.009	91%
CO ₂ Emissions from Stationary Combustion - Gas	CO ₂	4,458.539	5,183.028	0.009	92%
Emissions from Waste Water Handling	CH ₄	237.252	203.587	0.007	93%
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	1,241.920	803.798	0.007	93%
CO ₂ Emissions from Stationary Combustion - Oil	CO ₂	8,497.044	3,926.128	0.007	94%
Fuel Combustion - Stationary Sources	N ₂ O	62.365	49.736	0.006	95%
Mobile Combustion - Road Vehicles	N ₂ O	40.247	48.112	0.006	95%
N ₂ O Emissions from Manure Management	N ₂ O	381.844	204.588	0.005	96%
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	261.130	175.222	0.004	96%
CO ₂ Emissions from Stationary Combustion - Coal	CO ₂	2,780.447	2,825.237	0.004	97%
Fuel Combustion - Stationary Sources	CH ₄	168.641	120.535	0.004	97%
Fugitive Emissions from Oil and Gas Operations	CO ₂	639.818	577.155	0.004	97%
Land converted to Wetlands	CO ₂	29.997	17.325	0.004	98%
Total Solvent and Other Product Use	CO ₂	82.256	107.407	0.004	98%
CO ₂ Emissions from Cement Production	CO ₂	1,085.790	1,050.361	0.003	98%
Grassland converted to Cropland: mineral soils	N ₂ O	4.855	9.091	0.002	99%
Emissions from Waste Water Handling	N ₂ O	84.567	103.759	0.002	99%
CH ₄ Emissions from Manure Management	CH ₄	228.623	167.790	0.002	99%
CO ₂ Emissions from Ammonia Production	CO ₂	466.009	475.942	0.002	99%
Total Solvent and Other Product Use	N ₂ O	34.720	36.756	0.002	99%
Combustion - Agriculture/Forestry/Fishing	CO ₂	839.186	714.315	0.001	99%
CO ₂ Emissions from Limestone and Dolomite Use	CO ₂	51.490	41.825	0.001	100%
Forestland remaining Forestland	CH ₄	12.499	6.817	0.001	100%
CO ₂ Emissions from Iron and Steel Production	CO ₂	21.447	29.177	0.001	100%
Mobile Combustion: Water-borne Navigation	CO ₂	132.980	116.405	0.001	100%
CO ₂ Emissions from Soda Ash Production and Use	CO ₂	14.466	23.310	0.000	100%
SF ₆ Emissions from Other Consumption	SF ₆	10.954	9.817	0.000	100%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	8.857	0.000	100%
Mobile Combustion: Railways	CO ₂	138.142	82.678	0.000	100%
Mobile Combustion - Road Vehicles	CH ₄	34.117	13.652	0.000	100%
Mobile Combustion: Domestic Aviation	CO ₂	154.724	89.881	0.000	100%
Combustion - Agriculture/Forestry/Fishing	N ₂ O	2.038	1.738	0.000	100%

CO2 Emissions from Lime Production	CO2	153.440	89.243	0.000	100%
Grassland remaining Grassland	CO2	2.675	2.675	0.000	100%
Forestland remaining Forestland	N2O	2.858	1.559	0.000	100%
Fugitive Emissions from Oil and Gas Operations	N2O	0.668	0.211	0.000	100%
Mobile Combustion: Water-borne Navigation	N2O	0.337	0.295	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH4	1.299	1.077	0.000	100%
Mobile Combustion: Railways	N2O	0.392	0.210	0.000	100%
Mobile Combustion: Water-borne Navigation	CH4	0.190	0.166	0.000	100%
Mobile Combustion: Aircraft	N2O	1.355	0.033	0.000	100%
Mobile Combustion: Railways	CH4	0.214	0.118	0.000	100%
Emissions from Waste Incineration	CO2	0.043	0.048	0.000	100%
Mobile Combustion: Aircraft	CH4	0.023	0.001	0.000	100%
CO2 Emissions from Ferroalloys Production	CO2	118.836	0.000	0.000	100%
Aluminium Production	CO2	111.372	0.000	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	0.000	100%
Fugitive Emissions from Coal Mining and Handling	CH4	48.757	0.000	0.000	100%
Production of Other Chemicals	CH4	14.273	0.000	0.000	100%
PFC Emissions from Aluminium production	PFC	936.564	0.000	0.000	100%
TOTAL		39,380.393	36,756.299		

Table A1.2-11: Key categories analysis – Trend Assessment - Tier 2 (Excluding LULUCF)-2011

Tier 2 Analysis - Trend Assessment - Excluding LULUCF						
IPCC Source Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO ₂)	Last Year (2011) Estimate (Gg eq-CO ₂)	Trend Assessment Tier 2	% Contribution to Trend	Cumulative Total (%)
CO ₂ Emissions from Stationary Combustion - Oil	CO ₂	8,497.044	3,926.128	0.419	0.040	4%
Mobile Combustion - Road Vehicles	CO ₂	3,592.693	5,537.150	0.246	0.023	6%
CO ₂ Emissions from Stationary Combustion - Gas	CO ₂	4,458.539	5,183.028	0.131	0.012	8%
PFC Emissions from Aluminium production	PFC	936.564	0.000	0.900	0.085	16%
Solid Waste Disposal Sites	CH ₄	242.623	770.889	1.263	0.119	28%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	467.095	1.309	0.123	40%
Fugitive Emissions from Oil and Gas Operations	CH ₄	1,202.278	1,427.492	4.210	0.397	80%
CO ₂ Emissions from Stationary Combustion - Coal	CO ₂	2,780.447	2,825.237	0.030	0.003	80%
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	1,241.920	803.798	0.174	0.016	82%
N ₂ O Emissions from Manure Management	N ₂ O	381.844	204.588	0.195	0.018	84%
CO ₂ Emissions from Ferroalloys Production	CO ₂	118.836	0.000	0.123	0.012	85%
Aluminium Production	CO ₂	111.372	0.000	0.119	0.011	86%
Nitric Acid Production	N ₂ O	803.886	804.500	0.104	0.010	87%
CO ₂ Emissions from Cement Production	CO ₂	1,085.790	1,050.361	0.013	0.001	87%
CO ₂ Emissions from Ammonia Production	CO ₂	466.009	475.942	0.014	0.001	87%
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	261.130	175.222	0.086	0.008	88%
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.066	782.797	0.321	0.030	91%
Mobile Combustion: Domestic Aviation	CO ₂	154.724	89.881	0.008	0.001	91%
CO ₂ Emissions from Lime Production	CO ₂	153.440	89.243	0.006	0.001	91%
Fugitive Emissions from Coal Mining and Handling	CH ₄	48.757	0.000	0.431	0.041	95%
Mobile Combustion: Railways	CO ₂	138.142	82.678	0.011	0.001	95%
CH ₄ Emissions from Manure Management	CH ₄	228.623	167.790	0.025	0.002	96%
Combustion - Agriculture/Forestry/Fishing	CO ₂	839.186	714.315	0.004	0.000	96%
Total Solvent and Other Product Use	CO ₂	82.256	107.407	0.073	0.007	96%
Fuel Combustion - Stationary Sources	CH ₄	168.641	120.535	0.060	0.006	97%
Emissions from Waste Water Handling	N ₂ O	84.567	103.759	0.035	0.003	97%
Mobile Combustion - Road Vehicles	CH ₄	34.117	13.652	0.027	0.003	97%
Production of Chemicals	CH ₄	14.273	0.000	0.000	0.000	97%
Mobile Combustion - Road Vehicles	N ₂ O	40.247	48.112	0.097	0.009	98%
CO ₂ Emissions from Soda Ash Production and Use	CO ₂	14.466	23.310	0.013	0.001	99%
CO ₂ Emissions from Iron and Steel Production	CO ₂	21.447	29.177	0.012	0.001	99%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	8.857	0.025	0.002	99%
Emissions from Waste Water Handling	CH ₄	237.252	203.587	0.019	0.002	99%
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	1,333.134	1,184.327	0.012	0.001	99%
Fuel Combustion - Stationary Sources	N ₂ O	62.365	49.736	0.047	0.004	100%
Fugitive Emissions from Oil and Gas Operations	CO ₂	639.818	577.155	0.002	0.000	100%
Total Solvent and Other Product Use	N ₂ O	34.720	36.756	0.016	0.002	100%
CO ₂ Emissions from Limestone and Dolomite Use	CO ₂	51.490	41.825	0.005	0.000	100%
Mobile Combustion: Water-borne Navigation	CO ₂	132.980	116.405	0.001	0.000	100%
Mobile Combustion: Aircraft	N ₂ O	1.355	0.033	0.009	0.001	100%

Fugitive Emissions from Oil and Gas Operations	N2O	0.668	0.211	0.005	0.000	100%
Mobile Combustion: Railways	N2O	0.392	0.210	0.001	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH4	1.299	1.077	0.000	0.000	100%
Combustion - Agriculture/Forestry/Fishing	N2O	2.038	1.738	0.001	0.000	100%
Mobile Combustion: Railways	CH4	0.214	0.118	0.000	0.000	100%
SF6 Emissions from Other Consumption	SF6	10.954	9.817	0.000	0.000	100%
Mobile Combustion: Aircraft	CH4	0.023	0.001	0.000	0.000	100%
Emissions from Waste Incineration	CO2	0.043	0.048	0.000	0.000	100%
Mobile Combustion: Water-borne Navigation	N2O	0.337	0.295	0.000	0.000	100%
Mobile Combustion: Water-borne Navigation	CH4	0.190	0.166	0.000	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	0.000	0.000	100%
TOTAL		31,647.199	28,256.448			

Table A1.2-12: Key categories analysis – Trend Assessment - Tier 2 (Including LULUCF)-2011

Tier 2 Analysis - Trend Assessment - Including LULUCF						
IPCC Source/Sink Categories	Direct GHG	Base Year (1990) Estimate (Gg eq-CO ₂)	Last Year (2011) Estimate (Gg eq-CO ₂)	Trend Assessment Tier 2	% Contribution to Trend	Cumulative Total (%)
CO ₂ Emissions from Stationary Combustion - Oil	CO ₂	8,497.044	3,926.128	0.337	0.023	2%
Mobile Combustion - Road Vehicles	CO ₂	3,592.693	5,537.150	0.169	0.011	3%
Forestland remaining Forestland	CO ₂	6,711.706	7,462.514	2.161	0.146	18%
CO ₂ Emissions from Stationary Combustion - Gas	CO ₂	4,458.539	5,183.028	0.082	0.006	19%
PFC Emissions from Aluminium production	PFC	936.564	0.000	0.692	0.047	23%
Solid Waste Disposal Sites	CH ₄	242.623	770.889	0.912	0.062	29%
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	0.000	467.095	0.963	0.065	36%
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	1,241.920	803.798	0.149	0.010	37%
Fugitive Emissions from Oil and Gas Operations	CH ₄	1,202.278	1,427.492	2.670	0.181	55%
CO ₂ Emissions from Stationary Combustion - Coal	CO ₂	2,780.447	2,825.237	0.015	0.001	55%
Land converted to Settlements	CO ₂	448.146	602.576	0.836	0.057	61%
N ₂ O Emissions from Manure Management	N ₂ O	381.844	204.588	0.160	0.011	62%
CO ₂ Emissions from Ferroalloys Production	CO ₂	118.836	0.000	0.094	0.006	63%
Aluminium Production	CO ₂	111.372	0.000	0.091	0.006	63%
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.066	782.797	0.411	0.028	66%
Land converted to Forestland	CO ₂	272.638	174.962	0.400	0.027	69%
Cropland remaining Cropland	CO ₂	136.483	50.042	2.660	0.180	87%
Combustion - Agriculture/Forestry/Fishing	CO ₂	839.186	714.315	0.006	0.000	87%
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	261.130	175.222	0.075	0.005	87%
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	1,333.134	1,184.327	0.090	0.006	88%
Mobile Combustion: Domestic Aviation	CO ₂	154.724	89.881	0.007	0.000	88%
Nitric Acid Production	N ₂ O	803.886	804.500	0.048	0.003	88%
CO ₂ Emissions from Lime Production	CO ₂	153.440	89.243	0.005	0.000	88%
Land converted to Grassland	CO ₂	87.861	128.347	0.535	0.036	92%
Mobile Combustion: Railways	CO ₂	138.142	82.678	0.010	0.001	92%
CH ₄ Emissions from Manure Management	CH ₄	228.623	167.790	0.023	0.002	92%
Fugitive Emissions from Coal Mining and Handling	CH ₄	48.757	0.000	0.332	0.022	94%
CO ₂ Emissions from Ammonia Production	CO ₂	466.009	475.942	0.007	0.000	94%
CO ₂ Emissions from Cement Production	CO ₂	1,085.790	1,050.361	0.004	0.000	94%
Fuel Combustion - Stationary Sources	CH ₄	168.641	120.535	0.054	0.004	95%
Total Solvent and Other Product Use	CO ₂	82.256	107.407	0.048	0.003	95%
Emissions from Waste Water Handling	N ₂ O	84.567	103.759	0.023	0.002	95%
Land converted to Cropland	CO ₂	23.477	43.943	0.285	0.019	97%
Fugitive Emissions from Oil and Gas Operations	CO ₂	639.818	577.155	0.006	0.000	97%
Mobile Combustion - Road Vehicles	CH ₄	34.117	13.652	0.021	0.001	97%
Emissions from Waste Water Handling	CH ₄	237.252	203.587	0.030	0.002	98%
Production of Other Chemicals	CH ₄	14.273	0.000	0.000	0.000	98%
Land converted to Wetlands	CO ₂	29.997	17.325	0.107	0.007	98%
Mobile Combustion - Road Vehicles	N ₂ O	40.247	48.112	0.061	0.004	99%
CO ₂ Emissions from Soda Ash Production and Use	CO ₂	14.466	23.310	0.009	0.001	99%

CO2 Emissions from Iron and Steel Production	CO2	21.447	29.177	0.008	0.001	99%
HFC and PFC Emissions from Other Consumption	HFC/PFC	0.000	8.857	0.018	0.001	99%
Fuel Combustion - Stationary Sources	N2O	62.365	49.736	0.049	0.003	99%
Mobile Combustion: Water-borne Navigation	CO2	132.980	116.405	0.002	0.000	99%
CO2 Emissions from Limestone and Dolomite Use	CO2	51.490	41.825	0.006	0.000	99%
Forestland remaining Forestland	CH4	12.499	6.817	0.023	0.002	99%
Grassland converted to Cropland: mineral soils	N2O	4.855	9.091	0.053	0.004	100%
Total Solvent and Other Product Use	N2O	34.720	36.756	0.009	0.001	100%
Mobile Combustion: Aircraft	N2O	1.355	0.033	0.007	0.000	100%
Forestland remaining Forestland	N2O	2.858	1.559	0.005	0.000	100%
Fugitive Emissions from Oil and Gas Operations	N2O	0.668	0.211	0.004	0.000	100%
SF6 Emissions from Other Consumption	SF6	10.954	9.817	0.001	0.000	100%
Grassland remaining Grassland	CO2	2.675	2.675	0.000	0.000	100%
Combustion - Agriculture/Forestry/Fishing	N2O	2.038	1.738	0.001	0.000	100%
Mobile Combustion: Railways	N2O	0.392	0.210	0.001	0.000	100%
Combustion - Agriculture/Forestry/Fishing	CH4	1.299	1.077	0.000	0.000	100%
Mobile Combustion: Railways	CH4	0.214	0.118	0.000	0.000	100%
Mobile Combustion: Aircraft	CH4	0.023	0.001	0.000	0.000	100%
Mobile Combustion: Water-borne Navigation	N2O	0.337	0.295	0.000	0.000	100%
Mobile Combustion: Water-borne Navigation	CH4	0.190	0.166	0.000	0.000	100%
Emissions from Waste Incineration	CO2	0.043	0.048	0.000	0.000	100%
Other non-specified NEU	CO2	0.000	0.000	0.000	0.000	100%
TOTAL		39,380.393	36,756.299			

Table A1.2-13: Key categories for Croatia – summary (Excluding LULUCF)-1990

Tier 1 and Tier 2 Analysis – Source Analysis Summary (Croatian Inventory)			
IPCC Source Categories	Direct GHG	Key Source Category Flag	Criteria for Identification
ENERGY SECTOR			
CO ₂ Emissions from Stationary Combustion: Coal	CO ₂	Yes	L1
CO ₂ Emissions from Stationary Combustion: Oil	CO ₂	Yes	L1, L2
CO ₂ Emissions from Stationary Combustion: Gas	CO ₂	Yes	L1, L2
Non-CO ₂ Emissions from Stationary Combustion	CH ₄	No	
Non-CO ₂ Emissions from Stationary Combustion	N ₂ O	Yes	L2
Mobile Combustion: Road Vehicles	CO ₂	Yes	L1, L2
Mobile Combustion: Railways	CO ₂	No	
Mobile Combustion: Domestic Aviation	CO ₂	No	
Mobile Combustion: National Navigation	CO ₂	No	
Combustion: Agriculture/Forestry/Fishing	CO ₂	Yes	L1
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	
Combustion: Agriculture/Forestry/Fishing	CH ₄	No	
Mobile Combustion: Road Vehicles	N ₂ O	No	
Mobile Combustion: Railways	N ₂ O	No	
Mobile Combustion: Domestic Aviation	N ₂ O	No	
Mobile Combustion: National Navigation	N ₂ O	No	
Combustion: Agriculture/Forestry/Fishing	N ₂ O	No	
Fugitive Emissions from Coal Mining and Handling	CH ₄	Yes	L2
Fugitive Emissions from Oil and Gas Operations	CH ₄	Yes	L1, L2
Fugitive Emissions from Oil and Gas Operations	CO ₂	Yes	L1
Fugitive Emissions from Oil and Gas Operations	N ₂ O	No	
INDUSTRIAL SECTOR			
CO ₂ Emissions from Cement Production	CO ₂	Yes	L1
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	L1
CO ₂ Emissions from Iron and Steel Production	CO ₂	No	
CO ₂ Emissions from Ferroalloys Production	CO ₂	No	
CO ₂ Emissions from Aluminium Production	CO ₂	No	
CH ₄ Emissions from Production of Other Chemicals	CH ₄	No	
N ₂ O Emissions from Nitric Acid Production	N ₂ O	Yes	L1, L2
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	No	
HFC and PFC Emissions from Other Consumption	HFC/PFC	No	
SF ₆ Emissions from Other Consumption	SF ₆	No	
PFC Emissions from Aluminium production	PFC	Yes	L1, L2
CO ₂ Emissions from Other non-specified NEU	CO ₂	No	
SOLVENT AND OTHER PRODUCT USE			
CO ₂ Emissions from Solvent and Other product use	CO ₂	No	
N ₂ O Emissions from Solvent and Other product use	N ₂ O	No	
AGRICULTURE SECTOR			
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	Yes	L1, L2
CH ₄ Emissions from Manure Management	CH ₄	Yes	L1

Tier 1 and Tier 2 Analysis – Source Analysis Summary (Croatian Inventory)			
IPCC Source Categories	Direct GHG	Key Source Category Flag	Criteria for Identification
CH ₄ and N ₂ O Emissions from Agricultural Residue Burning	CH ₄	No	
N ₂ O Emissions from Manure Management	N ₂ O	Yes	L1, L2
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	Yes	L1, L2
N ₂ O Emissions from Pasture Range and Paddock Manure	N ₂ O	Yes	L1
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	Yes	L1, L2
CH ₄ and N ₂ O Emissions from Agricultural Residue Burning	N ₂ O	No	
WASTE SECTOR			
CH ₄ Emissions from Solid Waste Disposal Sites	CH ₄	Yes	L1, L2
CH ₄ Emissions from Waste Water Handling	CH ₄	Yes	L1, L2
N ₂ O Emissions from Human Sewage	N ₂ O	No	
CO ₂ Emissions from Waste Incineration	CO ₂	No	
N ₂ O Emissions from Waste Incineration	N ₂ O	No	

L1 - Level excluding LULUCF Tier1

L2 - Level excluding LULUCF Tier2

Table A1.2-14: Key categories for Croatia – summary (Excluding LULUCF)-2011

Tier 1 and Tier 2 Analysis – Source Analysis Summary (Croatian Inventory)			
IPCC Source Categories	Direct GHG	Key Source Category Flag	Criteria for Identification
ENERGY SECTOR			
CO ₂ Emissions from Stationary Combustion: Coal	CO ₂	Yes	L1, T1, T2
CO ₂ Emissions from Stationary Combustion: Oil	CO ₂	Yes	L1, T1, L2, T2
CO ₂ Emissions from Stationary Combustion: Gas	CO ₂	Yes	L1, T1, L2, T2
Non-CO ₂ Emissions from Stationary Combustion	CH ₄	No	
Non-CO ₂ Emissions from Stationary Combustion	N ₂ O	No	
Mobile Combustion: Road Vehicles	CO ₂	Yes	L1, T1, L2, T2
Mobile Combustion: Railways	CO ₂	No	
Mobile Combustion: Domestic Aviation	CO ₂	Yes	
Mobile Combustion: National Navigation	CO ₂	No	
Combustion: Agriculture/Forestry/Fishing	CO ₂	Yes	L1
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	
Combustion: Agriculture/Forestry/Fishing	CH ₄	No	
Mobile Combustion: Road Vehicles	N ₂ O	Yes	
Mobile Combustion: Railways	N ₂ O	No	
Mobile Combustion: Domestic Aviation	N ₂ O	No	
Mobile Combustion: National Navigation	N ₂ O	No	
Combustion: Agriculture/Forestry/Fishing	N ₂ O	No	
Fugitive Emissions from Coal Mining and Handling	CH ₄	Yes	
Fugitive Emissions from Oil and Gas Operations	CH ₄	Yes	L1, T1, L2
Fugitive Emissions from Oil and Gas Operations	CO ₂	Yes	L1
Fugitive Emissions from Oil and Gas Operations	N ₂ O		
INDUSTRIAL SECTOR			
CO ₂ Emissions from Cement Production	CO ₂	Yes	L1, T1, T2
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	L1, T1, T2
CO ₂ Emissions from Iron and Steel Production	CO ₂	No	
CO ₂ Emissions from Ferroalloys Production	CO ₂	Yes	T1, T2
CO ₂ Emissions from Aluminium Production	CO ₂	Yes	T1, T2
CH ₄ Emissions from Production of Other Chemicals	CH ₄	No	
N ₂ O Emissions from Nitric Acid Production	N ₂ O	Yes	L1, T1, L2, T2
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	Yes	L1, T1, L2, T2
HFC and PFC Emissions from Other Consumption	HFC/PFC	No	
SF ₆ Emissions from Other Consumption	SF ₆	No	
PFC Emissions from Aluminium production	PFC	Yes	T1, T2
CO ₂ Emissions from Other non-specified NEU	CO ₂	No	
SOLVENT AND OTHER PRODUCT USE			
CO ₂ Emissions from Solvent and Other Product Use	CO ₂	No	
N ₂ O Emissions from Solvent and Other Product Use	N ₂ O	No	
AGRICULTURE SECTOR			
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	Yes	L1, T1, L2, T2
CH ₄ Emissions from Manure Management	CH ₄	No	

Tier 1 and Tier 2 Analysis – Source Analysis Summary (Croatian Inventory)			
IPCC Source Categories	Direct GHG	Key Source Category Flag	Criteria for Identification
CH ₄ and N ₂ O Emissions from Agricultural Residue Burning	CH ₄	No	
N ₂ O Emissions from Manure Management	N ₂ O	Yes	L1, T1, T2
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	Yes	L1, L2
N ₂ O Emissions from Pasture Range and Paddock Manure	N ₂ O	Yes	L1, T2
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	Yes	T1, L1, L2
CH ₄ and N ₂ O Emissions from Agricultural Residue Burning	N ₂ O	No	
WASTE SECTOR			
CH ₄ Emissions from Solid Waste Disposal Sites	CH ₄	Yes	L1,T1,L2,T2
CH ₄ Emissions from Waste Water Handling	CH ₄	Yes	L1,L2
N ₂ O Emissions from Human Sewage	N ₂ O	No	
CO ₂ Emissions from Waste Incineration	CO ₂	No	
N ₂ O Emissions from Waste Incineration	N ₂ O	no	

L1 - Level excluding LULUCF Tier1

L2 - Level excluding LULUCF Tier2

T1 - Trend excluding LULUCF Tier1

T2 - Trend excluding LULUCF Tier2

Table A1.2-15: Key categories for Croatia – summary (Including LULUCF)-1990

Tier 1 and Tier 2 Analysis – Source Analysis Summary (Croatian Inventory)			
IPCC Source Categories	Direct GHG	Key Source Category Flag	Criteria for Identification
ENERGY SECTOR			
CO ₂ Emissions from Stationary Combustion: Coal	CO ₂	Yes	L1
CO ₂ Emissions from Stationary Combustion: Oil	CO ₂	Yes	L1, L2
CO ₂ Emissions from Stationary Combustion: Gas	CO ₂	Yes	L1, L2
Non-CO ₂ Emissions from Stationary Combustion	CH ₄	No	
Non-CO ₂ Emissions from Stationary Combustion	N ₂ O	No	
Mobile Combustion: Road Vehicles	CO ₂	Yes	L1
Mobile Combustion: Railways	CO ₂	No	
Mobile Combustion: Domestic Aviation	CO ₂	No	
Mobile Combustion: National Navigation	CO ₂	No	
Combustion :Agriculture/Forestry/Fishing	CO ₂	Yes	L1
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	
Combustion: Agriculture/Forestry/Fishing	CH ₄	No	
Mobile Combustion: Road Vehicles	N ₂ O	No	
Mobile Combustion: Railways	N ₂ O	No	
Mobile Combustion: Domestic Aviation	N ₂ O	No	
Mobile Combustion: National Navigation	N ₂ O	No	
Combustion: Agriculture/Forestry/Fishing	N ₂ O	No	
Fugitive Emissions from Coal Mining and Handling	CH ₄	No	
Fugitive Emissions from Oil and Gas Operations	CH ₄	Yes	L1, L2
Fugitive Emissions from Oil and Gas Operations	CO ₂	Yes	L1
Fugitive Emissions from Oil and Gas Operations	N ₂ O		
INDUSTRIAL SECTOR			
CO ₂ Emissions from Cement Production	CO ₂	Yes	L1
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	L1
CO ₂ Emissions from Iron and Steel Production	CO ₂	No	
CO ₂ Emissions from Ferroalloys Production	CO ₂	No	
CO ₂ Emissions from Aluminium Production	CO ₂	No	
CH ₄ Emissions from Production of Other Chemicals	CH ₄	No	
N ₂ O Emissions from Nitric Acid Production	N ₂ O	Yes	L1, L2
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	No	
HFC and PFC Emissions from Other Consumption	HFC/PFC		
SF ₆ Emissions from Other Consumption	SF ₆		
PFC Emissions from Aluminium production	PFC	Yes	L1, L2
CO ₂ Emissions from Other non-specified NEU	CO ₂	No	
SOLVENT AND OTHER PRODUCT USE			
CO ₂ Emissions from solvent and other product use	CO ₂	No	
N ₂ O Emissions from solvent and other product use	N ₂ O	No	
AGRICULTURE SECTOR			
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	Yes	L1, L2
CH ₄ Emissions from Manure Management	CH ₄	Yes	L1

Tier 1 and Tier 2 Analysis – Source Analysis Summary (Croatian Inventory)			
IPCC Source Categories	Direct GHG	Key Source Category Flag	Criteria for Identification
CH ₄ and N ₂ O Emissions from Agricultural Residue Burning	CH ₄	No	
N ₂ O Emissions from Manure Management	N ₂ O	Yes	L1, L2
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	Yes	L1, L2
N ₂ O Emissions from Pasture Range and Paddock Manure	N ₂ O	Yes	L1
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	Yes	L1, L2
CH ₄ and N ₂ O Emissions from Agricultural Residue Burning	N ₂ O	No	
LULUCF			
Forestland remaining Forestland	CO ₂	Yes	L1, L2
Forestland remaining Forestland	CH ₄	No	
Forestland remaining Forestland	N ₂ O	No	
Cropland remaining Cropland	CO ₂	Yes	L2
Grassland remaining Grassland	CO ₂	No	
Land converted to Forestland	CO ₂	Yes	L1, L2
Land converted to Cropland	CO ₂	No	
Land Converted to Grassland	CO ₂	Yes	L2
Land converted to Wetlands	CO ₂	No	
Land converted to Settlements	CO ₂	Yes	L1, L2
Grassland converted to Cropland: mineral soils	N ₂ O	No	
WASTE SECTOR			
CH ₄ Emissions from Solid Waste Disposal Sites	CH ₄	Yes	L1
CH ₄ Emissions from Waste Water Handling	CH ₄	Yes	L1, L2
N ₂ O Emissions from Human Sewage	N ₂ O	No	
CO ₂ Emissions from Waste Incineration	CO ₂	No	
N ₂ O Emissions from Waste Incineration	N ₂ O	No	

L1 - Level including LULUCF Tier1

L2 - Level including LULUCF Tier2

Table A1.2-16: Key categories for Croatia – summary (Including LULUCF)-2011

Tier 1 and Tier 2 Analysis – Source Analysis Summary (Croatian Inventory)			
IPCC Source Categories	Direct GHG	Key Source Category Flag	Criteria for Identification
ENERGY SECTOR			
CO ₂ Emissions from Stationary Combustion: Coal	CO ₂	Yes	L1, T1, T2
CO ₂ Emissions from Stationary Combustion: Oil	CO ₂	Yes	L1, T1, T2
CO ₂ Emissions from Stationary Combustion: Gas	CO ₂	Yes	L1, T1, T2
Non-CO ₂ Emissions from Stationary Combustion	CH ₄	No	
Non-CO ₂ Emissions from Stationary Combustion	N ₂ O	No	
Mobile Combustion: Road Vehicles	CO ₂	Yes	L1, T1, T2
Mobile Combustion: Railways	CO ₂	No	
Mobile Combustion: Domestic Aviation	CO ₂	Yes	T1, T2
Mobile Combustion: National Navigation	CO ₂	No	
Mobile Combustion: Agriculture/Forestry/Fishing	CO ₂	Yes	T1, L1, T2
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	
Mobile Combustion: Road Vehicles	N ₂ O	No	
Mobile Combustion: Railways	N ₂ O	No	
Mobile Combustion: Domestic Aviation	N ₂ O	No	
Mobile Combustion: National Navigation	N ₂ O	No	
Mobile Combustion: Agriculture/Forestry/Fishing	N ₂ O	No	
Fugitive Emissions from Coal Mining and Handling	CH ₄	Yes	T2
Fugitive Emissions from Oil and Gas Operations	CH ₄	Yes	L1, L2, T1
Fugitive Emissions from Oil and Gas Operations	CO ₂	Yes	L1
Fugitive Emissions from Oil and Gas Operations	N ₂ O		
INDUSTRIAL SECTOR			
CO ₂ Emissions from Cement Production	CO ₂	Yes	L1
CO ₂ Emissions from Lime Production	CO ₂	Yes	T2
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	L1
CO ₂ Emissions from Iron and Steel Production	CO ₂	No	
CO ₂ Emissions from Ferroalloys Production	CO ₂	Yes	T1, T2
CO ₂ Emissions from Aluminium Production	CO ₂	Yes	T1, T2
CH ₄ Emissions from Production of Other Chemicals	CH ₄	No	
N ₂ O Emissions from Nitric Acid Production	N ₂ O	Yes	L1, L2, T1, T2
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	Yes	L1, L2, T1, T2
HFC and PFC Emissions from Other Consumption	HFC/PFC	No	
SF ₆ Emissions from Other Consumption	SF ₆	No	
PFC Emissions from Aluminium production	PFC	Yes	T1, T2
CO ₂ Emissions from Other non-specified NEU	CO ₂	No	
SOLVENT AND OTHER PRODUCT USE			
CO ₂ Emissions from solvent and other product use	CO ₂	No	
N ₂ O Emissions from solvent and other product use	N ₂ O	No	
AGRICULTURE SECTOR			
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	Yes	L1, T1, T2
CH ₄ Emissions from Manure Management	CH ₄	No	

Tier 1 and Tier 2 Analysis – Source Analysis Summary (Croatian Inventory)

IPCC Source Categories	Direct GHG	Key Source Category Flag	Criteria for Identification
CH ₄ and N ₂ O Emissions from Agricultural Residue Burning	CH ₄	No	
N ₂ O Emissions from Manure Management	N ₂ O	Yes	L1, T1, T2
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	Yes	L1, L2, T1, T2
N ₂ O Emissions from Pasture Range and Paddock Manure	N ₂ O	Yes	T1, T2
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	Yes	L1, L2, T1, T2
CH ₄ and N ₂ O Emissions from Agricultural Residue Burning	N ₂ O	No	
LULUCF			
Forestland remaining Forestland	CO ₂	Yes	L1, L2, T1, T2
Forestland remaining Forestland	CH ₄	No	
Forestland remaining Forestland	N ₂ O	No	
Cropland remaining Cropland	CO ₂	Yes	L2, T1, T2
Grassland remaining Grassland	CO ₂	No	
Land converted to Forestland	CO ₂	Yes	L2, T1, T2
Land converted to Cropland	CO ₂	Yes	L2
Land Converted to Grassland	CO ₂	Yes	L2
Land converted to Wetlands	CO ₂	No	
Land converted to Settlements	CO ₂	Yes	L1, L2, T1, T2
Grassland converted to Cropland: mineral soils	N ₂ O	no	
WASTE SECTOR			
CH ₄ Emissions from Solid Waste Disposal Sites	CH ₄	Yes	L1, L2, T1, T2
CH ₄ Emissions from Waste Water Handling	CH ₄	Yes	L1
N ₂ O Emissions from Human Sewage	N ₂ O	No	
CO ₂ Emissions from Waste Incineration	CO ₂	No	
N ₂ O Emissions from Waste Incineration	N ₂ O	No	

L1 - Level including LULUCF Tier1

L2 - Level including LULUCF Tier2

T1 - Trend including LULUCF Tier1

T2 - Trend including LULUCF Tier2

Table A1.2-17: Table 7.A3 for 1990

Table 7.A3					
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 1990)					
A	B	C	D		E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification		Com.
ENERGY SECTOR					
CO2 Emissions from Stationary Combustion: Coal	CO2	Yes	L1e	L1i	
CO2 Emissions from Stationary Combustion: Oil	CO2	Yes	L1e, L2e	L1i, L2i	
CO2 Emissions from Stationary Combustion: Gas	CO2	Yes	L1e, L2e	L1i, L2i	
Non- CO2 Emissions from Stationary Combustion	CH4	No			
Non- CO2 Emissions from Stationary Combustion	N2O	Yes	L2e		
Mobile Combustion: Road Vehicles	CO2	Yes	L1e, L2e	L1i	
Mobile Combustion: Road Vehicles	CH4	No			
Mobile Combustion: Road Vehicles	N2O	No			
Mobile Combustion: Water-borne Navigation	CO2	No			
Mobile Combustion: Water-borne Navigation	CH4	No			
Mobile Combustion: Water-borne Navigation	N2O	No			
Mobile Combustion: Aircraft	CO2	No			
Mobile Combustion: Aircraft	CH4	No			
Mobile Combustion: Aircraft	N2O	No			
Combustion: Agriculture/Forestry/Fishing	CO2	Yes	L1e	L1i	
Combustion: Agriculture/Forestry/Fishing	CH4	No			
Combustion: Agriculture/Forestry/Fishing	N2O	No			
Fugitive Emissions from Coal Mining and Handling	CH4	Yes	L2e		
Fugitive Emissions from Oil and Gas Operations	CH4	Yes	L1e, L2e	L1i, L2i	
Fugitive Emissions from Oil and Gas Operations	CO2	Yes	L1e	L1i	
Fugitive Emissions from Oil and Gas Operations	N2O	No			
INDUSTRIAL SECTOR					
Emissions from Cement Production	CO2	Yes	L1e	L1i	
Emissions from Lime Production	CO2	No			
Emissions from Limestone and Dolomite Use	CO2	No			
Emissions from Soda Ash Production and Use	CO2	No			
Emissions from Ammonia Production	CO2	Yes	L1e	L1i	
Emissions from Iron and Steel Production	CO2	No			
Emissions from Ferroalloys Production	CO2	No			
Emissions from Aluminium Production	CO2	No			
Emissions from Production of Other Chemicals	CH4	No			
Emissions from Nitric Acid Production	N2O	Yes	L1e, L2e	L1i, L2i	
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	No			
HFC and PFC Emissions from Other Consumption	HFC/PFC	No			
SF6 Emissions from Other Consumption	SF6	No			
Emissions from Aluminium production	PFC	Yes	L1e, L2e	L1i, L2i	
Emissions from Other non-specified NEU	CO2	No			
SOLVENT AND OTHER PRODUCT USE					
CO2 Emissions from Solvent and Other Product Use	CO2	No			
N2O Emissions from Solvent and Other Product Use	N2O	No			
AGRICULTURE SECTOR					
CH4 Emissions from Enteric Fermentation in Domestic Livestock	CH4	Yes	L1e, L2e	L1i, L2i	
CH4 Emissions from Manure Management	CH4	Yes	L1e	L1i	
CH4 and N2O Emissions from Agricultural Residue	CH4	No			

Table 7.A3					
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 1990)					
A	B	C	D		E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification		Com.
Burning					
N ₂ O Emissions from Manure Management	N ₂ O	Yes	L1e, L2e	L1i, L2i	
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	Yes	L1e, L2e	L1i, L2i	
N ₂ O Emissions from Pasture Range and Paddock Manure	N ₂ O	Yes	L1e	L1i	
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	Yes	L1e, L2e	L1i, L2i	
CH ₄ and N ₂ O Emissions from Agricultural Residue Burning	N ₂ O	No			
LULUCF					
Forestland remaining Forestland	CO ₂	Yes		L1i, L2i	
Forestland remaining Forestland	CH ₄	No			
Forestland remaining Forestland	N ₂ O	No			
Cropland remaining Cropland	CO ₂	Yes		L2i	
Grassland remaining Grassland	CO ₂	No			
Land converted to Forestland	CO ₂	Yes		L1i, L2i	
Land converted to Cropland	CO ₂	No			
Land Converted to Grassland	CO ₂	Yes		L2i	
Land converted to Wetlands	CO ₂	No			
Land converted to Settlements	CO ₂	Yes		L1i, L2i	
Grassland converted to Cropland: mineral soils	N ₂ O	No			
WASTE SECTOR					
CH ₄ Emissions from Solid Waste Disposal Sites	CH ₄	Yes	L1e, L2e	L1i	
CH ₄ Emissions from Waste Water Handling	CH ₄	Yes	L1e, L2e	L1i, L2i	
N ₂ O Emissions from Waste Water Handling	N ₂ O	No			
CO ₂ Emissions from Waste Incineration	CO ₂	No			
N ₂ O Emissions from Waste Incineration	N ₂ O	No			

L1e - Level excluding LULUCF Tier1

L1i - Level including LULUCF Tier1

L2e - Level excluding LULUCF Tier2

L2i - Level including LULUCF Tier2

Table A1.2-18: Table 7.A3 for 2011

Table 7.A3						
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2011)						
A	B	C	D			E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification			Co
ENERGY SECTOR						
CO2 Emissions from Stationary Combustion: Coal	CO2	Yes	L1e	T1e, T2e	L1i	T1i, T2i
CO2 Emissions from Stationary Combustion: Oil	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i
CO2 Emissions from Stationary Combustion: Gas	CO2	Yes	L1e,L2e	T1e,T2e	L1i	T1i, T2i
Non- CO2 Emissions from Stationary Combustion	CH4	No				
Non- CO2 Emissions from Stationary Combustion	N2O	No				
Mobile Combustion: Road Vehicles	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i
Mobile Combustion: Road Vehicles	CH4	No				
Mobile Combustion: Road Vehicles	N2O	No				
Mobile Combustion: Water-borne Navigation	CO2	No				
Mobile Combustion: Water-borne Navigation	CH4	No				
Mobile Combustion: Water-borne Navigation	N2O	No				
Mobile Combustion: Aircraft	CO2	Yes				T1i, T2i
Mobile Combustion: Aircraft	CH4	No				
Mobile Combustion: Aircraft	N2O	No				
Combustion: Agriculture/Forestry/Fishing	CO2	Yes	L1e		L1i	T1i, T2i
Combustion: Agriculture/Forestry/Fishing	CH4	No				
Combustion: Agriculture/Forestry/Fishing	N2O	No				
Fugitive Emissions from Coal Mining and Handling	CH4	Yes				T2i
Fugitive Emissions from Oil and Gas Operations	CH4	Yes	L1e, L2e	T1e	L1i ,L2i	T1i
Fugitive Emissions from Oil and Gas Operations	CO2	Yes	L1e		L1i	
Fugitive Emissions from Oil and Gas Operations	N2O					
INDUSTRIAL SECTOR						
Emissions from Cement Production	CO2	Yes	L1e	T1e, T2e	L1i	
Emissions from Lime Production	CO2	Yes				T2i
Emissions from Limestone and Dolomite Use	CO2	No				
Emissions from Soda Ash Production and Use	CO2	No				
Emissions from Ammonia Production	CO2	Yes	L1e	T1e, T2e	L1i	
Emissions from Iron and Steel Production	CO2	No				
Emissions from Ferroalloys Production	CO2	Yes		T1e, T2e		T1i, T2i
Emissions from Aluminium Production	CO2	Yes		T1e, T2e		T1i, T2i
Emissions from Production of Other Chemicals	CH4	No				
Emissions from Nitric Acid Production	N2O	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i
HFC and PFC Emissions from Other Consumption	HFC/PFC	No				
SF6 Emissions from Other Consumption	SF6	No				
Emissions from Aluminium production	PFC	Yes		T1e, T2e		T1i, T2i
Emissions from Other non-specified NEU	CO2	No				
SOLVENT AND OTHER PRODUCT USE						
CO2 Emissions from Solvent and Other Product Use	CO2	No				
N2O Emissions from Solvent and Other Product Use	N2O	No				
AGRICULTURE SECTOR						
CH4 Emissions from Enteric Fermentation in Domestic Livestock	CH4	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i
CH4 Emissions from Manure Management	CH4	No				
CH4 and N2O Emissions from Agricultural Residue	CH4	No				

