NIR 2014

NATIONAL INVENTORY REPORT 2014

CROATIAN GREENHOUSE GAS INVENTORY FOR THE PERIOD 1990-2012

January 2015

CROATIAN ENVIRONMENT AGENCY

MINISTRY OF ENVIRONMENTAL AND NATURE PROTECTION

CROATIAN ENVIRONMENT AGENCY

NATIONAL INVENTORY REPORT 2014

Submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol

EKONERG – Energy and Environmental Protection Institute
Koranska 5, 10000 Zagreb, Croatia

Ordered by:	Croatian Environment Agency
Contract No.:	10-13-1811/79

Title:

NATIONAL INVENTORY REPORT 2014

Croatian greenhouse gas inventory
for the period 1990-2012

Project Coordinator:	Andrea Hublin
Authors (responsibilities/supports):	***Energy***: Iva Švedek, Valentina Delija-Ružić ***Industrial Processes***: Andrea Hublin, Renata Kos ***Solvent and Other Product Use***: Renata Kos ***Agriculture***: Berislav Marković ***LULUCF***: Delfa Radoš, Igor Stankić, Vladimir Jelavić, with the help of Peter Weiss (UBA Austria) ***Waste***: Andrea Hublin ***Uncertainty & Key Source Analyses***: Andrea Hublin ***QA/QC***: Davor Vešligaj ***CRF Database***: Iva Švedek, Berislav Marković
External authors:	***Energy Balance Expert***: Branko Vuk (Energy Institute Hrvoje Požar) ***National Registry***: Bernarda Rožman (Croatian Environment Agency)
Atmospheric Protection and Climate Change Department Manager:	General Manager:
Davor Vešligaj	Zdravko Mužek

Zagreb, January 2015

CONTENT:

LIST OF ABBREVIATIONS

AD	*- Activity Data*
ARKOD	*- Land parcel identification system*
CAA	*- Croatian Agricultural Agency*
CBS	*- Central Bureau of Statistics*
CEM	*- Continuous Emission Monitoring*
CFC	*- Chlorofluorocarbons*
CHC	*- 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
NMVOC - 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
int. - international
dom. - domestic

LIST OF TABLES AND FIGURES

LIST OF TABLES

LIST OF FIGURES

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 Protocol[1] 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, 47/14).

In this NIR, the inventory of the emissions and removals of the greenhouse gases (GHG) is reported for the period from 1990 to 2012. The NIR is prepared in accordance with the UNFCCC reporting guidelines on annual

---

[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.

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 nine reviews so far, in-country review in 2004, 2008 and 2012 and centralized reviews in 2005, 2006, 2009, 2010, 2011 and 2013. Issues recommended by the ERT have been included in this report as far as possible.

The calculation includes the emissions which are the result of anthropogenic activities and these include the following greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated carbons (HFCs, PFCs) and sulphur hexafluoride (SF_6) and indirect greenhouse gases: carbon monoxide (CO), oxides of nitrogen (NO_x), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2). 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 activity data (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 Chapter 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 calculation of greenhouse gas emissions and removals in line with good practices and national circumstances;
- consideration and approval of the National 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 assurance 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 2014 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-CO_2 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 2013 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 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. This national regulation has been replaced by Regulation (EU) No 525/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC.

New national Plan for Air Protection, Ozone Layer Protection and Climate Change Mitigation for the period 2013-2017 was prepared and published (Official Gazette No. 139/2013). The plan will stipulate concrete measures to improve performance of national system. It is planned to prepare and carry out several capacity building projects, related to improvements in emissions estimates in all IPCC sectors and specifically related for completeness reporting in LULUCF sector. This projects will start in 2014. Based on the one comprehensive project predicted within the plan in LULUCF sector in order to improve corresponding reporting, several smaller projects are developed. So far two projects were approved for the implementation, and additional new project proposal has been developed.

Committee for inter-sectorial coordination for national system was established by Governments decision in 2014. Committee will perform 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.

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 2012. The results are presented as total emissions of all greenhouse gases in CO_2 equivalents over sectors and then as emissions for the individual greenhouse gas by sectors. Since the certain greenhouse gases have different irradiation properties, and consequently 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 CO_2 impact which is accordingly defined as a referent value. In that case the emission of greenhouse gases is presented as the equivalent emission of carbon dioxide (CO_2-eq). If the removal of greenhouse gases occurs (e.g. the absorption of CO_2 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_20)	310
HFC-23	11700
HFC-32	650
HFC-125	2800
HFC-134a	1300
HFC-143a	3800
HFC-152a	140
HFC-227ea	2900
HFC-236fa	6300
CF_4	6500
C_3F_8	7000
C_2F_6	9200
SF_6	23900

Source: *Revised 1996 IPCC Guidelines*

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

Total emissions/removals of GHG for the period 1990-2012 and their trend in sectors are 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 1990-2012 (Gg CO_2-eq)

GHG source and sink categories	Emissions and removals of GHG (Gg CO_2-eq)								
	1990	1995	2000	2005	2008	2009	2010	2011	2012
Energy	22,797.11	17,264.19	19,482.23	22,675.67	22,902.11	21,649.26	21,039.69	20,749.87	18,923.16
Industrial Processes	3,769.49	2,008.26	2,849.02	3,295.62	3,590.93	2,979.76	3,204.93	3,004.19	2,850.61
Solvent and Other Product Use	116.98	108.34	109.22	193.61	238.17	151.76	151.32	143.05	155.57
Agriculture	4,682.71	3,496.04	3,478.00	3,699.53	3,646.52	3,552.98	3,446.17	3,563.15	3,394.67
Waste	610.76	667.44	759.83	861.15	1,054.53	1,095.75	1,087.98	1,118.42	1,125.61
Total emission (excluding net CO_2 from LULUCF)	**31,977.05**	**23,544.28**	**26,678.30**	**30,725.58**	**31,432.27**	**29,429.51**	**28,930.09**	**28,578.67**	**26,449.62**
LULUCF	-7,181.12	-9,832.95	-7,722.03	-8,630.06	-8,080.60	-8,304.30	-8,069.52	-6,996.35	-6,544.44
Total emission (including LULUCF)	**24,795.93**	**13,711.33**	**18,956.28**	**22,095.52**	**23,351.67**	**21,125.21**	**20,860.57**	**21,582.32**	**19,905.18**

Table ES.2-2: Emissions/removals of GHG by gases for the period 1990-2012 (Gg CO_2-eq)

GHG	Emissions and removals of GHG (Gg CO_2-eq)								
	1990	1995	2000	2005	2008	2009	2010	2011	2012
Carbon dioxide (CO_2)	23,339.56	17,213.76	20,099.51	23,501.38	23,770.70	21,991.10	21,330.41	20,918.00	19,233.20
Methane (CH_4)	3,696.55	3,086.83	3,009.21	3,333.13	3,631.17	3,633.41	3,686.79	3,626.13	3,422.54
Nitrous oxide (N_2O)	3,993.42	3,182.67	3,386.72	3,543.94	3,593.44	3,360.73	3,431.29	3,539.80	3,298.63
HFCs, PFCs and SF_6	947.52	61.02	182.86	347.13	436.97	444.27	481.60	494.74	495.24
Total emission (excluding net CO_2 from LULUCF)	**31,977.05**	**23,544.28**	**26,678.30**	**30,725.58**	**31,432.27**	**29,429.51**	**28,930.09**	**28,578.67**	**26,449.62**
CO_2 removals from LULUCF	-7,181.12	-9,832.95	-7,722.03	-8,630.06	-8,080.60	-8,304.30	-8,069.52	-6,996.35	-6,544.44
Total emission (including LULUCF)	**24,795.93**	**13,711.33**	**18,956.28**	**22,095.52**	**23,351.67**	**21,125.21**	**20,860.57**	**21,582.32**	**19,905.18**

Table ES.2-1 represents the contribution of the individual sectors to total emissions and removals of the GHGs. The largest contribution to the GHGs emission in 2012 has the Energy sector with 71.5 percent, followed by Agriculture with 12.8 percent, Industrial Processes with 10.8 percent, Waste with 4.3 percent and Solvent and Other product Use with 0.6 percent. This structure is with minor changes consistent through all the observed period from 1990 to 2012. In the year 2012, the total GHG emissions in Croatia was 26,449.6 Gg CO_2-eq excluding LULUCF sector while the total emission was 19,905.2 CO_2-eq including the LULUCF sector which represents removals by sink from 24.7% in that year.

Energy sector is the largest contributor to GHG emissions. In the year 2012, the GHG emission from Energy sector was 8.8 percent lower in relation to 2011 and 17.0 percent lower in relation to 1990. The total energy consumption in 2012 was 4.7 percent lower than in the previous year. The consumption of gaseous fuel decreased (6.3 percent) as well as consumption of solid fuel (10.4 percent). Consumption of fuel wood and other renewables increased (102.1 percent in relation to 2011). 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.

In 2012, the total electricity production was 2.52 percent lower than in the former year. Hydro power utilization has increased by 3.77 percent because of favorable hydrological conditions. Decrease in energy consumption from thermal power plants, public and industrial cogeneration plants was 7.2 percent. Electricity production in wind power plants was increased for 38.9 percent in relation to 2011. The import of electricity was about 30 percent of total electricity consumption in Croatia.

In Industrial Processes sector, the key emission sources are Cement Production, Ammonia Production, Nitric Acid Production and Consumption of HFCs in Refrigeration and Air Conditioning Equipment, which all together contribute with 94 percent in total sectoral emission in 2012. The iron production in blast furnaces and aluminium production ended in 1992, and ferroalloys production ended in 2003. Due to decreasing of economic activity after 2008, in 2012 emissions from industrial processes were decreased by 5.2 percent regarding 2011, by 20.5 percent regarding 2008 and by 24.3 percent regarding 1990.

The cement production fluctuated in the period 1990-1996 due to decline in industrial activities caused by the war in Croatia, whereas in the period 1997-2008 the cement production was constantly increasing. After that period, due to reduced economic activities, the cement production dropped by 22.6 percent in 2009, 26.5 percent in 2010, 28.4 percent in 2011, and 39.8 percent in 2012, regarding the year 2008. In the year 2012 the cement production was 13.8 percent lower in comparison to the 1990. 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 2.0 million tons of clinker was produced in the year 2012.

In the year 2012 the ammonia production was 7.0 percent lower in comparison to the 2011 and 6.4 percent lower in comparison to 2008, but 20.7 percent larger in comparison to 1990. In the year 2012 the nitric acid production was 13.4 percent lower in relation to 2011, 7.9 percent lower in relation to 2008 and 13.3 percent lower in relation to 1990.

Consumption of Halocarbons in Refrigeration and Air Conditioning Equipment in the period 1995-2012 was constantly increasing. Emissions in 2012 increased for 2.3 percent in comparison with 2011.

CO_2 emission from Solvent and Other Product Use contributes to the total GHG emission in 2012 with 0.6 percent. In the year 2012 emission was 8.8 percent larger in relation to 2011 and 33 percent larger in relation to 1990 since new activity data (regarding Other use of solvent) were included in the emission calculation.

Emission of CH_4 and N_2O in the Agricultural sector is conditioned by different agricultural activities. For the emission of CH_4, the most important source is livestock farming (Enteric Fermentation) which makes about 80 percent of sectoral CH_4 emission. The number of cattle showed continuous decrease in the period from 1990 to 2000. As a consequence, this led to CH_4 emission reduction. In the year 2000, the number of cattle has started increasing and this trend was mostly retained until 2006. From 2007 to 2010, cattle number decreased and remained at approximately the same level in 2011 and 2012. Compared to 2011, in 2012 CH_4 emission decreased by 1.7 percent. As for Manure management emissions, CH_4 emission decreased in 2012 compared to 2011 by 3.7 percent while N_2O emission remained at approximately same levels. 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. N_2O emission from Agricultural soils decreased in 2012 compared to 2011 by 6.1 percent. Overall, in the year 2012 the GHG emission from Agriculture sector decreased by 4.6 percent in comparison with 2011.

Waste sector includes waste disposal, waste water management and waste incineration, whereas the waste disposal represents dominant CH_4 emission source from that sector. Emissions from Waste sector have been constantly increasing in the period 1990-2012. Increasing emissions are a consequence of greater quantities of waste, activities in wastewater handling and waste incineration.

The emission from solid waste disposal on land 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. Although increasing of municipal solid waste amounts as a result of the growth in the living standard, amounts of municipal solid waste have 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. CH_4 that is recovered and burned in a flare in the period 2004-2012 have been included in emission estimation. It should be emphasized that Solid Waste Disposal on Land contributes with 70.5 percent in total sectoral emission in 2012. Waste sector contributes to total GHG emissions with 4.3 percent in 2012.

ES.2.1.1. CARBON DIOXIDE EMISSION (CO_2)

Carbon dioxide is the most significant anthropogenic GHG. The most significant anthropogenic sources of CO_2 emissions in Croatia are the processes of fossil fuel combustion for electricity or/and heat production, transport and industrial processes (cement and ammonia production). The results of the CO_2 emission calculation in Croatia are presented in Table ES.2-3.

Table ES.2-3: CO_2 emission/removal by sectors for the period 1990-2012 (Gg CO_2)

GHG source and sink categories	1990	1995	2000	2005	2008	2009	2010	2011	2012
Energy	21,234.20	15,905.02	18,085.92	21,060.62	21,154.54	19,955.07	19,282.49	19,086.50	17,452.57
Industrial processes	2,023.07	1,235.08	1,939.05	2,281.84	2,411.69	1,917.48	1,927.53	1,725.16	1,676.29
Solvent and Other Product Use	82.26	73.62	74.50	158.89	203.45	118.17	120.25	106.29	104.26
LULUCF	-7,187.90	-9,848.79	-7,877.52	-8,640.19	-8,103.07	-8,320.29	-8,080.86	-7,035.12	-6,615.42
Waste	0.04	0.04	0.04	0.03	1.01	0.38	0.13	0.05	0.08
Total CO_2 emission	**23,339.56**	**17,213.76**	**20,099.51**	**23,501.38**	**23,770.70**	**21,991.10**	**21,330.41**	**20,918.00**	**19,233.20**
Net CO_2 emission	**16,151.66**	**7,364.97**	**12,221.99**	**14,861.19**	**15,667.62**	**13,670.81**	**13,249.55**	**13,882.87**	**12,617.78**

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 GHG emission with share of 71.5 percent in total GHG emission (presented as equivalent emission of CO_2). CO_2 emission from fuel combustion makes the largest part of CO_2 emission (88.1 percent). Emission by sub-sectors is presented in Table ES.2-4.

Table ES.2-4: CO_2 emission by sub-sectors for the period 1990-2012 (Gg CO_2)

GHG source categories	1990	1995	2000	2005	2008	2009	2010	2011	2012
Energy Industries	7,126.54	5,262.45	5,877.45	6,779.24	6,705.03	6,373.34	5,883.79	6,252.91	5,597.70
Manufacturing Ind. and Construct.	5,842.92	3,540.91	3,616.74	4,081.03	4,197.67	3,378.56	3,396.64	3,174.56	2,787.48
Transport	4,019.17	3,406.63	4,463.69	5,553.23	6,177.71	6,180.53	5,960.80	5,825.15	5,647.74
Comm./Inst., Resid., Agr /For./Fish.	3,605.76	2,825.55	3,389.15	3,866.95	3,415.17	3,427.84	3,479.71	3,256.73	2,916.34
Fugitive emissions	639.82	869.47	738.88	780.17	658.97	594.79	561.56	577.16	503.31
Total CO_2 emission	**21,234.20**	**15,905.02**	**18,085.92**	**21,060.62**	**21,154.54**	**19,955.07**	**19,282.49**	**19,086.50**	**17,452.57**

Emission calculation is based on fuel consumption data recorded in annual national energy balance, where the fuel consumption and supply is presented at the sufficient level of detail which enables more detailed calculation by sub-sectors in the framework of the formal IPCC methodology (i.e. Sectoral approach). Furthermore, the simplest method of the calculation was carried out (i.e. Reference approach) which takes into account only the total balance of fuel, without sub-sector analysis. The relative deviation of CO_2 emissions between reference and sectoral approach for Croatia is around 2.5 percent (Table ES.2-5).

Table ES.2-5: CO_2 emission comparison due to fuel combustion (Gg)

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Reference approach	20,214.83	14,457.15	17,120.36	20,372.48	20,654.52	19,411.84	18,840.00	18,350.87	16,499.51
Sectoral approach	20,594.38	15,035.54	17,347.05	20,280.45	20,495.57	19,360.28	18,720.93	18,509.35	16,949.26
Relative Diff. (%)	**-1.84**	**-3.85**	**-1.31**	**0.45**	**0.78**	**0.27**	**0.64**	**-0.86**	**-2.65**

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 CO_2 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 CO_2 emission sources. This sector includes emission from road transport, civil aviation, railways and navigation. In the year 2012, the CO_2 emission from Transport sector contributed with 29.3 percent to the national total CO_2 emission. The largest part of the CO_2 emission from Transport sector arises from road transport (95.0 percent of CO_2 emission from transport sector in 2012) followed by national navigation, domestic civil aviation and railways.

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

Fugitive GHG 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 GHG 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 CO_2 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 IPCC, 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 CO_2 emission calculation for industrial processes are shown in Table ES.2-6.

Table ES.2-6: CO_2 emission from Industrial Processes for the period 1990-2012 (Gg CO2)

GHG source	1990	1995	2000	2005	2008	2009	2010	2011	2012
Cement production	1,085.79	628.67	1,243.59	1,499.86	1,526.87	1,224.17	1,198.26	1,050.36	998.87
Lime production	153.44	93.25	146.21	229.58	278.32	184.66	173.17	101.91	114.16
Limestone and dolomite use	51.71	17.86	16.82	33.32	32.50	31.51	36.87	44.46	37.82
Soda ash production and use	14.47	20.41	16.84	23.18	20.11	20.20	23.74	23.31	21.81
Ammonia production	466.01	438.77	497.96	484.65	530.39	445.63	468.22	475.94	503.32
Ferroalloys production	118.84	31.88	12.13	0.00	0.00	0.00	0.00	0.00	0.00
Aluminium production	111.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron and steel production	21.45	4.24	5.43	11.24	23.51	11.30	27.27	29.18	0.32
Total CO_2 emission	**2,023.07**	**1,235.08**	**1,938.98**	**2,281.84**	**2,411.69**	**1,917.48**	**1,927.52**	**1,725.16**	**1,676.29**

The most significant CO_2 industrial processes emission sources are production of cement, ammonia and lime. In 2012, cement production contributes in total sectoral CO_2 emission with 59.6 percent, lime production with 6.8 percent and ammonia production with 30.0 percent. Generally, CO_2 emissions from industrial processes declined from 1990 to 1995, due to the decline in industrial activities caused by the war in Croatia, while in the period 1996-2008 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, ammonia and steel productions. In 2012 CO_2 emissions from industrial processes dropped by 2.8 percent, regarding the year 2011, and by 30.5 percent, regarding the year 2008.

The quantity of the CO_2 emitted during cement production is directly proportional to the lime content of the clinker. Therefore, the CO_2 emissions are calculated using an emission factor, in tonnes of CO_2 released per tonne of clinker produced, to the annual clinker output corrected with the fraction of clinker that is lost from the kiln in the form of Cement Kiln Dust (CKD). The emission factor and correction factor for CKD is determined according to *Revised 1996 IPCC Guidelines and Good Practice Guidance*. 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 (CBS).

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

ES.2.1.1.3. CO_2 removals

The Low on Forest (Official Gazette No. 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 *Low on Forest*. 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 (according to the national definitions applied in the sector) and the 5 percent of the forests are grown artificially. The Plan determines, for 2006, growing stock of about 398 millions of m^3 while its yearly increment amounts around 10.5 million of m^3. The most frequent species are Common Beech (*Fagus sylvatica*), Pedunculate Oak (*Quercus robur*), Sessile Oak (*Quercus petrea*), Common Hornbeam (*Carpinus betulus*), Silver Fir (*Abies alba*), Narrow-leafed Ash (*Fraxinus angustifolia*), Spruce (*Picea abies*), Black Alder (*Alnus glutinosa*), Black Locust (*Robinia pseudoacacia*), Turkey Oak (*Quercus cerris*) and other.

The methodology used for CO_2 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 CO_2 emission/removal trend in the forestry sector.

Table ES.2-7: Emission trends in LULUCF sector for the period 1990-2012 (Gg CO_2)

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Removals	-7,187.90	-9,848.79	-7,877.52	-8,640.19	-8,103.07	-8,320.29	-8,080.86	-7,035.12	-6,615.42

ES.2.1.2. METHANE EMISSION (CH_4)

The major sources of methane (CH_4) emission are fugitive emission from production, processing, transportation and activities related with fuel use in Energy sector, Agriculture and Waste Disposal on Land. In Table ES.2-8, sectoral and total CH_4 emissions are reported.

Table ES.2-8: CH_4 emission in Croatia for the period 1990-2012 (Gg CH_4)

GHG source and sink categories	1990	1995	2000	2005	2008	2009	2010	2011	2012
Energy	69.31	61.26	59.33	69.20	77.86	75.41	78.49	74.43	65.27
Industrial processes	0.68	0.33	0.25	0.20	0.19	0.04	0.00	0.00	0.02
Agriculture	80.98	57.70	51.44	52.92	49.56	50.33	50.19	49.92	49.05
LULUCF	0.07	0.45	5.67	0.15	0.56	0.30	0.10	1.06	2.30
Waste	25.05	27.70	32.27	36.39	45.30	47.23	46.89	48.32	48.64
Total CH_4 emission	**176.10**	**147.44**	**148.97**	**158.88**	**173.47**	**173.32**	**175.67**	**173.73**	**165.28**

Fugitive methane emission is mainly the result of exploration, production, processing, transportation and distribution of natural gas (about 93.9 percent). The fugitive emission from oil and natural gas accounts with 35.9 percent in total methane emission, and venting and flaring of gas/oil production accounts with approximately 0.8 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 it 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 CH_4 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 CH_4 emissions.

ES.2.1.3. NITROUS OXIDE EMISSION (N_2O)

The most important sources of N_2O emissions in Croatia are agricultural activities, nitric acid production, but as well, the N_2O emissions occur in energy sector and waste management. In Table ES.2-9 the N_2O emission is reported according to sectors.

Table ES.2-9: N_2O emission in Croatia for the period 1990-2012 (Gg N_2O)

GHG source and sink categories	1990	1995	2000	2005	2008	2009	2010	2011	2012
Energy	0.35	0.23	0.48	0.52	0.36	0.36	0.35	0.32	0.32
Industrial Processes	2.53	2.27	2.33	2.14	2.38	1.99	2.57	2.53	2.19
Solvent and Other Product Use	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.12	0.17
Agriculture	9.62	7.37	7.73	8.35	8.41	8.05	7.72	8.11	7.63
LULUCF	0.02	0.02	0.12	0.02	0.03	0.03	0.03	0.05	0.07
Waste	0.27	0.28	0.26	0.31	0.33	0.33	0.33	0.33	0.34
Total N_2O emission	**12.90**	**10.29**	**11.04**	**11.45**	**11.63**	**10.87**	**11.10**	**11.47**	**10.71**

In the Agricultural sector, three N_2O emission sources are determined: direct N_2O emission from agricultural soils, direct N_2O emission from livestock farming and indirect N_2O emission induced by agricultural activities. The largest emission is a result of direct emission from agricultural soils which makes about 53.4 percent of total emission from agricultural soils in 2012. 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 is are separately analyzed.

In Industrial Processes sector, the N_2O emission occurs in nitric acid production, which is used as a raw material in nitrogen mineral fertilizers and in solvent and other product use. Catalytic decomposition of N_2O in nitric acid production has been applied since 2013, with the reduction of N_2O emission by 88%.

In Energy sector the emission was calculated on the basis of fuel consumption and adequate emission factors (IPCC). The major sources of N_2O emission in Energy sector is use of three-way catalytic converters in road transport motor vehicles.

N_2O 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 SF_6 EMISSIONS

Synthetic GHGs include halogenated carbons (HFCs and PFCs) and sulphur hexafluoride (SF_6). Although on an absolute scale their emissions are not great, due to their high global warming potential (GWP) their contribution to global warming is considerable. 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 SF_6 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 SF_6 (provided by the MENP) was used for emission calculation which is presented in Gg of CO_2-eq and showed in Table ES.2-10.

PFCs emissions that occur in Aluminium Production, an activity present in Croatia in 1990 and 1991, could represent a significant source of emissions due to high GWP values. Since only aluminium production statistics were available, emissions of PFCs in this report were estimated on the basis of annual primary aluminium production.

Table ES.2-10: HFCs, PFCs and SF_6 emission for the period from 1990-2012 (Gg CO_2-eq)

	1990	1995	2000	2005	2008	2009	2010	2011	2012
HFC, PFC and SF_6 emission	**947.52**	**61.02**	**182.86**	**347.13**	**436.97**	**444.27**	**494.97**	**495.45**	**495.24**

ES.3. EMISSION OF INDIRECT GREENHOUSE GASES

The photochemicaly 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 (SO_2), 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 2012* 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 SO_2 by different sectors (Gg)

GHG	Emissions (Gg)								
	1990	1995	2000	2005	2008	2009	2010	2011	2012
NO_x Emission	**93.3**	**64.5**	**72.5**	**72.6**	**74.6**	**68.6**	**62.8**	**60.3**	**55.0**
Energy Industries	17.5	14.5	13.8	12.2	11.5	11.5	9.5	9.6	8.4
Manufacturing Ind. & Construction	16.3	7.6	7.7	10.1	13.0	10.0	8.8	8.2	7.4
Transport	41.0	31.4	35.1	34.6	34.0	31.4	29.5	27.9	25.5
Other Energy (fuel comb.)	15.0	8.1	12.8	13.1	13.5	13.3	13.2	13.3	12.5
Fugitive Em. from Fuels	0.5	0.3	0.3	0.3	0.2	0.3	0.2	0.2	0.2
Industrial Processes	2.8	2.6	2.6	2.3	2.4	2.1	1.7	1.1	1.0
Agriculture	0.1	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1
CO Emission	**586.0**	**294.8**	**476.3**	**353.0**	**289.7**	**286.7**	**276.5**	**287.4**	**293.3**
Energy Industries	2.4	1.6	1.6	1.1	1.5	1.2	1.1	1.2	1.1
Manufacturing Ind. & Construction.	37.2	38.1	33.6	33.5	34.0	32.8	28.9	26.4	24.0
Transport	237.8	175.3	172.9	112.9	80.4	73.1	63.5	55.6	42.9
Other Energy (fuel comb.)	204.0	116.7	146.4	133.0	120.1	126.2	141.8	166.3	173.8
Fugitive Em. from Fuels	50.1	34.5	54.1	54.4	41.6	51.9	40.1	32.6	35.4
Industrial Processes	40.9	27.3	30.1	17.4	9.3	0.5	0.2	0.2	0.17
Agriculture	4.3	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	9.3	1.4	37.6	0.8	2.8	1.4	1.0	5.1	15.9

Table ES.3-1: Emissions of ozone precursors and SO_2 by different sectors (Gg), cont.

Gas	Emissions (Gg)								
	1990	1995	2000	2005	2008	2009	2010	2011	2012
NMVOC Emission	**117.7**	**80.0**	**90.4**	**103.9**	**111.5**	**79.2**	**78.1**	**73.8**	**70.0**
Energy Industries	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2
Manufacturing Ind. & Construction	1.6	1.3	1.4	1.8	2.1	1.8	1.5	1.4	1.3
Transport	41.7	30.5	34.1	21.3	17.4	15.6	13.4	12.3	9.5
Other Energy (fuel comb.)	12.1	6.9	9.0	8.3	7.7	8.0	8.8	10.1	10.4
Fugitive Em. from Fuels	8.5	6.7	9.1	8.5	7.5	8.0	7.7	7.1	6.4
Industrial Processes	24.4	9.0	7.7	9.6	6.8	5.1	5.3	5.8	5.1
Solvent and Other Product Use	28.1	25.1	25.4	54.2	69.4	40.3	41.0	36.3	35.6
LULUCF	0.8	0.1	3.4	0.1	0.3	0.1	0.1	0.5	1.4
SO_2 Emission	**174.0**	**81.7**	**61.5**	**63.5**	**57.1**	**59.3**	**35.3**	**33.2**	**25.6**
Energy Industries	99.5	54.0	32.9	32.7	32.0	36.7	19.7	17.9	14.6
Manufacturing Ind. & Construction.	39.8	16.7	11.0	9.7	8.2	6.1	4.7	4.3	2.8
Transport	5.9	3.5	6.0	9.2	7.4	6.9	3.1	2.6	0.7
Other Energy (fuel comb.)	23.9	4.7	6.5	6.8	4.3	4.5	4.2	3.7	2.8
Fugitive Em. from Fuels	1.8	1.2	3.1	3.1	2.8	3.3	2.3	3.5	3.7
Industrial Processes	3.2	1.6	2.0	2.1	2.4	1.8	1.3	1.1	1.0

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 Protocol[2] 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, 47/14).

---

[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 2012. 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 nine reviews so far, in-country review in 2004, 2008 and 2012 and centralized reviews in 2005, 2006, 2009, 2010, 2011 and 2013. Issues recommended by the ERT have been included in this report as far as possible.

The calculation includes the emissions which are the result of anthropogenic activities and these include the following greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated carbons (HFCs, PFCs) and sulphur hexafluoride (SF_6) and indirect greenhouse gases: carbon monoxide (CO), oxides of nitrogen (NO_x), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2). 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 activity data (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-CO_2 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 2013 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 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. This national regulation has been replaced by Regulation (EU) No 525/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC.

New national Plan for Air Protection, Ozone Layer Protection and Climate Change Mitigation for the period 2013-2017 was prepared and published (Official Gazette No. 139/2013). The plan will stipulate concrete measures to improve performance of national system. It is planned to prepare and carry out several capacity building projects, related to improvements in emissions estimates in all IPCC sectors and specifically related for completeness reporting in LULUCF sector. This projects will start in 2014. Based on the one comprehensive project predicted within the plan in LULUCF sector in order to improve corresponding reporting, several smaller projects are developed. So far two projects were approved for the implementation, and additional new project proposal has been developed.

Committee for inter-sectorial coordination for national system was established by Governments decision in 2014. Committee will perform 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.

Changes in national registry

There were no changes in national registry.

1.2. BRIEF DESCRIPTION OF THE INSTITUTIONAL ARRANGEMENT FOR INVENTORY PREPARATION

Institutional arrangement for inventory preparation in Croatia is regulated in Chapter 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 calculation of greenhouse gas emissions and removals in line with good practices and national circumstances;
- consideration and approval of the National 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 assurance 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 2014 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.

1.3. 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:
    - National GHG Inventory Improvement Strategy
    - National QA/QC plan
    - National QA/QC guidance
    - Manuals of procedures for compiling, archiving, updating and managing GHG Inventory
    - Description of inventory archives

- Description of awareness-raising campaign
- Improvement of GHG emission calculation from road transport
- 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 nine reviews so far, in-country review in 2004, 2008 and 2012 and centralized reviews in 2005, 2006, 2009, 2010, 2011 and 2013. Issues recommended by the ERT have been included in this report as far as possible.

1.4. 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. CO_2, CH_4, N_2O, HFCs, PFCs, SF_6. Emissions of indirect GHGs have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2012* Submission to the Convention on Long-range Transboundary Air Pollution'.

Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are principal greenhouse gases and though they occur naturally in the atmosphere, their recent atmospheric build-up appears to be largely the result of human activities. Synthetic gases such as halogenated hydrocarbons (PFCs, HFCs) and sulphur hexafluoride (SF_6) are also considered as greenhouse gases and they are solely the result of human activities. The methodology does not include the CFCs which are the subject of the Montreal Protocol. In addition, there are other photochemically active gases such as carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane volatile organic compounds (NMVOCs) that, although not considered as greenhouse gases, contribute indirectly to the greenhouse effect in the atmosphere. These are generally referred to as ozone precursors, because they participate in the creation and destruction of tropospheric and stratospheric ozone (which is also GHG). Sulphur dioxide (SO_2), as a precursor of 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 - Verified reports of CO_2 emission - 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	- CBS, Department of Manufacturing and Mining - CEA - 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2012* 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)	- MENP
	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 - CEA
Solvent and Other Product Use	Activity data on production for particular source category and number of inhabitants	- 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2012* Submission to the Convention on Long-range Transboundary Air Pollution'

CRF Sector/Sub-sector	Type of data	Source of data
Agriculture	Livestock number	- CBS - Croatian Agricultural Agency (CAA)
	Production of N-fixing crops and non N-fixing crops	- CBS
	Area of histosols	- Faculty of Agriculture
	Activity data on mineral fertilisers applied in Croatia	- Voluntary survey of Fertilizer Companies
	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 harvest and wildfires Activity data on crop production	- Ministry of Agriculture with assistance of public company "Hrvatske šume" - CEA - CBS
Waste	Activity data on municipal solid waste disposed to different types of SWDSs	- MENP - CEA
	Activity data on wastewater handling	- State company Croatian Water (Hrvatske vode)
	Activity data on waste incineration	- CEA

1.5. BRIEF DESCRIPTION OF KEY CATEGORIES

According to the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, key categories are those which represent 95% (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. Because of the minor difference between last submission of NIR 2014 (March 2014) and this submission of NIR 2014 (May 2014), especially for the last year 2012, key categories analysis presented in Annex 1 refers to submission of NIR 2014 from March 2014.

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 CO_2 equivalents from different sources and sinks on the sectoral level. The recommended IPCC categories as well as the categories recommended in *Good Practice Guidance for*

Land Use, Land-Use Change and Forestry to be assessed in the key category analysis are presented in Table A1-1 of the Annex 1.

The results of the Approach 1 Level Assessment including/excluding LULUCF for 1990 and 2012 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 2012 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 2012 using Approach 1 and Approach 2.

Key category analysis is used to drive improvements of the inventory. Most efforts are made to collect detailed information on emissions calculation regarding key sources. Considerable efforts are put into gathering more detailed information on activity data and important information for developing national emission factors for categories that represent key sources, in order to use higher tier method for emission calculation. Continue improvements and investigation of activity data and emission factors for key categories are performed with the purpose of more detailed explanation on their trends, to improve consistency and transparency of the inventory.

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 2012 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 CO_2 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 CO_2 emissions from fossil fuel combustion, within the framework of IPCC methodology, are estimated using two approaches: (1) Reference Approach and (2) Sectoral Approach (Tier 1).

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*. Because of the minor difference between last submission of NIR 2014 (March 2014) and this submission of NIR 2014 (May 2014), especially for the last year 2012, uncertainty analysis presented in Annex 5 refers to submission of NIR 2014 from March 2014.

According to the Tier 1 uncertainty analysis the total uncertainty excluding LULUCF is 15.17 percent, while the total uncertainty including LULUCF is 35.86 percent.

According to the Tier 2 Monte Carlo analysis the total uncertainty excluding LULUCF for all key source activities is estimated to be from -14.98 percent to +16.09 percent.

According to the Tier 2 Monte Carlo analysis the total uncertainty including LULUCF for all key source activities is estimated to be from -38.06 percent to +38.94 percent.

According to the Tier 1, the uncertainty introduced into the trend in total national emissions excluding LULUCF is estimated to be 16.84 percent and including LULUCF 37.73 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 -14.45 percent to +16.92 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 -32.41 percent to +43.11 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 2012.

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.

1.8. GENERAL ASSESSMENT OF THE COMPLETENESS

Croatian inventory consists of the emission estimates for the period from 1990-2012.

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 2012, excluding removals by sinks, amounted to 26.449,6 mil. t CO_2-eq (equivalent CO_2 emissions), which represents 17.3 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 2009-2012, emission has been reduced by 6.4 percent in 2009, 8.0 percent in 2010, 9.1 percent in 2011, 15.9 percent in 2012,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 2012 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. In 2012, overall emissions from industrial processes dropped by 5.1 precent, regarding 2011 and by 20.6 precent, regarding 2008.

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 CO_2 is the largest anthropogenic contributor to total national GHG emissions. In 2012, the shares of GHG emissions were as follows: 72.9 percent CO_2, 12.9 percent CH_4, 12.3 percent N_2O, 1.7 percent HFCs and 0.04 percent SF_6. 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 (1990-2012)

GHG	Emissions and removals of GHG (Gg CO_2-eq)								
	1990	1995	2000	2005	2008	2009	2010	2011	2012
Carbon dioxide (CO_2)	23,339.56	17,213.76	20,099.51	23,501.38	23,770.70	21,991.10	21,330.41	20,918.00	19,233.20
Methane (CH_4)	3,696.55	3,086.83	3,009.21	3,333.13	3,631.17	3,633.41	3,686.79	3,626.13	3,422.54
Nitrous oxide (N_2O)	3,993.42	3,182.67	3,386.72	3,543.94	3,593.44	3,360.73	3,431.29	3,539.80	3,298.63
HFCs, PFCs and SF_6	947.52	61.02	182.86	347.13	436.97	444.27	481.60	494.74	495.24
Total emission (excluding net CO_2 from LULUCF)	**31,977.05**	**23,544.28**	**26,678.30**	**30,725.58**	**31,432.27**	**29,429.51**	**28,930.09**	**28,578.67**	**26,449.62**
CO_2 removals from LULUCF	-7,181.12	-9,832.95	-7,722.03	-8,630.06	-8,080.60	-8,304.30	-8,069.52	-6,996.35	-6,544.44
Total emission (including LULUCF)	**24,795.93**	**13,711.33**	**18,956.28**	**22,095.52**	**23,351.67**	**21,125.21**	**20,860.57**	**21,582.32**	**19,905.18**

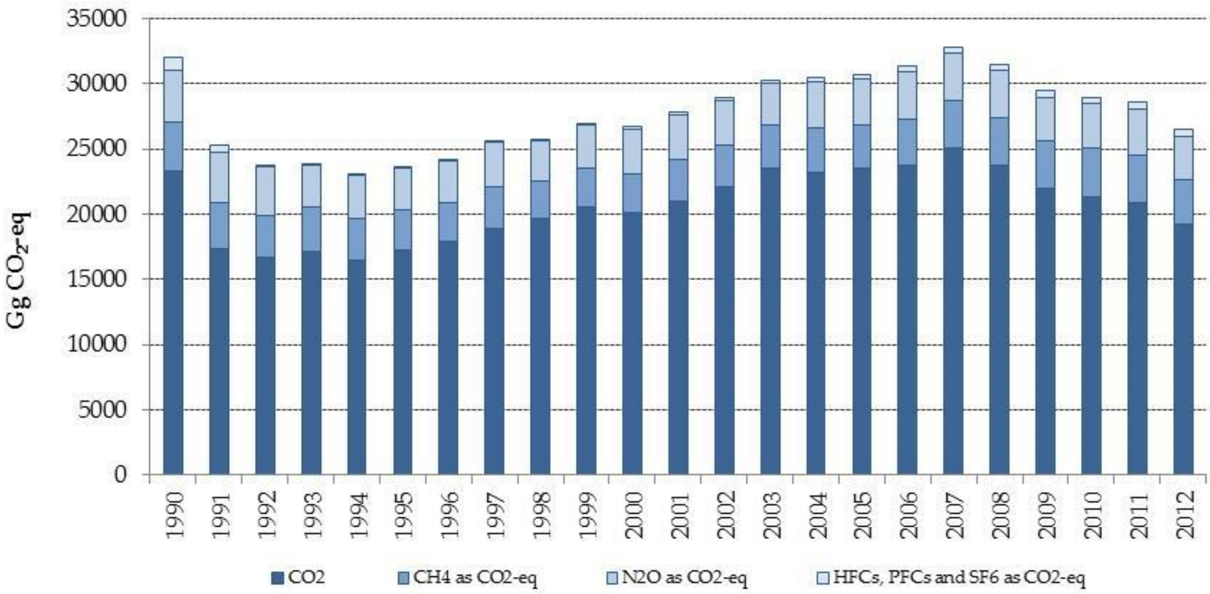


Figure 2.2-1: Trend of GHG emissions, by gases

2.2.1. CARBON DIOXIDE (CO_2)

The most significant anthropogenic greenhouse gas is carbon dioxide (CO_2). In 2012, CO_2 emission was 17.6 percent lower than in 1990. The largest CO_2 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. Large CO_2 emission growth is present in Solvent and Other Product use.

2.2.2. METHANE (CH_4)

The CH_4 emission in 2012 was 7.4 percent lower than in 1990, largely due to emission trend in Agriculture sector.

2.2.3. NITROUS OXIDE (N_2O)

The N_2O emission in 2012 was 17.4 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, 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 2012 was approximately 1.9 percent.

2.2.5. SULPHUR HEXAFLUORIDE (SF_6)

Total emissions of SF_6 used in GIS application and high voltage circuit-breakers have been estimated using data on total charge of SF_6 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 SF_6 in total national GHG emission in 2012 was approximately 0.04 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 (1990-2012)

GHG source and sink categories	Emissions and removals of GHG (Gg CO_2-eq)								
	1990	1995	2000	2005	2008	2009	2010	2011	2012
Energy	22,797.11	17,264.19	19,482.23	22,675.67	22,902.11	21,649.26	21,039.69	20,749.87	18,923.16
Industrial Processes	3,769.49	2,008.26	2,849.02	3,295.62	3,590.93	2,979.76	3,204.93	3,004.19	2,850.61
Solvent and Other Product Use	116.98	108.34	109.22	193.61	238.17	151.76	151.32	143.05	155.57
Agriculture	4,682.71	3,496.04	3,478.00	3,699.53	3,646.52	3,552.98	3,446.17	3,563.15	3,394.67
Waste	610.76	667.44	759.83	861.15	1,054.53	1,095.75	1,087.98	1,118.42	1,125.61
Total emission (excluding net CO_2 from LULUCF)	**31,977.05**	**23,544.28**	**26,678.30**	**30,725.58**	**31,432.27**	**29,429.51**	**28,930.09**	**28,578.67**	**26,449.62**
LULUCF	-7,181.12	-9,832.95	-7,722.03	-8,630.06	-8,080.60	-8,304.30	-8,069.52	-6,996.35	-6,544.44
Total emission (including LULUCF)	**24,795.93**	**13,711.33**	**18,956.28**	**22,095.52**	**23,351.67**	**21,125.21**	**20,860.57**	**21,582.32**	**19,905.18**

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 71.5 percent of the total national GHG emissions (presented as equivalent emission of CO_2). In 2012, the GHG emission from Energy sector was 8.8 percent lower in relation to 2011 and 17.0 percent smaller than emission in 1990.

The main reasons of GHG emission decrease in 2012 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 2012 was 6.9 percent lower than in the previous year. The consumption of all fuel types decreased; liquid fuel for 6.0 percent, solid fuels for 12.4 percent and gaseous fuels fuels for 11.0 percent. Only consumption of renewables increaseds for 15.9 percend in comparison to 2011.

In 2012, the total electricity production was 2.52 percent lower than in the former year. Hydro power utilization has increased by 3.77 percent because of favorable hydrological conditions. Decrease in energy consumption from thermal power plants, public and industrial cogeneration plants was 7.2 percent. Electricity production in wind power plants was increased for 38.9 percent in relation to 2011. 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 2012 emissions from this sector have dropped by 20.5 percent, regarding 2008. In 2012, cement production was decreased by 15.2 percent, lime production by 21.9 percent, iron and steel production by 98.9 percent and ammonia production by 7.0 percent, compared to 2011. Consequently, in 2012 emissions from industrial processes were decreased by 5.1 precent, regarding 2011.

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 CO_2). The GHG emission in 2012 was 24.8 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 2012 was about 27.5 percent lower in comparison with 1990 emission. According to estimation of Croatian experts for agriculture, 12.7 percent of total GHG emissions in 2012 belong to Agriculture.

2.3.5.WASTE

Emissions from Waste sector have been constantly increasing in the period 1990-2012. 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, amounts of municipal solid waste have slightly declined due to economic crisis and effects of measures undertaken to avoid/reduce, separatelly collect and recycle waste. Priority is given to avoiding and reducing waste generation and reducing its hazardous properties. The GHG emission in 2012 was 84.3 percent larger in comparison with 1990 emission. Contribution of waste sector to the total GHG emission is 4.3 percent.

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

Although they are not considered as greenhouse gases, photochemical active gases such as carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane volatile organic compounds (NMVOCs) indirectly contribute to the greenhouse effect. These are generally referred to as indirect greenhouse gases or ozone precursors because they take effect in the creation and degradation of O_3 as one of the GHGs. Sulphur dioxide (SO_2), as a precursor of sulphate and aerosols, is believed to contribute negatively to the greenhouse effect.

Emissions of indirect GHGs have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2012* Submission to the Convention on Long-range Transboundary Air Pollution'.

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

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

Gas	Emissions (Gg)								
	1990	1995	2000	2005	2008	2009	2010	2011	2012
NO_x Emission	**93.3**	**64.5**	**72.5**	**72.6**	**74.6**	**68.6**	**62.8**	**60.3**	**55.0**
Energy Industries	17.5	14.5	13.8	12.2	11.5	11.5	9.5	9.6	8.4
Manufacturing Ind. & Construction	16.3	7.6	7.7	10.1	13.0	10.0	8.8	8.2	7.4
Transport	41.0	31.4	35.1	34.6	34.0	31.4	29.5	27.9	25.5
Other Energy (fuel comb.)	15.0	8.1	12.8	13.1	13.5	13.3	13.2	13.3	12.5
Fugitive Em. from Fuels	0.5	0.3	0.3	0.3	0.2	0.3	0.2	0.2	0.2
Industrial Processes	2.8	2.6	2.6	2.3	2.4	2.1	1.7	1.1	1.0
Agriculture	0.1	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1
CO Emission	**586.0**	**294.8**	**476.3**	**353.0**	**289.7**	**286.7**	**276.5**	**287.4**	**293.3**
Energy Industries	2.4	1.6	1.6	1.1	1.5	1.2	1.1	1.2	1.1
Manufacturing Ind. & Construction.	37.2	38.1	33.6	33.5	34.0	32.8	28.9	26.4	24.0
Transport	237.8	175.3	172.9	112.9	80.4	73.1	63.5	55.6	42.9
Other Energy (fuel comb.)	204.0	116.7	146.4	133.0	120.1	126.2	141.8	166.3	173.8
Fugitive Em. from Fuels	50.1	34.5	54.1	54.4	41.6	51.9	40.1	32.6	35.4
Industrial Processes	40.9	27.3	30.1	17.4	9.3	0.5	0.2	0.2	0.17
Agriculture	4.3	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	9.3	1.4	37.6	0.8	2.8	1.4	1.0	5.1	15.9
NMVOC Emission	**117.7**	**80.0**	**90.4**	**103.9**	**111.5**	**79.2**	**78.1**	**73.8**	**70.0**
Energy Industries	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2
Manufacturing Ind. & Construction	1.6	1.3	1.4	1.8	2.1	1.8	1.5	1.4	1.3
Transport	41.7	30.5	34.1	21.3	17.4	15.6	13.4	12.3	9.5
Other Energy (fuel comb.)	12.1	6.9	9.0	8.3	7.7	8.0	8.8	10.1	10.4
Fugitive Em. from Fuels	8.5	6.7	9.1	8.5	7.5	8.0	7.7	7.1	6.4
Industrial Processes	24.4	9.0	7.7	9.6	6.8	5.1	5.3	5.8	5.1
Solvent and Other Product Use	28.1	25.1	25.4	54.2	69.4	40.3	41.0	36.3	35.6
LULUCF	0.8	0.1	3.4	0.1	0.3	0.1	0.1	0.5	1.4
SO_2 Emission	**174.0**	**81.7**	**61.5**	**63.5**	**57.1**	**59.3**	**35.3**	**33.2**	**25.6**
Energy Industries	99.5	54.0	32.9	32.7	32.0	36.7	19.7	17.9	14.6
Manufacturing Ind. & Construction.	39.8	16.7	11.0	9.7	8.2	6.1	4.7	4.3	2.8
Transport	5.9	3.5	6.0	9.2	7.4	6.9	3.1	2.6	0.7
Other Energy (fuel comb.)	23.9	4.7	6.5	6.8	4.3	4.5	4.2	3.7	2.8
Fugitive Em. from Fuels	1.8	1.2	3.1	3.1	2.8	3.3	2.3	3.5	3.7
Industrial Processes	3.2	1.6	2.0	2.1	2.4	1.8	1.3	1.1	1.0

3 ENERGY (CRF sector 1)
3.1. OVERVIEW OF SECTOR

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 2012 is presented in the Table 3.1-1.

Table 3.1-1: Primary energy production

PJ	1990	1995	2000	2005	2008	2009	2010	2011	2012
Coal and coke	4.21	1.96	0.00	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	29.17
Crude oil	104.54	62.81	51.35	40.11	35.42	33.07	30.69	28.37	25.62
Natural gas	74.27	69.12	59.4	79.76	94.05	93.50	93.88	85.02	69.19
Hydro power	38.55	51.75	56.93	62.40	50.19	65.77	79.71	42.59	45.45
Heat	-	-	-	0.61	1.25	1.48	1.71	1.73	1.71
Renewables	0.00	0.00	0.00	0.20	1.03	1.34	2.63	2.97	5.66
Total	**244.25**	**199.16**	**183.32**	**197.24**	**197.28**	**211.64**	**228.57**	**187.42**	**176.79**

Figure 3.1-1 presents the trends in the primary energy production from 1990 to 2012.

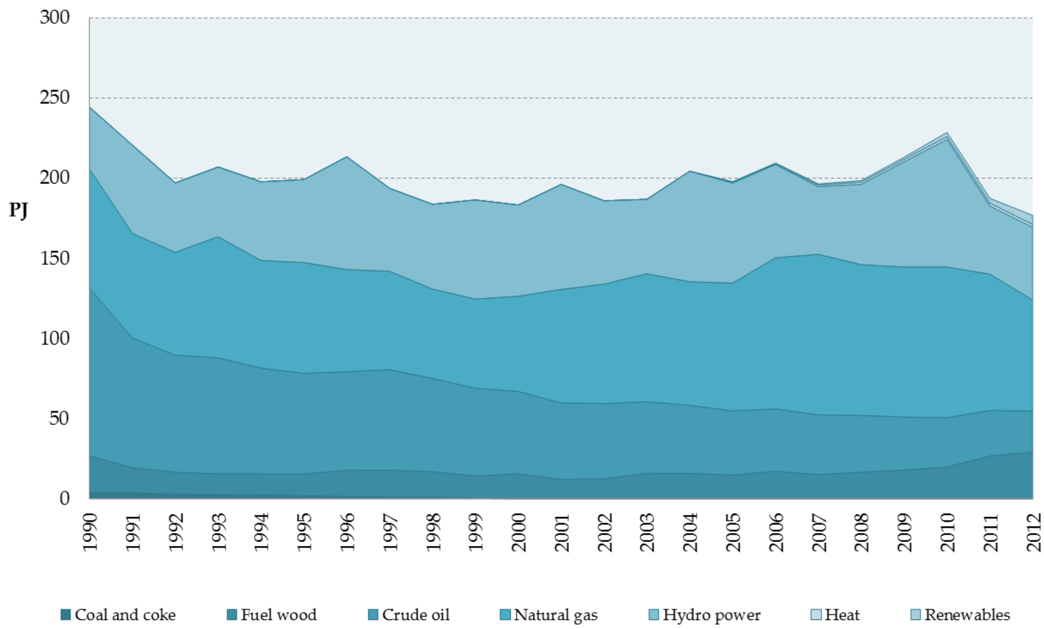


Figure 3.1-1: Trends in primary energy production for the period from 1990 to 2012

In 1990 primary energy production was about 244 PJ, which is 27.6% higher comparing to 2012. In 2012, the total primary energy production decreased by 5.7% with relation to the 2011. Comparing to 2011, the energy production from renewable sources increased two times in 2012. The production of natural gas decreased 6.3% as well as production of crude oil by 9.7%, while production of fuel wood increased (9.1%). Hydro power utilization increased by 6.7%.

While in 1990 the share of crude oil in primary energy production was the highest one with 42.8%, in 2012 its' share was only 14.5%. In 2012, the share of natural gas (39.1%) was the highest one. It was followed by hydro power with the share of 25.7%. The comparison of shares in primary energy productions for the 1990 and 2012 are presented in Figure 3.1-2.

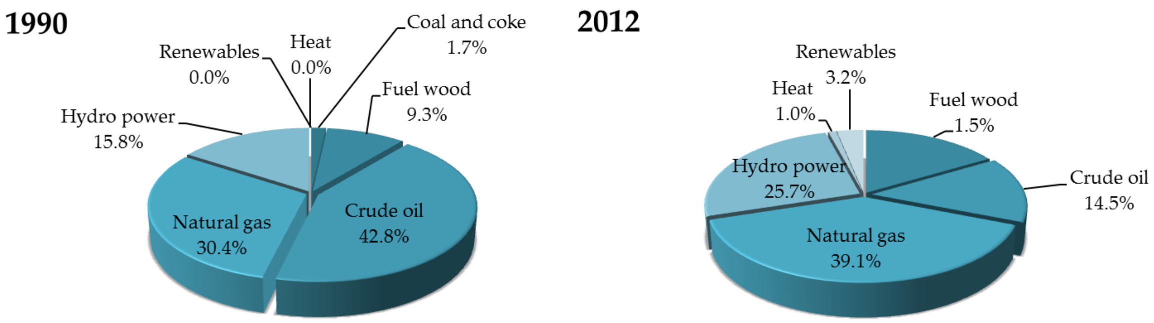


Figure 3.1-2: Shares of individual energy forms in the total production for the 1990 and 2012

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 2012 is presented in the Table 3.1-2.

Table 3.1-2: Primary energy supply

PJ	1990	1995	2000	2005	2008	2009	2010	2011	2012
Coal and coke	34.07	7.42	17.15	32.95	34.65	24.66	30.92	31.66	28.37
Fuel wood	22.68	13.52	15.64	14.77	13.38	14.42	16.05	19.23	20.88
Liquid fuels	192.6	146.03	160.52	181.88	180.15	178.04	152.54	149.16	134.17
Natural gas	98.22	82.77	94.98	101.06	110.22	102.15	111.37	108.60	101.78
Hydro power	38.55	51.75	56.93	62.40	50.19	65.77	79.71	42.59	45.45
Electricity	25.42	12.59	14.4	18.41	23.68	20.46	17.15	27.71	27.46
Heat	-	-	-	0.61	1.25	1.48	1.71	1.73	1.71
Renewables	0.00	0.00	0.00	0.20	0.97	1.43	2.24	2.97	5.72
Total	**411.54**	**314.08**	**359.62**	**411.67**	**413.24**	**406.92**	**411.69**	**383.65**	**365.54**

Figure 3.1-3 presents the trends in the primary energy supply from 1990 to 2012.

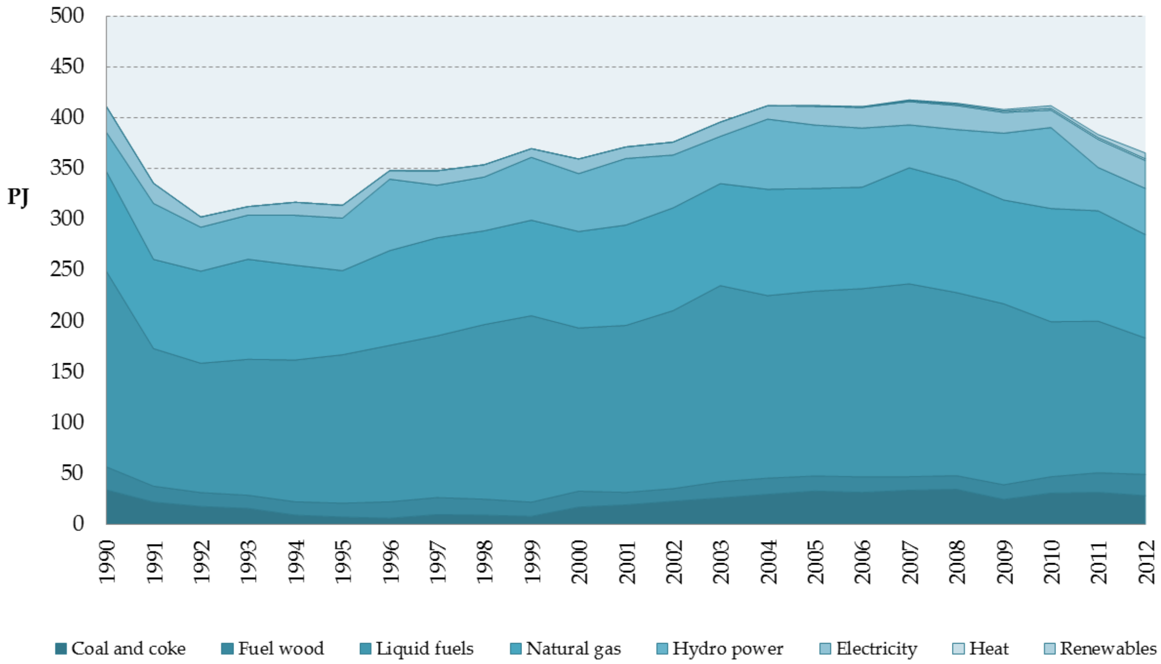


Figure 3.1-3: Trends in primary energy supply for the period from 1990 to 2012

In 1990 primary energy supply was about 412 PJ, which is 11.2.% higher comparing to 2012. In 2012, the total primary energy supply decreased by 4.7% with relation to the previous year. There was an increase in, fuel wood, renewable energy sources and hydro power while consumption of natural gas, liquid fuels and coal and coke decreased. Due to good hydrology conditions, hydro power energy supply increased by 6.7% with relation to the 2011. Figure 3.1-4 presents comparison of the shares of individual energy forms in the total primary energy supply for the 1990 and 2012.

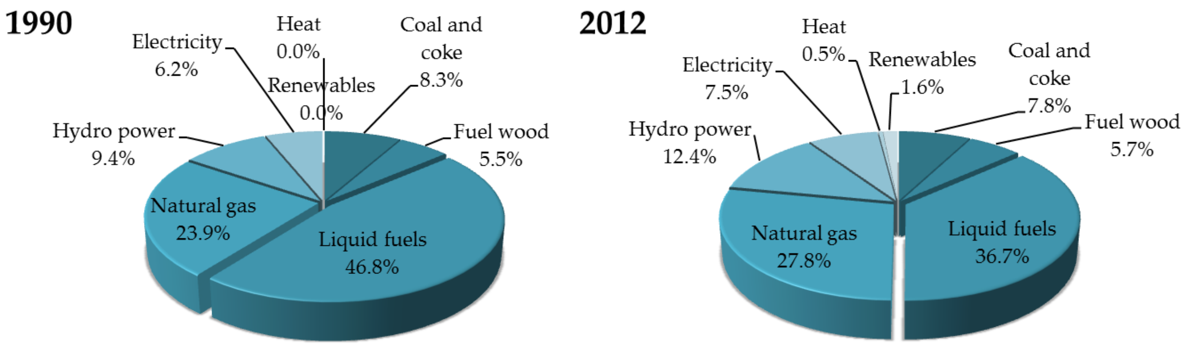


Figure 3.1-4: Comparison of the shares of individual energy forms for the 1990 and 2012

Liquid fuels had the largest share in total primary energy supply in 1990 as well as in 2012 (approximately 40%). It was followed by the natural gas with the share of approximately 25%. 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.

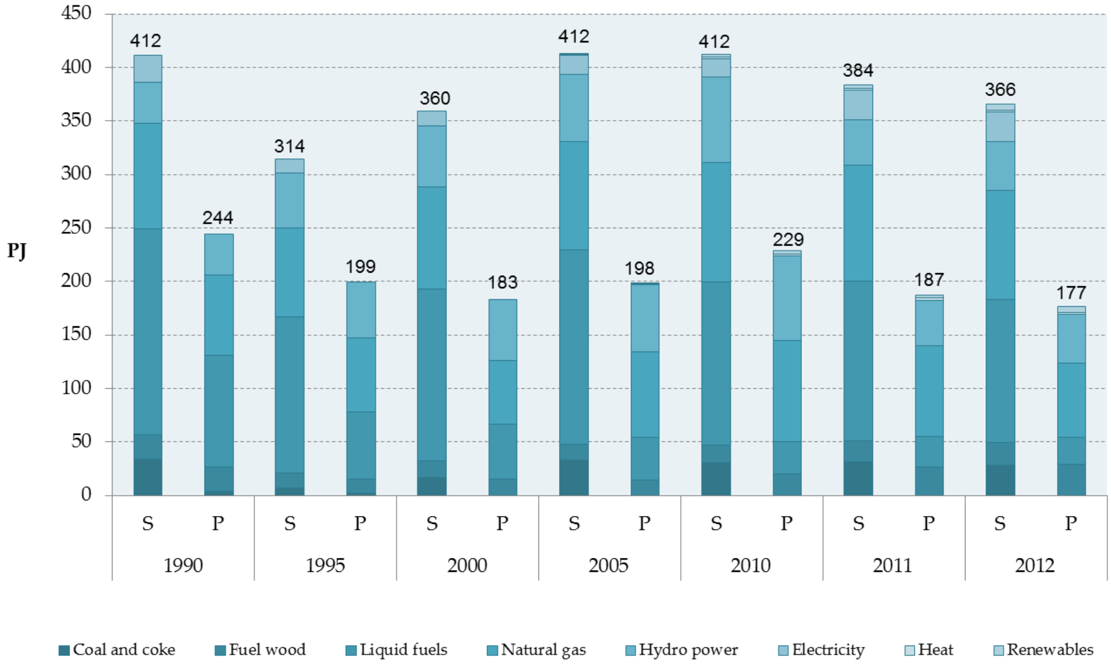


Figure 3.1-5: Total primary energy supply (S) and production (P)

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 2012 amounted 48.4%. 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 m^3) and energy units (PJ). National energy balance for 2012 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, CO_2 emission factors and oxidation factors for 1990 and 2012

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	2012			
SOLID FUELS						
Anthracite	TJ/Gg	29.29	29.31	26.80	98.27	0.98
Other Bituminous Coal	TJ/Gg	25.14	24.35	25.80	94.60	0.98
Sub-Bituminous Coal	TJ/Gg	16.74	17.80	26.20	96.07	0.98
Lignite	TJ/Gg	10.90	10.70	27.60	101.20	0.98
Brown Coal Briquettes	TJ/Gg	16.74	-	26.60	97.53	0.98
Coke oven Coke	TJ/Gg	29.31	29.31	29.50	108.17	0.98
LIQUID FUELS						
Motor gasoline	TJ/Gg	44.60	44.59	18.90	69.30	0.99
Aviation gasoline	TJ/Gg	44.60	44.59	18.90	69.30	0.99
Jet Kerosene	TJ/Gg	44.00	43.96	19.50	71.50	0.99
Gas/Diesel oil	TJ/Gg	42.71	42.71	20.20	74.07	0.99
Residual Fuel Oil	TJ/Gg	40.19	40.19	21.10	77.37	0.99
Liquefied Petroleum Gases	TJ/Gg	46.89	46.89	17.20	63.07	0.99
Petroleum Coke	TJ/Gg	29.31	31.00	27.50	100.83	0.99
Petroleum	TJ/Gg	44.00	43.96	19.60	71.87	0.99
Lubricants	TJ/Gg	33.57	33.50	20.00	73.33	0.99
GASEOUS FUELS						
Natural Gas	TJ/10^6m^3	34.00	34.00	15.3	56.10	0.995
Gas Works Gas	TJ/10^6m^3	15.82	17.10	13.0	47.67	0.995
Coke Oven Gas	TJ/10^6m^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 2012 is shown in Figure 3.1-6.

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

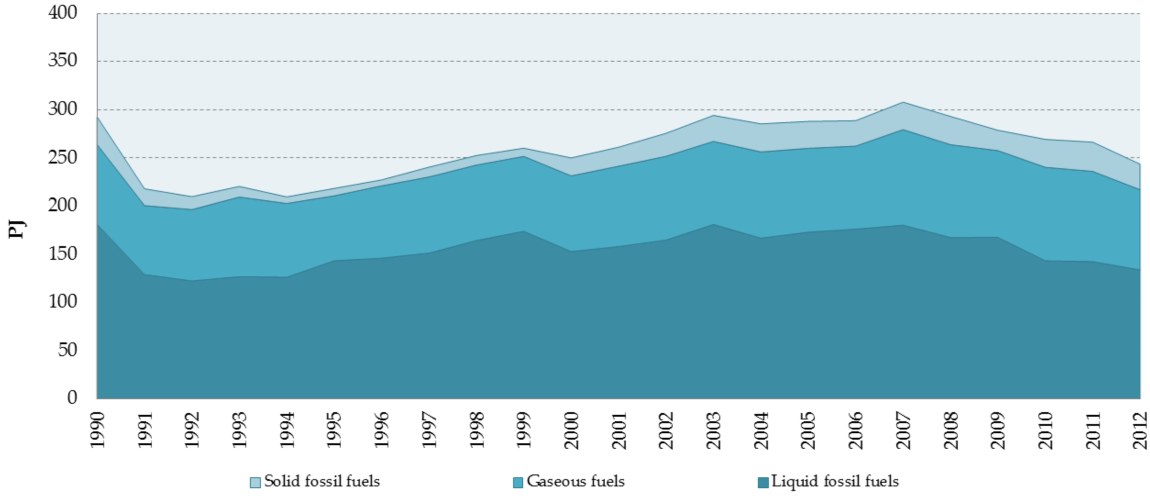


Figure 3.1-6: Structure of energy consumption

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 CO_2 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 CO_2. Looking at its contribution to total emission of carbon dioxide (CO_2), the energy sector accounts for about 90 percent. The contribution of energy in methane (CH_4) emission is substantially smaller (46 percent) while the contribution of energy in nitrous oxide (N_2O) emission is quite small (about 3 percent).

During complete combustion, the carbon contained in fuel oxidizes and transforms into CO_2, while through the incomplete combustion the small amounts of CH_4, CO and NMVOC emissions also appear. The CO_2 is the most important greenhouse gas from fuel combustion. The emission of CO_2 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 (CH_4) and nitrous oxide (N_2O), and indirect greenhouse gases such as nitrogen oxides (NO_x), carbon monoxide (CO) and non-methane volatile organic compounds (NMVOC). The indirect greenhouse gases participate in the process of creation and destruction of ozone, which is one of the GHGs. In the framework of the IPCC methodology, the calculation of sulphur dioxide (SO_2) emission is also recommended. The sulphur dioxide as a precursor of sulphate and aerosols 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 CH_4, and smaller quantities of CO_2 and N_2O, 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 1990-2012 is presented in Figure 3.1-7.

Table 3.1-4: Contribution of individual subsectors to emission of greenhouse gases, for 2012

GHG categories	Gg			Total	
	CO_2	CH_4	N_2O	CO_2-eq (Gg)	%
ENERGY	17,452.57	65.27	0.32	18,923.16	100.00
A. Fuel combustion activities	16,949.26	6.58	0.32	17,187.19	90.83
1. Energy industries	5,597.70	0.21	0.05	5,618.14	29.69
a) Electricity and heat production	3,829.96	0.14	0.04	3,844.84	20.32
b) Petroleum refining	1,550.63	0.06	0.01	1,555.99	8.22
c) Manufacture of solid fuels	217.12	0.00	0.00	217.32	1.15
2. Manufacturing ind. and constr.	2,787.48	0.28	0.03	2,801.41	14.80
3. Transport	5,647.74	0.56	0.16	5,709.19	30.17
a) Civil aviation	94.61	0.00	0.00	95.45	0.50
b) Road transport	5,364.70	0.55	0.16	5,424.56	28.67
c) Railways	77.67	0.01	0.00	77.98	0.41
d) Navigation (domestic)	110.76	0.01	0.00	111.20	0.59
4. Other sectors	2,916.34	5.53	0.08	3,058.45	16.16
5. Other					0.00
B. Fugitive emissions from fuels	503.31	58.69	0.00	1,735.97	9.17
1. Solid fuels	NO	NO	NO	NO	NO
2. Oil and natural gas	503.35	58.69	0.00	1,735.84	9.17

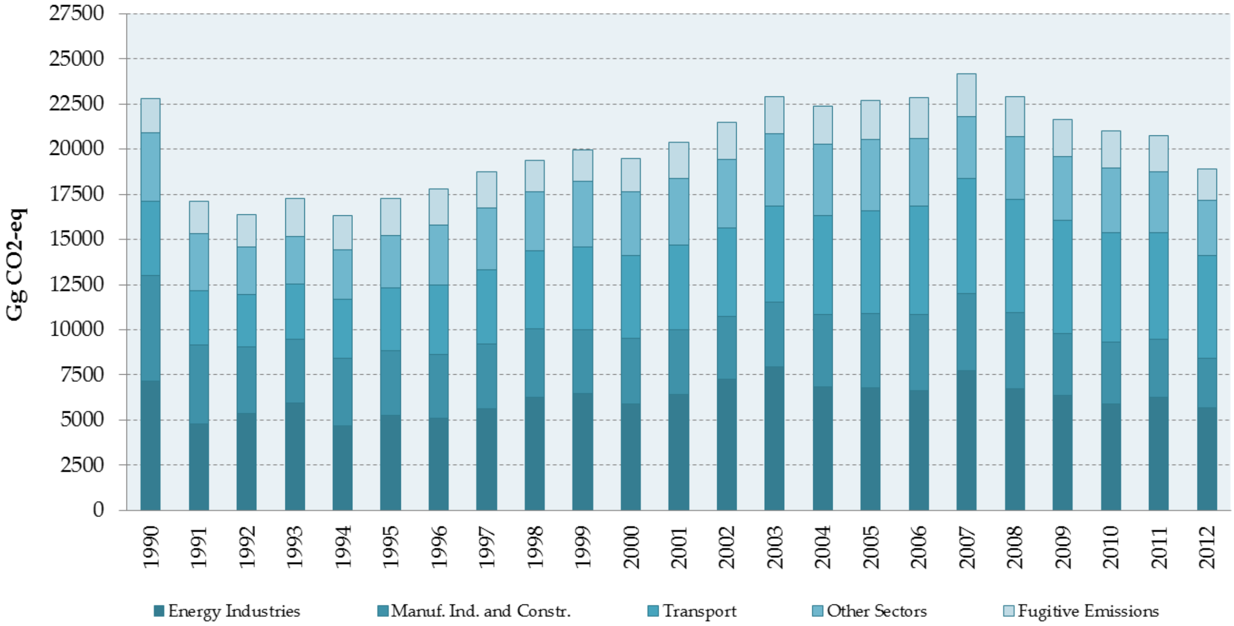


Figure 3.1-7: CO_2-eq emissions from Energy sector by subsectors in 1990-2012

The largest part (32.6 percent) of the emissions are a consequence of fuel combustion in Transport, then the combustion in Energy industries (32.3 percent in 2012) and the combustion in small stationary energy sources, such as Commercial/Institutional, Residential and Agriculture/Forestry/Fishing (17.5 percent in 2012). 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 CO_2 (91 to 93 percent), then follows CH_4 (6 to 9 percent) and N_2O (less than 1 percent).

Greenhouse gases are also generated during combustion of biomass and biomass-based fuels. The CO_2 emission from biomass, in line with IPCC guidelines, is not included into the national emission totals because emitted CO_2 had been previously absorbed from the atmosphere for growth and development of biomass. Removal or emission of CO_2 due to the changes in the forest biomass is estimated in the 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 2011[4]

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 CO_2 emissions follows the *Revised 1996 IPCC Guidelines.* The emission of CO_2 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 CO_2 emissions for chosen years are given in Table 3.2-1.

Table 3.2-1: The fuel consumption and CO_2 emissions from fuel combustion (Reference & Sectoral approach)

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Fuel consumption (PJ)									
Ref. approach	293.71	210.97	244.99	287.58	295.79	278.49	270.56	263.04	243.40
Sect. approach	292.77	218.62	250.15	287.97	292.75	278.48	269.94	266.47	243.87
Rel.Diff.(%)	0.32	-3.50	-2.06	-0.13	1.04	0.01	0.23	-1.29	-0.19
CO_2 Emission (Gg)									
Ref. approach	20,214.83	14,457.15	17,120.36	20,372.48	20,654.52	19,411.84	18,840.00	18,350.87	16,499.51
Sect. approach	20,594.38	15,035.54	17,347.05	20,280.45	20,495.57	19,360.28	18,720.93	18,509.35	16,949.26
Rel. Diff. (%)	-1.84	-3.85	-1.31	0.45	0.78	0.27	0.64	-0.86	-2.65

The CO_2 emission calculated by Sectoral approach is higher in comparison to Reference approach. The reason is that CO_2 emission from feedstock and non-energy fuel consumption is calculated under Reference approach while it is not accounted under Sectoral approach.

Namely, CO_2 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.

Detailed analysis for natural gas is presented in table 3.2-2.

Table 3.2-2: Detailed analysis of differences in sectoral and reference approach for natural gas

SECTORAL AND REFERNCE APPROACH, natural gas consumption		1990	1995	2000	2005	2008	2009	2010	2011	2012
Non energy consumption	Petrchemical industry	8.26	7.91	9.06	8.81	9.68	8.13	9.10	9.28	8.95
Losses		0.00	1.13	2.41	2.10	1.68	1.75	2.07	2.04	1.80
Transformation sector	Refineries				0.00	0.55	0.00	0.36	2.58	7.06
	NGL Plant	2.43	6.61	5.09	3.22	1.83	1.87	1.37	1.24	0.86
	Gas works	0.67			0.00	0.00	0.13	0.18	0.13	0.10
1AD5	TOTAL 1AD5	11.36	15.65	16.56	14.13	13.74	11.88	13.08	15.28	18.76
	Sectoral Total	82.84	67.37	78.45	86.99	96.22	90.07	97.93	93.51	83.19
	Total sectoral+non energy	94.20	83.02	95.01	101.13	109.96	101.95	111.00	108.79	101.95
	Total Refrence	91.34	82.77	94.98	101.06	110.22	102.15	111.37	108.60	101.78
	Difference SA-RA	2.86	0.25	0.03	0.06	-0.27	-0.21	-0.36	0.19	0.17
1A1C	TOTAL REFERNCE-TOTAL 1AD5	79.98	67.12	78.42	86.93	96.48	90.28	98.29	93.32	83.02

Natural gas emission from Sectoral approach is lower than emission calculated with Reference approach. The reason is that CO_2 from feedstock is not calculated under Sectoral approach. In table 3.2-2 is given detailed analysis of feedstock and losses which are not accounted under Sectoral approach. When consumption of natural gas as feedstock in Refineries, NGL Plant, Gas works and Petrochemical industry as well as losses are accounted under the Sectoral approach, difference is less smaller (0.17 PJ in 2012).

This small difference is due to different Net calorific values used for emission calculation. In reference approach for energy calculation standard net calorific value is used (34.00 TJ/10^6m^3), while emissions from thermal power plants (1A1a) are calculated using Net calorific values given directly from thermal power plants (Table 3.2-3)

Table 3.2-3: Comparison of energy calculation with NCV from balance and NCV from TPP and PCP

1A1a	BALANCE			CRF		
	10^6 m^3	NCV	PJ	10^6 m^3	NCV	PJ
thermal power plants	14.00	34.00	0.48	27.83	34.17	0.95
public cogeneration plants	673.90	34.00	22.91	673.56	34.25	23.07
public heating plants	76.60	34.00	2.60	63.11	34.00	2.15
TOTAL	764.50		25.99	764.50		26.17
Difference (CRF-BALANCE), PJ						0.17

To reconcile the differences between sectoral and reference approaches detailed analysis is given for liquid fuels for 2012. To prove that only identified reasons for differences between liquid fuels of two approaches are feedstock and non-energy fuel use and international air transport, the alternative energy and CO2 emission estimates are provided for the 2012. Energy and CO2 emission are calculated using the reference approach excluding the emissions from feedstock and non-energy fuel use. Detailed analysis for liquid fuels is presented in table 3.2-4.

Table 3.2-4: Energy and CO2 emission calculated with Reference approach and compared to Sectoral approach

Liquid fuels	Liquefied petroleum gases	Unleaded motor gasoline	Standard motor gasoline	Petroleum	Jet fuel	Diesel oil	Light heating oil	Low sulphur fuel oil	Standard fuel oil	Petroleum coke	Refinery gas
	103 t	103 t	103 t	103 t	103 t	103 t	103 t	103 t	103 t	103 t	103 t
Production	280.4	990.4			97.1	1132.8	153.5		562.5	84.7	293.8
Import	14.1	168.8	0.5	0.8	18.6	626.5	66.7	0.7	62.3	97.7	
Export	145.7	549.1			4.0	356.4	31.7		326.3	28.0	
Stock change	-1.5	-20.0		0.1	1.6	-4.0	0.1		37.4	-6.0	
Bunkers											
Energy supplied	147.3	590.1	0.5	0.9	113.3	1,398.9	188.6	0.7	335.9	148.4	293.8
NCV, TJ/Gg	46.9	44.6	44.6	44.0	44.0	42.7	42.7	40.2	40.2	31.0	46.0
TOTAL by fuel, TJ	6,906.9	26,312.6	22.3	39.6	4,980.7	59,747.0	8,055.1	28.1	13,499.8	4,600.4	13,514.8
RA, Total liquid fuels TJ						137,707.3					
EF CO2	62.4	68.6	68.6	70.8	70.8	73.3	73.3	76.6	76.6	99.8	66.1
Emission CO2, Gg	431.2	1,805.2	1.5	2.8	352.6	4,381.0	590.6	2.2	1,034.0	459.2	892.9
RA, Total Emission CO2, Gg						9,953.3					
International air transport, TJ					3,665.7						
RA, Total liq-inter.tr, TJ						134,041.6					
SA, Sectoral, TJ						134,092.6					
Difference SA-RA, TJ						51.1					
International air transport, CO2, Gg					259.5						
RA, Total emission-inter.tr, Gg						9,693.8					
SA, Sectoral, Gg						9,794.4					
Difference SA-RA, Gg						100.6					

The difference between Sectoral and Reference approach for liquid fuels for 2012 accounts 51.1 TJ. This small difference is due to different Net calorific values used for emission calculation. In reference approach for energy calculation standard net calorific values for each fuel is used, while emissions from thermal power plants (1A1a) are calculated using Net calorific values given directly from thermal power plants (Table 3.2-5).

Table 3.2-5: Difference in fuel consumption for thermal power plants using different NCVs for 2012

2012	TE Plomin	TE Rijeka	TE Sisak	TE-TO Zagreb	EL-TO Zagreb	TE-TO Osijek	KTE Jertovec
Fuel consumption with plant specific NCVs							
Fuel oil (1000 t)		40.680	19.429	35.561	11.557	2.546	
NCV for fuel oil (MJ/kg)		40.300	40.371	41.303	40.371	40.517	
Light heating oil (1000 t)	1.081	0.095		0.551			0.018
NCV for light heating oil (MJ/kg)	43.000	42.100		43.333			42.710
a) Total fuel cunsumption (TJ)				4537.4			
Fuel consumption with NCV from Energy balance							
Fuel oil (1000 t)		40.680	19.429	35.561	11.557	2.546	
NCV for fuel oil (MJ/kg)		40.190	40.190	40.190	40.190	40.190	
Light heating oil (1000 t)	1.081	0.095		0.551			0.018
NCV for light heating oil (MJ/kg)	42.710	42.710		42.710			42.710
b)Total fuel cunsumption (TJ)				4486.3			
Difference a-b				**51.1**			

Comparison of Croatian balance with IEA balance

In the ‘’Report of the individual review of the annual submission of Croatia submitted in 2013’’, ERT noted some issues concerning discrepancies between the data submitted to IEA and the data reported in Croatian energy balance. The reasons for differences are:

a) Production of liquid fuels in Croatian balance is systematically lower by 4-20 per cent because - there is methodology differences in presenting total consumption of crude oil by IEA and Croatian energy balance. According to IEA only production of LPG, ethane and pentane (natural gas liquids) are reported as products of NGL plant. In Croatian energy balance except output of NGL plant, input of natural gas and gas condensate are noted too.
b) Imports of sub-bituminous coal and lignite reported in Croatian energy balance appear to all be classified as lignite in the IEA data -In Croatian energy balance there is balance of bituminous coal, balance of hard coal and balance of lignite. Today, all amounts are from the import, while in past smaller production of solid fuels existed in Croatia. In IEA methodology, balance of hard coal and lignite are presented together as lignite.

3.2.2. INTERNATIONAL BUNKER FUELS

The CO_2 emissions from the consumption of fossil fuels for aviation and marine international transport activities, as required by the IPCC methodology, are reported separately and not included in national emission totals. The fuel consumption (PJ) and CO_2-eq emissions for International Aviation and Marine Bunkers are shown in the Table 3.2-6.

Table 3.2-6: Fuel consumption and CO_2-eq emissions for International aviation and marine bunkers, from 1990 to 2012

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Fuel combustion (PJ)									
Aviation bunkers	4.85	2.64	2.39	3.19	3.75	3.21	3.42	3.57	3.67
Marine bunkers	1.44	1.36	0.76	1.05	0.87	0.28	0.25	0.98	NO
Total bunkers	**6.29**	**4.00**	**3.15**	**4.24**	**4.62**	**3.49**	**3.68**	**4.55**	**3.67**
CO_2-eq emission (Gg)									
Aviation bunkers	346.35	188.42	170.91	228.16	270.37	231.31	246.63	256.98	264.21
Marine bunkers	108.96	102.40	57.24	79.29	67.05	21.71	19.50	75.47	NO
Total bunkers	**455.31**	**290.82**	**228.15**	**307.45**	**337.42**	**253.02**	**266.14**	**332.45**	**264.21**

Total CO_2-eq from the international bunker in 2012 amounted to 264.2 Gg which is 2.7% higher than in 2011 as a result of higher fuel consumption in the Aviation bunkers.

In comparison with 1990, the emission of CO_2-eq in 2012 was for a 41% lower because in Marine bunkers in 2012 fuel do not exist.

International marine bunkers are included in national energy balance for the period from 1994 to 2012, as separate data. Until the year 1994, international marine bunkers are based on expert estimation.

In last review process ERT noticed some discrapancies between the fuel consumption data in IEA and CRF tables for marine bunkers. Comparison of this data are given in table 3.2-7.

Table 3.2-7: Comparison of fuel consumption data for marine bunkers for the period from 1990 to 2012

Gas-Diesel Oil														
DataType	**Product**	**Item1**	**Flow**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
BALANCE	GASDIES	BUNKERS	International marine bunkers	19				14	14	12	7	12	14	7
HR balance				0	0	0	0	13.6	13.7	13.2	6.9	12.2	13.6	7.1
difference				-19.0	0.0	0.0	0.0	-0.4	-0.3	1.2	-0.1	0.2	-0.4	0.1
Residual Fuel Oil														
DataType	**Product**	**Item1**	**Flow**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
BALANCE	RESFUEL	BUNKERS	International marine bunkers	28				31	19	17	17	14	8	11
HR balance				0	0	0	0	31.1	19.2	23.9	16.9	13.9	7.5	11.3
difference				-28.0	0.0	0.0	0.0	0.1	0.2	6.9	-0.1	-0.1	-0.5	0.3

Gas-Diesel Oil

DataType	Product	Item1	Flow	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
BALANCE	GASDIES	BUNKERS	International marine bunkers	13	11	6	8	9	7	4		1	1	1	
HR balance				13.3	11	6.2	7.8	9.1	6.4	4.4	0	1.4	0.7	1.3	0
difference				0.3	0.0	0.2	-0.2	0.1	-0.6	0.4	0.0	0.4	-0.3	0.3	0.0

Residual Fuel Oil

DataType	Product	Item1	Flow	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
BALANCE	RESFUEL	BUNKERS	International marine bunkers	16	13	16	16	16	13	20	22	6	6	23	
HR balance				15.5	12.6	16	15.8	16.4	13.3	20.1	21.7	5.6	5.6	23.1	0
difference				-0.5	-0.4	0.0	-0.2	0.4	0.3	0.1	-0.3	-0.4	-0.4	0.1	0.0

All data for the IEA must be rounded to whole numbers and data from national energy balance are not rounded. This is result of differences. Fuel consumption for 1996 is different form data in national energy balance. Data from IEA for 1990 are correct and this error will be corrected in next annula submission.

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 CO_2 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 CO_2 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 CO_2 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 - Petrokemija Fertilizer Company Kutina, as described in Chapter 4.3.1.2. Natural gas which used as fuel in ammonia production is calculated 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. CO_2 CAPTURE FROM FLUE GASES AND SUBSEQUENT CO_2 STORAGE

There are no plants in operation for recovery and storage of CO_2 in Croatia, although there are plans for storage of CO_2 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 CO_2, more than 15 percent, and before coming to commercial pipeline has to be cleaned (scrubbed), but CO_2 is emitted without capture and storage. The CO_2 emission from gas scrubbing in Central Gas Station Molve, estimated by material balance method, is described in the Chapter 3.3.2.1.

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 CO_2 emission from natural gas scrubbing is not given in the IPCC Guidelines. The CO_2 emission is determined on the base of differences in CO_2 content before and after scrubbing units and quantity of scrubbed natural gas (material balance method). The data for estimating CO_2 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 3.2-8: The CO_2-eq emissions (Gg) from Energy Industries

CO_2-eq emission (Gg)	1990	1995	2000	2005	2008	2009	2010	2011	2012
Public Electricity and Heat Production	3,693.50	2,988.10	3,809.20	4,640.40	5,039.00	4,307.60	3,971.30	4,219.30	3,846.10
Petroleum Refining	2,574.80	1,892.10	1,792.40	1,810.50	1,441.70	1,706.00	1,479.60	1,759.30	1,606.10
Other Energy Industries	875.50	394.70	293.40	350.70	245.60	378.60	453.80	296.90	217.30
Total Energy Industries	**7,143.80**	**5,275.00**	**5,895.00**	**6,801.60**	**6,726.30**	**6,392.20**	**5,904.70**	**6,275.50**	**5,669.50**

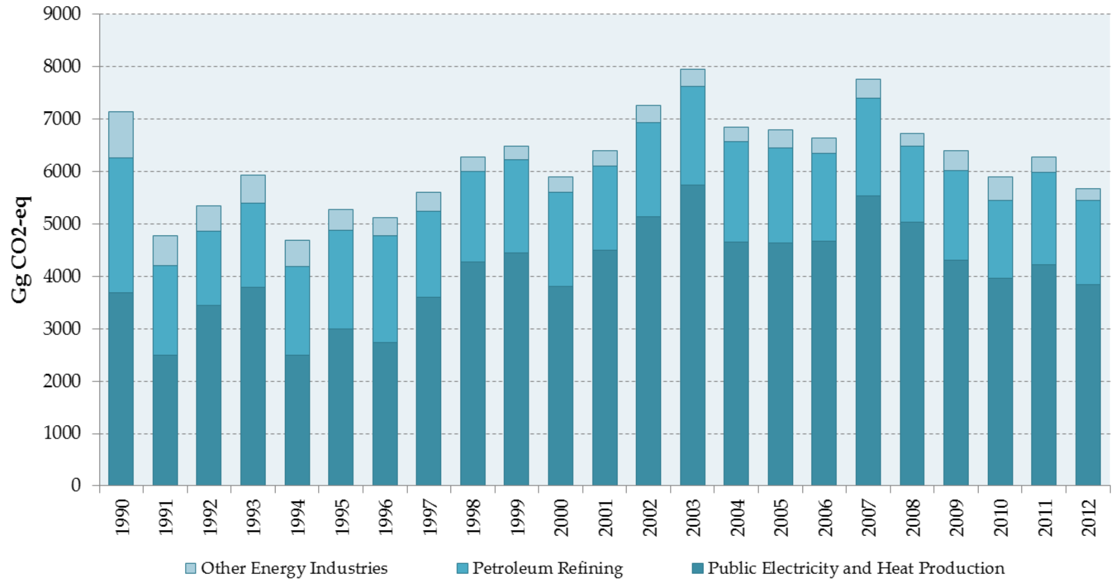


Figure 3.2-1: CO_2-eq emissions from Energy Industries

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 withdrow electricity on the basis of capacity lease and share-ownership arrangements. Generating capacities of HPPs, TPPs and NPP Krško are presented in the Table 3.2-9.

Table 3.2-9: Generating capacities of HPPs, TPPs and NPP Krško

	Available Power (MW) Net Output	Fuel
HPPs	2,136.76	-
NPP Krško*	348.00	uranium oxide (UO_2)
TPP Plomin 1	110.00	coal
TPP Plomin 2**	192.00	coal
TPP Rijeka	303.00	fuel oil
TPP Sisak	396.00	fuel oil / natural gas
CHP Zagreb (east)	422.00	fuel oil / natural gas / extra light oil
CHP Zagreb (west)	90.00	fuel oil / natural gas / extra light oil
CPP Osijek	90.00	fuel oil / natural gas / extra light oil
CCGT Jertovec	78.00	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.

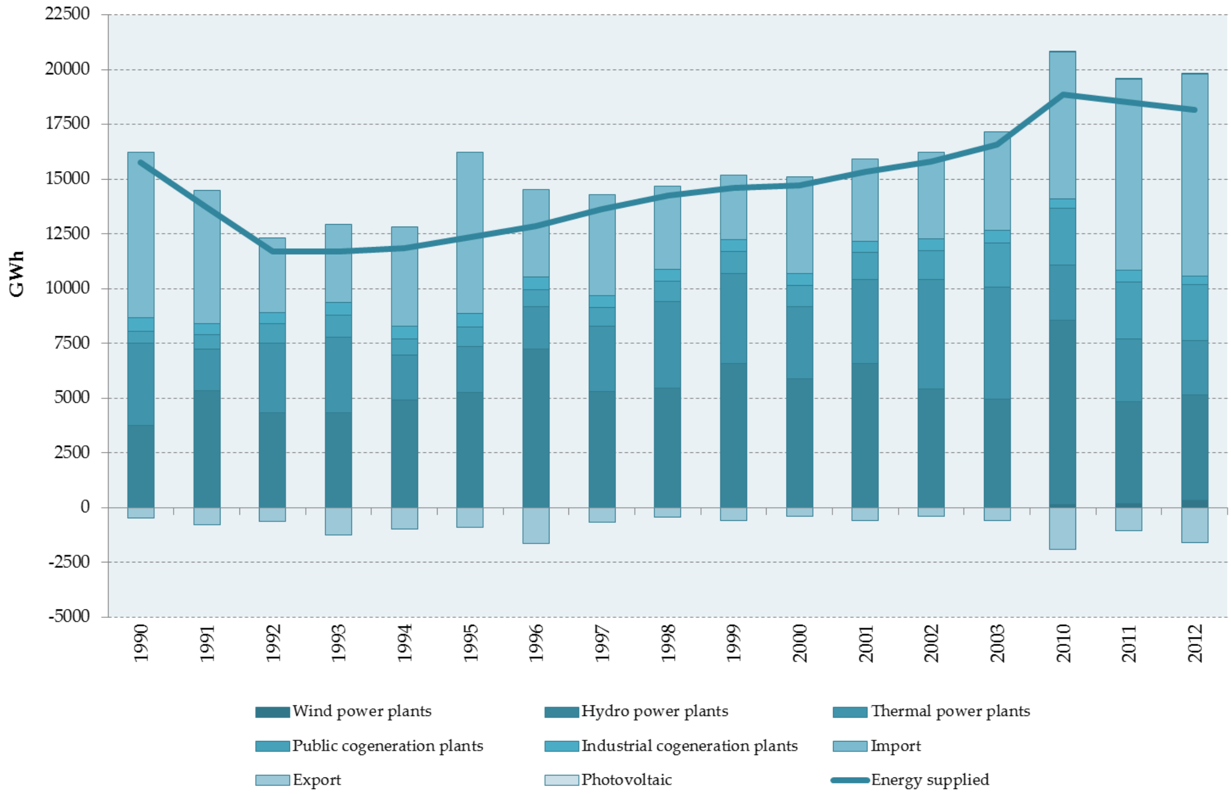


Figure 3.2-2: Electricity supply for the period from 1990 to 2012

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 2012.

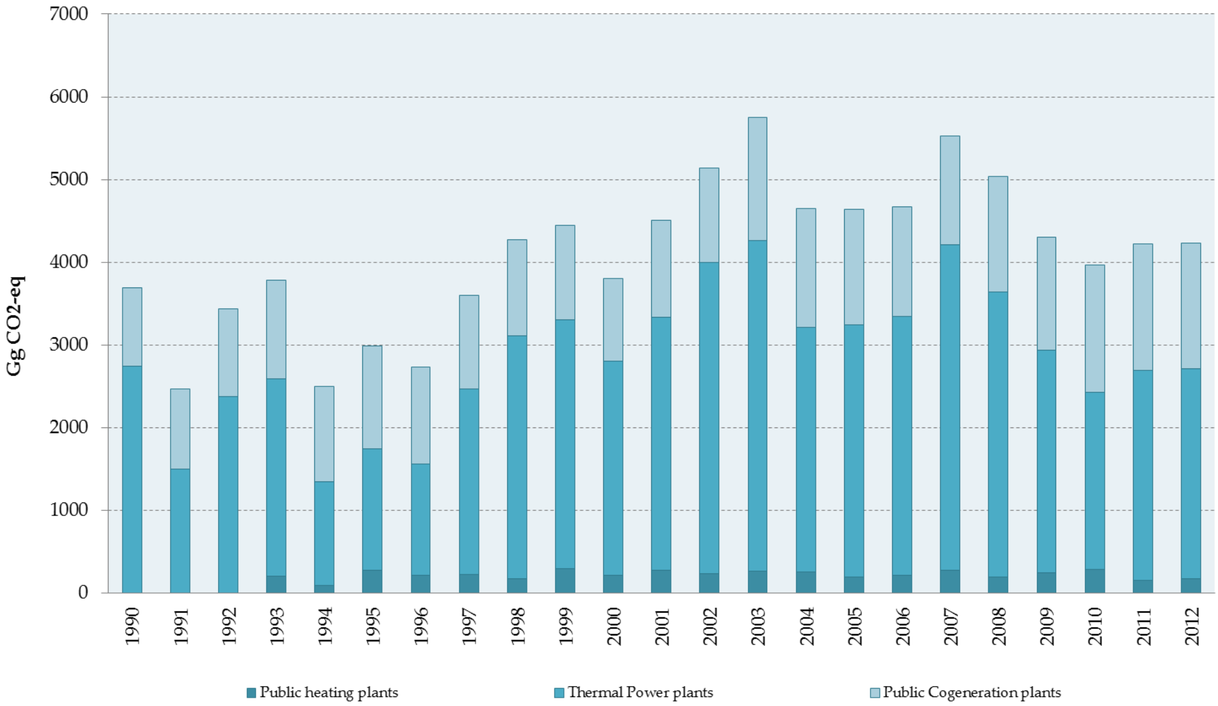


Figure 3.2-3: CO_2-eq emissions from Public Electricity and Heat Production subsector's

Production of electricity has increasing trend through the years, from 8 TWh (1990) to 14 TWh (2010) but CO_2 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 2012 is presented in Figure 3.2-4. In 2012, the total electricity production was 2.5 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 leaded to decrease in electricity production from hydro power by 45.2 percent (Table 3.2-10).

Table 3.2-10: Differences between electricity production in 2011 and 2012

ENERGY BALANCE	Electricity, GWh		Difference 2012-2011	Difference %
	2011	2012		
Production	10,830.30	10,557.40	-272.90	-2.52
Hydro power plants	4,620.00	4,801.20	181.20	3.92
Wind power plants	201.00	328.70	127.70	63.53
Photovoltaic	0.10	2.40	2.30	2,300.00
Thermal power plants	2,876.60	2,513.10	-363.50	-12.64
Public cogeneration plants	2,620.70	2,529.20	-91.50	-3.49
Industrial cogeneration plants	511.90	382.80	-129.10	-25.22
Import	8,729.90	9,230.80	500.90	5.74
Export	-1,032.60	-1,601.80	-569.20	55.12
Total consumption	**18,527.60**	**18,186.40**	**-341.20**	**-1.84**

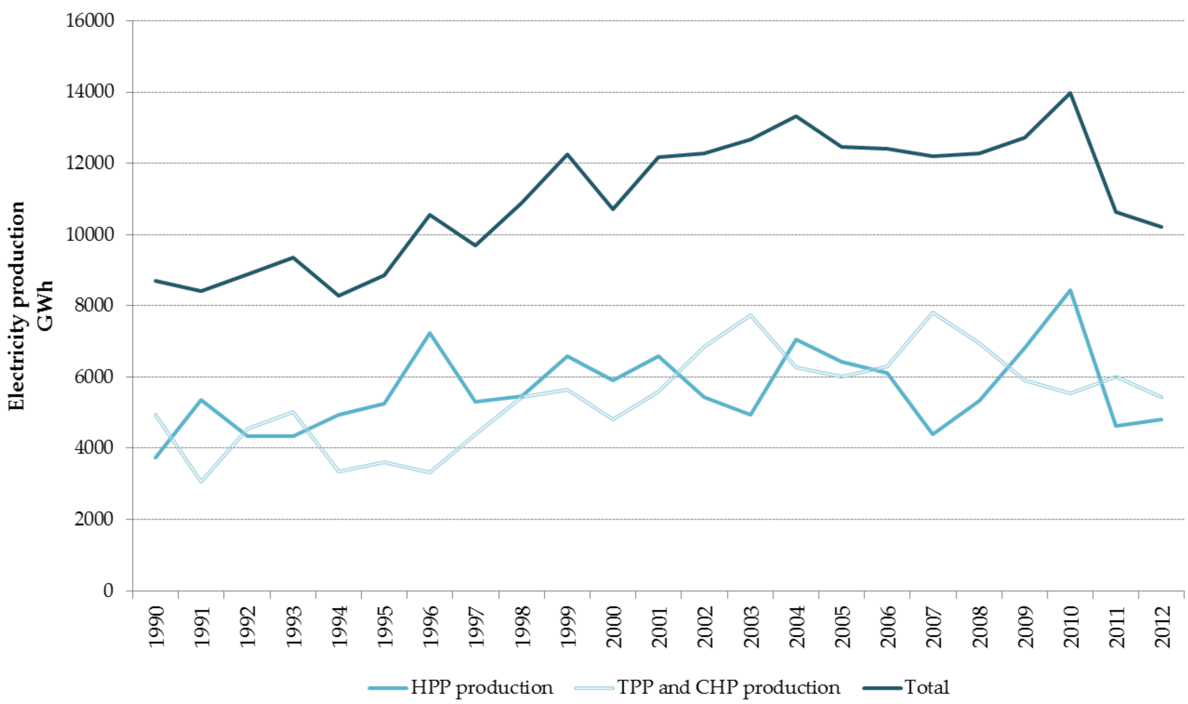


Figure 3.2-4: Domestic production of electricity by sources for the period from 1990 to 2012

Electricity and heat production, fuel consumption and GHG emissions for the years 1990, 2000, 2005 and for period 2008-2012 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 3.2-11.

Table 3.2-11: 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.

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

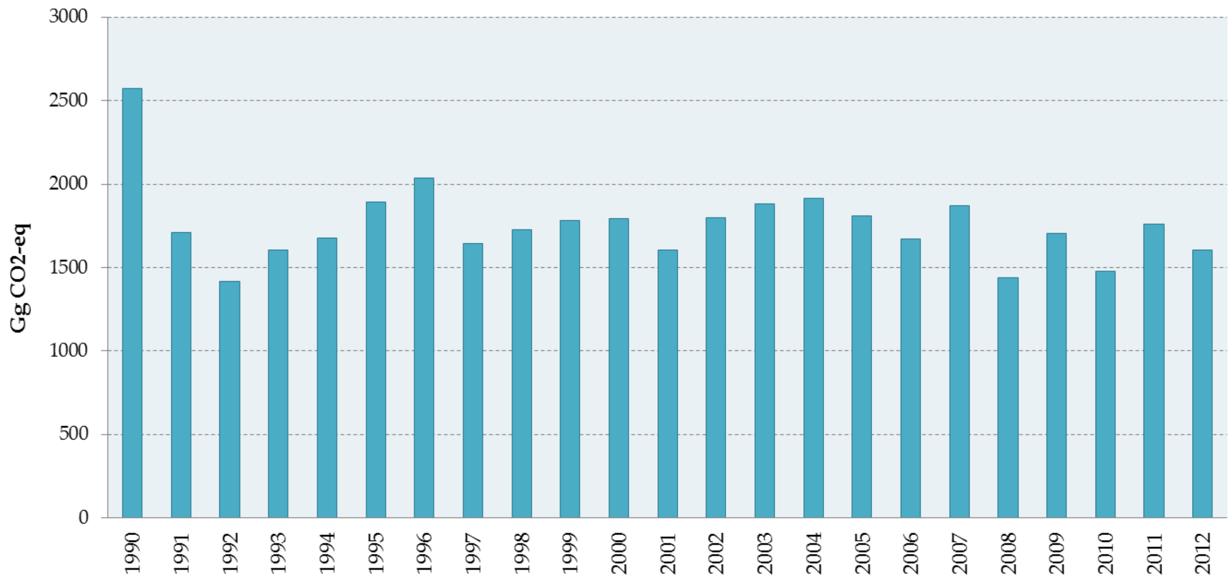


Figure 3.2-5: CO2-eq emissions from Petroleum Refining subsector for the period from 1990 to 2012

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 67.7 percent of total domestic demand in 2012. 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. m^3/day for Molve I
- 3 mill. m^3/day for Molve II
- 5 mill. m^3/day for Molve III

The underground gas storage Okoli was designed with the nominal capacity of 553 million m^3. Maximum injection capacity is 3.8 million m^3/day and maximal withdrawal capacity is 5.8 million m^3/day.