Table 7.A3							
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2011)							
A	B	C	D				E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification				Co
Burning							
N ₂ O Emissions from Manure Management	N ₂ O	Yes	L1e	T1e, T2e	L1i	T1i, T2i	
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	Yes	L1e, L2e		L1i, L2i	T1i, T2i	
N ₂ O Emissions from Pasture Range and Paddock Manure	N ₂ O	Yes	L1e, L2e			T1i, T2i	
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	Yes	L1e, L2e	T1e	L1i, L2i	T1i, T2i	
CH ₄ and N ₂ O Emissions from Agricultural Residue Burning	N ₂ O	No					
LULUCF							
Forestland remaining Forestland	CO ₂	Yes			L1i, L2i	T1i, T2i	
Forestland remaining Forestland	CH ₄	No					
Forestland remaining Forestland	N ₂ O	No					
Cropland remaining Cropland	CO ₂	Yes			L2i	T1i, T2i	
Grassland remaining Grassland	CO ₂	No					
Land converted to Forestland	CO ₂	Yes			L2i	T1i, T2i	
Land converted to Cropland	CO ₂	Yes			L2i		
Land Converted to Grassland	CO ₂	Yes			L2i		
Land converted to Wetlands	CO ₂	No					
Land converted to Settlements	CO ₂	Yes			L1i, L2i	T1i, T2i	
Grassland converted to Cropland: mineral soils	N ₂ O						
WASTE SECTOR							
CH ₄ Emissions from Solid Waste Disposal Sites	CH ₄	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i	
CH ₄ Emissions from Waste Water Handling	CH ₄	Yes	L1e, L2e		L1i		
N ₂ O Emissions from Waste Water Handling	N ₂ O	No					
CO ₂ Emissions from Waste Incineration	CO ₂	No					
N ₂ O Emissions from Waste Incineration	N ₂ O	No					

L1e - Level excluding LULUCF Tier1
 L2e - Level excluding LULUCF Tier2
 L1i - Level including LULUCF Tier1
 L2i - Level including LULUCF Tier2

T1e - Trend excluding LULUCF Tier1
 T2e - Trend excluding LULUCF Tier2
 T1i - Trend including LULUCF Tier1
 T2i - Trend including LULUCF Tier2

ANNEX 2

DETAILED DISCUSSION OF ACTIVITY DATA AND EMISSION FACTORS FOR ESTIMATING CO₂ EMISSIONS FROM FOSSIL FUEL COMBUSTION

Table A2-1: The GHG emissions from Thermal Power Plants

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Hard coal (1000 t)	253.7	569.9	915.0	925.0	640.3	897.5	957.1
NCV for hard coal (MJ/kg)	25.1	26.2	24.2	24.5	24.4	24.4	25.4
Fuel oil (1000 t)	570.4	283.4	284.0	331.6	304.8	15.2	59.5
NCV for fuel oil (MJ/kg)	40.4	40.5	40.3	40.2	40.2	40.2	40.3
Extra light oil (1000 t)	0.7	7.5	3.0	1.2	1.6	1.0	1.1
NCV for extra light oil (MJ/kg)	42.3	42.0	42.3	42.3	42.1	42.8	42.7
Natural gas (1000000 m ³)	194.6	155.7	48.2	166.4	157.9	24.2	45.6
NCV for natural gas (MJ/m ³)	33.4	33.4	33.4	33.3	33.3	33.3	34.2
Gas coke (1000000 m ³)	24.5						
NCV for gas coke (MJ/m ³)	17.6						
Total fuel consumption (TJ)	36347	31930	35336	41585	33216	23317	28267
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
EF CO ₂ – coke gas (t/TJ)	47.4						
CO ₂ emission (Gg)	2739	2577	3030	3435	2686	2121	2524
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	0.1	0.1	0.1	0.1
EF CH ₄ – coke gas (kg/TJ)	1.0						
CH ₄ emission (Mg)	37.4	22.9	26.1	31.4	28.4	20.7	22.6
EF N ₂ O – hard coal (kg/TJ)	1.6	1.6	1.6	1.6	1.6	1.6	1.6
EF N ₂ O – fuel oil (kg/TJ)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
EF N ₂ O – extra light oil (kg/TJ)	0.4	0.4	0.4	0.4	0.4	0.4	0.4
EF N ₂ O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O – coke gas (kg/TJ)	0.1						
N ₂ O emission (Mg)	17.8	28.0	39.1	40.8	29.2	35.2	39.7

Table A2-2: The GHG emissions from Public Cogeneration Plants

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Fuel oil (1000 t)	117.7	108.6	162.0	124.9	173.5	108.3	91.1
NCV for fuel oil (MJ/kg)	40.5	40.7	40.7	40.2	40.2	40.3	40.4
Extra light oil (1000 t)	0.0	0.9	0.0	0.2	0.1	0.1	0.0
NCV for extra light oil (MJ/kg)	0.0	21.4	21.4	21.4	21.4	42.8	43.0
Natural gas (1000000 m ³)	312.7	357.7	479.0	541.9	446.0	649.5	652.1
NCV for natural gas (MJ/m ³)	33.3	33.4	33.4	33.3	33.3	33.3	34.2
Total fuel consumption (TJ)	15196	16399	22567	23091	21854	26019	25898
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)	2739	1005	1397	1393	1365	1543	1522
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	0.1	0.1	0.1	0.1
CH ₄ emission (Mg)	11.6	34.4	88.6	90.3	85.2	119.8	118.4
EF N ₂ O – fuel oil (kg/TJ)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
EF N ₂ O – extra light oil (kg/TJ)	0.4	0.4	0.4	0.4	0.4	0.4	0.4
EF N ₂ O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N ₂ O emission (Mg)	17.8	2.5	3.6	3.3	3.6	3.5	3.3

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

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Fuel oil (1000 t)	0.0	37.0	39.0	20.8	21.6	23.1	10.3
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.2	40.2	40.2	40.2
Light heating oil (1000 t)	0.0	4.4	8.2	5.5	4.2	4.8	5.1
NCV for light heating oil (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Natural gas (1000000 m ³)	0.0	58.8	59.4	58.8	86.2	86.6	57.4
NCV for natural gas (MJ/m ³)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
LPG (1000 t)							
NCV for LPG (MJ/kg)							
Gas works gas (1000000 m ³)	0.0	0.0	1.5				
NCV for gas work gas (MJ/m ³)			21.5				
Landfill Gas (1000000 m ³)				2.2	3.3	8.8	9.2
NCV for landfill gas (MJ/m ³)				17.0	17.0	17.0	17.0
Total fuel consumption (TJ)	0.0	3359.8	3969.7	3109.7	4034.9	4228.7	2753.4
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 - light heating 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
EF CO ₂ - LPG (t/TJ)	62.4	62.4	62.4	64.4	64.4	64.4	64.4
EF CO ₂ - gas work gas (t/TJ)	47.4	47.4	47.4	47.4	47.4	47.4	47.4
EF CO ₂ - landfill gas (t/TJ)				54.6	54.6	54.6	54.6
CO ₂ Emission (Gg)	0.0	216.2	260.0	195.0	246.4	258.7	166.0
EF CH ₄ - fuel oil (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH ₄ - light heating 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
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 (t/TJ)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
EF CH ₄ - landfill gas (t/TJ)				1.0	1.0	1.0	1.0
CH ₄ Emission (Mg)	0.0	6.1	7.8	5.3	6.1	6.5	4.0
EF N ₂ O - fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - light heating oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O - LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - gas work gas (t/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O - landfill gas (t/TJ)				0.1	0.1	0.1	0.1
N ₂ O Emission (Mg)	0.0	1.0	1.4	0.8	0.9	1.0	0.6

The GHG emissions from thermal power plants and public cogeneration plants, for the whole period (from 1990 to 2011), 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 SO₂, NO_x, CO and particulates emission.

For estimation of CO₂ emissions, default IPCC emission factors were used, while emission factors for CH₄ and N₂O are based on technology type and configuration (Tier 2). The results of GHG emission calculation, using more detailed approach are presented in tables A2-2 and A2-3 for the 1990, 2000, 2005 and for period 2008-2011, on aggregated level. The GHG emissions on plant level, for the year 2011, are given in the Table A2-4.

Table A2-4: The GHG emissions from TPPs and PCPs (Tier 2), year 2011

	TE Plomin	TE Rijeka	TE Sisak	TE-TO Zagreb	EL-TO Zagreb	TE-TO Osijek	KTE Jertovec
Fuel consumption							
Hard coal (1000 t)	957.1						
NCV for hard coal (MJ/kg)	25.4						
Fuel oil (1000 t)		38.3	21.1	55.3	17.6	18.2	
NCV for fuel oil (MJ/kg)		40.2	40.4	40.3	40.3	40.5	
Extra light oil (1000 t)	0.891	0.122				0.001	0.042
NCV for extra light oil (MJ/kg)	43.0	42.1				43.0	43.0
Natural gas (1000000 m ³)			29.8	456.2	152.8	43.0	15.8
NCV for natural gas (MJ/m ³)			33.9	34.0	34.5	34.2	34.5
Total fuel consumption (TJ)	24308.9	1547.7	1863.0	17716.7	5973.2	2208.0	547.9
Emissions							
EF CO ₂ – hard coal (t/TJ)	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)	2252.9	118.5	121.7	1035.2	348.1	138.6	30.6
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	5.8	4.4	1.6	6.0
CH ₄ emission (Mg)	17.0	1.4	0.9	91.6	23.9	3.0	3.3
EF N ₂ O – hard coal (kg/TJ)	1.6	1.6	1.6	1.6	1.6	1.6	1.6
EF N ₂ O – fuel oil (kg/TJ)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
EF N ₂ O – extra light oil (kg/TJ)	0.4	0.4	0.4	0.4	0.4	0.4	0.4
EF N ₂ O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N ₂ O emission (Mg)	38.8	0.5	0.4	2.2	0.7	0.4	0.1

Table A2-5: The GHG emissions from Petroleum Refining

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Fuel oil (1000 t)	227.2	193.4	254.0	194.2	252.7	244.3	196.3
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.2	40.2	40.2	40.2
LPG (1000 t)	0.0	0.0	9.5	0.0	0.0	0.0	0.0
NCV for LPG (MJ/kg)	46.9	46.9	46.9	46.9	46.9	46.9	46.8
Petroleum coke (1000 t)	0.0	0.0	70.7	57.9	71.9	55.9	43.9
NCV for petroleum coke (MJ/kg)	33.6	31.0	31.0	31.0	31.0	31.0	31.0
Refinery gas (1000 t)	58.4	40.7	241.1	154.5	200.2	161.5	267.1
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	0.2	1.2	86.7	30.4	16.6	82.4
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)	12216	9756	24596	20052	23142	19960	25025
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	726.3	1804.4	1437.3	1700.5	1474.7	1753.6
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	29.3	73.7	54.3	67.4	58.8	69.5
EF N ₂ O – fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O – LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O – petroleum coke (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O – refinery gas (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N ₂ O emission (Mg)	7.2	5.9	14.7	10.6	13.4	11.7	13.6

Table A2-6: The GHG emissions from Manufacturing of Solid Fuels and Other Energy Industries

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
LPG (1000 t)	11.9	1.0					
NCV for LPG (MJ/kg)	46.9	46.9					
Coke gas (1000000 m ³)	107.4						
NCV for coke gas (MJ/m ³)	17.9						
Extra light oil (1000 t)	1.4	7.5	5.5				
NCV for extra light oil (MJ/kg)	42.7	42.7	42.7				
Natural gas (1000000 m ³)	392.0	140.5	175.5	129.3	199.3	238.90	156.3
NCV for natural gas (MJ/m ³)	34.0	34.0	34.0	34.0	34.0	34.00	34.0
Total fuel consumption (TJ)	15869.3	5144.2	6201.9	4396.2	6776.2	8122.6	5314.2
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)	47.4	47.4	47.4	47.4	47.4	47.4	47.4
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)	874.4	293.1	350.3	245.4	378.2	453.4	296.6
EF CH ₄ – LPG (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)	16.0	5.8	6.7	4.4	6.8	8.1	5.3
EF N ₂ O – LPG (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O – coke gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O – extra light oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O – natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N ₂ O emission (Mg)	2.3	0.7	0.7	0.4	0.7	0.8	0.5

Table A2-7: The GHG emissions from Manufacturing Industries and Construction – liquid fuels

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Gasoline (1000 t)	0.2	7.6	6.9	7.9	7.0	5.1	4.7
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)	246.5	130.8	161.6	194.3	145.4	130.2	125.3
NCV for gas/diesel o.(MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Fuel oil (1000 t)	419.2	302.2	198.6	124.3	90.7	56.3	51.2
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.2	40.2	40.2	40.2
LPG (1000 t)	17.5	21.0	22.8	30.4	20.1	16.2	16.1
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)	0.0		172.3	191.6	140.4	116.0	93.3
NCV for petroleum coke (MJ/kg)	29.3		31.0	31.0	31.0	31.0	31.0
Total fuel consumption (TJ)	28498	19056	21602	21012	15462	12407	11266
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
CO ₂ emission (Gg)	2135.5	1424.6	1738.5	1697.2	1249.3	1003.1	900.3
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
CH ₄ emission (Mg)	0.057	0.038	0.043	0.042	0.031	0.025	0.023
EF N ₂ O – gasoline (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O – petroleum (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O – gas/diesel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O – fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O – LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O – lubricants (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O – petroleum coke (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
N ₂ O emission (Mg)	0.017	0.011	0.013	0.013	0.009	0.007	0.007

Table A2-8: The GHG emissions from Manufacturing Industries and Construction – solid fuels

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Anthracite (1000 t)	107.2		0.3	0.0	0.3	1.3	2.1
NCV for anthracite (MJ/kg)	29.3	29.3	29.3	29.3	29.3	29.3	29.3
Hard coal (1000 t)	42.0	53.2	169.3	195.7	158.1	194.6	162.0
NCV for hard coal (MJ/kg)	25.1	26.2	25.1	24.9	24.6	24.8	24.4
Brown Coal (1000 t)	261.2	28.2	56.9	47.1	36.9	41.0	20.2
NCV for brown coal (MJ/kg)	16.7	17.8	18.5	18.0	18.0	17.6	17.1
Lignite (1000 t)	73.2	14.4	0.2				
NCV for lignite (MJ/kg)	10.9	12.0	12.1				
Briquettes (1000 t)	3.3						
NCV for briquettes (MJ/kg)	16.7						
Coke oven coke (1000 t)	251.2	37.7	22.6	24.9	25.4	27.6	27.2
NCV for coke oven coke (MJ/kg)	29.3	29.3	29.3	29.3	29.3	29.3	29.3
Total fuel consumption (TJ)	16784	3171	5976	6451	5307	6.390	5.157
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)	95.6	95.6	95.6	95.6	95.6	95.6	95.6
EF CO ₂ – coke oven coke (t/TJ)	106.0	106.0	106.0	106.0	106.0	106.0	106.0
CO ₂ emission (Gg)	1676.8	310.5	564.4	608.9	502.9	604.3	489.4
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
CH ₄ emission (Mg)	0.168	0.032	0.060	0.065	0.053	0.064	0.052
EF N ₂ O – anthracite (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O – hard coal (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O – brown coal (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O – lignite (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O – briquettes (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O – coke oven coke (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
N ₂ O emission (Mg)	0.003	0.002	0.008	0.009	0.007	0.009	0.007

Table A2-9: The GHG emissions from Manufacturing Industries and Construction –gaseous fuels

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Natural gas (1000000 m3)	1056.9	984.3	931.4	990.7	852.4	685.6	647.7
NCV for natural gas (MJ/m3)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Gas Works Gas (1000 t)	6.1	7.9	3.6	1.5	0.3		
NCV for gas work gas (MJ/kg)	15.8	15.8	21.5	19.6	19.6		
Coke Oven Gas (1000 t)	29.9						
NCV for COG (MJ/kg)	17.9						
Blast Furnace Gas (1000 t)	418.1						
NCV for blast fur. gas (MJ/kg)	3.6						
Total fuel consumption (TJ)	38072	33590	31744	33714	28988	23310	22022
Emissions							
EF CO ₂ - natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
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)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO ₂ Emission (Gg)	2030.6	1881.6	1778.2	1891.5	1626.4	1301.2	1229.2
EF CH ₄ - natural gas (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
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)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CH ₄ Emission (Mg)	0.183	0.168	0.159	0.169	0.145	0.117	0.110
EF N ₂ O - natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O - gas work gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O - coke oven gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O - blast furnace gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N ₂ O Emission (Mg)	0.004	0.003	0.003	0.003	0.003	0.002	0.002

Table A2-10: The number of road motor vehicles ('000) for year 1990, 2000, 2005 and for period 2008 – 2011 in Croatia

	1990	2000	2005	2008	2009	2010	2011
Passenger Cars, ('000)	1,120	1,145	1,395	1,533	1,516	1,492	1,480
Light Duty Vehicles, ('000)	54	96	130	141	136	130	126
Heavy Duty Vehicles and Buses, ('000)	33	36	41	43	41	38	37
Motorcycles and Mopeds, ('000)	30	73	133	190	192	184	177
Total, ('000)	1,237	1,350	1,699	1,907	1,885	1,844	1,820

Table A2-11: Quantities of consumed fuels, NCV and GHG emissions from Road Transportation (1.A.3.b.)

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
NCV for gasoline (MJ/kg)	44.6	44.6	44.6	44.6	44.6	44.6	44.6
Diesel oil (10 ³ t)	366.0	557.8	955.6	1,107.1	1,111.8	1,100.0	1,086.7
NCV for diesel oil (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
LPG (10 ³ t)	0.0	9.8	22.1	68.7	69.5	58.7	43.1
NCV for LPG (MJ/kg)	46.9	46.9	46.9	46.9	46.9	46.9	46.9
CNG (10 ⁶ m ³)	-	-	-	-	1.4	2.6	0.8
NCV for CNG (MJ/m ³)	-	-	-	-	34.0	34.0	34.0
Biodiesel (10 ³ t)	-	-	-	1.4	9.0	3.1	4.2
NCV for biodiesel (MJ/kg)	-	-	-	37.0	32.8	36.9	32.9
Emissions							
CO ₂ (Gg)	3,592.7	4,237.60	5,291.66	5,857.92	5,870.19	5,677.94	5,537.15
CH ₄ (Gg)	1.6	1.4	0.9	0.8	0.8	0.7	0.7
N ₂ O (Gg)	0.13	0.33	0.35	0.21	0.21	0.19	0.16

Table A2-12: Fossil fuel consumption, their net calorific values, appropriate GHG emission factors and GHG emissions for sub-sector Civil aviation for years 1990, 2000, 2005 and for period 2008 – 2011

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Gasoline (1000 t)		0.1	1.1	1.0	1.0	0.6	0.6
NCV for gasoline (MJ/kg)		44.6	44.6	44.6	44.6	44.6	44.6
Jet kerosene (1000 t)	49.7	17.6	20.3	27.4	23.9	25.5	28.3
NCV for jet kerosene (MJ/kg)	44.0	44.0	44.0	44.0	44.0	44.0	44.0
Total fuel consumption (TJ)	2186	776	943	1248	1095	1147	1271
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)	154.7	55.0	66.6	88.2	77.4	81.1	89.9
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)	1.1	0.4	0.5	0.6	0.5	0.6	0.6
EF N ₂ O – gasoline (kg/TJ)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
EF N ₂ O – jet kerosene (kg/TJ)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
N ₂ O emission (Mg)	4.4	1.6	1.9	2.5	2.2	2.3	2.5

Table A2-13: Quantities of fossil fuel consumed, their net calorific values and appropriate GHG emission factors and GHG emissions in the sub-sector Navigation for the years 1990, 2000, 2005 and for period 2008 – 2011

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Gasoline (1000 t)	0.1	0.3					
NCV for gasoline (MJ/kg)	44.6	44.6					
Diesel (1000 t)	38.7	25.7	31.8	40.3	46.0	34.8	35.4
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	1.4	NO	1.5	0.4	2.0	1.8
NCV for fuel oil (MJ/kg)	40.2	40.2	-	40.2	40.2	40.2	40.2
Light heating oil (1000 t)	1.6						
NCV for light heating oil (MJ/kg)	42.7						
Total fuel consumption (TJ)	1810	1167	1358	17812	1981	1567	1584
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 - light heating oil (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
CO ₂ Emission (Gg)	133.0	85.7	99.6	130.8	145.3	115.1	116.4
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 - light heating oil (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CH ₄ Emission (Mg)	9.1	5.8	6.8	8.9	9.9	7.8	7.9
EF N ₂ O - gasoline (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - diesel (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - light heating oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
N ₂ O Emission (Mg)	1.0	0.7	0.8	1.1	1.2	0.9	1.0

Table A2-14: Quantities of fossil fuel consumed their net calorific values and appropriate GHG emission factors and GHG emissions in the sub-sector Railways for the years 1990, 2000, 2005 and for period 2008 – 2011

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Gasoline (1000 t)	0.1	0.1					
NCV for gasoline (MJ/kg)	44.6	44.6					
Diesel (1000 t)	36.1	27.2	30.5	32.3	28.5	28.5	26.4
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						
NCV for fuel oil (MJ/kg)	40.2						
Light heating oil (1000 t)	1.1						
NCV for light heating oil (MJ/kg)	42.7						
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						
Jet Kerosene (1000 t)	0.1						
NCV for jet kerosene (MJ/m3)	43.9						
Total fuel consumption (TJ)	1820	1166	1303	1380	1217	1217	1128
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 - light heating oil (t/TJ)	73.3	73.3	73.3	73.3	73.3	73.3	73.3
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 - jet kerosene (t/TJ)	70.8	70.8	70.8	70.8	70.8	70.8	70.8
CO ₂ Emission (Gg)	138.1	85.5	95.5	101.2	89.3	89.3	82.7
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 - light heating 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
EF CH ₄ - jet kerosene (t/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CH ₄ Emission (Mg)	10.2	5.8	6.5	6.9	6.1	6.1	5.6
EF N ₂ O - gasoline (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - diesel (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - light heating oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - brown coal (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O - lignite (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O - jet kerosene (t/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
N ₂ O Emission (Mg)	1.3	0.7	0.8	0.8	0.7	0.7	0.7

Table A2-15: The GHG emissions from Commercial/Institutional

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Petroleum (1000 t)	3.8						
NCV for petroleum (MJ/kg)	43.9						
Light heating oil (1000 t)	92.0	120.5	131.6	87.2	78.3	73.8	64.8
NCV for light heating oil (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Fuel oil (1000 t)	67.6	3.9	6.6	3.2	8.4	8.0	9.7
NCV for fuel oil (MJ/kg)	40.2	40.2	40.2	40.2	40.2	40.2	40.2
LPG (1000 t)	4.3	13.9	20.1	10.4	11.9	12.9	13.7
NCV for LPG (MJ/kg)	46.9	46.9	46.9	46.9	46.9	46.9	46.9
Brown coal (1000 t)	24.5	9.5	0.2	1.7	3.8	2.2	5.2
NCV for brown coal (MJ/kg)	16.74	17.80	18.50	18.0	18.0	17.6	17.1
Lignite (1000 t)	40.0	1.2	0.6	0.1	0.4	0.3	0.1
NCV for lignite (MJ/kg)	10.9	12.0	12.1	11.8	11.7	11.6	11.6
Briquettes (1000 t)	2.9						
NCV for briquettes (MJ/kg)	16.7						
Gas work gas (1000000 m3)	4.9	1.5	3.4	2.4	3.1	2.8	2.5
NCV for gas work gas (MJ/m3)	15.8	19.5	21.5	19.6	18.7	18.7	17.2
Natural gas (1000000 m3)	82.0	98.2	151.2	160.4	162.5	192.7	173.5
NCV for natural gas (MJ/m3)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Petroleum coke (1000 t)	1.5						
NCV for petroleum coke (MJ/kg)	29.31						
Solid Biomass-Wood (TJ)				80.3	125.60	112.1	139.6
Bio gas (TJ)				170.9	116.7	102.3	110.6
Total fuel consumption (TJ)	10819	9507	12054	10125	10139	10940	10082
Emissions							
EF CO ₂ - petroleum (t/TJ)	73.3	73.3	73.3	74.3	74.3	74.3	73.3
EF CO ₂ - light heating 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 - 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)	95.6	95.6	95.6	95.6	95.6	95.6	95.6
EF CO ₂ - gas work gas (t/TJ)	47.4	47.4	47.4	47.4	47.4	47.4	47.4
EF CO ₂ - natural gas (t/TJ)	55.8	55.8	55.8	55.8	55.8	55.8	55.8
EF CO ₂ - petroleum coke (t/TJ)	99.8	99.8	99.8	99.8	99.8	99.8	99.8
EF CO ₂ - solid biomass wood (t/TJ)	107.4	107.4	107.4	107.4	107.4	107.4	107.4
EF CO ₂ - landfill gas (t/TJ)	54.6	54.6	54.6	54.6	54.6	54.6	54.6
CO ₂ Emission (Gg)	771.2	635.2	782.8	641.0	643.9	683.4	633.7

Table A2-15: The GHG emissions from Commercial/Institutional (cont.)

	1990	2000	2005	2008	2009	2010	2011
EF CH ₄ - petroleum (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH ₄ - light heating oil (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)	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)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
EF CH ₄ - natural gas (kg/TJ)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
EF CH ₄ - petroleum coke (kg/TJ)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
EF CH ₄ - solid biomass wood (kg/TJ)	300.0	300.0	300.0	300.0	300.0	300.0	300.0
EF CH ₄ - landfill gas (t/TJ)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CH ₄ Emission (Mg)	93.6	78.2	94.5	95.5	108.8	108.0	110.6
EF N ₂ O - petroleum (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - light heating oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - brown coal (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O - lignite (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O - briquettes (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O - gas work gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O - natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O - petroleum coke (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - solid biomass wood (kg/TJ)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
EF N ₂ O - landfill gas (t/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N ₂ O Emission (Mg)	5.8	4.2	4.6	3.5	3.7	3.6	3.6

Table A2-16: The GHG emissions from Residential sector

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Petroleum (1000 t)		1.6	1	1.1	0.9	0.9	1.0
NCV for petroleum (MJ/kg)		44.0	44.0	44.0	44.0	44.0	44.0
Light heating oil (1000 t)	215.9	231.5	252.8	151.0	147.3	138.8	122.0
NCV for light heating oil (MJ/kg)	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Fuel oil (1000 t)	48.7	8.1	15.4	4.5	10.8	10.4	11.9
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	51.9	60.9	74.0	77.8	72.2	74.4
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	12.0	14	3.8	2.2	6.1	2.3
NCV for brown coal (MJ/kg)	16.7	17.8	18.5	18.0	18.0	17.6	17.1
Lignite (1000 t)	207.3	15.0	11.7	8.1	5.7	9.4	9.0
NCV for lignite (MJ/kg)	10.9	12.0	12.1	11.8	11.7	11.6	11.6
Briquettes (1000 t)	6.1						
NCV for briquettes (MJ/kg)	16.7						
Gas work gas (1000000 m ³)	24.4	9.9	10.24	6.4	6.8	7.2	5.0
NCV for gas work gas (MJ/m ³)	15.8	19.5	21.5	19.6	18.7	17.2	17.2
Natural gas (1000000 m ³)	230.0	496.6	687.8	682.7	699.5	732.9	670.2
NCV for natural gas (MJ/m ³)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Biomass (TJ)	19080	13410	12510	11055	11720	13462	16222
Total fuel consumption (TJ)	47477	43598	50831	44705	46149	48492	48460
Emissions							
EF CO ₂ - petroleum (t/TJ)	71.1	71.1	71.1	71.1	71.1	71.1	71.1
EF CO ₂ - light heating 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 - 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)	95.6	95.6	95.6	95.6	95.6	95.6	95.6
EF CO ₂ - gas work gas (t/TJ)	47.4	47.4	47.4	47.4	47.4	47.4	47.4
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)	107.4	107.4	107.4	107.4	107.4	107.4	107.4
CO ₂ Emission (Gg)	4045.3	3337.3	3718.8	3212.2	3328.3	3545.0	3672.6
EF CH ₄ - petroleum (kg/TJ)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
EF CH ₄ - light heating oil (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)	1.0	1.0	1.0	5.0	5.0	5.0	5.0

Table A2-16: The GHG emissions from Residential sector (cont.)

	1990	2000	2005	2008	2009	2010	2011
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)	7249.4	4353.6	4134.4	3584.0	3771.6	4326.6	5116.3
EF N ₂ O - petroleum (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - light heating oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - brown coal (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O - lignite (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O - briquettes (kg/TJ)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
EF N ₂ O - gas work gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O - natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O - biomass (kg/TJ)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
N ₂ O Emission (Mg)	92.8	63.5	61.6	52.9	55.7	62.5	72.9

Table A2-17: The GHG emissions from Agriculture/Forestry/Fishing

	1990	2000	2005	2008	2009	2010	2011
Fuel consumption							
Gasoline (1000 t)	4.0	12.1	8.1	8.9	8.5	8.2	8.2
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						
NCV for other kerosene (MJ/kg)	44.4						
Extra light oil (1000 t)	232.6	237.6	197.4	216.7	207.3	200.1	200.2
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	10687	8792	9869	9233	8912	8916
Fuel oil (1000 t)	12.3	13.4	4.7	4.6	4.6	4.4	4.4
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	2.6	2.7	2.8	2.8	2.7	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 m3)							
NCV for gas work gas (MJ/m3)							
Natural gas (1000000 m3)	25.0	14.5	23.2	20.8	19.6	22.2	21.5
NCV for natural gas (MJ/m3)	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Fuel consumption - stationary (TJ)	1551	1154	1104	1023	983	1058	1034
Total fuel consumption (TJ)	11668	11841	9896	10892	10215	9970	9951
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	781.1	643.0	721.8	675.2	651.7	652.1
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)	47.4	107.6	107.6	47.4	47.4	47.4	47.4
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	76.4	66.4	61.8	59.6	63.6	62.3
Total CO ₂ emission (Gg)	839.2	857.5	709.4	783.6	734.8	715.3	714.3
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	53.4	44.0	49.3	46.2	44.6	44.6
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)	1.0	1.0	1.0	5.0	5.0	5.0	5.0
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	9.1	7.1	6.7	6.5	6.8	6.7
Total CH ₄ emission (Mg)	61.8	62.5	51.1	56.0	52.7	51.4	51.3

Table A2-17: The GHG emissions from Agriculture/Forestry/Fishing (cont.)

	1990	2000	2005	2008	2009	2010	2011
EF N ₂ O - gasoline (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - other kerosene (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - diesel (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
N ₂ O emission (Mg) - mobile	6.1	6.4	5.3	5.9	5.5	5.3	5.3
EF N ₂ O - fuel oil (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - LPG (kg/TJ)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF N ₂ O - gas work gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EF N ₂ O - natural gas (kg/TJ)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N ₂ O emission (Mg) - stationary	0.5	0.4	0.3	0.3	0.3	0.3	0.3
Total N ₂ O emission (Mg)	6.6	6.9	5.5	6.2	5.8	5.6	5.6

Table A2-18: 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 ³ CH 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/m³ – Methane density at 20°C and pressure 1 atm.

Table A2-19: Fugitive emissions from Oil and Gas Activities

OIL (1B2a)	1990	2000	2005	2008	2009	2010	2011
Activity data							
Exploration (number of wells)	712	739	771	656	646	674	660
Production (PJ)	112.9	51.4	40.1	35.4	33.1	30.7	28.4
Transport (PJ)	174.1	165.6	169.5	147.3	172.5	150.6	121.2
Refining (PJ)	287.3	218.4	211.6	187.6	204.7	181.8	143.4
Distribution (PJ)	287.3	218.4	211.6	187.6	204.7	181.8	143.4
CO₂ emissions (Gg)							
Exploration	0.0003	0.0004	0.0403	0.0003	0.0003	0.1599	0.0003
Production	0.8465	0.3811	0.2970	0.2623	0.2437	0.2262	0.2086
Transport	0.0024	0.0022	0.0023	0.0020	0.0023	0.0020	0.0016
Refining	NO	NO	NO	NO	NO	NO	NO
Distribution	NO	NO	NO	NO	NO	NO	NO
Total CO₂ emissions (Gg)	0.8492	0.3837	0.3395	0.2646	0.2463	0.3881	0.2105
CH₄ emissions (Gg)							
Exploration	0.0456	0.0473	0.0512	0.0420	0.0413	0.0507	0.0422
Production	0.2992	0.1361	0.1063	0.0939	0.0876	0.0813	0.0752
Transport	0.1297	0.1234	0.1263	0.1097	0.1285	0.1122	0.0903
Refining	0.0388	0.0295	0.0286	0.0253	0.0276	0.0245	0.0194
Distribution	0.2140	0.1627	0.1577	0.1397	0.1525	0.1354	0.1068
Total CH₄ emissions (Gg)	0.7272	0.4989	0.4701	0.4106	0.4376	0.4042	0.3339
N₂O emissions (Gg)							
Exploration	NO	NO	4.76E-07	NO	NO	1.9E-06	NO
Refining	NO	NO	NO	NO	NO	NO	NO
Total N₂O emissions (Gg)	NO	NO	4.76E-07	NO	NO	1.9E-06	NO

Table A2-19: Fugitive emissions from Oil and Gas Activities (cont.)

Gas (1B2b)	1990	2000	2005	2008	2009	2010	2011
Activity data							
Exploration (number of wells)	105	94	113	130	123	124	128
Production / Processing (PJ)	67.4	59.4	79.8	94.1	93.5	93.9	85.0
Transmission and Distribution (PJ)	91.3	95.0	101.1	110.2	102.2	111.4	108.6
Other Leakage							
Non-residential gas consumed (PJ)	83.5	78.1	77.7	87.0	78.4	86.5	85.8
Residential gas -consumed (PJ)	7.8	16.9	23.4	23.2	23.8	24.9	22.8
CO₂ emissions (Gg)							
Exploration	0.0001	0.0627	0.0001	0.0115	0.0001	0.0058	0.0229
Production / Processing	416.14	633.17	691.46	576.08	516.69	487.52	509.27
Transmission	0.0540	0.0534	0.0406	0.0518	0.0518	0.0578	0.0615
Distribution	NO	NO	NO	NO	NO	NO	NO
Other Leakage							
Non-residential gas consumed	NO	NO	NO	NO	NO	NO	NO
Residential gas -consumed	NO	NO	NO	NO	NO	NO	NO
Total CO₂ emissions (Gg)	416.19	633.29	691.50	576.15	516.75	487.58	509.36
CH₄ emissions (Gg)							
Exploration	0.0067	0.0090	0.0072	0.0089	0.0079	0.0082	0.0093
Production / Processing	30.87	27.21	36.53	43.08	42.82	43.00	38.94
Transmission	IE	IE	IE	IE	IE	IE	IE
Distribution	IE	IE	IE	IE	IE	IE	IE
Other Leakage							
Non-residential gas consumed	23.35	21.83	21.71	24.32	21.90	24.16	23.98
Residential gas -consumed	1.09	2.34	3.26	3.24	3.32	3.48	3.18
Total CH₄ emissions (Gg)	55.31	51.40	61.51	70.64	68.05	70.64	66.11
N₂O emissions (Gg)							
Exploration	NO	7.48E-07	NO	1.36E-07	NO	6.8E-08	2.72E-07
Total N₂O emissions (Gg)	NO	7.48E-07	NO	1.36E-07	NO	6.8E-08	2.72E-07

Table A2-19: Fugitive emissions from Oil and Gas Activities (cont.)

Venting (1B2c)	1990	2000	2005	2008	2009	2010	2011
Activity data							
Oil (1000 m3)	3135.1	1411.5	1100.0	971.4	902.6	837.7	772.6
Gas (1000000 m3)	1982.3	1658.5	2283.4	2729.4	2704.8	2727.2	2471.4
Combined	NO	NO	NO	NO	NO	NO	NO
CO₂ emissions (Gg)							
Oil	210.1	94.6	73.7	65.1	60.5	56.1	51.8
Gas	12.7	10.6	14.6	17.5	17.3	17.5	15.8
Combined	NO	NO	NO	NO	NO	NO	NO
Total CO₂ emissions (Gg)	222.8	105.2	88.3	82.6	77.8	73.6	67.56
CH₄ emissions (Gg)							
Oil	NO	NO	NO	NO	NO	NO	NO
Gas	1.213	1.069	1.436	1.693	1.683	1.690	1.530
Combined	NO	NO	NO	NO	NO	NO	NO
Total CH₄ emissions (Gg)	1.213	1.069	1.436	1.693	1.683	1.690	1.530
N₂O emissions (Gg)							
Oil	0.0020	0.0009	0.0007	0.0006	0.0006	0.0005	0.0005
Gas	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002
Total N₂O emissions (Gg)	0.0022	0.0010	0.0009	0.0008	0.0008	0.0007	0.0007

ANNEX 3

CO₂ REFERENCE APPROACH AND COMPARISON WITH SECTORAL APPROACH, AND RELEVANT INFORMATION ON THE NATIONAL ENERGY BALANCE

Table A3-1: Fuel combustion CO₂ emissions (Reference and Sectoral Approach)

YEAR	FUEL TYPES	Reference approach		Sectoral approach		Difference	
		Energy	CO ₂	Energy	CO ₂	Energy	CO ₂
1990	Liquid Fuels	179.45	12,651.34	181.25	13,286.91	-1.00	-4,78
	Solid Fuels	34.27	3,102.87	28.67	2,800.86	19.54	10,78
	Gaseous Fuels	85.99	4,937.87	82.84	4,505.99	3.79	9,58
	Total	299.71	20,692.08	292.77	20,593.76	2.37	0,48
1991	Liquid Fuels	124.89	8,939.29	129.21	9,483.38	-3.34	-5,74
	Solid Fuels	21.07	1,850.52	17.41	1,692.68	21.06	9,32
	Gaseous Fuels	79.15	4,567.67	71.54	3,927.11	10.64	16,31
	Total	225.12	15,357.48	218.16	15,103.18	3.19	1,68
1992	Liquid Fuels	118.55	8,452.70	122.56	9,032.36	-3.27	-6,42
	Solid Fuels	17.25	1,476.32	13.47	1,284.85	28.08	14,90
	Gaseous Fuels	79.86	4,697.44	73.97	4,095.82	7.96	14,69
	Total	215.67	14,626.46	210.00	14,413.03	2.70	1,48
1993	Liquid Fuels	117.00	8,471.38	127.09	9,345.65	-7.94	-9,35
	Solid Fuels	14.71	1,225.37	10.98	1,043.62	33.97	17,41
	Gaseous Fuels	94.66	5,450.19	82.60	4,591.99	14.61	18,69
	Total	226.38	15,146.94	220.67	14,981.26	2.59	1,11
1994	Liquid Fuels	122.08	9,061.90	126.83	9,295.94	-3.75	-2,52
	Solid Fuels	9.20	771.63	6.83	661.23	34.57	16,70
	Gaseous Fuels	80.52	4,703.41	76.54	4,261.47	5.19	10,37
	Total	211.80	14,536.94	210.21	14,218.65	0.76	2,24
1995	Liquid Fuels	136.13	9,978.13	143.60	10,545.32	-5.20	-5,38
	Solid Fuels	7.71	735.29	7.63	728.68	1.04	0,91
	Gaseous Fuels	72.59	4,339.43	67.37	3,760.38	7.76	15,40
	Total	216.44	15,052.85	218.60	15,034.38	-0.99	0,12
1996	Liquid Fuels	147.23	10,567.62	147.01	10,795.43	0.15	-2,11
	Solid Fuels	6.21	591.97	6.18	589.85	0.44	0,36
	Gaseous Fuels	81.58	4,867.77	75.01	4,189.67	8.75	16,19
	Total	235.01	16,027.36	228.21	15,574.95	2.98	2,90
1997	Liquid Fuels	147.25	10,550.01	151.38	11,103.97	-2.73	-4,99
	Solid Fuels	10.17	960.12	10.20	962.55	-0.22	-0,25
	Gaseous Fuels	84.09	5,037.38	78.95	4,412.26	6.51	14,17
	Total	241.51	16,547.51	240.53	16,478.78	0.41	0,42
1998	Liquid Fuels	162.90	11,750.01	164.49	12,104.56	-0.96	-2,93
	Solid Fuels	9.87	929.44	9.87	929.24	0.02	0,02
	Gaseous Fuels	82.84	4,879.69	78.23	4,369.71	5.89	11,67
	Total	255.61	17,559.14	252.59	17,403.51	1.20	0,89
1999	Liquid Fuels	170.71	12,642.55	174.02	12,836.17	-1.90	-1,51
	Solid Fuels	8.63	810.25	8.52	800.59	1.22	1,21
	Gaseous Fuels	82.21	4,914.30	77.69	4,339.74	5.82	13,24
	Total	261.55	18,367.09	260.23	17,976.50	0.51	2,17
2000	Liquid Fuels	147.92	10,998.18	153.02	11,213.08	-3.33	-1,92
	Solid Fuels	18.65	1,747.47	18.68	1,750.05	-0.15	-0,15
	Gaseous Fuels	82.90	4,957.53	78.45	4,383.98	5.67	13,08
	Total	249.47	17,703.17	250.15	17,347.11	-0.27	2,05
2001	Liquid Fuels	153.62	11,425.81	158.20	11,627.29	-2.89	-1,73
	Solid Fuels	19.83	1,849.61	19.69	1,836.22	0.73	0,73
	Gaseous Fuels	89.07	5,236.00	83.37	4,653.78	6.84	12,51
	Total	262.52	18,511.43	261.25	18,117.29	0.49	2,18

Table A3-1: Fuel combustion CO₂ emissions (Reference and Sectoral Approach) - cont.