CO_2-eq emissions from this subsector for the whole period from 1990 to 2012 are presented in Figure 3.2-6.

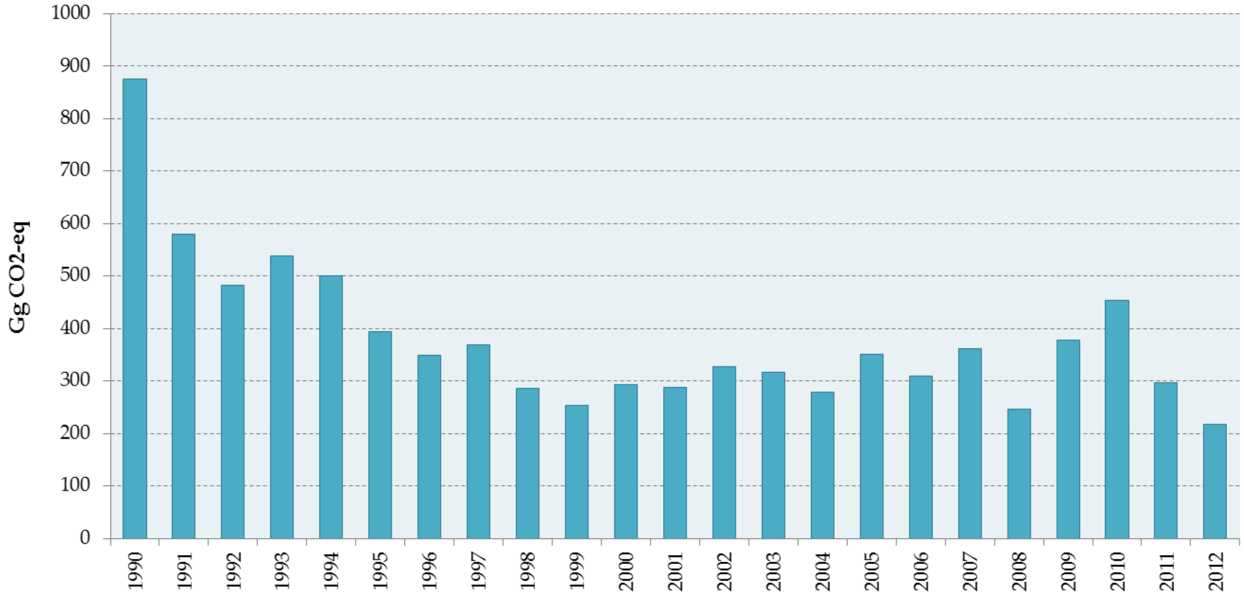


Figure 3.2-6: CO_2-eq emissions from Manufacturing of Solid Fuels and Other Energy Industries for the period from 1990 to 2012

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 1990-2012, 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 CH_4 and N_2O 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 2012 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 CO_2 emissions, default IPCC emission factors were used, while implied emission factors for CH_4 and N_2O are based on technology type and configuration (Tier 2).

3.2.6.3. Uncertainties and time-series consistency

Uncertainty of CO_2 emissions

The CO_2 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 CO_2 emission factors for fuels are generally well determined within 5 percent, as they are primarily dependent on the carbon content of the fuel.

Uncertainty of CH_4 and N_2O emissions

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

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

The uncertainty of CH_4 emission is estimated to ±40 percent; while the uncertainty of N_2O emission is estimated to factor 2 (the emission could be twice larger or smaller than the estimated one). The largest part of uncertainty refers to the emission factor applied while the fuel consumption data (national energy balance) are rather good. Implementation of Tier 2 approach for estimation of CH_4 and N_2O 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 2012, 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 CO_2 emission factors, which are calculated using fuel characteristics data, specific for every plant in next annual submission. 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 2012. The total GHG emission from Manufacturing Industries and Construction is given in the Table 3.2-12 and Figure 3.2-7.

Table 3.2-12: The CO_2-eq emissions (Gg) from Manufacturing Industries and Construction

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Iron and Steel Industry	IE	IE	IE	89.00	98.00	79.00	93.00	84.00	51.00
Non-Ferrous Metals	IE	IE	IE	21.00	21.00	18.00	14.00	18.00	20.00
Chemicals	IE	IE	IE	578.00	568.00	501.00	448.00	417.00	279.00
Pulp, Paper and Print	IE	IE	IE	174.00	153.00	148.00	161.00	148.00	127.00
Food Proc., Bev. and Tobac.	IE	IE	IE	589.00	639.00	490.00	511.00	493.00	425.00
Other	IE	IE	IE	2,647.00	2,736.00	2,158.00	2,103.00	1,993.00	1,826.00
Total Manuf. Ind. and Cons.	**5,872.00**	**3,524.00**	**3,632.00**	**4,098.00**	**4,215**.00	**3,394**.00	**3,330**.00	**3,153**.00	**2,727**.00

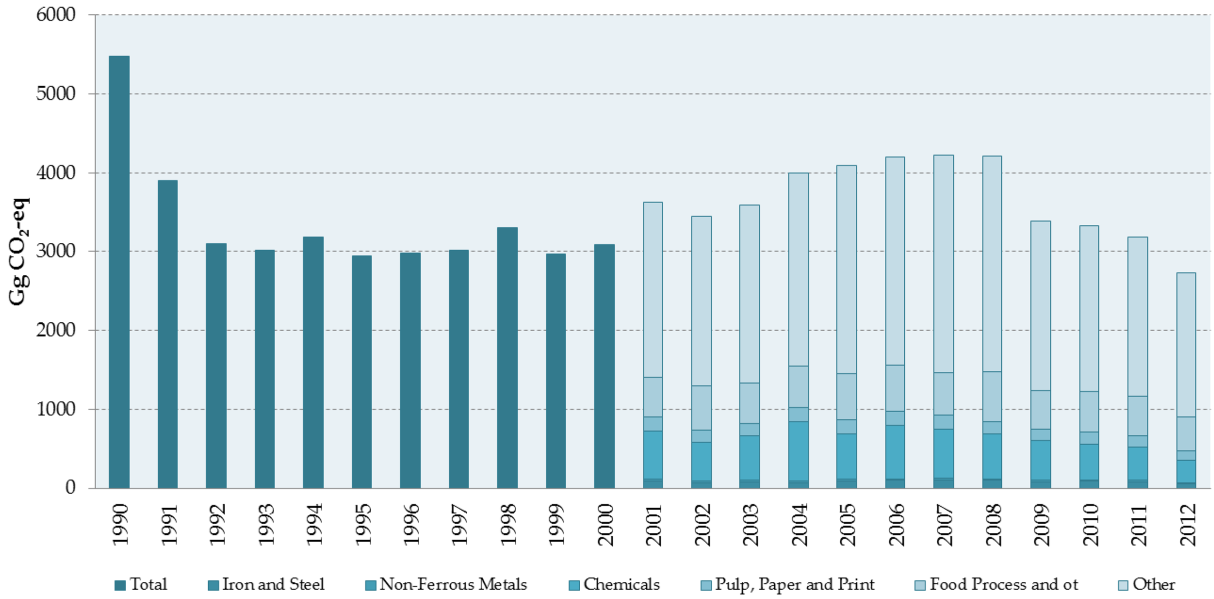


Figure 3.2-7: CO_2-eq emissions from Manufacturing Industries and Construction

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 2001-2012 (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 CO_2 emissions

The CO_2 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 organized 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 CO_2 emission factors for fuels are generally well determined within 5 percent, as they are primarily dependent on the carbon content of the fuel.

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

Overall uncertainty for CO_2 emission estimates from the fossil fuel combustion are considered accurate within 3 percent.

Uncertainty of CH_4 and N_2O emissions

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

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

The uncertainty of CH_4 emission is estimated to ±40 percent; while the uncertainty of N_2O emission is estimated to factor 2 (the emission could be twice larger or smaller than the estimated one). The largest part of uncertainty refers to the emission factor applied while the fuel consumption data (national energy balance) are rather good.

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

There are no recalculations in this sub-sector.

3.2.7.6.Source-specific planned improvements

On long term basis, inventory team is planning apply more detailed Tier 2 approach for calculation CO_2 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 3.2-13 and Figure 3.2-8.

Table 3.2-13: The CO_2-eq emissions (Gg) from sector Transport

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Civil Aviation	156.10	79.40	55.40	67.20	89.00	78.10	81.80	89.90	95.50
Road Transport	3,667.00	3,181.10	4,370.00	5,421.50	5,939.80	5,951.10	5,750.60	5,598.30	5,425.00
Railways	138.70	106.80	85.80	95.90	101.60	89.60	89.60	83.01	77.980
Navigation	133.50	98.70	86.10	100.00	131.30	145.90	115.60	116.90	111.20
Total Transport	**4,095.40**	**3,466.00**	**4,597.30**	**5,684.60**	**6,261.70**	**6,264.60**	**6,037.60**	**5,888.00**	**5,709.60**

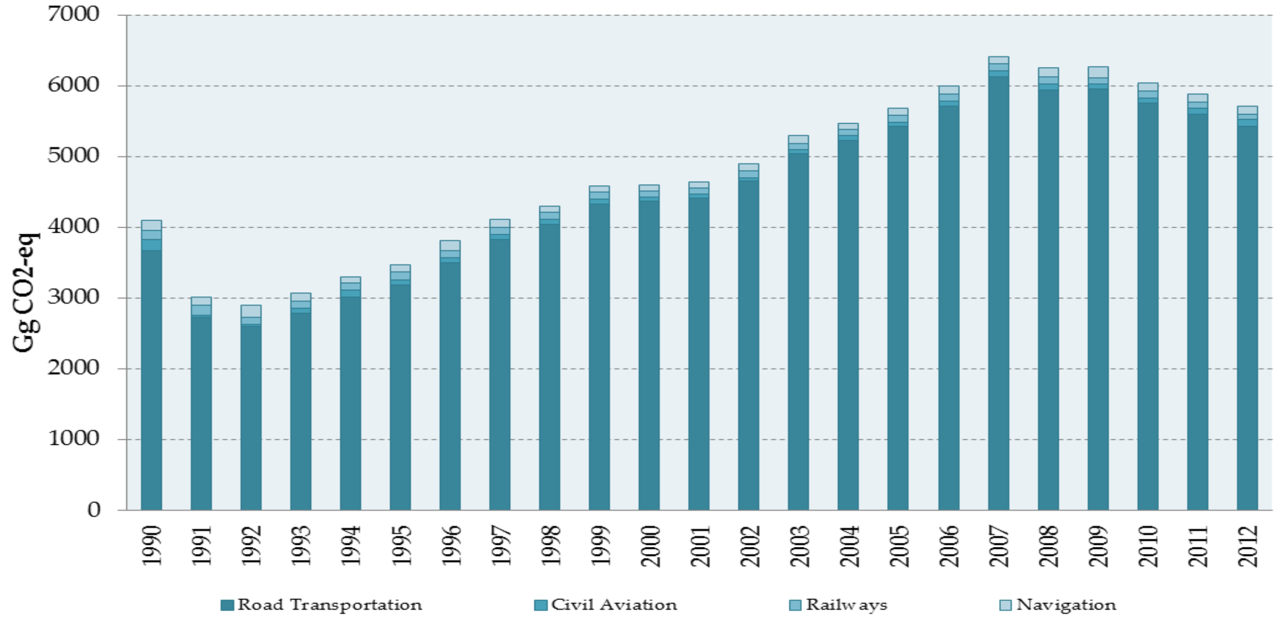


Figure 3.2-8: The CO_2-eq emissions from Transport

The contribution from Transport sector to the total CO_2-eq emissions from Energy sector in 2012 was 30.2%. CO_2-eq emissions from the transport sector in 2012 amounted to 5,709.6 Gg, which is 3.0% less than in 2011 as a result of less fuel consumption in road transport. Specifically, the emission of CO_2-eq emissions from Road transport sector (CRF 1.A.3.b) was dominant one in the transport sector (CRF 1.A.3) in 2012 and contributed to the CO_2-eq emissions from the transport sector with 95.0%. In 2012, the sector Civil aviation (domestic) was contributed to the CO_2-eq emissions from the transport sector with 1.7%, Railways with 1.9% and Navigation with 1.3% (Figure 2.3-8).

In comparison with 1990, CO_2-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 CO_2-eq emission from the sub-sector domestic civil aviation in 2012 was amounted to 95.5 Gg, which is 5.9% higher than in 2011, as a result of increase of fuel jet kerosene consumption. In comparison with 1990, CO_2-eq emission was by 38.8% 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 21.7 percent in 2012 and 11.6 percent in 1990. In the period from 1990 to 2012 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 CO_2-eq from the sub-sectors Railways in 2012 was amounted to 77.9 Gg, which is 6.1% lower than in 2011 as a result of decrease of fuel diesel consumption. In comparison with 1990, CO_2-eq was decreased by 39.4% as a result of decrease in railways transportation and consequently decreases in fuel consumption.

Navigation (CRF 1.A.3.d)

The CO_2-eq from the sub-sectors Navigation in 2012 was amounted to 111.2 Gg, which is for 4.8% lower than in 2011 as a result of increase in fuel consumption. In comparison with 1990, CO_2-eq was decreased by 16.7% 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 3.2-14).

Data were obtained from Statistical yearbooks and Energy balance.

Table 3.2-14: Estimation of civil aviation drivers

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Total jet kerosene (10^3 t)	160.00	85.00	72.00	93.00	112.70	96.90	103.30	109.40	113.30
Passangers carried - Total (10^3)		679	1,072	2,099	2,329	2,053	1,861.0	2,078.0	1,960.9
Passangers carried – intern. (10^3)		346	712	1,633	1,775	1,561	1,418	1,571	1460.0
Passangers carried – domastic (10^3)		333	360	466	554	492	443	507	500.9
Passangers kilometers- total (10^6)		444.0	763.0	1,989.0	1,945.0	1,636.0	1,510.0	1,591.0	1451.0
Passangers kilometers-inter. (10^6)		317.0	656.0	1,842.0	1,768.0	1,483.0	1,370.0	1,430.0	1292.0
Passangers kilometers-dom. (10^6)		127.0	107.0	147.0	177.0	153.0	140.0	161.0	159.0
Passangers domestic/km		381.4	297.2	315.5	319.5	311.0	316.0	317.6	317.4
Passangers international/km		916.2	921.3	1,128.0	996.1	950.0	966.1	910.2	884.9
Passangers intern.+domastic		1,297.6	1,218.1	1,443.4	1,315.6	1,261.0	1,282.2	1,227.8	1202.4
share domestic	0.311	0.294	0.244	0.219	0.243	0.247	0.246	0.259	0.264
Jet kerosene in domestic aviation	**49.68**	**24.98**	**17.56**	**20.32**	**27.37**	**23.90**	**25.46**	**28.29**	**29.91**
Jet kerosene in international	**110.32**	**60.02**	**54.44**	**72.68**	**85.33**	**73.00**	**77.84**	**81.11**	**83.39**

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).

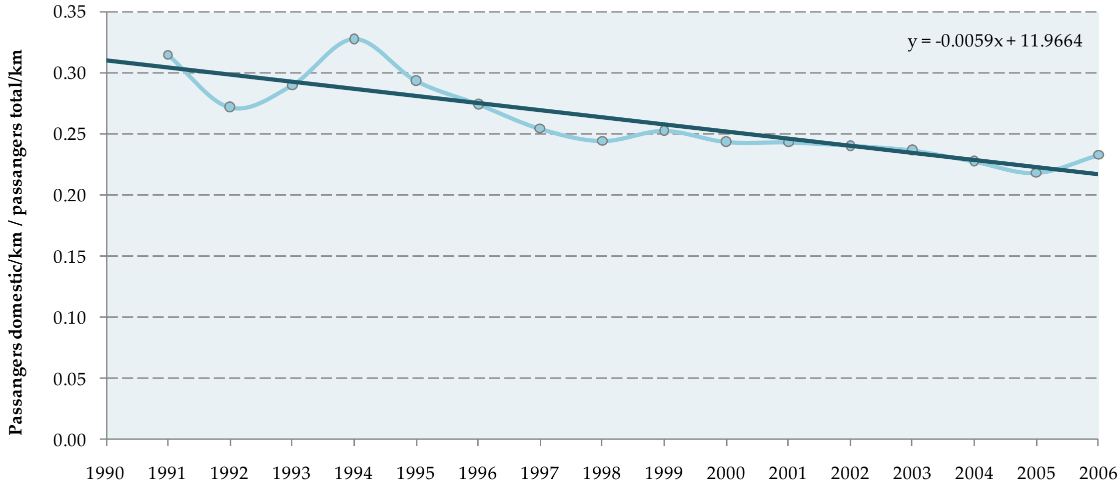


Figure 3.2-9: The average km traveled per passenger on domestic/international routes for the period 1991-2006

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 - 2012 are shown in Table A2-12 Annex 2.

Road Transport

Emissions of CO_2 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 CO_2 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 2012 were extracted from national energy balance. Emissions factors used for calculating CO_2 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), 74 g/MJ for diesel oil (oxidation factor 0.99), 64.4 g/MJ for LPG (oxidation factor 0.99) and 55.8 g/MJ CNG(oxidation factor 0.99).

Emissions of CH_4 and N_2O 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 – 2012 are presented in the Table A2-10 of the Annex 2. Comparing the total number of vehicles in 2012 with the number of vehicles in 1990 it can be notice the increase by 38.4 percent. The increase was largely the result of increase in the number of passenger cars by 25.5 percent, constituting 82.1 percent of the total number of road vehicles in 2012. Other classes of vehicles were also increased in this period: the number of Light Duty vehicles increased by 2.1 times, Heavy Duty vehicles included buses by 1.1 times, motorcycles and mopeds by 5.2 times. It is important to emphasize that number of registered vehicles gradually decreased in the period 2008-2012 due to economic crisis, where number of passenger cars which have a highest share in total number of vehicles decreased by 8.2 percent.

During review of NIR 2014, ERT noticed the fluctuation in the IEF values for the time period 1995-2006 for N2O emissions. Fluctuations occur only in Sector Passenger cars , subsector Gasoline 0,8-1,4 l, 1,4-2,0 l and >2,0 l, Technology PC Euro 1. These fluctuations are direct in line with fluctuations in sulfur contained of Gasoline fuel (see figure 3.2-10). Data on sulfur contain in fuels are given from Croatian Oil Company.

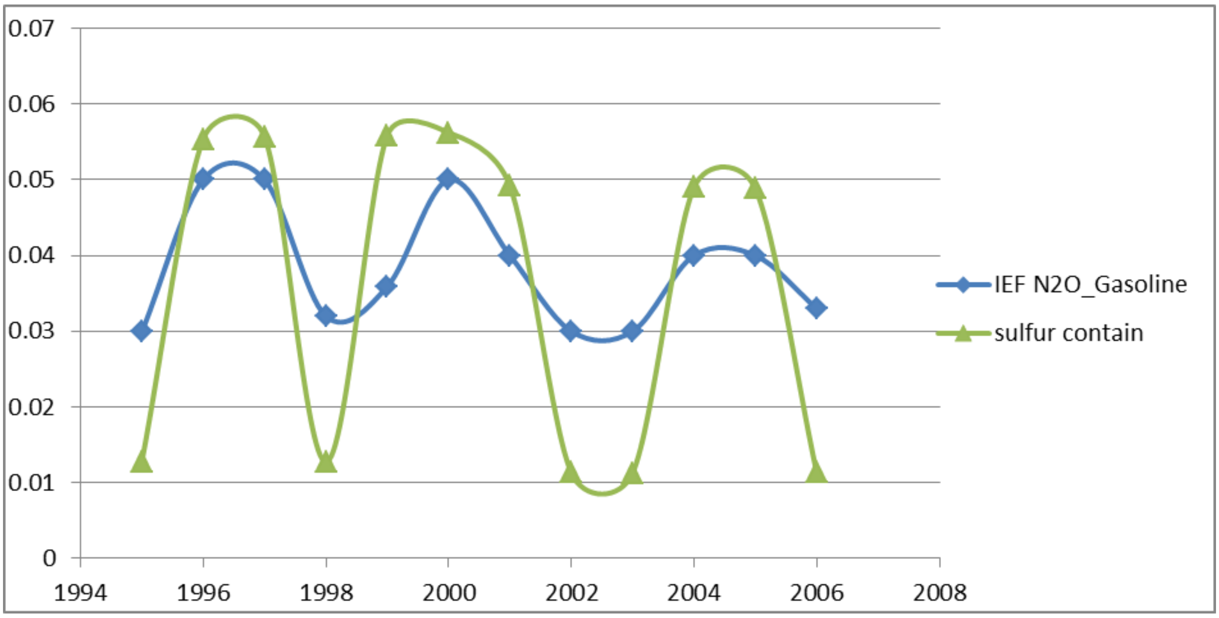


Figure 3.2-10: Fluctuations in IEF for N2O and fluctuations on sluphur content of the fuel

For conformation of this statement, N2O emission calculation with constant sulfur contain for Passenger Euro I Gasoline vehicles was performed. Obtained IEF for N2O did not have fluctuations (see figure 3.2-11).

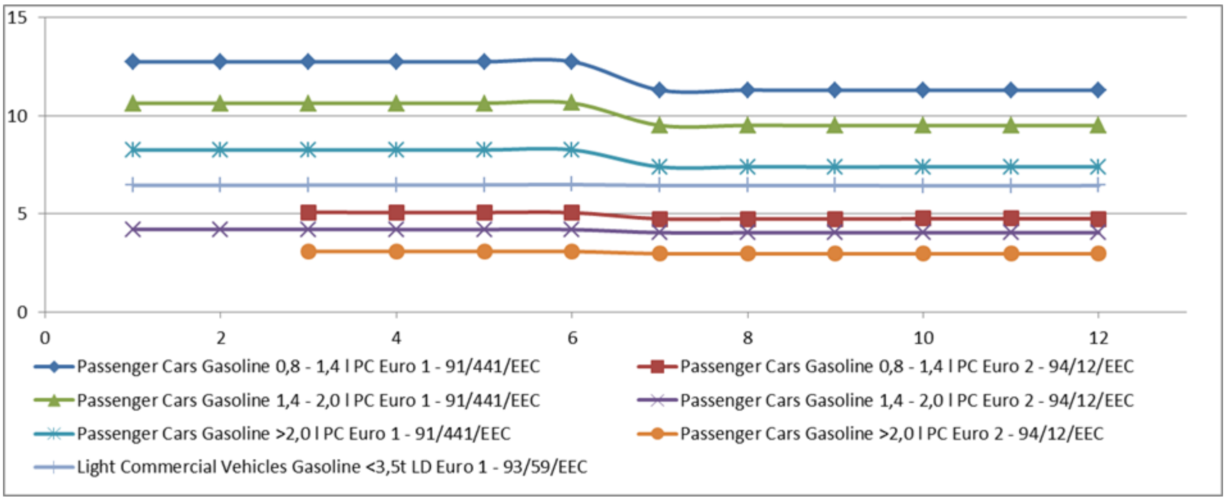


Figure 3.2-11: IEF for N2O when sulphur content is constant

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 - 2012 are shown in Table A2-11 Annex 2.

The CO_2-eq from the sub-sectors Road transport in 2012 amounted to 5,424.9 Gg, which is 3.1 percent less than in 2011 as a result of decrease in fuel consumption. In comparison with 1990, CO_2-eq increased by 47.9% as a result of grow in diesel fuel consumption (by 1.9 times compared to 1990). At the same time gasoline consumption was decreased by 23.9%.

Trends of CO_2-eq emissions for fossil fuel type consumed in road transport for the period from 1990 to 2012 are shown in Figure 3.2-12.

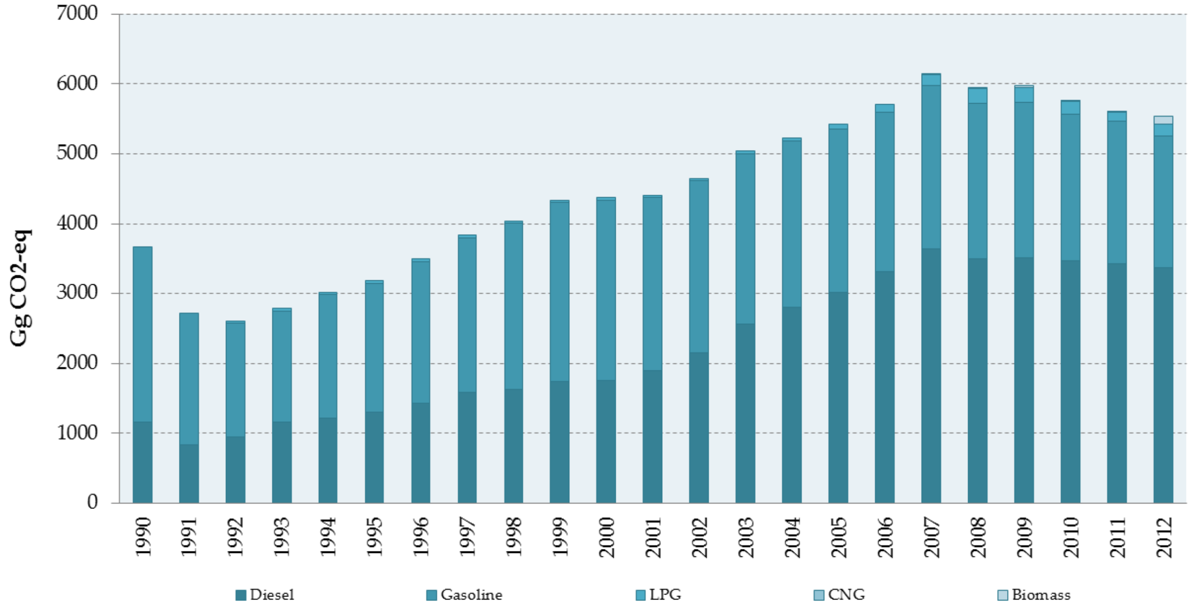


Figure 3.2-12: The CO_2-eq emission from Road transport sub-sector by fossil fuel type for the period from 1990 to 2012

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 - 2012 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 - 2012 are shown in the Table A2-13 of the Annex 2.

3.2.8.3. Uncertainties and time-series consistency

Uncertainty of CO_2 emissions

The CO_2 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 CO_2 emissions for International Marine and Aviation Transport are not included in nationals totals.

The other data needed for calculation, such as, carbon emission factors, the fraction of carbon stored for non-energy uses of fuel and the fraction of carbon oxidized, are taken from *Revised 1996 IPCC Guidelines for National GHG Inventories*.

Experts believe that CO_2 emission factors for fuels are generally well determined within 5 percent, as they are primarily dependent on the carbon content of the fuel.

Uncertainty of CH_4 and N_2O emissions

Estimates of CH_4 and N_2O 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 CH_4 emission is estimated to ±40 percent; while the uncertainty of N_2O emission is estimated to factor 2 (the emission could be twice larger or smaller than the estimated one). The largest part of uncertainty refers to the emission factor applied while the fuel consumption data (national energy balance) are rather good.

Implementation of Tier 2/3 approach for estimation of CH_4 and N_2O emissions from 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 CO_2 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 CO_2 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. CH_4 and N_2O are reliable and accurate as well.

3.2.8.5. Source-specific recalculations

Recalculation was made for sub-sector Road transportation (1.A.3.b) in the period from1990 to 2012 due to changing in tear method for emission calculation for LPG and CNG (from Tier 3 to Tier 1). Recalculations are made foe CH4 and N2O emissions due to new COPERT IV version.

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

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
GASOLINE											
CH_4	-0.01	0.00	0.02	-0.21	0.03	-0.03	0.00	0.02	0.01	0.00	-0.02
N_2O	-0.01	0.00	0.02	-0.24	0.03	-0.03	0.00	0.01	0.01	0.00	-0.02
DIESEL											
CH_4	-0.01	-0.02	0.02	0.00	-0.01	-0.01	0.00	-0.02	0.03	0.00	0.03
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
LPG											
CO_2	NO	NO	-0.01	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	-0.01
CH_4	NO	NO	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
N_2O	NO	NO	NO	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
NATURAL GAS											
CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
GASOLINE											
CH_4	-0.02	-0.13	0.27	0.86	2.63	2.56	3.40	3.84	5.39	6.10	0.00
N_2O	-0.03	-0.13	-0.21	-0.45	-0.33	-0.77	-0.98	-1.11	-1.37	-1.43	0.00
DIESEL											
CH_4	0.02	0.02	-0.03	0.01	24.06	0.00	0.01	-0.50	0.00	-0.38	0.00
N_2O	0.01	0.01	-0.02	0.01	12.04	0.00	0.01	-0.77	0.00	-0.62	0.00
LPG											
CO_2	0.00	-0.01	0.01	-0.01	-0.02	0.01	-0.01	-0.01	0.01	0.00	0.00
CH_4	0.01	0.00	0.01	0.00	-0.01	0.01	0.00	0.00	0.01	0.00	0.00
N_2O	0.01	0.00	0.01	0.00	-0.01	0.01	0.00	0.00	0.01	-0.04	0.00
NATURAL GAS											
CO_2	NO	NO	NO	NO	NO	NO	NO	NO	-41.41	-41.43	-41.45
CH_4	NO	NO	NO	NO	NO	NO	NO	NO	-39.88	-39.24	-40.32
N_2O	NO	NO	NO	NO	NO	NO	NO	NO	-160.7	-299.8	-112.9

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 CO_2 emissions from gasoline and diesel oil, and reasons for high uncertainties of emission factors for CH_4 and N_2O.

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 3.2-15 and Figure 3.2-13.

Table 3.2-15: The CO_2-eq emissions (Gg) from Small Stationary Energy Sources

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Commercial/ Institutional	775.00	652.00	638.00	786.00	626.00	627.00	669.00	616.00	542.00
Residential	2,176.00	1,688.00	2,008.00	2,481.00	2,116.00	2,166.00	2,209.00	2,060.00	1,848.00
Agric./Fores/ Fishing	843.00	583.00	861.00	712.00	771.00	738.00	718.00	717.00	669.00
Total	**3,794.00**	**2,923.00**	**3,507.00**	**3,979.00**	**3,513.00**	**3,531.00**	**3,596.00**	**3,393.00**	**3,058.00**

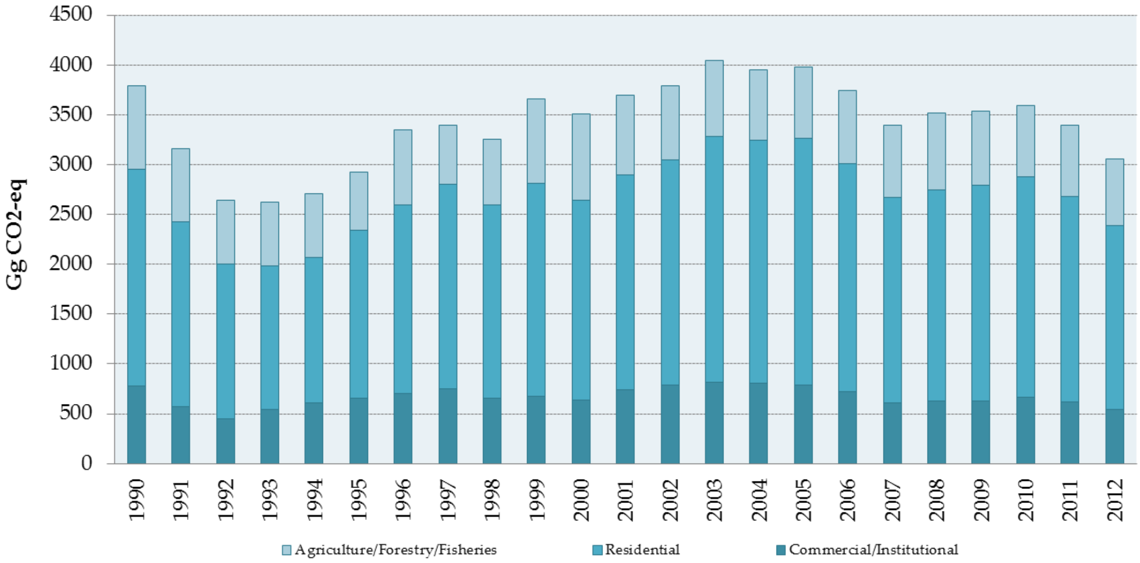


Figure 3.2-13: The CO_2-eq emissions from Small Stationary Energy Sources

The CO_2-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 CO_2 emissions

The CO_2 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 CO_2 emission factors for fuels are generally well determined within 5 percent, as they are primarily dependent on the carbon content of the fuel.

Uncertainty of CH_4 and N_2O emissions

Estimates of CH_4 and N_2O 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 CH_4 and N_2O emissions from the fossil fuel combustion.

The uncertainty of CH_4 emission is estimated to ±40 percent; while the uncertainty of N_2O emission is estimated to factor 2 (the emission could be twice larger or smaller than the estimated one).

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 SO_2 are described in this chapter. Ozone precursors are cause of greenhouse gas - tropospheric ozone, whereas SO_2 was added to a list of pollutants first time in Revised 1996 IPCC Guidelines for National GHG Inventories due to the importance of this gas from the position of acidification and eutrophication. Emissions of indirect GHGs for whole time period, from 1990 to 2012 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).

NOx emissions

The NOx emission encompasses nitrogen monoxide and nitrogen dioxide emissions. The emissions are expressed as equivalents of NO_2. NOx 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, NOx takes part in ground ozone formation.

The emission of NOx from Energy sector (Fuel Combustion Activities) in 2012 was 56.7 Gg which is 3.9 percent lower than the year before and 36.8 percent lower compared to 1990. The NOx emissions from Energy sector contribute with 95.8 percent to national total NOx emission. The structure of NOx emission in Energy sector has not changed significantly in the period from 1990 to 2012 (Figure 3.2-14). The main source of NOx emission is transport (46.4 percent of total emission). Small stationary energy sources accounted for 22.1 percent to national total NOx emission and emission from industry sectors accounted for 15.6 percent to the national total.

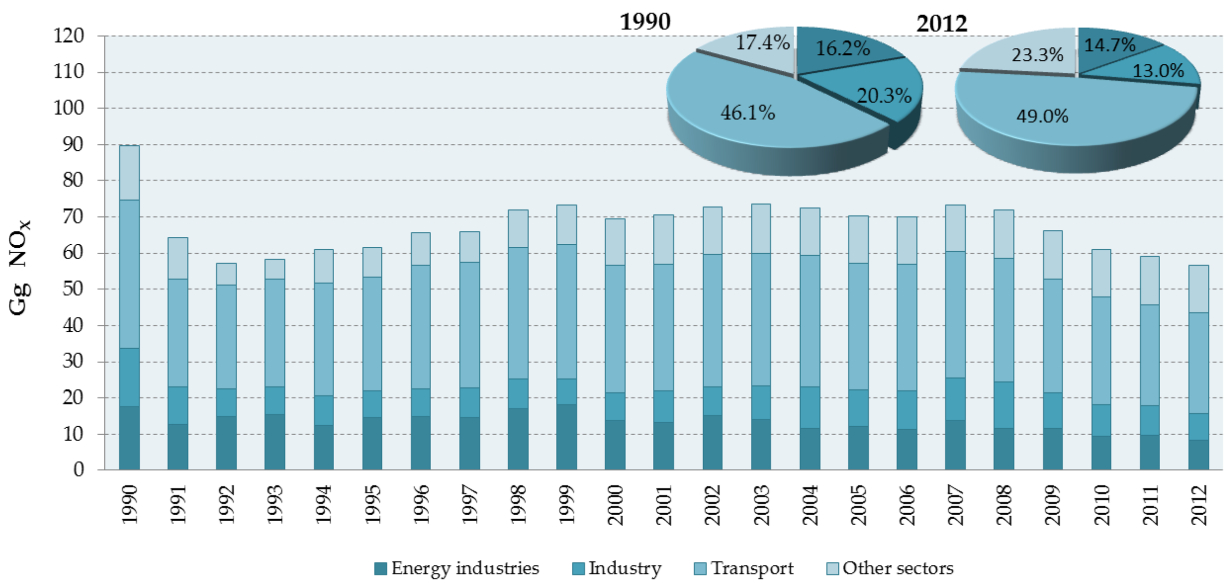


Figure 3.2-14: NOx emissions from Energy sector in the period 1990-2012

CO emissions

In 2011, the emission of CO from Fuel Combustion Activities was 254.6 Gg which is 2.0 percent higher than in the year before and 47.1 percent lower compared to 1990, the year with maximum emission (481.4 Gg) of CO in the observed period. The CO emissions from Energy sector in 2012 contribute with 90.7 percent to national total CO emission. 22.0 percent of CO emission in Energy sector in 2012 was the result of incomplete fossil fuel combustion in Road transport sector and 65.9 percent in Commercial and Residential sector (Figure 3.2-15). Large combustion plants have automatic regulation of air throughput and combustion control, so CO emissions are low (about 0.4% of national total emission).

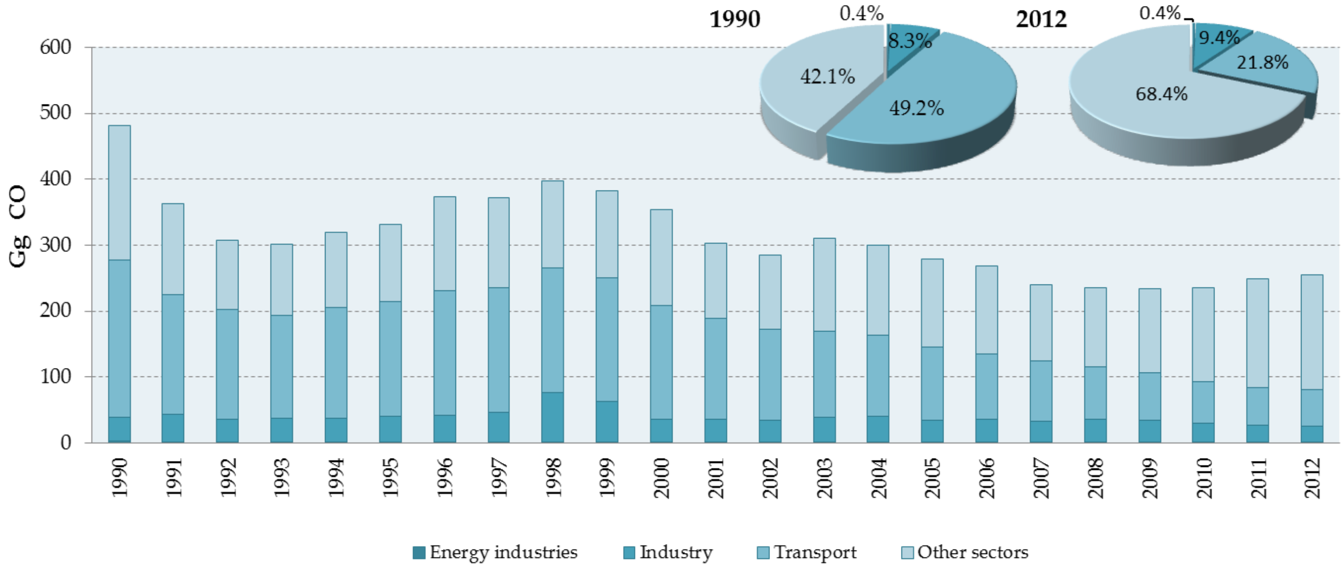


Figure 3.2-15: CO emissions from Energy sector in the period 1990-2012

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 22.3 Gg in 2012 which was 1.1 percent higher than the year before and 54.7 percent lower than 1990. The NMVOC emissions from Energy sector contribute with 32.6 percent to national total NMVOC emission.

The structure of NMVOC emission from Energy sector has not changed significantly in the period from 1990 to 2012 (Figure 3.2-16). The main source of NMVOC emission is stationary combustion sectors accounted with 15.4 percent to the national total, mainly from the Commercial and Residential sector.

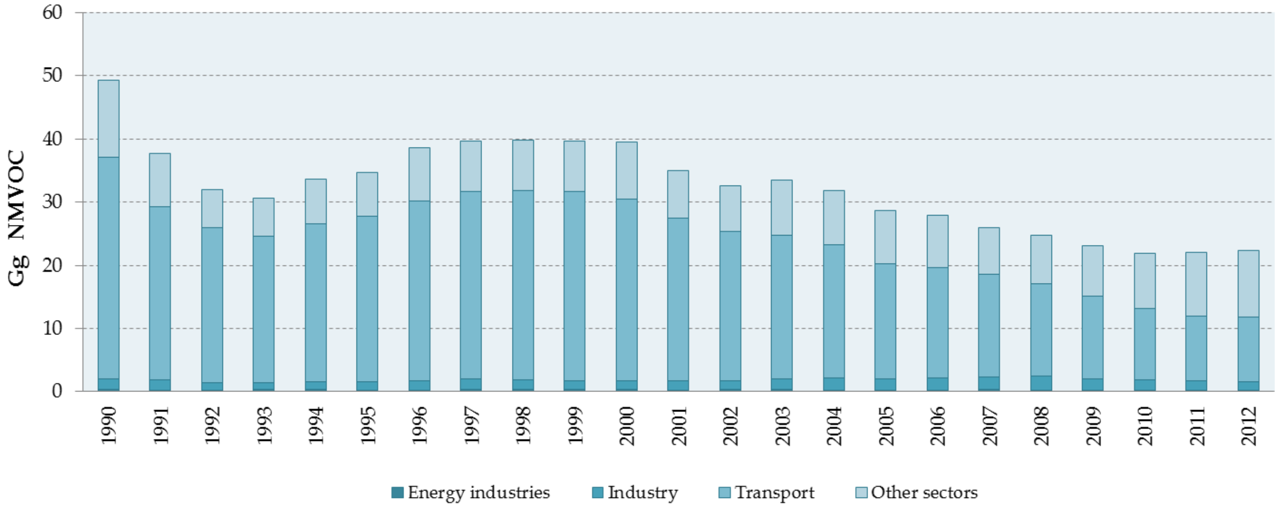


Figure 3.2-16: NMVOC emissions from Energy sector in the period 1990-2012

<u>SO_2 emissions</u>

In accordance with the calculated results, the level of SO_2 emission from Fuel Combustion Activities in 2012 reached 23.3 Gg which is 90.6 percent of total national SO_2 emission. The trend shows that emissions of SO_2 have decreased by 18.6 percent compared to the emission in 2011 and decreased by 86.2 percent since 1990. Since 1990, SO_2 emission has the overall decreasing trend due to consumption of fossil fuel with lower sulphur content. The outstanding high level of SO_2 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 2012, the decrease of SO_2 emissions was achieved in almost all sectors and the greatest decrease of SO_2 emission was in Energy Industries sector (85.4). Emission trend for SO_2 in the period of 1990 to 2012 as well as the share of the particular sectors in total emission of SO_2 in Energy sector 1990 and 2012 is presented in Figure 3.2-17.

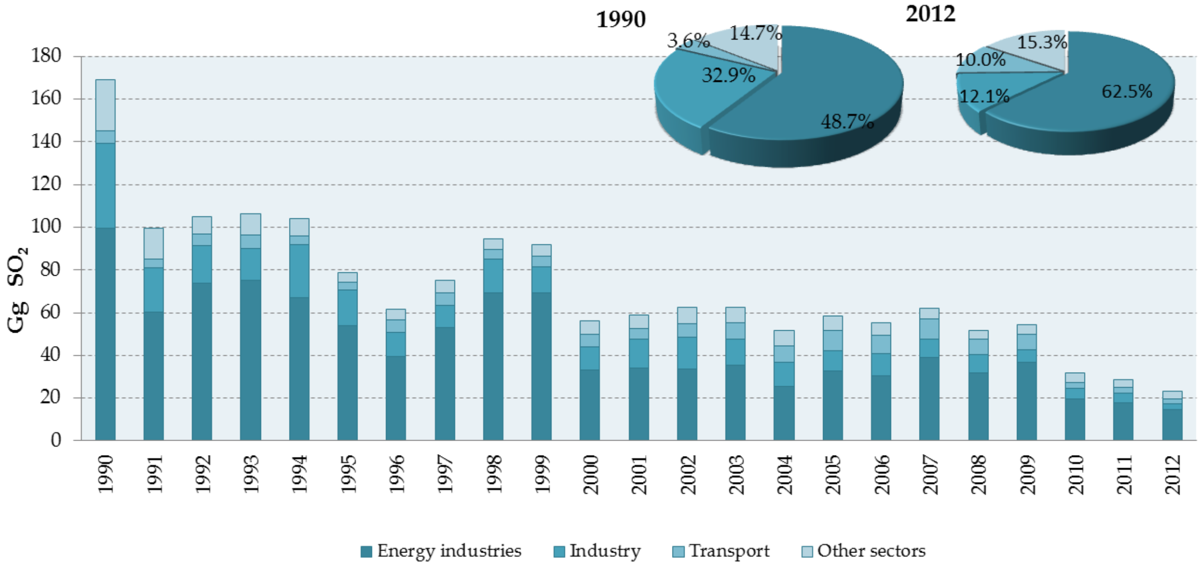


Figure 3.2-17: SO_2 emissions from Energy sector in the period 1990-2012

The emissions of ozone precursors and SO_2 are shown in the Table 3.2-16.

Table 3.2-16: Emissions of ozone precursors and SO_2 from Fuel Combustion sector (Gg)

Emission (Gg)	1990	1995	2000	2005	2008	2009	2010	2011	2012
NO_x Emission	**89.81**	**61.63**	**69.42**	**70.43**	**71.96**	**66.12**	**60.98**	**59.02**	**56.73**
Energy Industries	17.47	14.48	13.75	12.19	11.48	11.47	9.48	9.57	8.37
Manuf. Ind. & Con.	16.33	7.57	7.73	10.10	13.00	9.99	8.76	8.24	7.36
Transport	40.98	31.45	35.08	34.99	33.98	31.38	29.56	27.90	27.78
Other Sectors	15.03	8.13	12.85	13.15	13.51	13.29	13.18	13.30	13.22
CO Emission	**481.41**	**331.62**	**354.45**	**279.11**	**235.92**	**233.17**	**235.24**	**249.51**	**254.57**
Energy Industries	2.39	1.56	1.62	1.15	1.45	1.18	1.07	1.22	1.10
Manuf. Ind. & Con.	37.23	38.10	33.56	33.45	34.01	32.77	28.92	26.43	23.96
Transport	237.84	175.27	172.87	111.55	80.40	73.07	63.49	55.60	55.48
Other Sectors	203.95	116.68	146.39	132.96	120.06	126.15	141.77	166.26	174.03
NMVOC Emission	**49.26**	**34.62**	**39.51**	**28.60**	**24.77**	**23.15**	**21.90**	**22.06**	**22.31**
Energy Industries	0.35	0.26	0.29	0.26	0.28	0.26	0.25	0.28	0.24
Manuf. Ind. & Con.	1.64	1.33	1.40	1.76	2.13	1.76	1.55	1.45	1.34
Transport	35.12	26.12	28.81	18.28	14.64	13.12	11.31	10.22	10.20
Other Sectors	12.14	6.91	9.01	8.29	7.72	8.01	8.80	10.11	10.52
SO_2 Emission	**169.04**	**78.83**	**56.38**	**58.32**	**51.87**	**54.28**	**31.66**	**28.59**	**23.29**
Energy Industries	99.53	53.98	32.93	32.73	31.96	36.74	19.67	17.94	14.56
Manuf. Ind. & Con.	39.75	16.66	10.99	9.66	8.19	6.09	4.68	4.32	2.83
Transport	5.89	3.53	5.96	9.15	7.44	6.93	3.13	2.61	2.33
Other Sectors	23.87	4.65	6.50	6.78	4.27	4.51	4.18	3.72	3.57

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 2012, 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 CO_2 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.

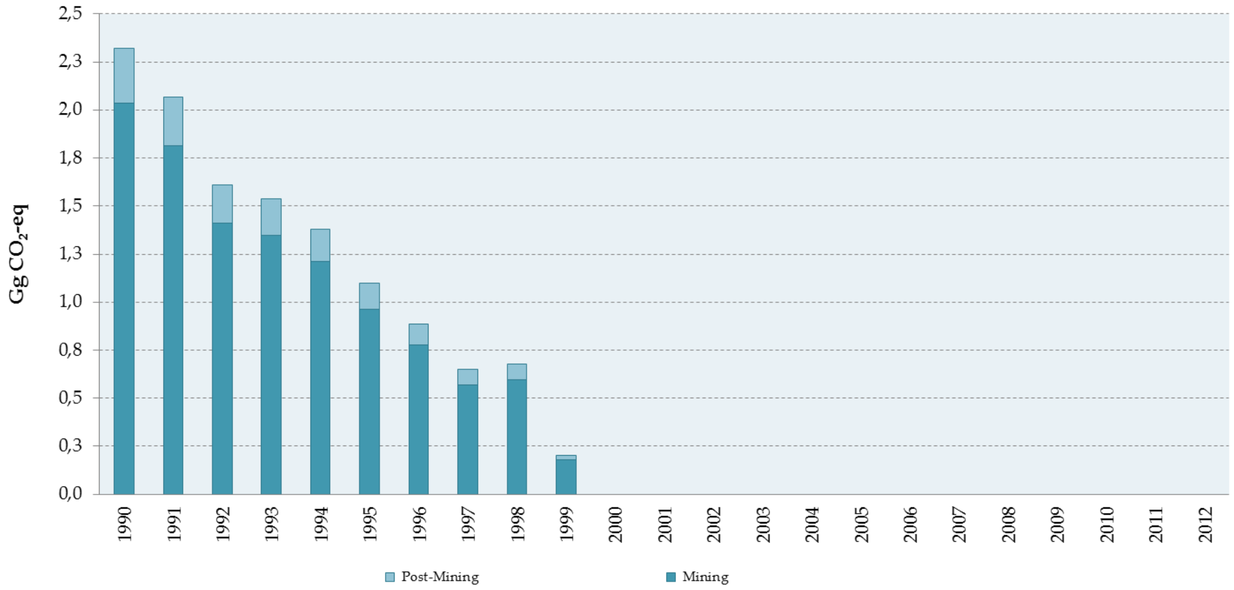


Figure 3.3-1: The fugitive emissions of methane from coal mines

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). Used emission factors are an average value of the range proposed in the IPCC Guidelines. For underground mines, for mining activities emission factor of 17.5 m^3CH_4/t (average value between Low CH_4 emission factor = 10 m^3/tonne and High CH_4 emission factor = 25 m^3/tonne) was used and for Post-mining activities 2.45 m^3CH_4/t (average value between 0.9 and 4.0 m^3/tonne) was used. Conversion factor amounted 0.67 Gg CH_4 /million m^3.

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

<u>**Uncertainty**</u>

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 a high as a factor of 2 and for post-mining activities a factor of 3.

<u>**Time-series consistency**</u>

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

The coal production data were summed twice in CRF table 1B1A1. Data on coal production were corrected for the whole period from 1990 to 1999.

Differences in fuel consumption data before and after recalculation are:

	1990	1991	1992	1993	1994	1995	1996	1997	1998	2000
Difference, Mt	0.1737	0.1548	0.1203	0.1151	0.1032	0.0822	0.0663	0.0485	0.0508	0.0153

Although production data were incorrectly entered into the CRF, CH_4 emission calculation is correct. This error did not affect the CH_4 emission from surface coal mines.

3.3.1.6. Source-specific planned improvements

For estimation of fugitive emissions from coal mines a Tier 1 method was applied. For emission estimation data on saleable coal was used. On long term basis, inventory team is planning to determine the amount of production of coal that is washed.

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 CO_2 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 CO_2, more than 15 percent, and before coming to commercial pipeline has to be cleaned (scrubbed). Since the maximum volume content of CO_2 in commercial natural gas is 3 percent, it is necessary to clean the natural gas before transporting through pipeline to end-users. Because of that, the Scrubbing Units exist at largest Croatian gas field. The estimated CO_2 emissions, by the material balance method, are presented in Table 3.3-1.

Table 3.3-1: The CO_2 emissions (Gg) from natural gas scrubbing in CGS Molve

CO_2 emission (Gg)	1990	1995	2000	2005	2008	2009	2010	2011	2012
Central Gas Station MOLVE	416.00	739.00	633.00	691.00	576.00	516.00	487.00	509.00	429.00

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 CO_2-eq emissions (Gg) from oil and gas systems

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Oil activities	16.10	11.50	10.90	10.20	8.90	9.40	8.90	7.20	6.50
Gas activities	1,577.70	1,852.20	1,712.70	1,983.20	2,059.60	1,945.80	1,971.10	1,897.70	1,629.60
Venting and Flaring	248.90	156.00	128.00	118.70	118.40	113.40	109.30	99.94	99.97
Total	**1,842.80**	**2,019.60**	**1,851.50**	**2,112.20**	**2,186.90**	**2,068.60**	**2,089.30**	**2,004.90**	**1,736.00**

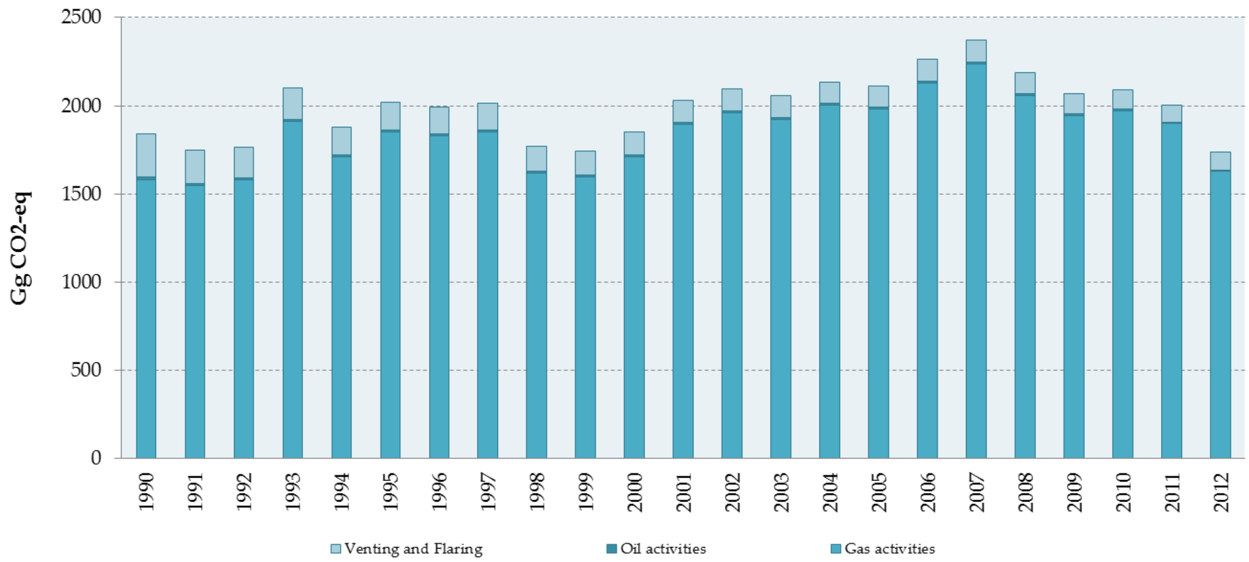


Figure 3.3-2: The fugitive emissions from oil and gas activities

The CO_2-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 SO_2

Emissions of indirect GHGs for whole time period (1990-2012) was set up according to the EMEP/CORINAIR methodology. Emissions were obtained from the emission inventory report 'Republic of Croatia Informative Inventory Report for 2012, 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 SO_2 are illustrated in the Table 3.3-3 and Figure 3.3-3.

Table 3.3-3: The fugitive emissions of ozone precursors and SO_2 from oil refining

Emissions (Gg)	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO emission	50.06	34.51	54.07	54.42	41.61	51.91	40.12	32.64	35.37
NO_x emission	0.49	0.30	0.30	0.30	0.24	0.29	0.21	0.17	0.19
NMVOC emission	8.50	6.73	9.06	8.45	7.47	7.98	7.67	7.06	6.35
SO_2 emission	1.80	1.24	3.11	3.09	2.83	3.27	2.33	3.46	3.73

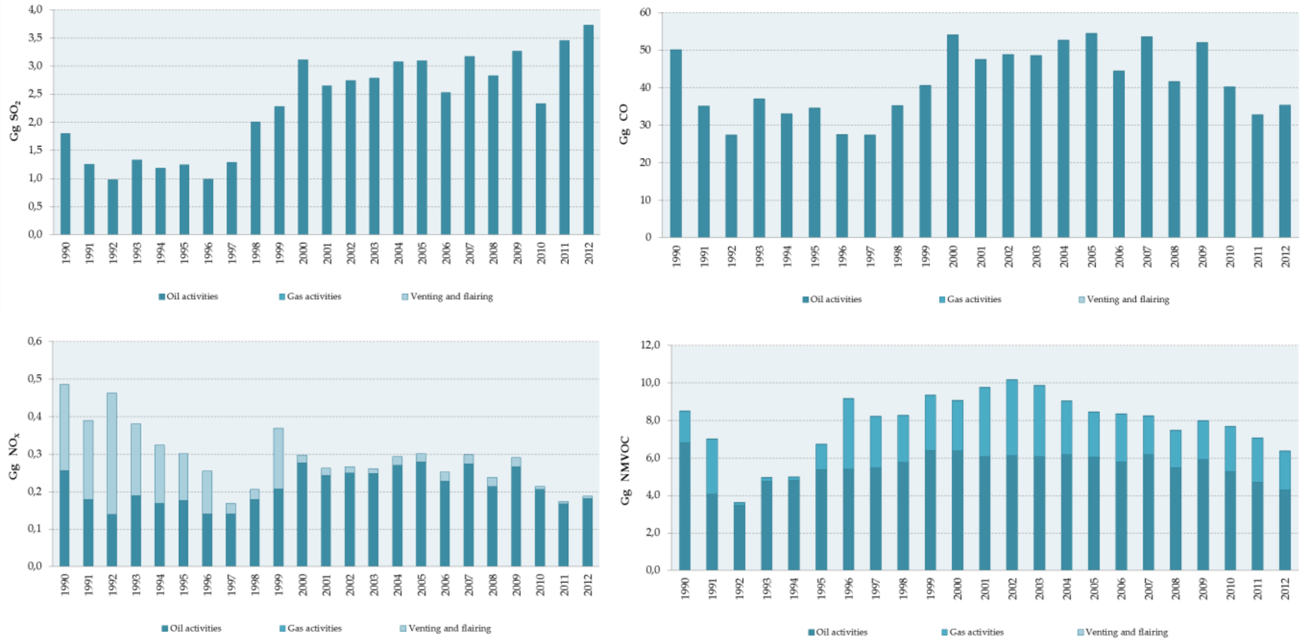


Figure 3.3-3: The fugitive emissions of CO, NO_X, NMVOC and SO_2

3.3.2.2. Methodological issues

Fugitive emission of CH_4

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 CO_2 and N_2O

For estimating the fugitive emission of CO_2 and N_2O 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).

CO_2 emission from natural gas scrubbing

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

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

Fugitive emission of ozone precursors and SO_2

A simplified Tier 1 procedure was used for fugitive emission estimates of ozone precursors and SO_2 from oil refineries, for the entire period from 1990 to 2012. 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 SO_2 is also very high.

The CO_2 emission from scrubbing of natural gas is also shown here. The calculation is based on material balance which gives much better accuracy (±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 CO_2 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

There are no recalculations in this sub-sector.

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.

3.4. REFERENCES

Central Bureau of Statistics (2012) Statistical Yearbook – for period from 1990 till 2012, Zagreb

Croatian Environment Agency (2013) Republic of Croatia Informative Inventory Report for 2012, under Convention on Long-range Transboundary Air Pollution (CLRTAP), EKONERG Ltd., Zagreb

FCCC/IRR/2008/HRV Report of the review of the initial report of Croatia, 26 August 2009

FCCC/ARR/2008/HRV Report of the initial review of the greenhouse gas inventories of Croatia submitted in 2007 and 2008, 5 November 2009 (advance version)

FCCC/ARR/2009/HRV Report of the individual review of the greenhouse gas inventory of Croatia submitted in 2009 Centralized Review Report

FCCC/ARR/2010/HRV Report of the individual review of the annual submission of Croatia submitted in 2010, 20 January 2011

FCCC/ARR/2012/HRV Report of the individual review of the annual submission of Croatia submitted in 2012, 8 February 2013

EEA (2000) COPERT IV Computer Programme to Calculate Emissions from Road Transport, Denmark

INA (2012) Data about natural gas scrubbing in Central Gas Station MOLVE and sulphur content in liquid fossil fuels, INA – Oil and Gas Company, data sent by fax or by mail

INA (2013) Data about number of active wells, INA – Oil and Gas Company, data sent by mail

IPCC/UNEP/WMO (2006) IPCC Guidelines for National Greenhouse Inventories, Volume 2, Energy, Japan

IPCC (2000) Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Japan

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

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

Ministry of Economy, Labour and Entrepreneurship (2012) Energy in Croatia 2012, Annual Energy Report, Energy Institute "Hrvoje Požar", Zagreb

Ministry of Environmental and Nature Protection (2012) National Inventory Report 2013, Croatian greenhouse gas inventory for the period 1990 – 2011, EKONERG, Zagreb

Ministry of Environmental and Nature Protection (2010) Fifth National Communication of the Republic of Croatia under the United Nations Framework Convention on Climate Change (UNFCCC), Zagreb

Ministry of Environmental and Nature Protection (2006) Second, Third and Fourth National Communication of the Republic of Croatia under the United Nations Framework Convention on Climate Change (UNFCCC), Zagreb

Ministry of Interior (2012) Motor Vehicle Databases for 1990-2012, data on CD

Vuk B. National Energy Balances–for period from 1990 till 2012, Energy Institute Hrvoje Požar, Zagreb

Vuk B. Industry analysis balance–for period from 2001 till 2012, Energy Institute Hrvoje Požar, Zagreb

4. INDUSTRIAL PROCESSES (CRF sector 2)

4.1. OVERVIEW OF SECTOR

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

Industrial processes whose contribution to CO_2 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 N_2O emissions. Emissions of CH_4 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. SF_6 is used as an insulation medium in electrical equipment. During SF_6 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 (SO_2). 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, CO_2 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 2012 still considerably lower than in 2008.

The total annual emissions of GHGs, expressed in Gg CO_2-eq, from Industrial Processes in the period 1990-2012 are presented in the Figure 4.1-1.

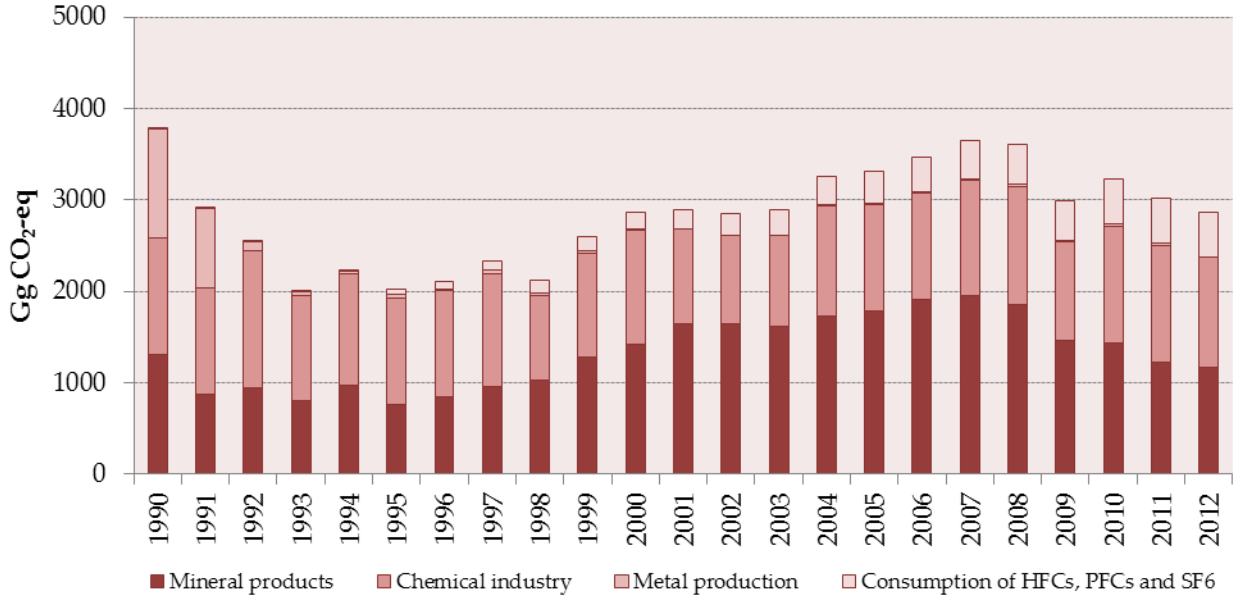


Figure 4.1-1: Emissions of GHGs from Industrial Processes (1990-2012)

In Industrial processes, seven 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 2012[5]

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	T1i, T2i
CO_2 Emissions from Ammonia Production	CO_2	L1e	L1i	T1e, T2e	T1i, T2i
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_2O Emissions from Nitric Acid Production	N_2O	L1e, L2e	L1i, L2i		
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 L2e - Level excluding LULUCF Tier 2
L1i - Level including LULUCF Tier 1 L2i - Level including LULUCF Tier 2
T1e - Trend excluding LULUCF Tier 1 T2e - Trend excluding LULUCF Tier 2
T1i - Trend including LULUCF Tier 1 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:

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

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 (1990-2012)

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
2012	1,896,912	99,587	2,036,429	0.501	0.301

[1] Clinker production according to survey of cement manufacturers
[2] 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 (1990-2012)

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 (1990-2012), 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
2012	0	0	283,797	680	69,843	440

The resulting emissions of CO_2 from Cement Production in the period 1990-2012 are presented in the Figure 4.2-1.

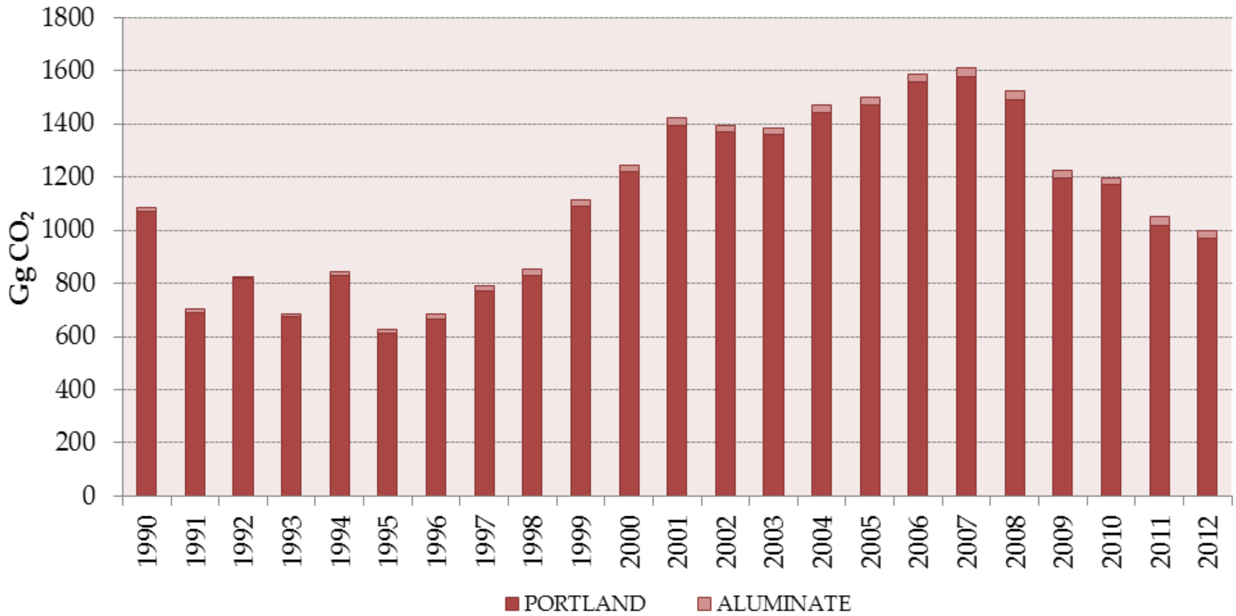


Figure 4.2-1: Emissions of CO_2 from Cement Production (1990-2012)

CO_2 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 decreased every year (22.6 percent in 2009, 26.5 percent in 2010, 28.4 percent in 2011, and 39.8 percent in 2012, regarding the year 2008). CO_2 emissions from this activity decreased by 34.6 percent in 2012, 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 (1990-2012)

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
2012	2,177,413	100,174

SO_2 emissions originate from sulphur in the fuel and in the clay raw material. The fuel emissions are counted as energy emissions (these emissions are presented in the chapter on emissions from energy sources). SO_2 emissions from the clay are counted as process emissions and calculated on the basis of produced quantities of cement. About 70-95 percent of the SO_2 generated in the process is absorbed in the produced alkaline clinker.

Emissions of SO_2, 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 2012* Submission to the Convention on Long-range Transboundary Air Pollution'.

The resulting emissions of SO_2, CO, NO_x and NMVOC from Cement Production in the period 1990-2012 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 to 3 percent (1 to 5 percent), based on expert judgements. Uncertainty estimate associated with emission factors amounts to 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. CO_2 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.

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 qurrying the raw material, crushing and sizing, calcination and hydration. CO_2 is generated during the calcination stage, when limestone ($CaCO_3$) or dolomite ($CaCO_3$*$MgCO_3$) are burned at high temperature (900-1,200°C) in a kiln to produce quicklime (CaO) or dolomitic lime (CaO*MgO) and CO_2 which is released in the atmosphere:

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

During the reporting period, in operation were total of four manufacturers (five factories) of lime in Croatia, with one of them producing both quicklime and dolomitic lime and the others producing only quicklime, which had a varying production and even periods of halted operations over the years. Total of seven kilns were used, among which four are parallel-flow regenerative shaft kilns, two are annular shaft kilns and one is long rotary kiln. Since March 2011, two of the factories ceased their production.

Emissions from the production of sugar (in three factories), where a certain amount of quicklime is produced, have been also included in this sub-sector.

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

4.2.2.2.Methodological issues

Calculation of CO_2 emissions from lime production is accomplished by applying an emission factor in tonnes of CO_2 released per tonne of quicklime or dolomitic lime produced, to the annual lime output. The emission factors were derived on the basis of calcination reaction depending on the type of raw material used in the process.

Country-specific emission factor for quicklime was estimated by using data on CaO content of the lime and stoichiometric ratio between CO_2 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 CO_2 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 CO_2 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.

Data for one lime factory regarding their operation in 2012 could not be obtained in the required form in time to incorporate them in this report. The missing data will be obtained and included in the next submission and for the purpose of this submission data for the year 2011 were used in the emission calculation.

Table 4.2-4: Lime production and emission factors (1990-2012)

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	165,397	0.736	0	-
1992	124,493	0.654	0	-
1993	134,482	0.658	0	-
1994	140,116	0.664	0	-
1995	139,701	0.667	0	-
1996	137,667	0.659	38,070	0.862
1997	131,741	0.658	55,171	0.850
1998	142,018	0.676	53,367	0.874
1999	136,408	0.690	52,704	0.870
2000	124,437	0.686	68,572	0.887
2001	154,526	0.695	84,838	0.887
2002	174,893	0.696	94,378	0.892
2003	153,146	0.697	96,191	0.879
2004	227,322	0.705	56,689	0.895
2005	233,235	0.698	76,351	0.875
2006	260,584	0.695	105,653	0.895
2007	261,276	0.703	115,315	0.899
2008	246,700	0.688	120,680	0.900
2009	163,210	0.668	87,789	0.861
2010	129,900	0.690	92,574	0.903
2011	110,380	0.691	71,761	0.357
2012	82,885	0.748	59,334	0.879

The resulting emissions of CO_2 from Lime Production in the period 1990-2012 are presented in the Figure 4.2-2.

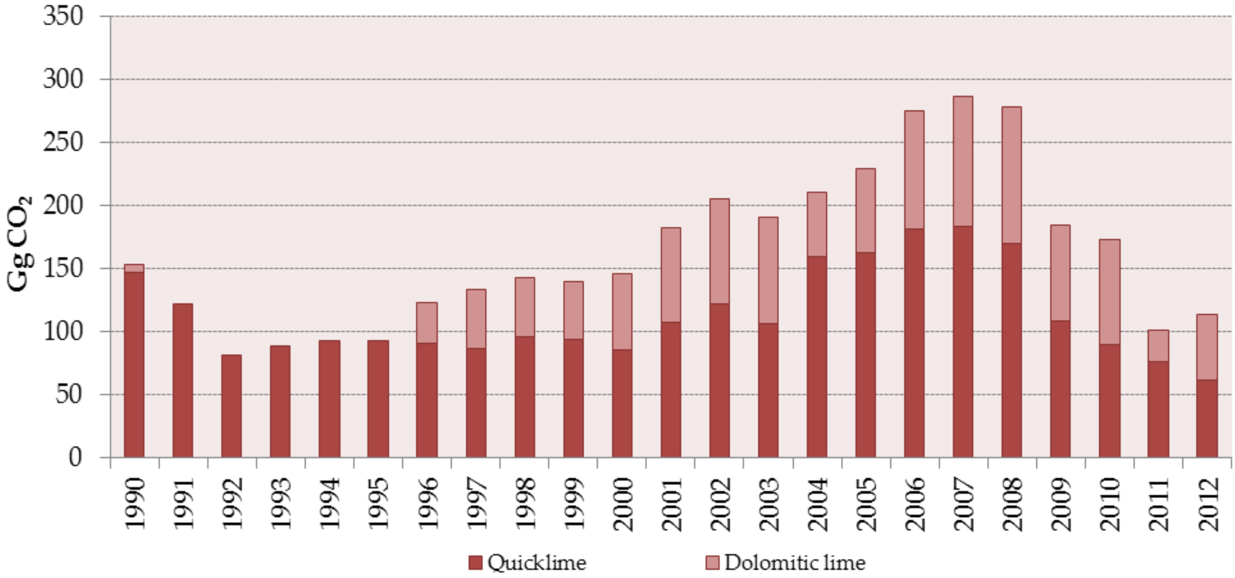


Figure 4.2-2: Emissions of CO_2 from Lime Production (1990-2012)

CO_2 emissions from lime production generally 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 gradually increased. After that period, due to a decrease of economic activity in Croatia, the production started to slightly decrease during 2008 to significantly drop by 32 percent in 2009, by 39 percent in 2010 and by 50 percent in 2011. Emissions decreased by 34 percent in 2009, 38 percent in 2010 and by 63 percent in 2011, regarding the year 2008. In 2012, three factories were not in operation and one factory ceased the production of quicklime and started the production of dolomitic lime. The total production of lime in 2012 decreased by 22 precent compared to 2011, while the total emission increased by 11 precent.

The methodology for calculation of SO_2 emissions from Lime Production is not available in *Revised 1996 IPCC Guidelines*. Process (non-combustion) SO_2 emissions depend on the sulphur content and mineralogical form of the stone feed, the quality of the lime produced and the type of kiln.

Emissions of CO have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2012* Submission to the Convention on Long-range Transboundary Air Pollution'.

The resulting emissions of CO from Lime Production in the period 1990-2012 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 to 2.1 percent (1 to 5 percent), based on expert judgements. Uncertainty estimate associated with emission factors amounts to 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.

CO_2 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 submission recalculations were performed for the period 1991-2011.

4.2.2.6. Source–specific planned improvements

Data for one lime factory regarding their operation in 2012 could not be obtained in the required form in time to incorporate them in this report. The missing data will be obtained and included in 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 ($CaCO_3*MgCO_3$) 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 2000-2012 also include significant limestone use in desulphurization process in Thermal Power Plant (TPP) Plomin 2[6].

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 carbonate[7]. 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. Currently, additional data investigation is in progress and competent authorities are cooperating in the process of determining the quality of available data for the entire reporting period.

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 (1990-2012)

Year	Limestone use (tonnes)	Dolomite and other carbonates* use (tonnes)
1990	61,108	52,031
1991	30,990	40,452
1992	10,414	21,505
1993	10,723	20,134
1994	14,864	32,504
1995	15,167	23,461
1996	14,159	25,063
1997	12,272	14,762
1998	14,730	19,546
1999	13,183	18,396
2000	20,258	16,577
2001	24,013	19,219
2002	28,042	19,265
2003	32,263	23,108
2004	34,603	25,448
2005	34,711	37,842
2006	32,086	37,914
2007	29,461	35,794
2008	34,392	36,410
2009	31,338	37,158
2010	44,101	36,441
2011	63,642	34,494
2012	49,742	33,398

* Li_2CO_3 from glass production, used in 2010

The resulting emissions of CO_2 from Limestone and Dolomite Use in the period 1990-2012 are presented in the Figure 4.2-3.

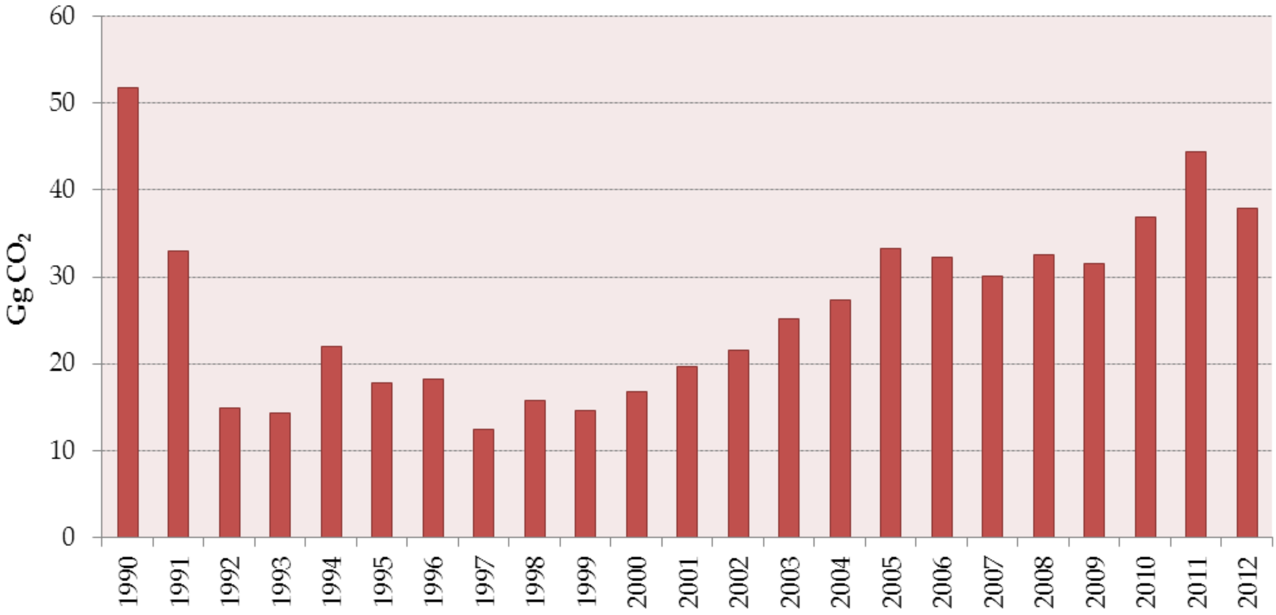


Figure 4.2-3: Emissions of CO_2 from Limestone and Dolomite Use (1990-2012)

CO_2 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 partly for 2008, and for the period 2009-2011 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 data regarding this subsector are currently being further investigated in order to ensure accurate CO_2 emission calculation for the whole time series.

4.2.3.3.Uncertainties and time-series consistency

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

Uncertainty estimate associated with activity data amounts to 7.5 percent (5 to 10 percent), based on expert judgements. Uncertainty estimate associated with default emission factors amounts to 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 1997-2012. 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 the period 2008-2012 are more detailed than data for previous years and therefore discrepancy has occurred concerning the whole time-series. All data regarding this subsector are currently being further investigated in order to ensure accurate CO_2 emission calculation for the whole time series. 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 prescribes source specific quality control procedures.

4.2.3.5.Source specific recalculations

New data have been obtained from several manufacturers for the entire reporting period (limestone use 1990-2011; dolomite use 2000-2011). Therefore, recalculations for this subsector have been performed for the period 1990-2011.

4.2.3.6.Source–specific planned improvements

More detailed activity data have been collected from individual plants for the period 2008-2012. The improved gathering of data for entire time-series should be performed to avoid potential inconsistency. All data regarding this subsector are currently being further investigated in order to ensure accurate CO_2 emission calculation for the whole time series.

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 1990-2012. Therefore, only CO_2 emissions arising in soda ash consumption in Croatia have been estimated.

4.2.4.2.Methodological issues

Emissions of CO_2 from the soda ash use have been calculated by multiplying annual consumption of soda ash by emission factor, which is based on a ratio between CO_2 and soda ash used. Default emission factor equals 415 kg CO_2/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 (1990-2012)

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

Table 4.2-6: Soda ash use (1990-2012), cont.

Year	Soda ash use (tonnes)
2006	52,672
2007	49,190
2008	48,450
2009	48,667
2010	57,196
2011	56,168
2012	52,561

The resulting emissions of CO_2 from Soda Ash Use in the period 1990-2012 are presented in the Figure 4.2-4.

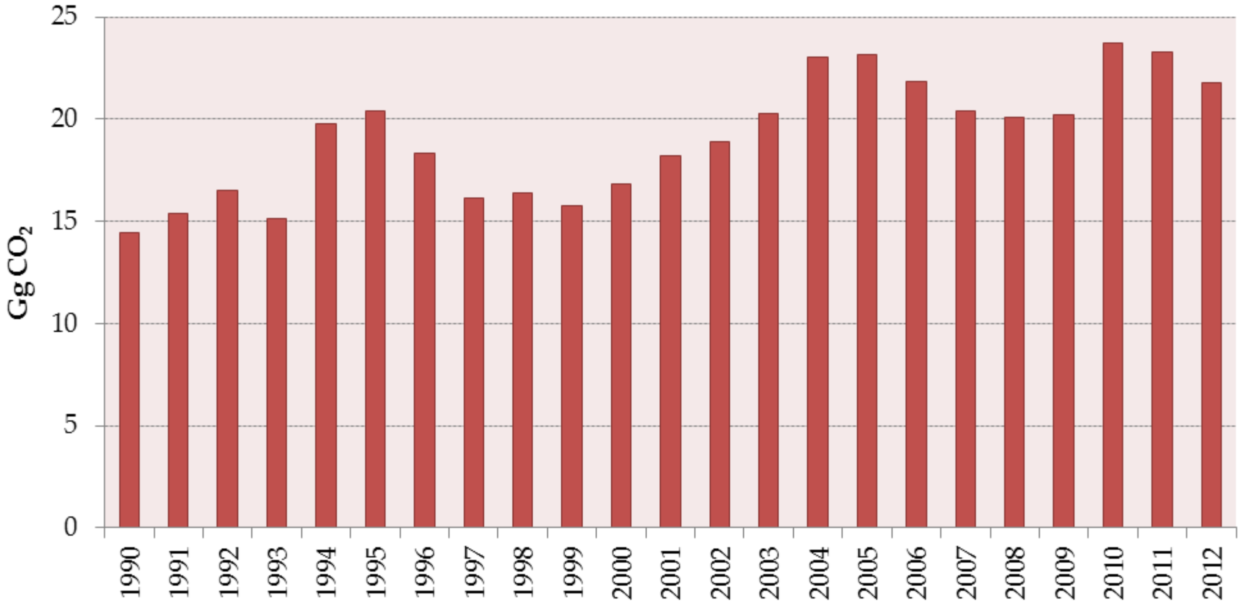


Figure 4.2-4: Emissions of CO_2 from Soda Ash Use (1990-2012)

4.2.4.3.Uncertainties and time-series consistency

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

Uncertainty estimate associated with activity data amounts to 7.5 percent (5 to 10 percent), based on expert judgements. Uncertainty estimate associated with default emission factors amounts to 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 prescribes source specific quality control procedures.

4.2.4.5.Source specific recalculations

There are no 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

CO_2 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 2012* 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 1990-2012 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 prescribes 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.

4.3. 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 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 only one manufacturer of ammonia in Croatia.

4.3.1.2.Methodological issues

For purposes of ammonia production in Croatia, natural gas is used as both feedstock and fuel. Only the CO_2 emission occurring from natural gas used as feedstock has been calculated for this subsector and included in the Industrial processes sector. Emission of CO_2 from natural gas used as fuel in the process of ammonia production is calculated separately and presented in the Energy sector.

Emission of CO_2 from natural gas used as feedstock has been calculated by multiplying annual consumption of natural gas used as feedstock (see Table 4.3-1, second column) by average annual value of carbon content of natural gas used as feedstock (see Table 4.3-1, third column) and molecular weight ratio between CO_2 and carbon (44/12) (Tier 1a, *Revised 1996 IPCC Guidelines*).

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). Consumption of natural gas for ammonia production process (without the part that is being used as fuel) in the plant is measured by the measuring screen where the output is compensated with respect to pressure and temperature in the Distributed Control System (DCS). Data are collected and stored in the DCS system, during the 24 hour work regime. Data provided by the ammonia manufacturer were 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 are performed daily, at standard conditions (1 atm, 15°C). Therefore, molar volume were corrected ($V = R*T/p = 23.64$ 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 (1990-2012)

Year	Natural gas consumption (m^3)	Carbon content of gas
	Feedstock	(kg C/m^3)
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
2012	263,268,440	0.5214

Composition of natural gas is the reason for low CO_2 IEF since natural gas is the main feedstock for ammonia production in Croatia.

The resulting emissions of CO_2 from Ammonia Production in the period 1990-2012 are presented in the Figure 4.3-1.

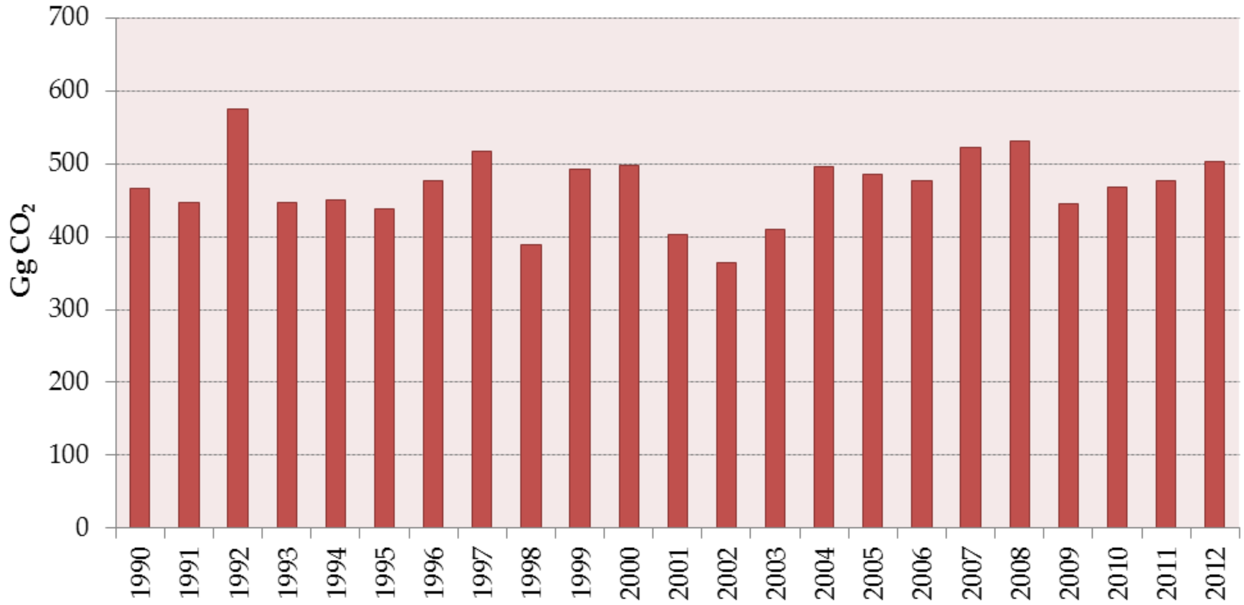


Figure 4.3-1: Emissions of CO_2 from Ammonia Production (1990-2012)

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 CO_2 as a feedstock in downstream manufacturing processes, in the production of urea, dry ice and fertilizer. According to *Revised 1996 IPCC Guidelines,* no account should consequently be taken for intermediate binding of CO_2 in production of urea, dry ice and fertilizer.

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data amounts to 3 percent, based on information provided by manufacturer. Uncertainty estimate associated with emission factors amounts to 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 CO_2 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

There are no recalculations in this subsector.

4.3.1.6.Source–specific planned improvements

Since Ammonia Production is a key source category, more detailed information about use of CO_2 as a feedstock in downstream manufacturing processes are planned to be investigated for future reports (long-term goal).

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 N_2O from nitric acid production have been calculated by multiplying annual nitric acid production by plant-specific EFs. In previous reports, the EF of 7.8 kg N_2O/tonne nitric acid was applied to the total amount of nitric acid produced. Since the production of nitric acid is being performed in two separate production units and data on production in each unit as well as data on plant-specific EF for each unit[8] (7.5 kg N_2O/tonne nitric acid for UNIT 1 and 7.8 kg N_2O/tonne nitric acid for UNIT 2) have been obtained from the manufacturer (Fertilizer Company), emission recalculations were made in this report.

[8] Determined on the basis of measurements done in previous years

Data on nitric acid production (see Table 4.3-3), collected by survey of manufacturer were 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 (1990-2012)

Year	Nitric acid production UNIT 1 (tonnes)	Nitric acid production UNIT 2 (tonnes)	Nitric acid production TOTAL (tonnes)
1990	206,962	125,497	332,459
1991	178,267	113,730	291,997
1992	248,601	133,196	381,797
1993	187,465	100,339	287,805
1994	192,133	119,103	311,236
1995	199,251	100,046	299,297
1996	179,387	99,296	278,683
1997	175,990	116,902	292,892
1998	132,760	87,749	220,509
1999	163,204	96,994	260,198
2000	199,027	107,174	306,201
2001	181,263	76,271	257,534
2002	160,789	89,203	249,992
2003	132,470	103,176	235,646
2004	189,608	97,959	287,567
2005	176,988	103,758	280,746
2006	177,916	99,673	277,590
2007	204,984	101,635	306,619
2008	196,676	116,252	312,928
2009	163,042	98,436	261,478
2010	199,650	137,145	336,794
2011	217,288	115,425	332,713
2012	196,200	92,007	288,207

The resulting emissions of N_2O from Nitric Acid Production in the period 1990-2012 are presented in the Figure 4.3-2.

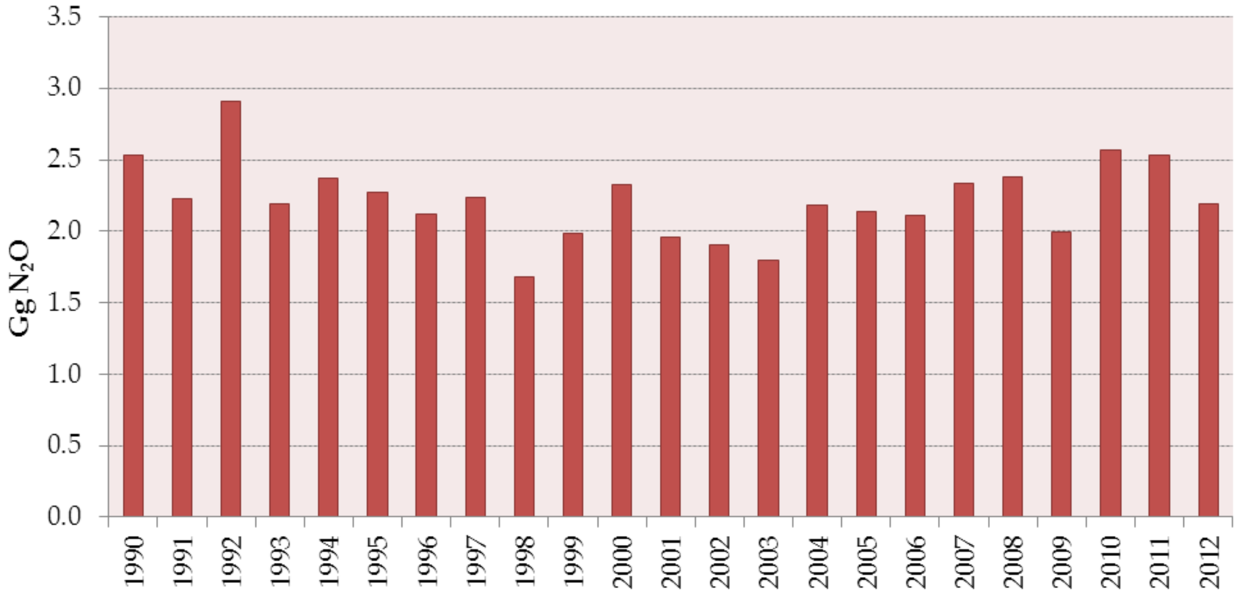


Figure 4.3-2: Emissions of N_2O from Nitric Acid Production (1990-2012)

4.3.2.3.Uncertainties and time-series consistency

The main uncertainties concerning the emissions of N_2O from nitric acid production are due to applied emission factor. This plant-specific EF does not completely outline the real value, because Fertilizer Company does not continuously measure N_2O emissions. In the future, this company will perform continuously measurement of N_2O emissions.

Activity data and emission factor uncertainty was calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with activity data amounts to 3 percent, based on information provided by manufacturer. Uncertainty estimate associated with emission factors amounts to 30 percent, based on expert judgements and information provided by manufacturer (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 N_2O 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

New data on nitric acid production and plant-specific emission factors have been provided by the manufacturer. Therefore, emission recalculations have been performed for the entire reporting period.

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 N_2O emissions.

More information for EFs 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, dichlorethylene, styrene) can be sources of CH_4 emissions. Although most CH_4 sources from industrial processes individually are small, collectively they may be significant.

4.3.3.2.Methodological issues

Emissions of CH_4 from the production of other chemicals have been calculated by multiplying an annual production of each chemical with related emission factor provided by *Revised 1996 IPCC Guidelines*. The annual production of chemicals (see Table 4.3-4) was extracted from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Emissions of CH_4 from Production of Other Chemicals in the period 1990-2012 are reported in Table 4.3-5.

Table 4.3-3: Production of Other chemicals (1990-2012)

Year	Carbon black (tonnes)	Ethylene (tonnes)	Dichloroethylene (tonnes)	Styrene (tonnes)	Methanol (tonnes)	Coke (tonnes)
1990	30,624	72,631	72,653	8,923	0	556,084
1991	18,783	66,871	68,325	0	0	441,584
1992	13,479	68,318	92,089	0	0	409,371
1993	17,123	68,634	79,608	0	0	420,676
1994	21,468	65,285	97,528	0	0	276,854
1995	27,185	67,547	84,374	0	0	0
1996	26,735	64,782	48,630	0	0	0
1997	24,214	63,554	26,264	0	0	0
1998	24,087	60,148	31,308	0	0	0
1999	20,627	60,295	47,686	0	0	0
2000	20,029	38,918	71,364	0	0	0
2001	21,180	46,632	64,442	0	0	0
2002	19,416	43,554	0	0	0	0
2003	21,295	41,252	0	0	4	0
2004	20,272	49,886	0	0	4	0
2005	18,498	50,263	0	0	3	0
2006	26,264	48,824	0	0	3	0
2007	23,724	45,438	0	0	2	0
2008	16,904	43,045	0	0	2	0
2009	3,976	38,797	0	0	1	0
2010	0	36,271	0	0	1	0
2011	0	23,323	0	0	2	0
2012	0	0	0	0	3	41,932

Table 4.3-4: Emissions of CH_4 from Production of Other Chemicals (1990-2012)

Year	Emissions of CH_4 from production of other chemicals (Gg)					
	Carbon black	Ethylene	Dichloro-ethylene	Styrene	Methanol	Coke
1990	0.34	0.07	0.03	0.04	0.00	0.28
1991	0.21	0.07	0.03	0.03	0.00	0.22
1992	0.15	0.07	0.04	0.01	0.00	0.20
1993	0.19	0.07	0.03	0.00	0.00	0.21
1994	0.24	0.07	0.04	0.00	0.00	0.14
1995	0.30	0.07	0.03	0.00	0.00	0.00
1996	0.29	0.06	0.02	0.00	0.00	0.00
1997	0.27	0.06	0.01	0.00	0.00	0.00
1998	0.26	0.06	0.01	0.00	0.00	0.00
1999	0.23	0.06	0.02	0.00	0.00	0.00
2000	0.22	0.04	0.03	0.00	0.00	0.00
2001	0.23	0.05	0.03	0.00	0.00	0.00
2002	0.21	0.04	0.00	0.00	0.00	0.00

Table 4.3-4: Emissions of CH_4 from Production of Other Chemicals (1990-2012), cont.

Year	Emissions of CH_4 from production of other chemicals (Gg)					
	Carbon black	Ethylene	Dichloro-ethylene	Styrene	Methanol	Coke
2003	0.23	0.04	0.00	0.00	0.000007	0.00
2004	0.22	0.05	0.00	0.00	0.000008	0.00
2005	0.20	0.05	0.00	0.00	0.000006	0.00
2006	0.29	0.05	0.00	0.00	0.000006	0.00
2007	0.26	0.05	0.00	0.00	0.000004	0.00
2008	0.19	0.04	0.00	0.00	0.000004	0.00
2009	0.04	0.04	0.00	0.00	0.000002	0.00
2010	0.00	0.04	0.00	0.00	0.000002	0.00
2011	0.00	0.02	0.00	0.00	0.000004	0.00
2012	0.00	0.00	0.00	0.00	0.000006	0.02

The emissions of indirect GHGs from Production of Other Chemicals for the period 1990-2012 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 CH_4 emissions amounts to 7.5 percent (5 to 10 percent), based on expert judgements. Uncertainty estimate associated with default emission factor for CH_4 emissions amounts to 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 prescribes source specific quality control procedures.

4.3.3.5. Source–specific recalculations

There are no recalculations for this subsector.

4.3.3.6.Source–specific planned improvements

Due to a discontinuous trend of currently available activity data regarding coke production, an investigation of the entire reporting period is planned for this activity.

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 CO_2.

4.4.1.2.Methodological issues

Pig Iron Production

Emissions of CO_2 have been calculated by multiplying annual production of pig iron by the emission factor proposed by *Revised 1996 IPCC Guidelines* (1.6 tonnes CO_2/tonne pig iron produced).

The 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 manufacturer[9].

The resulting emission of CO_2 from Pig Iron Production in 1990 amounted to 335,000 tonnes. In 1991 about 111,000 tonnes of CO_2 was emitted. CO_2 emissions are not included in Metal Production to avoid double-counting. These emissions are included in Energy sector because Coke Oven Coke used in blast furnace is given in energy balance.

[9] 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.

Steel Production

There are two steel manufacturers in Croatia. Steel production by one manufacturer was halted in 2009. In 2012, steel production by second manufacturer was considerably reduced.

A method based on annual consumption of carbon donors in EAFs has been used for CO_2 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 2005-2012 CO_2 emissions have been taken for the inventory.

The same methodology has been used for the entire time series. Calculation of CO_2 emissions is accomplished by applying an emission factor in tonnes of CO_2 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 CO_2 emission has been calculated as follows:

CO_2 emission (t CO_2) $= \sum$ (activity $\text{data}_{\text{input}}$ * emission $\text{factor}_{\text{input}}$) - $\sum$ (activity $\text{data}_{\text{output}}$ * emission $\text{factor}_{\text{output}}$)

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).

Table 4.4-1: Consumption of main carbon donors (input materials) in EAFs (1990-2012)

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

Table 4.4-1: Consumption of main carbon donors (input materials) in EAFs (1990-2012), cont.

Year	Scrap iron (tonnes)	Steel scrap (tonnes)	EAF carbon electrodes (tonnes)	EAF charge carbon (tonnes)	Petroleum coke (tonnes)
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
2012	1,233	0	5.26	15.8	0

Table 4.4-2: Consumption of other carbon donors (input materials) and reducing fuels in EAFs (1990-2012)

Year	Lime (tonnes)	Other carbon donors* (tonnes)	Natural gas (m^3)	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
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
2012	47.14	30	40,266	0	0

* other carbon donors include alloys Fe-Cr, Fe-Mn,, Fe-Si, Fe-Si-Mn and antracite

Default emission factors for main carbon donors[10] (Table 4.4-3) and reducing fuels[11] (Table 4.4-4) have been used.

Table 4.4-3: EF for carbon donors (input materials) in EAFs (1990-2012)

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 (1990-2012)

Reducing fuels	EF (t CO_2/TJ)	NCV (TJ/Gg)
Natural gas	56.10	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 (1990-2012)

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

[10] See 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 4.3 - EF expressed in t C/t multiplied with a CO_2/C conversion factor of 3.664

[11] see Annex 8 (oxidation factor OF = 1 is used)

Table 4.4-5: Steel production (1990-2012), cont.

Year	Steel production (tonnes)
2007	76,252
2008	138,865
2009	46,264
2010	103,427
2011	95,907
2012	1,037

The resulting emissions of CO_2 from Steel Production in the period 1990-2012 are presented in the Figure 4.4-1.