YEAR	FUEL TYPES	Reference approach		Sectoral approach		Difference	
		Energy Consump. excluding non-energy (PJ)	CO ₂ emissions (Gg)	Energy Consump. (PJ)	CO ₂ emission (Gg)	Energy Consump. (%)	CO ₂ emission (%)
2002	Liquid Fuels	167.62	12,429.84	164.88	12,121.99	1.66	2.54
	Solid Fuels	24.43	2,277.22	23.88	2,225.62	2.30	2.32
	Gaseous Fuels	92.10	5,377.83	86.92	4,850.52	5.96	10.87
	Total	284.15	20,084.89	275.68	19,198.13	3.07	4.62
2003	Liquid Fuels	178.01	13,212.60	181.13	13,313.89	-1.73	-0.76
	Solid Fuels	27.20	2,532.94	27.00	2,514.72	0.73	0.72
	Gaseous Fuels	90.70	5,329.75	86.07	4,802.30	5.38	10.98
	Total	295.90	21,075.28	294.20	20,630.90	0.58	2.15
2004	Liquid Fuels	165.03	12,283.59	166.92	12,271.80	-1.13	0.10
	Solid Fuels	28.88	2,687.52	29.09	2,707.62	-0.75	-0.74
	Gaseous Fuels	93.33	5,536.73	89.45	4,996.18	4.33	10.82
	Total	287.23	20,507.84	285.46	19,975.60	0.62	2.66
2005	Liquid Fuels	172.01	12,856.05	173.10	12,824.63	-0.63	0.25
	Solid Fuels	28.64	2,667.30	27.88	2,596.45	2.74	2.73
	Gaseous Fuels	90.13	5,351.48	86.99	4,859.52	3.60	10.12
	Total	290.78	20,874.83	287.97	20,280.60	0.98	2.93
2006	Liquid Fuels	173.28	12,943.77	176.28	13,084.97	-1.70	-1.08
	Solid Fuels	26.56	2,472.98	26.38	2,456.68	0.67	0.66
	Gaseous Fuels	89.21	5,293.81	86.09	4,805.78	3.62	10.16
	Total	289.06	20,710.56	288.76	20,347.42	0.10	1.78
2007	Liquid Fuels	179.52	13,421.81	180.39	13,380.60	-0.48	0.31
	Solid Fuels	28.96	2,695.65	28.50	2,655.09	1.60	1.53
	Gaseous Fuels	102.90	6,091.12	99.08	5,537.49	3.85	10.00
	Total	311.37	22,208.59	307.97	21,573.18	1.10	2.95
2008	Liquid Fuels	169.62	12,549.53	167.21	12,387.09	1.44	1.31
	Solid Fuels	29.69	2,722.73	29.32	2,729.99	1.26	-0.27
	Gaseous Fuels	99.30	5,895.52	96.22	5,378.92	3.20	9.60
	Total	298.61	21,167.77	292.75	20,496.00	2.00	3.28
2009	Liquid Fuels	166.98	12,396.16	167.29	12,357.06	-0.19	0.32
	Solid Fuels	21.24	1,980.39	21.12	1,969.25	0.57	0.57
	Gaseous Fuels	92.49	5,458.09	90.07	5,035.59	2.69	8.39
	Total	280.71	19,834.64	278.48	19,361.89	0.80	2.44
2010	Liquid Fuels	142.94	10,557.64	143.07	10,520.53	-0.09	0.35
	Solid Fuels	29.33	2,732.05	28.94	2,696.20	1.34	1.33
	Gaseous Fuels	101.29	5,975.33	97.93	5,473.69	3.44	9.16
	Total	273.56	19,265.02	269.94	18,690.42	1.34	3.07
2011	Liquid Fuels	140.30	10,330.03	142.63	10,423.54	-1.63	-0.90
	Solid Fuels	29.41	2,740.10	30.33	2,825.24	-3.03	-3.01
	Gaseous Fuels	98.33	5,833.99	93.51	5,226.04	5.15	11.63
	Total	268.04	18,904.12	266.47	18,474.82	0.59	2.32

Table A3-2: Net calorific values for different fossil fuels from 1990 to 2011

			Net calorific values 1990- 2011 MJ/kg(m³)
Liquid Fossil	Primary Fuel	Crude Oil	41.87-42.70
	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	33.50
		Lubricants	33.50
		Refinery Gas	48.57
		Petroleum Coke	29.31-31.00
		Ethane	47.31
Solid Fossil	Primary Fuel	Anthracite	29.29-29.31
		Other Bituminous Coal	24.30-26.90
		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/Mm³
Natural Gas		Natural Gas	34.00
Biomass		Solid Biomass Fuel Wood	9.00

Table A3-3: National energy balance for 2011

ENERGY BALANCE 2010 natural units	Anthracite	Hard coal	Brown coal	Lignite	Crude oil	Natural gas
	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ⁶ m ³
Production					664,4	2471,4
Import	2,3	1101,9	66,9	9,1	2838,3	876,1
Export	0,2					258,6
Import-processing						
Export-processing						
Stock change		17,2			-144,7	76,1
Bunkers						
Energy supplied	2,1	1119,1	66,9	9,1	3358,0	3165,0
Production						
hydro power plants						
– small HPP						
Wind power plants						
Solar power plants						
Geothermal power plants						
thermal power plants						
public cogeneration plants						
public heating plants						
industrial cogeneration plants						
– in refineries						
– in gas production						
Industrial heating plants						
Petroleum refineries						
NGL-plant						
Coke plant						
Gas works						
Total production						
Transformation sector						
hydro power plants						
– small HPP						
Wind power plants						
Solar power plants						
Geothermal power plants						
thermal power plants		957,1				27,0
public cogeneration plants						652,1
public heating plants						76,0
industrial cogeneration plants			39,2			302,5
– in refineries						11,8
– in gas production						43,3
Industrial heating plants						67,2
Petroleum refineries					3273,2	76,0
NGL-plant					84,8	7,3
Coke plant						
Gas works						3,9
Total transformation sector		957,1	39,2		3358,0	1212,0
Energy sector own use						
Oil and gas extraction						96,6
Coal production						
Electric energy supply industry						
hydro power plants						
thermal power plants						
public cogeneration plants						
industrial cogeneration plants						
Industrial heating plants						
Petroleum refineries						70,6
NGL-plant						16,4
Gas works						
Total energy sector own use						183,6
Losses						60,0
Final energy demand	2,1	162,0	27,7	9,1	0,0	1709,4
Energy consumption	2,1	162,0	27,7	9,1	0,0	1199,1
Industry	2,1	162,0	20,2			333,1
Iron and steel	1,6					29,8
Non-ferrous metals						1,2
Non-metallic minerals						51,1
Chemical						55,1
Construction materials		162,0	18,4			67,6
Pulp and paper						7,8
Food production	0,5		1,8			68,1
Not elsewhere specified						52,4
Transport						0,8
Rail						
Road						0,2
Air						
– international						
– domestic						
Sea and River						
Public transport						0,6
Not elsewhere specified						
Other sectors			7,5	9,1		865,2
Households			2,3	9,0		670,2
Services			5,2	0,1		173,5
Agriculture						21,5
Construction						

Table A3-3: National energy balance for 2011 (continue)

ENERGY BALANCE 2010 natural units	Hydro energy	Fuel wood	Wind energy	Solar energy	Geothermal energy	Landfill gas	Biofuels	Other biomass
	TJ	10 ³ m ³	TJ	TJ	TJ	10 ³ m ³	10 ³ t	TJ
Production	42588,3	2162,9	1852,9	254,4	286,7	16366,0	7,6	7274,5
Import		5,2					1,8	137,1
Export		348,5					5,4	4585,9
Import-processing								
Export-processing								
Stock change							0,4	23,6
Bunkers								
Energy supplied	42588,3	1819,6	1852,9	254,4	286,7	16366,0	4,4	2849,3
Production								
hydro power plants								
– small HPP								
Wind power plants								
Solar power plants								
Geothermal power plants								
thermal power plants								
public cogeneration plants								
public heating plants								
industrial cogeneration plants								
– in refineries								
– in gas production								
Industrial heating plants								
Petroleum refineries								
NGL-plant								
Coke plant								
Gas works								
Total production								
Transformation sector								
hydro power plants	42588,3							
– small HPP	618,5							
Wind power plants			1852,9					
Solar power plants				0,9				
Geothermal power plants								
thermal power plants								
public cogeneration plants						9191,0		803,2
public heating plants								
industrial cogeneration plants						6812,0		106,3
– in refineries								
– in gas production								
Industrial heating plants								1319,7
Petroleum refineries								
NGL-plant								
Coke plant								
Gas works								
Total transformation sector	42588,3		1852,9	0,9		16003,0		2229,2
Energy sector own use								
Oil and gas extraction								
Coal production						363,0		
Electric energy supply industry								
hydro power plants								
thermal power plants								
public cogeneration plants								
industrial cogeneration plants								
Industrial heating plants								
Petroleum refineries								
NGL-plant								
Gas works								
Total energy sector own use						363,0		
Losses								
Final energy demand		1819,6		253,5	286,7		4,4	620,1
Energy consumption		1819,6		253,5	286,7		4,4	620,1
Industry		46,8						213,6
Iron and steel		0,7						
Non-ferrous metals		0,6						
Non-metallic minerals								
Chemical		0,1						
Construction materials		0,2						213,6
Pulp and paper								
Food production		0,7						
Not elsewhere specified		44,5						
Transport							4,2	
Rail								
Road							4,2	
Air								
– international								
– domestic								
Sea and River								
Public transport								
Not elsewhere specified								
Other sectors		1772,8		253,5	286,7		0,2	406,5
Households		1760,0		253,5				382,1
Services		12,8			286,7			24,4
Agriculture							0,1	
Construction							0,1	

Table A3-3: National energy balance for 2011 (continue)

ENERGY BALANCE 2010 natural units	Coke oven coke	Liquefied petroleum gases	Unleaded motor gasoline	Standard motor gasoline	Petroleum	Jet fuel	Diesel oil	Light heating oil	Low sulphur fuel oil	Standard fuel oil
	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t
Production		266,0	871,1			117,2	933,8	196,9	10,3	721,1
Import	26,6	14,0	215,8	0,6	0,9	1,1	872,0	72,7		13,3
Export	0,9	127,3	501,4			6,4	335,7	41,5	17,9	353,8
Import-processing										
Export-processing										
Stock change	1,5	-2,7	49,4		0,1	-2,5	-22,7	6,3	19,6	79,4
Bunkers							1,3			23,1
Energy supplied	27,2	150,0	634,9	0,6	1,0	109,4	1446,1	234,4	12,0	436,9
Production										
hydro power plants										
- small HPP										
Wind power plants										
Solar power plants										
Geothermal power plants										
thermal power plants										
public cogeneration plants										
public heating plants										
industrial cogeneration plants										
- in refineries										
- in gas production										
Industrial heating plants										
Petroleum refineries		214,4	871,1			117,2	933,8	196,9	10,3	721,1
NGL-plant		51,6								
Coke plant										
Gas works										
Total production		266,0	871,1			117,2	933,8	196,9	10,3	721,1
Transformation sector										
hydro power plants										
- small HPP										
Wind power plants										
Solar power plants										
Geothermal power plants										
thermal power plants								0,9		58,5
public cogeneration plants									12,0	78,9
public heating plants								5,3		23,5
industrial cogeneration plants										160,7
- in refineries										156,7
- in gas production										
Industrial heating plants										22,3
Petroleum refineries										
NGL-plant										
Coke plant										
Gas works										
Total transformation sector								6,2	12,0	343,9
Energy sector own use										
Oil and gas extraction										
Coal production										
Electric energy supply industry										
hydro power plants										
thermal power plants										
public cogeneration plants										
industrial cogeneration plants										
Industrial heating plants										
Petroleum refineries										39,6
NGL-plant										
Gas works										
Total energy sector own use										39,6
Losses										
Final energy demand	27,2	150,0	634,9	0,6	1,0	109,4	1446,1	228,2	0,0	53,4
Energy consumption	27,2	150,0	634,9	0,6	1,0	109,4	1446,1	228,2	0,0	53,4
Industry	27,2	13,8					13,5	20,0		26,2
Iron and steel	2,0	2,1						1,2		0,3
Non-ferrous metals		3,8						0,2		1,4
Non-metallic minerals		0,2						0,1		1,8
Chemical		0,1						0,4		0,9
Construction materials	18,7	2,8					13,5	3,5		5,6
Pulp and paper		0,1						0,1		0,2
Food production	6,4	1,5						9,9		13,5
Not elsewhere specified	0,1	3,2						4,6		2,5
Transport		43,1	622,0	0,6		109,4	1148,5			1,8
Rail							26,4			
Road		43,1	622,0				1060,0			
Air				0,6		109,4				
- international						53,5				
- domestic				0,6		55,9				
Sea and River							35,4			1,8
Public transport							26,7			
Not elsewhere specified										
Other sectors		93,1	12,9		1,0		284,1	208,2		25,4
Households		74,4			1,0			122,0		11,9
Services		13,7						64,8		9,1
Agriculture		2,7	8,2				185,8	14,4		4,4
Construction		2,3	4,7				98,3	7,0		

Table A3-3: National energy balance for 2011 (continue)

ENERGY BALANCE 2010 natural units	Naphta	White spirit	Bitumen	Other oils	Lubricants	Petroleum coke	Etan	Other derivates	Refinery gas	Refinery semiproducts	Additives
	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t	10 ³ t
Production	113,1		49,5	9,0		64,6	29,3	46,0	267,1		
Import		2,7	100,8	32,0	7,8	94,9				202,9	77,4
Export	95,4	0,1	10,1	8,1	0,1	21,2		54,3			
Import-processing											
Export-processing											
Stock change	5,5		1,3	0,5		-1,1		17,4		-16,4	0,2
Bunkers											
Energy supplied	23,2	2,6	141,5	33,4	7,7	137,2	29,3	9,1	267,1	186,5	77,6
Production											
hydro power plants											
– small HPP											
Wind power plants											
Solar power plants											
Geothermal power plants											
thermal power plants											
public cogeneration plants											
public heating plants											
industrial cogeneration plants											
– in refineries											
– in gas production											
Industrial heating plants											
Petroleum refineries	90,1		49,5	9,0		64,6		46,0	267,1		
NGL-plant	23,0						29,3				
Coke plant											
Gas works											
Total production	113,1		49,5	9,0		64,6	29,3	46,0	267,1		
Transformation sector											
hydro power plants											
– small HPP											
Wind power plants											
Solar power plants											
Geothermal power plants											
thermal power plants											
public cogeneration plants											
public heating plants											
industrial cogeneration plants						2,8			2,5		
– in refineries						2,8			2,5		
– in gas production											
Industrial heating plants											
Petroleum refineries	23,2									186,5	77,6
NGL-plant											
Coke plant											
Gas works											
Total transformation sector	23,2					2,8			2,5	186,5	77,6
Energy sector own use											
Oil and gas extraction											
Coal production											
Electric energy supply industry											
hydro power plants											
thermal power plants											
public cogeneration plants											
industrial cogeneration plants											
Industrial heating plants											
Petroleum refineries						41,1		9,1	264,6		
NGL-plant											
Gas works											
Total energy sector own use						41,1		9,1	264,6		
Losses											
Final energy demand	0,0	2,6	141,5	33,4	7,7	93,3	29,3	0,0			
Energy consumption	0,0					93,3		0,0			
Industry						93,3					
Iron and steel											
Non-ferrous metals											
Non-metallic minerals											
Chemical											
Construction materials						93,3					
Pulp and paper											
Food production											
Not elsewhere specified											
Transport											
Rail											
Road											
Air											
– international											
– domestic											
Sea and River											
Public transport											
Not elsewhere specified											
Other sectors											
Households											
Services											
Agriculture											
Construction											

Table A3-3: National energy balance for 2011 (continue)

ENERGY BALANCE 2010 natural units	Gas works gas 10 ³ m ³	Electricity CWh	Steam and hot water TJ
Production	7537,6	10830,3	29414,4
Import		8729,9	
Export		1032,6	
Import-processing			
Export-processing			
Stock change			
Bunkers			
Energy supplied	7537,6	18527,6	29414,4
Production			
hydro power plants		4620,0	
– small HPP		67,1	
Wind power plants		201,0	
Solar power plants		0,1	
Geothermal power plants			
thermal power plants		2876,6	
public cogeneration plants		2620,7	9042,4
public heating plants			3022,3
industrial cogeneration plants		511,9	11898,9
– in refineries		180,7	4673,1
– in gas production		61,8	912,0
Industrial heating plants			3721,1
Petroleum refineries			
NGL-plant			
Coke plant			
Gas works	7537,6		
Total production	7537,6	10830,3	27684,7
Transformation sector			
hydro power plants			
– small HPP			
Wind power plants			
Solar power plants			
Geothermal power plants			
thermal power plants			
public cogeneration plants			
public heating plants			
industrial cogeneration plants			
– in refineries			
– in gas production			
Industrial heating plants			
Petroleum refineries			
NGL-plant			
Coke plant			
Gas works			
Total transformation sector			
Energy sector own use			
Oil and gas extraction		92,9	702,0
Coal production			14,0
Electric energy supply industry		32,5	
hydro power plants		216,7	
thermal power plants		265,5	
public cogeneration plants		97,2	575,0
industrial cogeneration plants			
Industrial heating plants			
Petroleum refineries		264,2	4673,1
NGL-plant		11,6	210,0
Gas works			
Total energy sector own use		980,6	6174,1
Losses	75,4	1830,7	1510,2
Final energy demand	7462,2	15716,3	21730,1
Energy consumption	7462,2	15716,3	21730,1
Industry		3265,8	11930,8
Iron and steel		333,0	75,2
Non-ferrous metals		82,3	
Non-metallic minerals		122,9	117,8
Chemical		415,8	4489,2
Construction materials		463,8	0,9
Pulp and paper		249,3	1589,7
Food production		648,1	3750,2
Not elsewhere specified		950,6	1907,8
Transport		303,4	
Rail		171,7	
Road			
Air		22,9	
– international			
– domestic		22,9	
Sea and River		19,4	
Public transport		68,6	
Not elsewhere specified		20,8	
Other sectors	7462,2	12147,1	9799,3
Households	4976,4	6523,1	7864,5
Services	2485,8	5344,9	1864,0
Agriculture		68,1	70,8
Construction		211,0	

Table A3-3: National energy balance for 2011 (continue)

<i>PJ</i>	Anthracite	Hard coal	Brown coal	Lignite	Crude oil	Natural gas
PRIMARNA BILANCA						
Production	-	-	-	-	28,37	85,020
Import	0,07	26,88	1,14	0,11	121,20	29,787
Export	0,01	-	-	-	-	8,792
Import-processing	-	-	-	-	-	-
Export-processing	-	-	-	-	-	-
Stock change	-	0,42	-	-	6,18	2,587
Bunkers	-	-	-	-	-	-
Energy supplied	0,06	27,30	1,14	0,11	143,39	108,60
Production	-	-	-	-	-	-
hydro power plants	-	-	-	-	-	-
- small HPP	-	-	-	-	-	-
Wind power plants	-	-	-	-	-	-
Solar power plants	-	-	-	-	-	-
Geothermal power plants	-	-	-	-	-	-
thermal power plants	-	-	-	-	-	-
public cogeneration plants	-	-	-	-	-	-
public heating plants	-	-	-	-	-	-
industrial cogeneration plants	-	-	-	-	-	-
- in refineries	-	-	-	-	-	-
- in gas production	-	-	-	-	-	-
Industrial heating plants	-	-	-	-	-	-
Petroleum refineries	-	-	-	-	-	-
NGL-plant	-	-	-	-	-	-
Coke plant	-	-	-	-	-	-
Gas works	-	-	-	-	-	-
Total production	-	-	-	-	-	-
Gross production	0,06	27,30	1,14	0,11	143,39	108,60
Transformation sector	-	-	-	-	-	-
hydro power plants	-	-	-	-	-	-
- small HPP	-	-	-	-	-	-
Wind power plants	-	-	-	-	-	-
Solar power plants	-	-	-	-	-	-
Geothermal power plants	-	-	-	-	-	-
thermal power plants	-	23,21	-	-	-	0,92
public cogeneration plants	-	-	-	-	-	22,17
public heating plants	-	-	-	-	-	2,58
industrial cogeneration plants	-	-	0,67	-	-	10,29
- in refineries	-	-	-	-	-	0,40
- in gas production	-	-	-	-	-	1,47
Industrial heating plants	-	-	-	-	-	2,28
Petroleum refineries	-	-	-	-	139,77	2,58
NGL-plant	-	-	-	-	3,62	1,24
Coke plant	-	-	-	-	-	-
Gas works	-	-	-	-	-	0,13
Total transformation sector	-	23,21	0,67	-	143,39	42,20
Energy sector own use	-	-	-	-	-	-
Oil and gas extraction	-	-	-	-	-	3,28
Coal production	-	-	-	-	-	-
Electric energy supply industry	-	-	-	-	-	-
hydro power plants	-	-	-	-	-	-
thermal power plants	-	-	-	-	-	-
public cogeneration plants	-	-	-	-	-	-
industrial cogeneration plants	-	-	-	-	-	-
Industrial heating plants	-	-	-	-	-	-
Petroleum refineries	-	-	-	-	-	2,40
NGL-plant	-	-	-	-	-	0,56
Gas works	-	-	-	-	-	-
Total energy sector own use	-	-	-	-	-	6,24
Losses	-	-	-	-	-	2,04
Final energy demand	0,06	4,09	0,47	0,11	0,00	58,12
Energy consumption	0,06	4,09	0,47	0,11	0,00	40,77
Industry	0,06	4,09	0,35	-	-	11,33
Iron and steel	0,05	-	-	-	-	1,01
Non-ferrous metals	-	-	-	-	-	0,04
Non-metallic minerals	-	-	-	-	-	1,74
Chemical	-	-	-	-	-	1,87
Construction materials	-	4,09	0,31	-	-	2,30
Pulp and paper	-	-	-	-	-	0,27
Food production	0,01	-	0,03	-	-	2,32
Not elsewhere specified	-	-	-	-	-	1,78
Transport	-	-	-	-	-	0,03
Rail	-	-	-	-	-	-
Road	-	-	-	-	-	0,01
Air	-	-	-	-	-	-
- international	-	-	-	-	-	-
- domestic	-	-	-	-	-	-
Sea and River	-	-	-	-	-	-
Public transport	-	-	-	-	-	0,02
Not elsewhere specified	-	-	-	-	-	-
Other sectors	-	-	0,13	0,11	-	29,42
Households	-	-	0,04	0,10	-	22,79
Services	-	-	0,09	0,00	-	5,90
Agriculture	-	-	-	-	-	0,73
Construction	-	-	-	-	-	-

Table A3-3: National energy balance for 2011 (continue)

PJ	Hydro energy	Fuel wood	Wind energy	Solar energy	Geothermal energy	Landfill gas	Biofuels	Other biomass
PRIMARNA BILANCA								
Production	42,59	19,466	1,853	0,254	0,287	0,2969	0,283	7,275
Import	-	0,05	-	-	-	-	0,05	0,14
Export	-	3,14	-	-	-	-	0,20	4,59
Import-processing	-	-	-	-	-	-	-	-
Export-processing	-	-	-	-	-	-	-	-
Stock change	-	-	-	-	-	-	0,01	0,02
Bunkers	-	-	-	-	-	-	-	-
Energy supplied	42,59	16,38	1,85	0,25	0,29	0,2969	0,14	2,85
Production	-	-	-	-	-	-	-	-
hydro power plants	-	-	-	-	-	-	-	-
- small HPP	-	-	-	-	-	-	-	-
Wind power plants	-	-	-	-	-	-	-	-
Solar power plants	-	-	-	-	-	-	-	-
Geothermal power plants	-	-	-	-	-	-	-	-
thermal power plants	-	-	-	-	-	-	-	-
public cogeneration plants	-	-	-	-	-	-	-	-
public heating plants	-	-	-	-	-	-	-	-
industrial cogeneration plants	-	-	-	-	-	-	-	-
- in refineries	-	-	-	-	-	-	-	-
- in gas production	-	-	-	-	-	-	-	-
Industrial heating plants	-	-	-	-	-	-	-	-
Petroleum refineries	-	-	-	-	-	-	-	-
NGL-plant	-	-	-	-	-	-	-	-
Coke plant	-	-	-	-	-	-	-	-
Gas works	-	-	-	-	-	-	-	-
Total production	-	-	-	-	-	-	-	-
Gross production	42,59	16,38	1,85	0,25	0,29	0,2969	0,14	2,85
Transformation sector	-	-	-	-	-	-	-	-
hydro power plants	42,59	-	-	-	-	-	-	-
- small HPP	0,62	-	-	-	-	-	-	-
Wind power plants	-	-	1,85	-	-	-	-	-
Solar power plants	-	-	-	0,00	-	-	-	-
Geothermal power plants	-	-	-	-	-	-	-	-
thermal power plants	-	-	-	-	-	-	-	-
public cogeneration plants	-	-	-	-	-	0,1654	-	0,80
public heating plants	-	-	-	-	-	-	-	-
industrial cogeneration plants	-	-	-	-	-	0,1249	-	0,11
- in refineries	-	-	-	-	-	-	-	-
- in gas production	-	-	-	-	-	-	-	-
Industrial heating plants	-	-	-	-	-	-	-	1,32
Petroleum refineries	-	-	-	-	-	-	-	-
NGL-plant	-	-	-	-	-	-	-	-
Coke plant	-	-	-	-	-	-	-	-
Gas works	-	-	-	-	-	-	-	-
Total transformation sector	42,59	-	1,85	0,00	-	0,2904	-	2,23
Energy sector own use	-	-	-	-	-	-	-	-
Oil and gas extraction	-	-	-	-	-	-	-	-
Coal production	-	-	-	-	-	0,0065	-	-
Electric energy supply industry	-	-	-	-	-	-	-	-
hydro power plants	-	-	-	-	-	-	-	-
thermal power plants	-	-	-	-	-	-	-	-
public cogeneration plants	-	-	-	-	-	-	-	-
industrial cogeneration plants	-	-	-	-	-	-	-	-
Industrial heating plants	-	-	-	-	-	-	-	-
Petroleum refineries	-	-	-	-	-	-	-	-
NGL-plant	-	-	-	-	-	-	-	-
Gas works	-	-	-	-	-	-	-	-
Total energy sector own use	-	-	-	-	-	0,0065	-	-
Losses	-	-	-	-	-	-	-	-
Final energy demand	-	16,38	-	0,25	0,29	-	0,0000	0,14
Energy consumption	-	16,38	-	0,25	0,29	-	0,0000	0,14
Industry	-	0,42	-	-	-	-	-	0,21
Iron and steel	-	0,01	-	-	-	-	-	-
Non-ferrous metals	-	0,01	-	-	-	-	-	-
Non-metallic minerals	-	-	-	-	-	-	-	-
Chemical	-	0,00	-	-	-	-	-	-
Construction materials	-	0,00	-	-	-	-	-	0,21
Pulp and paper	-	-	-	-	-	-	-	-
Food production	-	0,01	-	-	-	-	-	-
Not elsewhere specified	-	0,40	-	-	-	-	-	-
Transport	-	-	-	-	-	-	0,14	-
Rail	-	-	-	-	-	-	-	-
Road	-	-	-	-	-	-	0,14	-
Air	-	-	-	-	-	-	-	-
- international	-	-	-	-	-	-	-	-
- domestic	-	-	-	-	-	-	-	-
Sea and River	-	-	-	-	-	-	-	-
Public transport	-	-	-	-	-	-	-	-
Not elsewhere specified	-	-	-	-	-	-	-	-
Other sectors	-	15,96	-	0,25	0,29	-	0,01	0,41
Households	-	15,84	-	0,25	-	-	-	0,38
Services	-	0,12	-	-	0,29	-	-	0,02
Agriculture	-	-	-	-	-	-	0,00	-
Construction	-	-	-	-	-	-	0,00	-

Table A3-3: National energy balance for 2011 (continue)

PJ	Coke oven coke	Liquefied petroleum gases	Unleaded motor gasoline	Standard motor gasoline	Petroleum	Jet fuel	Diesel oil	Light heating oil	Low sulphur fuel oil	Standard fuel oil
PRIMARNA BILANCA										
Production	-	-	-	-	-	-	-	-	-	-
Import	0,78	0,66	9,62	0,03	0,04	0,05	37,24	3,11	-	0,53
Export	0,03	5,97	22,36	-	-	0,28	14,34	1,77	0,72	14,22
Import-processing	-	-	-	-	-	-	-	-	-	-
Export-processing	-	-	-	-	-	-	-	-	-	-
Stock change	0,04	- 0,13	2,20	-	0,00	- 0,11	- 0,97	0,27	0,79	3,19
Bunkers	-	-	-	-	-	-	0,06	-	-	0,93
Energy supplied	0,80	- 5,44	- 10,53	0,03	0,04	- 0,34	21,88	1,60	0,07	- 11,42
Production										
hydro power plants	-	-	-	-	-	-	-	-	-	-
- small HPP	-	-	-	-	-	-	-	-	-	-
Wind power plants	-	-	-	-	-	-	-	-	-	-
Solar power plants	-	-	-	-	-	-	-	-	-	-
Geothermal power plants	-	-	-	-	-	-	-	-	-	-
thermal power plants	-	-	-	-	-	-	-	-	-	-
public cogeneration plants	-	-	-	-	-	-	-	-	-	-
public heating plants	-	-	-	-	-	-	-	-	-	-
industrial cogeneration plants	-	-	-	-	-	-	-	-	-	-
- in refineries	-	-	-	-	-	-	-	-	-	-
- in gas production	-	-	-	-	-	-	-	-	-	-
Industrial heating plants	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	-	10,05	38,84	-	-	5,15	39,88	8,41	0,41	28,98
NGL-plant	-	2,42	-	-	-	-	-	-	-	-
Coke plant	-	-	-	-	-	-	-	-	-	-
Gas works	-	-	-	-	-	-	-	-	-	-
Total production	-	12,47	38,84	-	-	5,15	39,88	8,41	0,41	28,98
Gross production	0,80	7,03	28,31	0,03	0,04	4,81	61,76	10,01	0,48	17,56
Transformation sector										
hydro power plants	-	-	-	-	-	-	-	-	-	-
- small HPP	-	-	-	-	-	-	-	-	-	-
Wind power plants	-	-	-	-	-	-	-	-	-	-
Solar power plants	-	-	-	-	-	-	-	-	-	-
Geothermal power plants	-	-	-	-	-	-	-	-	-	-
thermal power plants	-	-	-	-	-	-	-	0,04	-	2,35
public cogeneration plants	-	-	-	-	-	-	-	-	0,48	3,17
public heating plants	-	-	-	-	-	-	-	0,23	-	0,94
industrial cogeneration plants	-	-	-	-	-	-	-	-	-	6,46
- in refineries	-	-	-	-	-	-	-	-	-	6,30
- in gas production	-	-	-	-	-	-	-	-	-	-
Industrial heating plants	-	-	-	-	-	-	-	-	-	0,90
Petroleum refineries	-	-	-	-	-	-	-	-	-	-
NGL-plant	-	-	-	-	-	-	-	-	-	-
Coke plant	-	-	-	-	-	-	-	-	-	-
Gas works	-	-	-	-	-	-	-	-	-	-
Total transformation sector	-	-	-	-	-	-	-	0,26	0,48	13,82
Energy sector own use										
Oil and gas extraction	-	-	-	-	-	-	-	-	-	-
Coal production	-	-	-	-	-	-	-	-	-	-
Electric energy supply industry	-	-	-	-	-	-	-	-	-	-
hydro power plants	-	-	-	-	-	-	-	-	-	-
thermal power plants	-	-	-	-	-	-	-	-	-	-
public cogeneration plants	-	-	-	-	-	-	-	-	-	-
industrial cogeneration plants	-	-	-	-	-	-	-	-	-	-
Industrial heating plants	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	-	-	-	-	-	-	-	-	-	1,59
NGL-plant	-	-	-	-	-	-	-	-	-	-
Gas works	-	-	-	-	-	-	-	-	-	-
Total energy sector own use	-	-	-	-	-	-	-	-	-	1,59
Losses										
Final energy demand	0,80	7,03	28,31	0,03	0,04	4,81	61,76	9,75	0,00	2,15
Energy consumption	0,80	7,03	28,31	0,03	0,04	4,81	61,76	9,75	0,00	2,15
Industry	0,80	0,65	-	-	-	-	0,58	0,85	-	1,05
Iron and steel	0,06	0,10	-	-	-	-	-	0,05	-	0,01
Non-ferrous metals	-	0,18	-	-	-	-	-	0,01	-	0,06
Non-metallic minerals	-	0,01	-	-	-	-	-	0,00	-	0,07
Chemical	-	0,00	-	-	-	-	-	0,02	-	0,04
Construction materials	0,55	0,13	-	-	-	-	0,58	0,15	-	0,23
Pulp and paper	-	0,00	-	-	-	-	-	0,00	-	0,01
Food production	0,19	0,07	-	-	-	-	-	0,42	-	0,54
Not elsewhere specified	0,00	0,15	-	-	-	-	-	0,20	-	0,10
Transport	-	2,02	27,73	0,03	-	4,81	49,05	-	-	0,07
Rail	-	-	-	-	-	-	1,13	-	-	-
Road	-	2,02	27,73	-	-	-	45,27	-	-	-
Air	-	-	-	0,03	-	4,81	-	-	-	-
- international	-	-	-	-	-	2,35	-	-	-	-
- domestic	-	-	-	0,03	-	2,46	-	-	-	-
Sea and River	-	-	-	-	-	-	1,51	-	-	0,07
Public transport	-	-	-	-	-	-	1,14	-	-	-
Not elsewhere specified	-	-	-	-	-	-	-	-	-	-
Other sectors	-	4,37	0,58	-	0,04	-	12,13	8,89	-	1,02
Households	-	3,49	-	-	0,04	-	-	5,21	-	0,48
Services	-	0,64	-	-	-	-	-	2,77	-	0,37
Agriculture	-	0,13	0,37	-	-	-	7,94	0,62	-	0,18
Construction	-	0,11	0,21	-	-	-	4,20	0,30	-	-

Table A3-3: National energy balance for 2011 (continue)

PJ	Naphta	White spirit	Bitumen	Other oils	Lubricants	Petroleum coke	Etan	Other derivatives	Refinery gas	Refinery semiproducts	Additives
PRIMARNA BILANCA											
Production	-	-	-	-	-	-	-	-	-	-	-
Import	-	0,09	3,38	1,07	0,26	2,94	-	-	-	8,66	3,30
Export	4,25	0,00	0,34	0,27	0,00	0,66	-	2,18	-	-	-
Import-processing	-	-	-	-	-	-	-	-	-	-	-
Export-processing	-	-	-	-	-	-	-	-	-	-	-
Stock change	0,25	-	0,04	0,02	-	0,03	-	0,70	-	0,70	0,01
Bunkers	-	-	-	-	-	-	-	-	-	-	-
Energy supplied	- 4,01	0,09	3,08	0,82	0,26	2,25	-	1,48	-	7,96	3,31
Production	-	-	-	-	-	-	-	-	-	-	-
hydro power plants	-	-	-	-	-	-	-	-	-	-	-
- small HPP	-	-	-	-	-	-	-	-	-	-	-
Wind power plants	-	-	-	-	-	-	-	-	-	-	-
Solar power plants	-	-	-	-	-	-	-	-	-	-	-
Geothermal power plants	-	-	-	-	-	-	-	-	-	-	-
thermal power plants	-	-	-	-	-	-	-	-	-	-	-
public cogeneration plants	-	-	-	-	-	-	-	-	-	-	-
public heating plants	-	-	-	-	-	-	-	-	-	-	-
industrial cogeneration plants	-	-	-	-	-	-	-	-	-	-	-
- in refineries	-	-	-	-	-	-	-	-	-	-	-
- in gas production	-	-	-	-	-	-	-	-	-	-	-
Industrial heating plants	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	4,02	-	1,66	0,30	-	2,00	-	1,85	12,97	-	-
NGL-plant	1,03	-	-	-	-	-	1,39	-	-	-	-
Coke plant	-	-	-	-	-	-	-	-	-	-	-
Gas works	-	-	-	-	-	-	-	-	-	-	-
Total production	5,04	-	1,66	0,30	-	2,00	1,39	1,85	12,97	-	-
Gross production	1,03	0,09	4,74	1,12	0,26	4,25	1,39	0,37	12,97	7,96	3,31
Transformation sector	-	-	-	-	-	-	-	-	-	-	-
hydro power plants	-	-	-	-	-	-	-	-	-	-	-
- small HPP	-	-	-	-	-	-	-	-	-	-	-
Wind power plants	-	-	-	-	-	-	-	-	-	-	-
Solar power plants	-	-	-	-	-	-	-	-	-	-	-
Geothermal power plants	-	-	-	-	-	-	-	-	-	-	-
thermal power plants	-	-	-	-	-	-	-	-	-	-	-
public cogeneration plants	-	-	-	-	-	-	-	-	-	-	-
public heating plants	-	-	-	-	-	-	-	-	-	-	-
industrial cogeneration plants	-	-	-	-	-	0,09	-	-	0,12	-	-
- in refineries	-	-	-	-	-	0,09	-	-	0,12	-	-
- in gas production	-	-	-	-	-	-	-	-	-	-	-
Industrial heating plants	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	1,03	-	-	-	-	-	-	-	-	7,96	3,31
NGL-plant	-	-	-	-	-	-	-	-	-	-	-
Coke plant	-	-	-	-	-	-	-	-	-	-	-
Gas works	-	-	-	-	-	-	-	-	-	-	-
Total transformation sector	1,03	-	-	-	-	0,09	-	-	0,12	7,96	3,31
Energy sector own use	-	-	-	-	-	-	-	-	-	-	-
Oil and gas extraction	-	-	-	-	-	-	-	-	-	-	-
Coal production	-	-	-	-	-	-	-	-	-	-	-
Electric energy supply industry	-	-	-	-	-	-	-	-	-	-	-
hydro power plants	-	-	-	-	-	-	-	-	-	-	-
thermal power plants	-	-	-	-	-	-	-	-	-	-	-
public cogeneration plants	-	-	-	-	-	-	-	-	-	-	-
industrial cogeneration plants	-	-	-	-	-	-	-	-	-	-	-
Industrial heating plants	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	-	-	-	-	-	1,27	-	0,37	12,85	-	-
NGL-plant	-	-	-	-	-	-	-	-	-	-	-
Gas works	-	-	-	-	-	-	-	-	-	-	-
Total energy sector own use	-	-	-	-	-	1,27	-	0,37	12,85	-	-
Losses	-	-	-	-	-	-	-	-	-	-	-
Final energy demand	0,00	0,09	4,74	1,12	0,26	2,89	1,39	0,00	-	-	-
Energy consumption	0,00	-	-	-	-	2,89	-	0,00	-	-	-
Industry	-	-	-	-	-	2,89	-	-	-	-	-
Iron and steel	-	-	-	-	-	-	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-	-	-	-	-	-	-
Non-metallic minerals	-	-	-	-	-	-	-	-	-	-	-
Chemical	-	-	-	-	-	-	-	-	-	-	-
Construction materials	-	-	-	-	-	2,89	-	-	-	-	-
Pulp and paper	-	-	-	-	-	-	-	-	-	-	-
Food production	-	-	-	-	-	-	-	-	-	-	-
Not elsewhere specified	-	-	-	-	-	-	-	-	-	-	-
Transport	-	-	-	-	-	-	-	-	-	-	-
Rail	-	-	-	-	-	-	-	-	-	-	-
Road	-	-	-	-	-	-	-	-	-	-	-
Air	-	-	-	-	-	-	-	-	-	-	-
- international	-	-	-	-	-	-	-	-	-	-	-
- domestic	-	-	-	-	-	-	-	-	-	-	-
Sea and River	-	-	-	-	-	-	-	-	-	-	-
Public transport	-	-	-	-	-	-	-	-	-	-	-
Not elsewhere specified	-	-	-	-	-	-	-	-	-	-	-
Other sectors	-	-	-	-	-	-	-	-	-	-	-
Households	-	-	-	-	-	-	-	-	-	-	-
Services	-	-	-	-	-	-	-	-	-	-	-
Agriculture	-	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-	-	-	-	-

Table A3-3: National energy balance for 2011 (continue)

PJ	Gas works gas	Electricity	Steam and hot water
PRIMARNA BILANCA			
Production	-	-	1,73
Import	-	31,43	-
Export	-	3,72	-
Import-processing	-	-	-
Export-processing	-	-	-
Stock change	-	-	-
Bunkers	-	-	-
Energy supplied	-	27,71	1,73
Production	-	-	-
hydro power plants	-	16,63	-
- small HPP	-	0,24	-
Wind power plants	-	0,72	-
Solar power plants	-	0,00	-
Geothermal power plants	-	-	-
thermal power plants	-	10,36	-
public cogeneration plants	-	9,43	9,04
public heating plants	-	-	3,02
industrial cogeneration plants	-	1,84	11,90
- in refineries	-	0,65	4,67
- in gas production	-	0,22	0,91
Industrial heating plants	-	-	3,72
Petroleum refineries	-	-	-
NGL-plant	-	-	-
Coke plant	-	-	-
Gas works	0,13	-	-
Total production	0,13	38,99	27,68
Gross production	0,13	66,70	29,41
Transformation sector	-	-	-
hydro power plants	-	-	-
- small HPP	-	-	-
Wind power plants	-	-	-
Solar power plants	-	-	-
Geothermal power plants	-	-	-
thermal power plants	-	-	-
public cogeneration plants	-	-	-
public heating plants	-	-	-
industrial cogeneration plants	-	-	-
- in refineries	-	-	-
- in gas production	-	-	-
Industrial heating plants	-	-	-
Petroleum refineries	-	-	-
NGL-plant	-	-	-
Coke plant	-	-	-
Gas works	-	-	-
Total transformation sector	-	-	-
Energy sector own use	-	-	-
Oil and gas extraction	-	0,33	0,70
Coal production	-	-	0,01
Electric energy supply industry	-	0,12	-
hydro power plants	-	0,78	-
thermal power plants	-	0,96	-
public cogeneration plants	-	0,35	0,58
industrial cogeneration plants	-	-	-
Industrial heating plants	-	-	-
Petroleum refineries	-	0,95	4,67
NGL-plant	-	0,04	0,21
Gas works	-	-	-
Total energy sector own use	-	3,53	6,17
Losses	0,00	6,59	1,51
Final energy demand	0,13	56,58	21,73
Energy consumption	0,13	56,58	21,73
Industry	-	11,76	11,93
Iron and steel	-	1,20	0,08
Non-ferrous metals	-	0,30	-
Non-metallic minerals	-	0,44	0,12
Chemical	-	1,50	4,49
Construction materials	-	1,67	0,00
Pulp and paper	-	0,90	1,59
Food production	-	2,33	3,75
Not elsewhere specified	-	3,42	1,91
Transport	-	1,09	-
Rail	-	0,62	-
Road	-	-	-
Air	-	0,08	-
- international	-	-	-
- domestic	-	0,08	-
Sea and River	-	0,07	-
Public transport	-	0,25	-
Not elsewhere specified	-	0,07	-
Other sectors	0,13	43,73	9,80
Households	0,09	23,48	7,86
Services	0,04	19,24	1,86
Agriculture	-	0,25	0,07
Construction	-	0,76	-

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 Table9a.

Table A4-1: GHGs and source/sink categories not considered in the Croatian GHG inventory

GHG	Sector ⁽²⁾	Source/sink category ⁽²⁾	Explanation
Carbon	5 LULUCF	5.A.2.5 Other Land converted to Forest Land	Dificulties in collecting adequate activity data.
Carbon	5 LULUCF	5.D.1 5.D.1 Wetlands remaining Wetlands	According to the IPCC Tier 1 NE is acceptable
Carbon	5 LULUCF	5.E.1 5.E.1 Settlements remaining Settlements	According to the IPCC Tier 1 NE is acceptable
Carbon	5 LULUCF	5.A.2.5 Other Land converted to Forest Land	Dificulties in collecting adequate activity data.
Carbon	5 LULUCF	5.D.1 5.D.1 Wetlands remaining Wetlands	According to the IPCC Tier 1 NE is acceptable
Carbon	5 LULUCF	5.E.1 5.E.1 Settlements remaining Settlements	According to the IPCC Tier 1 NE is acceptable
Carbon	5 LULUCF	5.A.2.5 Other Land converted to Forest Land	Dificulties in collecting adequate activity data.
Carbon	5 LULUCF	5.D.1 5.D.1 Wetlands remaining Wetlands	According to the IPCC Tier 1 NE is acceptable
Carbon	5 LULUCF	5.E.1 5.E.1 Settlements remaining Settlements	According to the IPCC Tier 1 NE is acceptable
Carbon	5 LULUCF	5.D.1 5.D.1 Wetlands remaining Wetlands	According to the IPCC Tier 1 NE is acceptable
Carbon	5 LULUCF	5.E.1 5.E.1 Settlements remaining Settlements	According to the IPCC Tier 1 NE is acceptable
Carbon	5 LULUCF	5.A.2.5 Other Land converted to Forest Land	Dificulties in collecting adequate activity data.
CH ₄	2 Industrial Processes	2.A.7.1 Glass Production	The IPCC Guidelines do not provide methodology for the calculation of CH ₄ emission.
CH ₄	2 Industrial Processes	2.C.1.1 Steel	The IPCC Guidelines do not provide methodology for the calculation of CH ₄ emission.
CH ₄	2 Industrial Processes	2.B.5 Propylene	IPCC Guidelines do not provide methodology for the calculation of CH ₄ emission.
CH ₄	2 Industrial Processes	2.B.5 Polyvinylchloride	IPCC Guidelines do not provide methodology for the calculation of CH ₄ emission.
CH ₄	2 Industrial Processes	2.B.5 Polystyrene	IPCC Guidelines do not provide methodology for the calculation of CH ₄ emission.
CH ₄	2 Industrial Processes	2.B.5 Polyethene low density	IPCC Guidelines do not provide methodology for the calculation of CH ₄ emission.
CH ₄	5 LULUCF	5.B.1 5.B.1 Cropland remaining Cropland	Dificulies in collecting adequate activity data.
CH ₄	5 LULUCF	5.C.1 5.C.1 Grassland remaining Grassland	Dificulies in collecting adequate activity data.
CH ₄	5 LULUCF	5.D.1 5.D.1 Wetlands remaining Wetlands	Dificulies in collecting adequate activity data.
CH ₄	5 LULUCF	5.E.1 Settlements remaining Settlements	Dificulies in collecting adequate activity data.
CH ₄	5 LULUCF	5.E.2 Land converted to Settlements	Dificulies in collecting adequate activity data.
CH ₄	5 LULUCF	5.F.2 Land converted to Other Land	Dificulties in collecting adequate activity data.
CH ₄	5 LULUCF	5.G Harvested Wood Products	Dificulies in collecting adequate activity data.
CH ₄	6 Waste	6.B.1 6.B.1 Industrial Wastewater	CH ₄ emission has not been estimated because data for calculation of kg COD/year are not available in appropriate form.
CH ₄	6 Waste	6.C.2 Incineration of hospital wastes	IPCC Guidelines do not provide default emission factor for CH ₄ emission calculation from incineration of clinical waste. There is no national information on these data. Information on type of incineration technology is lacking.
CH ₄	6 Waste	6.C.2 Incineration of hazardous waste	IPCC Guidelines do not provide default emission factor for CH ₄ emission calculation from incineration of hazardous waste. There is no national information on these data. Information about categorisation of waste types and type of incineration technology is lacking.
CO ₂	2 Industrial Processes	2.A.5 Asphalt Roofing	IPCC Guidelines do not provide methodology for the calculation of CO ₂ emission.
CO ₂	2 Industrial Processes	2.A.6 Road Paving with Asphalt	The IPCC Guidelines do not provide methodology for the calculation of CO ₂ emission.

GHG	Sector ⁽²⁾	Source/sink category ⁽²⁾	Explanation
CO2	2 Industrial Processes	2.B.5.2 Ethylene	IPCC Guidelines do not provide methodology for the calculation of CO2 emission.
CO2	2 Industrial Processes	2.D.2 Food and Drink	CO2 from Food and Drink Production (e.g. gasification of water) can be of biogenic or non-biogenic origin. Only information on CO2 emission of non-biogenic origin should be reported.
CO2	2 Industrial Processes	2.B.5 Propylene	IPCC Guidelines do not provide methodology for the calculation of CO2 emission.
CO2	2 Industrial Processes	2.B.5 Polyvinylchloride	IPCC Guidelines do not provide methodology for the calculation of CO2 emission.
CO2	2 Industrial Processes	2.B.5 Polystyrene	IPCC Guidelines do not provide methodology for the calculation of CO2 emission.
CO2	2 Industrial Processes	2.B.5 Polyethylene low density	IPCC Guidelines do not provide methodology for the calculation of CO2 emission.
CO2	5 LULUCF	5.B.1 5.B.1 Cropland remaining Cropland	Dificulies in collecting adequate activity data.
CO2	5 LULUCF	5.B.1 5.B.1 Cropland remaining Cropland	Dificulies in collecting adequate activity data.
CO2	5 LULUCF	5.B.1 5.B.1 Cropland remaining Cropland	Dificulies in collecting adequate activity data.
CO2	5 LULUCF	5.C.1 5.C.1 Grassland remaining Grassland	Dificulies in collecting adequate activity data.
CO2	5 LULUCF	5.C.1 5.C.1 Grassland remaining Grassland	Dificulies in collecting adequate activity data.
CO2	5 LULUCF	5.C.1 5.C.1 Grassland remaining Grassland	Dificulies in collecting adequate activity data.
CO2	5 LULUCF	5.D.1 5.D.1 Wetlands remaining Wetlands	Dificulies in collecting adequate activity data.
CO2	5 LULUCF	5.G Harvested Wood Products	Dificulies in collecting adequate activity data.
N2O	2 Industrial Processes	2.A.7.1 Glass Production	The IPCC Guidelines do not provide methodology for the calculation of N2O emission.
N2O	2 Industrial Processes	2.B.5.2 Ethylene	IPCC Guidelines do not provide methodology for the calculation of N2O emission.
N2O	2 Industrial Processes	2.B.5 Propylene	IPCC Guidelines do not provide methodology for the calculation of N2O emission.
N2O	2 Industrial Processes	2.B.5 Polyvinylchloride	IPCC Guidelines do not provide methodology for the calculation of N2O emission.
N2O	2 Industrial Processes	2.B.5 Polystyrene	IPCC Guidelines do not provide methodology for the calculation of N2O emission.
N2O	2 Industrial Processes	2.B.5 Polyethylene low density	IPCC Guidelines do not provide methodology for the calculation of N2O emission.
N2O	3 Solvent and Other Product Use	3.B Degreasing and Dry Cleaning	IPCC Guidelines do not provide methodology for the calculation of N2O emission from Degreasing and Dry Cleaning.
N2O	3 Solvent and Other Product Use	3.D.2 Fire Extinguishers	N2O emission has not been estimated because activity data are not available.
N2O	3 Solvent and Other Product Use	3.D.4 Other Use of N2O	N2O emission has not been estimated because activity data are not available.
N2O	3 Solvent and Other Product Use	3.D.5 Other Solvent Use (SNAP 0604)	IPCC Guidelines do not provide methodology for the calculation of N2O emission.
N2O	5 LULUCF	5.B.1 5.B.1 Cropland remaining Cropland	Dificulies in collecting adequate activity data.
N2O	5 LULUCF	5.C.1 5.C.1 Grassland remaining Grassland	Dificulies in collecting adequate activity data.
N2O	5 LULUCF	5.D.1 5.D.1 Wetlands remaining Wetlands	Dificulies in collecting adequate activity data.
N2O	5 LULUCF	5.E.1 Settlements remaining Settlements	Dificulies in collecting adequate activity data.
N2O	5 LULUCF	5.E.2 Land converted to Settlements	Dificulies in collecting adequate activity data.
N2O	5 LULUCF	5.F.2 Land converted to Other Land	Dificulies in collecting adequate activity data.
N2O	5 LULUCF	5.G Harvested Wood Products	Dificulies in collecting adequate activity data.

GHG	Sector ⁽²⁾	Source/sink category ⁽²⁾	Explanation
N ₂ O	6 Waste	6.C.2 Incineration of hospital wastes	IPCC Guidelines do not provide default emission factor for N ₂ O emission calculation from incineration of clinical waste. There is no national information on these data. Information on type of incineration technology is lacking.
N ₂ O	6 Waste	6.C.2 Incineration of hazardous waste	Information on type of incineration technology is not available.

ANNEX 5

UNCERTAINTY ANALYSIS

A.5. METHODOLOGY FOR UNCERTAINTY ANALYSIS

Uncertainty estimates are calculated using two methods: Approach 1 (error propagation) and Approach 2 (Monte Carlo simulation). Use of the terminology Approach 1 and Approach 2 follows that defined in the IPCC's General Guidance and Reporting: 2006 IPCC Guidelines for National Greenhouse gas *Inventories* (2006 Guidelines) and 2000 IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000 GPG).

The Monte Carlo method was reviewed and revised in this submission, taking into account guidance from the 2006 Good Practice Guidance (IPCC, 2006). It will be discussed later in the chapter.

Uncertainty analysis using Approach 2 method was calculated for all key sources, those which represent more than 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.

Approach 2 method was calculated only for key sources because the analysis is very detail and because of lack of data for each source category, that are needed to determine uncertainty of input data; which implies the determination of appropriate distribution of input parameters.

Categories that were included in the model are those that were calculated for key sources using level assessment or trend assessment.

Sources that are included in the uncertainty model contribute to total emissions more than 97%.

Uncertainty estimates were calculated in Excel spreadsheet application. Data have been divided into six sectors according to modus how the inventory work is organized (Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Land Use, Land-Use Change and Forestry and Waste).

Every sector has been divided into sources. Each source was evaluated regarding uncertainties (%) on activity data (AD), emission factors (EF) or direct emissions (EM).

A.5.1. ESTIMATION OF UNCERTAINTY BY MONTE CARLO SIMULATION (APPROACH 2)

A.5.1.1. Overview of the method

The Monte Carlo analysis is suitable for detailed category-by-category assessment of uncertainty, particularly where uncertainties are large, distribution is non-normal, distribution functions are complex and/or there are correlations between some of the activity sets, emissions factors, or both.

The principle of Monte Carlo analysis is to select random values of emission factor, activity data and other estimation parameters from within their individual probability density functions, and to calculate the corresponding emission values.

This procedure is repeated many times, using a computer, and the results of each calculation run build up the overall emission probability density function.

Monte Carlo analysis can be performed at the category level, for aggregations of categories or for the inventory as a whole.

Detailed procedure:

- A probability distribution function (PDF) was allocated to each emission factor and activity data. The PDFs were mostly normal, log-normal or triangle. The parameters of the PDFs were set by analysing the available data on emission factors and activity data or by expert judgement.
If there was a lack of data for some emission source, associated uncertainties were extracted from the IPCC guidelines which imply that default uncertainty parameters were set.
- Using the software tool @RISK 5.7, each PDF was sampled 10,000 times and the emission calculations performed to produce a converged output distribution.
- The uncertainty in the trend between 1990 and the latest reported year, according to gas, was also estimated.

A.5.1.2. Uncertainty distributions

Distributions

All of the input parameters in inventory are modelled using normal (97%), triangle and log-normal distributions.

Correlations

The Monte Carlo model contains a number of correlations. Omitting these correlations would lead to the uncertainties being underestimated.

The trend uncertainty in the Monte Carlo model is particularly sensitive to some correlations.

Activity data and emission factor uncertainty

If for activity data or emission factor uncertainty default value from IPCC guidance was used, average value from range of given uncertainty was set.

For some pollutants and source categories, no information on uncertainty ranges were available in the Guideline so uncertainty estimates derive from expert judgment or were taken from other inventories (Japan).

Uncertainty in the emissions excluding LULUCF

The overall uncertainty of the key source emission was estimated at around 17% in year 2011 and 14% in year 1990 (bottom of the Table A5.1-2).

The central estimate of CO₂-eq emissions in 2011 was estimated at 28,256.448 Gg CO₂-eq.

The central estimate of CO₂-eq emissions in 1990 was estimated at 31,647.199 Gg CO₂-eq.

All key sources (level/trend) represent 97.97% (27,682.758 Gg CO₂-eq) of the total inventory emission for the year 2011, and 97.99% (31,009.659 Gg CO₂-eq) for the year 1990.

Monte Carlo analysis shows that with a certainty of 95% we can say that the total emissions of all key categories for the year 2011 (27,685.831 Gg CO₂-eq) varies between 23,122.563 Gg CO₂-eq (2.5% percentile) and 32,364.787 Gg CO₂-eq (97.5% percentile).

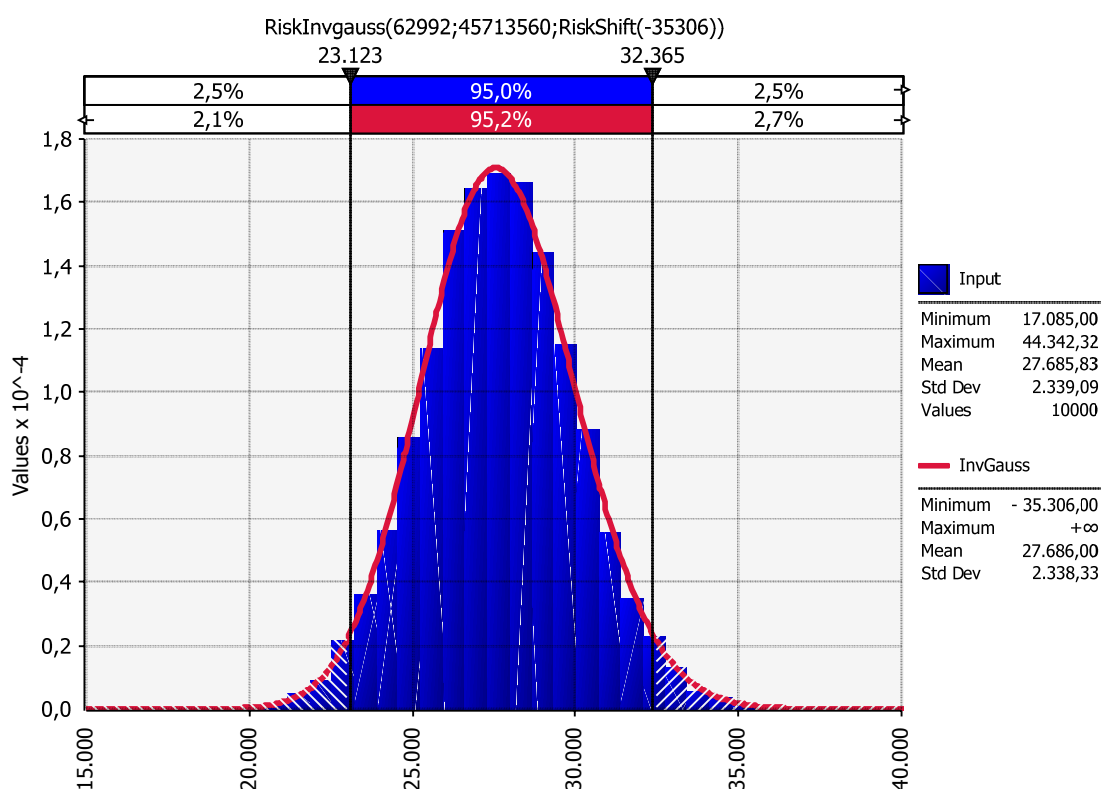


Figure A5.1-1: Distribution of total CO₂ emission for year 2011

Figure A5.1-1 shows the distribution of total CO₂ emission for year 2011 with a corresponding probability density function (red line) that best matches the simulation results.

Monte Carlo analysis shows that with a certainty of 95% we can say that the total emissions of all key categories for the year 1990 (31,013.873 Gg CO₂-eq) varies between 27,060.403 Gg CO₂-eq (2.5% percentile) and 35,335.542 Gg CO₂-eq (97.5% percentile).

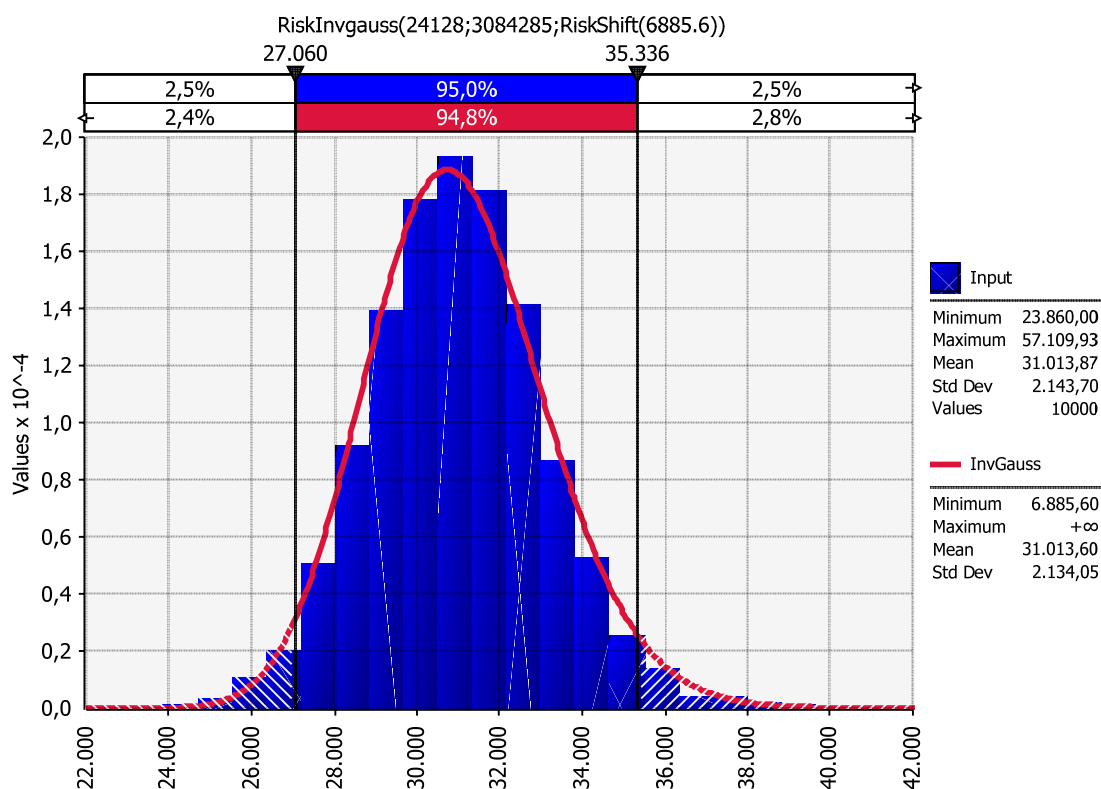


Figure A5.1-2: Distribution of total CO₂ emission for year 1990

Figure A5.1-2 shows the distribution of total CO₂ emission for year 1990 with a corresponding probability density function (red line) that best matches the simulation results.

Uncertainty in the trend excluding LULUCF

The uncertainty in the trend between 1990 and 2011 was estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources in year 1990 and 2011.

If source emission factors are correlated this will have the effect of reducing the trend uncertainty.

The assumptions were as follows:

- Activity data are not correlated;
- Emission factors of some similar fuels are correlated;
- Emission factors for agriculture are all default and the same for 1990 and 2011 for all the activities except for: CH₄ emissions from enteric fermentation (dairy cattle). They are separately calculated which implies that they are different every year;

- Energy emission factors are not correlated;
- In Industry sector emission factors for categories Nitric Acid Production and CH₄ Production of Chemicals are correlated for both years, but for categories CO₂ Emissions from Cement Production and CO₂ Emissions from Lime Production are not correlated;
- In Solvent sector there is no correlation between years;
- In Waste sector in category Solid Waste Disposal there isn't correlation between years and in category Waste Water Handling there is correlation.

The trend in the inventory is estimated for each category and for the total summary emission (all categories included) with the following formula:

$$\text{Mean Trend (\%)} = \left(\frac{\text{Year } t \text{ emissions} - \text{Base year emissions}}{\text{Base year emissions}} \right) \cdot 100$$

For the 'total' at the foot of the Table A5.1-2, the overall uncertainty in the trend for the entire key source activities is given.

The Inventory trend is -10.39%, and the 95% probability range of the trend is -27.01% (2.5% percentile) to 8.62% (97.5% percentile), so the uncertainty in trend is from -16.28% to 19.35% with respect to the base year emissions.

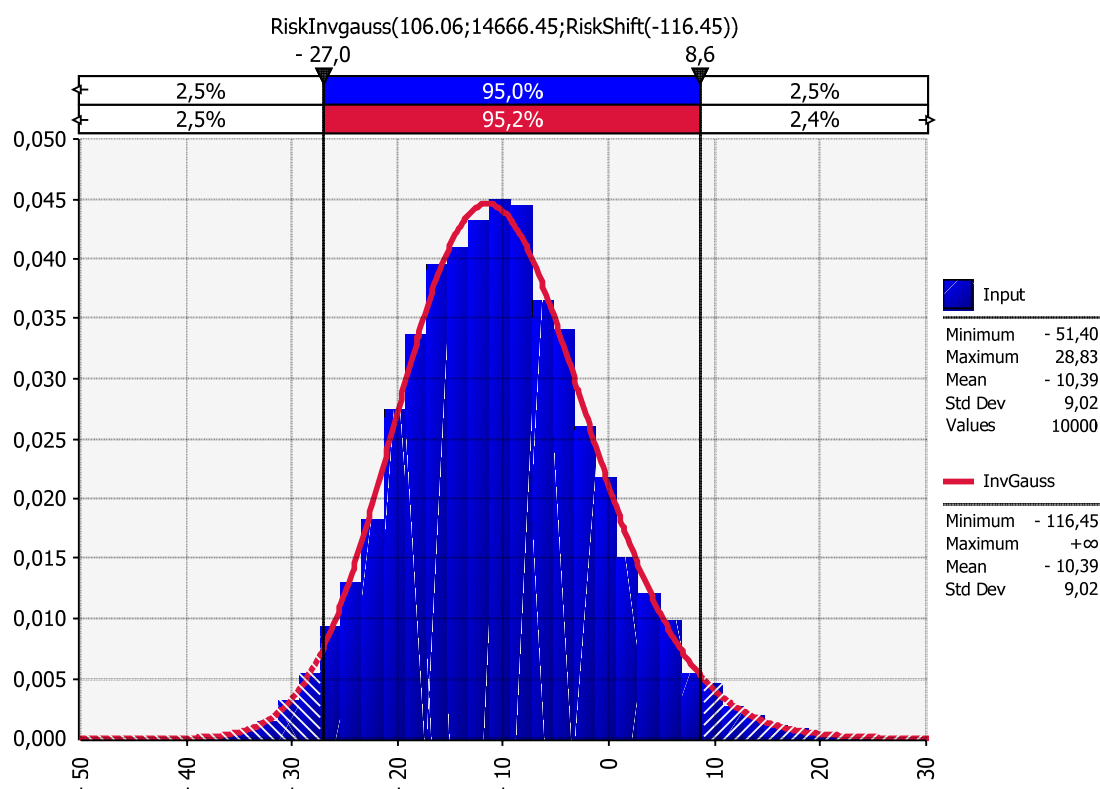


Figure A5.1-3: Distribution of trend for year 2011 respect to year 1990

Figure A5.1-3: shows the distribution of trend for year 2011 respect to year 1990 with a corresponding probability density function (red line) that best matches the simulation results.

Uncertainty in the emissions including LULUCF

The overall uncertainty of the key source emission was estimated at around 33% in year 2011 and 24% in year 1990 (bottom of the Table A5.1-3).

The central estimate of CO₂-eq emissions in 2011 was estimated at 21,224.652 Gg CO₂-eq including LULUCF.

The central estimate of CO₂-eq emissions in 1990 was estimated at 25,235.984 Gg CO₂-eq including LULUCF.

All key sources (level/trend) represent 97.30% (20,650.962 Gg CO₂-eq) of the total inventory emission for the year 2011, and 97.47% (24,598.444 Gg CO₂-eq) for the year 1990.

Monte Carlo analysis shows that with a certainty of 95% we can say that the total emissions of all key categories for the year 2011 (20,654.071 Gg CO₂-eq) varies between 14,018.011 Gg CO₂-eq (2.5% percentile) and 27,436.609 Gg CO₂-eq (97.5% percentile).

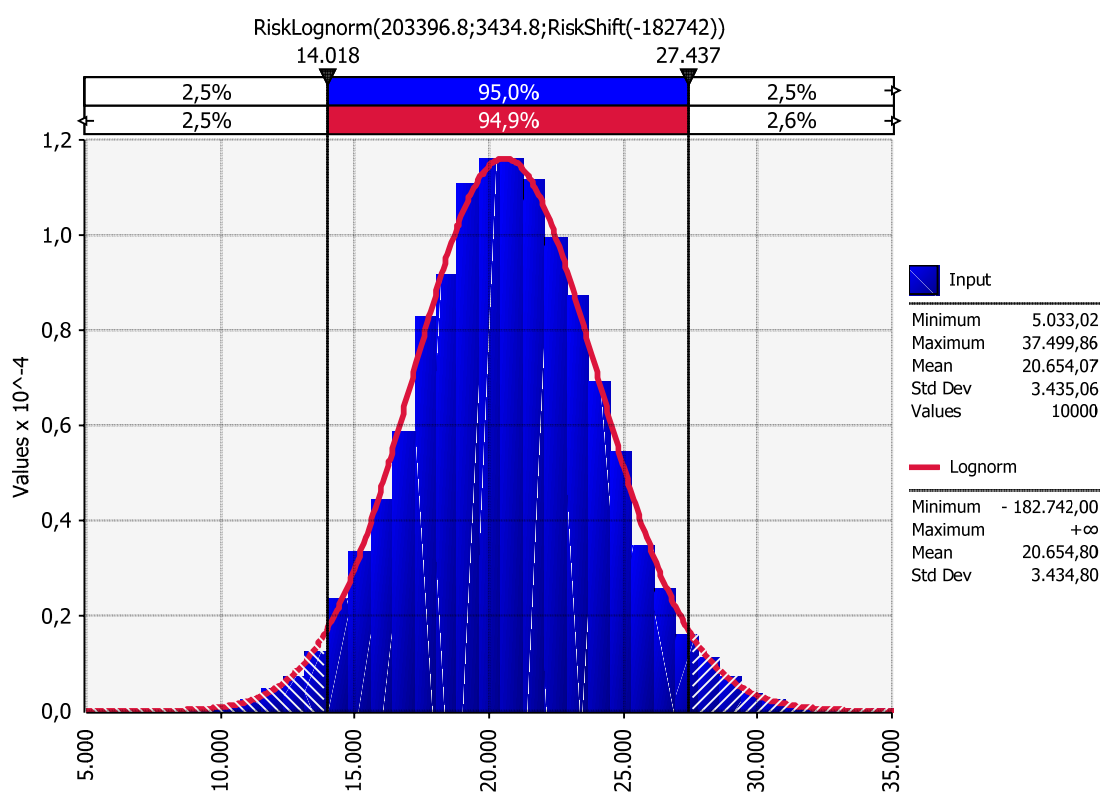


Figure A5.1-4: Distribution of total CO₂ emission for year 2011

Figure A5.1-4 shows the distribution of total CO₂ emission for year 2011 with a corresponding probability density function (red line) that best matches the simulation results.

Monte Carlo analysis shows that with a certainty of 95% we can say that the total emissions of all key categories for the year 1990 (24,602.700 Gg CO₂-eq) varies between 18,793.089 Gg CO₂-eq (2.5% percentile) and 30,620.483 Gg CO₂-eq (97.5% percentile).

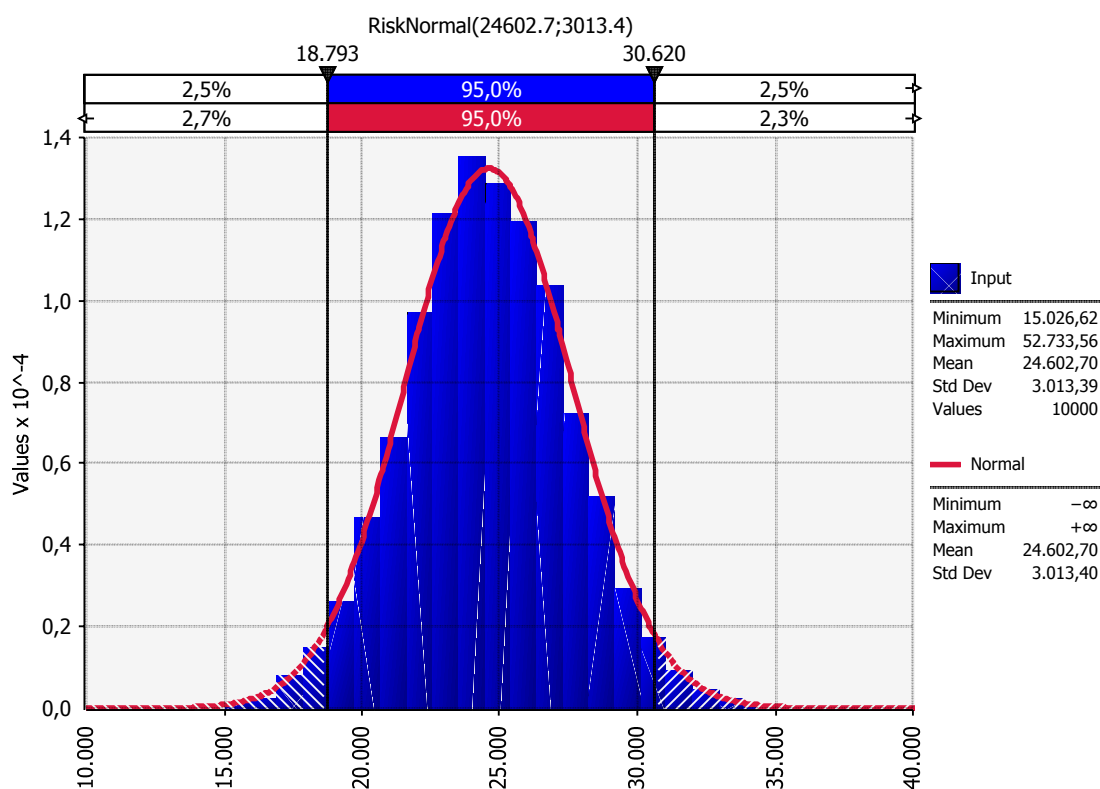


Figure A5.1-5: Distribution of total CO₂ emission for year 1990

Figure A5.1-5 shows the distribution of total CO₂ emission for year 1990 with a corresponding probability density function (red line) that best matches the simulation results.

Uncertainty in the trend including LULUCF

The Inventory trend is -14.88%, and the 95% probability range of the trend is -45.40% (2.5% percentile) to 22.07% (97.5% percentile), so the uncertainty in trend is from -29.35% to 38.11% with respect to the base year emissions.

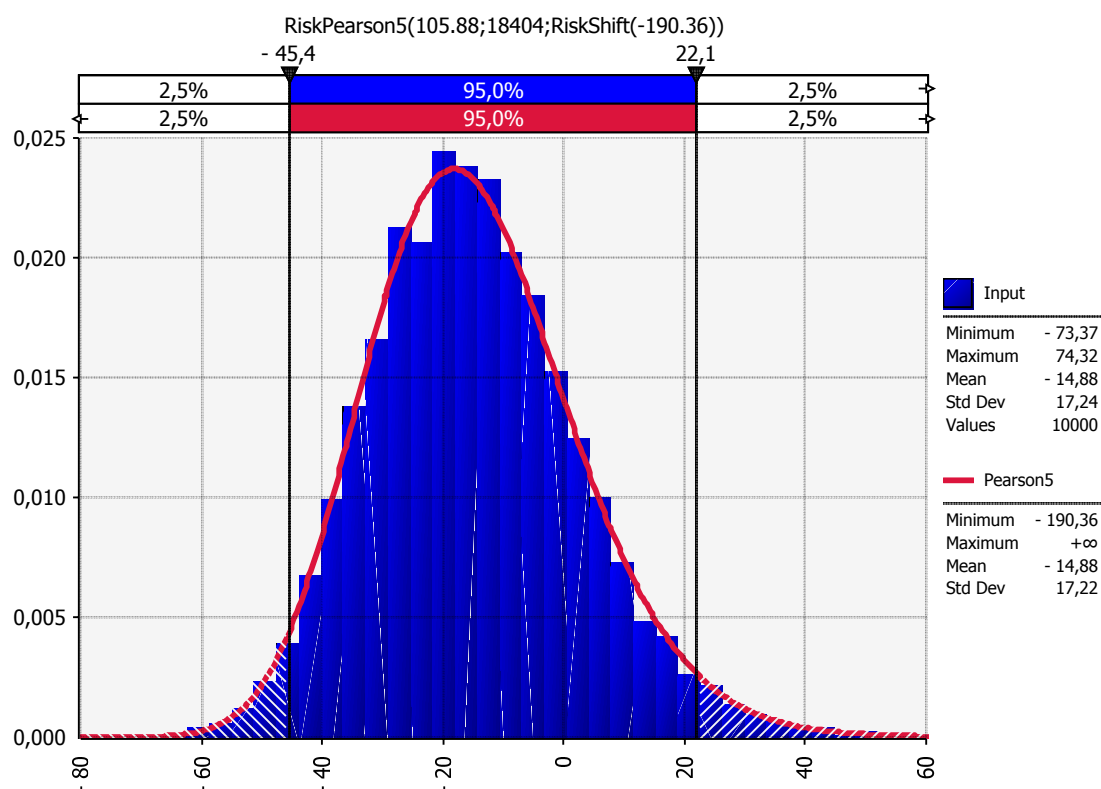


Figure A5.1-6: Distribution of trend for year 2011 respect to year 1990

Figure A5.1-6: shows the distribution of trend for year 2011 respect to year 1990 with a corresponding probability density function (red line) that best matches the simulation results.

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
	IPCC Source Category	Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach
1	ENERGY SECTOR													
1.1	CO2 Emissions from Stationary Combustion: Coal	CO2	2780.45	2825.24										
	1.A.1. Energy Industries	CO2												
	a. Public Electricity and Heat Production	CO2	589.30	2250.17	1.50	1.50	2.00	2.00	2.47	2.50	281.84	-26.66	30.22	
	1.A.2 Manufacturing Industries and Construction	CO2												
	a. Iron and Steel	CO2	IE,NO	10.73	2.50	2.50	5.00	5.00	5.42	5.62				5,6
	c. Chemicals	CO2	IE,NO		2.50	2.50	5.00	5.00	5.42	5.62				5,6
	e. Food Processing, Beverages and Tobacco	CO2	IE,NO	87.30	4.00	4.00	5.00	5.00	6.43	6.46				5,6
	Mineral industry	CO2	IE	454.49	2.50	2.50	5.00	5.00	5.62	5.70				5,6
	Manufacturing Industries and Construction Total (1990-2000)	CO2	1676.79	IE										1,5
	1.A.4 Other Sectors	CO2												
	a. Commercial/Institutional	CO2	86.49	8.49	4.00	4.00	5.00	5.00	6.25	6.55	-90.19	-0.84	0.92	
	b. Residential	CO2	427.86	14.06	4.00	4.00	5.00	5.00	6.29	6.40	-96.71	-0.29	0.31	
	Summary results for a given category	CO2	2780.45	2825.24					2.17	2.20	1.61	-4.26	4.53	
1.2	CO2 Emissions from Stationary Combustion: Oil	CO2	8497.04	3926.13										
	1.A.1. Energy Industries													
	a. Public Electricity and Heat Production	CO2	2132.15	516.13	5.00	5.00	5.00	5.00	7.02	7.26	-75.79	-2.31	2.57	
	b. Petroleum Refining	CO2	2552.06	1597.19	2.50	2.50	5.00	5.00	5.57	5.74	-37.42	-4.73	5.26	
	c. Manufacture of Solid Fuels and Other Energy Industries	CO2	39.22	IE	4.00	4.00	5.00	5.00						
	1.A.2 Manufacturing Industries and Construction	CO2												
	a. Iron and Steel	CO2	IE,NO	12.98	2.50	2.50	5.00	5.00	5.50	5.53				5,6
	b. Non-Ferrous Metals	CO2	IE,NO	16.06	2.50	2.50	5.00	5.00	5.62	5.61				5,6

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011 (cont.)

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
	IPCC Source Category	Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach 2
	c. Chemicals	CO2	IE,NO	16.63	4.0	4.0	5.0	5.0	6.3	6.5				5,6
	d. Pulp, Paper and Print	CO2	IE,NO	22.46	4.0	4.0	5.0	5.0	6.3	6.4				5,6
	e. Food Processing, Beverages and Tobacco	CO2	IE,NO	108.04	4.0	4.0	5.0	5.0	6.4	6.5				5,6
	Mineral industry	CO2	IE,NO	724.07	2.5	2.5	5.0	5.0	5.6	5.7				5,6
	Manufacturing Industries and Construction Total (1990-2000)	CO2	2135.51	IE										1,5
	1.A.4 Other Sectors													
	a. Commercial/Institutional	CO2	525.43	272.91	4.0	4.0	5.0	5.0	6.3	6.5	-48.06	-4.52	4.94	
	b. Residential	CO2	1112.67	639.65	4.0	4.0	5.0	5.0	6.4	6.3	-42.51	-4.91	5.47	
	Summary results for a given category	CO2	8497.04	3926.13					2.9	2.9	-53.79	-1.86	1.97	
1.3	CO2 Emissions from Stationary Combustion: Gas	CO2	4458.54	5183.03										
	1.A.1. Energy Industries	CO2												
	a. Public Electricity and Heat Production	CO2	964.76	1436.40	5.00	5.00	5.00	5.00	6.85	7.09	48.89	-14.46	-15.38	
	b. Petroleum Refining	CO2	13.85	156.38	2.50	2.50	5.00	5.00	5.56	5.71	1028.77	-85.93	-91.93	
	c. Manufacture of Solid Fuels and Other Energy Industries	CO2	835.19	296.64	4.00	4.00	5.00	5.00	6.23	6.48	-64.48	-3.09	-3.43	
	1.A.2 Manufacturing Industries and Construction	CO2												
	a. Iron and Steel	CO2	IE,NO	59.78	2.50	2.50	5.00	5.00	5.57	5.56				5,6
	b. Non-Ferrous Metals	CO2	IE,NO	2.28	2.50	2.50	5.00	5.00	5.52	5.67				5,6
	c. Chemicals	CO2	IE,NO	398.93	4.00	4.00	5.00	5.00	6.33	6.52				5,6
	d. Pulp, Paper and Print	CO2	IE,NO	124.88	4.00	4.00	5.00	5.00	6.30	6.49				5,6
	e. Food Processing, Beverages and Tobacco	CO2	IE,NO	296.26	4.00	4.00	5.00	5.00	6.36	6.55				5,6
	Mineral industry	CO2	IE	347.12	2.50	2.50	5.00	5.00	5.57	5.67				5,6

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011 (cont.)