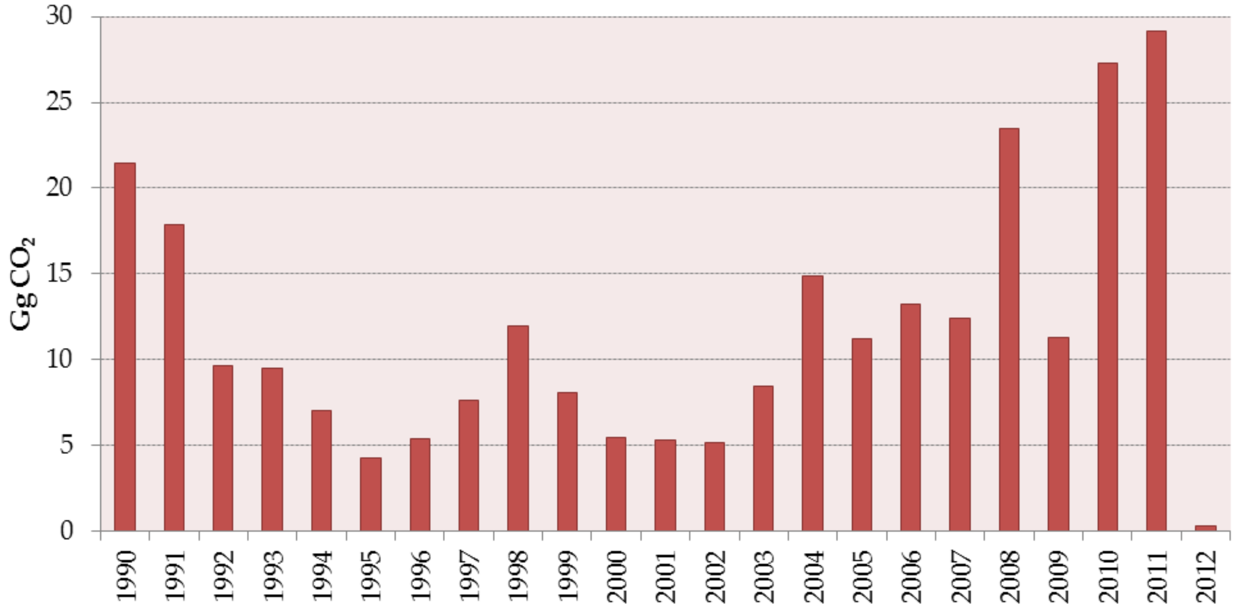


Figure 4.4-1: Emissions of CO_2 from Steel Production (1990-2012)

CO_2 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 to 7.5 percent (5 to 10 percent), based on expert judgements. The main uncertainties concerning the emission of CO_2 from steel production are due to applied emission factor. Uncertainty estimate associated with emission factors amounts to 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 prescribes source specific quality control procedures.

4.4.1.5.Source–specific recalculations

There are no recalculations for this subsector.

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, CO_2 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 CO_2 emissions calculation. Applying a higher tier method enables avoiding of possible double counting of CO_2 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 CO_2 have been calculated by multiplying annual data on reducing agents (see Table 4.4-6) by default emission factor (3.1 tonne CO_2/tonne coke from coal and 3.6 tonne CO_2/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), which has consequently decreased the possibility to recheck activity data.

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
1995	9,529	650
1996	3,860	266
1997	11,867	818
1998	5,166	356
1999	6,054	417
2000	3,624	250
2001	1,195	82
2002	4	0
2003	13	1

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
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 CO_2 from Ferroalloys Production in the period 1990-2003 are presented in the Figure 4.4-2.

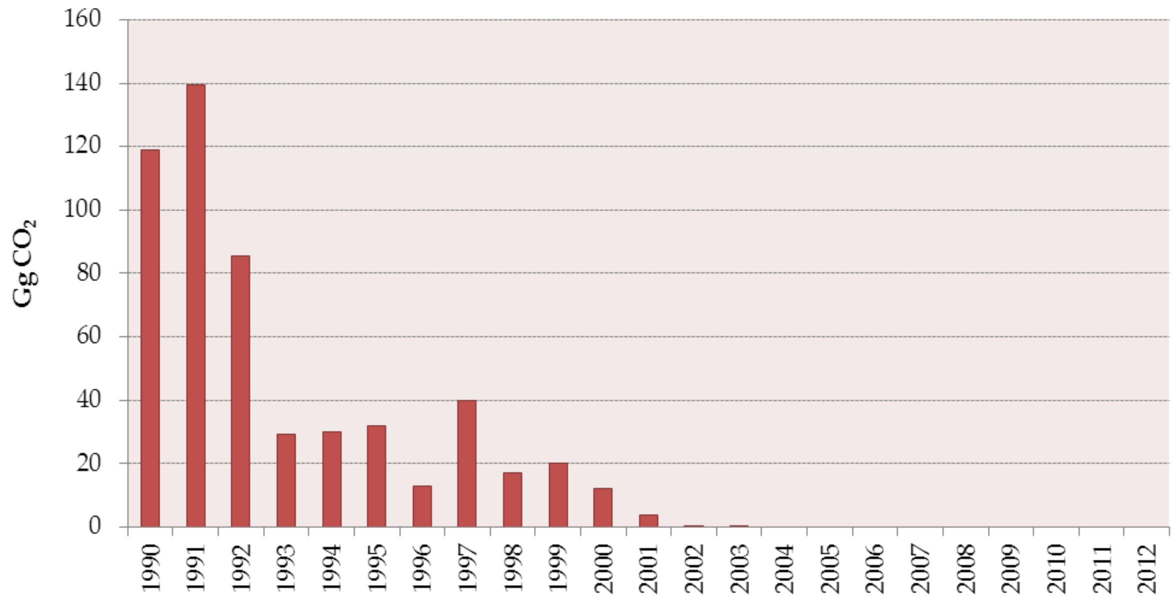


Figure 4.4-2: Emissions of CO_2 from Ferroalloys Production (1990-2003)

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 to 7.5 percent (5 to 10 percent), based on expert judgements. Uncertainty estimate associated with default emission factors amounts to 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 prescribes source specific quality control procedures.

4.4.2.5.Source–specific recalculations

There are no source-specific recalculations in this report.

4.4.2.6.Source-specific planned improvements

Ferroalloys production fluctuated over the period and was halted in 2003, which has consequently decreased the possibility to recheck activity data. According to ERT recommendation, Croatia should provide more details on its plan to increase the transparency and accuracy of its estimates by obtaining AD for ferroalloys production to replace the interpolated dana. This is planned as long-term goal, depending on statistical research.

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 manufacturer[12].

The resulting emission of CO_2 from Aluminium Production in 1990 amounted to about 111 Gg CO_2. In 1991 about 76 Gg CO_2 was emitted.

PFCs emissions from Aluminium Production could represent a significant source of emissions due to high GWP values. Since only aluminium production statistics were available, emissions of CF_4 (PFC-14) and C_2F_6 (PFC-116) were estimated by multiplying annual primary aluminium production with default emission factors provided by *Good Practice Guidance*. Default emission factors equal 1.7 kg/tonne Al for CF_4 and 0.17 kg/tonne Al for C_2F_6

[12] 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.

(Side Worked Prebaked Anodes). 820 Gg CO_2-eq of CF_4 and 116 Gg CO_2-eq of C_2F_6 were emitted in 1990. 563 Gg CO_2-eq of CF_4 and 80 Gg CO_2-eq of C_2F_6 were emitted in 1991.

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

4.4.3.3.Uncertainties and time-series consistency

Uncertainties related to calculation of CO_2 emissions are primarily due to applied emission factor. A less uncertain method to calculate CO_2 emissions would be based upon the amount of reducing agent, i.e. amount of prebaked anodes used in the 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 CO_2 emissions amounts to 3 percent (1 to 5 percent), based on expert judgements. Uncertainty estimate associated with default emission factor for CO_2 emissions amounts to 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 to 30 percent, based on expert judgements. Uncertainty estimate associated with default emission factor for PFCs emissions amounts to 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 prescribes 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 2012* Submission to the Convention on Long-range Transboundary Air Pollution'.

The resulting emissions of indirect GHGs from Pulp and Paper in the period 1990-2012 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 prescribes 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 2012* Submission to the Convention on Long-range Transboundary Air Pollution'.

The resulting emissions of NMVOC from Food and Drink in the period 1990-2012 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 prescribes 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 SF_6 (CRF 2.F.)

Ministry of Environmental and Nature Protection (MENP) is responsible for monitoring of consumption of substitutes and mixtures of substitutes for gases that deplete the ozone layer. According to obligations defined under the Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia (Official Gazette No. 87/12), all sources of HFCs, PFCs and SF_6 emissions should report required activity data. Regulation on controls of ozone-depleting substances and fluorinated greenhouse gases (Official Gazette No. 92/12) prescribes control of import and export of these gases and providing of register to the MENP. There is no production of HFCs PFCs and SF_6 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 relatively short time of use of HFCs PFCs and SF_6 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 referes 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 SF_6 from their use in refrigeration and air conditioning equipment, foam blowing, fire extinguishers, aerosols/metered dose inhalers and electrical equipment.
There are no information available to MENP on the use of halocarbons as solvents. Thus, it has been determined that the use of halocarbons did not occur in this activity during the period 1990-2012. A similar situation exists

in some EU member states that do not use fluorinated greenhouse gases in this sector. There is no legal basis for obtaining these data and any further investigation would cause additional costs for obtaining these presumably negligible quantities of gases.

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

The resulting HFCs, PFCs and SF_6 emissions (Gg CO_2-eq) from Consumption of Halocarbons and SF_6 in the period 1990-2012 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 SF_6 used in Electrical Equipment. Further clarification is given in the subsequent chapters.

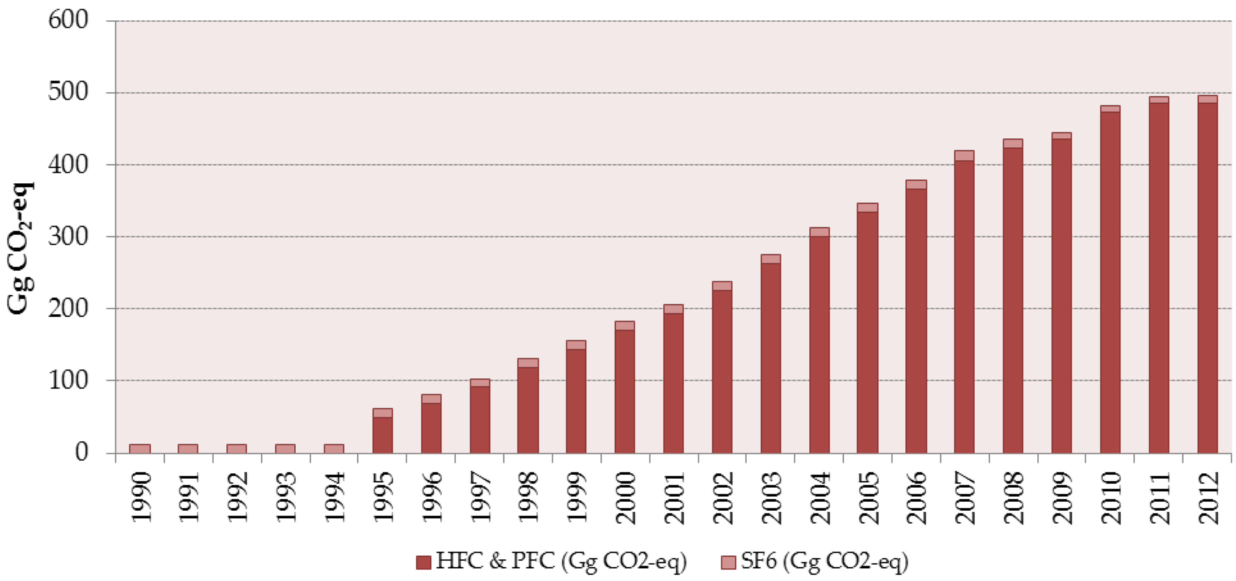


Figure 4.6-1: Emissions of HFCs, PFCs and SF_6 (Gg CO_2-eq) from Consumption of Halocarbons and SF_6 (1990-2012)

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 SF_6.

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.

MENP collects data on installed quantities of fluorinated greenhouse gases in refrigeration and air conditioning equipment. Pursuant to Article 3 paragraph 6 of the Regulation (EC) No. 842/2006 on Certain Fluorinated Greenhouse Gases, it is required to submit data for devices and equipment containing 3 kg or more of fluorinated greenhouse gases. Other data are estimated based on data on gas consumption and CBS data on imports of motor vehicles. Additional research would cause unreasonable costs and thus it is not currently planned.

Currently, there are 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 have been established. If the recovery is not possible, waste gases are exported to be destroyed. However, MENP does not have any information on recovered fluorinated greenhouse gases, as centers for the collection, reuse and recovery currently store minor collected amounts and are unable to recover fluorinated greenhouse gases due to lack of proper equipment and inability for analysis of these substances.

MENP does not have any information on the destroyed quantities of these substances, nor on the quantities of equipment containing fluorinated greenhouse gases that are no longer in use. The reason for this is that the lifespan of the equipment is 20 years and more if it is regularly maintained by a certified professional. The current economic situation in the country also extends the use of the equipment because the end users are not able to acquire new equipment as is the case in developed countries.

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 1995-2012, since there was no use of these substances prior to 1995.

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 2009-2012).

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.

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 1995-2012.

In accordance with Article 6 of the Regulation (EC) No. 842/2006 on Certain Fluorinated Greenhouse Gases, with respect to the information on the consumption of fluorinated greenhouse gases, there is no legal basis for requesting the importer/exporter to supply quantities of less than 1 tonne of HFCs or their mixtures.

Consumption of fluorinated greenhouse gases is related to servicing of the existing installed equipment in the Republic of Croatia and is only for the minor part related to the filling or refilling of new equipment which is being installed becacuse the equipment generally comes to the market already filled with gas.

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 1995-2012 are reported in Table 4.6-1.

Table 4.6-1: Actual emissions of HFCs (t) (1990-2012)

Source/Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003
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	0.33
Commercial Refrigeration									
HFC-125	1.41	2.38	2.90	4.31	4.58	5.28	5.54	6.60	7.13
HFC-134a	0.13	0.22	0.26	0.39	0.42	0.48	0.50	0.60	0.65
HFC-143a	1.66	2.81	3.43	5.10	5.41	6.24	6.55	7.80	8.42
Transport Refrigeration									
HFC-134a	24.38	26.33	29.90	32.50	39.00	44.85	55.58	66.95	80.93
Industrial Refrigeration									
HFC-125	0.56	0.68	0.92	1.24	1.52	2.00	2.32	2.48	2.60
HFC-134a	0.33	0.42	0.58	0.92	1.00	1.16	1.66	1.83	1.91
HFC-32	0.55	0.66	0.90	1.20	1.48	1.96	2.26	2.41	2.53
HFC-143a	NO	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	2.80
HFC-134a	0.29	0.44	0.81	0.99	1.22	1.51	1.82	1.90	2.18
HFC-32	0.30	0.50	0.96	1.24	1.67	2.02	2.33	2.49	2.72
Mobile Air-Conditioning									
HFC-134a	2.40	8.40	16.80	25.05	33.60	42.60	45.30	51.15	54.90

Table 4.6-1: Actual emissions of HFCs (t) (1990-2012), cont.

Source/Gas	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.F.1. Refrigeration and Air Conditioning Equipment									
Domestic Refrigeration									
HFC-134a	0.42	0.45	0.41	0.32	0.30	0.29	0.29	0.29	0.28
Commercial Refrigeration									
HFC-125	8.18	8.80	9.33	10.38	10.56	10.65	11.62	13.73	14.08
HFC-134a	0.74	0.80	0.85	0.94	0.96	0.97	1.06	1.25	1.28
HFC-143a	9.67	10.40	11.02	12.27	12.48	12.58	13.73	16.22	16.64
Transport Refrigeration									
HFC-134a	93.93	105.30	113.75	124.80	133.25	134.88	144.30	145.92	146.58
Industrial Refrigeration									
HFC-125	3.08	3.69	3.96	4.14	4.27	4.56	4.92	5.16	5.28
HFC-134a	2.25	2.66	2.83	2.83	2.91	3.00	3.41	3.58	3.66
HFC-32	2.99	3.58	3.81	3.97	4.09	4.36	4.71	4.94	5.06
HFC-143a	NO	0.01	0.04	0.06	0.07	0.08	0.08	0.08	0.08
Stationary Air-Conditioning									
HFC-125	3.23	3.60	3.94	4.20	4.31	4.34	4.45	4.52	4.60
HFC-134a	2.39	2.55	2.73	2.86	2.99	2.99	3.12	3.17	3.22
HFC-32	3.13	3.50	3.83	4.09	4.20	4.22	4.33	4.40	4.48
Mobile Air-Conditioning									
HFC-134a	61.50	68.40	80.85	89.25	97.20	97.50	107.40	107.70	108.00

In Croatia there are huge amount of stationary air conditioning equipment which use HCFC 22 because it is allowed to use this refrigerant by end of 2014 and after that owner can use equipment without servicing if it is work properly. During preparation of HPMP project (Phase-out of HCFC in Croatia) data about all refrigeration equipment using HCFC was collected. Because of that, quantities of installed HFC are not so huge. In many hotels, industry and commercial refrigeration HCFC 22 based equipment is still in use.
Also, according to actual economic situation, import and placing of transport refrigeration was decreased on the Croatian market.

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 1990-2012 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 CO_2-eq) (1990-2012)

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**	**104.42**
1998	NO	NO	1.59	4.27	19.12	48.47	78.01	26.83	19.36	47.42	**118.07**	**126.99**
1999	NO	NO	2.05	4.12	21.86	51.46	98.04	28.91	20.55	53.35	**142.50**	**137.85**
2000	NO	NO	2.58	5.22	26.19	60.06	118.0	33.70	23.71	59.28	**170.56**	**158.26**
2001	NO	NO	2.98	4.24	28.74	57.09	136.6	40.25	24.90	61.26	**193.24**	**162.84**
2002	NO	NO	3.18	5.54	32.60	63.92	159.5	44.20	29.64	63.23	**224.93**	**176.90**
2003	NO	NO	3.41	7.27	35.08	80.25	183.1	51.84	32.01	77.06	**253.66**	**216.42**
2004	NO	NO	3.98	8.37	40.57	92.54	209.7	60.68	36.75	88.92	**291.02**	**250.51**
2005	NO	NO	4.60	5.74	45.04	117.01	234.0	110.24	39.52	145.54	**323.16**	**378.53**
2006	NO	NO	4.97	7.34	48.22	125.69	261.9	101.30	41.89	148.43	**357.00**	**382.76**
2007	NO	NO	5.24	9.04	52.42	140.73	287.3	106.39	46.63	160.51	**391.63**	**416.66**
2008	NO	NO	5.39	14.83	53.60	183.10	308.6	131.82	47.42	187.46	**415.06**	**517.22**
2009	NO	NO	5.58	13.23	54.73	183.51	311.5	134.00	47.82	198.48	**419.64**	**529.43**
2010	0.77	0.77	5.88	7.65	58.76	155.93	337.4	121.86	52.17	191.75	**455.01**	**477.99**
2011	0.42	0.42	6.07	11.92	65.56	193.36	340.4	155.01	61.96	225.28	**474.49**	**586.00**
2012	0.00	0.00	6.20	14.49	67.09	219.24	341.9	175.41	63.54	248.14	**478.75**	**657.30**

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.

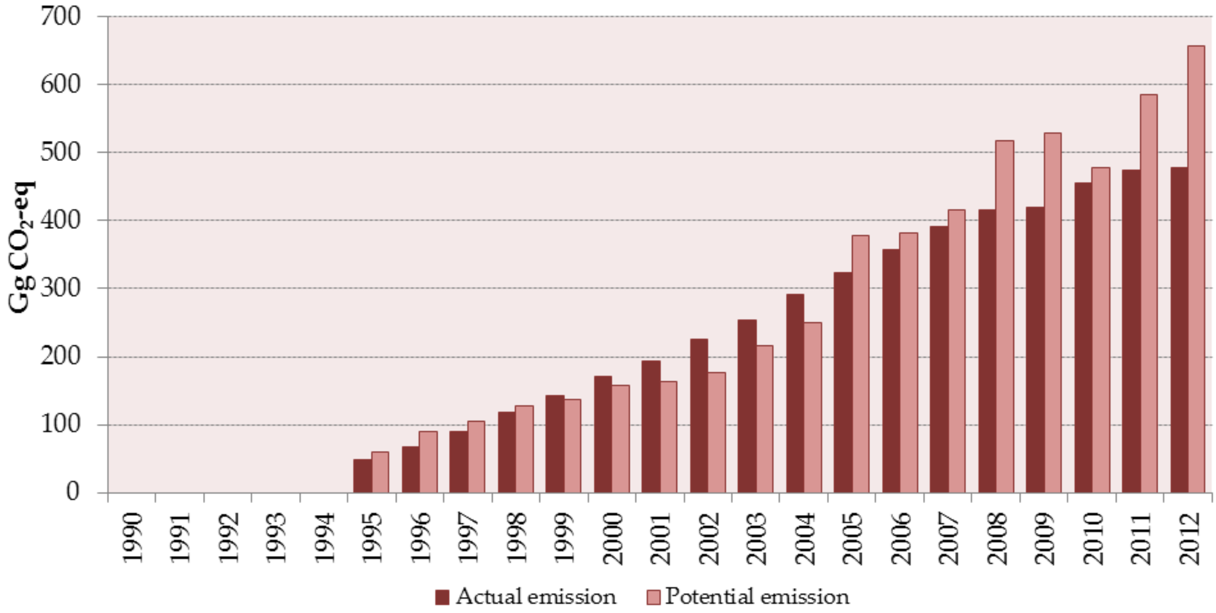


Figure 4.6-2: Actual and potential emission of HFCs in Refrigeration and Air Conditioning Equipment (Gg CO_2-eq) (1990-2012)

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 to 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

New data for the year 2011 were provided for HFC-134a used in Transport Refrigeration, HFC-410a and HFC-407c used in Industrial Refrigeration, HFC-410a and HFC-407c used in Stationary Air-Conditioning and HFC-134a used in Mobile Air-Conditioning. Recalculations were made respectively.

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 SF_6 and Customs Departments Tariff Number to distinguish these compounds from other fluorinated chemicals which are controlled with Montreal Protocol.
More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.

4.6.2. OTHER CONSUMPTION OF HFCs, PFCs AND SF_6

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 SF_6 in electrical equipment. All data on HFCs, PFCs and SF_6 have been compiled by the MENP.
According to the available data, the use of HFCs and SF_6 in the aforementioned activities was present in Croatia as follows:

- in Fire Extinguishers
  - HFC-227ea (1995-2012)
  - HFC-125 (2003-2012)
  - HFC-236fa (2006-2011)
- in Foam Blowing
  - HFC-152a (2006-2010)
- in Aerosols/Metered Dose Inhalers
  - HFC-134a[13] (2003-2012)
- in Electrical Equipment
  - SF_6 (1990-2012)

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.

MENP collects data on installed quantities of fluorinated greenhouse gases in Fire Extinguishers. Pursuant to Article 3 paragraph 6 of the Regulation (EC) No. 842/2006 on Certain Fluorinated Greenhouse Gases, it is required to submit data for devices and equipment containing 3 kg or more of fluorinated greenhouse gases. Other data are estimated based on data on gas consumption. Additional research would cause unreasonable costs and thus it is not currently planned.

All available data regarding Foam Blowing activities were provided by MENP. There is no legal basis for obtaining these data and any further investigation would cause additional costs. Since the quantities of gases used in these activities are in fact negligible, additional investigation is not planned. The same applies to data on Aerosols. Only data on the use of fluorinated greenhouse gases for medical inhalers (MDI) are available to MENP and additional investigation on this activity is not planned.

Information on recovered fluorinated greenhouse gases is not available to MENP, as centers for the collection, reuse and recovery currently store minor collected amounts and are unable to recover fluorinated greenhouse gases due to lack of proper equipment and inability for analysis of these substances. Furthermore, MENP does not have any information on the destroyed quantities of these substances, nor on the quantities of equipment containing fluorinated greenhouse gases that are no longer in use.

Potential emissions (Tier 1a method, *Revised 1996 IPCC Guidelines*) from Foam Blowing and Fire Extinguishers have been calculated for the period 2006-2010 (according to available data; for 2011 and 2012 emissions from Foam Blowing equal 0). Insufficient data on HFC-152a used in Foam Blowig 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 2003-2012.

[13] Fluticasone propionate, salmeterol/fluticason propionate, salmeterol and salbutamol

Actual emissions of HFCs used in Fire Extinguishers and Aerosols/Metered Dose Inhalers in the period 1995-2012 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 (t) (1990-2012)

Source/Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003
2.F.2 Foam Blowing									
HFC-152a	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F.3 Fire Extinguishers									
HFC-227ea	0.04	0.04	0.04	0.04	0.04	0.04	0.06	0.06	0.06
HFC-125	NO	NO	NO	NO	NO	NO	NO	NO	0.01
HFC-236fa	NO	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	7.05

Table 4.6-3: Actual emissions of HFCs used Fire Extinguishers and Aerosols/Metered Dose Inhalers, by gas (t) (1990-2012), cont.

Source/Gas	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.F.2 Foam Blowing									
HFC-152a	NO	NO	0.0004	0.0004	0.0004	45.78	36.09	NO	NO
2.F.3 Fire Extinguishers									
HFC-227ea	0.06	0.07	0.15	0.32	0.07	0.48	0.56	0.68	0.91
HFC-125	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.06	0.06
HFC-236fa	NO	NO	0.04	0.08	0.12	NO	NO	0.05	NO
2.F.4 Aerosols/Metered Dose Inhalers									
HFC-134a	6.84	7.74	5.85	9.73	5.51	6.07	7.80	6.13	3.13

Certain amount of SF_6 is contained in electrical equipment used in Croatian National Electricity (HEP) and KONČAR Electrical Industries Inc. Total quantity of SF_6 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 SF_6 have been calculated using data on total charge of SF_6 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 SF_6 contained in the gas insulated switchgear and circuit-breakers and leakage/maintenance losses of the total charge, as well as losses during SF_6 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-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 - member of HEP Group);
- HOPS/former HEP OPS (Croatian Transmission System Operator);
- Končar Group (High Voltage Apparatus and Switchgear and Medium Voltage Apparatus and Switchgear)

Potential emissions of SF_6 used in electronic equipment have been calculated only for the period 2006-2012, because data for potential emission calculation for the previous period are not available. Data on the amount of consumed gas for the period 2006-2012 have been compiled by the MENP. It is important to point out that activity data regarding SF_6 emissions are being currently revised. Several workshops on this topic involving competent bodies were held since the last submission of the Croatia's Inventory. All data are being processed and necessary adjustments will be included in the next submission.

Actual emissions of SF_6 expressed in Gg CO_2-eq for the period 1990-2012 are presented in the Table 4.6-5.

Table 4.6-4: Emissions of SF_6 (Gg CO_2-eq) (1990-2012)

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
2012	9.60

4.6.2.3.Uncertainties and time-series consistency

The main uncertainties of HFCs and SF_6 emissions calculation are 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 SF_6 amounts to 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 SF_6 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

New data were provided for gases HFC-236fa for 2008, HFC-227ea and HFC-125 for 2011, all used in Fire Extinguishers. Recalculations were made respectively.

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 SF_6 and Customs Departments Tariff Number to distinguish these compounds from other fluorinated chemicals which are controlled with Montreal Protocol.

Activity data regarding SF_6 emissions are being currently revised. Any potential changes in data will be included in the next submission.

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 (naphta, 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, CO_2 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 1990-2012 are presented in Table 4.8-1.

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2012)

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg CO_2-eq)	Percent in Industrial Processes
Cement production	1990	CO_2	1,085.79	1	1,085.79	28.65
	1991		702.56		702.56	24.03
	1992		826.23		826.23	32.36
	1993		687.13		687.13	34.22
	1994		841.87		841.87	37.62
	1995		628.67		628.67	31.00
	1996		684.69		684.69	32.57
	1997		792.26		792.26	33.89
	1998		852.93		852.93	40.30
	1999		1,115.06		1,115.06	42.94
	2000		1,243.59		1,243.59	43.36
	2001		1,423.55		1,423.55	49.23
	2002		1,392.12		1,392.12	48.76
	2003		1,383.62		1,383.62	47.88
	2004		1,470.38		1,470.38	45.15
	2005		1,499.86		1,499.86	45.27
	2006		1,588.04		1,588.04	45.72
	2007		1,611.88		1,611.88	44.14
	2008		1,526.87		1,526.87	42.30
	2009		1,224.17		1,224.17	40.86
	2010		1,198.26		1,198.26	37.16
	2011		1,050.36		1,050.36	34.72
	2012		998.87		998.87	34.82
Lime production	1990	CO_2	153.44	1	153.44	4.05
	1991		121.74		121.74	4.16
	1992		81.41		81.41	3.19
	1993		88.50		88.50	4.41
	1994		93.10		93.10	4.16
	1995		93.25		93.25	4.60
	1996		123.59		123.59	5.88
	1997		133.59		133.59	5.71
	1998		142.68		142.68	6.74
	1999		139.90		139.90	5.39
	2000		146.21		146.21	5.10
	2001		182.61		182.61	6.31
	2002		205.97		205.97	7.21

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2012), cont.

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg CO_2-eq)	Percent in Industrial Processes
Lime production	2003	CO_2	191.24	1	191.24	6.62
	2004		210.93		210.93	6.48
	2005		229.58		229.58	6.93
	2006		275.77		275.77	7.94
	2007		287.25		287.25	7.87
	2008		278.32		278.32	7.71
	2009		184.66		184.66	6.16
	2010		173.17		173.17	5.37
	2011		101.91		101.91	3.37
	2012		114.16		114.16	3.98
Limestone and dolomite use	1990	CO_2	51.71	1	51.71	1.36
	1991		32.93		32.93	1.13
	1992		14.84		14.84	0.58
	1993		14.32		14.32	0.71
	1994		22.04		22.04	0.99
	1995		17.86		17.86	0.88
	1996		18.19		18.19	0.87
	1997		12.44		12.44	0.53
	1998		15.80		15.80	0.75
	1999		14.58		14.58	0.56
	2000		16.82		16.82	0.59
	2001		19.73		19.73	0.68
	2002		21.53		21.53	0.75
	2003		25.22		25.22	0.87
	2004		27.36		27.36	0.84
	2005		33.32		33.32	1.01
	2006		32.20		32.20	0.93
	2007		30.04		30.04	0.82
	2008		32.50		32.50	0.90
	2009		31.51		31.51	1.05
	2010		36.87		36.87	1.14
	2011		44.46		44.46	1.47
	2012		37.82		37.82	1.32
Soda ash production and use	1990	CO_2	14.47	1	14.47	0.38
	1991		15.36		15.36	0.53
	1992		16.51		16.51	0.65
	1993		15.13		15.13	0.75
	1994		19.78		19.78	0.88
	1995		20.41		20.41	1.01
	1996		18.33		18.33	0.87
	1997		16.14		16.14	0.69
	1998		16.37		16.37	0.77
	1999		15.76		15.76	0.61

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2012), cont.

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg CO_2-eq)	Percent in Industrial Processes
Soda ash production and use	2000	CO_2	16.84	1	16.84	0.59
	2001		18.21		18.21	0.63
	2002		18.89		18.89	0.66
	2003		20.29		20.29	0.70
	2004		23.01		23.01	0.71
	2005		23.18		23.18	0.70
	2006		21.86		21.86	0.63
	2007		20.41		20.41	0.56
	2008		20.11		20.11	0.56
	2009		20.20		20.20	0.67
	2010		23.74		23.74	0.74
	2011		23.31		23.31	0.77
	2012		21.81		21.81	0.76
Ammonia production	1990	CO_2	466.01	1	466.01	12.29
	1991		447.00		447.00	15.29
	1992		575.22		575.22	22.53
	1993		446.83		446.83	22.25
	1994		450.03		450.03	20.11
	1995		438.77		438.77	21.63
	1996		476.59		476.59	22.67
	1997		517.83		517.83	22.15
	1998		388.43		388.43	18.35
	1999		492.14		492.14	18.95
	2000		497.96		497.96	17.36
	2001		403.70		403.70	13.96
	2002		363.78		363.78	12.74
	2003		409.38		409.38	14.17
	2004		495.43		495.43	15.21
	2005		484.65		484.65	14.63
	2006		477.34		477.34	13.95
	2007		521.51		521.51	14.28
	2008		530.39		530.39	14.69
	2009		445.63		445.63	14.87
	2010		468.22		468.22	14.52
	2011		475.94		475.94	15.73
	2012		503.32		503.32	17.54
Nitric acid production	1990	N_2O	2.53	310	784.64	21.21
	1991		2.22		689.47	24.15
	1992		2.90		900.06	36.16
	1993		2.19		678.48	34.66
	1994		2.37		734.70	33.63
	1995		2.27		705.17	35.68
	1996		2.12		657.17	32.06

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2012), cont.

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg CO_2-eq)	Percent in Industrial Processes
Nitric acid production	1997	N_2O	2.23	310	691.85	30.29
	1998		1.68		520.84	25.19
	1999		1.98		613.98	24.23
	2000		2.33		721.89	25.81
	2001		1.95		605.86	21.53
	2002		1.90		589.53	21.17
	2003		1.80		557.47	19.72
	2004		2.19		677.70	21.35
	2005		2.14		662.38	20.49
	2006		2.11		654.67	19.33
	2007		2.33		722.34	20.30
	2008		2.38		738.37	20.96
	2009		1.99		617.09	21.10
	2010		2.57		795.80	25.25
	2011		2.53		784.29	26.59
	2012		2.19		678.64	24.29
Production of other chemicals	1990	CH_4	0.75	21	15.80	0.42
	1991		0.52		10.95	0.37
	1992		0.46		9.62	0.38
	1993		0.50		10.48	0.52
	1994		0.48		10.06	0.45
	1995		0.40		8.41	0.41
	1996		0.38		7.94	0.38
	1997		0.34		7.15	0.31
	1998		0.34		7.09	0.33
	1999		0.31		6.43	0.25
	2000		0.29		6.04	0.21
	2001		0.31		6.41	0.22
	2002		0.26		5.40	0.19
	2003		0.28		5.79	0.20
	2004		0.27		5.73	0.18
	2005		0.25		5.33	0.16
	2006		0.34		7.09	0.20
	2007		0.31		6.43	0.20
	2008		0.23		4.81	0.15
	2009		0.08		1.73	0.08
	2010		0.04		0.76	0.05
	2011		0.02		0.49	0.03
	2012		0.02		0.44	0.02
Steel production	1990	CO_2	21.45	1	21.45	0.57
	1991		17.86		17.86	0.61
	1992		9.65		9.65	0.38
	1993		9.46		9.46	0.47

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2012), cont.

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg CO_2-eq)	Percent in Industrial Processes
Steel production	1994	CO_2	7.06	1	7.06	0.32
	1995		4.24		4.24	0.21
	1996		5.36		5.36	0.25
	1997		7.64		7.64	0.33
	1998		11.96		11.96	0.57
	1999		8.06		8.06	0.31
	2000		5.43		5.43	0.19
	2001		5.27		5.27	0.18
	2002		5.14		5.14	0.18
	2003		8.47		8.47	0.29
	2004		14.89		14.89	0.46
	2005		11.24		11.24	0.34
	2006		13.25		13.25	0.38
	2007		12.42		12.42	0.34
	2008		23.51		23.51	0.65
	2009		11.30		11.30	0.38
	2010		27.27		27.27	0.85
	2011		29.18		29.18	0.96
	2012		0.32		0.32	0.01
Ferroalloys production	1990	CO_2	118.84	1	118.84	3.14
	1991		139.26		139.26	4.76
	1992		85.34		85.34	3.34
	1993		29.29		29.29	1.46
	1994		30.11		30.11	1.35
	1995		31.88		31.88	1.57
	1996		12.92		12.92	0.61
	1997		36.79		36.79	1.70
	1998		16.01		16.01	0.82
	1999		18.77		18.77	0.78
	2000		11.24		11.24	0.42
	2001		3.70		3.70	0.14
	2002		0.01		0.01	0.0005
	2003		0.04		0.04	0.002
	2004-2012		-		-	-
Aluminium production	1990	CO_2	111.37	1	111.37	2.93
	1991		76.40		76.40	2.61
	1992-2012		-		-	-
	1990	CF_4	0.13	6500	820.44	21.58
	1991		0.09		562.79	19.26
	1992-2012		-		-	-

Table 4.8-1: Emissions of GHGs from Industrial Processes (1990-2012), cont.

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg CO_2-eq)	Percent in Industrial Processes
Aluminium production	1990	C_2F_6	0.013	9200	116.12	3.05
	1991		0.009		79.66	2.73
	1992-2012		-		-	-
Consumption of HFCs, PFCs and SF_6	1990	HFC PFC SF_6	[2]	[2]	10.95	0.29
	1991				10.83	0.37
	1992				10.92	0.43
	1993				11.04	0.55
	1994				11.16	0.50
	1995				61.02	3.01
	1996				80.45	3.83
	1997				102.85	4.40
	1998				130.76	6.18
	1999				155.19	5.98
	2000				182.86	6.38
	2001				205.67	7.11
	2002				237.70	8.33
	2003				275.90	9.55
	2004				313.28	9.62
	2005				347.10	10.48
	2006				378.95	10.91
	2007				419.41	11.49
	2008				435.76	12.07
	2009				443.97	14.82
	2010				481.29	14.93
	2011				494.74	16.35
	2012				495.24	17.26

[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); SF_6 (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 (SO_2) (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 2012* 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 1990-2012 are reported in table 4.8-3.

Table 4.8-3: Emissions of indirect GHGs from Industrial Processes (1990-2012)

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

Table 4.8-3: Emissions of indirect GHGs from Industrial Processes (1990-2012), cont.

Year	SO_2 (Gg)	NO_x (Gg)	CO (Gg)	NMVOC (Gg)
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	8.83	19.79	8.74
2006	1.90	9.49	41.81	8.35
2007	2.06	10.05	37.99	6.26
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
2012	1.00	3.47	3.14	5.20

4.9. REFERENCES

Central Bureau of Statistics, Department of Manufacturing and Mining, *Annual PRODCOM results (1990 – 2012)*, Zagreb

Central Bureau of Statistics, *Statistical Yearbooks (1990-2012)*, Zagreb

CROATIA CEMENT g.i.u (2007) *Report: Activity data for CO_2 emission calculations from Portland cement production*, in the framework of study Croatian Cement Industry and Climate Change, EKONERG Ltd., Zagreb

Croatian Environment Agency (2014) Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2012* Submission to the Convention on Long-range Transboundary Air Pollution, EKONERG Ltd., Zagreb

FCCC/ARR/2013/HRV *Report of the individual review of the annual submission of Croatia submitted in 2013, 21 March 2014*

IPCC (2000) *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, Japan

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

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

ISTRA CEMENT Ltd. (2008) *Report: Activity data for CO_2 emission calculations from Portland and Aluminate cement production*, in the framework of survey Programme of Reduction of CO_2 Emission in Istra Cement Ltd., EKONERG Ltd., Zagreb

Ministry of Environmental and Nature Protection (2013) *National Inventory Report 2013, Croatian greenhouse gas inventory for the period 1990 – 2011*, EKONERG, Zagreb

Ministry of Environmental and Nature Protection (2010) *Fifth National Communication of the Republic of Croatia under the United Nations Framework Convention on Climate Change (UNFCCC)*, Zagreb

PROMINS g.i.u (2008) *Report: Activity data for CO_2 emission calculations from lime production*, in the framework of study Croatian Lime Industry and Climate Change, EKONERG Ltd., Zagreb

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 CO_2 emissions are generated as a consequence of this oxidation.

N_2O emissions are caused by medical uses of N_2O (for anaesthesia) and other possible sources emissions (aerosol cans).

NMVOC, CO_2 and N_2O emissions are included in emissions estimates in this sector.

In Solvent and Other Product Use, one source category represent key source category regardless of LULUCF (detailed in Table 5.1-1):

Table 5.1-1: Key categories in Solvent and Other Product Use sector based on the level and trend assessment in 2012[14]

IPCC Source Categories	Direct GHG	Criteria for Identification			
		Level		Trend	
		excl. LULUCF	incl. LULUCF	excl. LULUCF	incl. LULUCF
SOLVENT AND OTHER PRODUCT USE					
CO_2 Emissions from Solvent and Other Product Use	CO_2				T2i

T2i - Trend including LULUCF Tier 2

5.1.2. METHODOLOGICAL ISSUES

<u>NMVOC emissions</u>

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*

[14] Data on key categories are taken from Annex 1 Key categories (Tier 1 and Tier 2)

Inventory Report for LRTAP Convention for the Year 2012 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 5.1-2.

Table 5.1-2: Activity data for NMVOC emissions from Solvent and Other Product Use (1990-2012)

Source and Sink Categories	Activity Data, t (1000 capita*)								EF, kg/t (cap)
	1990	1995	2000	2005	2009	2010	2011	2012	1990-2012
Paint application									
Decorative coating application	7,318	3,694	5,036	5,464	5,062	5,465	5,539	4,754	150
Industrial coating application	7,318	3,694	5,036	5,464	5,062	5,465	5,539	4,754	400
Other coating application	7,318	3,694	5,036	5,464	5,062	5,465	5,539	4,754	200
Degreasing, dry cleaning and electronics									
Metal degreasing *	4,778	4,669	4,381	4,312	4,303	4,290	4,281	4,268	0.85
Dry cleaning *	4,778	4,669	4,381	4,312	4,303	4,290	4,281	4,268	0.25
Chemical products manufacturing or processing									
Polyester	6,047	2,225	12,848	10,886	13,989	7,268	7,070	7,660	50
Polyvinylchloride	30,718	5,346	1,462	9,396	6,815	4,670	3,832	3,768	40
Polyurethane	3,763	2,909	1,860	2,919	1,026	780	615	563	15
Polystyrene	7,844	6,449	3,654	1,684	11,053	10,130	581	0	60
Rubber	5,739	2,285	21	4	0	0	0	0	15
Pharmaceutical products manufac.*	4,778	4,669	4,381	4,312	4,303	4,290	4,281	4,268	0.014
Paints manufacturing	21,956	10,773	15,107	16,393	15,186	16,394	16,618	14,263	15
Inks manufacturing	4,713	1,417	924	669	616	345	421	261	30
Glues manufacturing	5,139	10,076	10,355	56,573	33,821	35,507	28,722	28,801	20
Other use of solvents and related activities									
Printing industry	4,672	1,367	916	665	612	341	417	258	800
Application of glues and adhesives	5,139	10,076	10,355	56,573	33,849	35,507	28,722	28,801	600
Domestic solvent use*	4,778	4,669	4,381	4,312	4,303	4,290	4,281	4,268	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.

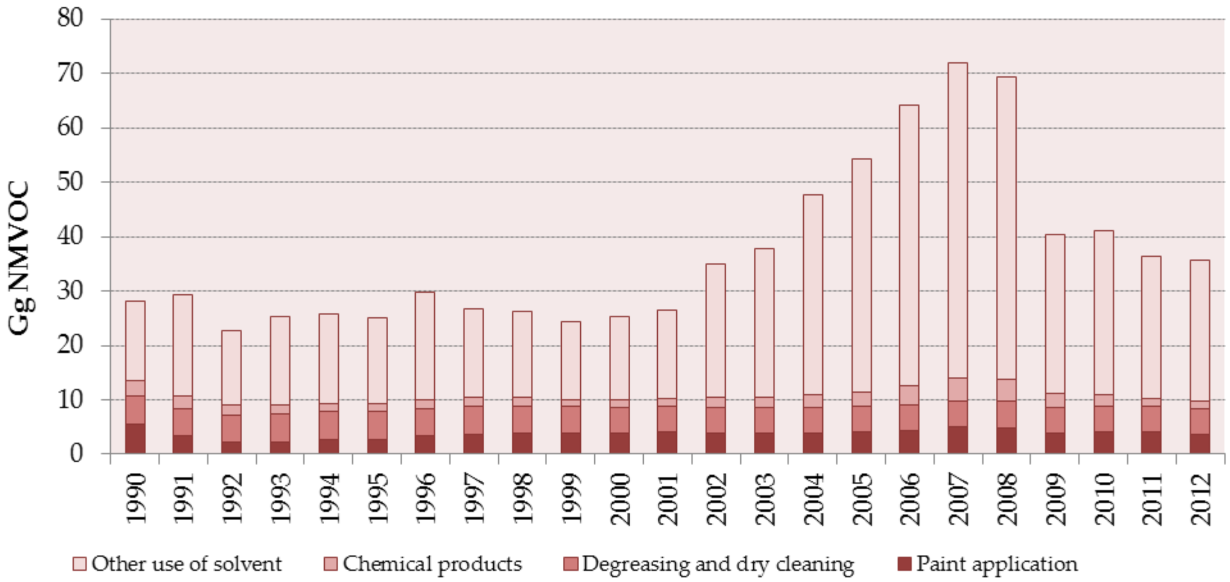


Figure 5.1-1: Emissions of NMVOC from Solvent and Other Product Use (1990-2012)

CO_2 emissions

IPCC Guidelines do not provide methodology for calculation of CO_2 emissions from Solvent and Other Product Use. CO_2 emissions are calculated using conversion factor which contains ratio C/NMVOC = 0.8 and recalculation ratio of C to CO_2 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 CO_2 emission calculation.

N_2O emissions

N_2O emissions have been calculated by multiplying annual quantity of N_2O used for anaesthesia and aerosol cans and default emission factor. According to available data, there is no use of N_2O in fire extinguishers or other uses. Activity data were obtained by producers and distributors of N_2O in Croatia.

It is assumed that none of the N_2O is chemically changed by the body or reacted during the process and all of the N_2O is emitted to the atmosphere, which resulting in an emission factor of 1.0 for these sources.

The resulting emissions of CO_2 and N_2O (Gg CO_2-eq) from Solvent and Other Product Use in the period 1990-2012 are presented in the Figure 5.1-2.

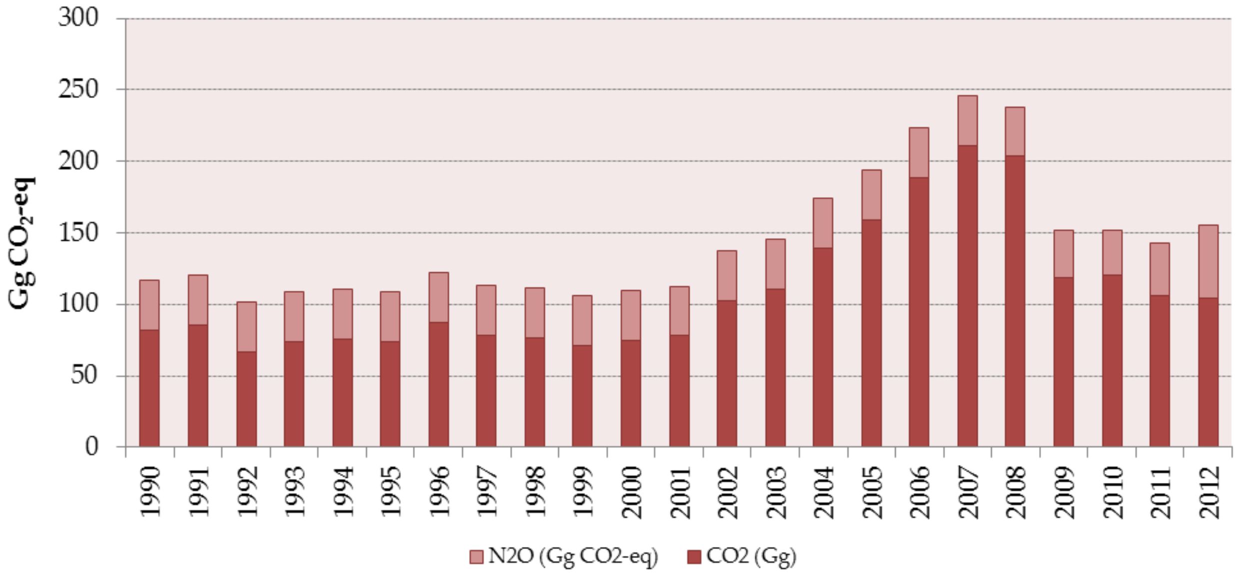


Figure 5.1-2: Emissions of CO_2 and N_2O from Solvent and Other Product Use (1990-2012)

5.1.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties in CO_2 emissions estimates are mainly due to the accuracy of used conversion factor (C/NMVOC) and reliability of calculation is very low. Uncertainties in N_2O 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 to 50 percent. Uncertainty estimate associated with emission factors amounts to 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.

CO_2 Emissions from Solvent and Other Product Use is a key source. Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. CO_2 emissions from Solvent and Other Product Use were estimated using C/NMVOC conversion factor which has been assessed using cluster analysis.

5.1.5. SOURCE–SPECIFIC RECALCULATIONS

Activity data for NMVOC emission calculation for the period 2001-2011 have been updated according to the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2012* Submission to the Convention on Long-range Transboundary Air Pollution' for activities: degreasing, dry cleaning, pharmaceutical products manufacturing and domestic solvent use. Therefore, CO_2 emissions from these activities have been recalculated for the period 2001-2011 in this report.

Also, according to available data, it has been concluded that there is no use of N_2O in fire extinguishers or other uses apart from the use for anaesthesia and aerosol cans. Therefore, notation keyes "NE" previousely used for these activities were changed to "NO" in this report.

5.1.6. SOURCE–SPECIFIC PLANNED IMPROVEMENTS

Croatia is currently working on the revision of data regarding the N_2O use in anaesthesia, aerosol cans, fire extinguishers and other uses, for the entire reporting period. Revised data are planned to be included in the next submission.

Investigation of conversion factor C/NMVOC needs to be performed during the next period (long-term goals), with a purpose of accurate CO_2 emission calculation.

5.2. REFERENCES

Central Bureau of Statistics, Department of Manufacturing and Mining, *Annual PRODCOM results (1990 – 2012),* Zagreb

Central Bureau of Statistics, *Statistical Yearbooks (1990-2012),* Zagreb

Croatian Environment Agency (2014) Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2012* Submission to the Convention on Long-range Transboundary Air Pollution, EKONERG Ltd., Zagreb

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

FCCC/ARR/2013/HRV *Report of the individual review of the annual submission of Croatia submitted in 2013, 21 March 2014*

Ministry of Environmental and Nature Protection (2013) *National Inventory Report 2013, Croatian greenhouse gas inventory for the period 1990 – 2011,* EKONERG Ltd., Zagreb

Ministry of Environmental and Nature Protection (2010) *Fifth National Communication of the Republic of Croatia under the United Nations Framework Convention on Climate Change (UNFCCC)*, Zagreb

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 2012 caused by agricultural activities was 3,363.86Gg CO_2-eq, which represents 12.73 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.