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
	IPCC Source Category	Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach 2
	Manufacturing Industries and Construction Total (1990-2000)	CO ₂	1635.00	IE										1,5
	Petrochemical Production	CO ₂	395.62	457.05	4.00	4.00	5.00	5.00	6.41	6.55	15.53	-9.96	11.03	
	1.A.4 Other Sectors	CO ₂												
	a. Commercial/Institutional	CO ₂	159.30	331.31	4.00	4.00	5.00	5.00	6.40	6.50	107.98	-18.07	19.78	
	b. Residential	CO ₂	454.82	1276.01	4.00	4.00	5.00	5.00	6.30	6.40	180.55	-24.20	27.09	
	Summary results for a given category	CO ₂	4458.54	5183.03					2.69	2.71	16.25	-4.54	4.76	
1.4	Mobile Combustion: Road Vehicles	CO ₂	3592.69	5534.94										
	Gasoline	CO ₂	2447.50	2004.41	3.00	3.00	3.00	5.00	4.18	4.37	-18.10	-4.80	5.19	
	Diesel	CO ₂	1145.19	3400.21	3.00	3.00	2.00	1.00	3.56	3.60	196.91	-14.71	15.67	
	LPG	CO ₂		130.32	3.00	3.00	2.00	4.00	3.62	3.68				1,5
	Summary results for a given category		3592.69	5534.94					2.69	2.67	54.06	-6.27	6.44	
1.5	Combustion: Agriculture/Forestry/Fishing	CO ₂	839.19	714.32										
	Gasoline	CO ₂	12.24	25.09	3.00	3.00	3.00	5.00	4.24	4.20	105.00	-8.63	8.78	
	Other kerosene	CO ₂	0.32		3.00	3.00	2.00	2.00						5
	Diesel	CO ₂	728.45	626.98	3.00	3.00	2.00	1.00	3.59	3.63	-13.93	-4.27	4.50	
	Fuel oil	CO ₂	37.86	13.54	3.00	3.00	3.00	2.00	4.24	4.20	-64.23	-2.08	2.18	
	LPG	CO ₂	12.88	7.90	3.00	3.00	2.00	4.00	3.59	3.69	-38.64	-3.04	3.21	
	Natural gas	CO ₂	47.45	40.80	3.00	3.00	3.00	4.00	4.21	4.27	-14.00	-3.60	3.68	
	Summary results for a given category		839.19	714.32					3.15	3.20	-14.88	-3.68	3.87	

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011 (cont.)

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
	IPCC Source Category	Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach 2
1.6	Mobile Combustion: Aircraft	CO2												
	Jet Gasoline	CO2	NO	1.84	3.0	3.0	4.0	4.0	5.0	5.1		-3.26	3.57	
	Jet kerosene	CO2	154.72	88.05	3.0	3.0	3.0	4.0	4.2	4.3	-43.10	-3.26	3.57	
	Summary results for a given category		154.72	77.42					4.1	4.2	-41.91	-3.29	3.61	
1.7	Fugitive Emissions from Oil and Gas Operations	CH4	1202.28	1427.49	5.0	5.0	300.0	300.0						2,4
	Summary results for a given category		1202.28	1427.49					300.2	299.8	18.73	-1608.00	1270.53	2,4
1.8	Fugitive Emissions from Oil and Gas Operations	CO2	839.19	714.32	10.0	10.0	3.0	3.0	10.3	10.3				
	Summary results for a given category		839.19	714.32					10.3	10.3	-14.88	-11.48	13.48	3,4

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011 (cont.)

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
	IPCC Source Category	Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach 2
2	INDUSTRIAL PROCESSES													
2.1	2(I)A.1. CO2 Emissions from Cement Production	CO2	1085.79	1050.36										
	Portland cement		1071.58	1017.69	3.00	3.00	3.00	3.00	4.18	4.33	-5.03	-5.47	5.84	
	Aluminate cement		14.21	32.67	3.00	3.00	3.00	3.00	4.16	4.26	129.88	-13.39	14.28	
	Summary results for a given category		1085.79	1050.36					4.06	4.20	-3.26	-5.45	5.84	
2.2	2(I)A.2. CO2 Emissions from Lime Production	CO2	153.44	89.24										
	Quicklime		146.94	63.65	3.00	3.00	3.00	3.00	4.21	4.28	-56.69	-2.52	2.65	
	Dolomitic lime		6.50	25.60	3.00	3.00	3.00	3.00	4.19	4.17	293.92	-22.66	24.29	
	Summary results for a given category		153.44	89.24					3.27	3.25	-41.84	-2.98	3.08	
2.3	2(I)B.1. CO2 Emissions from Ammonia Production	CO2	466.01	475.94										
	Natural gas consumption in process				3.00	3.00	5.00	5.00	5.80	5.81	2.13	-7.98	8.72	
	Summary results for a given category		466.01	475.94					5.80	5.81	2.13	-7.98	8.72	
2.4	2(I)C.2. CO2 Emissions from Ferroalloys Production	CO2	118.84											
	Coke from coal		112.27		7.50	7.50	30.00	30.00						5
	Coal electrode		6.57		7.50	7.50	30.00	30.00						5
	Summary results for a given category		118.84											
2.5	2(I)C.3. CO2 Emissions from Aluminium Production	CO2	111.37											5
	Aluminium production				3.00	3.00	30.00	30.00						5
	Summary results for a given category		111.37											5
2.6	2(II)B.5.CH4 Emissions from Production of Other Chemicals	CH4	15.80											
	Carbon black		7.07		7.50	7.50	30.00	30.00			-100.00			
	Ethylene		1.53		7.50	7.50	30.00	30.00			-100.00			
	Dichloroethylene		0.61		7.50	7.50	30.00	30.00			-100.00			5
	Styrene		0.75		7.50	7.50	30.00	30.00			-100.00			5
	Coke		5.84		7.50	7.50	30.00	30.00			-100.00			5
	Summary results for a given category		15.80								-100.00			
2.7	2(II)B.2. N2O Emissions from Nitric Acid Production	N2O	803.89	804.50										
	Nitric acid production				3.00	3.00	30.00	30.00	30.09	30.45	0.08	-4.15	4.35	
	Summary results for a given category		803.89	804.50					30.09	30.45	0.08	-4.15	4.35	

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011(cont.)

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
	IPCC Source Category	Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach 2
2.8.	2(II)F(a) HFC Emissions from Consumption of HFCs, PFCs, SF6		10.95	485.77										
	2(II)F(a)1. Refrigeration and air conditioning equipment													
	Domestic Refrigeration													
	HFC-134a	HFC-134a		0.37	50.00	50.00	50.00	50.00	62.25	80.62				5
	Commercial Refrigeration			101.71										5
	HFC-125	HFC-125		38.44	50.00	50.00	50.00	50.00	62.90	80.50				5
	HFC-134a	HFC-134a		1.62	50.00	50.00	50.00	50.00	62.79	81.46				5
	HFC-143a	HFC-143a		61.65	50.00	50.00	50.00	50.00	61.84	78.98				5
	Transport Refrigeration													
	HFC-134a	HFC-134a		186.32	50.00	50.00	50.00	50.00	62.69	77.78				5
	Industrial Refrigeration			21.58										5
	HFC-125	HFC-125		13.78	50.00	50.00	50.00	50.00	62.49	81.11				5
	HFC-134a	HFC-134a		4.43	50.00	50.00	50.00	50.00	61.81	80.53				5
	HFC-32	HFC-32		3.06	50.00	50.00	50.00	50.00	62.14	80.41				5
	HFC-143a	HFC-143a		0.30	50.00	50.00	50.00	50.00	93.61	-69.04				5
	Stationary Air-Conditioning													
	HFC-125	HFC-125		11.83	50.00	50.00	50.00	50.00	62.17	79.64				5
	HFC-134a	HFC-134a		3.92	50.00	50.00	50.00	50.00	61.74	79.60				5
	HFC-32	HFC-32		2.67	50.00	50.00	50.00	50.00	61.76	77.89				5
	Mobile Air-Conditioning													
	HFC-134a	HFC-134a		138.26	50.00	50.00	50.00	50.00	62.79	80.28				5
	2(II)F(a)1. Refrigeration and Air Conditioning Equipment - potential													5
	PFC-14	PFC-14		0.01	50.00	50.00	50.00	50.00						5
	PFC-218	PFC-218		0.42	50.00	50.00	50.00	50.00	50.03	49.98				5
	HFC-23	HFC-23		0.88	50.00	50.00	50.00	50.00	50.02	49.96				5
	2(II)F(a)3. Fire Extinguishers													
	HFC-227ea	HFC-227ea		0.58	50.00	50.00	50.00	50.00	100.00	81.13				5
	HFC-125	HFC-125			50.00	50.00	50.00	50.00						5
	HFC-236fa	HFC-236fa		0.30	50.00	50.00	50.00	50.00	61.76	81.13				5
	2(II)F(a)4. Aerosols/Metered Dose Inhalers													
	HFC-134a	HFC-134a		7.97	50.00	50.00	50.00	50.00	50.01	49.97				
	2(II)F(a)8. Electrical Equipment													
	SF6	SF6	10.95	9.82	50.00	50.00	50.00	50.00	50.00	49.97	-10.38	-48.85	107.80	
	Summary results for a given category		10.95	485.77					31.95	36.18	4495.52	-1975.33	4925.17	

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011(cont.)

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
	IPCC Source Category	Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach 2
2.9	2.(I)C.3. PFC Emissions from Aluminium Production	N2O	936.56											
	Aluminium production													
	CF4	CF4	820.44	NO	3.00	3.00	30.00	30.00						5
	C2F6	C2F6	116.12	NO	3.00	3.00	30.00	30.00						5
	Summary results for a given category		936.56											5
	Swine	N2O												
3	3.CO2 Emissions from Solvent and Other Product use	CO2	82.26	107.41										
	3.A. Paint application	CO2	16.08	12.17	50.00	50.00	50.00	50.00	62.76	81.29	-24.31	-51.46	148.51	
	3.B.Degreasing and dry cleaning	CO2	15.40	14.19	50.00	50.00	50.00	50.00	50.02	49.98	-7.85	-50.41	113.50	
	3.C. Chemical products	CO2	8.26	4.26	50.00	50.00	50.00	50.00	61.94	79.20	-48.45	-34.63	106.45	
	3.D. Other use of solvent	CO2	42.51	76.78	50.00	50.00	50.00	50.00	62.37	80.57	80.63	-121.58	378.54	
	Summary results for a given category		82.26	107.41					46.01	58.98	30.58	-66.51	122.77	

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011 (cont.)

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
	IPCC Source Category	Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach 2
4	AGRICULTURE SECTOR													
4.1	4.A.CH4 Emissions from Enteric Fermentation in Domestic Livestock	CH4												
	Dairy Cattle	CH4	751.97	403.22	10.00	10.00	20.00	20.00	21.87	22.25	-46.38	-14.76	20.30	
	Mature non-dairy	CH4	66.13	36.84	10.00	10.00	20.00	20.00	21.77	22.73	-44.29	-15.25	21.22	
	Young	CH4	275.56	202.07	10.00	10.00	20.00	20.00	22.21	22.95	-26.67	-20.22	27.36	
	Sheep	CH4	78.86	107.29	10.00	10.00	20.00	20.00	21.73	23.10	36.05	-37.19	51.77	
	Goats	CH4	18.06	7.35	10.00	10.00	20.00	20.00	22.19	22.76	-59.28	-11.16	15.44	
	Horses	CH4	14.74	7.58	10.00	10.00	20.00	20.00	21.63	22.99	-48.61	-14.17	19.41	
	Mules & Asses	CH4	3.57	0.59	10.00	10.00	20.00	20.00	21.53	22.89	-83.36	-4.57	6.24	
	Swine	CH4	33.03	38.85	10.00	10.00	20.00	20.00	22.07	23.11	17.62	-32.92	44.57	
	Poultry	CH4												5
	Summary results for a given category		1241.92	803.80					12.84	12.98	-35.28	-11.43	14.03	
4.2.	4.B(a) CH4 Emissions from Manure Management		228.62	167.79										
	Dairy Cattle	CH4	58.01	23.14	10.00	10.00	20.00	20.00	21.87	22.99	-60.10	-10.91	14.91	
	Mature non-dairy	CH4	4.03	2.25	10.00	10.00	20.00	20.00	21.94	22.75	-44.29	-15.34	21.57	
	Young	CH4	27.05	19.83	10.00	10.00	20.00	20.00	22.08	23.04	-26.67	-20.30	27.35	
	Sheep	CH4	1.58	2.55	10.00	10.00	20.00	20.00	21.67	23.18	61.57	-44.38	59.62	
	Goats	CH4	0.40	0.18	10.00	10.00	20.00	20.00	21.77	23.21	-55.58	-12.27	16.87	
	Horses	CH4	0.90	0.59	10.00	10.00	20.00	20.00	22.06	23.08	-34.60	-17.63	24.71	
	Mules & Asses	CH4	0.21	0.05	10.00	10.00	20.00	20.00	21.54	22.75	-78.93	-5.68	7.74	
	Swine	CH4	132.13	103.61	10.00	10.00	20.00	20.00	21.92	23.12	-21.59	-21.70	29.38	
	Poultry	CH4	4.31	15.60	10.00	10.00	20.00	20.00	22.06	23.47	261.96	-99.41	135.56	
	Summary results for a given category		228.62	172.36					14.33	15.02	-26.61	-13.68	16.77	
4.3.	4.B(b) N2O Emissions from Manure Management	N2O	381.84	204.59										
	Anaerobic lagoons	N2O	0.72	0.51										
	Mature non-dairy	N2O	0.09	0.05	10.00	10.00	50.00	100.00	50.64	80.59	-44.29	-7.43	8.56	
	Young	N2O	0.63	0.46	10.00	10.00	50.00	100.00	50.28	82.30	-26.67	-9.64	11.18	
	Liquid systems	N2O	12.18	7.89										
	Dairy Cattle	N2O	2.83	1.13	10.00	10.00	50.00	100.00	50.61	80.83	-60.10	-5.35	6.06	

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011 (cont.)

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
IPCC Source Category		Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach 2
Mature non-dairy		N ₂ O	0.46	0.25	10.00	10.00	50.00	100.00	50.33	80.39	-44.29	-7.38	8.46	
Young		N ₂ O	3.06	2.24	10.00	10.00	50.00	100.00	50.56	81.17	-26.67	-9.72	11.05	
Swine		N ₂ O	4.44	3.48	10.00	10.00	50.00	100.00	50.34	80.89	-21.59	-10.51	12.10	
Poultry		N ₂ O	1.40	0.78	10.00	10.00	50.00	100.00	50.32	80.67	-44.31	-7.28	8.29	
Solid storage & drylot		N ₂ O	307.25	151.77										
Dairy Cattle		N ₂ O	213.52	85.19	10.00	10.00	50.00	100.00	50.18	79.29	-60.10	-5.25	6.00	
Mature non-dairy		N ₂ O	12.16	6.77	10.00	10.00	50.00	100.00	50.32	80.62	-44.29	-7.30	8.41	
Young		N ₂ O	81.57	59.81	10.00	10.00	50.00	100.00	50.70	80.79	-26.67	-9.69	11.14	
Other		N ₂ O	61.69	44.41										
Mature non-dairy		N ₂ O	0.06	0.03	10.00	10.00	50.00	100.00	58.39	102.71	-44.29	-7.42	8.61	
Young		N ₂ O	0.39	0.29	10.00	10.00	50.00	100.00	57.82	103.00	-26.67	-9.80	11.12	
Sheep		N ₂ O	7.90	6.72	10.00	10.00	50.00	100.00	58.42	101.53	-14.97	-11.44	13.09	
Goats		N ₂ O	0.84	0.34	10.00	10.00	50.00	100.00	58.38	102.83	-59.28	-5.39	6.15	
Horses		N ₂ O	0.19	0.10	10.00	10.00	50.00	100.00	58.09	103.92	-48.61	-6.79	7.72	
Mules & Asses		N ₂ O	0.08	0.01	10.00	10.00	50.00	100.00	58.37	102.28	-83.36	-2.16	2.54	
Swine		N ₂ O	34.48	27.04	10.00	10.00	50.00	100.00	58.23	103.59	-21.59	-10.33	12.18	
Poultry		N ₂ O	17.75	9.88	10.00	10.00	50.00	100.00	58.29	103.72	-44.31	-7.31	8.54	
Summary results for a given category			381.84	212.24					30.41	41.45	-46.42	-6.79	7.82	
4.4. 4.D Agricultural Soils														
Direct N₂O Emissions from Agricultural Soils		N ₂ O	1333.13	1184.33										
Synthetic fertiliser (FSN)		N ₂ O	616.15	642.62	30.00		80.00	80.00	81.29	95.04	5.27	-43.27	113.05	
Animal waste (FAW)		N ₂ O	407.63	249.35	10.00	10.00	80.00	80.00	79.95	81.88	-38.83	-8.11	9.36	
N-fixing crops (FBN)		N ₂ O	105.36	96.65	10.00	10.00	80.00	80.00	80.41	82.83	-8.26	-12.14	14.12	
Crop residue (FCR)		N ₂ O	198.25	189.94	10.00	10.00	80.00	80.00	79.91	82.01	-4.19	-12.58	14.85	
Histosols		N ₂ O	5.74		20.00	20.00	60.00	60.00	61.18	64.84		-24.85	33.39	
Sewage sludge (NSLUDGE)		N ₂ O		0.02	50.00	50.00	80.00	80.00	82.62	109.37				5
Summary results for a given category			1333.13	1184.33					49.88	55.74	-10.71	-21.87	38.95	
N₂O Emissions from Pasture Range and Paddock Manure		N ₂ O	261.13	175.22										
Dairy Cattle		N ₂ O	40.82	16.29	10.00	10.00	63.00	63.00	63.26	64.80	-60.10	-5.32	5.98	
Sheep		N ₂ O	85.46	72.67	10.00	10.00	63.00	63.00	63.29	64.79	-14.97	-11.47	12.93	

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011 (cont.)

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
	IPCC Source Category	Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach 2
	Goats	N ₂ O	38.54	15.69	10.00	10.00	63.00	63.00	63.45	65.33	-59.28	-5.50	6.18	
	Horses	N ₂ O	8.74	4.49	10.00	10.00	63.00	63.00	63.19	63.96	-48.61	-6.70	7.77	
	Mules & Asses	N ₂ O	3.81	0.63	10.00	10.00	63.00	63.00	63.34	65.89	-83.36	-2.16	2.56	
	Swine	N ₂ O	82.76	64.89	10.00	10.00	63.00	63.00	63.52	64.71	-21.59	-10.41	12.18	
	Poultry	N ₂ O	1.00	0.56	10.00	10.00	63.00	63.00	63.63	64.19	-44.31	-7.42	8.27	
	Summary results for a given category	N ₂ O	261.13	177.39					35.91	37.19	-32.90	-8.22	7.90	
	Indirect N₂O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.07	782.80										
	Deposition	N ₂ O	137.97	111.46					64.27	76.59	-19.22	-9.80	15.11	4,7
	Synthetic fertiliser	N ₂ O	30.34	44.06										
	Livestock excretion	N ₂ O	107.64	67.39										
	Leaching	N ₂ O	796.09	671.34					89.16	299.84	-23.52	-17.00	27.22	4,7
	Synthetic fertiliser	N ₂ O	392.44	418.62										
	Livestock excretion	N ₂ O	403.65	252.72										
	Summary results for a given category	N ₂ O	934.07	782.80					77.71	256.71	-22.89	-14.58	21.07	4,7

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011 (cont.)

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
	IPCC Source Category	Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach 2
6	WASTE SECTOR													
6.1.	6 A.CH4 Emissions from Solid Waste Disposal Sites		242.62	770.89										
	Managed SWDS	CH4	12.01	565.61	50.00	50.00	50.00	50.00	72.70	94.17	4609.17	-3504.21	10008.32	
	Unmanaged SWDS > 5m	CH4	150.54	183.11	50.00	50.00	50.00	50.00	63.14	81.30	21.64	-83.13	251.66	
	Unmanaged SWDS < 5m	CH4	80.07	22.17	50.00	50.00	50.00	50.00	61.80	81.73	-72.32	-18.81	57.40	
	Summary results for a given category		242.62	770.89					56.53	70.43	217.73	-190.55	387.59	
6.2.	6 B.CH4 Emissions from Wastewater Handling		237.25	203.59										
	6 B 1. Industrial Wastewater	CH4			50.00	50.00	30.00	30.00						
	6 B.2 Domestic and Commercial Wastewater	CH4	237.25	203.59	50.00	50.00	30.00	30.00	53.82	61.67	-14.19	-46.95	101.61	
	Summary results for a given category		237.25	203.59					53.82	61.67	-14.19	-46.95	101.61	

Table A.5.1-1: Uncertainty estimates from the Monte Carlo simulation for year 2011 (cont.), including LULUCF

Emissions, removals and uncertainties are from National Inventory of Croatia for year 2011														
YEAR 2011														
	A	B	C	D	E		F		G		I	J		K
	IPCC Source Category	Greenhouse Gas	Year 1990 emissions or removals	Year t emissions or removals 2011	Activity data uncertainty		Emission factor uncertainty		Combined uncertainty		Inventory trend in national emissions for year t increase with respect to year 1990 (distribution function)	Uncertainty introduced into the trend in total national emissions with respect to year 1990		Approach and Comments
			Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(% of year 1990)	(-)%	(+)%	Approach 2
5	LULUCF													
5.A.1.	Forestland remaining Forestland	CO2	-6711.71	-7462.51					61.87	61.86	11.19	-73.13	193.30	8
5.A.1.	Forestland remaining Forestland	CH4	12.50	6.82					160.89	160.81	-45.46	-552.50	535.88	8
5.A.1.	Forestland remaining Forestland	N2O	2.86	1.56					163.13	162.88	-45.46	-578.56	571.20	8
5.A.2.	Land converted to Forestland	CO2	-272.64	-174.96					172.69	172.48	-35.83	-691.88	622.99	8
5.B.1.	Cropland remaining Cropland	CO2	136.48	50.04					1179.99	1179.63	-63.33	-791.82	718.71	8
5.B.2.	Land converted to Cropland	CO2	23.48	43.94					444.33	444.22	87.18	-2090.52	2174.27	8
5.B.2.2.	Grassland converted to Cropland: mineral soils	N2O	4.86	9.09					398.02	397.53	87.24	-2442.98	2240.64	8
5.C.1.	Grassland remaining Grassland	CO2	2.67	2.67					96.22	96.18		-134.07	523.30	8
5.C.2.	Land converted to Grassland	CO2	87.86	128.35					396.60	396.22	46.08	-2119.33	1919.36	8
5.D.2.	Land converted to Wetlands	CO2	30.00	17.32					343.08	342.76	-42.24	-829.21	728.80	8
5.E.2.	Land converted to Settlements	CO2	448.15	602.58					155.63	155.56	34.46	-260.48	665.08	8
	Summary results for a given category		-6411.22	-7031.80										

Approach and Comments:

1. Manufacturing Industries and Construction Total (1990-2000) is emission category which existed till 2000 year; afterwards its emission was included in other source categories.
2. Fugitive Emissions from Oil and Gas Operations: for this category wasn't enough data to calculate combine uncertainty with Monte-Carlo method, therefore combine uncertainty data from tier 1 method was implied in model.
3. CO₂ Emissions from Natural Gas Scrubbing: for this category wasn't enough data to calculate combine uncertainty with Monte-Carlo method, therefore combine uncertainty data from tier 1 method was implied in model.
4. A more complex method for estimation of uncertainties is used, and therefore activity data and emission factor uncertainties are left blank. Only combined uncertainty and trend uncertainty is shown in model.
5. Trend not calculated, when base year or year *t* emissions are zero or included elsewhere
6. Emission is included in category Other Manufacturing Industries and Construction Total (1990-2000). There were no disaggregated data till 2000.
7. Because of the existence of variables in model with triangle distribution there is a slight deviation of emission in model and in CRF-REPORTER
*Left value is "real" value from crf reporter and right value is mean value of variable with its distribution
8. Combined uncertainty was used in Monte Carlo simulation for LULUCF sector

Table A5.1-2: Summary uncertainty table for year 1990 and 2011 excluding LULUCF

IPCC Source Category	Greenhouse Gas	1990 Emissions Gg CO ₂ equivalent Gg CO ₂ equivalent	2011 Emissions Gg CO ₂ equivalent Gg CO ₂ equivalent	Uncertainty in 1990 emissions as % of emissions in category		Uncertainty introduced on national total in 1990		Uncertainty in 2011 emissions as % of emissions in category		Uncertainty introduced on national total in 2011		% change in emissions between 2011 and 1990 %	Range of likely % change between 2011 and 1990	
				2.5 percentile Gg CO ₂ equivalent	97.5 percentile Gg CO ₂ equivalent	(-)% (-)%	(+) % (+) %	2.5 percentile Gg CO ₂ equivalent	97.5 percentile Gg CO ₂ equivalent	(-)% (-) %	(+) % (+) %			
ENERGY SECTOR														
CO2 Emissions from Stationary Combustion: Coal	CO2	2780.45	2825.24	2677.63	2884.15	4%	4%	2763.86	2887.49	2%	2%	1.61	-2.65	6.14
CO2 Emissions from Stationary Combustion: Oil	CO2	8497.04	3926.13	8246.39	8748.07	3%	3%	3813.72	4041.09	3%	3%	-53.79	-55.66	-51.82
CO2 Emissions from Stationary Combustion: Gas	CO2	4458.54	5183.03	4327.60	4594.21	3%	3%	5043.35	5323.55	3%	3%	16.25	11.71	21.01
Mobile Combustion: Road Vehicles	CO2	3592.69	5537.15	3480.14	3703.86	3%	3%	5386.20	5682.62	3%	3%	54.06	47.79	60.50
Combustion: Agriculture/Forestry/Fishing	CO2	839.19	714.32	812.74	865.37	3%	3%	691.79	737.16	3%	3%	-14.88	-18.56	-11.01
Fugitive Emissions from Oil and Gas Operations	CH4	1202.28	1427.49	-2408.81	4807.53	300%	300%	-2857.28	5707.65	300%	300%	18.73	-1589.26	1289.26
Fugitive Emissions from Oil and Gas Operations	CO2	639.82	577.16	752.69	925.55	10%	10%	640.71	787.85	10%	10%	-14.88	-26.36	-1.40
Mobile Combustion: Aircraft	CO2	154.72	89.88	148.06	161.24	4%	4%	86.17	93.70	4%	4%	-41.91	-45.20	-38.30
INDUSTRIAL PROCESSES														
CO ₂ Emissions from Cement Production	CO2	1085.79	1050.36	1040.28	1131.10	4%	4%	1007.73	1094.51	4%	4%	-3.26	-8.71	2.57
CO ₂ Emissions from Lime Production	CO2	153.44	89.24	147.27	159.84	4%	4%	86.32	92.15	3%	3%	-41.84	-44.82	-38.76
CO ₂ Emissions from Ammonia Production	CO2	466.01	475.94	438.90	493.16	6%	6%	448.33	503.59	6%	6%	2.13	-5.85	10.85
CO ₂ Emissions from Ferroalloys Production	CO2	118.84		84.25	154.27	29%	30%							
CO ₂ Emissions from Aluminium Production	CO2	111.37		77.68	145.32	30%	30%							
CH ₄ Emissions from Production of Other Chemicals	CH4	14.27	0.00	12.91	18.70	18%	18%					-100.00	-100.00	-100.00
N ₂ O Emissions from Nitric Acid Production	N2O	803.89	804.50	560.86	1046.49	30%	30%	562.41	1049.46	30%	30%	0.08	-4.07	4.43
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC		467.10	5.47	16.43	50%	50%	342.55	685.56	32%	36%	4495.52	2520.19	9420.69
HFC and PFC Emissions from Other Consumption	HFC/PFC		8.86	5.47	16.43	50%	50%	342.55	685.56	32%	36%	4495.52	2520.19	9420.69
SF ₆ Emissions from Other Consumption	SF6	10.95	9.82	5.47	16.43	50%	50%	342.55	685.56	32%	36%	4495.52	2520.19	9420.69
PFC Emissions from Aluminium production	PFC	936.56		687.15	1186.68	27%	27%							
SOLVENT AND OTHER PRODUCT USE														
CO ₂ Emissions from solvent and other product use	CO2	82.26	107.41	51.53	119.73	37%	46%	57.99	170.77	46%	59%	30.58	-35.94	153.34
AGRICULTURE SECTOR														
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH4	1241.92	803.80	1064.38	1424.18	14%	15%	700.63	908.12	13%	13%	-35.28	-46.71	-21.25
CH ₄ Emissions from Manure Management	CH4	228.62	167.79	196.36	262.21	14%	15%	143.74	192.98	14%	15%	-26.61	-40.29	-9.84
N ₂ O Emissions from Manure Management	N2O	381.84	204.59	256.61	565.98	33%	48%	142.38	289.39	30%	41%	-46.42	-53.21	-38.60
Direct N ₂ O Emissions from Agricultural Soils	N2O	1333.13	1184.33	676.12	2092.77	49%	57%	596.61	1853.80	50%	56%	-10.71	-32.59	28.24
N ₂ O Emissions from Pasture Range and Paddock Manure	N2O	261.13	175.22	176.93	345.83	32%	32%	112.31	240.39	36%	37%	-32.90	-41.12	-24.99
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N2O	934.07	782.80			78%	260%			78%	257%	-22.89	-37.47	-1.81
LULUCF														
WASTE SECTOR														
CH ₄ Emissions from Solid Waste Disposal Sites	CH4	242.62	770.89	131.98	375.28	46%	55%	335.16	1313.94	57%	70%	217.73	27.18	605.32
CH ₄ Emissions from Wastewater Handling	CH4	237.25	203.59	109.46	389.90	54%	64%	94.02	329.16	54%	62%	-14.19	-61.14	87.42
TOTAL		31009.66	27682.76	27060.40	35335.54	13%	14%	23122.56	32364.79	16%	17%	-10.73	-27.01	8.62

Table A5.1-2: Summary uncertainty table for year 1990 and 2011 including LULUCF

SUMMARY TABLE OF KEY SOURCE EMISSIONS AND THEIR UNCERTAINTIES FOR YEAR 1990 AND 2011														
IPCC Source Category	Greenhouse Gas	1990 Emissions	2011 Emissions	Uncertainty in 1990 emissions as % of emissions in category		Uncertainty introduced on national total in 1990		Uncertainty in 2011 emissions as % of emissions in category		Uncertainty introduced on national total in 2011		% change in emissions between 2011 and 1990	Range of likely % change between 2011 and 1990	
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	2.5 percentile	97.5 percentile	(-)%	(+)%	2.5 percentile	97.5 percentile	(-)%	(+)%	%	2.5 percentile	97.5 percentile
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	Gg CO ₂ equivalent	Gg CO ₂ equivalent	(-)%	(+)%	%	Gg CO ₂ equivalent	Gg CO ₂ equivalent
ENERGY SECTOR														
CO2 Emissions from Stationary Combustion: Coal	CO2	2780.45	2825.24	2677.63	2884.15	4%	4%	2763.86	2887.49	2%	2%	1.61	-2.65	6.14
CO2 Emissions from Stationary Combustion: Oil	CO2	8497.04	3926.13	8246.39	8748.07	3%	3%	3813.72	4041.09	3%	3%	-53.79	-55.66	-51.82
CO2 Emissions from Stationary Combustion: Gas	CO2	4458.54	5183.03	4327.60	4594.21	3%	3%	5043.35	5323.55	3%	3%	16.25	11.71	21.01
Mobile Combustion: Road Vehicles	CO2	3592.69	5537.15	3480.14	3703.86	3%	3%	5386.20	5682.62	3%	3%	54.06	47.79	60.50
Combustion: Agriculture/Forestry/Fishing	CO2	839.19	714.32	812.74	865.37	3%	3%	691.79	737.16	3%	3%	-14.88	-18.56	-11.01
Fugitive Emissions from Oil and Gas Operations	CH4	1202.28	1427.49	-2408.81	4807.53	300%	300%	-2857.28	5707.65	300%	300%	18.73	-1589.26	1289.26
CO2 Emissions from Natural Gas Scrubbing	CO2	639.82	577.16	752.69	925.55	10%	10%	640.71	787.85	10%	10%	-14.88	-26.36	-1.40
Mobile Combustion: Aircraft	CO2	154.72	89.88	148.06	161.24	4%	4%	86.17	93.70	4%	4%	-41.91	-45.20	-38.30
INDUSTRIAL PROCESSES														
CO ₂ Emissions from Cement Production	CO2	1085.79	1050.36	1040.28	1131.10	4%	4%	1007.73	1094.51	4%	4%	-3.26	-8.71	2.57
CO ₂ Emissions from Lime Production	CO2	153.44	89.24	147.27	159.84	4%	4%	86.32	92.15	3%	3%	-41.84	-44.82	-38.76
CO ₂ Emissions from Ammonia Production	CO2	466.01	475.94	438.90	493.16	6%	6%	448.33	503.59	6%	6%	2.13	-5.85	10.85
CO ₂ Emissions from Ferroalloys Production	CO2	118.84	0.00	84.25	154.27	29%	30%	0.00	0.00	0%	0%	0.00	0.00	0.00
CO ₂ Emissions from Aluminium Production	CO2	111.37	0.00	77.68	145.32	30%	30%	0.00	0.00	0%	0%	0.00	0.00	0.00
CH ₄ Emissions from Production of Other Chemicals	CH4	14.27	0.00	12.91	18.70	18%	18%	0.00	0.00	0%	0%	-100.00	-100.00	-100.00
N ₂ O Emissions from Nitric Acid Production	N2O	803.89	804.50	560.86	1046.49	30%	30%	562.41	1049.46	30%	30%	0.08	-4.07	4.43
HFC Emissions from Consumption of HFCs, PFCs, SF ₆	HFC	0.00	467.10	5.47	16.43	50%	50%	342.55	685.56	32%	36%	4495.52	2520.19	9420.69
PFC Emissions from Aluminium production	PFC	936.56	0.00	687.15	1186.68	27%	27%	0.00	0.00	0%	0%	0.00	0.00	0.00
SOLVENT AND OTHER PRODUCT USE														
CO ₂ Emissions from solvent and other product use	CO2	82.26	107.41	51.53	119.73	37%	46%	57.99	170.77	46%	59%	30.58	-35.94	153.34
AGRICULTURE SECTOR														
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH4	1241.92	803.80	1064.38	1424.18	14%	15%	700.63	908.12	13%	13%	-35.28	-46.71	-21.25
CH ₄ Emissions from Manure Management	CH4	228.62	167.79	196.36	262.21	14%	15%	143.74	192.98	14%	15%	-26.61	-40.29	-9.84
N ₂ O Emissions from Manure Management	N2O	381.84	204.59	256.61	565.98	33%	48%	142.38	289.39	30%	41%	-46.42	-53.21	-38.60
Direct N ₂ O Emissions from Agricultural Soils	N2O	1333.13	1184.33	676.12	2092.77	49%	57%	596.61	1853.80	50%	56%	-10.71	-32.59	28.24
N ₂ O Emissions from Pasture Range and Paddock Manure	N2O	261.13	175.22	176.93	345.83	32%	32%	112.31	240.39	36%	37%	-32.90	-41.12	-24.99
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N2O	934.07	782.80	0.00	0.00	78%	260%	0.00	0.00	78%	257%	-22.89	-37.47	-1.81
LULUCF														
Forestland remaining Forestland	CO2	-6711.71	-7462.51	-10699.14	-2726.58	59%	59%	-12079.51	-2846.31	62%	62%	11.19	-61.94	204.49
Forestland remaining Forestland	CH4	12.50	6.82	-8.11	33.10	165%	165%	-4.15	17.78	161%	161%	-45.46	-597.96	490.42
Forestland remaining Forestland	N2O	2.86	1.56	-1.79	7.51	163%	163%	-0.98	4.10	163%	163%	-45.46	-624.02	525.74
Land converted to Forestland	CO2	-272.64	-174.96	-700.65	154.89	157%	157%	-477.10	126.82	173%	172%	-35.83	-727.71	587.17
Cropland remaining Cropland	CO2	136.48	50.04	-920.31	1191.80	774%	773%	-540.45	640.35	1180%	1180%	-63.33	-855.15	655.38
Land converted to Cropland	CO2	23.48	43.94	-96.23	143.01	510%	509%	-151.31	239.15	444%	444%	87.18	-2003.34	2261.45
Grassland converted to Cropland: mineral soils	N2O	4.86	9.09	-15.85	25.54	426%	426%	-27.09	45.23	398%	398%	87.24	-2355.75	2327.88
Grassland remaining Grassland	CO2	2.67	2.67	0.10	5.25	96%	96%	0.10	5.25	96%	96%	0.00	-134.07	523.30
Land converted to Grassland	CO2	-87.86	-128.35	-403.39	227.32	359%	359%	-637.37	380.19	397%	396%	46.08	-2073.25	1965.44
Land converted to Wetlands	CO2	30.00	17.32	-58.27	118.17	294%	294%	-42.11	76.71	343%	343%	-42.24	-871.45	686.55
Land converted to Settlements	CO2	448.15	602.58	50.67	845.22	89%	89%	-335.21	1539.95	156%	156%	34.46	-226.02	699.54
WASTE SECTOR														
CH ₄ Emissions from Solid Waste Disposal Sites	CH4	242.62	770.89	131.98	375.28	46%	55%	335.16	1313.94	57%	70%	217.73	27.18	605.32
CH ₄ Emissions from Wastewater Handling	CH4	237.25	203.59	109.46	389.90	54%	64%	94.02	329.16	54%	62%	-14.19	-61.14	87.42
TOTAL		24598.44	20650.96	18793.09	30620.48	24%	24%	14018.01	27436.61	32%	33%	-16.05	-45.40	22.07

A.5.2. ESTIMATION OF UNCERTAINTIES USING AN ERROR PROPAGATION APPROACH (APPROACH 1)

A.5.2.1. Overview of the method

In the Approach 1, an uncertainty in an emission can be propagated from uncertainties in the activity data and the emission factor through the error propagation equation (Mandel 1984, Belington and Robinson 1992).

This method is presented in the current 1996 IPCC Guidelines for National Greenhouse Gas Inventories (officially in use), where the conditions imposed for use of the method are:

- The uncertainties are relatively small, the standard deviation divided by the mean (coefficient of variation) value being less than 0.3;
- Input parameters (emission factor, activity data) have Gaussian (normal) distributions. Uncertainty is symmetric with respect to the mean value. The length of the range from mean to upper larger value (97.5% percentile) is equal to the length of the range from mean to lower, smaller value (2.5% percentile).
- The correlation between the input data in model between years doesn't exist.

Under these conditions, the uncertainty calculated for the emission rate is appropriate.

Summary uncertainty value is calculated for all emission sources and separately for key source categories that were included in Monte-Carlo analysis (Tier 2). The results of the error propagation approach are shown in Table A5.2-1 (gray shaded area).

The uncertainties used and calculated in the error propagation approach are not exactly the same as those used in the Monte Carlo Simulation since the error propagation source categorisation is far less detailed.

However, the values used were chosen to agree approximately with those used in the Monte Carlo Simulation.

A.5.2.2. Correlation assumptions

Calculation of trend uncertainty using tier 1 method is based on the essential assumption that the input uncertainty of emission factors and activity data for 1990 and 2011 are equal. With that assumption, we can use the default 3.2. Table from 2006 IPCC Guidelines. Formulas in columns K and L are used as they are given. That kind of assumption is not expected in real life.

Uncertainties for 1990 and 2011 are not equal (activity data uncertainty, emission factor uncertainty).

Therefore, the formulas in columns K, L of the 3.2. Table should change the default format, according to existence of new different activity data and emission factor uncertainty into:

Column K

Under the assumption that the same emission factor is used in both years and the actual emission factors are fully correlated, the percent error introduced by it is equal in both years. Therefore the formula for the uncertainty introduced on the trend by the emission factor is:

$$K = I * F = \text{sensitivity A} * \text{uncertainty of emission factor}$$

In case no correlation between emission factors is assumed, sensitivity B should be used and the result needs to be increased by $\sqrt{\text{uncertainty}(\text{emission factor, base year})^2 + \text{uncertainty}(\text{emission factor, year t})^2}$.

$$J = \text{sensitivity B}$$

$$K = J * \sqrt{\text{uncertainty}(\text{emission factor, base year})^2 + \text{uncertainty}(\text{emission factor, year t})^2}$$

Column L

The trend is the difference between the emissions in the base year and in the year t. Therefore the uncertainty of the activity data of the base year and year t has to be taken into account.