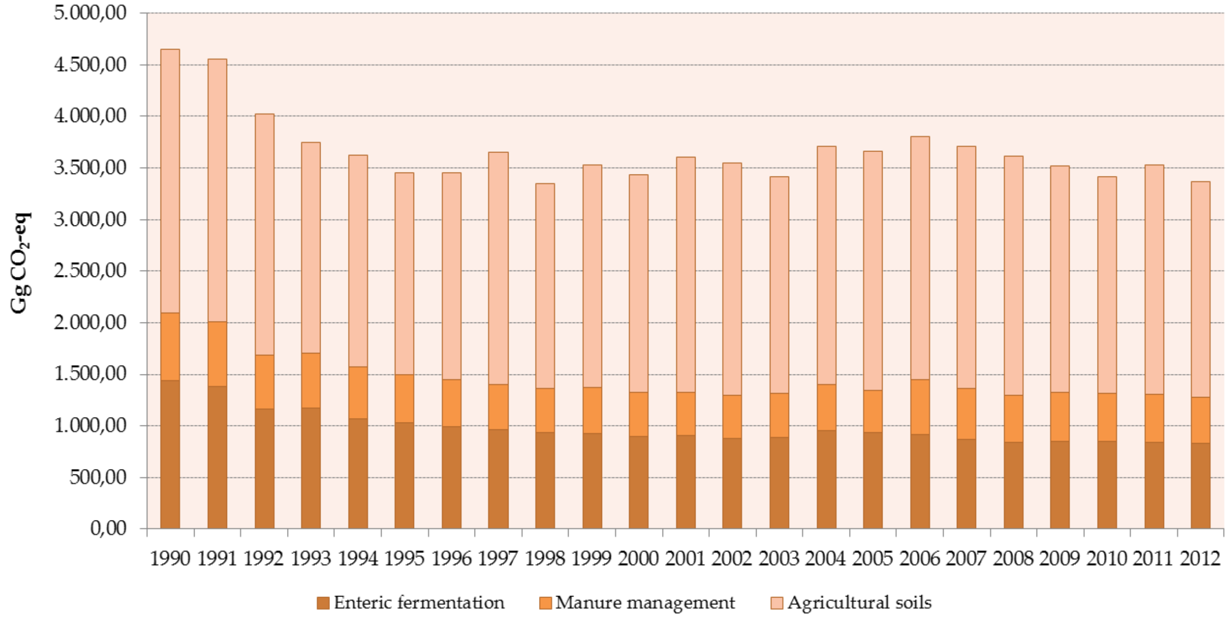


Figure 6.1-1: Agriculture emission trend

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 1990-2012.

Table 6.1-1: Emission of greenhouse gases from agriculture

Year	Methane emission / Gg CH_4			Nitrous oxide emission / Gg N_2O		
	Enteric fermentation	Manure management	Total	Manure management	Agricultural soils	Total
1990	68.72	12.26	80.98	1.45	8.17	9.62
1991	65.58	12.14	77.72	1.43	8.13	9.56
1992	55.53	9.49	65.02	1.21	7.48	8.69
1993	56.05	9.79	65.84	1.21	6.52	7.73
1994	50.81	9.73	60.54	1.20	6.54	7.74
1995	48.84	8.86	57.7	1.11	6.26	7.37
1996	47.16	8.74	55.9	1.08	6.39	7.47
1997	45.85	8.53	54.38	1.05	7.17	8.22
1998	44.56	8.33	52.89	1.02	6.33	7.35
1999	44.07	9.10	53.17	1.07	6.88	7.95
2000	42.92	8.52	51.44	1.01	6.72	7.73
2001	43.12	8.57	51.69	1.00	7.27	8.27
2002	42.00	8.65	50.65	0.99	7.19	8.18
2003	42.27	8.92	51.19	1.00	6.70	7.7
2004	45.46	9.60	55.06	1.04	7.28	8.32
2005	44.57	8.35	52.92	0.93	7.42	8.35
2006	43.79	11.41	55.2	1.17	7.53	8.7
2007	41.39	10.62	52.01	1.10	7.48	8.58
2008	40.10	9.46	49.56	0.98	7.42	8.4
2009	40.25	10.08	50.33	1.03	7.02	8.05
2010	40.39	9.80	50.19	0.99	6.72	7.71
2011	40.14	9.78	49.92	0.99	7.12	8.11
2012	39.65	9.45	49.1	0.94	6.69	7.63

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	1,443.12	257.5	1,700.62	450.8	2,531.34	2,982.14	4,682.76
1991	1,377.22	254.9	1,632.12	443.5	2,519.91	2,963.41	4,595.53
1992	1,166.17	199.3	1,365.47	373.7	2,318.58	2,692.28	4,057.75
1993	1,176.98	205.7	1,382.68	375.2	2,020.65	2,395.85	3,778.53
1994	1,067.04	204.4	1,271.44	370.9	2,028.60	2,399.50	3,670.94
1995	1,025.72	186	1,211.72	343.4	1,940.24	2,283.64	3,495.36
1996	990.41	183.5	1,173.91	336.3	1,981.13	2,317.43	3,491.34
1997	962.85	179.2	1,142.05	326.6	2,223.48	2,550.08	3,692.13
1998	935.77	174.8	1,110.57	317.1	1,963.70	2,280.80	3,391.37
1999	925.39	191.1	1,116.49	333.1	2,131.55	2,464.65	3,581.14
2000	901.4	178.9	1,080.30	313.2	2,084.46	2,397.66	3,477.96
2001	905.56	179.9	1,085.46	309.1	2,253.32	2,562.42	3,647.88
2002	882.05	181.6	1,063.65	308.3	2,229.76	2,538.06	3,601.71
2003	887.64	187.3	1,074.94	310.7	2,076.71	2,387.41	3,462.35
2004	954.59	201.5	1,156.09	323.5	2,258.09	2,581.59	3,737.68
2005	936.03	175.4	1,111.43	288.6	2,299.52	2,588.12	3,699.55
2006	919.51	239.5	1,159.01	363.4	2,334.53	2,697.93	3,856.94
2007	869.2	223	1,092.20	339.8	2,319.27	2,659.07	3,751.27
2008	842.17	198.6	1,040.77	304.4	2,301.35	2,605.75	3,646.52
2009	845.28	211.8	1,057.08	320	2,177.22	2,497.22	3,554.30
2010	848.16	205.8	1,053.96	307.9	2,084.45	2,392.35	3,446.31
2011	843.03	205.4	1,048.43	306.4	2,208.60	2,515.00	3,563.43
2012	832.61	198.5	1,031.11	292.4	2,073.46	2,365.86	3,396.97

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 2014[15]

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
CH_4 Emissions from Manure Management	CH_4		L1i		
N_2O Emissions from Manure Management	N_2O	L1e	L1i	T1e, T2e	T1i, T2i
Direct N_2O Emissions from Agricultural Soils	N_2O	L1e, L2e	L1i, L2i		T1i, T2i
N_2O Emissions from Pasture, Range and Paddock Manure	N_2O				T2i
Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O	L1e, L2e	L1i, L2i		

L1e - Level excluding LULUCF Tier1 L2e - Level excluding LULUCF Tier 2
L1i - Level including LULUCF Tier1 L2i - Level including LULUCF Tier 2
T1e - Trend excluding LULUCF Tier1 T2e - Trend excluding LULUCF Tier2
T1i - Trend including LULUCF Tier1 T2i - Trend including LULUCF Tier2

[15] Data on key categories are taken from Annex 1 Key Categories.

6.2. CH_4 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 CH_4 emission from Enteric fermentation in 2012, followed by non dairy cattle representing about 30%. Jointly, cattle are responsible for around 80% of total CH_4 emission from Enteric fermentation. No methodology for calculating CH_4 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 1990-2012. 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).

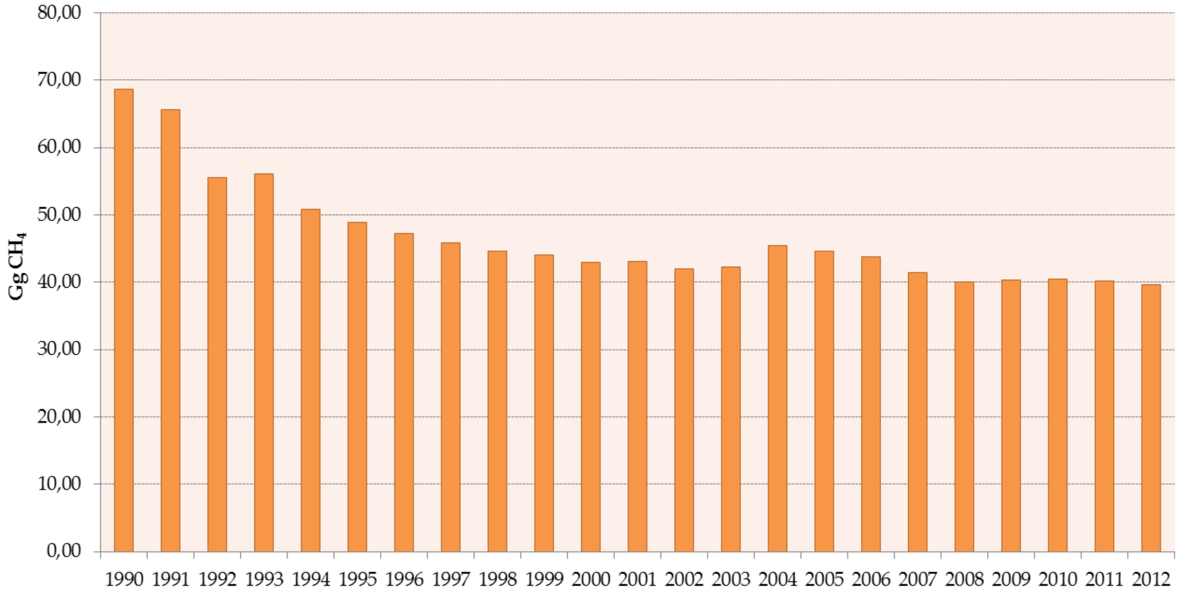


Figure 6.2-1: CH_4 emission from Enteric fermentation

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 was used.

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 numbers was provided by Croatian Agricultural Agency (CAA) as a replacement of the previously used Croatian Horse breeding Centre dataset (CHC). This was done due to changes in the management of equidae registry from the CHC to CAA (Official Gazette 106/12). See Table 6.2-1 for detailed information. New numbers on dairy cattle category was also provided by CAA for the years 2008-2012. Animal number for the rest of the dataset (years 1990 to 2007) was extrapolated based on the 2008-2012 numbers, based on the expert opinion of Croatian Environment Agency.
National data (provided by Croatian CBS and CAA) are considered to be the most accurate source. For animal categoriers where national data was not available, FAO data was considered an adequate replacement source.

Table 6.2-1: Sources of activity data regarding animal population

Animal category	CBS	FAO	Croatian Agricultural Agency	Extrapolation
Dairy cattle			2008-2012	1990-2007
Other cattle	1990-2012			
Sheep	1990-2012			
Goats	1990-1991; 1999-2012	1992-1998		
Horses	1990-1994		1995-2012	
Mules/assess	1990-1991	1992-1994	1995-2012	
Swine	1990-2012			
Poultry	1990-2012			

The number of livestock is reported in Table 6.2-2.

Table 6.2-2: Livestock population in the period from 1990 – 2012

Year	Animal number / 1000 heads							
	Dairy cattle	Non-dairy cattle	Sheep	Goats	Horses	Mules/asses	Swine	Poultry
1990	488	370	751	172	39	17	1573	17102
1991	468	335	753	133	36	13	1621	16512
1992	448	221	539	114	26	13	1182	13142
1993	430	256	525	105	22	12	1262	12697

1994	412	191	444	108	21	7	1347	12503
1995	395	185	453	107	5	2	1175	12024
1996	379	178	427	105	5	2	1197	10993
1997	364	172	453	100	6	2	1176	10945
1998	349	173	427	84	7	2	1166	9959
1999	335	170	488	78	7	2	1362	10871
2000	321	164	529	79	10	3	1234	11256
2001	308	184	539	93	11	3	1234	11747
2002	295	170	580	97	14	3	1286	11665
2003	283	192	587	86	15	3	1347	11778
2004	271	240	722	126	17	3	1489	11185
2005	260	236	796	134	18	3	1205	10641
2006	250	250	680	103	19	3	1488	10088
2007	239	232	646	92	18	3	1348	10053
2008	226	234	643	84	20	4	1104	10015
2009	225	235	619	76	20	4	1250	10787
2010	209	262	629	75	21	4	1231	9469
2011	206	263	639	70	22	3	1233	9523
2012	191	270	679	72	22	3	1166	10608

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 1990-2012, so this trend was followed for the data extrapolation. 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. CAA provided new detailed national data for the population numbers of horses (1995-2012) and mules/asses (1995-2012). For the missing years, CBS data was used for horse population and CBS / FAOSTAT data for mules/assess population respectively, due to current unavailability of detailed national data. More investigation into the accuracy of source data for the years 1990-1995 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

Non-dairy 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 IPCC 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**	**2007-2012**
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, following ERT recommendation, considerable effort was also put into gathering national factors for milk fat percentage and weight of live animals. CAA data of fat percentage indicated that the default 4% can continue to be used and in accordance to national value on milk fat percentage available for the years 2009-2012.

Average value of national live animal weights dataset for the years 2010-2012 was used for cattle categories.

Replacement of default factors with national values for Tier 2 emission calculation for cattle is expected following further data analysis, in the next resubmission of NIR 2014.
(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	**562.82**	0.335	0.00	0.00	**4.00**	0.10	60.00	0.060
mature non-dairy	**529.06**	0.322	0.17	0.00			60.00	0.065
young	**301.64**	0.322	0.17	0.40			60.00	0.060

Milk yield per cow per day for the period from 1990-2012 is presented in Table 6.2-5. AD set on milk yield per cow was provided by CAA for the years 2008-2012, while the rest of the data set (1990-2007) was extrapolated based on CAA data and expert judgement of Croatian Environment Agency.

Table 6.2-5: Milk yield per cow

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Milk yield (kg/day)	6.27	6.38	6.50	6.61	6.73	6.85	6.98	7.10	7.23	7.36

Table 6.2-5: Milk yield per cow, cont.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Milk yield (kg/day)	7.49	7.63	7.77	7.91	8.05	8.19	8.34	8.49	8.64	8.91	8.87	9.03	9.38

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 diary and non-dairy cattle are calculated upon the following equation (IPCC Guidelines - equation 14):

Emission factor (kg/yr) = [Intake (MJ/day) x Ym x (365 days/yr)] / 55.65 MJ/kg of methane]

Emission factor for mature non-dairy cattle and young cattle is about 66 kg CH_4/head/yr and 41 kg CH_4/head/yr respectively while the emission factor used for dairy cattle is presented in Figure 6.2-2.

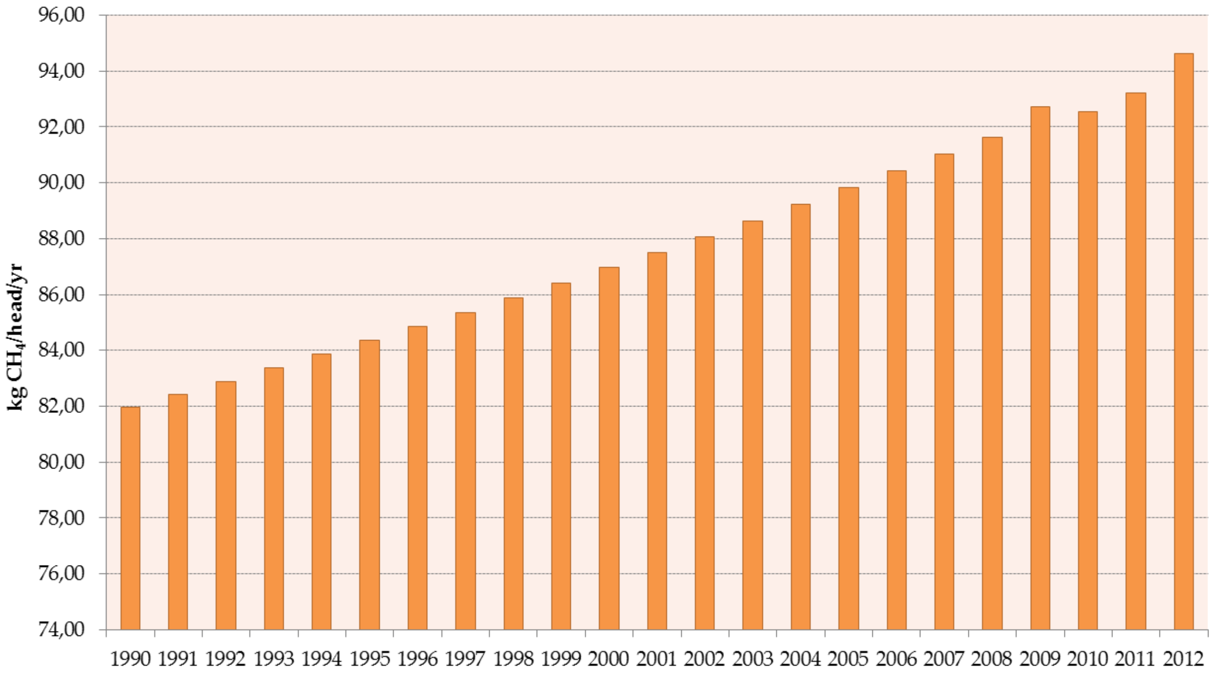


Figure 6.2-2: Enteric fermentation emission factors used for dairy cattle

For other animals (sheep, goats, horses, mules/asses, swine), Tier 1 has been used as well as default EF for 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 1990-2012 (developed countries)
Sheep	8
Goats	5
Horses	18
Mules/asses	10
Swine	1.5
Poultry	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 ±10% and maximum of ±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).

CH_4 emissions from Enteric Fermentation have been calculated using the same method and data sets for every year in the time series.

Additional efforts are required in order to reconcile the probable inconsistency of AD for animal numbers trend, specifically the numbers of mules/asses and horses during the war period (1990-1995). CBS is the main data source for other animals with the exception of FAO data for goats. Trend analysis was performed for the goats AD timeseries – FAO data was found to be inline and consistent with CBS data.

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 1995-2011 period due to changes in activity data (number of horses and mules/asses)
- for the 1990-2011 period due to change in dairy cattle population, live animal weights and milk yield AD
- for the 1990-2007 period due to change of usage of default emission factors from those for developing to those for developed countries

6.2.6. SOURCE SPECIFIC PLANNED IMPROVEMENT

Short term goals (1 year) are as follows:

- Continued investigation of activity data (livestock population numbers) with the purpose of gathering more detailed activity data and improving consistency, especially the number of horses and mules/asses and new CAA data on dairy cattle.
- Collecting relevant data from the CBS 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:

- The development of national emission factors for the calculation of CH_4 emission.
- Investigation of the difference in statistical data of mineral fertilizer usage that is possibly leading to the overestimation of direct N_2O 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 – CH_4 EMISSIONS (CRF 4.B.)

6.3.1. SOURCE CATEGORY DESCRIPTION

Management of livestock manure produces both methane (CH_4) and nitrous oxide (N_2O) 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 2012 is presented in Figure 6.3-1. The emission trend depends on the animal population trend.

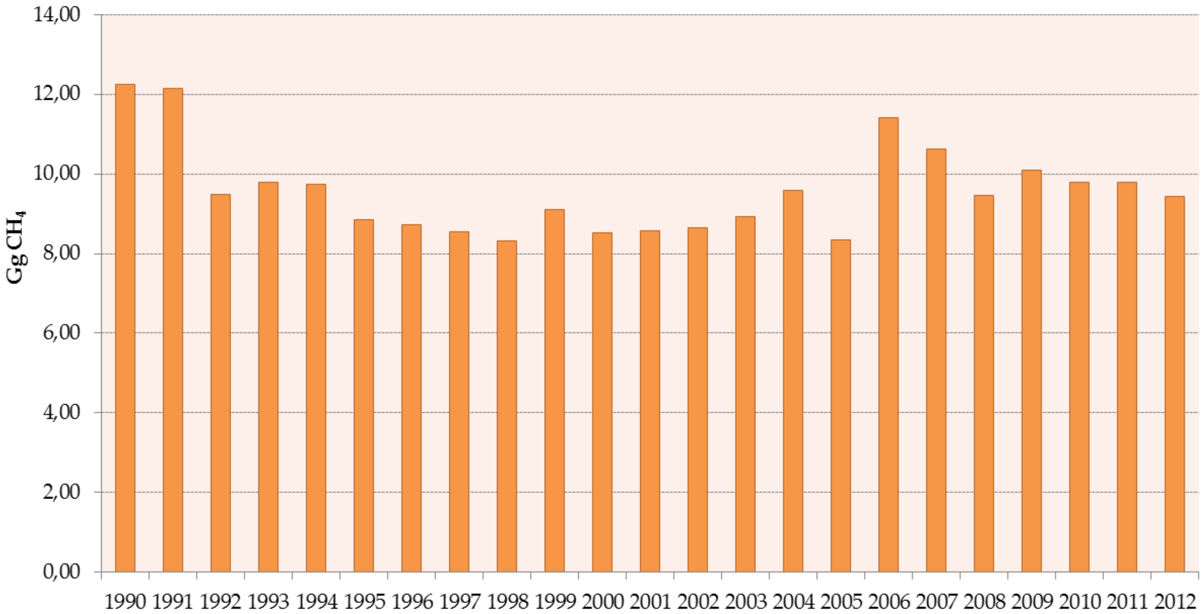


Figure 6.3-1: CH_4 emission from Manure management

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. According to 2013 ERT Saturday paper recommendation based on the average annual milk production, CH_4 emission from dairy cattle for the years 2006 - 2011 has been calculated using the appropriate default tier I EF value of 14 kg CH_4/head/yr (Westen Europe defaults) from the Revised 1996 IPCC Guidelines, page 4.43 - table B-3, while for the years 1990-2005 appropriate default tier I EF value of 6 kg CH_4/head/yr (Eastern Europe default) was used. For swine, emission factors for Eastern Europe have been used for the entire time period. For sheep, goats, horses, mules/asses and poultry, default EFs of developed countries were used for period from 1990 to 2012. 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 2008-2012 (developed countries)
Sheep	0.10
Goats	0.11
Horses	1.1
Mules/asses	0.60
Poultry	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 ±10% and maximum of ±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

Emissions were recalculated for the 1995-2011 period due to changes in activity data (number of horses and mules/asses).
Emissions were also recalculated for the entire 1990-2011 period due to reconciliation of the discrepancy regarding the usage of IPCC default EFs for developing countries for the period 1990-2007 and default EFs for developed countries for the period 2008-2011 for the estimation of emissions from manure management (sheep, goats, horses, mules and assess, swine and poultry). EFs for developed countries will be used for the entire timeseries as a short term replacement until national factors are developed.

6.3.6. SOURCE SPECIFIC PLANNED IMPROVEMENT

Planned improvements for the *Enteric Fermentation* source will also improve emissions calculation from *Manure management* sector. Please refer to chapter 6.2.6 for the planned improvements for *Enteric Fermentation*.

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

6.4.1. SOURCE CATEGORY DESCRIPTION

Emissions of nitrous oxide (N_2O) 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 N_2O 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 (N_2O) emission is calculated according to the following equations:

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

where

$Nex_{(AWMS)}$ 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

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

where

$N_2O_{(AWMS)}$	stands for	N_2O 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 (N_2O) emissions from Manure management for the period from 1990 to 2012 are presented in Figure 6.4-1. The emission trend depends on the animal population trend.

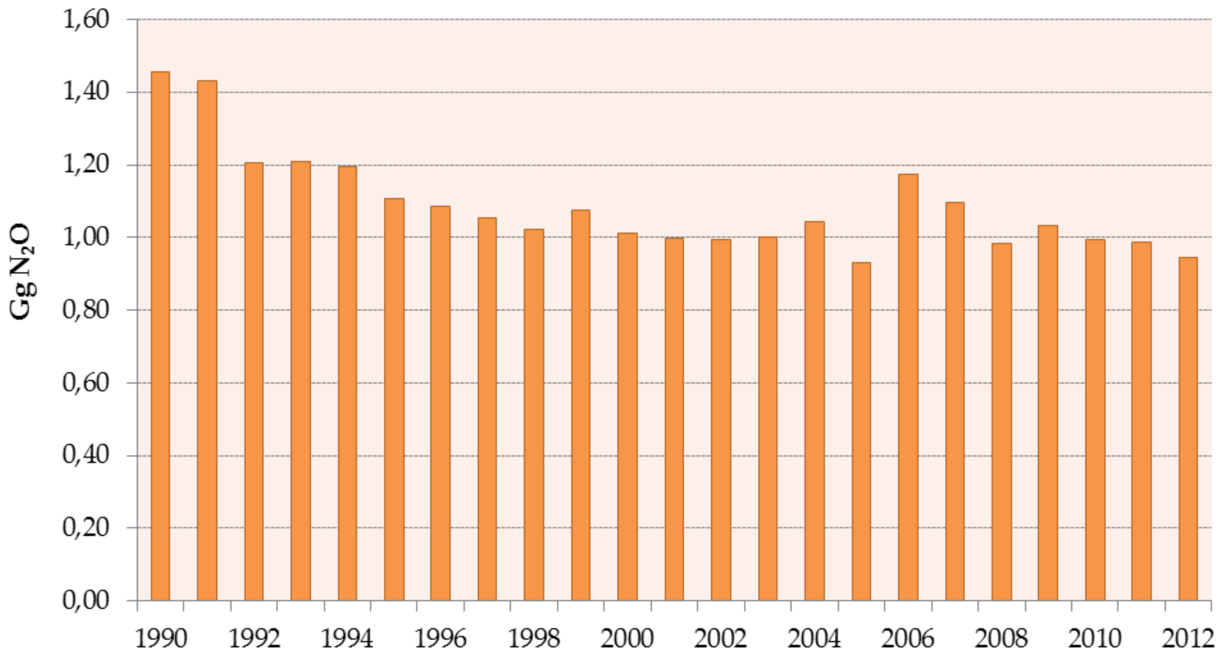


Figure 6.4-1: N_2O Emissions from Manure management

Activity data regarding livestock population are the same as for the calculation of CH_4 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. According to 2013 ERT Saturday paper recommendation based on the average annual milk production (CBS data), CH_4 emission from dairy cattle for the years 2006 - 2011 has been calculated using the appropriate default *Nex* value of 100 kg N excretion/head/yr (from the Revised 1996 IPCC Guidelines, p.4.99, table 4-20), while for the years 1990-2005 appropriate default value of 70 kg N/head/yr was used. This is to be reconciled with the new CAA annual milk production data.

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)					
			Anaerob. lagoon	Liquid system	Daily spread	Solid storage and drylot	Pasture range and paddock	Other systems
Non-dairy Cattle	*(years 1990-2005)* **50.0**	*(years 2006-2012)* **100.0**	8%	39%	52%	0%	0%	1%
Dairy Cattle	**70.0**		0	18%	68%	1%	13%	0%
Poultry	**0.6**		0	28%	0%	0%	1%	71%
Sheep	**16.0**		0	0	0	0	73%	27%
Swine	**20.0**		0	29%	0%	0%	27%	45%
Goats	**25.0**		0	0	0	0	92%	8%
Horses; Mules/Asses	**25.0**		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 (±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 for N excretion rates is default IPPC value of ±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

Emissions were recalculated:

- for the 1995-2011 period due to changes in activity data (number of horses and mules/asses)
- for the entire 1990-2011 due to changes in activity data on dairy cattle population

- for the entire 1990-2011 due to changes in that fractions of manure N per AWMS for swine. ERT pointed out that fractions of manure N per AWMS for swine which are presented in the table 6.4- are not correct, because the sum of the fractions for liquid systems (29 per cent), pasture, range and paddock (27 per cent) and other systems (45 per cent) amounts to 101%. NIR team would like to reiterate that this is an error present both in Revised 1996 IPCC Guidelines, p.4.101, table 4-21) and in the original reference document used by the Guidelines. Croatian NIR team changed the percentage values to address this issue by lowering all AWMS fractions percentage for swine by 0.33% and 0.34, respectively.
- for the 1990-2007 period due to reconciliation of the discrepancy regarding the usage of IPCC default EFs for developing countries for the period 1990-2007 and default EFs for developed countries for the period 2008-2011 for the estimation of emissions from manure management (sheep, goats, horses, mules and assess, swine and poultry). EFs for developed countries will be used for the entire timeseries as a short term replacement until national factors are developed.

6.4.6. SOURCE SPECIFIC PLANNED IMPROVEMENT

Short term goals (1 year) are as follows:

- Reconciliation of 2013 ERT Saturday paper recommendation based on the average annual milk production, where CH_4 emission from dairy cattle for the years 2006 - 2011 has been calculated using the appropriate default *Nex* value of 100 kg N excretion/head/yr (from the Revised 1996 IPCC Guidelines, p.4.99, table 4-20), while for the years 1990-2005 appropriate default value of 70 kg N/head/yr was used. This was based on the interannual change of CBS milk per cow data justifying change of *Nex* value from those default for eastern European to Western countries. This is now subject to a new change, following additional investigation into availiability of additional CAA data.

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 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 (CH_4) 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 N_2O emitted.

Three sources of nitrous oxide emissions are distinguished:

- Direct emissions of N_2O from agricultural soils (CRF 4.D.1.)
- Direct N_2O 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 (N_2O) from Agricultural soils for the period from 1990 to 2012 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. Data for the year 2012 again shows decline in consumption, inline with the year 2010 data.

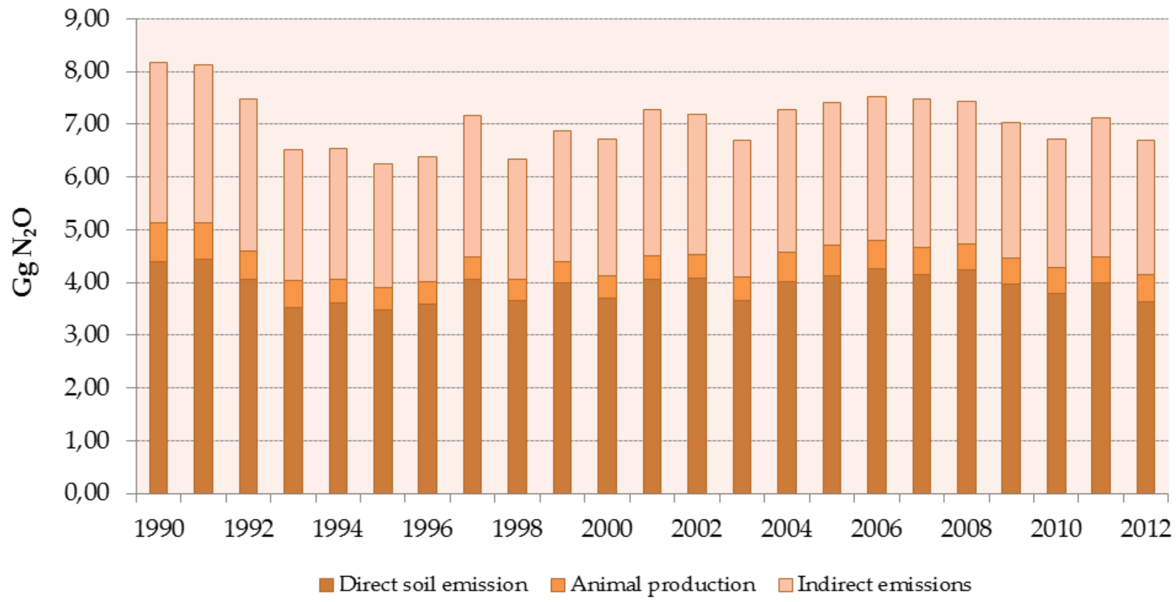


Figure 6.6-1: Total N_2O emissions from Agricultural soils

6.6.1.DIRECT EMISSION FROM AGRICULTURAL SOILS (CRF 4.D.1.)

6.6.1.1. Source category description

Direct N_2O 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 form 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:

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

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 2012 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.

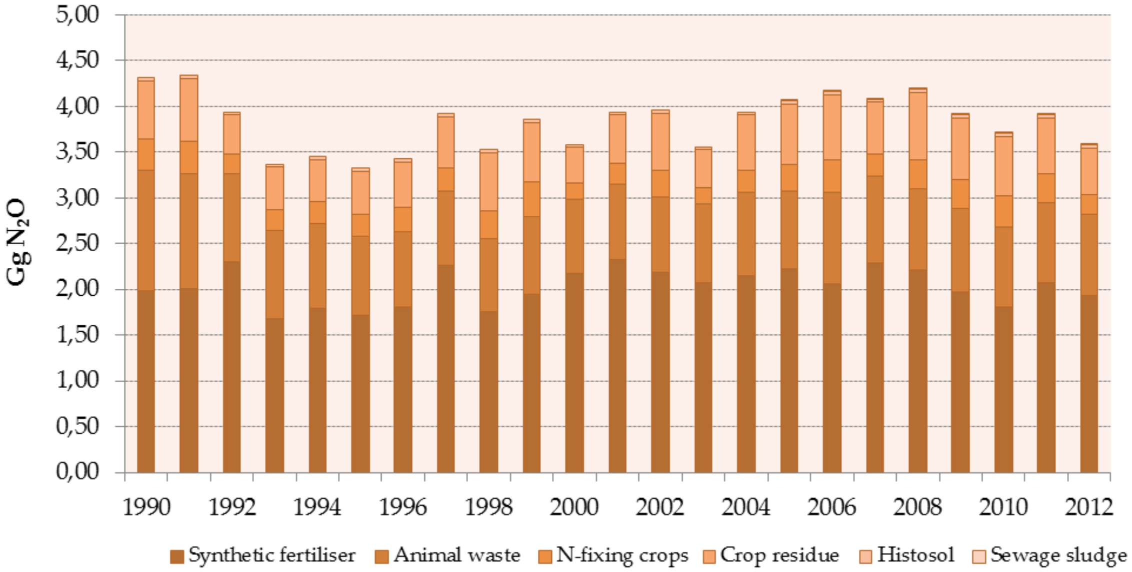


Figure 6.6-2: Direct N_2O emissions from Agricultural soils

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 1992-2012. 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.

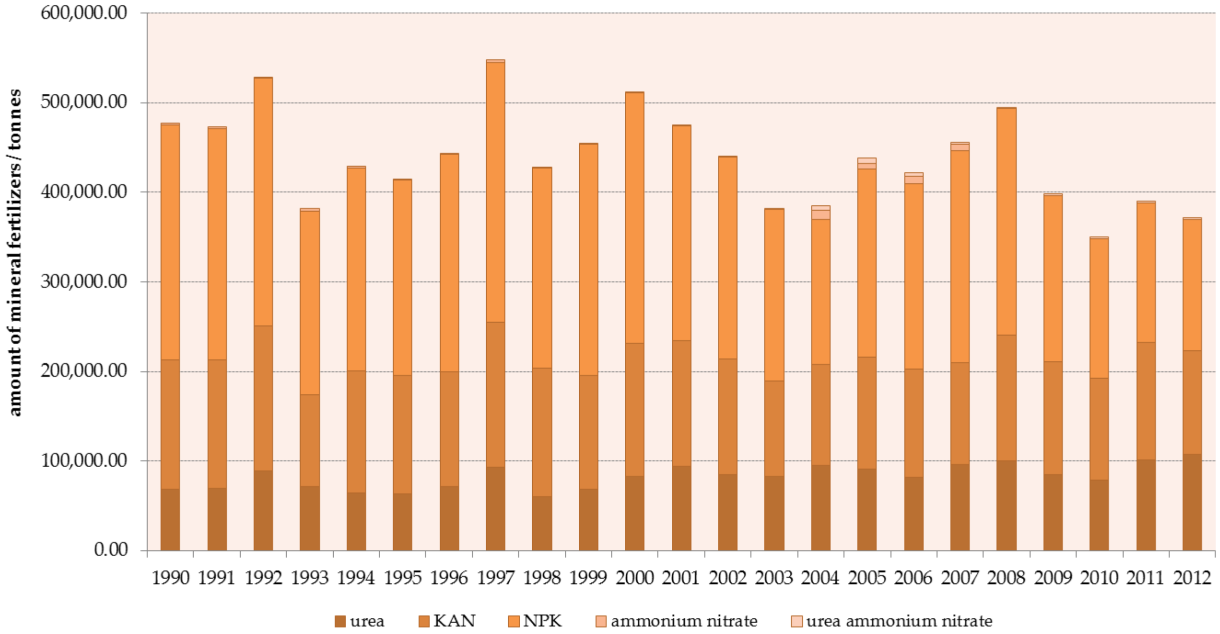


Figure 6.6-3: Mineral fertilizers applied to soil in the period from 1990-2012

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 1990-2012

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**

Year	Nitrogen applied / tonnes					
	Urea	Calcium ammonium nitrate	NPK	Ammonium nitrate	Urea ammonium nitrate	TOTAL
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**
2012	53,466	31,327	22,414	0	662	**107,869**

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 NH3 and NOx

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 N_2O-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 NH_3 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	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
$Frac_{GRAZ}$	0.24235	0.24296	0.24193	0.23718	0.23948	0.23797	0.24084	0.24411	0.24038	0.24609	0.25185

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
$Frac_{GRAZ}$	0.25301	0.26273	0.25665	0.27493	0.28539	0.25515	0.25175	0.25138	0.24746	0.25115	0.25067	0.25229

Emission of nitrous oxide was then calculated by multiplying the quantity of the remaining N with emission factor 0.0125 kg N_2O-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	1990-2012		
Beans, dry	1990-2012		
Cow peas, dry	2008-2012	1992-2007	1990-1991
Lentils		1992-2012	1990-1991
Peas, dry	2008-2012	1992-2007	1990-1991
Vetches		1992-2012	1990-1991
Clover	1990-2012		
Alfaalfa	1990-2012		

**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 – 2012

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
2012	96,718	472	1,863	100

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	1,700	105,075	153,240
2012	404	1,600	83,817	124,055

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 souces 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

Valeus from Slovenian NIR

Emission of nitrous oxide was then calculated by multiplying the quantity of the remaining N with emission factor 0.0125 kg N_2O-N/kg N (Revised 1996 IPCC Guidelines).

<u>Emissions of nitrous oxide from crop residue</u>

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	1990-2012	
Maize	1990-1991, 1994-2012	1992-1993
Potatoes	1990-2012	

Sugar beets	1990-2012	
Tobacco	1990-2012	
Sunflowers	1990-2012	
Rape seed	1990-2012	
Tomatoes	1990-2011	
Barley	1990-2012	
Oats	1990-1991; 2000-2012	1992-1999
Cabbages and other brassicas	1990-2012	
Garlic**	1990-2012	
Onions**	1990-2012	
Rye	1990-2012	
Sorghum	1990-1997*, 2012	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 – 2012

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	1,537,663	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
2012	999,681	1,297,590	151,278	919,230	11,787

Table 6.6-7: Production of non N-fixing crops in the period from 1990 – 2012 (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
2012	90,019	26,406	25,418	235,778	94,542

Table 6.6-7: Production of non N-fixing crops in the period from 1990 – 2012 (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	1,000	23,313
2011	36,877	2,728	19,569	2,949	1,280	19,902
2012	23,014	2,805	20,128	2,426	1,300	20,226

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 souces 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)

Valeus 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, updated activity data regarding the area of histosols in the Republic of Croatia have been obtained from the Croatian Environment Agency, based on new information available from ARKOD (Croatian Land Parcel identification System – *LPIS*). Resulting total histosol area amounts to 2685.49 ha. According to CEA expert judgment this value is accurate on a national level and can be used for each year in the entire period from 1990-2012.

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

Sufficient activity data was provided for the period 2005-2011, while for the period 1990-2004 no data was not provided or could be estimated. Current AD set is limited to data provided by private owned companies to the Croatian Environment Agency. The resulting sludge is the result of their production process, thus there is no driver that can be used to obtain relevant data prior to the initial year of operation. Spreading of discharge on agricultural land is not a practice in Croatia. Release od septic tanks is controlled by Croatian legislative regulations („Municipal management law“, Official Gazette of the Republic of Croatia 26/03, 82/04, 178/04, 38/09, 79/09, 49/11, 144/12) - authorized municipal and transport companies collect and release the content from domestic septic tanks into the public sewage system at permitted locations.
Sewage sludge nitrogen was included and calculated according to direct N_2O 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)	Average nitrogen percentage (N % in dry matter mass)
2005	3	11%
2006	6	11%
2007	7	11%
2008	16	11%
2009	459	2%
2010	434	2%
2011	683	2%
2012	956	2%

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, ±10% for animal manure, N-fixing crops and crop residues while for histosols it is ±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, higherfor FAO and other data), observing annual variation in AD and of periodic revisions of the AD. Uncertainty of emission factors amounts ±80% for mineral fertilizers, animal manure, N-fixing crops and crop residues while for histosols it is ±60%.Direct N_2O emissions from agricultural soils have been calculated using the same method and data sets for every year in the time series.

Data on the production of crops were obtained from the Central Bureau of Statistics and FAO database. Croatian CBS are considered to be the most accurate data source and CBS AD was always used when available. For crops where national data was not available, FAO data was considered an adequate replacement source following trend analysis. 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, with no outliers.

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

<u>N_2O emissions from animal manure and liquid/slurry</u>

Recalculations were performed for the 1995-2011 time period due to updated activity data (change in AD source) regarding the number of animals (horses, mules/asses).

<u>N_2O emissions due to cultivation of organic soils</u>

Recalculations were performed for the entire time period 1990-2011 due to updated activity data regarding the area of histosols in the Republic of Croatia.

<u>N_2O emissions originating from biological fixation of nitrogen and crop residue</u>

Recalculations were performed for the year 1992 and 2011 due to the change in activity data for maize (1992) and vetches (2011) crops.

<u>N_2O emissions due to application of sewage sludge</u>

Recalculations were performed for the years 2009-2011 due to the new activity data.

<u>Nitrous oxide from animal manure and liquid/slurry</u>

Recalculations were performed for the years 1990-2011 due to change of fraction of Manure Nitrogen per AWMS for swine and due to updated activity data (change in AD source) regarding the number of animals (dairy cattle).

6.6.1.6. Source specific planned improvement

Short term goals (1 year) are as follows:

- 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 N_2O emissions from the Agricultural Soils .
- Continued improvements and investigation of activity data (mineral fertilizer, crop production, sewage sludge) with the purpose of more detailed explanation of the activity data trends and further verification of source data.

6.6.2. DIRECT N_2O EMISSION FROM PASTURE, RANGE AND PADDOCK MANURE (CRF 4.D.2.)

6.6.2.1. Methodological issues

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

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

where

$N_2O_{animals}$	stands for	N_2O emissions from animal production (kg N/yr)
$N_2O_{(AWMS)}$	stands for	N_2O 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 N_2O-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 N_2O 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.

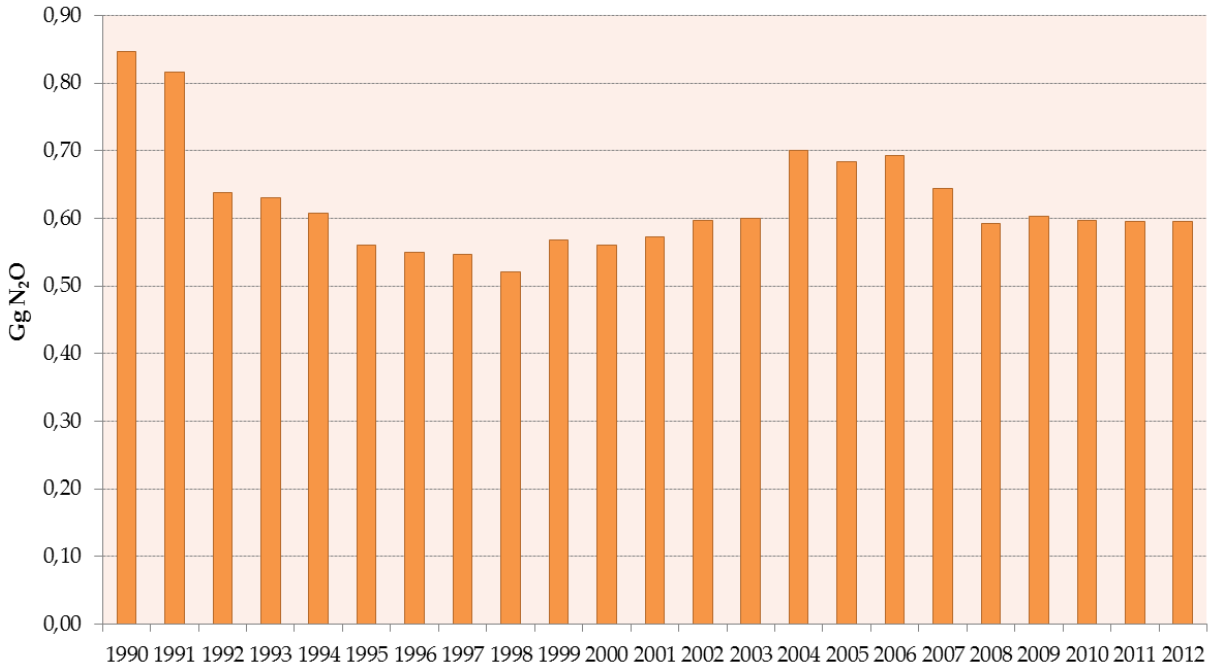


Figure 6.6-4: Direct N_2O emissions from animal production

6.6.2.2. 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 ±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 N_2O emissions from Pasture, Range and Paddock Manure have been calculated using the same method and data sets for every year in the time series.

6.6.2.3. 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

Emissions were recalculated:

- for the 1995-2011 period due to changes in activity data (number of horses and mules/asses)
- for the entire 1990-2011 due to changes in activity data on dairy cattle population

- for the entire 1990-2011 due to changes in that fractions of manure N per AWMS for swine.
- for the 1990-2007 period due to reconciliation of the discrepancy regarding the usage of IPCC default EFs for developing countries for the period 1990-2007 and default EFs for developed countries for the period 2008-2011 for the estimation of emissions from manure management (sheep, goats, horses, mules and assess, swine and poultry). EFs for developed countries will be used for the entire timeseries as a short term replacement until national factors are developed.

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 N_2O EMISSIONS FROM NITROGEN USED IN AGRICULTURE (CRF 4.D.1.)

6.6.3.1. Source category description

Calculations of indirect N_2O emission from nitrogen used in agriculture are based on two pathways. These are: volatilization and subsequent atmospheric deposition of NH_3 and NO_x (originating from the application of fertilizers and animal manure) and leaching and runoff of the 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 N_2O from the agriculture is calculated using the following equation:

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

where

$N_2O_{indirect}$	stands for	indirect N_2O emissions (kg N/yr)
$N_2O_{(g)}$	stands for	N_2O emissions due to atmospheric deposition of NH_3 and NO_x (kg N/yr)
$N_2O_{(L)}$	stands for	N_2O emissions due to nitrogen leaching an runoff (kg N/yr)

Emissions of N_2O produced from the discharge of human sewage N into rivers are reported under the sector waste.

Indirect emission of N_2O from agriculture sector for the period from 1990 to 2011 is shown in Figure 6.6-5. The 2emission trend is influenced by the mineral fertilizer consumption and animal population altogether.

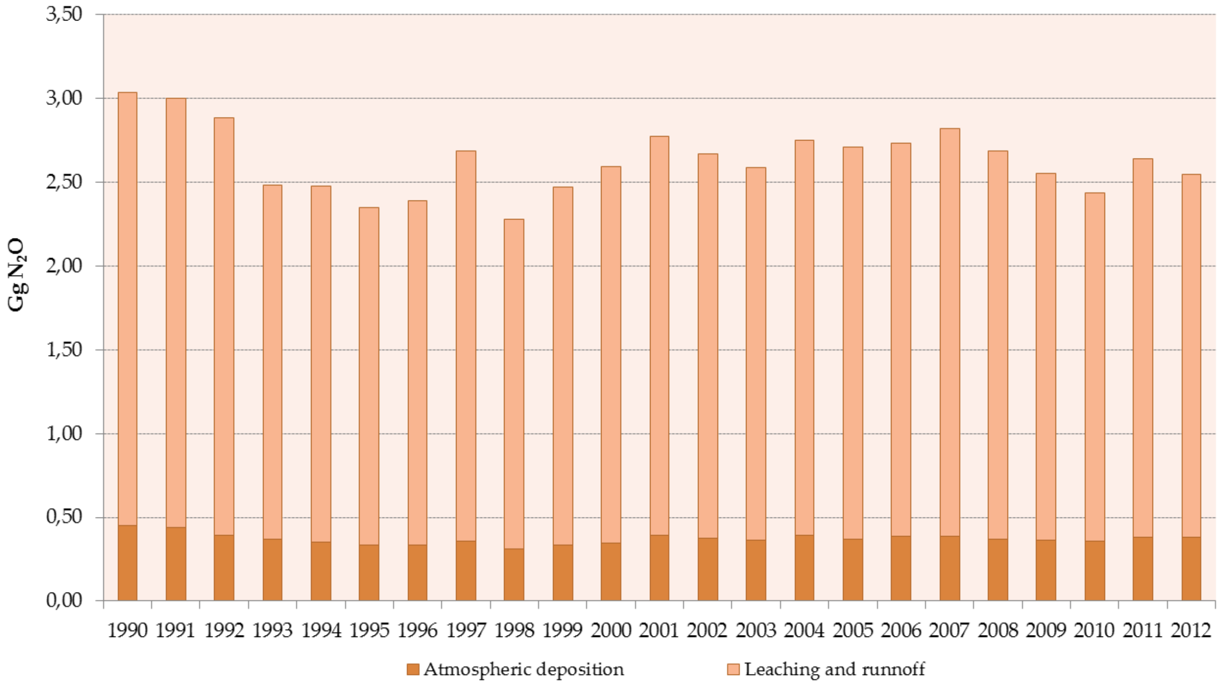


Figure 6.6-5: Indirect N_2O emissions from Agriculture

6.6.3.2. Methodological issues

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

While fertilizing agricultural soils with nitrogen fertilizers, some N volatilises in form of ammonia (NH_3) 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 N_2O. Emissions are attributed to the place of origin of ammonia and NO_x, not to the place where N is re-deposited, causing N_2O emissions.

Emissions from mineral fertilizers

Indirect emissions of nitrous oxide from mineral fertilizers depend to a large extent on the fraction of N that volatilises during 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 NH_3 and NO_x were obtained from Croatian documents reporting to the LRTAP Convention for each fertilizer type (see Table 6.6-2). For calculation of indirect emissions of nitrous oxide, the emission factor 0.01 kg N_2O-N/kg NH_3 and NO_x-N has been used (Revised 1996 IPCC Guidelines).

<u>*Emissions from animal manure*</u>

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 N_2O-N/kg NH_3-N and NO_x-N (Revised 1996 IPCC Guidelines).