Since activity data in both years are assumed to be independent, Column L equals:

$$L = \text{sensitivity B} \bullet \text{combined uncertainty of activity data of both years}$$

$$= J * \sqrt{\text{uncertainty}(\text{activity data, base year})^2 + \text{uncertainty}(\text{activity data, year t})^2}$$

In case correlation between activity data is assumed what is not expected in real life, sensitivity A should be used and the final formula is: $L = I * E$.

Two columns (O and P) reflecting uncertainty of emission factors and activity data for year 1990 have been added in Table A5.2-1 and Table A5.2-2.

Activity data and emission factor uncertainty in tables – (Table A5.2-1, Table A5.2-2) for the key source activities that have been checked and calculated in detail using Monte Carlo analysis have been updated.

IPCC Source category Mobile Combustion: Agriculture/Forestry/Fishing has been changed to Combustion: Agriculture/Forestry/Fishing because the emission value includes both mobile and stationary sources.

Emissions uncertainty

The error propagation analysis, including LULUCF emissions, shows an uncertainty of +/- 31.14% in the combined GWP total emission in 2011, the latest reported year in this inventory.

The error propagation analysis, excluding LULUCF emissions, shows an uncertainty of +/- 16.12% in the combined GWP total emission in 2011, the latest reported year in this inventory.

Uncertainty in the Trend

The analysis, including LULUCF emissions, estimates an uncertainty of +/- 36.30% in the trend between the year 1990 and 2011, the latest reported year in this inventory.

The analysis, excluding LULUCF emissions, estimates an uncertainty of +/- 19.43% in the trend between the year 1990 and 2011, the latest reported year in this inventory.

Table A5.2-1: 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	O	P
IPCC Source Category	GHG	Base year emissions 1990	Year t emissions 2011	Activity data uncertainty 2011	Emission factor uncertainty 2011	Combined uncertainty 2011	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	Activity data uncertainty 1990	Emission factor uncertainty 1990
		Gg CO2 equivalent	Gg CO2 equivalent	%	%	%	%	%	%	I*F or Note C	J*SQRT(E ² +O ²) or Note D	%	%	%
CO2 Emissions from Stationary Combustion - Coal	CO2	2,780.447	2,825.237	1.291470873	1.785472366	2.203589931	0.220327197	0.01081904	0.089272895	0.332467238	0.195336901	0.38560468	1.766303943	3.268258539
CO2 Emissions from Stationary Combustion - Oil	CO2	8,497.044	3,926.128	1.46578195	2.490061482	2.889450278	0.401478303	-0.11535687	0.124059248	0.437375543	0.270793988	0.514418846	1.617408361	2.495798302
CO2 Emissions from Stationary Combustion - Gas	CO2	4,458.539	5,183.028	1.819808911	2.0490404	2.740487371	0.502682561	0.0379337	0.163775262	0.520672334	0.405722219	0.660083478	1.680881944	2.43077543
Mobile Combustion - Road Vehicles	CO2	3,592.693	5,537.150	2.109881756	1.623815018	2.662400465	0.521725507	0.07352132	0.174964919	0.472782657	0.545766993	0.722069977	2.297475362	2.159832522
Mobile Combustion: Water-borne Navigation	CO2	132.980	116.405	5	5	7.071067812	0.029129896	-7.3533E-05	0.003678207	0.026008854	0.026008854	0.036782075	5	5
Mobile Combustion: Domestic Aviation	CO2	154.724	89.881	2.934141635	2.93716325	4.151640049	0.013205918	-0.00152504	0.002840084	0.011927037	0.011921192	0.016863245	3.001606302	3.001529642
Mobile Combustion: Railways	CO2	138.142	82.678	5	5	7.071067812	0.020689926	-0.00128483	0.0026125	0.018473161	0.018473161	0.026124995	5	5
Combustion - Agriculture/Forestry/Fishing	CO2	839.186	714.315	2.605746994	1.767643731	3.148727006	0.079598972	-0.00110434	0.022571205	0.05638176	0.082802667	0.100175768	2.582254931	1.764991209
Fugitive Emissions from Oil and Gas Operations	CO2	639.818	577.155	10	3	10.44030651	0.213249648	0.00018604	0.018237167	0.000558134	0.257912483	0.257913087	10	3
CO2 Emissions from Cement Production	CO2	1,085.790	1,050.361	2.865686018	2.919308244	4.090784396	0.152064386	0.00255558	0.033189691	0.138113055	0.136523174	0.194200394	2.950944986	2.96551105
CO2 Emissions from Lime Production	CO2	153.440	89.243	2.174817964	2.379141791	3.22337538	0.010180474	-0.00150897	0.002819937	0.010504514	0.010248459	0.014675685	2.911735942	2.866350849
CO2 Emissions from Limestone and Dolomite Use	CO2	51.490	41.825	7.5	30	30.92329219	0.045772512	-0.00013109	0.001321604	0.056070905	0.014017726	0.057796566	7.5	30
CO2 Emissions from Soda Ash Production and Use	CO2	14.466	23.310	7.5	30	30.92329219	0.025509878	0.00032842	0.000736555	0.031249366	0.007812341	0.032211109	7.5	30
CO2 Emissions from Iron and Steel Production	CO2	21.447	29.177	7.5	30	30.92329219	0.031931012	0.00031688	0.000921954	0.039115195	0.009778799	0.04031902	7.5	30
CO2 Emissions from Ammonia Production	CO2	466.009	475.942	3.001470231	5.001211345	5.832747077	0.098244767	0.00189127	0.015038987	0.106366749	0.063822402	0.12404509	3.000164526	5.001144791
CO2 Emissions from Ferroalloys Production	CO2	118.836		7.159338575	28.31457934	29.20567636		-0.00335258					7.159338575	28.31457934
Aluminium Production	CO2	111.372		3.002390389	30.00138144	30.15123939		-0.00314201					3.002390389	30.00138144
Emissions from Waste Incineration	CO2	0.043	0.048	50	30	58.30951895	9.91102E-05	2.9816E-07	1.51761E-06	8.94483E-06	0.000107311	0.000107684	50	30
Total Solvent and Other Product Use	CO2	82.256	107.407	31.73981536	43.7702492	54.06709345	0.205517906	0.0010732	0.003393899	0.199384963	0.168143609	0.260819165	38.0405459	39.18544182
Other non-specified NEU	CO2			5	50	50.24937811							5	50
CO2 Total	CO2 Total	23,338.722	20,869.291											
Fuel Combustion - Stationary Sources	CH4	168.641	120.535	5	50	50.24937811	0.214351345	-0.00094907	0.003808709	0.269316408	0.026931641	0.27065964	5	50
Mobile Combustion - Road Vehicles	CH4	34.117	13.652	2.109881756	40	40.05560636	0.019353055	-0.00053115	0.000431388	0.024403016	0.002341116	0.024515057	5	40
Mobile Combustion: Water-borne Navigation	CH4	0.190	0.166	5	40	40.31128874	0.000237317	-1.0571E-07	5.25636E-06	0.000297344	3.71681E-05	0.000299658	5	40
Mobile Combustion: Aircraft	CH4	0.023	0.001	5	40	40.31128874	0.01525E-07	-6.2977E-07	1.7753E-08	1.00426E-06	1.25533E-07	1.01208E-06	5	40
Mobile Combustion: Railways	CH4	0.214	0.118	5	40	40.31128874	0.000168901	-2.2851E-06	3.741E-06	0.000211623	2.64529E-05	0.00021327	5	40
Combustion - Agriculture/Forestry/Fishing	CH4	1.299	1.077	5	40	40.31128874	0.001536011	-2.6183E-06	3.40212E-05	0.00192453	0.000240566	0.001939508	5	40
Fugitive Emissions from Coal Mining and Handling	CH4	48.757		5	250	250.049995		-0.00137555					5	250
Fugitive Emissions from Oil and Gas Operations	CH4	1,202.278	1,427.492	5	300	300.0416638	15.15784863	0.01118248	0.045106413	19.13703025	0.318950504	19.13968799	5	300
Production of Chemicals	CH4	14.273	0.000					-0.00040267	2.54145E-09	4.58754E-08	1.45178E-08	4.81178E-08	5.712409464	18.05086672
CH4 Emissions from Enteric Fermentation in Domestic Livestock	CH4	1,241.920	803.798	5.860162367	13.12100553	14.37018751	0.408781842	-0.00963562	0.025398698	0.487761622	0.203596503	0.52854795	5.469469337	14.02285403
CH4 Emissions from Manure Management	CH4	228.623	167.790	8.070185695	15.03542052	17.06434198	0.101329869	-0.00114814	0.005301884	0.114376657	0.061881445	0.13004358	8.431977203	15.4700753
Solid Waste Disposal Sites	CH4	242.623	770.889	35.60779865	45.14770756	57.49983324	1.568704298	0.01751242	0.024358851	1.472564105	1.208656392	1.905070948	34.55586459	40.20251639
Emissions from Waste Water Handling	CH4	237.252	203.587	49.98885209	30.01272353	58.30650827	0.420096974	-0.00026051	0.006433019	-0.007818593	0.45485606	0.454923253	50.00520018	29.99312374
CH4 Total	CH4 Total	3,420.208	3,509.105											

Table A5.2-1: 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	O	P
IPCC Source Category	GHG	Base year emissions 1990	Year t emissions 2011	Activity data uncertainty 2011	Emission factor uncertainty 2011	Combined uncertainty 2011	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	Activity data uncertainty 1990	Emission factor uncertainty 1990
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%	%	%	%	I*F or Note C	J*SQRT(E ² +O ²) or Note D	%	%	%
Fuel Combustion - Stationary Sources	N ₂ O	62.365	49.736	5	200	200.0624902	0.352143441	-0.00018792	0.001571579	0.444509674	0.011112742	0.444648562	5	200
Mobile Combustion - Road Vehicles	N ₂ O	40.247	48.112	2.109881756	200	200.0111287	0.340559602	0.00038479	0.001520272	0.429997819	0.008250413	0.430076963	5	200
Mobile Combustion: Water-borne Navigation	N ₂ O	0.337	0.295	5	200	200.0624902	0.002086373	-1.8725E-07	9.31126E-06	0.002633622	6.58406E-05	0.002634445	5	200
Mobile Combustion: Aircraft	N ₂ O	1.355	0.033	5	200	200.0624902	0.000234887	-3.7186E-05	1.04827E-06	0.000296497	7.41242E-06	0.00029659	5	200
Mobile Combustion: Railways	N ₂ O	0.392	0.210	5	200	200.0624902	0.001484891	-4.4228E-06	6.62691E-06	0.001874374	4.68593E-05	0.001874959	5	200
Combustion - Agriculture/Forestry/Fishing	N ₂ O	2.038	1.738	5	200	200.0624902	0.012301992	-2.6081E-06	5.49025E-05	0.01552877	0.000388219	0.015533622	5	200
Fugitive Emissions from Oil and Gas Operations	N ₂ O	0.668	0.211	5	300	300.0416638	0.002238595	-1.2187E-05	6.66157E-06	0.002826263	4.71044E-05	0.002826656	5	300
Nitric Acid Production	N ₂ O	803.886	804.500	3.000041603	30.0204552	30.16998476	0.858981324	0.00274029	0.0254209	0.082264747	0.10786263	0.135653366	3.000563986	30.0204552
Total Solvent and Other Product Use	N ₂ O	34.720	36.756	50	50	70.71067812	0.091980682	0.00018188	0.001161432	0.082125668	0.082125668	0.116143233	50	50
N ₂ O Emissions from Manure Management	N ₂ O	381.844	204.588	5.837264366	35.67151224	36.14596023	0.261710866	-0.00430775	0.006464639	-0.153663873	0.053940034	0.162856111	5.962073513	33.1756511
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	1,333.134	1,184.327	16.57418699	48.73317033	51.47451374	2.157477718	-0.00018864	0.037422807	-0.009193125	1.070085889	1.070125377	23.30109233	46.20733461
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	261.130	175.222	8.207056504	36.65531475	37.56285234	0.232932659	-0.00183034	0.00553674	-0.067091803	0.065338916	0.093650863	8.479810529	32.90826679
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.066	782.797	36.385803	153.6916472	157.9400173	4.375460133	-0.00161709	0.02473511	-0.248532919	1.328441943	1.351490513	39.5029944	145.2094152
Emissions from Waste Water Handling	N ₂ O	84.567	103.759	10	30	31.6227766	0.116120109	0.00089271	0.00327861	0.026781214	0.046366544	0.053545213	10	30
	N ₂ O Total	3,940.750	3,392.283											
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC		467.095	50	50	70.71067812	1.168888164	0.01475945	0.014759453	1.043650898	1.043650898	1.475945254	50	50
HFC and PFC Emissions from Other Consumption	HFC/PFC		8.857	50	50	70.71067812	0.022163302	0.00027985	0.000279854	0.019788677	0.019788677	0.027985415	50	50
SF ₆ Emissions from Other Consumption	SF ₆	10.954	9.817	50	50	70.71067812	0.024567316	1.159E-06	0.000310209	0.021935119	0.021935119	0.031020943	50	50
PFC Emissions from Aluminium production	PFC	936.564		3	27	27.16615541		-0.02641533					2.143670053	26.70993611
Total GHG Emissions	CO₂-eq	31,647.199	28,256.448											
Total Uncertainties (Level/Trend)							16.12					19.43		

Note C $K = J \cdot \sqrt{\text{uncertainty}(\text{emission factor, base year})^2 + \text{uncertainty}(\text{emission factor, year t})^2}$

Note D $L = I \cdot E$

Table A5.2-2: 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	O	P
IPCC Source Category	GHG	Base year emissions 1990	Year t emissions 2011	Activity data uncertainty 2011	Emission factor uncertainty 2011	Combined uncertainty 2011	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	Activity data uncertainty 1990	Emission factor uncertainty 1990
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%	%	%	%	I*F or Note C	J*SQRT(E²+O²) or Note D		%	%
CO ₂ Emissions from Stationary Combustion - Coal	CO ₂	2,780.447	2,825.237	1.291470873	1.785472366	2.203589931	0.293322306	0.019266703	0.111952723	0.416930721	0.244962347	0.483567759	1.766303943	3.268258539
CO ₂ Emissions from Stationary Combustion - Oil	CO ₂	8,497.044	3,926.128	1.46578195	2.490061482	2.889450278	0.534489355	-0.127178726	0.155576568	0.548491038	0.339589349	0.645107235	1.617408361	2.495798302
CO ₂ Emissions from Stationary Combustion - Gas	CO ₂	4,458.539	5,183.028	1.819808911	2.0490404	2.740487371	0.669222909	0.056691224	0.205382457	0.652949424	0.50879617	0.827778046	1.680881944	2.43077543
Mobile Combustion - Road Vehicles	CO ₂	3,592.693	5,537.150	2.109881756	1.623815018	2.662400465	0.694574845	0.099538376	0.219414852	0.592893349	0.684419396	0.905512249	2.297475362	2.159832522
Mobile Combustion: Water-borne Navigation	CO ₂	132.980	116.405	5	5	7.071067812	0.038780724	0.000180786	0.004612658	0.032616418	0.032616418	0.046126581	5	5
Mobile Combustion: Domestic Aviation	CO ₂	154.724	89.881	2.934141635	2.93716325	4.151640049	0.017581081	-0.001594822	0.003561609	0.014957107	0.014949778	0.021147362	3.001606302	3.001529642
Mobile Combustion: Railways	CO ₂	138.142	82.678	5	5	7.071067812	0.027544564	-0.001327625	0.003276206	0.023166278	0.023166278	0.032762064	5	5
Combustion - Agriculture/Forestry/Fishing	CO ₂	839.186	714.315	2.605746994	1.767643731	3.148727006	0.105970368	0.000337509	0.028305432	0.070705577	0.10383873	0.125625476	2.582254931	1.764991209
Fugitive Emissions from Oil and Gas Operations	CO ₂	639.818	577.155	10	3	10.44030651	0.283899942	0.00154654	0.022870329	0.097030587	0.32343529	0.337676357	10	3
CO ₂ Emissions from Cement Production	CO ₂	1,085.790	1,050.361	2.865686018	2.919308244	4.090784396	0.202443806	0.00543277	0.04162155	0.173200752	0.171206691	0.24353711	2.950944986	2.96551105
CO ₂ Emissions from Lime Production	CO ₂	153.440	89.243	2.174817964	2.379141791	3.22337538	0.013553297	-0.001577297	0.003536343	0.013173191	0.012852085	0.01840405	2.911735942	2.866350849
CO ₂ Emissions from Limestone and Dolomite Use	CO ₂	51.490	41.825	7.5	30	30.92329219	0.060937092	-5.86796E-05	0.001657358	0.070315749	0.017578937	0.072479815	7.5	30
CO ₂ Emissions from Soda Ash Production and Use	CO ₂	14.466	23.310	7.5	30	30.92329219	0.033961383	0.000441559	0.000923677	0.039188284	0.009797071	0.040394359	7.5	30
CO ₂ Emissions from Iron and Steel Production	CO ₂	21.447	29.177	7.5	30	30.92329219	0.042509859	0.000441409	0.001156177	0.049052432	0.012263108	0.050562089	7.5	30
CO ₂ Emissions from Ammonia Production	CO ₂	466.009	475.942	3.001470231	5.001211345	5.832747077	0.130793574	0.003328222	0.018859649	0.13338928	0.080036518	0.155558813	3.000164526	5.001144791
CO ₂ Emissions from Ferrous Alloys Production	CO ₂	118.836		7.159338575	28.31457934	29.20567636		-0.003960296					7.159338575	28.31457934
Aluminium Production	CO ₂	111.372		3.002390389	30.00138144	30.15123939		-0.003711564					3.002390389	30.00138144
Forestland remaining Forestland	CO ₂	-6,711.706	-7,462.514			61.86864431	-21.75280131	-0.072218326	-0.295709273			-25.35869427		
Land converted to Forestland	CO ₂	-272.638	-174.962			172.5938808	-1.422750474	0.00215348	-0.00693304			-1.616989499		
Cropland remaining Cropland	CO ₂	136.483	50.042			1179.832902	2.781745121	-0.002565505	0.001982975			2.797978364		
Land converted to Cropland	CO ₂	23.477	43.943			444.2541173	0.919783232	0.000958881	0.001741303			1.17712773		
Grassland remaining Grassland	CO ₂	2.675	2.675			96.22383949	0.012126594	1.68478E-05	0.000105993			0.014423432		
Land converted to Grassland	CO ₂	-87.861	-128.347			396.3273984	-2.396621949	-0.002157773	-0.005085876			-2.719336592		
Land converted to Wetlands	CO ₂	29.997	17.325			342.9871438	0.279962623	-0.000313201	0.000686503			0.310218321		
Land converted to Settlements	CO ₂	448.146	602.576			155.6129725	4.417913828	0.008940587	0.023877662			4.276347465		
Emissions from Waste Incineration	CO ₂	0.043	0.048	50	30	58.30951895	0.000131946	4.62648E-07	1.90316E-06	8.07444E-05	0.000134574	0.000156939	50	30
Total Solvent and Other Product Use	CO ₂	82.256	107.407	31.73981536	43.7702492	54.06709345	0.27360665	0.001514709	0.004256121	0.250038821	0.210860585	0.327080416	38.0405459	39.18544182
Other non-specified NEU	CO ₂			5	50	50.24937811							5	50
CO ₂ Total		16,907.295	13,820.029											
Fuel Combustion - Stationary Sources	CH ₄	168.641	120.535	5	50	50.24937811	0.285366634	-0.000843965	0.004776314	0.337736388	0.033773639	0.339420869	5	50
Mobile Combustion - Road Vehicles	CH ₄	34.117	13.652	2.109881756	40	40.05560636	0.025764785	-0.000596038	0.000540983	0.030602615	0.002935878	0.03074312	5	40
Mobile Combustion: Water-borne Navigation	CH ₄	0.190	0.166	5	40	40.31128874	0.000315941	2.57636E-07	6.59174E-06	0.000372885	4.66106E-05	0.000375787	5	40
Mobile Combustion: Aircraft	CH ₄	0.023	0.001	5	40	40.31128874	1.06707E-06	-7.42638E-07	2.22632E-08	1.2594E-06	1.57425E-07	1.2692E-06	5	40
Mobile Combustion: Railways	CH ₄	0.214	0.118	5	40	40.31128874	0.000224858	-2.42716E-06	4.6914E-06	0.000265386	3.31732E-05	0.000267451	5	40
Combustion - Agriculture/Forestry/Fishing	CH ₄	1.299	1.077	5	40	40.31128874	0.002044896	-6.1727E-07	4.26643E-05	0.002413458	0.000301682	0.00243224	5	40
Fugitive Emissions from Coal Mining and Handling	CH ₄	48.757		5	250	250.049995		-0.001624907					5	250
Fugitive Emissions from Oil and Gas Operations	CH ₄	1,202.278	1,427.492	5	300	300.0416638	20.17969262	0.016489196	0.056565722	23.99880324	0.399980054	24.00213617	5	300
Production of Other Chemicals	CH ₄	14.273	0.000					-0.000475669	3.18711E-09		1.82061E-08	1.82061E-08	5.712409464	18.05086672
CH ₄ Emissions from Enteric Fermentation in Domestic Livestock	CH ₄	1,241.920	803.798	5.860162367	13.12100553	14.37018751	0.54421258	-0.009533883	0.031851251	0.611677728	0.255320306	0.662825846	5.469469337	14.02285403
CH ₄ Emissions from Manure Management	CH ₄	228.623	167.790	8.070185695	15.03542052	17.06434198	0.134900781	-0.000970473	0.006648831	0.143434109	0.07760246	0.163081223	8.431977203	15.4700753
Forestland remaining Forestland	CH ₄	12.499	6.817			160.8612961	0.051662777	-0.000146427	0.00270114			0.062211413		
Solid Waste Disposal Sites	CH ₄	242.623	770.889	35.60779865	45.14770756	57.49983324	2.088421075	0.022459101	0.03054723	1.84666982	1.515716208	2.389055263	34.55586459	40.20251639
Emissions from Waste Water Handling	CH ₄	237.252	203.587	49.98885209	30.01272353	58.30650827	0.559276452	0.000160357	0.008067331	0.004812754	0.570412491	0.570432794	50.00520018	29.99312374
CH ₄ Total		3,432.706	3,515.921											

Table A5.2-2: 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	O	P
IPCC Source Category	GHG	Base year emissions 1990	Year t emissions 2011	Activity data uncertainty 2011	Emission factor uncertainty 2011	Combined uncertainty 2011	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	Activity data uncertainty 1990	Emission factor uncertainty 1990
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%	%	%	%	I*F or Note C	J*SQRT(E+O ²) or Note D	%	%	%
Fuel Combustion - Stationary Sources	N ₂ O	62.365	49.736	5	200	200.0624902	0.468809695	-0.000107626	0.00197084	0.557437599	0.01393594	0.557611771	5	200
Mobile Combustion - Road Vehicles	N ₂ O	40.247	48.112	2.109881756	200	200.0111287	0.453388094	0.000565175	0.001906498	0.539239	0.010346436	0.53933825	5	200
Mobile Combustion: Water-borne Navigation	N ₂ O	0.337	0.295	5	200	200.0624902	0.002777595	4.56384E-07	1.16768E-05	0.003302696	8.25674E-05	0.003303728	5	200
Mobile Combustion: Aircraft	N ₂ O	1.355	0.033	5	200	200.0624902	0.000312705	-4.3851E-05	1.31459E-06	0.000371822	9.29555E-06	0.000371938	5	200
Mobile Combustion: Railways	N ₂ O	0.392	0.210	5	200	200.0624902	0.00197684	-4.74229E-06	8.31048E-06	0.002350559	5.8764E-05	0.002351294	5	200
Combustion - Agriculture/Forestry/Fishing	N ₂ O	2.038	1.738	5	200	200.0624902	0.016377682	9.14388E-07	6.88505E-05	0.019473863	0.000486847	0.019479947	5	200
Fugitive Emissions from Oil and Gas Operations	N ₂ O	0.668	0.211	5	300	300.0416638	0.002980249	-1.39119E-05	8.35394E-06	0.003544277	5.90713E-05	0.003544769	5	300
Nitric Acid Production	N ₂ O	803.886	804.500	3.000041603	30.0204552	30.16998476	1.143564598	0.005086129	0.031879093	0.152687904	0.13526519	0.20398595	3.000563986	30.0204552
Total Solvent and Other Product Use	N ₂ O	34.720	36.756	50	50	70.71067812	0.122454177	0.000299367	0.001456495	0.102989738	0.102989738	0.145649485	50	50
N ₂ O Emissions from Manure Management	N ₂ O	381.844	204.588	5.837264366	35.67151224	36.14596023	0.348416517	-0.004618143	0.008106984	-0.164736159	0.067643528	0.178083264	5.962073513	33.1756511
Direct N ₂ O Emissions from Agricultural Soils	N ₂ O	1,333.134	1,184.327	16.57418699	48.73317033	51.47451374	2.872257022	0.002498999	0.046930091	0.121784157	1.341941793	1.347456551	23.30109233	46.20733461
N ₂ O Emissions from Pasture, Range and Paddock Manure	N ₂ O	261.130	175.222	8.207056504	36.65531475	37.56285234	0.310103998	-0.001759238	0.006943352	-0.064485406	0.081938304	0.104270097	8.479810529	32.90826679
Indirect N ₂ O Emissions from Nitrogen Used in Agriculture	N ₂ O	934.066	782.797	36.385803	153.6916472	157.9400173	5.825064142	-0.000110787	0.031019078	6.558675493	1.665933343	6.766945997	39.5029944	145.2094152
Forestland remaining Forestland	N ₂ O	2.858	1.559			163.0082136	0.01197326	-3.34888E-05	6.17765E-05			0.014229093		
Grassland converted to Cropland: mineral soils	N ₂ O	4.855	9.091			397.6981578	0.17034071	0.000198422	0.000360234			0.210009711		
Emissions from Waste Water Handling	N ₂ O	84.567	103.759	10	30	31.6227766	0.154591074	0.001293107	0.004111542	0.174437968	0.058145989	0.183873763	10	30
N ₂ O Total		3,948.464	3,402.933											
HFC and PFC Emissions from Consumption in Refrigeration and Air Conditioning Equipment	HFC/PFC		467.095	50	50	70.71067812	1.55614457	0.0185091	0.0185091	1.308790978	1.308790978	1.850909951	50	50
HFC and PFC Emissions from Other Consumption			8.857	50	50	70.71067812	0.029506075	0.000350951	0.000350951	0.024816001	0.024816001	0.035095125	50	50
SF ₆ Emissions from Other Consumption		10.954	9.817	50	50	70.71067812	0.032706547	2.39429E-05	0.000389018	0.027507748	0.027507748	0.038901831	50	50
PFC Emissions from Aluminium production	PFC	936.564		3	27	27.16615541		-0.031201578					2.143670053	26.70993611
Total GHG Emissions	CO₂-eq	25,235.984	21,224.652											
Total Uncertainties (Level/Trend)							31.14					36.30		

Note C $K = J \cdot \sqrt{\text{uncertainty}(\text{emission factor, base year})^2 + \text{uncertainty}(\text{emission factor, year t})^2} = \sqrt{F^2 + P^2}$

Note D $L = I \cdot E$

A.5.3 COMPARISON OF UNCERTAINTIES FROM THE ERROR PROPAGATION AND MONTE CARLO ANALYSES

Where the conditions for applicability are met (relatively low uncertainty, no correlation between sources except those dealt with explicitly by Approach 1, symmetrical distributions), Approach 1 and Approach 2 will give identical results.

Comparing the results of the error propagation approach, and the Monte Carlo estimation of uncertainty by simulation, is a useful quality control check on the behaviour of the Monte Carlo model.

The reason that the error propagation approach is used as a reference is because the mathematical approach to the error propagation approach has been defined and revised in the 2000 GPG and the 2006 Guidelines.

The implementation of uncertainty estimation by simulation cannot be prescriptive, and will depend on the Monte Carlo software a country chooses to use, how the country constructs its model, and the correlations included within that model.

Therefore, there is a greater possibility of errors being introduced in the model used to estimate uncertainty by simulation.

If all the distributions in the Monte Carlo model were normal, and there were no correlations between sources, the estimated errors on the trend from the Monte Carlo model should be identical to those estimated by the error propagation approach.

In reality there will be correlations between sources, and some distributions are not normal and are heavily skewed. The error propagation approach does not account for the correlations, and so we might expect the trend uncertainty estimated by this method to be greater than obtained value.

The assumption of equivalence between the two methods relies on the fact that the distributions of individual uncertainties in the activity data and emissions factors in the two approaches are both normal. However, there are a number of lognormal and triangle distributions in the Monte Carlo model and the effects of these can not be fully reproduced in the error propagation model. These log-normal and triangle distributions will have the effect of increasing the uncertainty on the trend as the distributions are more skewed.

In Monte Carlo model used in this inventory, we were concentrated on uncertainties of key source categories that contribute 97.97% to total emissions.

Only the key sources were considered because for them we had enough data to set model mathematically correct.

Model is set up so that each sector is divided in its category, and each category is divided into subcategories. Accordingly, uncertainty would not be underestimated.

But, for some subcategories, uncertainty has been estimated on the basis of expert judgement or default uncertainty from the 2000 GPG has been used.

It is not expected that the central estimates from the two methods will be identical, which could be mathematically explained.

For some variables that could only assume negative values, in the Monte Carlo model for the definition of distribution of input parameters risk truncate function was used which resulted in slight change in mean value. The same slight change in mean value cause also log-normally distributed variables.

Total uncertainty for all key sources approximately amounts +/- 16-17% for error propagation approach and approach 2 (Monte Carlo) for year 2011 (excluding LULUCF).

Total uncertainty for all key sources approximately amounts +/- 31-33% for error propagation approach and approach 2 (Monte Carlo) for year 2011 (Including LULUCF).

Trend uncertainty (variability) using Monte Carlo simulation model is lower (+/- 1%) than trend uncertainty using error propagation error.

One of the reasons for that is because error propagation model deals with variables that have normal distributions, which implies symmetrical uncertainties for activity data and emission factor.

In Monte Carlo model some variables have log-normal or triangle distribution, which means that their value can vary plus infinite.

Because of asymmetry of some input variables, it should not be expected for the final result (trend) to vary symmetrically. Also the uncertainty of input data for the year 1990 is not equal to the uncertainty for the year 2010, which also affects the changes in the variability of the trend.

Key category Indirect N₂O Emissions from Nitrogen Used in Agriculture has created problems in defining the distribution functions which resulted in lower summary emission.

It was due to the large asymmetry of variability of input values that are included in the calculation of emission of this source category.

We should point out also categories CO₂ Emissions from Ferroalloys Production, CO₂ Emissions from Aluminium Production and PFC Emissions from Aluminium production and few subcategories which emission was zero in year 2011, but in year 1990 they had emission which varied in accordance with the uncertainty of input parameters.

ANNEX 6

ARCHIVING

INVENTORY DATA RECORD SHEET, UNFCCC SEF APPLICATION

Table A6-1: An example of Inventory Data Record Sheet for 2011 in Waste

INVENTORY DATA RECORD SHEET

Year: 2011

MODULE: WASTE	
SUBMODULE: METHANE EMISSIONS FROM SOLID WASTE DISPOSAL SITES	
WORKSHEET: 6-1	SHEET: 1 OF 1 CH₄ EMISSIONS
STEP: 1 TO 4	PAGE: 1 of 2
DIRECT DATA SOURCE: A. ACTIVITY DATA: Environmental Pollution Register database and Landfill Inventory database (Croatian Environmental Agency, CEA). Assessment of inappropriate activity data on quantities of MSW disposed to different types of SWDs - <i>Guidelines Development for starting implementation of Waste Management Plan in the Republic of Croatia</i> , EKONERG Ltd. <u>Quantities of MSW disposed to SWDSs:</u> Managed: 1,040.38 Gg Unmanaged – deep: 421.02 Gg Unmanaged – shallow: 101.93 Gg Country-specific methane correction factor (MCF): 0.907 Country-specific fraction of degradable organic carbon (DOC): 0.16 Recovered methane: 4.40 Gg B. METHODOLOGY/EMISSION FACTOR: Publications: IPCC/UNEP/OECD/IEA (1997), <i>Greenhouse Gas Inventory Workbook</i> , Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/UNEP/OECD/IEA (1997), <i>Greenhouse Gas Inventory Reference Manual</i> , Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3. IPCC (2000), <i>Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories</i> Methodology: First Order Decay method (Tier 2) Methane generation rate constant k=0.05 Fraction of DOC which really degrades: 0.55 (0.5-0.6) Fraction of carbon released as methane: 0.5	
ORIGINAL DATA SOURCE: A. ACTIVITY DATA: Ministry of Environmental and Nature Protection (2007) <i>Waste Management Plan in the Republic of Croatia (2007-2015)</i> , Zagreb Environmental Pollution Register database and Landfill Inventory database (CEA)	
METHOD: bottom-up (see publications in original data source)	
ADDITIONAL INTERCALCULATION: Evaluation and compiling of data coming from original data source and adjusting to recommended Intergovernmental Panel on Climate Change (IPCC) methodology.	

MODULE: WASTE	
SUBMODULE: METHANE EMISSIONS FROM SOLID WASTE DISPOSAL SITES	
WORKSHEET: 6-1	SHEET: 1 OF 1 CH₄ EMISSIONS
STEP: 1 TO 4	PAGE: 2 of 2
DATA ARCHIVATION: Publications: Fundurulja, D., Mužinić, M. (2000) <i>Estimation of the Quantities of Municipal Solid Waste in the Republic of Croatia in the period 1990 – 1998 and 1998 – 2010.</i> Potočnik, V. (2000), Report: The basis for methane emission estimation in Croatia 1990-1998, B. Data on Municipal Solid Waste in Croatia 1990-1998 Schaller, A. (2000), Republic of Croatia: First National Communication, Waste Management Review – Waste Disposal Sites.	
DATA GAPS: Quantities on MSW were in most cases gained by test weighing in order to estimate average volumes of waste delivered by vehicles and density of MSW. Analysis of waste composition must be carried out.	
SUGGESTION FOR THE FUTURE: For the purposes of improvement activity data gathering from solid waste disposal activities it is necessary to improve quality of existing data: • more accurate determination on waste quantities disposed to different types of SWDS (managed, unmanaged deep and unmanaged shallow) – based on measurement/weighing or more accurate estimation; • providing methodology to determine country-specific MSW composition and periodic analysis of waste composition at major landfills according to provided methodology; • modification of Environmental Pollution Register and Landfill Inventory database regarding to MSW with additional information (provided on regular basis) on technical and environmental protection measures implemented at landfills, waste quantities disposed to different types of SWDS (managed, unmanaged deep and unmanaged shallow) and waste composition. For the purposes of emission inventory improvement it is necessary to adjust country-specific to IPCC SWDS classification for entire time series, in order to accurately estimate the MCF. Due to lack of adequate information, interpolation/extrapolation method has been applied for estimation of waste and landfills characteristics over a long period of time. It is necessary to improve the quality of existing data and to reconstruct historical data. More detailed background information related to the sources of AD and EFs are necessary in order to improve transparency. Research should be conducted in order to develop country-specific parameters for the first order decay method to increase the accuracy of the emission estimates. More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.	
NOTES: -	
RESPONSIBILITY: Andrea Hublin, PhD EKONERG address: Koranska 5, 10000 Zagreb tel.: +385 1 6000 134 e-mail: andrea.hublin@ekonerg.hr	

UNFCCC SEF application

Version 1.2.1

Workflow

Unlock file

Completeness Check

Consistency Check

Lock file

Functions

Mandatory data

Import XML

Reset SEF

Export XML

Export XML (Imported)

Settings

Party: Croatia
ISO: HR
Submission year: 2013
Reported year: 2012
Commitment period: 1

Completeness check: YES
Consistency check: YES
File locked: YES

Lock timestamp: 16/05/2013 13:32
Submission version number: 2
Submission type: Official

Party Croatia
 Submission year 2013
 Reported year 2012
 Commitment period 1

Table 1. Total quantities of Kyoto Protocol units by account type at beginning of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Party holding accounts	NO	NO	NO	NO	NO	NO
Entity holding accounts	NO	NO	NO	NO	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	NO	NO	NO	NO	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
ICER replacement account for expiry	NO	NO	NO	NO		
ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	NO	NO	NO	NO	NO	NO

Party Croatia
 Submission year 2013
 Reported year 2012
 Commitment period 1

Table 2 (a). Annual internal transactions

Transaction type	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Article 6 issuance and conversion												
Party-verified projects		NO					NO		NO			
Independently verified projects		NO					NO		NO			
Article 3.3 and 3.4 issuance or cancellation												
3.3 Afforestation and reforestation			NO				NO	NO	NO	NO		
3.3 Deforestation			NO				NO	NO	NO	NO		
3.4 Forest management			NO				NO	NO	NO	NO		
3.4 Cropland management			NO				NO	NO	NO	NO		
3.4 Grazing land management			NO				NO	NO	NO	NO		
3.4 Revegetation			NO				NO	NO	NO	NO		
Article 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired ICERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Other cancellation												
Sub-total		NO	NO				NO	NO	NO	NO	NO	NO

Transaction type	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Retirement	NO	NO	NO	NO	NO	NO

Party Croatia
 Submission year 2013
 Reported year 2012
 Commitment period 1

Add registry

Delete registry

No external transactions

Table 2 (b). Annual external transactions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Transfers and acquisitions												
Sub-total												

Additional information

Independently verified ERUs								NO				

Table 2 (c). Total annual transactions

Total (Sum of tables 2a and 2b)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Party Croatia
 Submission year 2013
 Reported year 2012
 Commitment period 1

Table 3. Expiry, cancellation and replacement

Transaction or event type	Expiry, cancellation and requirement to replace		Replacement					
	Unit type		Unit type					
	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Temporary CERs (tCERs)								
Expired in retirement and replacement accounts	NO							
Replacement of expired tCERs			NO	NO	NO	NO	NO	
Expired in holding accounts	NO							
Cancellation of tCERs expired in holding accounts	NO							
Long-term CERs (ICERs)								
Expired in retirement and replacement accounts		NO						
Replacement of expired ICERs			NO	NO	NO	NO		
Expired in holding accounts		NO						
Cancellation of ICERs expired in holding accounts		NO						
Subject to replacement for reversal of storage		NO						
Replacement for reversal of storage			NO	NO	NO	NO		NO
Subject to replacement for non-submission of certification report		NO						
Replacement for non-submission of certification report			NO	NO	NO	NO		NO
Total			NO	NO	NO	NO	NO	NO

Party Croatia
 Submission year 2013
 Reported year 2012
 Commitment period 1

Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Party holding accounts	1.49E+08	NO	NO	NO	NO	NO
Entity holding accounts	NO	NO	NO	NO	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	NO	NO	NO	NO	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
ICER replacement account for expiry	NO	NO	NO	NO		
ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	1.49E+08	NO	NO	NO	NO	NO

Party Croatia
 Submission year 2013
 Reported year 2012
 Commitment period 1

Table 5 (a). Summary information on additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Starting values												
Issuance pursuant to Article 3.7 and 3.8	1.49E+08											
Non-compliance cancellation							NO	NO	NO	NO		
Carry-over	NO	NO		NO								
Sub-total	1.49E+08	NO		NO			NO	NO	NO	NO		
Annual transactions												
Year 0 (2007)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 1 (2008)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	1.49E+08	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 5 (b). Summary information on replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Previous CPs			NO	NO	NO	NO	NO	NO
Year 1 (2008)		NO	NO	NO	NO	NO	NO	NO
Year 2 (2009)		NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)		NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)		NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO	NO	NO

Table 5 (c). Summary information on retirement

Year	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Year 1 (2008)	NO	NO	NO	NO	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO

Party Croatia
 Submission year 2013
 Reported year 2012
 Commitment period 1

Add transaction

Delete transaction

No corrective transaction

Table 6 (a). Memo item: Corrective transactions relating to additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs

Add transaction

Delete transaction

No corrective transaction

Table 6 (b). Memo item: Corrective transactions relating to replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs

Add transaction

Delete transaction

No corrective transaction

Table 6 (c). Memo item: Corrective transactions relating to retirement

	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs

No problems found!