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

<u>*Surface runoff and leaching of N into groundwater, surface waters, and watercourses due to mineral fertilisers*</u>

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 N_2O-N is emitted (Revised 1996 IPCC Guidelines).

<u>*Nitrogen leaching and runoff into groundwater, surface waters, and watercourses due to animal manure*</u>

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 N_2O-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 N_2O 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 N_2O emissions were recalculated due to the changes in activity data for application of sewage sludge, recalculations of indirect N_2O emissions were performed for the same time period. For detailed explanation, see Chapter 6.6.1.5.

Emissions were also recalculated:

- for the 1995-2011 period due to changes in activity data (number of horses and mules/asses)
- for the entire 1990-2011 due to changes in activity data on dairy cattle population
- For the entire 1990-2011 due to changes in that fractions of manure N per AWMS for swine.

For the 1990-2007 period due to reconciliation of the discrepancy regarding the usage of IPCC default EFs for developing countries for the period 1990-2007 and default EFs for developed countries for the period 2008-2011 for the estimation of emissions from manure management (sheep, goats, horses, mules and assess, swine and poultry). EFs for developed countries will be used for the entire timeseries as a short term replacement until national factors are developed.

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 occasionall 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 ceral 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 („Ordnance 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

Bašić, F., O. Nestroy, I. Kisić, A. Butorac, M. Mesić (1988*) Protection from erosion – the key role of soil cultivation in present and changed climate conditions*, Croatian Academy of Sciences and Arts – Scientific conference with international participation "The adjustment of agriculture and forestry to climate and its changes", pages 115-125, Zagreb

Butorac, A., (1963) *Thermal condition of soil and the most characteristic temperature thresholds for certain sites in main agricultural regions of Croatia*, Agricultural Gazette 12/63

Central Bureau of Statistics, Statistical Yearbooks (1990-2011), Zagreb

Croatian Environment Agency (2012) *Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2011 Submission to the Convention on Long-range Transboundary Air Pollution*, EKONERG Ltd., Zagreb

EMEP/CORINAIR Atmospheric Emission Inventory Guidebook 2007

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

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

FAO database www.fao.org

Ministry of Environmental and Nature Protection (2013) *National Inventory Report 2013, Croatian greenhouse gas inventory for the period 1990 – 2011*, EKONERG Ltd., Zagreb

Ministry of Environmental and Nature Protection (2010) *Fifth National Communication of the Republic of Croatia under the United Nations Framework Convention on Climate Change (UNFCCC)*, Zagreb

Response of Croatia to Potential Problems and Further Questions from the ERT formulated in the course of the 2012 review of the greenhouse gas inventories of Croatia submitted in 2012

FCCC/ARR/2011/HRV *Report of the individual review of the annual submission of Croatia submitted in 2012*

Znaor, D. and Karoglan Todorović, S.,(2005) *Analysis of yields, nitrogen content and N-fixation of Croatian agricultural production in 2002-2003*, University of Essex, Colchester. Unpublished

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 Forest land remaining Forest land, Cropland remaining Cropland and Land converted to Settlement categories are 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 2012

IPCC Categories	Direct GHG	Criteria for Identification			
		Level		Trend	
		excl. LULUCF	incl. LULUCF	excl. LULUCF	incl. LULUCF
FOREST LAND					
Forest land remaining forest land	CO_2		L1i, L2i		T1i, T2i
Land converted to Forest land	CO_2		L2i		T2i
Cropland remaining Cropland	CO_2		L1i, L2i		T1i, T2i
Land converted to Cropland	CO_2		L2i		
Land converted to Grassland	CO_2		L2i		T1i, T2i
Land converted to Settlements	CO_2		L1i, L2i		T1i, T2i

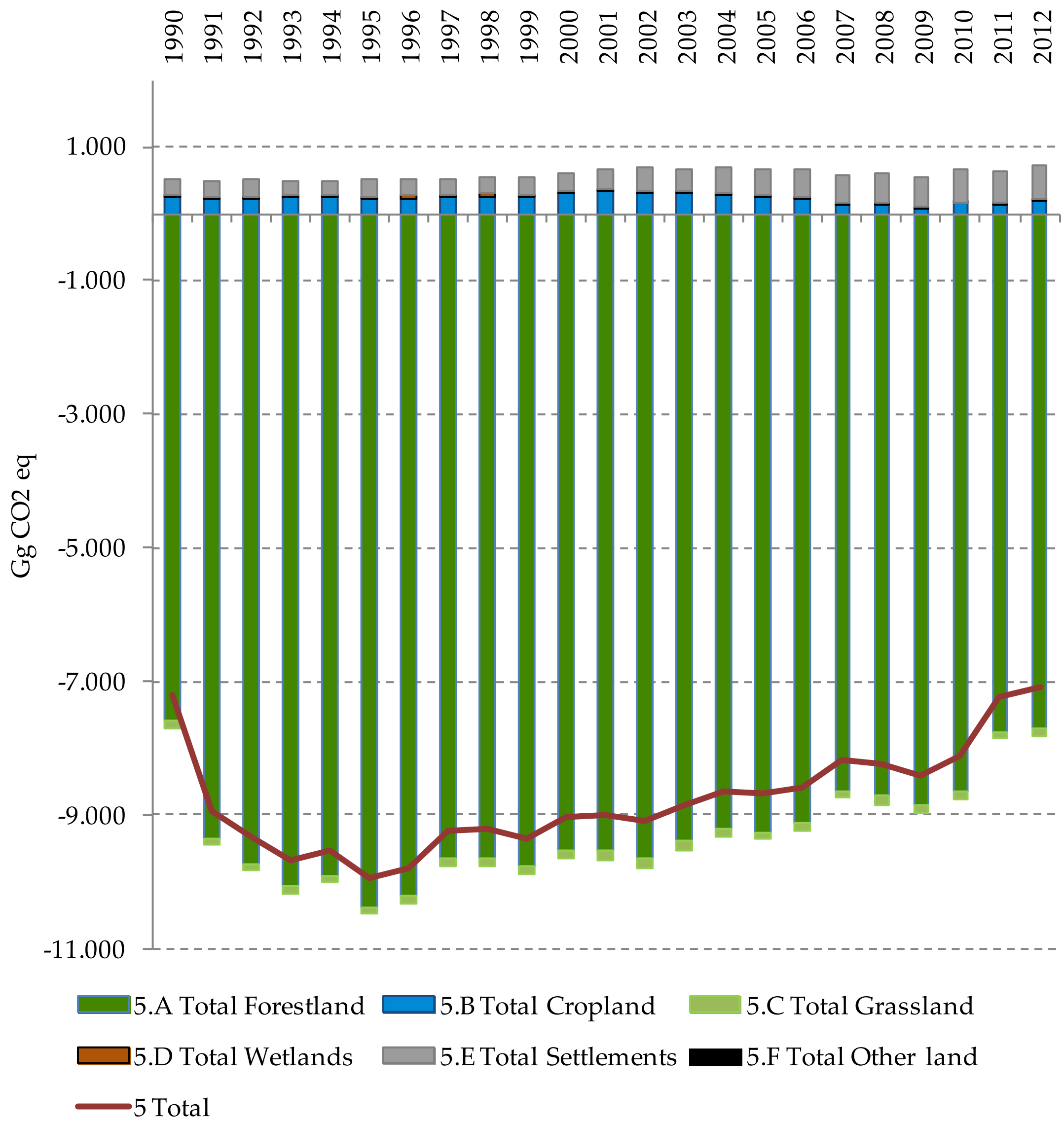
The completeness of the estimated emissions/removals is presented in Table 7.1-2.

Table 7.1-2: Reported LULUCF categories - status of emission estimates

LAND USE CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O
A. Forest land	x	x	x
1.Forest land remaining forest land	x	x	x
2.Land converted to Forest Land	x	x	x
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	x	x	x
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 CO_2 removals, while every other category represents an emission source.



[1] *Refers to the Land converted to Wetlands, Settlements and Other land*

* *Without emissions from fires*

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 (maquies and shrub) were obtained from the *Croatian Forest Ltd.* company which was pursuant to the relevant legislation[16] for many years obliged to manage all forests in Croatia. Consequently this company disposes with all forestry related data regardless the ownership type and current administrative organization of the sector. In order to comply with requirements set in ARR 2012 regarding the traceability and identification of lands that are subject of forest activities, Croatia developed and implemented project *Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol"* (abbreviated LULUCF 1). Through the project special surveys were executed and areas belonging to the categories of *Forest land remaining Forest land* and areas converted to/from forest land were identified. Detailed description of the conducted work is presented in Chapters 7.2.4.2 and 11.3.1.1-11.3.1.3. Surveys conducted in forest land category are performed for all type of forests (coniferous, deciduous, Out of yield forests (maquies and shrub)) regardless the ownership type. The project was initiated by Ministry of Environmental and Nature Protection through joint cooperation with relevant institutions.

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. When presenting areas of Settlement, correction factor has to be defined and applied since these areas were observed to be much smaller that areas in other countries.

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
- 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. By the conducted survey under the LULUCF 1 project, it was concluded that there is no conversion from *Other land to forest land*, as it was reported by Croatia in NIR 2013.

[16] Forest Act (OG 140/05, 82/06, 129/08, 80/10, 124/10, 25/12, 68/12,148/13,94/14)

After the total area of each category of land was determined, the LUC to and from each categories were defined. The major problem in presenting the land use changes were the limited number of information on the land use changes between specific categories. The exact data on land use changes on yearly bases were available only for conversion from/to forest land and were collected through the LULUCF 1 project. Through the conducted survey, former land use on the identified new forest areas also was determined and known for each type of forest ownership.

For representing LUC in other categories of land, IPCC GPG Approach 1 was used for representing the areas by using information from available statistics and assumptions based on recognized pattern on land use changes. 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.

Based on annual land use changes, a matrix for LUC transition period was developed (Table 7.1-4). The table describes the initial and final areas of each land-use categories in transition period of 20 years and the identified annual land use changes among categories of land. It should be noted that in matrix the annual totals for the individual years do not match annual totals in CRF tables where the changes are reported in transition period of 20 years.

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 1990-2012

Area in kha	1990	2012	2012-1990
5. A Forest land - Total	2,302.47	2,334.27	31.80
5 A 1. Forest land remaining forest land	2,298.93	2,298.63	-0.29
5A1a Forest land remaining forest land -coniferous	199.55	201.98	2.43
5A1b Forest land remaining forest land -deciduous	1,662.34	1,662.01	-0.33
5A1c Forest land remaining forest land -out of yield	437.04	434.65	-2.39
5 A2. LUC in Forest land	3.54	35.64	32.10
A2.1a Annual cropland in forest land	0.00	0.93	0.93
5A2.1b Perennial cropland in forest land	0.00	0.09	0.09
5A2.2 Grassland in forest land	3.54	34.62	31.08
5A2.3 Wetlands in forest land	0.00	0.00	0.00
5A2.4 Settlement in forest land	0.00	0.00	0.00
5A2.5 Other land in forest land	0.00	0.00	0.00
5.B Cropland - Total	1,623.77	1,539.81	-83.96
Cropland annual	1,479.23	1,416.39	-62.84
Cropland perennial	144.54	123.41	-21.12
5B1. Cropland remaining cropland	1,616.44	1,524.05	-92.39
5B1a Annual cropland remaining annual cropland	1,472.06	1,402.70	-69.36
5B1b Perennial cropland remaining perennial cropland	143.06	120.98	-22.08
5B1c LUC perennial cropland in annual cropland	0.43	0.19	-0.24
5B1d LUC annual cropland in perennial cropland	0.89	0.19	-0.70

Area in kha	1990	2012	2012-1990
5B2 LUC in cropland	7.33	15.75	8.43
5B2.1a Forest land in annual cropland	0.00	0.00	0.00
5B2.1b Forest land in perennial cropland	0.00	1.31	1.31
5B2.2a Grassland in annual cropland	6.74	13.51	6.77
5B2.2b Grassland in perennial cropland	0.59	0.94	0.35
5B2.3a Wetlands in annual cropland	0.00	0.00	0.00
5B2.3b Wetlands in perennial cropland	0.00	0.00	0.00
5B2.4a Settlements in annual cropland	0.00	0.00	0.00
5B2.4b Settlements in perennial cropland	0.00	0.00	0.00
5B2.5a Other land in annual cropland	0.00	0.00	0.00
5B2.5b Other land in perennial cropland	0.00	0.00	0.00
5. C Grassland	1,210.53	1,216.85	6.32
5C1. Grassland remaining grassland	1,179.49	1,147.30	-31.36
5C2. LUC in grassland	31.03	69.55	37.68
5C2.1 Forest land in grassland	0.00	0.00	0.00
5C2.2a Annual cropland in grassland	28.35	63.86	34.66
5C2.2b Perennial cropland in grassland	2.68	5.68	3.01
5C2.3 wetlands in grassland	0.00	0.00	0.00
5C2.4 Settlements in grassland	0.00	0.00	0.00
5C2.5 Other land in grassland	0.00	0.00	0.00
5. D Wetlands	72.32	74.37	2.05
5D1. Wetlands remaining wetlands	70.06	72.70	2.64
5D2. LUC in wetlands	2.26	1.67	-0.59
5D2.1 Forest land in wetlands	0.00	0.00	0.00
5D2.2a Annual cropland in wetlands	2.04	1.51	-0.53
5D2.2b Perennial cropland in wetlands	0.23	0.17	-0.06
5D2.3 Grassland in wetlands	0.00	0.00	0.00
5D2.4 Settlements in wetlands	0.00	0.00	0.00
5D2.5 Other land in wetlands	0.00	0.00	0.00
5. E Settlements	212.98	256.02	43.04
5E1. Settlements remaining Settlements	190.89	216.32	25.43
5E2. LUC in Settlements	22.09	39.70	17.61
5E2.1 Forest land in Settlements	0.23	2.91	2.68
5E2.2a Annual cropland in Settlements	12.89	16.56	3.66
5E2.2b Perennial cropland in Settlements	1.43	1.84	0.41
5E2.3 Grassland in Settlements	7.54	18.40	10.86
5E2.4 Wetlands in Settlements	0.00	0.00	0.00
5E2.5 Other land in Settlements	0.00	0.00	0.00
5. F Other land	237.34	238.09	0.75
5F1. Other land remaining other land	237.34	238.09	0.75
5F2. LUC in Other land	0.00	0.00	0.00
5F2.1 Forest land in Other land	0.00	0.00	0.00
5F2.2a Annual cropland in Other land	0.00	0.00	0.00

Area in kha	1990	2012	2012-1990
5F2.2b Perennial cropland in Other land	0.00	0.00	0.00
5F2.3 Grassland in Other land	0.00	0.00	0.00
5F2.3 Wetlands in Other land	0.00	0.00	0.00
5F2.5 Settlements in other land	0.00	0.00	0.00
Total area Croatia	5,659.40	5,659.40	0.00

Table 7.1-4 Land use matrixes

Category	FL	CL	GL	WL	SL	OL
FL	**2,302.471**				0.000	
CL		**1,623.401**	0.000	0.226	0.377	
GL	0.000	0.366	**1,210.526**		0.377	
WL				**72.094**		
SL					**212.226**	
OL						**237.336**
1990 calculated	**2,302.471**	**1,623.767**	**1,210.526**	**72.320**	**212.980**	**237.336**
1990 reported	**2,302.471**	**1,623.767**	**1,210.526**	**72.320**	**212.980**	**237.336**
FL	**2,302.471**				0.000	
CL		**1,620.030**	2.161	0.189	0.556	
GL	0.213	0.103	**1,210.484**		0.556	
WL				**72.320**		
SL					**212.980**	
OL						**237.893**
1991 calculated	**2,302.684**	**1,620.133**	**1,212.644**	**72.509**	**213.537**	**237.893**
1991 reported	**2,302.684**	**1,607.072**	**1,212.644**	**72.509**	**214.093**	**250.398**
FL	**2,302.684**				0.000	
CL		**1,603.386**	2.941	0.189	0.556	
GL	0.163	0.103	**1,211.822**		0.556	
WL				**72.509**		
SL					**214.093**	
OL						**250.398**
1992 calculated	**2,302.847**	**1,603.489**	**1,214.763**	**72.699**	**215.206**	**250.398**
1992 reported	**2,302.847**	**1,604.209**	**1,214.763**	**72.699**	**215.206**	**249.678**
FL	**2,302.847**				0.000	
CL		**1,601.500**	2.520	0.189	0.000	
GL	0.298	0.103	**1,214.361**		0.000	
WL				**72.699**		
SL					**216.318**	
OL						**248.565**
1993 calculated	**2,303.144**	**1,601.603**	**1,216.881**	**72.888**	**216.318**	**248.565**
1993 reported	**2,303.144**	**1,601.345**	**1,216.881**	**72.888**	**216.318**	**248.823**
FL	**2,303.085**				0.059	
CL		**1,598.676**	2.480	0.189	0.000	
GL	0.259	0.103	**1,216.519**		0.000	

Category	FL	CL	GL	WL	SL	OL
WL				72.888		
SL					217.372	
OL						247.769
1994 calculated	2,303.344	1,598.779	1,218.999	73.077	217.431	247.769
1994 reported	2,303.344	1,598.482	1,218.999	73.077	217.431	248.066
FL	2,303.341				0.003	
CL		1,593.676	3.535	0.189	1.082	
GL	0.232	0.103	1,217.583		1.082	
WL				73.077		
SL					216.378	
OL						249.120
1995 calculated	2,303.572	1,593.780	1,221.118	73.267	218.544	249.120
1995 reported	2,303.572	1,595.619	1,221.118	73.267	218.544	247.281
FL	2,303.572				0.000	
CL		1,591.808	3.065	0.189	0.556	
GL	0.287	0.103	1,220.170		0.556	
WL				73.267		
SL					218.544	
OL						247.281
1996 calculated	2,303.860	1,591.911	1,223.236	73.456	219.657	247.281
1996 reported	2,303.860	1,592.756	1,223.236	73.456	219.657	246.436
FL	2,303.781				0.079	
CL		1,589.114	2.935	0.189	0.517	
GL	0.196	0.103	1,222.419		0.517	
WL				73.456		
SL					219.657	
OL						246.436
1997 calculated	2,303.978	1,589.218	1,225.354	73.645	220.769	246.436
1997 reported	2,303.978	1,589.892	1,225.354	73.645	220.769	245.761
FL	2,303.873				0.105	
CL		1,586.213	2.986	0.189	0.504	
GL	0.260	0.103	1,224.487		0.504	
WL				73.645		
SL					220.769	
OL						245.761
1998 calculated	2,304.133	1,586.316	1,227.472	73.834	221.882	245.761
1998 reported	2,304.133	1,587.029	1,227.472	73.834	221.882	245.049
FL	2,304.101				0.032	
CL		1,583.206	3.094	0.189	0.540	
GL	0.332	0.103	1,226.497		0.540	
WL				73.834		
SL					221.882	
OL						245.049

Category	FL	CL	GL	WL	SL	OL
1999 calculated	2,304.432	1,583.309	1,229.591	74.024	222.995	245.049
1999 reported	2,304.432	1,590.224	1,229.591	74.024	222.995	238.134
FL	2,304.264				0.168	
CL		1,586.625	2.938	0.189	0.472	
GL	0.244	0.103	1,228.771		0.472	
WL				74.024		
SL					222.995	
OL						238.134
2000 calculated	2,304.508	1,586.728	1,231.709	74.213	224.108	238.134
2000 reported	2,304.508	1,591.808	1,231.709	74.213	224.108	233.054
FL	2,304.154				0.354	
CL		1,589.340	1.302	0.013	1.152	
GL	0.254	1.135	1,229.168		1.152	
WL				74.213		
SL					224.108	
OL						233.054
2001 calculated	2,304.407	1,590.475	1,230.470	74.226	226.767	233.054
2001 reported	2,304.407	1,587.474	1,230.470	74.226	226.767	236.055
FL	2,304.180				0.227	
CL		1,584.834	1.411	0.013	1.216	
GL	0.299	1.135	1,227.820		1.216	
WL				74.226		
SL					226.767	
OL						236.055
2002 calculated	2,304.479	1,585.969	1,229.232	74.239	229.426	236.055
2002 reported	2,304.479	1,583.141	1,229.232	74.239	229.426	238.883
FL	2,304.384				0.095	
CL		1,580.383	1.462	0.013	1.282	
GL	0.284	1.135	1,226.531		1.282	
WL				74.239		
SL					229.426	
OL						238.883
2003 calculated	2,304.668	1,581.518	1,227.993	74.253	232.086	238.883
2003 reported	2,304.668	1,578.807	1,227.993	74.253	232.086	241.594
FL	2,304.321	0.042			0.305	
CL	0.032	1,575.925	1.692	0.013	1.177	
GL	0.619	1.135	1,225.062		1.177	
WL				74.253		
SL					232.086	
OL						241.636
2004 calculated	2,304.972	1,577.102	1,226.754	74.266	234.745	241.636
2004 reported	2,304.972	1,574.474	1,226.754	74.266	234.745	244.190
FL	2,304.607	0.030			0.335	

Category	FL	CL	GL	WL	SL	OL
CL	0.061	**1,569.255**	4.043	0.013	1.162	
GL	2.985	1.135	**1,221.472**		1.162	
WL				**74.266**		
SL					**234.745**	
OL						**244.220**
2005 calculated	**2,307.653**	**1,570.420**	**1,225.516**	**74.279**	**237.404**	**244.220**
2005 reported	2,307.653	1,570.140	1,225.516	74.279	237.404	244.408
FL	**2,307.300**	0.028			0.324	
CL	0.064	**1,565.087**	3.872	0.013	1.167	
GL	2.809	1.135	**1,220.405**		1.167	
WL				**74.279**		
SL					**237.404**	
OL						**244.436**
2006 calculated	**2,310.173**	**1,566.250**	**1,224.277**	**74.292**	**240.063**	**244.436**
2006 reported	2,310.173	1,565.807	1,224.277	74.292	240.063	244.788
FL	**2,309.948**	0.147			0.078	
CL	0.082	**1,559.436**	5.067	0.013	1.290	
GL	3.880	1.135	**1,217.972**		1.290	
WL				**74.292**		
SL					**240.063**	
OL						**244.935**
2007 calculated	**2,313.910**	**1,560.718**	**1,223.038**	**74.305**	**242.723**	**244.935**
2007 reported	2,313.910	1,561.473	1,223.038	74.305	242.723	243.950
FL	**2,313.501**	0.131			0.278	
CL	0.084	**1,557.432**	2.837	0.013	1.191	
GL	1.750	1.135	**1,218.963**		1.191	
WL				**74.305**		
SL					**242.723**	
OL						**244.082**
2008 calculated	**2,315.335**	**1,558.699**	**1,221.800**	**74.318**	**245.382**	**244.082**
2008 reported	2,315.335	1,557.140	1,221.800	74.318	245.382	245.426
FL	**2,314.729**	0.487			0.119	
CL	0.122	**1,550.362**	5.494	0.013	1.270	
GL	4.328	1.135	**1,215.067**		1.270	
WL				**74.318**		
SL					**245.382**	
OL						**245.912**
2009 calculated	**2,319.179**	**1,551.984**	**1,220.561**	**74.332**	**248.041**	**245.912**
2009 reported	2,319.179	1,552.806	1,220.561	74.332	248.041	244.481
FL	**2,318.830**	0.171			0.179	
CL	0.164	**1,545.773**	5.780	0.013	1.240	
GL	4.644	1.135	**1,213.542**		1.240	
WL				**74.332**		

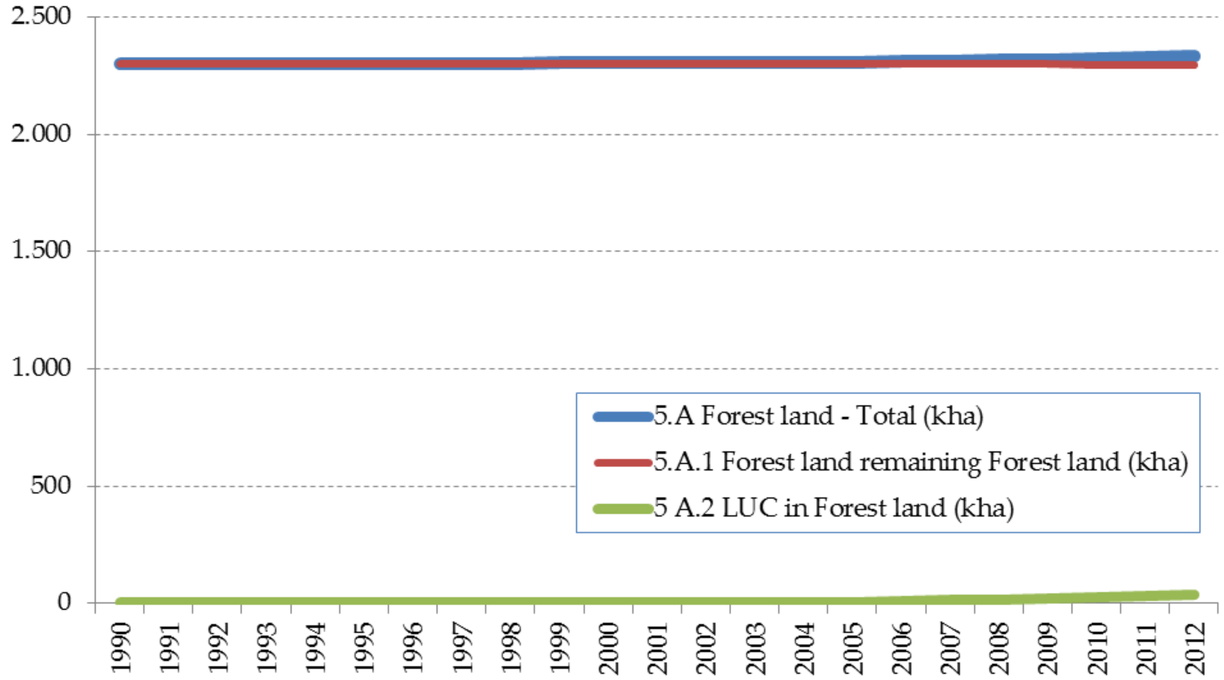
Category	FL	CL	GL	WL	SL	OL
SL					**248.041**	
OL						**244.652**
2010 calculated	**2,323.637**	**1,547.078**	**1,219.322**	**74.345**	**250.701**	**244.652**
2010 reported	2,323.637	1,548.473	1,219.322	74.345	250.701	242.922
FL	**2,323.446**	0.167			0.025	
CL	0.140	**1,540.024**	7.118	0.013	1.317	
GL	5.904	1.135	**1,210.966**		1.317	
WL				**74.345**		
SL					**250.701**	
OL						**243.089**
2011 calculated	**2,329.491**	**1,541.326**	**1,218.084**	**74.358**	**253.360**	**243.089**
2011 reported	2,329.491	1,544.139	1,218.084	74.358	253.360	239.969
FL	**2,329.246**	0.104			0.141	
CL	0.267	**1,536.952**	5.915	0.013	1.259	
GL	4.760	1.135	**1,210.930**		1.259	
WL				**74.358**		
SL					**253.360**	
OL						**240.073**
2012 calculated	**2,334.273**	**1,538.191**	**1,216.845**	**74.371**	**256.019**	**240.073**
2012 reported	2,334.273	1,539.806	1,216.845	74.371	256.019	238.087

7.2. FOREST LAND (5.A)

7.2.1 DESCRIPTION

Under this land category, CO_2 emissions/removals from soil and living biomass[17] 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. CO_2 and non-CO_2 emissions due to wildfires are estimated and reported for the *Forest land remaining forest land* and *Land converted to Forest land* separately based on the data and information that are gained through the survey under the LULUCF 1 project. Emissions for total category of *Forest land* are presented in Table 7.2.1 and detailed description of conducted survey is presented in Chapter 7.12.
Figure 7.2-1 represents the trend of forest area and LUC area to forest land in conversion period of 20 years as it was determined through survey performed under the LULUCF 1 project.

[17] Below ground biomass is combined with the above ground and thus the notation key IE is used for below ground biomass.



* 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 (1990-2012) in kha**

CO_2 removals from forest land remaining forest land in 2012 are -7,508.83 Gg CO_2 and from Land converted to Forest land -181.42 Gg CO_2. Therefore, the share of removals from land conversion in total Forest land removals makes only 2.4%. Annual emissions/removals from each land use category to forest land are presented in Table 7.2-1.

Table 7.2.-1: Emissions/Removals of CO2 in Forest land category (Gg CO_2)

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	-7,587.47	-7,548.19	-39.28	0.00	-39.28	NO	NO	NO
1991	-9,355.40	-9,319.15	-36.26	0.00	-36.26	NO	NO	NO
1992	-9,744.90	-9,708.14	-36.76	0.00	-36.76	NO	NO	NO
1993	-10,066.40	-10,030.52	-35.88	0.00	-35.88	NO	NO	NO
1994	-9,904.95	-9,867.67	-37.27	0.00	-37.27	NO	NO	NO
1995	-10,375.88	-10,337.68	-38.19	0.00	-38.19	NO	NO	NO

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
1996	-10,216.62	-10,178.18	-38.44	0.00	-38.44	NO	NO	NO
1997	-9,655.51	-9,615.47	-40.03	0.00	-40.03	NO	NO	NO
1998	-9,655.21	-9,615.35	-39.86	0.00	-39.86	NO	NO	NO
1999	-9,765.52	-9,725.25	-40.27	0.00	-40.27	NO	NO	NO
2000	-9,528.64	-9,486.27	-42.37	0.00	-42.37	NO	NO	NO
2001	-9,530.84	-9,487.88	-42.97	0.00	-42.97	NO	NO	NO
2002	-9,640.58	-9,596.99	-43.59	0.00	-43.59	NO	NO	NO
2003	-9,382.96	-9,338.03	-44.92	0.00	-44.92	NO	NO	NO
2004	-9,193.02	-9,148.37	-44.65	0.73	-45.38	NO	NO	NO
2005	-9,258.18	-9,237.69	-20.49	1.28	-21.78	NO	NO	NO
2006	-9,129.55	-9,093.06	-36.49	0.77	-37.26	NO	NO	NO
2007	-8,660.99	-8,623.60	-37.39	0.75	-38.14	NO	NO	NO
2008	-8,702.57	-8,615.92	-86.64	-0.50	-86.14	NO	NO	NO
2009	-8,860.33	-8,787.86	-72.48	-0.49	-71.98	NO	NO	NO
2010	-8,653.45	-8,547.42	-106.03	-1.19	-104.84	NO	NO	NO
2011	-7,772.45	-7,653.58	-118.87	-3.65	-115.22	NO	NO	NO
2012	-7,690.26	-7,508.83	-181.42	-2.89	-178.53	NO	NO	NO

Table 7.2.-2: CO_2 emissions from wildfires

Year	Area burnt (ha)	CO_2 emission CO_2 equivalent (Gg)	CH_4 emission CO_2 equivalent (Gg)	N_2O emission CO_2 equivalent (Gg)
1990	482	14.62	1.42	0.33
1991	1,291	39.15	3.81	0.87
1992	5,864	177.75	17.31	3.96
1993	14,102	427.48	41.63	9.52
1994	4,591	139.18	13.55	3.10
1995	3,011	91.27	8.89	2.03
1996	6,494	196.85	19.17	4.38
1997	6,885	208.70	20.32	4.65
1998	17,093	518.15	50.46	11.54
1999	1,830	55.47	5.40	1.24
2000	37,364	1132.64	110.30	25.23
2001	6,880	208.55	20.31	4.65

Year	Area burnt (ha)	CO_2 emission CO_2 equivalent (Gg)	CH_4 emission CO_2 equivalent (Gg)	N_2O emission CO_2 equivalent (Gg)
2002	2,414	73.17	7.13	1.63
2003	15,395	466.69	45.45	10.39
2004	839	25.43	2.48	0.57
2005	913	27.66	2.69	0.62
2006	2,322	70.39	6.85	1.57
2007	12,575	381.19	37.12	8.49
2008	3,643	110.42	10.75	2.46
2009	2,044	61.95	6.03	1.38
2010	688	20.85	2.03	0.46
2011	6,478	196.38	19.12	4.37
2012	15,270	462.89	45.08	10.31

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* and collected through the surveys under the LULUCF 1 project 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 *Ordinance*[18] *on Forest Management* 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, In February this year Croatian Government adopted changes to Forest Act re-establishing this service again.

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.
The system is divided in 16 organizational and territorial units – regional forest administrations (Figure 7.2-2). This division was established in 1996.

Regional forests administrations consist of regional forest offices and today Croatian area is divided into 170 regional forest offices. The forest office is the basic organizational unit for performing all expert and technical activities in forest management and they are directly supervised by the regional forest administration. 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 forest administration divided into 12 forest offices is presented in Figure 7.2-3.

Each forest office 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

[18] Ordinance on Forest Management (OG 111/06, 141/08)

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 office is variable. Figure 7.2-4 shows forest office “Cerna” and its division 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 7.2-5 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 7.2-6 shows that compartment 7 of the management unit “Krivsko ostrvo” is divided into 3 sub-compartments.

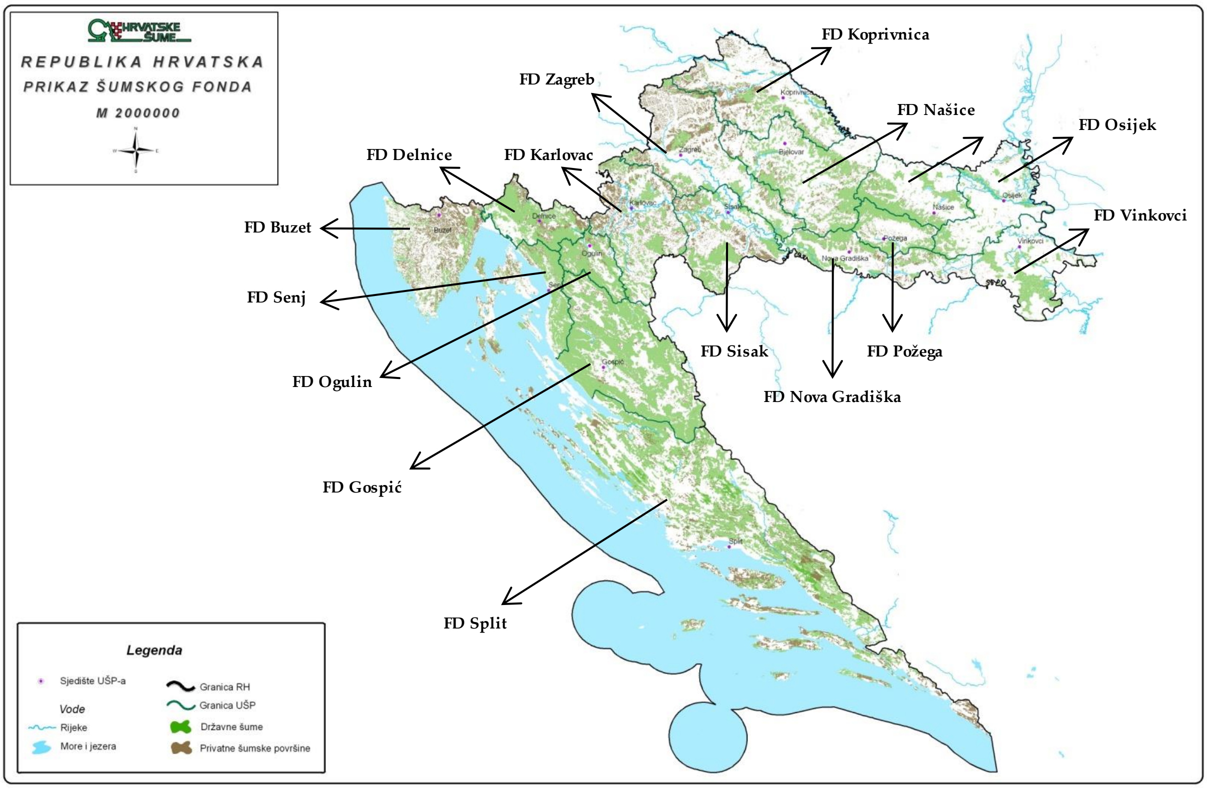


Figure 7.2-2: Spatial division of the Republic of Croatia on forest districts

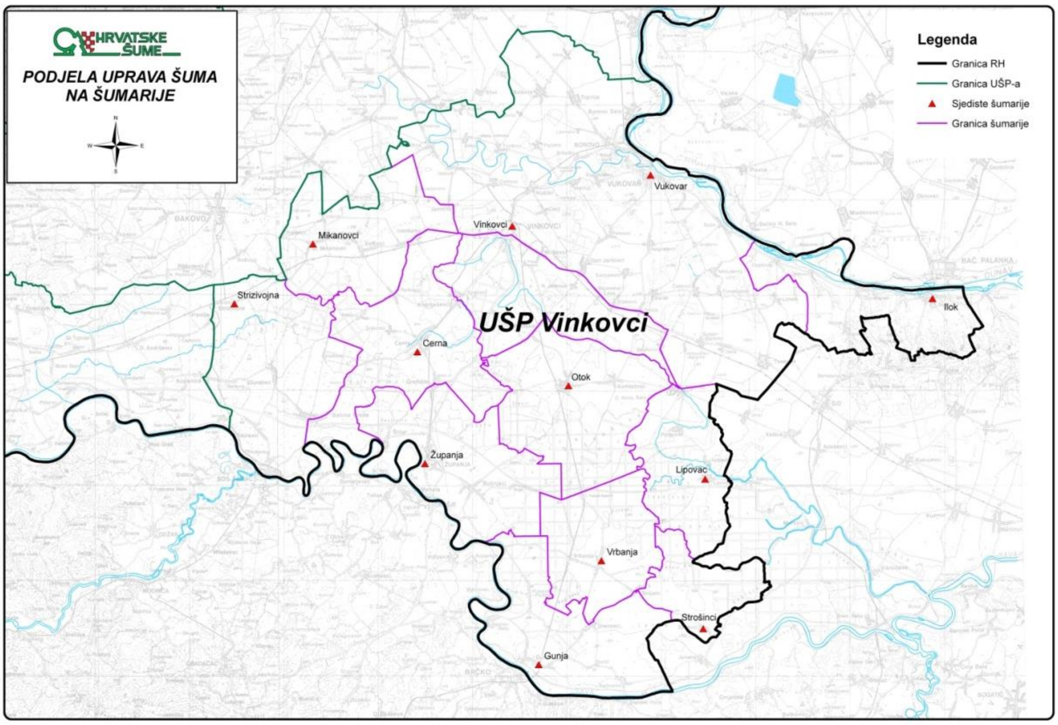


Figure 7.2-3: Division of forest district "Vinkovci" on related forest units (example, UŠP refers to FD)

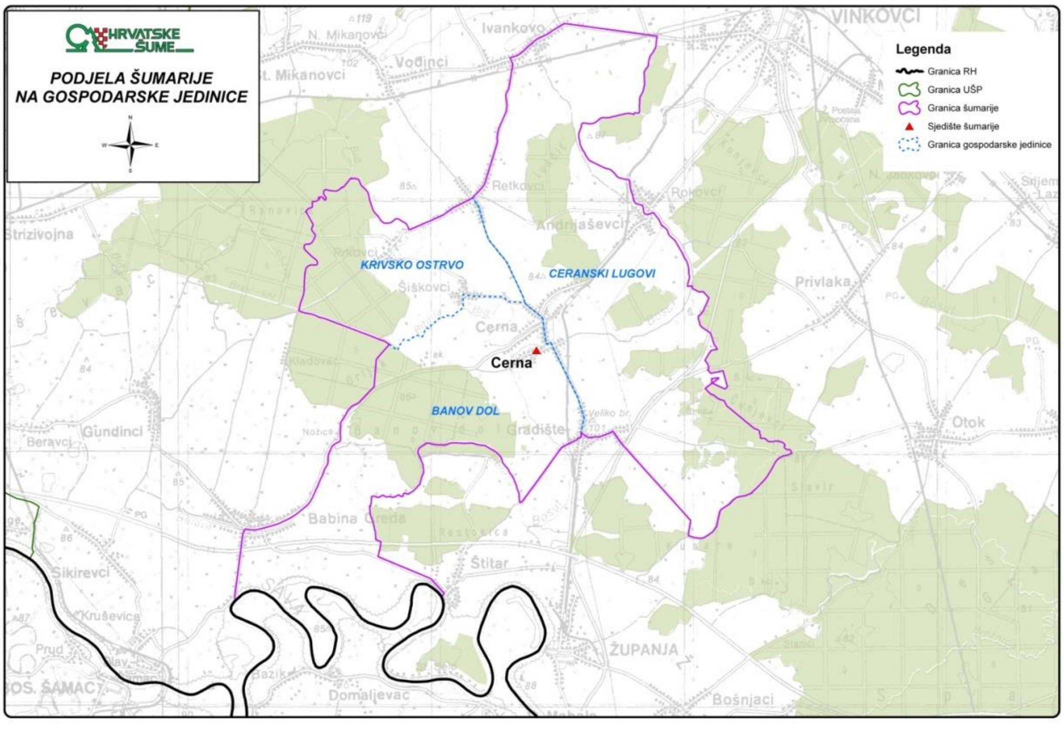


Figure 7.2-4: Area of a forest unit "Cerna" with the spatial division on related management units (example)

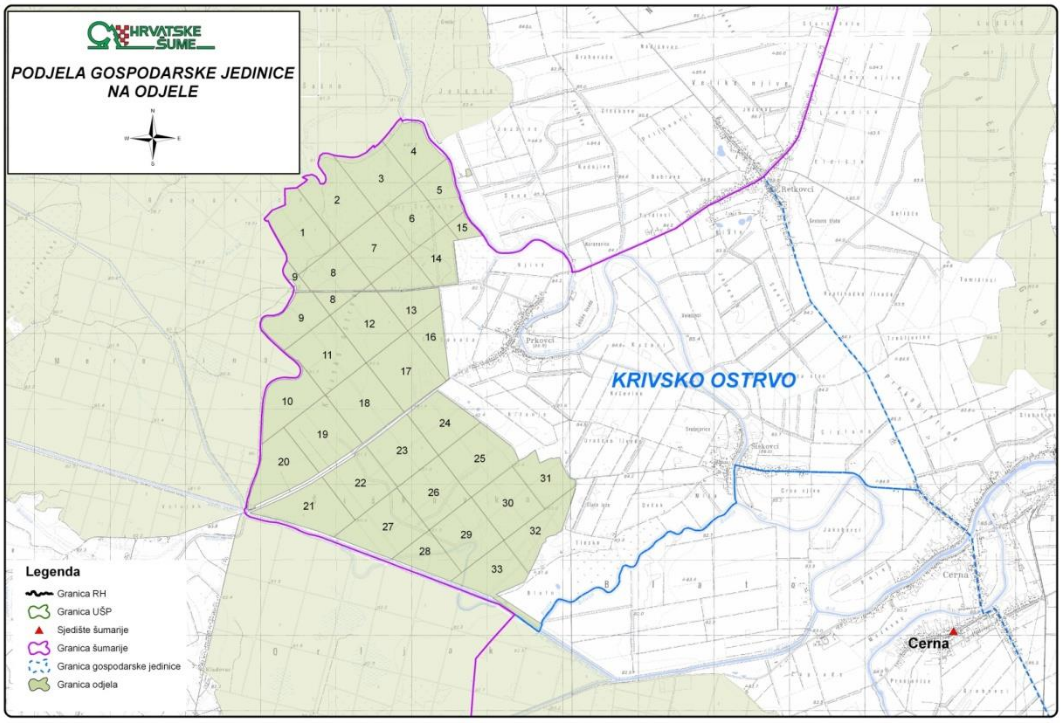


Figure 7.2-5: Area of a management unit "Krivsko ostrvo" divided into compartments (example)

Figure 7.2-6: Compartment area divided into sub-compartments (example)

Short scheme of the system's structure is presented in Figure 7.2-7.

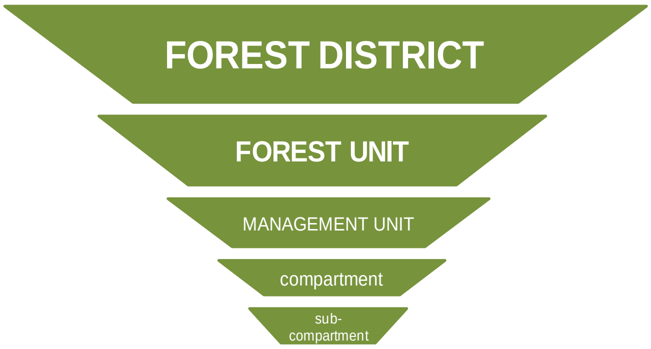


Figure 7.2-7: The scheme of the national system's structure

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) and presents forest area in Croatia as defined by *Forest Act* and *Ordinance on Forest management*.

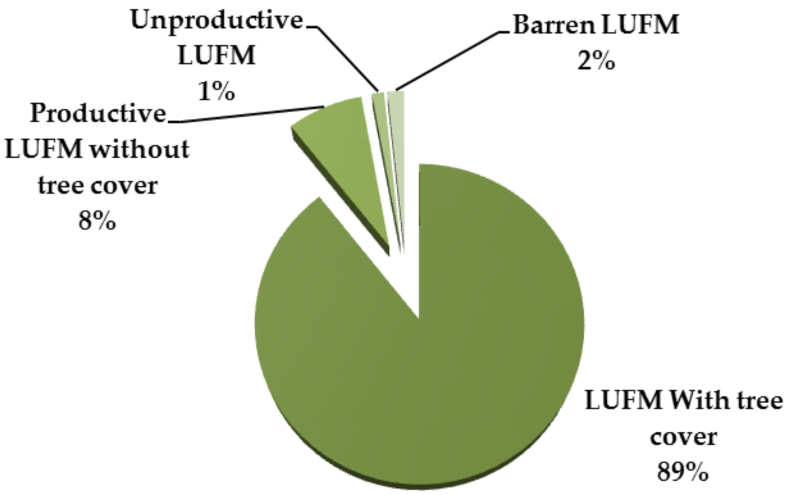


Figure 7.2-8: The share of categories of land under the forest management (LUFM)

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 7.2-9,

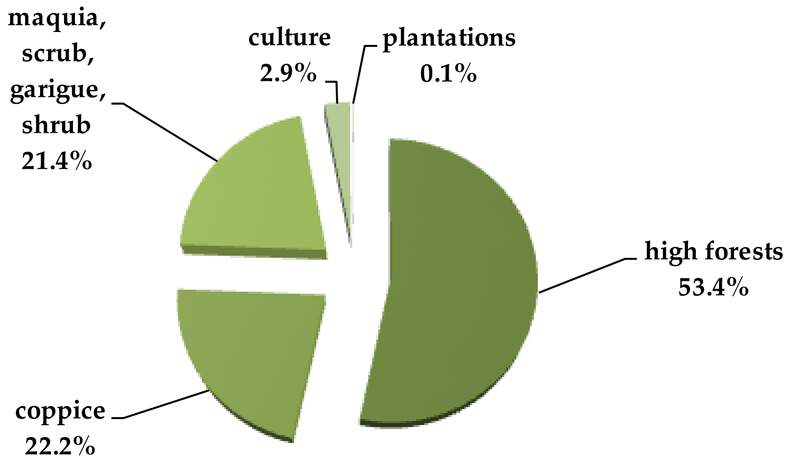


Figure 7.2-9: The share of each forest stand in forest land with tree cover, year 2006

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 7.2-10).

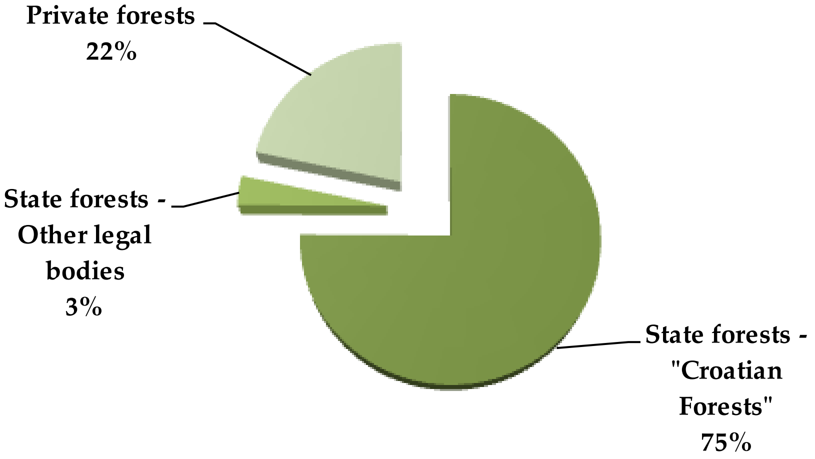


Figure 7.2-10: The ownership structure of forest area in Croatia, year 2006

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. m^3 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, garigue and scrub forests and this is why carbon stock changes in these forests are not taken into consideration in the report. In case of maquies and shrub forests estimation was done for this year reporting for the first time.

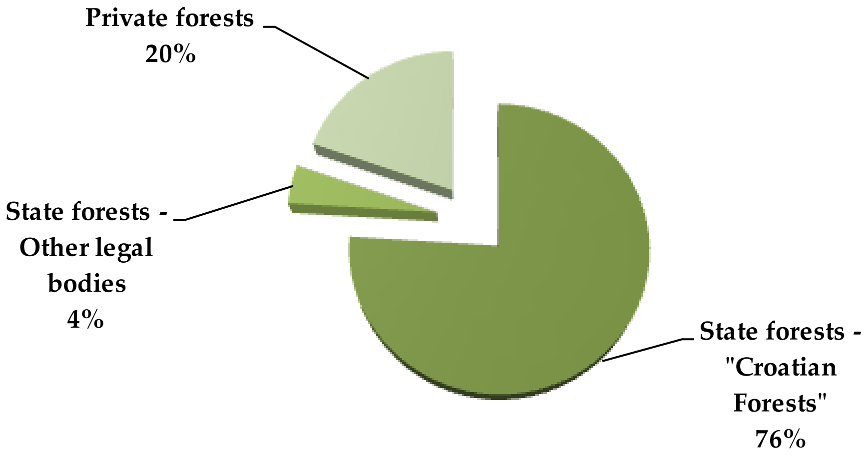


Figure 7.2-11: The share of growing stock in state and private forests, year 2006

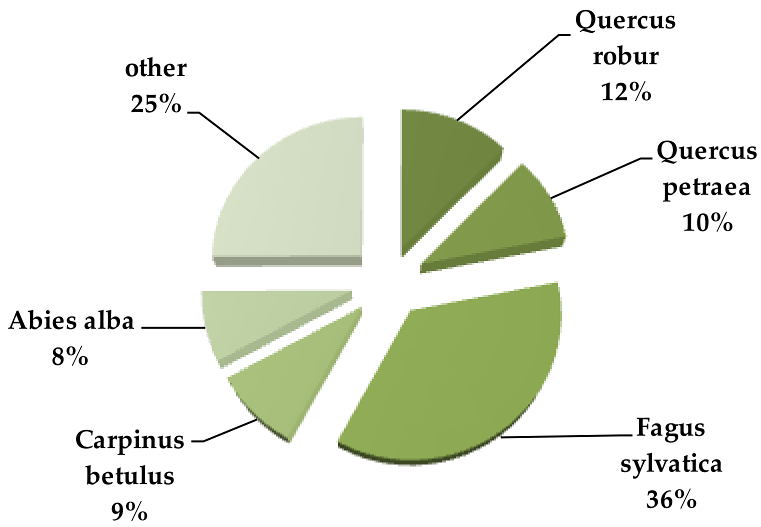


Figure 7.2-12: Share of main species in total growing stock, year 2006

- 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 legislation[19], 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 7.2-13.