ANNEX 7

GHG EMISSION TREND

Table A7-1: GHG emission in Croatia, Base year

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Base year	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	20582.79	69.13	1451.68	0.37	114.52	NO	22148.99	70.71
A. Fuel Comb (Sectoral Appr.)	20166.84	9.61	201.74	0.55	114.52	NO	20483.11	65.40
1. Energy Industries	7126.54	0.17	3.61	0.07	13.80	NO	7143.95	22.81
2. Man. Ind. and Constr.	5447.30	0.48	10.08	0.09	17.96	NO	5475.33	17.48
3. Transport	3987.25	1.55	32.56	0.24	50.17	NO	4069.97	12.99
4. Comm./Inst, Resid., Agric.	3605.76	7.40	155.50	0.16	32.59	NO	3793.85	12.11
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	415.95	59.52	1249.94	NO	NO	NO	1665.89	5.32
1. Solid Fuels	NO	NO	48.76	NO	NO	NO	48.76	NO
2. Oil and Natural Gas	415.95	57.20	1201.18	NO	NO	NO	1617.13	5.16
2. Industrial Processes	2417.36	0.78	16.45	2.59	804.08	947.58	4185.46	13.36
A. Mineral Products	1315.38	NE,NO	NE,NO	NE,NO	NE,NO	NO	1315.38	4.20
B. Chemical Industry	870.99	16.45	16.45	2.59	804.08	NO	1691.52	5.40
C. Metal Production	230.99	NE,NO	NE,NO	NO	NO	936.56	1167.56	3.73
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	11.01	11.01	0.04
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	80.21	NO	NO	NE	NE	NO	80.21	0.26
4. Agriculture	NO	69.42	1457.81	9.26	2870.60	NO	4328.40	13.82
A. Enteric Fermentation	NO	58.54	1229.36	0.00	0.00	NO	1229.36	3.92
B. Manure Management	NO	10.88	228.44	1.22	378.74	NO	607.18	1.94
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	8.04	2491.86	NO	2491.86	7.96
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NE,NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-4184.93	0.00	0.01	0.00	0.00	NO	-4184.92	-13.36
A. Forest Land	-4184.93	0.00	0.01	0.00	0.00	NO	-4184.92	-13.36
B. Cropland	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
C. Grassland	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.09	23.81	499.94	0.25	78.69	NO	578.72	1.85
A. Solid Waste Disp. on Land	NE,NO	10.53	221.21	0.00	0.00	NO	221.21	0.71
B. Waste-water Handling	0.00	13.27	278.73	0.25	78.69	NO	357.42	1.14
C. Waste Incineration	0.09	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.09	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	18895.52	163.14	3425.89	12.48	3867.89	947.58	27136.87	86.64
Total Emissions without LUCF	23080.45	163.14	3425.89	12.48	3867.89	947.58	31321.79	100.0
Share of Gases in Total Em./Rem.	69.63		12.62		14.25		100.00	
Share of Gases in Total Emissions	73.69		10.94		12.35		100.00	
Memo Items:								
International Bunkers	451.83	0.01	0.20	0.01	3.28	NO	455.31	
Aviation	343.29	0.00	0.05	0.01	3.01	NO	346.35	
Marine	108.54	0.01	0.15	0.00	0.27	NO	108.96	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	2,436.76	NO	NO	NO	NO	NO	2436.76	

Table A7-1: GHG emission in Croatia, 1990

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 1990	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	21233.57	69.31	1455.52	0.35	107.40	NO	22796.49	72.03
A. Fuel Comb (Sectoral Appr.)	20593.76	9.74	204.48	0.51	106.73	NO	20904.97	66.06
1. Energy Industries	7126.54	0.17	3.61	0.06	13.63	NO	7143.78	22.57
2. Man. Ind. and Constr.	5842.92	0.52	10.83	0.09	18.18	NO	5871.93	18.55
3. Transport	4018.54	1.64	34.54	0.20	42.33	NO	4095.41	12.94
4. Comm./Inst, Resid., Agric.	3605.76	7.40	155.50	0.16	32.59	NO	3793.85	11.99
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	639.82	59.57	1251.03	0.67	0.67	NO	1891.52	5.98
1. Solid Fuels	NO	NO	48.76	NO	NO	NO	48.76	NO
2. Oil and Natural Gas	639.82	57.25	1202.28	0.67	0.67	NO	1842.76	5.82
2. Industrial Processes	2022.85	0.68	14.27	2.59	803.89	947.52	3788.53	11.97
A. Mineral Products	1305.19	NE,NO	NE,NO	NE,NO	NE,NO	NO	1305.19	4.12
B. Chemical Industry	466.01	14.27	14.27	2.59	803.89	NO	1284.17	4.06
C. Metal Production	251.65	NE,NO	NE,NO	NO	NO	936.56	1188.22	3.75
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	10.95	10.95	0.03
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	82.26	NO	NO	0.11	34.72	NO	116.98	0.37
4. Agriculture	NO	70.03	1470.54	9.39	2910.18	NO	4380.72	13.84
A. Enteric Fermentation	NO	59.14	1241.92	0.00	0.00	NO	1241.92	3.92
B. Manure Management	NO	10.89	228.62	1.23	381.84	NO	610.47	1.93
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	8.16	2528.33	NO	2528.33	7.99
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NE,NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-6431.43	0.60	12.50	0.02	7.71	NO	-6411.22	-20.26
A. Forest Land	-6984.34	0.60	12.50	0.01	2.86	NO	-6968.99	-22.02
B. Cropland	159.96	NE,NO	NE,NO	4.86	4.86	NO	164.82	NO
C. Grassland	-85.19	NE,NO	NE,NO	NE,NO	NE,NO	NO	-85.19	NO
D. Wetlands	30.00	NE,NO	NE,NO	NE,NO	NE,NO	NO	30.00	NO
E. Settlements	448.15	NE,NO	NE,NO	NE,NO	NE,NO	NO	448.15	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	22.85	479.87	0.27	84.57	NO	564.49	1.78
A. Solid Waste Disp. on Land	NA,NO	11.55	242.62	0.00	0.00	NO	242.62	0.77
B. Waste-water Handling	0.00	11.30	237.25	0.27	84.57	NO	321.82	1.02
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	16907.29	163.46	3432.71	12.62	3913.74	947.52	25235.98	79.74
Total Emissions without LUCF	23338.72	162.87	3432.71	12.62	3913.74	947.52	31647.20	100.0
Share of Gases in Total Em./Rem.	67.00		13.60		15.51		100.00	
Share of Gases in Total Emissions	73.75		10.85		12.37		100.00	
Memo Items:								
International Bunkers	451.83	0.01	0.20	0.01	3.28	NO	455.31	
Aviation	343.29	0.00	0.05	0.01	3.01	NO	346.35	
Marine	108.54	0.01	0.15	0.00	0.27	NO	108.96	
Multilateral Operations	C	C	C	C	C	NO	C	
CO₂ Emissions from Biomass	2,436.76	NO	NO	NO	NO	NO	2436.76	

Table A7-1: GHG emission in Croatia, 1991

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 1991	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	15721.99	62.20	1306.10	0.24	74.43	NO	17102.52	68.60
A. Fuel Comb (Sectoral Appr.)	15103.18	6.42	134.79	0.35	73.95	NO	15311.91	61.42
1. Energy Industries	4768.18	0.11	2.27	0.04	9.03	NO	4779.47	19.17
2. Man. Ind. and Constr.	4344.22	0.41	8.58	0.06	13.36	NO	4366.16	17.51
3. Transport	2954.92	1.24	26.05	0.14	29.78	NO	3010.75	12.08
4. Comm./Inst, Resid., Agric.	3035.86	4.66	97.89	0.10	21.77	NO	3155.53	12.66
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	618.81	55.78	1171.31	0.49	0.49	NO	1790.61	7.18
1. Solid Fuels	NO	NO	43.45	NO	NO	NO	43.45	NO
2. Oil and Natural Gas	618.81	53.71	1127.85	0.49	0.49	NO	1747.16	7.01
2. Industrial Processes	1544.74	0.45	9.55	2.28	706.05	653.27	2913.62	11.69
A. Mineral Products	864.23	NE,NO	NE,NO	NE,NO	NE,NO	NO	864.23	3.47
B. Chemical Industry	447.00	9.55	9.55	2.28	706.05	NO	1162.60	4.66
C. Metal Production	233.51	NE,NO	NE,NO	NO	NO	642.44	875.96	3.51
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	10.83	10.83	0.04
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	85.68	NO	NO	0.11	34.72	NO	120.40	0.48
4. Agriculture	NO	64.92	1363.31	9.23	2862.62	NO	4225.93	16.95
A. Enteric Fermentation	NO	54.23	1138.74	0.00	0.00	NO	1138.74	4.57
B. Manure Management	NO	10.69	224.57	1.15	354.98	NO	579.54	2.32
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	8.09	2507.64	NO	2507.64	10.06
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8104.42	0.60	12.50	0.02	7.54	NO	-8084.38	-32.43
A. Forest Land	-8650.93	0.60	12.50	0.01	2.86	NO	-8635.57	-34.64
B. Cropland	146.68	NE,NO	NE,NO	4.69	4.69	NO	151.37	NO
C. Grassland	-56.59	NE,NO	NE,NO	NE,NO	NE,NO	NO	-56.59	NO
D. Wetlands	30.17	NE,NO	NE,NO	NE,NO	NE,NO	NO	30.17	NO
E. Settlements	426.24	NE,NO	NE,NO	NE,NO	NE,NO	NO	426.24	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	23.30	489.27	0.25	78.91	NO	568.23	2.28
A. Solid Waste Disp. on Land	NA,NO	12.09	253.95	0.00	0.00	NO	253.95	1.02
B. Waste-water Handling	0.00	11.21	235.33	0.25	78.91	NO	314.24	1.26
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	9248.03	151.46	3180.73	12.03	3729.56	653.27	16846.31	67.57
Total Emissions without LUCF	17352.45	150.87	3180.73	12.03	3729.56	653.27	24930.70	100.0
Share of Gases in Total Em./Rem.	54.90		18.88		22.14		100.00	
Share of Gases in Total Emissions	69.60		12.76		14.96		100.00	
Memo Items:								
International Bunkers	139.53	0.01	0.11	0.00	0.77	NO	140.41	
Aviation	68.19	0.00	0.01	0.00	0.60	NO	68.80	
Marine	71.34	0.00	0.10	0.00	0.18	NO	71.61	
Multilateral Operations	C	C	C	C	C	NO	C	
CO₂ Emissions from Biomass	1,680.37	NO	NO	NO	NO	NO	1680.37	

Table A7-1: GHG emission in Croatia, 1992

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 1992	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	15038.48	60.97	1280.31	0.22	66.77	NO	16385.56	70.52
A. Fuel Comb (Sectoral Appr.)	14413.03	5.26	110.41	0.32	66.32	NO	14589.76	62.79
1. Energy Industries	5338.81	0.11	2.35	0.05	9.79	NO	5350.95	23.03
2. Man. Ind. and Constr.	3680.56	0.35	7.39	0.05	10.30	NO	3698.25	15.92
3. Transport	2844.51	1.10	23.17	0.13	27.80	NO	2895.48	12.46
4. Comm./Inst, Resid., Agric.	2549.15	3.69	77.50	0.09	18.43	NO	2645.07	11.38
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	625.45	55.71	1169.91	0.44	0.44	NO	1795.80	7.73
1. Solid Fuels	NO	NO	33.77	NO	NO	NO	33.77	NO
2. Oil and Natural Gas	625.45	54.10	1136.14	0.44	0.44	NO	1762.03	7.58
2. Industrial Processes	1602.70	0.39	8.19	2.98	923.19	10.92	2544.99	10.95
A. Mineral Products	932.50	NE,NO	NE,NO	NE,NO	NE,NO	NO	932.50	4.01
B. Chemical Industry	575.22	8.19	8.19	2.98	923.19	NO	1506.59	6.48
C. Metal Production	94.99	NE,NO	NE,NO	NO	NO	NO	94.99	0.41
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	10.92	10.92	0.05
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	66.86	NO	NO	0.11	34.72	NO	101.58	0.44
4. Agriculture	NO	51.17	1074.54	8.23	2551.75	NO	3626.30	15.61
A. Enteric Fermentation	NO	43.08	904.73	0.00	0.00	NO	904.73	3.89
B. Manure Management	NO	8.09	169.82	0.91	282.53	NO	452.34	1.95
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	7.32	2269.23	NO	2269.23	9.77
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8582.46	0.14	2.85	0.02	5.17	NO	-8574.44	-36.90
A. Forest Land	-9067.56	0.14	2.85	0.00	0.65	NO	-9064.06	-39.01
B. Cropland	137.49	NE,NO	NE,NO	4.52	4.52	NO	142.01	NO
C. Grassland	-47.84	NE,NO	NE,NO	NE,NO	NE,NO	NO	-47.84	NO
D. Wetlands	31.89	NE,NO	NE,NO	NE,NO	NE,NO	NO	31.89	NO
E. Settlements	363.57	NE,NO	NE,NO	NE,NO	NE,NO	NO	363.57	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	23.74	498.64	0.25	78.46	NO	577.14	2.48
A. Solid Waste Disp. on Land	NA,NO	12.63	265.23	0.00	0.00	NO	265.23	1.14
B. Waste-water Handling	0.00	11.11	233.41	0.25	78.46	NO	311.87	1.34
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	8125.62	136.41	2864.53	11.69	3625.33	10.92	14661.12	63.10
Total Emissions without LUCF	16708.08	136.27	2864.53	11.69	3625.33	10.92	23235.57	100.0
Share of Gases in Total Em./Rem.	55.42		19.54		24.73		100.00	
Share of Gases in Total Emissions	71.91		12.33		15.60		100.00	
Memo Items:								
International Bunkers	137.25	0.01	0.12	0.00	0.70	NO	138.1	
Aviation	56.62	0.00	0.01	0.00	0.50	NO	57.1	
Marine	80.62	0.01	0.11	0.00	0.20	NO	80.9	
Multilateral Operations	C	C	C	C	C	NO	C	
CO₂ Emissions from Biomass	1,459.04	NO	NO	NO	NO	NO	1459.0	

Table A7-1: GHG emission in Croatia, 1993

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 1993	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	14981.26	4.99	104.85	0.35	74.41	NO	15160.52	65.11
A. Fuel Comb (Sectoral Appr.)	5918.93	0.14	2.93	0.05	10.07	NO	5931.93	25.47
1. Energy Industries	3515.57	0.34	7.04	0.05	9.82	NO	3532.42	15.17
2. Man. Ind. and Constr.	3015.56	1.09	22.82	0.18	37.12	NO	3075.50	13.21
3. Transport	2531.21	3.43	72.06	0.08	17.40	NO	2620.67	11.25
4. Comm./Inst, Resid., Agric.	NO	NO	NO	NO	NO	NO	NO	NO
5. Other	824.60	62.17	1305.59	0.45	0.45	NO	2130.64	9.15
B. Fugitive Emissions from Fuels	NO	NO	32.31	NO	NO	NO	32.31	NO
1. Solid Fuels	824.60	60.63	1273.29	0.45	0.45	NO	2098.33	9.01
2. Oil and Natural Gas	1285.25	0.43	9.04	2.24	695.91	11.04	2001.25	8.59
2. Industrial Processes	799.69	NE,NO	NE,NO	NE,NO	NE,NO	NO	799.69	3.43
A. Mineral Products	446.83	9.04	9.04	2.24	695.91	NO	1151.78	4.95
B. Chemical Industry	38.74	NE,NO	NE,NO	NO	NO	NO	38.74	0.17
C. Metal Production	NE	NO	NO	NO	NO	NO	NE	NE
D. Other Production	NO	NO	NO	NO	NO	NO	NO	NO
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	11.04	11.04	0.05
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	74.02	NO	NO	0.11	34.72	NO	108.74	0.47
3. Solvent and Other Product Use	NO	50.27	1055.75	7.23	2242.72	NO	3298.47	14.17
4. Agriculture	NO	41.96	881.07	0.00	0.00	NO	881.07	3.78
A. Enteric Fermentation	NO	8.32	174.68	0.89	276.21	NO	450.89	1.94
B. Manure Management	NO	NO	NO	0.00	0.00	NO	NO	NO
C. Rice Cultivation	NO	NO	NO	6.34	1966.50	NO	1966.50	8.45
D. Agricultural Soils	NO	NO	NO	NO	NO	NO	NO	NO
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	-8594.82	1.15	24.20	0.03	9.88	NO	-8560.75	-36.76
5. Land-Use Change and Forestry	-9109.25	1.15	24.20	0.02	5.53	NO	-9079.52	-38.99
A. Forest Land	140.48	NE,NO	NE,NO	4.35	4.35	NO	144.83	NO
B. Cropland	-60.10	NE,NO	NE,NO	NE,NO	NE,NO	NO	-60.10	NO
C. Grassland	33.60	NE,NO	NE,NO	NE,NO	NE,NO	NO	33.60	NO
D. Wetlands	400.45	NE,NO	NE,NO	NE,NO	NE,NO	NO	400.45	NO
E. Settlements	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
F. Other Land	NE	NE	NE	NE	NE	NO	NE	NE
G. Other	0.04	24.22	508.64	0.25	77.64	NO	586.32	2.52
6. Waste	NA,NO	13.20	277.15	0.00	0.00	NO	277.15	1.19
A. Solid Waste Disp. on Land	0.00	11.02	231.49	0.25	77.64	NO	309.12	1.33
B. Waste-water Handling	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
C. Waste Incineration	NO	NO	NO	NO	NO	NO	NO	NO
D. Other								
Total Em./Rem. with LUCF	17165.18	142.09	3008.08	10.00	3101.00	11.04	23285.93	100.0
Total Emissions without LUCF	58.20		20.43		21.06		100.00	
Share of Gases in Total Em./Rem.	73.71		12.92		13.32		100.00	
Share of Gases in Total Emissions								
Memo Items:	253.72	0.01	0.18	0.00	1.50	NO	255.40	
International Bunkers	139.18	0.00	0.02	0.00	1.22	NO	140.42	
Aviation	114.54	0.01	0.16	0.00	0.28	NO	114.98	
Marine	C	C	C	C	C	NO	C	
Multilateral Operations	1,388.13	NO	NO	NO	NO	NO	1388.13	
CO₂ Emissions from Biomass	14981.26	4.99	104.85	0.35	74.41	NO	15160.52	65.11

Table A7-1: GHG emission in Croatia, 1994

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 1994	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	14958.57	60.80	1276.71	0.25	76.41	NO	16311.69	72.60
A. Fuel Comb (Sectoral Appr.)	14218.65	5.25	110.27	0.36	76.00	NO	14404.91	64.11
1. Energy Industries	4671.23	0.12	2.48	0.04	7.45	NO	4681.17	20.83
2. Man. Ind. and Constr.	3700.16	0.33	6.88	0.04	9.25	NO	3716.28	16.54
3. Transport	3231.46	1.18	24.80	0.19	40.72	NO	3296.97	14.67
4. Comm./Inst, Resid., Agric.	2615.80	3.62	76.11	0.09	18.58	NO	2710.49	12.06
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	739.92	55.55	1166.45	0.41	0.41	NO	1906.77	8.49
1. Solid Fuels	NO	NO	28.97	NO	NO	NO	28.97	NO
2. Oil and Natural Gas	739.92	54.17	1137.48	0.41	0.41	NO	1877.80	8.36
2. Industrial Processes	1455.87	0.41	8.69	2.43	752.57	11.16	2228.29	9.92
A. Mineral Products	968.67	NE,NO	NE,NO	NE,NO	NE,NO	NO	968.67	4.31
B. Chemical Industry	450.03	8.69	8.69	2.43	752.57	NO	1211.29	5.39
C. Metal Production	37.17	NE,NO	NE,NO	NO	NO	NO	37.17	0.17
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	11.16	11.16	0.05
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	75.80	NO	NO	0.11	34.72	NO	110.52	0.49
4. Agriculture	NO	46.29	972.03	7.25	2247.09	NO	3219.12	14.33
A. Enteric Fermentation	NO	37.94	796.64	0.00	0.00	NO	796.64	3.55
B. Manure Management	NO	8.35	175.38	0.83	257.44	NO	432.82	1.93
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	6.42	1989.65	NO	1989.65	8.86
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8512.33	0.52	10.99	0.02	6.69	NO	-8494.64	-37.81
A. Forest Land	-9047.00	0.52	10.99	0.01	2.51	NO	-9033.50	-40.20
B. Cropland	143.34	NE,NO	NE,NO	4.18	4.18	NO	147.51	NO
C. Grassland	-57.91	NE,NO	NE,NO	NE,NO	NE,NO	NO	-57.91	NO
D. Wetlands	35.32	NE,NO	NE,NO	NE,NO	NE,NO	NO	35.32	NO
E. Settlements	413.93	NE,NO	NE,NO	NE,NO	NE,NO	NO	413.93	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	24.75	519.70	0.26	79.62	NO	599.36	2.67
A. Solid Waste Disp. on Land	NA,NO	13.82	290.13	0.00	0.00	NO	290.13	1.29
B. Waste-water Handling	0.00	10.93	229.57	0.26	79.62	NO	309.19	1.38
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	7977.96	132.77	2788.12	10.20	3162.38	11.16	13974.33	62.19
Total Emissions without LUCF	16490.29	132.24	2788.12	10.20	3162.38	11.16	22468.98	100.0
Share of Gases in Total Em./Rem.	57.09		19.95		22.63		100.00	
Share of Gases in Total Emissions	73.39		12.41		14.07		100.00	
Memo Items:								
International Bunkers	326.50	0.01	0.22	0.01	1.99	NO	328.71	
Aviation	188.18	0.00	0.03	0.01	1.65	NO	189.85	
Marine	138.33	0.01	0.19	0.00	0.34	NO	138.86	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,403.18	NO	NO	NO	NO	NO	1403.18	

Table A7-1: GHG emission in Croatia, 1995

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 1995	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	15903.85	61.26	1286.40	0.23	72.80	NO	17263.04	74.86
A. Fuel Comb (Sectoral Appr.)	15034.38	5.41	113.56	0.34	72.40	NO	15220.34	66.00
1. Energy Industries	5262.45	0.14	2.93	0.05	9.58	NO	5274.96	22.87
2. Man. Ind. and Constr.	3540.91	0.32	6.71	0.04	9.13	NO	3556.75	15.42
3. Transport	3405.46	1.23	25.92	0.16	34.61	NO	3466.00	15.03
4. Comm./Inst, Resid., Agric.	2825.55	3.71	78.00	0.09	19.09	NO	2922.64	12.67
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	869.47	55.85	1172.83	0.39	0.39	NO	2042.70	8.86
1. Solid Fuels	NO	NO	23.07	NO	NO	NO	23.07	NO
2. Oil and Natural Gas	869.47	54.75	1149.76	0.39	0.39	NO	2019.62	8.76
2. Industrial Processes	1224.15	0.33	6.99	2.33	723.70	61.02	2015.86	8.74
A. Mineral Products	749.26	NE,NO	NE,NO	NE,NO	NE,NO	NO	749.26	3.25
B. Chemical Industry	438.77	6.99	6.99	2.33	723.70	NO	1169.46	5.07
C. Metal Production	36.12	NE,NO	NE,NO	NO	NO	NO	36.12	0.16
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	61.02	61.02	0.26
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	73.62	NO	NO	0.11	34.72	NO	108.34	0.47
4. Agriculture	NO	43.70	917.65	6.89	2137.18	NO	3054.84	13.25
A. Enteric Fermentation	NO	36.20	760.22	0.00	0.00	NO	760.22	3.30
B. Manure Management	NO	7.50	157.43	0.78	241.97	NO	399.41	1.73
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	6.11	1895.21	NO	1895.21	8.22
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-9084.88	0.09	1.87	0.01	4.44	NO	-9078.57	-39.37
A. Forest Land	-9551.57	0.09	1.87	0.00	0.43	NO	-9549.27	-41.41
B. Cropland	162.63	NE,NO	NE,NO	4.01	4.01	NO	166.64	NO
C. Grassland	-80.97	NE,NO	NE,NO	NE,NO	NE,NO	NO	-80.97	NO
D. Wetlands	37.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	37.04	NO
E. Settlements	348.00	NE,NO	NE,NO	NE,NO	NE,NO	NO	348.00	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	25.38	532.91	0.28	85.67	NO	618.62	2.68
A. Solid Waste Disp. on Land	NA,NO	14.54	305.26	0.00	0.00	NO	305.26	1.32
B. Waste-water Handling	0.00	10.84	227.65	0.28	85.67	NO	313.33	1.36
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	8116.78	130.75	2745.81	9.75	3023.79	61.02	13982.12	60.63
Total Emissions without LUCF	17201.66	130.66	2745.81	9.75	3023.79	61.02	23060.70	100.0
Share of Gases in Total Em./Rem.	58.05		19.64		21.63		100.00	
Share of Gases in Total Emissions	74.59		11.91		13.11		100.00	
Memo Items:								
International Bunkers	288.76	0.01	0.17	0.01	1.89	NO	290.82	
Aviation	186.75	0.00	0.03	0.01	1.64	NO	188.42	
Marine	102.01	0.01	0.14	0.00	0.25	NO	102.40	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,452.60	NO	NO	NO	NO	NO	1452.60	

Table A7-1: GHG emission in Croatia, 1996

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 1996	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	16418.24	61.92	1300.33	0.34	104.78	NO	17823.3	75.20
A. Fuel Comb (Sectoral Appr.)	15574.95	6.32	132.74	0.50	104.39	NO	15812.1	66.71
1. Energy Industries	5110.49	0.13	2.80	0.04	8.83	NO	5122.1	21.61
2. Man. Ind. and Constr.	3507.98	0.31	6.58	0.04	9.06	NO	3523.6	14.87
3. Transport	3727.43	1.33	27.94	0.30	63.48	NO	3818.8	16.11
4. Comm./Inst, Resid., Agric.	3229.05	4.54	95.42	0.11	23.03	NO	3347.5	14.12
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	843.29	55.60	1167.59	0.38	0.38	NO	2011.3	8.49
1. Solid Fuels	NO	NO	18.61	NO	NO	NO	18.6	NO
2. Oil and Natural Gas	843.29	54.71	1148.98	0.38	0.38	NO	1992.7	8.41
2. Industrial Processes	1328.47	0.31	6.58	2.17	673.86	80.45	2089.4	8.82
A. Mineral Products	833.60	NE,NO	NE,NO	NE,NO	NE,NO	NO	833.6	3.52
B. Chemical Industry	476.59	6.58	6.58	2.17	673.86	NO	1157.0	4.88
C. Metal Production	18.28	NE,NO	NE,NO	NO	NO	NO	18.3	0.08
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	80.45	80.4	0.34
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	87.50	NO	NO	0.11	34.72	NO	122.2	0.52
4. Agriculture	NO	41.89	879.69	6.96	2158.43	NO	3038.1	12.82
A. Enteric Fermentation	NO	34.50	724.43	0.00	0.00	NO	724.4	3.06
B. Manure Management	NO	7.39	155.26	0.73	227.56	NO	382.8	1.62
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	6.23	1930.88	NO	1930.9	8.15
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8836.97	0.36	7.53	0.02	5.56	NO	-8823.9	-37.23
A. Forest Land	-9303.55	0.36	7.53	0.01	1.72	NO	-9294.3	-39.21
B. Cropland	157.28	NE,NO	NE,NO	3.84	3.84	NO	161.1	NO
C. Grassland	-94.19	NE,NO	NE,NO	NE,NO	NE,NO	NO	-94.2	NO
D. Wetlands	38.76	NE,NO	NE,NO	NE,NO	NE,NO	NO	38.8	NO
E. Settlements	364.73	NE,NO	NE,NO	NE,NO	NE,NO	NO	364.7	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	26.09	547.96	0.26	81.19	NO	629.2	2.65
A. Solid Waste Disp. on Land	NA,NO	15.32	321.80	0.00	0.00	NO	321.8	1.36
B. Waste-water Handling	0.00	10.77	226.16	0.26	81.19	NO	307.3	1.30
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.0	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	8997.28	130.58	2742.09	9.75	3023.81	80.45	14878.3	62.77
Total Emissions without LUCF	17834.25	130.22	2742.09	9.75	3023.81	80.45	23702.2	100.0
Share of Gases in Total Em./Rem.	60.47		18.43		20.32		100.0	
Share of Gases in Total Emissions	75.24		11.57		12.76		100.0	
Memo Items:								
International Bunkers	290.93	0.01	0.19	0.01	1.83	NO	292.9	
Aviation	176.02	0.00	0.03	0.00	1.54	NO	177.6	
Marine	114.91	0.01	0.16	0.00	0.28	NO	115.4	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,734.09	NO	NO	NO	NO	NO	1734.1	

Table A7-1: GHG emission in Croatia, 1997

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 1997	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	17274.25	64.99	1364.77	0.37	115.77	NO	18754.80	74.66
A. Fuel Comb (Sectoral Appr.)	16478.78	6.38	134.06	0.55	115.39	NO	16728.23	66.60
1. Energy Industries	5593.57	0.12	2.62	0.05	10.65	NO	5606.84	22.32
2. Man. Ind. and Constr.	3594.79	0.34	7.24	0.05	9.74	NO	3611.77	14.38
3. Transport	4010.17	1.41	29.54	0.34	72.05	NO	4111.76	16.37
4. Comm./Inst, Resid., Agric.	3280.24	4.51	94.67	0.11	22.95	NO	3397.86	13.53
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	795.48	58.61	1230.71	0.39	0.39	NO	2026.57	8.07
1. Solid Fuels	NO	NO	13.61	NO	NO	NO	13.61	NO
2. Oil and Natural Gas	795.48	57.96	1217.09	0.39	0.39	NO	2012.95	8.01
2. Industrial Processes	1508.56	0.28	5.81	2.28	708.21	102.85	2325.44	9.26
A. Mineral Products	943.13	NE,NO	NE,NO	NE,NO	NE,NO	NO	943.13	3.75
B. Chemical Industry	517.83	5.81	5.81	2.28	708.21	NO	1231.85	4.90
C. Metal Production	47.61	NE,NO	NE,NO	NO	NO	NO	47.61	0.19
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	102.85	102.85	0.41
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	78.52	NO	NO	0.11	34.72	NO	113.24	0.45
4. Agriculture	NO	41.61	873.86	7.76	2404.80	NO	3278.66	13.05
A. Enteric Fermentation	NO	34.35	721.36	0.00	0.00	NO	721.36	2.87
B. Manure Management	NO	7.26	152.50	0.72	223.66	NO	376.16	1.50
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	7.04	2181.14	NO	2181.14	8.68
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8281.55	0.57	11.88	0.02	6.39	NO	-8263.27	-32.90
A. Forest Land	-8756.02	0.57	11.88	0.01	2.72	NO	-8741.42	-34.80
B. Cropland	160.35	NE,NO	NE,NO	3.67	3.67	NO	164.02	NO
C. Grassland	-89.27	NE,NO	NE,NO	NE,NO	NE,NO	NO	-89.27	NO
D. Wetlands	40.47	NE,NO	NE,NO	NE,NO	NE,NO	NO	40.47	NO
E. Settlements	362.92	NE,NO	NE,NO	NE,NO	NE,NO	NO	362.92	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	26.90	564.97	0.26	81.55	NO	646.57	2.57
A. Solid Waste Disp. on Land	NA,NO	16.20	340.30	0.00	0.00	NO	340.30	1.35
B. Waste-water Handling	0.00	10.70	224.67	0.26	81.55	NO	306.22	1.22
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	10579.83	134.35	2821.30	10.70	3316.73	102.85	16855.44	67.10
Total Emissions without LUCF	18861.38	133.78	2821.30	10.70	3316.73	102.85	25118.71	100.0
Share of Gases in Total Em./Rem.	62.77		16.74		19.68		100.00	
Share of Gases in Total Emissions	75.09		11.23		13.20		100.00	
Memo Items:								
International Bunkers	263.80	0.01	0.13	0.01	1.85	NO	265.78	
Aviation	190.17	0.00	0.03	0.01	1.67	NO	191.87	
Marine	73.63	0.00	0.10	0.00	0.18	NO	73.92	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,793.72	NO	NO	NO	NO	NO	1793.72	

Table A7-1: GHG emission in Croatia, 1998

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 1998	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	18111.63	57.29	1203.14	0.30	92.46	NO	19407.22	76.73
A. Fuel Comb (Sectoral Appr.)	17403.51	6.16	129.41	0.44	92.10	NO	17625.01	69.69
1. Energy Industries	6272.23	0.14	2.88	0.06	11.67	NO	6286.78	24.86
2. Man. Ind. and Constr.	3770.72	0.34	7.10	0.05	9.85	NO	3787.68	14.98
3. Transport	4219.35	1.45	30.39	0.23	49.12	NO	4298.87	17.00
4. Comm./Inst, Resid., Agric.	3141.20	4.24	89.03	0.10	21.45	NO	3251.69	12.86
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	708.12	51.13	1073.73	0.36	0.36	NO	1782.21	7.05
1. Solid Fuels	NO	NO	14.26	NO	NO	NO	14.26	NO
2. Oil and Natural Gas	708.12	50.45	1059.47	0.36	0.36	NO	1767.95	6.99
2. Industrial Processes	1435.11	0.28	5.83	1.72	533.19	130.76	2104.88	8.32
A. Mineral Products	1017.32	NE,NO	NE,NO	NE,NO	NE,NO	NO	1017.32	4.02
B. Chemical Industry	388.43	5.83	5.83	1.72	533.19	NO	927.44	3.67
C. Metal Production	29.36	NE,NO	NE,NO	NO	NO	NO	29.36	0.12
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	130.76	130.76	0.52
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	76.87	NO	NO	0.11	34.72	NO	111.59	0.44
4. Agriculture	NO	41.08	862.71	6.91	2143.02	NO	3005.73	11.88
A. Enteric Fermentation	NO	33.93	712.46	0.00	0.00	NO	712.46	2.82
B. Manure Management	NO	7.15	150.25	0.70	217.88	NO	368.13	1.46
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	6.21	1925.14	NO	1925.14	7.61
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8196.33	1.06	22.29	0.03	8.60	NO	-8165.44	-32.28
A. Forest Land	-8680.36	1.06	22.29	0.02	5.10	NO	-8652.97	-34.21
B. Cropland	178.77	NE,NO	NE,NO	3.50	3.50	NO	182.27	NO
C. Grassland	-103.01	NE,NO	NE,NO	NE,NO	NE,NO	NO	-103.01	NO
D. Wetlands	42.19	NE,NO	NE,NO	NE,NO	NE,NO	NO	42.19	NO
E. Settlements	366.07	NE,NO	NE,NO	NE,NO	NE,NO	NO	366.07	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	27.76	582.93	0.26	79.52	NO	662.49	2.62
A. Solid Waste Disp. on Land	NA,NO	17.13	359.75	0.00	0.00	NO	359.75	1.42
B. Waste-water Handling	0.00	10.63	223.18	0.26	79.52	NO	302.70	1.20
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	11427.31	127.47	2676.90	9.22	2856.79	130.76	17126.47	67.72
Total Emissions without LUCF	19623.64	126.41	2676.90	9.22	2856.79	130.76	25291.91	100.0
Share of Gases in Total Em./Rem.	66.72		15.63		16.68		100.00	
Share of Gases in Total Emissions	77.59		10.58		11.30		100.00	
Memo Items:								
International Bunkers	287.83	0.01	0.14	0.01	2.01	NO	289.98	
Aviation	206.83	0.00	0.03	0.01	1.81	NO	208.67	
Marine	81.00	0.01	0.11	0.00	0.20	NO	81.31	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,678.97	NO	NO	NO	NO	NO	1678.97	

Table A7-1: GHG emission in Croatia, 1999

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 1999	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	18667.94	56.12	1178.53	0.45	138.27	NO	19984.74	75.21
A. Fuel Comb (Sectoral Appr.)	17976.50	5.92	124.39	0.66	137.93	NO	18238.83	68.64
1. Energy Industries	6467.65	0.14	2.94	0.06	11.81	NO	6482.41	24.40
2. Man. Ind. and Constr.	3506.30	0.30	6.26	0.04	8.37	NO	3520.93	13.25
3. Transport	4453.38	1.48	31.00	0.46	96.75	NO	4581.14	17.24
4. Comm./Inst, Resid., Agric.	3549.17	4.01	84.19	0.10	20.99	NO	3654.36	13.75
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	691.44	50.20	1054.14	0.34	0.34	NO	1745.91	6.57
1. Solid Fuels	NO	NO	4.29	NO	NO	NO	4.29	NO
2. Oil and Natural Gas	691.44	49.99	1049.85	0.34	0.34	NO	1741.62	6.55
2. Industrial Processes	1795.81	0.25	5.17	2.03	629.16	155.19	2585.32	9.73
A. Mineral Products	1275.21	NE,NO	NE,NO	NE,NO	NE,NO	NO	1275.21	4.80
B. Chemical Industry	492.14	5.17	5.17	2.03	629.16	NO	1126.47	4.24
C. Metal Production	28.45	NE,NO	NE,NO	NO	NO	NO	28.45	0.11
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	155.19	155.19	0.58
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	71.49	NO	NO	0.11	34.72	NO	106.21	0.40
4. Agriculture	NO	41.75	876.80	7.52	2329.87	NO	3206.66	12.07
A. Enteric Fermentation	NO	33.82	710.19	0.00	0.00	NO	710.19	2.67
B. Manure Management	NO	7.93	166.61	0.72	222.78	NO	389.39	1.47
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	6.80	2107.08	NO	2107.08	7.93
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8556.41	0.07	1.39	0.01	3.65	NO	-8551.37	-32.18
A. Forest Land	-9032.40	0.07	1.39	0.00	0.32	NO	-9030.69	-33.99
B. Cropland	168.37	NE,NO	NE,NO	3.33	3.33	NO	171.70	NO
C. Grassland	-108.60	NE,NO	NE,NO	NE,NO	NE,NO	NO	-108.60	NO
D. Wetlands	43.91	NE,NO	NE,NO	NE,NO	NE,NO	NO	43.91	NO
E. Settlements	372.30	NE,NO	NE,NO	NE,NO	NE,NO	NO	372.30	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	28.74	603.53	0.28	85.38	NO	688.95	2.59
A. Solid Waste Disp. on Land	NA,NO	18.18	381.84	0.00	0.00	NO	381.84	1.44
B. Waste-water Handling	0.00	10.56	221.69	0.28	85.38	NO	307.07	1.16
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	11978.86	126.92	2665.42	10.28	3186.32	155.19	18020.51	67.82
Total Emissions without LUCF	20535.28	126.86	2665.42	10.28	3186.32	155.19	26571.88	100.0
Share of Gases in Total Em./Rem.	66.47		14.79		17.68		100.00	
Share of Gases in Total Emissions	77.28		10.03		11.99		100.00	
Memo Items:								
International Bunkers	263.26	0.01	0.12	0.01	1.89	NO	265.28	
Aviation	197.59	0.00	0.03	0.01	1.73	NO	199.35	
Marine	65.68	0.00	0.09	0.00	0.16	NO	65.94	
Multilateral Operations	C	C	C	C	C	NO	C	
CO₂ Emissions from Biomass	1,495.79	NO	NO	NO	NO	NO	1495.79	

Table A7-1: GHG emission in Croatia, 2000

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 2000	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	18085.98	59.33	1246.02	0.48	150.31	NO	19482.32	74.10
A. Fuel Comb (Sectoral Appr.)	17347.11	6.37	133.72	0.71	149.99	NO	17630.83	67.06
1. Energy Industries	5877.45	0.14	3.00	0.07	14.56	NO	5895.01	22.42
2. Man. Ind. and Constr.	3616.74	0.30	6.40	0.04	8.72	NO	3631.87	13.81
3. Transport	4463.76	1.43	29.95	0.49	103.60	NO	4597.31	17.49
4. Comm./Inst, Resid., Agric.	3389.15	4.49	94.38	0.11	23.11	NO	3506.65	13.34
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	738.88	52.97	1112.30	0.32	0.32	NO	1851.49	7.04
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	738.88	52.97	1112.30	0.32	0.32	NO	1851.49	7.04
2. Industrial Processes	1932.72	0.25	5.23	2.39	740.39	182.86	2861.20	10.88
A. Mineral Products	1417.12	NE,NO	NE,NO	NE,NO	NE,NO	NO	1417.12	5.39
B. Chemical Industry	497.96	5.23	5.23	2.39	740.39	NO	1243.58	4.73
C. Metal Production	17.64	NE,NO	NE,NO	NO	NO	NO	17.64	0.07
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	182.86	182.86	0.70
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	74.50	NO	NO	0.11	34.72	NO	109.22	0.42
4. Agriculture	NO	40.65	853.60	7.34	2276.56	NO	3130.16	11.91
A. Enteric Fermentation	NO	33.28	698.87	0.00	0.00	NO	698.87	2.66
B. Manure Management	NO	7.37	154.73	0.70	216.04	NO	370.76	1.41
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	6.65	2060.53	NO	2060.53	7.84
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-7784.70	2.41	50.70	0.05	14.76	NO	-7719.24	-29.36
A. Forest Land	-8334.12	2.41	50.70	0.04	11.60	NO	-8271.82	-31.46
B. Cropland	245.45	NE,NO	NE,NO	3.16	3.16	NO	248.61	NO
C. Grassland	-125.55	NE,NO	NE,NO	NE,NO	NE,NO	NO	-125.55	NO
D. Wetlands	45.63	NE,NO	NE,NO	NE,NO	NE,NO	NO	45.63	NO
E. Settlements	383.89	NE,NO	NE,NO	NE,NO	NE,NO	NO	383.89	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	29.73	624.31	0.27	82.98	NO	707.33	2.69
A. Solid Waste Disp. on Land	NA,NO	19.24	404.11	0.00	0.00	NO	404.11	1.54
B. Waste-water Handling	0.00	10.49	220.20	0.27	82.98	NO	303.18	1.15
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	12308.54	132.37	2779.85	10.53	3265.01	182.86	18570.98	70.64
Total Emissions without LUCF	20093.24	129.96	2779.85	10.53	3265.01	182.86	26290.22	100.0
Share of Gases in Total Em./Rem.	66.28		14.97		17.58		100.00	
Share of Gases in Total Emissions	76.43		10.57		12.42		100.00	
Memo Items:								
International Bunkers	226.42	0.00	0.10	0.01	1.62	NO	228.15	
Aviation	169.40	0.00	0.03	0.00	1.48	NO	170.91	
Marine	57.02	0.00	0.08	0.00	0.14	NO	57.24	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,680.11	NO	NO	NO	NO	NO	1680.11	

Table A7-1: GHG emission in Croatia, 2001

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 2001	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	18905.85	64.37	1351.86	0.46	141.67	NO	20399.39	74.30
A. Fuel Comb (Sectoral Appr.)	18117.29	5.19	108.99	0.67	141.37	NO	18367.65	66.90
1. Energy Industries	6376.36	0.16	3.42	0.07	15.23	NO	6395.01	23.29
2. Man. Ind. and Constr.	3613.71	0.29	6.10	0.04	8.67	NO	3628.47	13.22
3. Transport	4521.54	1.22	25.71	0.47	98.17	NO	4645.42	16.92
4. Comm./Inst, Resid., Agric.	3605.68	3.51	73.76	0.09	19.30	NO	3698.74	13.47
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	788.56	59.18	1242.88	0.31	0.31	NO	2031.74	7.40
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	788.56	59.18	1242.88	0.31	0.31	NO	2031.74	7.40
2. Industrial Processes	2049.05	0.26	5.43	2.01	622.72	205.67	2882.87	10.50
A. Mineral Products	1636.05	NE,NO	NE,NO	NE,NO	NE,NO	NO	1636.05	5.96
B. Chemical Industry	403.70	5.43	5.43	2.01	622.72	NO	1031.85	3.76
C. Metal Production	9.29	NE,NO	NE,NO	NO	NO	NO	9.29	0.03
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	205.67	205.67	0.75
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	79.04	NO	NO	0.11	34.72	NO	113.76	0.41
4. Agriculture	NO	41.54	872.37	7.90	2449.50	NO	3321.87	12.10
A. Enteric Fermentation	NO	34.13	716.79	0.00	0.00	NO	716.79	2.61
B. Manure Management	NO	7.41	155.59	0.70	218.27	NO	373.86	1.36
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	7.20	2231.23	NO	2231.23	8.13
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8188.47	0.49	10.37	0.02	6.06	NO	-8172.03	-29.77
A. Forest Land	-8783.26	0.49	10.37	0.01	2.37	NO	-8770.52	-31.95
B. Cropland	278.07	NE,NO	NE,NO	3.69	3.69	NO	281.75	NO
C. Grassland	-171.74	NE,NO	NE,NO	NE,NO	NE,NO	NO	-171.74	NO
D. Wetlands	36.33	NE,NO	NE,NO	NE,NO	NE,NO	NO	36.33	NO
E. Settlements	452.14	NE,NO	NE,NO	NE,NO	NE,NO	NO	452.14	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	30.84	647.57	0.29	89.30	NO	736.91	2.68
A. Solid Waste Disp. on Land	NA,NO	20.47	429.83	0.00	0.00	NO	429.83	1.57
B. Waste-water Handling	0.00	10.37	217.74	0.29	89.30	NO	307.04	1.12
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	12845.52	137.51	2887.61	10.68	3309.25	205.67	19282.77	70.23
Total Emissions without LUCF	21033.98	137.01	2887.61	10.68	3309.25	205.67	27454.81	100.0
Share of Gases in Total Em./Rem.	66.62		14.98		17.16		100.00	
Share of Gases in Total Emissions	76.61		10.52		12.05		100.00	
Memo Items:								
International Bunkers	258.85	0.01	0.15	0.01	1.71	NO	260.70	
Aviation	169.48	0.00	0.03	0.00	1.48	NO	170.99	
Marine	89.37	0.01	0.13	0.00	0.22	NO	89.71	
Multilateral Operations	C	C	C	C	C	NO	C	
CO₂ Emissions from Biomass	1,315.01	NO	NO	NO	NO	NO	1315.01	

Table A7-1: GHG emission in Croatia, 2002

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 2002	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	20000.80	66.85	1403.88	0.33	102.91	NO	21507.59	75.31
A. Fuel Comb (Sectoral Appr.)	19198.13	5.24	110.04	0.49	102.60	NO	19410.77	67.97
1. Energy Industries	7247.35	0.19	3.94	0.08	17.84	NO	7269.12	25.45
2. Man. Ind. and Constr.	3436.58	0.28	5.86	0.04	8.51	NO	3450.96	12.08
3. Transport	4822.39	1.19	24.92	0.27	56.50	NO	4903.81	17.17
4. Comm./Inst, Resid., Agric.	3691.81	3.59	75.33	0.09	19.75	NO	3786.89	13.26
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	802.67	61.61	1293.84	0.31	0.31	NO	2096.82	7.34
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	802.67	61.61	1293.84	0.31	0.31	NO	2096.82	7.34
2. Industrial Processes	2003.28	0.21	4.49	1.95	604.48	237.70	2849.94	9.98
A. Mineral Products	1634.34	NE,NO	NE,NO	NE,NO	NE,NO	NO	1634.34	5.72
B. Chemical Industry	363.78	4.49	4.49	1.95	604.48	NO	972.75	3.41
C. Metal Production	5.16	NE,NO	NE,NO	NO	NO	NO	5.16	0.02
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	237.70	237.70	0.83
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	103.91	NO	NO	0.11	34.72	NO	138.63	0.49
4. Agriculture	NO	41.25	866.16	7.83	2426.07	NO	3292.23	11.53
A. Enteric Fermentation	NO	33.72	708.14	0.00	0.00	NO	708.14	2.48
B. Manure Management	NO	7.52	158.02	0.69	212.82	NO	370.84	1.30
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	7.14	2213.25	NO	2213.25	7.75
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8378.67	0.25	5.22	0.02	5.40	NO	-8368.05	-29.30
A. Forest Land	-8968.17	0.25	5.22	0.00	1.19	NO	-8961.76	-31.38
B. Cropland	254.40	NE,NO	NE,NO	4.21	4.21	NO	258.61	NO
C. Grassland	-158.65	NE,NO	NE,NO	NE,NO	NE,NO	NO	-158.65	NO
D. Wetlands	34.40	NE,NO	NE,NO	NE,NO	NE,NO	NO	34.40	NO
E. Settlements	459.36	NE,NO	NE,NO	NE,NO	NE,NO	NO	459.36	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	32.11	674.26	0.31	94.86	NO	769.17	2.69
A. Solid Waste Disp. on Land	NA,NO	21.85	458.90	0.00	0.00	NO	458.90	1.61
B. Waste-water Handling	0.00	10.26	215.37	0.31	94.86	NO	310.23	1.09
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	13729.35	140.67	2954.01	10.43	3233.73	237.70	20189.51	70.70
Total Emissions without LUCF	22108.03	140.42	2954.01	10.43	3233.73	237.70	28557.56	100.0
Share of Gases in Total Em./Rem.	68.00		14.63		16.02		100.00	
Share of Gases in Total Emissions	77.42		10.34		11.32		100.00	
Memo Items:								
International Bunkers	236.22	0.01	0.13	0.01	1.61	NO	237.96	
Aviation	162.99	0.00	0.02	0.00	1.43	NO	164.44	
Marine	73.24	0.00	0.10	0.00	0.18	NO	73.52	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,331.36	NO	NO	NO	NO	NO	1331.36	

Table A7-1: GHG emission in Croatia, 2003

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year2003	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	21385.03	68.34	1435.14	0.36	112.13	NO	22932.30	76.54
A. Fuel Comb (Sectoral Appr.)	20630.90	6.23	130.85	0.53	111.84	NO	20873.59	69.66
1. Energy Industries	7924.83	0.22	4.55	0.09	19.72	NO	7949.10	26.53
2. Man. Ind. and Constr.	3575.58	0.31	6.54	0.05	9.56	NO	3591.68	11.99
3. Transport	5210.40	1.14	23.91	0.28	58.69	NO	5293.00	17.67
4. Comm./Inst, Resid., Agric.	3920.10	4.56	95.85	0.11	23.86	NO	4039.81	13.48
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	754.13	62.11	1304.29	0.29	0.29	NO	2058.71	6.87
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	754.13	62.11	1304.29	0.29	0.29	NO	2058.71	6.87
2. Industrial Processes	2031.46	0.23	4.92	1.84	569.79	275.90	2882.06	9.62
A. Mineral Products	1613.56	NE,NO	NE,NO	NE,NO	NE,NO	NO	1613.56	5.39
B. Chemical Industry	409.38	4.92	4.92	1.84	569.79	NO	984.09	3.28
C. Metal Production	8.51	NE,NO	NE,NO	NO	NO	NO	8.51	0.03
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	275.90	275.90	0.92
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	112.13	NO	NO	0.11	34.72	NO	146.85	0.49
4. Agriculture	NO	43.16	906.46	7.40	2295.26	NO	3201.72	10.69
A. Enteric Fermentation	NO	35.28	740.85	0.00	0.00	NO	740.85	2.47
B. Manure Management	NO	7.89	165.62	0.72	222.75	NO	388.37	1.30
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	6.69	2072.50	NO	2072.50	6.92
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-7969.18	1.16	24.42	0.03	10.32	NO	-7934.44	-26.48
A. Forest Land	-8557.00	1.16	24.42	0.02	5.58	NO	-8527.00	-28.46
B. Cropland	239.61	NE,NO	NE,NO	4.73	4.73	NO	244.34	NO
C. Grassland	-155.77	NE,NO	NE,NO	NE,NO	NE,NO	NO	-155.77	NO
D. Wetlands	32.46	NE,NO	NE,NO	NE,NO	NE,NO	NO	32.46	NO
E. Settlements	471.53	NE,NO	NE,NO	NE,NO	NE,NO	NO	471.53	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	33.53	704.23	0.31	95.62	NO	799.89	2.67
A. Solid Waste Disp. on Land	NA,NO	23.39	491.15	0.00	0.00	NO	491.15	1.64
B. Waste-water Handling	0.00	10.15	213.08	0.31	95.62	NO	308.70	1.03
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	15559.48	146.44	3075.17	9.95	3083.12	275.90	22028.39	73.52
Total Emissions without LUCF	23528.66	145.27	3075.17	9.95	3083.12	275.90	29962.83	100.0
Share of Gases in Total Em./Rem.	70.63		13.96		14.00		100.00	
Share of Gases in Total Emissions	78.53		10.26		10.29		100.00	
Memo Items:								
International Bunkers	230.13	0.01	0.12	0.01	1.58	NO	231.83	
Aviation	161.46	0.00	0.02	0.00	1.41	NO	162.90	
Marine	68.67	0.00	0.10	0.00	0.17	NO	68.93	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,714.51	NO	NO	NO	NO	NO	1714.51	

Table A7-1: GHG emission in Croatia, 2004

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 2004	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	20777.85	69.50	1459.55	0.53	162.78	NO	22400.19	74.44
A. Fuel Comb (Sectoral Appr.)	19975.60	6.06	127.25	0.77	162.50	NO	20265.35	67.35
1. Energy Industries	6821.48	0.21	4.40	0.08	17.79	NO	6843.66	22.74
2. Man. Ind. and Constr.	3976.89	0.36	7.55	0.05	11.36	NO	3995.80	13.28
3. Transport	5343.72	1.07	22.38	0.52	110.16	NO	5476.25	18.20
4. Comm./Inst, Resid., Agric.	3833.52	4.42	92.92	0.11	23.20	NO	3949.64	13.13
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	802.25	63.44	1332.30	0.28	0.28	NO	2134.84	7.09
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	802.25	63.44	1332.30	0.28	0.28	NO	2134.84	7.09
2. Industrial Processes	2233.70	0.22	4.68	2.24	695.34	313.28	3247.00	10.79
A. Mineral Products	1723.39	NE,NO	NE,NO	NE,NO	NE,NO	NO	1723.39	5.73
B. Chemical Industry	495.43	4.68	4.68	2.24	695.34	NO	1195.45	3.97
C. Metal Production	14.89	NE,NO	NE,NO	NO	NO	NO	14.89	0.05
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	313.28	313.28	1.04
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	140.80	NO	NO	0.11	34.72	NO	175.52	0.58
4. Agriculture	NO	45.20	949.30	8.03	2488.94	NO	3438.24	11.43
A. Enteric Fermentation	NO	36.70	770.70	0.00	0.00	NO	770.70	2.56
B. Manure Management	NO	8.50	178.60	0.73	227.71	NO	406.31	1.35
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	7.29	2261.23	NO	2261.23	7.51
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8013.91	0.05	1.05	0.02	5.50	NO	-8007.36	-26.61
A. Forest Land	-8654.74	0.05	1.05	0.00	0.24	NO	-8653.45	-28.76
B. Cropland	249.08	NE,NO	NE,NO	5.26	5.26	NO	254.34	NO
C. Grassland	-173.86	NE,NO	NE,NO	NE,NO	NE,NO	NO	-173.86	NO
D. Wetlands	30.53	NE,NO	NE,NO	NE,NO	NE,NO	NO	30.53	NO
E. Settlements	535.08	NE,NO	NE,NO	NE,NO	NE,NO	NO	535.08	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	34.92	733.24	0.31	95.60	NO	828.88	2.75
A. Solid Waste Disp. on Land	NA,NO	24.82	521.32	0.00	0.00	NO	521.32	1.73
B. Waste-water Handling	0.00	10.09	211.92	0.31	95.60	NO	307.52	1.02
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	15138.48	149.90	3147.82	11.12	3448.15	313.28	22082.46	73.39
Total Emissions without LUCF	23152.39	149.85	3147.82	11.12	3448.15	313.28	30089.82	100.0
Share of Gases in Total Em./Rem.	68.55		14.25		15.61		100.00	
Share of Gases in Total Emissions	76.94		10.46		11.46		100.00	
Memo Items:								
International Bunkers	260.46	0.01	0.13	0.01	1.82	NO	262.41	
Aviation	187.39	0.00	0.03	0.01	1.64	NO	189.06	
Marine	73.06	0.00	0.10	0.00	0.18	NO	73.35	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,704.33	NO	NO	NO	NO	NO	1704.33	

Table A7-1: GHG emission in Croatia, 2005

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 2005	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	21060.77	69.14	1451.96	0.51	159.65	NO	22672.38	74.45
A. Fuel Comb (Sectoral Appr.)	20280.60	5.72	120.22	0.76	159.38	NO	20560.20	67.51
1. Energy Industries	6779.24	0.20	4.25	0.09	18.12	NO	6801.61	22.33
2. Man. Ind. and Constr.	4081.03	0.33	6.92	0.05	10.39	NO	4098.34	13.46
3. Transport	5553.38	0.91	19.17	0.52	108.63	NO	5681.18	18.66
4. Comm./Inst, Resid., Agric.	3866.95	4.28	89.88	0.11	22.24	NO	3979.06	13.07
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	780.17	63.42	1331.74	0.27	0.27	NO	2112.18	6.94
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	780.17	63.42	1331.74	0.27	0.27	NO	2112.18	6.94
2. Industrial Processes	2264.29	0.20	4.27	2.19	678.84	347.13	3294.53	10.82
A. Mineral Products	1768.40	NE,NO	NE,NO	NE,NO	NE,NO	NO	1768.40	5.81
B. Chemical Industry	484.65	4.27	4.27	2.19	678.84	NO	1167.77	3.83
C. Metal Production	11.24	NE,NO	NE,NO	NO	NO	NO	11.24	0.04
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	347.13	347.13	1.14
G. Other	NO	NO	NO	NO	NO	NO	NA,NO	NA,NO
3. Solvent and Other Product Use	160.07	NO	NO	0.11	34.72	NO	194.79	0.64
4. Agriculture	NO	45.77	961.15	8.12	2516.55	NO	3477.70	11.42
A. Enteric Fermentation	NO	38.36	805.58	0.00	0.00	NO	805.58	2.65
B. Manure Management	NO	7.41	155.57	0.72	224.02	NO	379.59	1.25
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	7.40	2292.53	NO	2292.53	7.53
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8158.60	0.05	1.12	0.02	6.04	NO	-8151.44	-26.77
A. Forest Land	-8783.84	0.05	1.12	0.00	0.26	NO	-8782.46	-28.84
B. Cropland	230.06	NE,NO	NE,NO	5.78	5.78	NO	235.84	NO
C. Grassland	-162.37	NE,NO	NE,NO	NE,NO	NE,NO	NO	-162.37	NO
D. Wetlands	28.59	NE,NO	NE,NO	NE,NO	NE,NO	NO	28.59	NO
E. Settlements	528.96	NE,NO	NE,NO	NE,NO	NE,NO	NO	528.96	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.03	34.03	714.53	0.32	99.83	NO	814.40	2.67
A. Solid Waste Disp. on Land	NA,NO	24.01	504.14	0.00	0.00	NO	504.14	1.66
B. Waste-water Handling	0.00	10.02	210.39	0.32	99.83	NO	310.22	1.02
C. Waste Incineration	0.03	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.03	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	15326.56	149.19	3133.04	11.16	3460.91	347.13	22302.36	73.23
Total Emissions without LUCF	23485.16	149.14	3133.04	11.16	3460.91	347.13	30453.79	100.0
Share of Gases in Total Em./Rem.	68.72		14.05		15.52		100.00	
Share of Gases in Total Emissions	77.12		10.29		11.36		100.00	
Memo Items:								
International Bunkers	305.13	0.01	0.14	0.01	2.18	NO	307.45	
Aviation	226.15	0.00	0.03	0.01	1.98	NO	228.16	
Marine	78.98	0.01	0.11	0.00	0.19	NO	79.29	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,586.57	NO	NO	NO	NO	NO	1586.57	

Table A7-1: GHG emission in Croatia, 2006

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 2006	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	21137.23	75.86	1593.02	0.37	115.15	NO	22845.40	73.94
A. Fuel Comb (Sectoral Appr.)	20347.42	5.71	120.00	0.55	114.87	NO	20582.29	66.62
1. Energy Industries	6628.38	0.19	4.05	0.08	17.31	NO	6649.74	21.52
2. Man. Ind. and Constr.	4181.48	0.34	7.10	0.05	11.07	NO	4199.64	13.59
3. Transport	5907.68	0.95	19.87	0.31	64.60	NO	5992.14	19.39
4. Comm./Inst, Resid., Agric.	3629.88	4.24	88.99	0.10	21.90	NO	3740.77	12.11
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	789.81	70.14	1473.02	0.28	0.28	NO	2263.11	7.32
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	789.81	70.14	1473.02	0.28	0.28	NO	2263.11	7.32
2. Industrial Processes	2389.75	0.29	6.07	2.17	671.21	379.09	3446.11	11.15
A. Mineral Products	1899.15	NE,NO	NE,NO	NE,NO	NE,NO	NO	1899.15	6.15
B. Chemical Industry	477.34	6.07	6.07	2.17	671.21	NO	1154.62	3.74
C. Metal Production	13.25	NE,NO	NE,NO	NO	NO	NO	13.25	0.04
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	379.09	379.09	1.23
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	189.51	NO	NO	0.11	34.72	NO	224.23	0.73
4. Agriculture	NO	47.66	1000.88	8.05	2496.89	NO	3497.77	11.32
A. Enteric Fermentation	NO	39.10	821.00	0.00	0.00	NO	821.00	2.66
B. Manure Management	NO	8.57	179.88	0.75	231.79	NO	411.67	1.33
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	7.31	2265.10	NO	2265.10	7.33
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8082.76	0.07	1.50	0.02	6.65	NO	-8074.62	-26.13
A. Forest Land	-8681.14	0.07	1.50	0.00	0.34	NO	-8679.30	-28.09
B. Cropland	208.00	NE,NO	NE,NO	6.30	6.30	NO	214.30	NO
C. Grassland	-166.34	NE,NO	NE,NO	NE,NO	NE,NO	NO	-166.34	NO
D. Wetlands	26.66	NE,NO	NE,NO	NE,NO	NE,NO	NO	26.66	NO
E. Settlements	530.06	NE,NO	NE,NO	NE,NO	NE,NO	NO	530.06	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.04	37.09	778.93	0.33	103.58	NO	882.55	2.86
A. Solid Waste Disp. on Land	NA,NO	27.14	569.87	0.00	0.00	NO	569.87	1.84
B. Waste-water Handling	0.00	9.96	209.06	0.33	103.58	NO	312.64	1.01
C. Waste Incineration	0.04	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.04	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	15633.76	160.97	3380.39	10.95	3393.47	379.09	22821.44	73.87
Total Emissions without LUCF	23716.52	160.90	3380.39	10.95	3393.47	379.09	30896.06	100.0
Share of Gases in Total Em./Rem.	68.50		14.81		14.87		100.00	
Share of Gases in Total Emissions	76.76		10.94		10.98		100.00	
Memo Items:								
International Bunkers	290.81	0.01	0.12	0.01	2.16	NO	293.09	
Aviation	229.82	0.00	0.03	0.01	2.01	NO	231.87	
Marine	60.98	0.00	0.08	0.00	0.15	NO	61.22	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,641.97	NO	NO	NO	NO	NO	1641.97	

Table A7-1: GHG emission in Croatia, 2007

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 2007	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	22324.12	82.17	1725.51	0.38	117.94	NO	24167.57	74.52
A. Fuel Comb (Sectoral Appr.)	21573.18	5.08	106.58	0.56	117.66	NO	21797.43	67.21
1. Energy Industries	7737.05	0.22	4.69	0.09	18.94	NO	7760.68	23.93
2. Man. Ind. and Constr.	4204.52	0.35	7.39	0.05	10.97	NO	4222.89	13.02
3. Transport	6330.19	0.91	19.09	0.33	68.95	NO	6418.22	19.79
4. Comm./Inst, Resid., Agric.	3301.42	3.59	75.41	0.09	18.81	NO	3395.64	10.47
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	750.94	77.09	1618.92	0.27	0.27	NO	2370.14	7.31
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	750.94	77.09	1618.92	0.27	0.27	NO	2370.14	7.31
2. Industrial Processes	2462.81	0.26	5.48	2.39	741.40	419.62	3629.32	11.19
A. Mineral Products	1928.88	NE,NO	NE,NO	NE,NO	NE,NO	NO	1928.88	5.95
B. Chemical Industry	521.51	5.48	5.48	2.39	741.40	NO	1268.39	3.91
C. Metal Production	12.42	NE,NO	NE,NO	NO	NO	NO	12.42	0.04
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NO	NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	419.62	419.62	1.29
G. Other	NO	NO	NO	NO	NO	NO	NA,NO	NA,NO
3. Solvent and Other Product Use	212.10	NO	NO	0.11	34.72	NO	246.82	0.76
4. Agriculture	NO	45.95	964.89	8.00	2480.97	NO	3445.87	10.63
A. Enteric Fermentation	NO	38.00	798.02	0.00	0.00	NO	798.02	2.46
B. Manure Management	NO	7.95	166.87	0.72	222.14	NO	389.01	1.20
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	7.29	2258.84	NO	2258.84	6.97
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-7737.34	0.24	5.01	0.03	7.97	NO	-7724.35	-23.82
A. Forest Land	-8269.28	0.24	5.01	0.00	1.15	NO	-8263.12	-25.48
B. Cropland	132.82	NE,NO	NE,NO	6.83	6.83	NO	139.65	NO
C. Grassland	-162.02	NE,NO	NE,NO	NE,NO	NE,NO	NO	-162.02	NO
D. Wetlands	24.72	NE,NO	NE,NO	NE,NO	NE,NO	NO	24.72	NO
E. Settlements	536.42	NE,NO	NE,NO	NE,NO	NE,NO	NO	536.42	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.08	39.77	835.23	0.34	105.25	NO	940.57	2.90
A. Solid Waste Disp. on Land	NA,NO	29.86	627.08	0.00	0.00	NO	627.08	1.93
B. Waste-water Handling	0.00	9.91	208.15	0.34	105.25	NO	313.40	0.97
C. Waste Incineration	0.08	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.08	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	17261.78	168.39	3536.13	11.14	3453.54	419.62	24705.79	76.18
Total Emissions without LUCF	24999.12	168.15	3536.13	11.14	3453.54	419.62	32430.13	100.0
Share of Gases in Total Em./Rem.	69.87		14.31		13.98		100.00	
Share of Gases in Total Emissions	77.09		10.90		10.65		100.00	
Memo Items:								
International Bunkers	312.94	0.01	0.21	0.01	3.30	NO	316.45	
Aviation	237.29	0.01	0.11	0.01	3.12	NO	240.51	
Marine	75.65	0.00	0.10	0.00	0.19	NO	75.94	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,442.73	NO	NO	NO	NO	NO	1442.73	

Table A7-1: GHG emission in Croatia, 2008

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 2008	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	21154.97	77.84	1634.59	0.36	113.07	NO	22902.63	73.48
A. Fuel Comb (Sectoral Appr.)	20496.00	5.09	106.93	0.54	112.82	NO	20715.75	66.47
1. Energy Industries	6705.03	0.19	3.90	0.08	17.36	NO	6726.30	21.58
2. Man. Ind. and Constr.	4197.67	0.33	6.95	0.05	10.07	NO	4214.68	13.52
3. Transport	6178.13	0.84	17.66	0.31	66.02	NO	6261.82	20.09
4. Comm./Inst, Resid., Agric.	3415.17	3.73	78.42	0.09	19.36	NO	3512.95	11.27
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	658.97	72.75	1527.65	0.26	0.26	NO	2186.88	7.02
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	658.97	72.75	1527.65	0.26	0.26	NO	2186.88	7.02
2. Industrial Processes	2395.16	0.19	3.90	2.44	756.66	436.72	3592.44	11.53
A. Mineral Products	1841.26	NE,NO	NE,NO	NE,NO	NE,NO	NO	1841.26	5.91
B. Chemical Industry	530.39	3.90	3.90	2.44	756.66	NO	1290.95	4.14
C. Metal Production	23.51	NE,NO	NE,NO	NO	NO	NO	23.51	0.08
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NA,NO	NA,NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	436.72	436.72	1.40
G. Other	NO	NO	NO	NO	NO	NO	NA,NO	NA,NO
3. Solvent and Other Product Use	204.59	NO	NO	0.11	34.72	NO	239.31	0.77
4. Agriculture	NO	46.86	984.16	7.89	2446.72	NO	3430.88	11.01
A. Enteric Fermentation	NO	39.26	824.43	0.00	0.00	NO	824.43	2.65
B. Manure Management	NO	7.61	159.74	0.68	209.79	NO	369.52	1.19
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	7.22	2236.93	NO	2236.93	7.18
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-7835.58	0.18	3.83	0.03	8.23	NO	-7823.51	-25.10
A. Forest Land	-8371.98	0.18	3.83	0.00	0.88	NO	-8367.27	-26.85
B. Cropland	98.94	NE,NO	NE,NO	7.35	7.35	NO	106.29	NO
C. Grassland	-164.52	NE,NO	NE,NO	NE,NO	NE,NO	NO	-164.52	NO
D. Wetlands	22.79	NE,NO	NE,NO	NE,NO	NE,NO	NO	22.79	NO
E. Settlements	579.19	NE,NO	NE,NO	NE,NO	NE,NO	NO	579.19	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	1.01	42.64	895.38	0.34	105.08	NO	1001.46	3.21
A. Solid Waste Disp. on Land	NA,NO	32.87	690.17	0.00	0.00	NO	690.17	2.21
B. Waste-water Handling	0.00	9.77	205.21	0.34	105.08	NO	310.29	1.00
C. Waste Incineration	1.01	NE,NO	NE,NO	NE,NO	NE,NO	NO	1.01	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	15920.15	167.71	3521.86	11.06	3429.75	436.72	23343.20	74.90
Total Emissions without LUCF	23755.72	167.53	3521.86	11.06	3429.75	436.72	31166.72	100.0
Share of Gases in Total Em./Rem.	68.20		15.09		14.69		100.00	
Share of Gases in Total Emissions	76.22		11.30		11.00		100.00	
Memo Items:								
International Bunkers	332.32	0.01	0.29	0.02	4.81	NO	337.42	
Aviation	265.52	0.01	0.20	0.02	4.65	NO	270.37	
Marine	66.80	0.00	0.09	0.00	0.16	NO	67.05	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,412.76	NO	NO	NO	NO	NO	1412.76	

Table A7-1: GHG emission in Croatia, 2009

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 2009	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	19956.68	75.37	1582.87	0.36	111.13	NO	21650.68	74.25
A. Fuel Comb (Sectoral Appr.)	19361.89	5.20	109.25	0.53	110.89	NO	19582.04	67.16
1. Energy Industries	6373.34	0.19	4.07	0.07	14.82	NO	6392.23	21.92
2. Man. Ind. and Constr.	3378.56	0.30	6.20	0.04	8.83	NO	3393.59	11.64
3. Transport	6182.15	0.78	16.38	0.32	67.04	NO	6265.58	21.49
4. Comm./Inst, Resid., Agric.	3427.84	3.93	82.59	0.10	20.21	NO	3530.65	12.11
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	594.79	70.17	1473.62	0.24	0.24	NO	2068.64	7.09
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	594.79	70.17	1473.62	0.24	0.24	NO	2068.64	7.09
2. Industrial Processes	1906.09	0.04	0.92	2.04	632.25	444.27	2983.54	10.23
A. Mineral Products	1449.16	NE,NO	NE,NO	NE,NO	NE,NO	NO	1449.16	4.97
B. Chemical Industry	445.63	0.92	0.92	2.04	632.25	NO	1078.80	3.70
C. Metal Production	11.30	NE,NO	NE,NO	NO	NO	NO	11.30	0.04
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NA,NO	NA,NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	444.27	444.27	1.52
G. Other	NO	NO	NO	NO	NO	NO	NA,NO	NA,NO
3. Solvent and Other Product Use	119.32	NO	NO	0.11	33.59	NO	152.91	0.52
4. Agriculture	NO	47.02	987.44	7.51	2326.68	NO	3314.12	11.37
A. Enteric Fermentation	NO	38.81	815.09	0.00	0.00	NO	815.09	2.80
B. Manure Management	NO	8.21	172.35	0.68	212.23	NO	384.58	1.32
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	6.82	2114.45	NO	2114.45	7.25
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-8075.86	0.09	1.91	0.03	8.31	NO	-8065.64	-27.66
A. Forest Land	-8602.65	0.09	1.91	0.00	0.44	NO	-8600.30	-29.49
B. Cropland	85.30	NE,NO	NE,NO	7.87	7.87	NO	93.18	NO
C. Grassland	-160.58	NE,NO	NE,NO	NE,NO	NE,NO	NO	-160.58	NO
D. Wetlands	20.86	NE,NO	NE,NO	NE,NO	NE,NO	NO	20.86	NO
E. Settlements	581.22	NE,NO	NE,NO	NE,NO	NE,NO	NO	581.22	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.38	45.26	950.55	0.34	106.47	NO	1057.41	3.63
A. Solid Waste Disp. on Land	NA,NO	35.57	746.97	0.00	0.00	NO	746.97	2.56
B. Waste-water Handling	0.00	9.69	203.59	0.34	106.47	NO	310.06	1.06
C. Waste Incineration	0.38	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.38	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	13906.62	167.79	3523.69	10.27	3184.85	444.27	21093.03	72.34
Total Emissions without LUCF	21982.48	167.70	3523.69	10.27	3184.85	444.27	29158.67	100.0
Share of Gases in Total Em./Rem.	65.93		16.71		15.10		100.00	
Share of Gases in Total Emissions	75.39		12.08		10.92		100.00	
Memo Items:								
International Bunkers	248.79	0.01	0.20	0.01	4.03	NO	253.02	
Aviation	227.17	0.01	0.17	0.01	3.98	NO	231.31	
Marine	21.62	0.00	0.03	0.00	0.05	NO	21.71	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,541.07	NO	NO	NO	NO	NO	1541.07	

Table A7-1: GHG emission in Croatia, 2010

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 2010	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	19251.98	78.46	1647.57	0.35	109.59	NO	21009.15	73.42
A. Fuel Comb (Sectoral Appr.)	18690.42	5.72	120.07	0.52	109.36	NO	18919.85	66.12
1. Energy Industries	5883.79	0.21	4.50	0.08	16.41	NO	5904.69	20.63
2. Man. Ind. and Constr.	3363.53	0.32	6.71	0.04	9.12	NO	3379.36	11.81
3. Transport	5963.40	0.70	14.66	0.29	61.59	NO	6039.64	21.11
4. Comm./Inst, Resid., Agric.	3479.71	4.49	94.20	0.11	22.24	NO	3596.16	12.57
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	561.56	72.74	1527.50	0.23	0.23	NO	2089.29	7.30
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	561.56	72.74	1527.50	0.23	0.23	NO	2089.29	7.30
2. Industrial Processes	1915.25	0.00	0.00	2.63	814.37	481.60	3211.22	11.22
A. Mineral Products	1419.76	NE,NO	NE,NO	NE,NO	NE,NO	NO	1419.76	4.96
B. Chemical Industry	468.22	0.00	0.00	2.63	814.37	NO	1282.59	4.48
C. Metal Production	27.27	NE,NO	NE,NO	NO	NO	NO	27.27	0.10
D. Other Production	NE	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NA,NO	NA,NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	481.60	481.60	1.68
G. Other	NO	NO	NO	NO	NO	NO	NA,NO	NA,NO
3. Solvent and Other Product Use	121.42	NO	NO	0.10	31.07	NO	152.48	0.53
4. Agriculture	NO	46.45	975.35	7.15	2217.78	NO	3193.13	11.16
A. Enteric Fermentation	NO	38.48	808.18	0.00	0.00	NO	808.18	2.82
B. Manure Management	NO	7.96	167.17	0.66	203.53	NO	370.70	1.30
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	6.50	2014.24	NO	2014.24	7.04
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-7881.67	0.06	1.32	0.03	8.70	NO	-7871.65	-27.51
A. Forest Land	-8467.79	0.06	1.32	0.00	0.30	NO	-8466.17	-29.59
B. Cropland	118.71	NE,NO	NE,NO	8.40	8.40	NO	127.10	NO
C. Grassland	-139.91	NE,NO	NE,NO	NE,NO	NE,NO	NO	-139.91	NO
D. Wetlands	18.92	NE,NO	NE,NO	NE,NO	NE,NO	NO	18.92	NO
E. Settlements	588.40	NE,NO	NE,NO	NE,NO	NE,NO	NO	588.40	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.13	44.91	943.08	0.34	106.29	NO	1049.51	3.67
A. Solid Waste Disp. on Land	NA,NO	35.21	739.50	0.00	0.00	NO	739.50	2.58
B. Waste-water Handling	0.00	9.69	203.59	0.34	106.29	NO	309.88	1.08
C. Waste Incineration	0.13	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.13	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	13407.12	169.87	3567.32	10.51	3256.73	481.60	20743.83	72.49
Total Emissions without LUCF	21288.79	169.81	3567.32	10.51	3256.73	481.60	28615.49	100.0
Share of Gases in Total Em./Rem.	64.63		17.20		15.70		100.00	
Share of Gases in Total Emissions	74.40		12.47		11.38		100.00	
Memo Items:								
International Bunkers	261.64	0.01	0.21	0.01	4.29	NO	266.14	
Aviation	242.21	0.01	0.18	0.01	4.24	NO	246.63	
Marine	19.43	0.00	0.03	0.00	0.05	NO	19.50	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	1,746.18	NO	NO	NO	NO	NO	1746.18	

Table A7-1: GHG emission in Croatia, 2011

Croatia	CO ₂	CH ₄		N ₂ O		HFC,PFC,SF ₆	Total	Share
Year 2011	Gg	Gg	Gg CO ₂ eq	Gg	Gg CO ₂ eq	Gg CO ₂ eq	Gg CO ₂ eq	%
1. Energy	19051.98	74.43	1563.04	0.32	100.33	NO	20715.35	73.31
A. Fuel Comb (Sectoral Appr.)	18474.82	6.45	135.55	0.48	100.12	NO	18710.49	66.22
1. Energy Industries	6252.91	0.22	4.62	0.09	17.91	NO	6275.44	22.21
2. Man. Ind. and Constr.	3139.07	0.29	6.15	0.04	8.11	NO	3153.34	11.16
3. Transport	5826.11	0.66	13.94	0.23	48.65	NO	5888.70	20.84
4. Comm./Inst, Resid., Agric.	3256.73	5.28	110.84	0.12	25.45	NO	3393.01	12.01
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive Emissions from Fuels	577.16	67.98	1427.49	0.21	0.21	NO	2004.86	7.10
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	577.16	67.98	1427.49	0.21	0.21	NO	2004.86	7.10
2. Industrial Processes	1709.86	0.00	0.00	2.60	804.50	485.77	3000.13	10.62
A. Mineral Products	1204.74	NE,NO	NE,NO	NE,NO	NE,NO	NO	1204.74	4.26
B. Chemical Industry	475.94	0.00	0.00	2.60	804.50	NO	1280.44	4.53
C. Metal Production	29.18	NE,NO	NE,NO	NO	NO	NO	29.18	0.10
D. Other Production	0.00	NO	NO	NO	NO	NO	NE	NE
E. Prod. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	NO	NA,NO	NA,NO
F. Cons. of Halocarbons & SF ₆	NO	NO	NO	NO	NO	485.77	485.77	1.72
G. Other	NO	NO	NO	NO	NO	NO	NA,NO	NA,NO
3. Solvent and Other Product Use	107.41	NO	NO	0.12	36.76	NO	144.16	0.51
4. Agriculture	NO	46.27	971.59	7.57	2346.93	NO	3318.52	11.74
A. Enteric Fermentation	NO	38.28	803.80	0.00	0.00	NO	803.80	2.84
B. Manure Management	NO	7.99	167.79	0.66	204.59	NO	372.38	1.32
C. Rice Cultivation	NO	NO	NO	0.00	0.00	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	6.91	2142.35	NO	2142.35	7.58
E. Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agr. Residues	NO	NO	NO	NO	NO	NO	NO	NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry	-7049.26	0.32	6.82	0.03	10.65	NO	-7031.80	-24.89
A. Forest Land	-7637.48	0.32	6.82	0.01	1.56	NO	-7629.10	-27.00
B. Cropland	93.99	NE,NO	NE,NO	9.09	9.09	NO	103.08	NO
C. Grassland	-125.67	NE,NO	NE,NO	NE,NO	NE,NO	NO	-125.67	NO
D. Wetlands	17.32	NE,NO	NE,NO	NE,NO	NE,NO	NO	17.32	NO
E. Settlements	602.58	NE,NO	NE,NO	NE,NO	NE,NO	NO	602.58	NO
F. Other Land	NO	NE,NO	NE,NO	NE,NO	NE,NO	NO	NE,NO	NO
G. Other	NE	NE	NE	NE	NE	NO	NE	NE
6. Waste	0.05	46.40	974.48	0.33	103.76	NO	1078.28	3.82
A. Solid Waste Disp. on Land	NA,NO	36.71	770.89	0.00	0.00	NO	770.89	2.73
B. Waste-water Handling	0.00	9.69	203.59	0.33	103.76	NO	307.35	1.09
C. Waste Incineration	0.05	NE,NO	NE,NO	NE,NO	NE,NO	NO	0.05	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO
Total Em./Rem. with LUCF	13820.03	167.42	3515.92	10.86	3366.18	485.77	21224.65	75.11
Total Emissions without LUCF	20869.29	167.10	3515.92	10.86	3366.18	485.77	28256.45	100.0
Share of Gases in Total Em./Rem.	65.11		16.57		15.86		100.00	
Share of Gases in Total Emissions	73.86		12.44		11.91		100.00	
Memo Items:								
International Bunkers	327.56	0.01	0.29	0.01	4.60	NO	332.45	
Aviation	252.38	0.01	0.19	0.01	4.42	NO	256.98	
Marine	75.18	0.00	0.10	0.00	0.18	NO	75.47	
Multilateral Operations	C	C	C	C	C	NO	C	
CO ₂ Emissions from Biomass	2,004.31	NO	NO	NO	NO	NO	2004.31	

ANNEX 8

CO₂ EMISSION FACTORS, OXIDATION FACTORS AND NATIONAL NET CALORIFIC VALUES (needed for monitoring and reporting on CO₂ emission)

Table 8-1: National net calorific values, CO₂ emission factors and oxidation factors for 1990 and 2011

Fuel	Net Caloric Value			Carbon emission factor ⁵³ (t C/TJ)	CO ₂ emission factor (t CO ₂ /TJ) (with OF=1.0)	Real oxidation factor (OF)
	Unit	1990	2011			
SOLID FUELS						
Anthracite	TJ/Gg	29.29	29.31	26.8	98.27	0.98
Other Bituminous Coal	TJ/Gg	25.14	24.40	25.8	94.60	0.98
Sub-Bituminous Coal	TJ/Gg	16.74	17.10	26.2	96.07	0.98
Lignite	TJ/Gg	10.90	11.60	27.6	101.20	0.98
Brown Coal Briquettes	TJ/Gg	16.74	-	26.6	97.53	0.98
Coke oven Coke	TJ/Gg	29.31	29.31	29.5	108.17	0.98
LIQUID FUELS						
Motor gasoline	TJ/Gg	44.60	44.59	18.9	69.30	0.99
Aviation gasoline	TJ/Gg	44.60	44.59	18.9	69.30	0.99
Jet Kerosene	TJ/Gg	44.00	43.96	19.5	71.50	0.99
Gas/Diesel oil	TJ/Gg	42.71	42.71	20.2	74.07	0.99
Residual Fuel Oil	TJ/Gg	40.19	40.19	21.1	77.37	0.99
Liquefied Petroleum Gases	TJ/Gg	46.89	46.89	17.2	63.07	0.99
Petroleum Coke	TJ/Gg	29.31	31.00	27.5	100.83	0.99
Petroleum	TJ/Gg	44.00	43.96	19.6	71.87	0.99
Lubricants	TJ/Gg	33.57	33.50	20.0	73.33	0.99
GASEOUS FUELS						
Natural Gas	TJ/10 ⁶ m ³	34.00	34.00	15.3	56.10	0.995
Gas Works Gas	TJ/10 ⁶ m ³	15.82	17.20	13.0	47.67	0.995
Coke Oven Gas	TJ/10 ⁶ m ³	17.9	-	13.0	47.67	0.995
BIOMASS FUELS						
Wood biomass	TJ/Gg	-	9.00	29.9	109.63	0.98
Industrial waste	TJ/Gg	-	-	29.9	109.63	0.98

⁵³ IPCC default (from "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook")