- 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 legislation[20], 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 7.2-13.

[19] Ordinance on Forest Management (OG 111/06, 141/08)
[20] Ordinance on Forest Management (OG 111/06, 141/08)

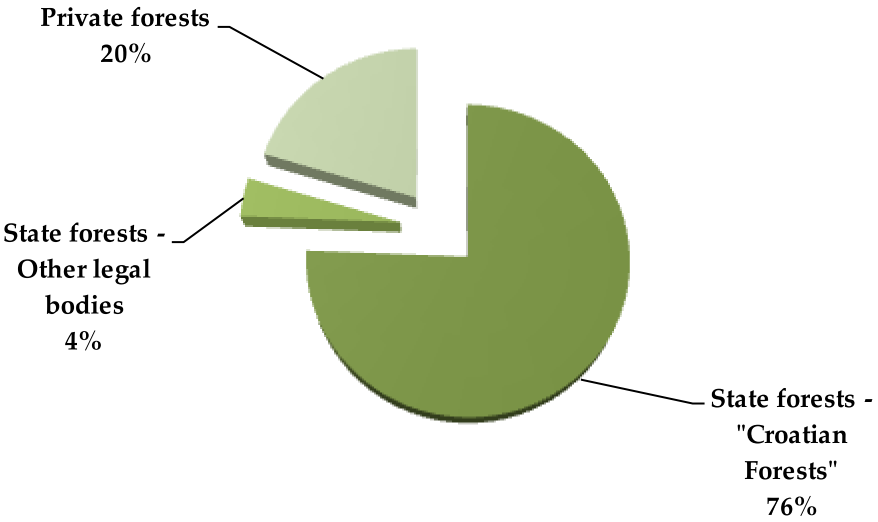


Figure 7.2-13: The share of increment in state and private forests, year 2006

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* and *Cropland* 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 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 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. Therefore, the *Forest* *land remaining forest land* is forest land covered with high forests, plantations, cultures, coppice, maquies and shrub.

According to the *Ordinance*[21] 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)
- 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 1990-2012 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:

$$\Delta C_{FFLB} = (\Delta CFFG_{CFj} - \Delta CFFL_{CFj}) + (\Delta CFFG_{Other\,j} - \Delta CFFL_{Other\,j}) + (\Delta CFFG_{Private\,j} - \Delta CFFL_{Private\,j})$$

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}

$\Delta CFFG_{CFj}$, $\Delta CFFG_{Other\,j}$, $\Delta CFFG_{Private\,j}$ = 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}

$\Delta CFFL_{CFj}$, $\Delta CFFL_{Other\,j}$, $\Delta CFFL_{Private\,j}$ = annual decrease in carbon stocks due to biomass loss, in state forests managed by "Croatian Forests" (CF), other state forests (Other) and private forests (Private), by forest types (j=1,2), Cyr^{-1}

Where j = 1 - broadlevaed
2 - coniferous

The activity data for CO_2 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.

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, coniferous and maquies and shrub forests for all type of forest ownerships. Data are presented in CRF tables for coniferous, deciduous and Out of yield forests (maquies and shrub) without previously used disaggregation on forest ownerships. Emissions/removals in this category of land are calculated for whole Crotaia without taking into consideration type of ownership.

[21] Ordinance on Forest Management (OG 111/06, 141/08). See list of references

Since the War period, in Croatia there is an active process of returning previously confiscated forests to private owners[22] which makes difficult to follow difference in area based on ownership structure which was one of reasons for performing estimation of emissions/removals for whole Croatia without separating forests based on forests ownership.

The carbon loss due to felling 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 felling already include the volume cut after natural disturbances, carbon losses due to natural disturbances are allocated within the carbon losses due to felling. Therefore, notation key IE was used in the CRF tables.

Data used in the CO_2 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
Deciduous	0.56	1.20	0.26	1.40	0.50
Coniferous	0.39	1.15	0.32	1.30	
Out of Yield (maquies and shrub)	0.68	1.0	0.26	NA	

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 investigations[23] and share of species in total growing stock in Croatia[24], 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_o/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% [25].
In case of fir it was concluded that wood density is highly dependable on geological basis and amounts of 0.37 t d.m/m^3 or 0.405 t d.m/m^3 depending on whether fir appears on silicate or limestone[26]. Since there is no exact

[22] Draft strategy for management and disposal of property of the Republic of Croatia 2013-2017. See list of References

[23] Scientific papers of Badjun, Horvat,Sinković, Govorčin, Štajduhar. See list of References
[24] Forest Management Area Plan of the Republic of Croatia 2006-2015. See list of References
[25] Scientific paper of Sinković, Govorčin and Sedlar. See list of References
[26] Scientific paper of Horvat. See list of References

data about area of fir on silicate and limestone, mean value of 0.387 t d.m/m^3 was used when calculating contribution of fir wood density to the wood density of coniferous species in general.

It was concluded by expert judgement that oriental hornbeam should be used as representative specie of maquies and scrub forests. Wood density of hornbeam in absolute dry[27] were used and corrected by the shrinkage factor of 19.7% in order to calculate wood density of absolute dry wood per fresh volume. Since shrinking factor for oriental hornbeam was not subject of scientific investigation on national level so far, shrinkage factor determined on national level as valid for all *Carpinus genus* was used[28].

The detailed overview of the approach is shown below:

$$\mathbf{\Delta C_{FFLB} = \Delta CFFG_{CFj} - \Delta CFFL_{CFj}}$$

$$\mathbf{\Delta CFFG_{CF}} = \Sigma_j (I_{t1CFj} \times Dj \times BEF1j \times (1+Rj) \times CF$$

Where:

$\Delta CFFG_{CFj}$ = annual increase in carbon stocks due to biomass growth by forest types (j=1,2), Cyr^{-1}

$\Delta CFFL_{CFj}$ = annual decrease in carbon stocks due to biomass losses by forest types (j=1,2), Cyr^{-1}

I_{t1CFj} = Increment in forests managed at time t_1, by forest types (j=1,2), m^3

H_{t1CFj} = gross volume felled at time t_1 (all losses), by forest types (j=1,2), m^3

D_j = basic wood density, by forest types (j=1,2), tonnes d.m,m^{-3}

$BEF1_j$ = 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 = Root-to-shoot ratio appropriate to increments, by forest types (j=1,2), dimensionless

[27] Scientific paper of Govorčin, Sinković, Trajković, Šefc. See list of References
[28] Mali šumarsko-tehnički priručnik. See list of References

CF	=	carbon fraction of dry matter, (tonnes d.m)$^{-1}$
$\Delta CFFL_{CF}$	=	$L_{fellings}+L_{fuelwood}+L_{other\ losses}$
$L_{fellings}$	=	$\Sigma_j H_{t1CFj} \times D_j \times BEF2_j \times CF$
H_{t1CFj}	=	gross volume felled in forests at time t_1, by forest types (j=1,2), m^3
$BEF2_j$	=	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
$L_{other\ losses}$	=	no other losses, already included in volume felled

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. Corresponding arguments are provided under the Chapter 11.3.1.1.

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. Corresponding arguments are provided under the Chapter 11.3.1.1.

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. Corresponding arguments are provided under the Chapter 11.3.1.1.

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 1990-2012.

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 estimation of emissions/removals was the area afforested. In order to identify complete afforested areas, both types of afforestation were included in the survey as defined by IPCC GPG: afforestation by seeding and planting and afforestation due to human induced promotion of natural seed sources. The survey was conducted within the framework of project *"Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol"*(LULUCF 1) in order to comply with requirements set in ARR 2012.The project was initiated by Ministry of Environmental and Nature Protection through joint cooperation with relevant institutions.
All data and information concerning afforested areas are presented in a separate document[29] as one of outcomes of the project. Detailed description of the conducted survey is presented in Chapter 11.1.3.1.

In case of State owned forests that are managed by other legal bodies, conducted analyses proved that there is no increase of forests area in this type of forest ownership due to conversion from other land use categories. This applies conversion to forest land in case of afforesattion by seeding and planting and also afforestation due to human induced promotion of natural seed sources. This was an expected outcome since forests belonging to this category of ownership are under strict or certain type of protection under provisions of Low of nature protection and their area is fixed, well known and can not be changed without strict legal procedures that require involvements of many institutions in Croatia.

Conducted survey showed that increase in forest area happens in state owned forests managed by Croatian forests Ltd, and private forests as a result of afforestation due to human induced promotion of natural seed sources in period 1990-2012. Additionally, analyses proved that conversion to forest land due to afforestation by seeding and planting occurs only in case of state owned forests managed by Croatian forests Ltd.

In case of afforestation in private forests generated through planting and seeding measures, analyses conducted through LULUCF 1 project proved that in period 1990-2012 in private forests no afforestation has occurred

[29] D. Janes & all (2014), Separation of areas under the Article 3.3 and 3.4 of the Kyoto protocol. See list of References

through planting and seeding measures. This was expected outcome, since according to the Ordinance[30] that prescribes rules for entitlement to funding for work performed in private forests and Article 9 of the Ordinance on the Register of forest owners[31], funds can be obtained by private owners only for works performed on area that is registered in cadastre as forest or land 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 meant that some of afforestation work could occur on grasslands owned by private owners. The type of land that is without real forest cover on private lands and which is in cadastre registered as forest land 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 did not occur.

Through the conducted survey detailed data and information about conversion to forest land category through seeding and planting measures were collected and areas of conversion are well know (**Figure 7.2-1**)

[30] Regulations on the procedure for granting funds from fees for the use of beneficial functions of forests for work performed in private forests (OG 66/06, 25/11). See list of References

[31] Ordinance on amendments to the Ordinance on the Register of forest owners (OG 84/2008). See list of References

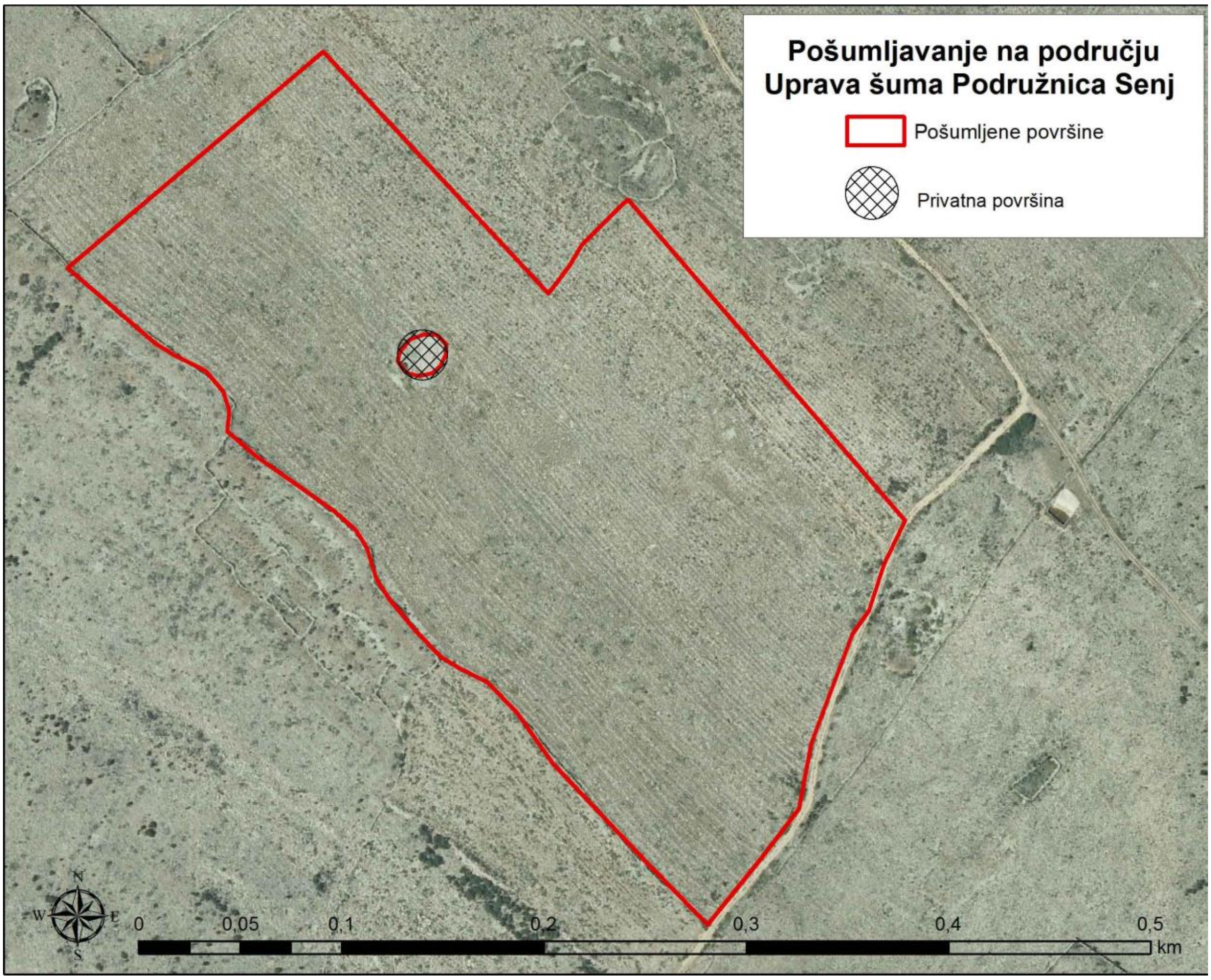


Figure 7.2.-1: *State owned area of land under the forests management (grassland) converted to Forestland (marked in red) and area of private grasslands excluded from conversion, marked as circle*

Total area of grassland, annual Cropland and perennial Cropland converted to Forest land in period 1990-2012 for state and private owned forests through afforestation measures (seeding and planting and human induced promotion of natural seed sources) on yearly bases as it is determined through conducted survey under the LULUCF 1 project is presented in Table 7.2-4.

Table7.2-4: Land converted to forest land (ha)

Year	LUCs		
	aCL – FL	pCL - FL	GL - FL
1990	-	-	-
1991	-	-	213.35
1992	-	-	162.59
1993	-	-	297.99
1994	-	-	258.65

1995	-	-	231.58
1996	-	-	287.49
1997	-	-	196.21
1998	-	-	260.21
1999	-	-	331.75
2000	-	-	243.87
2001	-	-	253.75
2002	-	-	299.41
2003	0.00	0.00	284.19
2004	29.45	2.89	618.97
2005	55.17	5.42	2,985.04
2006	57.92	5.69	2,808.87
2007	75.11	7.37	3,880.09
2008	76.15	7.47	1,750.37
2009	111.49	10.94	4,327.89
2010	149.46	14.67	4,643.51
2011	127.89	12.55	5,904.36
2012	243.39	23.89	4,759.52

In order to perform estimation, in case of period before 1990 (transition period of 20 years), the mean afforestation area 1990-1994 was used.

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 and that was reported by Croatia in NIR 2013, within the scope of LULUCF 1 project Croatia performed a survey to determine reasons for the forest area increase that comes from Other land category. The analyses included all types of forests and all type of forests ownerships. After the conducted analyses and determination of forest area increase as a result of human induce promotion of natural seed sources, conclusion is that there is no conversion from other land to forest land category. Only types of conversion that are identified and geographically explicit determined are conversion from Grassland, annual and perennial Cropland to Forest land. In case of conversion of *Other land* to *Forest land* Croatia reports *Not occurring*. Detailed description of work performed is presented in Chapter 11.1.3.

Conducted survey confirmed that beyond the increase of forest area in state owned forests managed by Croatia forests as a result of afforestation through seeding and planting, an additional increase in area of Private forests and in state owned forests managed by Croatian forests Ltd, due to human-induced promotion of natural seed sources. In case of state owned forests managed by other legal bodies no increase of forest areas was recorded in period 1990-2012.

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 has been estimated for this year reporting also based on the survey conducted through LULUCF 1 project and CO_2 and non-CO_2 emissions are reported under the *Forest land remaining Forest land* and *Land converted to Forest land* subcategory in CRF tables.

A)Biomass

To determine the changes in biomass carbon stocks in areas converted to Forest land in Croatia, results and outcomes of the conducted survey under the LULUCF 1 project were used as presented below:

1.During the reporting period, there was no conversion to forest land from other categories of land in case of state owned forests managed by other legal bodies

2.In private forests conversion from grassland and annual and perennial cropland occurred since 1998. According to the conducted survey, 82.1% conversion refers to conversion of Grasslands, 16.3% to conversion of annual Cropland and 1.6% to conversion of perennial Cropland to forest land. These figures were determined by using and comparing data and information from two consecutive Forest management programs in private forests presenting 10% of areas of private forests that are covered by official forest management programs

3.In case of state owned forests conversion that happens refers only to Grassland converted to forest land. This is a result of the conducted survey based on checks performed using and comparing data and information available at two consecutive forest management plans/programs for when performing survey as described in Chapter 11.3.1

For the purposes of estimation, below presented values according to the type of conversion (from Grassland or Cropland) and type of forests were used:

1.Average annual increments from the IPCC GPG 2003 were used for the aboveground biomass in natural regeneration

2.Values for the *Temperate forest* in age class ≤ 20 years and ≥ 20 years were applied

3.The applied values are the same for both age classes (3 tdm/ha annually (for coniferous), 4 tdm/ha (for deciduous), and 0.5 tdm/ha (for maquies and shrub)

4.Mean values of the average Root to Shoot ratio from IPCC GPG were used (0.46 (for coniferous), 0.43 (for deciduous). Regarding the maquies and shrub forests conservative approach was applied using the lowest value (0.26) from the range defined for *Other forests/woodland*

5.IPCC GPG default value of 0.5 tC/ t dm for the Carbon fraction was used for all types of forests

Based on the above mentioned factors, average biomass growth was calculated to be 2.19 tC/ha annually in case of coniferous forests. Values of 2.86 tC/ha and 0.32 tC/ha as average biomass growth for deciduous and maquies and shrub forests were used accordingly.

In order to calculate the biomass carbon stock losses as a result of grassland and cropland conversion to the forestland, the nationally determined value of 4.29 tC/ ha annually for grassland category and 5.67 tC/ha annually for annual Cropland category were used. When estimating carbon stock losses due to conversion of perennial Cropland to forestland IPCC GPG value of 63.0 tC/ha annually was used.

Although, estimation was performed taking into consideration also type of forests (i.e. area of grassland that are converted to deciduous forests, to coniferous forests and to maquies and shrub forests separately) data that corresponds to whole forest area in specific years are presented in CRF database under specific categories of LUC.

B) Soil

The 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 method[32] 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.

The estimates of the soil carbon stock changes at land converted to forest land (afforestation) follow the equation below:

$$\Delta C_{LFMineral} = [(SOC_{ref} - SOC_{Non\ Forest\ Land}) \times A_{Aff}]/T_{Aff}$$

where:

$\Delta C_{LFMineral}$ = annual change in carbon stock in mineral soils for inventory year
SOC_{ref} = reference carbon stock
$SOC_{Non\ Forest\ Land}$ = stable soil organic carbon on previous land use
T_{Aff} = duration of the transition from $SOC_{Non\ Forest\ Land}$ to SOC_{ref} (20 years)
A_{Aff} = total afforested/reforested area after conversion

[32] Work performed by Croatian Geological Institute. See list of References

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

Soil removal factor determined in this case is 0.695 tC/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 CO_2 removal.

Table 7.2-5: Annual change in carbon stock in living biomass and soil for Land converted to forest land

Gg C					
Year	Biomass carbon stocks gains	Biomass carbon stocks losses	Biomass net carbon stock change	Net soil carbon stock change	Total
1990	8.25	0.00	8.25	2.46	10.71
1991	8.32	-0.92	7.41	2.48	9.89
1992	8.26	-0.70	7.56	2.46	10.02
1993	8.52	-1.28	7.24	2.54	9.78
1994	8.68	-1.11	7.57	2.59	10.17
1995	8.79	-0.99	7.79	2.62	10.42
1996	9.02	-1.23	7.79	2.69	10.48
1997	9.06	-0.84	8.22	2.70	10.92
1998	9.24	-1.12	8.12	2.75	10.87
1999	9.55	-1.42	8.13	2.85	10.98
2000	9.71	-1.05	8.66	2.89	11.56
2001	9.87	-1.09	8.78	2.94	11.72
2002	10.16	-1.29	8.87	3.02	11.89
2003	10.39	-1.22	9.17	3.09	12.25
2004	11.74	-3.01	8.73	3.44	12.18
2005	13.57	-13.47	0.09	5.50	5.59
2006	15.27	-12.75	2.52	7.43	9.95
2007	17.61	-17.55	0.05	10.14	10.20

Gg C					
Year	Biomass carbon stocks gains	Biomass carbon stocks losses	Biomass net carbon stock change	Net soil carbon stock change	Total
2008	20.67	-8.42	12.25	11.38	23.63
2009	25.20	-19.91	5.29	14.47	19.77
2010	32.64	-21.71	10.93	17.99	28.92
2011	37.10	-26.87	10.23	22.19	32.42
2012	46.94	-23.33	23.62	25.86	49.48

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)"** in 2013**.**

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	42%	Default, IPCC GPG 2003

Inputs	Uncertainty	Source of information
afforestated areas		
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 to and from aCL	156%	Expert judgment
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

Inputs	Uncertainty	Source of information
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

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 N_2O emissions form LUC to Cropland were added to the totals of Cropland remaining Cropland. Relative uncertainty for the whole LULUCF sector ranges between ± 41% and ± 79%.

As regarding the *Forest land remaining forest land*, the relative uncertainty of $CO_{2equivalent}$ emission/removal ranges between ± 44 and ± 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 $CO_{2equivalent}$ is calculated to ranges between -147 and +173%.
In regards to N_2O emission uncertainty it is calculated to ranges between ±160 and ±164%.

In case of *Grassland converted to forest land*, the uncertainty of CO_2 emission/removal calculation is calculated as range of ± 148 to ± 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 form 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:

- Changes in area of forest land based of the results of survey conducted under the LULUCF 1 project
- For this year submission Croatia applied new values for R/S factor in its estimation
- For this year submission estimation has been performed using the per ha values for increment and harvest that corresponds to total forest areas while in last year’s report estimation was done using the per/ha values for each type of ownership and finally summing them up

- CO_2 and non-CO_2 emissions from wildfires are estimated separately for *Forest land remaining Forest land* and *Land converted to Forest land*

7.2.8 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

- Disaggregation of data based on forest types as *Coniferous, Deciduous and Out of yield forests* (maquies and shrub) are to be reviewed under the new, recently approved project "*Upgrading the National System for the reporting of greenhouse gas emissions for the implementation of the Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities*"
- Further investigation on BEFs is part of a new project proposal within the LULUCF sector
- Investigation trough available national scientific papers is to be conducted in relation to maquis and shrub forests through the LULUCF project "*Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol*" and recommendations for an conservative estimate are to be given

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

7.3.1 CATEGORY DESCRIPTION

In this category emissions/removals from cropland management (Cropland Remaining Cropland and Land Converted to Cropland) were considered.

Cropland area ranged from 1,539.81 kha to 1,623.77 kha in the period 1990-2012. Emissions from the change in carbon stock in biomass and soil ranged from 76.54 $GgCO_2$ to 326.43 $GgCO_2$ for the period 1990-2012.

Annual LUCs to Cropland occurs from the Forest land and 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 1990-2012.

*Table 7.3-1: Activity Data of Cropland from 1990 to 2012 in kha**

Year	5.B Total Cropland	5.B.1 Cropland remaining cropland	5,B,1,a Annual cropland remaining annual cropland	5.B.1.b Perennial cropland remaining perennial cropland	5.B.1.c Perennial cropland converted to annual cropland	5.B.1.d Annual cropland converted to perennial cropland	5.B.2 Land converted to Cropland	5.B.2.2.a Grassland converted to annual cropland	5.B.2.2.b Grassland converted to perennial cropland
1990	1,623.77	1,616.44	1,472.06	143.06	0.43	0.89	7.33	6.74	0.59
1991	1,607.07	1,600.01	1,457.79	140.92	0.43	0.87	7.06	6.50	0.56
1992	1,604.21	1,597.41	1,457.03	139.11	0.42	0.84	6.80	6.27	0.53
1993	1,601.35	1,594.81	1,456.28	137.30	0.42	0.81	6.54	6.03	0.51
1994	1,598.48	1,592.21	1,455.52	135.48	0.42	0.79	6.27	5.79	0.48
1995	1,595.62	1,589.61	1,454.76	133.67	0.42	0.76	6.01	5.56	0.46
1996	1,592.76	1,587.01	1,454.00	131.86	0.41	0.73	5.75	5.32	0.43
1997	1,589.89	1,584.41	1,453.25	130.04	0.41	0.71	5.49	5.08	0.40
1998	1,587.03	1,581.81	1,452.49	128.23	0.41	0.68	5.22	4.85	0.38
1999	1,590.22	1,585.27	1,455.79	128.42	0.41	0.65	4.96	4.61	0.35
2000	1,591.81	1,587.11	1,466.66	119.42	0.40	0.63	4.70	4.37	0.32
2001	1,587.47	1,582.01	1,463.56	117.48	0.39	0.59	5.46	5.09	0.37
2002	1,583.14	1,576.91	1,458.01	117.98	0.37	0.54	6.23	5.82	0.42
2003	1,578.81	1,571.81	1,453.40	117.56	0.35	0.50	7.00	6.54	0.46
2004	1,574.47	1,566.66	1,446.37	119.49	0.33	0.46	7.81	7.26	0.51
2005	1,570.14	1,561.53	1,441.33	119.46	0.31	0.42	8.61	7.98	0.56
2006	1,565.81	1.556,40	1,432.28	123.44	0.29	0.38	9.41	8.70	0.60
2007	1,561.47	1.551,15	1,418.08	132.45	0.28	0.34	10.32	9.42	0.65

Year	5.B Total Cropland	5.B.1 Cropland remaining cropland	5,B.1,a Annual cropland remaining annual cropland	5.B.1.b Perennial cropland remaining perennial cropland	5.B.1.c Perennial cropland converted to annual cropland	5.B.1.d Annual cropland converted to perenial cropland	5.B.2 Land converted to Cropland	5.B.2.2.a Grassland converted to annual cropland	5.B.2.2.b Grassland converted to perennial cropland
2008	1,557.14	1.545,92	1,407.50	137.86	0.26	0.30	11.22	10.15	0.70
2009	1,552.81	1,540.33	1,399.85	139.98	0.24	0.26	12.48	10.87	0.74
2010	1,548.47	1,535.06	1,405.55	129.06	0.22	0.22	13.42	11.59	0.79
2011	1,544.14	1,529.52	1,400.20	128.91	0.20	0.20	14.62	12.55	0.86
2012	1,539.81	1,524.05	1,402.70	120.98	0.19	0.19	15.75	13.51	0.94

Table 7.3-2: Emissions (+) / removals (-) of CO_2 in Cropland from 1990 to 2012 (Gg CO_2 equivalent)

Year	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	240.15	211.82	28.33	0.00	23.48	NO	NO	NO	4.86
1991	236.24	208.12	28.12	0.00	23.44	NO	NO	NO	4.69
1992	225.66	198.52	27.14	0.00	22.62	NO	NO	NO	4.52
1993	237.51	211.35	26.15	0.00	21.81	NO	NO	NO	4.35
1994	251.65	226.48	25.17	0.00	20.99	NO	NO	NO	4.18
1995	210.37	186.19	24.19	0.00	20.18	NO	NO	NO	4.01
1996	230.20	207.00	23.20	0.00	19.36	NO	NO	NO	3.84
1997	247.14	224.93	22.22	0.00	18.54	NO	NO	NO	3.67
1998	259.71	238.48	21.23	0.00	17.73	NO	NO	NO	3.50
1999	246.88	226.63	20.25	0.00	16.91	NO	NO	NO	3.33
2000	297.58	278.32	19.26	0.00	16.10	NO	NO	NO	3.16
2001	326.43	307.53	18.90	0.00	15.21	NO	NO	NO	3.69
2002	309.59	287.37	22.21	0.00	18.00	NO	NO	NO	4.21
2003	298.45	272.92	25.53	0.00	20.80	NO	NO	NO	4.73
2004	285.10	255.42	29.68	0.83	23.59	NO	NO	NO	5.26
2005	246.28	199.30	32.49	0.31	26.38	NO	NO	NO	5.79
2006	225.49	172.44	35.57	0.08	29.17	NO	NO	NO	6.32
2007	136.99	75.49	44.90	6.07	31.96	NO	NO	NO	6.87
2008	146.79	82.87	43.14	0.97	34.75	NO	NO	NO	7.42
2009	81.57	17.02	52.63	7.06	37.54	NO	NO	NO	8.02
2010	155.35	95.23	46.65	-2.26	40.34	NO	NO	NO	8.58
2011	134.02	66.89	52.67	-0.57	43.94	NO	NO	NO	9.30
2012	208.32	146.18	52.53	-5.02	47.55	NO	NO	NO	10.01

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.[33]

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 since the entry of Croatia into the EU when the ARKOD will have to contain information on all farms in Croatia.

[33] Croatian Environment Agency, Corine Land Cover database. See list of References

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 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 interviewer. 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 do 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 recommendations"[34].

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

[34] Statistical Yearbook of the Republic of Croatia 2012. See list of References

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.

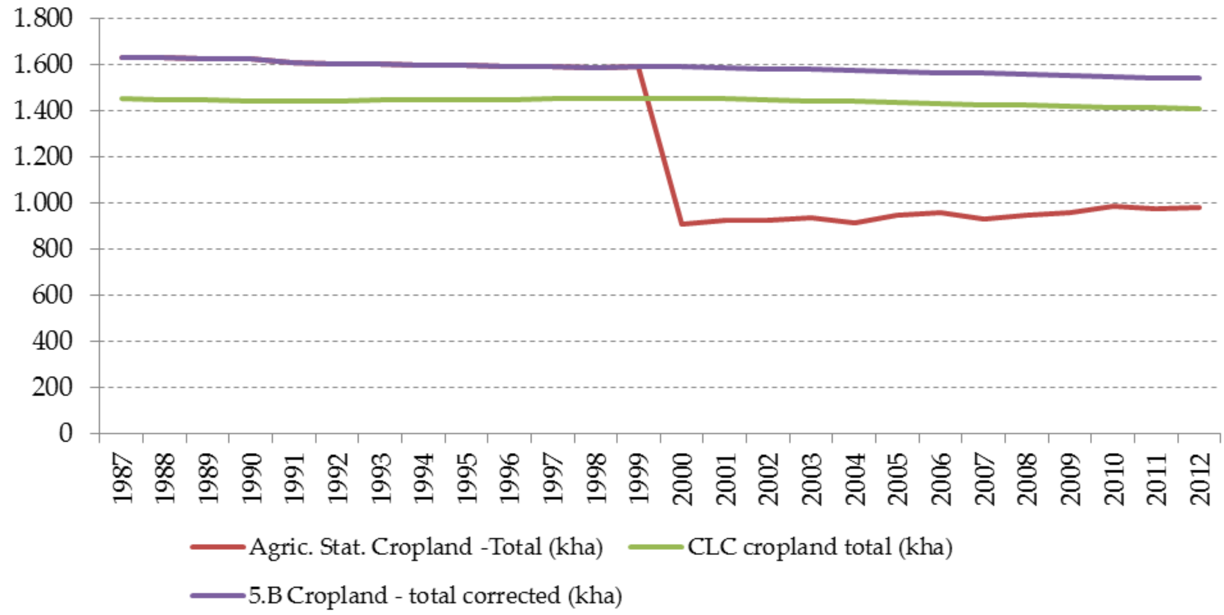


Figure 7.3-1: Total Cropland Area Corrected, kha

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).

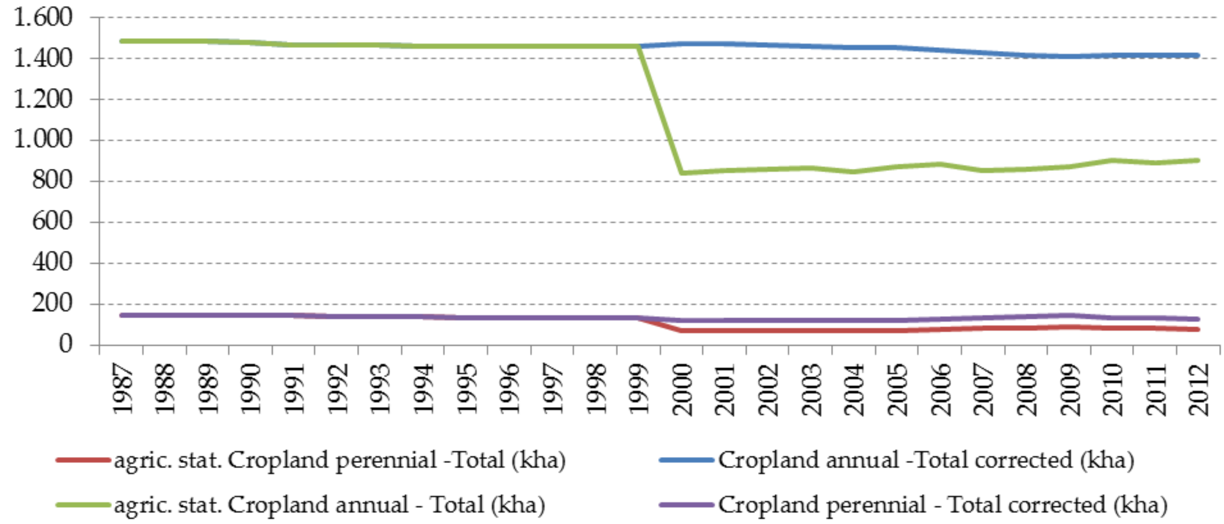


Figure 7.3-2: Area of annual and perennial cropland in Croatia after adjustement of CBS data, kha

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, Luxemburg[35]) 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:

Annual change in biomass = *(area of perennial cropland remaining perennial cropland x carbon accumulation rate) – (area of perennial cropland 30 years[1] ago x 0,033 x biomass carbon stock at harvest)*

[35] Bulgaria’s National Inventory Report for 2012; Austria’s National Inventory Report 2012; Luxembourg’s National Inventory Report 2012. See list of References

[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:

Annual change in carbon stock in biomass = conversion area for a transition period of 20 years x ΔC_{Growth} + *annual area of currently converted land x* $L_{Conversion}$

where:

$L_{Conversion} = C_{After} - C_{Before}$

ΔC_{Growth} = Carbon accumulation rate of perennial cropland = 2.1 t C/ ha annually (IPCC GPG 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, Bulgaria[36]), as well as expansion factors from the Austrian Expert Panel for Soil Fertility[37]. 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

---

[36] Bulgaria's National Inventory Report for 2012; Austria's National Inventory Report 2012; Luxembourg's National Inventory Report 2012. See list of References

[37] Bulgaria's National Inventory Report for 2012; Austria's National Inventory Report 2012; Luxembourg's National Inventory Report 2012. See list of References

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 in Croatia. 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:

Annual change in carbon stock in biomass = Annual area of converted land x $(L_{Conversion} + \Delta C_{Growth})$

where:

$L_{Conversion} = C_{After} - C_{Before}$

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)

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 2012 was 1,524.05 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 analysed. 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 2571 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, 25th (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 the reporting, additional analyze was conducted in 2013 using the dry combustion method[38] 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.

- The land use change area from annual cropland converted to perennial cropland in the conversion status of 20 years changed from 0.19 kha to 0.89 kha from 1990 to 2012.

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 x 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 = Croatian soil organic carbon stock in the inventory year = 77.81 tC/ha for perennial cropland
SOC_{0-T} = Croatian soil organic carbon stock *T* years prior to the inventory = 46.35 tC/ha for annual cropland
T = Assessment period (20 years)

[38] Work performed by Croatian Geological Institute. See list of References

- 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 x ΔSOC

$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = -1.57$ tC/ha annually

ORGANIC SOILS

For this year reporting and based on the recommendation given by ERT, Croatia separately reported emissions from organic soils under annual and under perennial crops. Organic soils distribution was determined on the basis of current Basic Soil Map of the Republic of Croatia in scale 1:50.000 and available data and information in *Land Parcel identification System* database of ARKOD. According to the available data, organic soil area in case of annual cropland is 2.23 kha and 0.23 kha in case of perennial cropland and with emissions of 22.32 and 0.23 Gg of carbon annually respectively,

For estimating CO_2 emissions from organic soils in the Cropland Remaining Cropland category the IPCC GPG 3.3.5 equation was applied:

$\Delta C_{CC\ Organic} = AxEF$

Where:

$\Delta C_{CC\ Organic}$= 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)

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)

Through the conducted survey within the scope of LULUCF 1 project it was determined that conversion from Forest land to perennial Cropland happens in Croatia starting from 2004 while conversion to annual Cropland did not occur in period 1990-2012. Additionally, it was determined on yearly basis from which type of forests conversion to perennial cropland occurs. By the conducted analyse it was concluded that there is no conversion from coniferous forests to perennial cropland.

When calculating gains due to biomass growth of Cropland, below presented values were used:

1. 2.10 tC/ha – for perennial Cropland (IPCC GPG)

For the purposes of calculating losses due to conversion from forest land, following nationally determined values were use:

1. 38.69 tC/ha when calculating losses due to conversion of deciduous forests to perennial Cropland
2. 4.27 tC/ha when calculating losses due to conversion of maquies and shrub forests to perennial Cropland

The values of soil carbon stock determined through national scientific investigation were used in order to estimate the carbon stock changes in soil due to conversion to Cropland. Conversion that happens refers to perennial cropland to Forest land, Estimation with following soil C stocks:

- perennial Cropland: 77.8 tC/ha
- Forestland: 84.5 tC/ha

Soil removal factor determined in this case is 0.336 tC/ha annually.

7.3.4.2.2 Grassland Converted to Cropland (5.B.2.2)

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, 14.44 kha of grassland area were converted to cropland in 2012. 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 28.33 Gg CO_2 and in 2012 in emissions of 51.14 GgCO_2.

A)Changes in Carbon Stocks in Biomass

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:

Annual change in carbon stock in biomass = annual area of converted land x ($L_{Conversion} + \Delta C_{Growth}$)
where:
$L_{Conversion} = C_{After} - C_{Before}$

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:
$\Delta SOC = (SOC_0 - SOC_{0-T})/20$

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 0.43 to 1.23 $GgCO_2$ in case of grassland converted to perennial cropland and in emissions in case of grassland converted to annual cropland in the range of 19.47 to 60.15 $GgCO_2$ for the period 1990-2012.

7.3.4.2.3 N_2O Emissions in Soils of Land Converted to Cropland

The annual release of N_2O due to the conversion of grassland to cropland and forest land to cropland were calculated using the IPCC default value (Tier 1) and equations 3.3.14 and 3.3.15:

$$N_2O_{net\text{-}min} - N = EF_1 \times \Delta C_{LCmineral} \times 1/(C/N \text{ ratio})$$

where:

EF_1 = the emission factor for calculating emissions of N_2O from N in the soil = 0.0125 kg N_2O-N/kg N (IPCC GPG default value)

$\Delta C_{LCmineral}$ = change in the carbon stock in mineral soils in land to cropland

C/N = ratio by mass of C to N in the soil organic matter (10 in case of grassland converted to cropland and 12 in case of forest land converted to cropland)

7.3.5.UNCERTAINTIES AND TIME SERIES CONSISTENCY

According to the Tier 2 method uncertainty for the CO_2 eq total in Cropland category ranges between ± 353 and ± 1157%. The uncertainty values for total CO_2 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 CO_2 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 available data, organic soils emissions are calculated for annual and perennial cropland using the new data on areas
- New CBS data for cropland areas in 2010 and 2011 were used
- Coorection in areas of GL-CL due to error when performing interpolation for period 1990-1999. Instead of using data from period 1990-1996, data from period 200-2006 were used
- Emissions due to liming since 2005 are added to soil emissions

Consequently estimation in this category of land differ that estimation in NIR 2013.

7.3.8. CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

- Further investigation on liming application is to be conducted in Croatia
- Further investigation for the determination of expansion factors from yield to total biomass and survey for existing data for the determination of biomasses in perennial cropland and rotation periods are foreseen to be implemented within the recently defined new LULUCF project proposal
- All data regarding the C stock in soils will be reviewed under the scope of new project "*SOC stock changes, total nitrogen and total organic carbon trends, C:N ratio*)"

7.4. GRASSLAND 5.C

7.4.1.CATEGORY 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 1990-2012. Removals from the change in carbon stock in biomass and soil ranges from 77.09 GgCO_2 to 140.05 GgCO_2 in period 1990-2012.

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 2012.

Table 7.4-1: Activity Data of Grassland in the period 1990-2012 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.a Annual cropland converted to grassland	5.C.2.2.b Perennial cropland converted to grassland	5.C.2.3 Wetlands converted to grassland	5.C.2.4 Settlements convertet to grassland	5.C.2.5 Other land converted to grassland
1990	1,210.53	1,179.49	31.03	NO	31.03	28.35	2.68	NO	NO	NO
1991	1,212.64	1,181.08	31.56	NO	31.56	28.91	2.65	NO	NO	NO
1992	1,214.76	1,181.89	32.87	NO	32.87	30.19	2.68	NO	NO	NO
1993	1,216.88	1,183.13	33.76	NO	33.76	31.08	2.68	NO	NO	NO
1994	1,219.00	1,184.40	34.60	NO	34.60	31.93	2.67	NO	NO	NO
1995	1,221.12	1,184.61	36.50	NO	36.50	33.74	2.76	NO	NO	NO
1996	1,223.24	1,185.30	37.94	NO	37.94	35.13	2.81	NO	NO	NO
1997	1,225.35	1,186.12	39.24	NO	39.24	36.40	2.84	NO	NO	NO
1998	1,227.47	1,186.88	40.59	NO	40.59	37.71	2.88	NO	NO	NO
1999	1,229.59	1,187.54	42.05	NO	42.05	39.12	2.93	NO	NO	NO
2000	1,231.71	1,188.36	43.35	NO	43.35	40.30	3.05	NO	NO	NO
2001	1,230.47	1,187.45	43.02	NO	43.02	39.99	3.03	NO	NO	NO
2002	1,229.23	1,186.43	42.80	NO	42.80	39.78	3.02	NO	NO	NO
2003	1,227.99	1,185.36	42.63	NO	42.63	39.61	3.02	NO	NO	NO
2004	1,226.75	1,184.07	42.69	NO	42.69	39.66	3.03	NO	NO	NO
2005	1,225.52	1,180.42	45.10	NO	45.10	41.84	3.26	NO	NO	NO
2006	1,224.28	1,176.94	47.34	NO	47.34	43.87	3.47	NO	NO	NO
2007	1,223.04	1,172.27	50.77	NO	50.77	46.98	3.79	NO	NO	NO
2008	1,221.80	1,169.82	51.97	NO	51.97	48.07	3.90	NO	NO	NO
2009	1,220.56	1,164.73	55.84	NO	55.84	51.57	4.26	NO	NO	NO
2010	1,219.32	1,157.71	61.62	NO	61.62	56.83	4.78	NO	NO	NO
2011	1,218.08	1,151.51	66.57	NO	66.57	61.25	5.32	NO	NO	NO
2012	1,216.85	1,147.30	69.55	NO	69.55	63.86	5.68	NO	NO	NO

Table 7.4-2: Emissions (+) / removals (-) of CO2 in Grassland 1990-2012 (Gg CO_2 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 convertet to grassland	5.C.2.5 Other land converted to grassland
1990	-120.66	2.07	-122.72	NO	-122.72	NO	NO	NO
1991	-90.15	2.07	-92.22	NO	-92.22	NO	NO	NO

1992	-77.09	2.07	-79.16	NO	-79.16	NO	NO	NO
1993	-91.14	2.07	-93.21	NO	-93.21	NO	NO	NO
1994	-95.90	2.07	-97.97	NO	-97.97	NO	NO	NO
1995	-78.59	2.07	-80.66	NO	-80.66	NO	NO	NO
1996	-95.95	2.07	-98.02	NO	-98.02	NO	NO	NO
1997	-104.68	2.07	-106.75	NO	-106.75	NO	NO	NO
1998	-109.26	2.07	-111.33	NO	-111.33	NO	NO	NO
1999	-112.90	2.07	-114.97	NO	-114.97	NO	NO	NO
2000	-102.22	2.07	-104.29	NO	-104.29	NO	NO	NO
2001	-140.05	2.07	-142.12	NO	-142.12	NO	NO	NO
2002	-136.51	2.07	-138.58	NO	-138.58	NO	NO	NO
2003	-134.56	2.07	-136.63	NO	-136.63	NO	NO	NO
2004	-129.23	2.07	-131.30	NO	-131.30	NO	NO	NO
2005	-82.32	2.07	-84.39	NO	-84.39	NO	NO	NO
2006	-95.17	2.07	-97.24	NO	-97.24	NO	NO	NO
2007	-80.01	2.07	-82.08	NO	-82.08	NO	NO	NO
2008	-138.11	2.07	-140.18	NO	-140.18	NO	NO	NO
2009	-89.58	2.07	-91.65	NO	-91.65	NO	NO	NO
2010	-105.45	2.07	-107.52	NO	-107.52	NO	NO	NO
2011	-92.36	2.07	-94.43	NO	-94.43	NO	NO	NO
2012	-132.35	2.07	-134.42	NO	-134.42	NO	NO	NO

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).

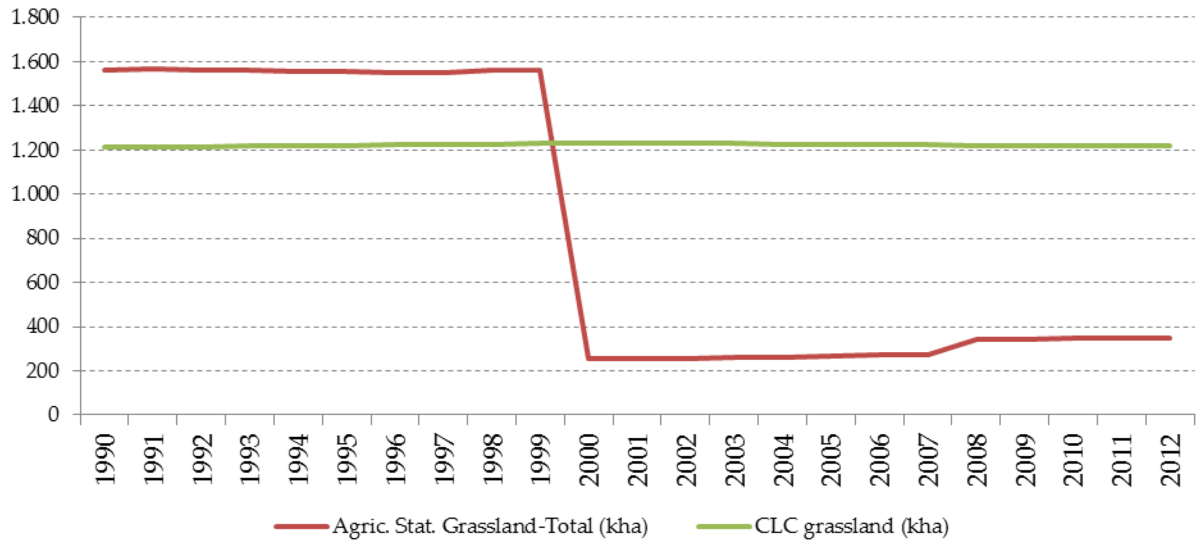


Figure 7.4-1: Total grassland area in Croatia according to the CBS data andd CLC database, kha

In this report CLC data were used to present grassland 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 2001-2012 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 2012 amounts to 1,147.30 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 is defined to be 0.23 kha according to the new available information.

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 2.07 GgCO_2 annually for the period 1990-2012.

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)

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, 69.55 kha of Cropland area were converted into Grassland in year 2012. 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 removal of 123.20Gg CO_2 and in year 2012 in removal of 132.35GgCO_2,

A) Changes in carbon stocks in biomass

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 tones of Carbon.

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:

Annual change in carbon stock in biomass = *Annual area of converted land* x ($L_{Conversion} + \Delta C_{Growth}$)
where:
$L_{Conversion} = C_{After} - C_{Before}$

ΔC_{Growth} = Carbon accumulation rate in Grasslands in Croatia = 4.29 t C/ ha
C_{Before} = Carbon stock of Cropland biomass before conversion is: **1)** 5.7 t C/ ha for annual Cropland and **2)** 63 t C/ha for perennial Cropland (IPCC GPG value)
C_{After} = Carbon stock immediately after conversion = 0 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:
$\Delta SOC = (SOC_0 – SOC_{0-T})/20$

ΔSOC = annual change in carbon stock soil
SOC_0 =soil organic carbon stock in the inventory year, which is: **1)** 46.4 tC/ha for annual Cropland **2)** 77.8 tC/ha for perennial Cropland
SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory, which is 70.6 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 79.16 to 142.12 GgCO_2 in Cropland converted to Grassland, while emissions in case of perennial Cropland converted to Grassland in range of 3.53 to 145.69 GgCO_2 in period 1990-2012.

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 CO_2 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 CO_2 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 new organic soil area
- Using the new data and information Croatia gained through activities of LULUCF project, estimation of emissions due to fires was performed

7.4.8.CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

- Further investigation for the determination of expansion factors from hay yield to total grassland biomass is foreseen to be implemented within the recently defined new LULUCF project proposal,
- Further analyses of data collected through the project *"Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol"* needs to be performed in order to investigate possibility to use higher Tier in estimation of emissions due to forest fires

7.5. WETLANDS 5.D

7.5.1.CATEGORY 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.

Peat extraction does not occur in Croatia.

The wetland area ranged from 72.32 ha in 1990 to 74.37 ha in 2012.

The land use change and removals/emissions from the IPCC land use categories to wetland in the period 1990-2012 are presented in Tables 7.5-1 and 7.5-2.

Table 7.5-1: Activity data of wetland in the period 1990-2012 in kha

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	72.32	70.06	2.26	NO	2.26	NO	NO	NO
1991	72.51	70.06	2.45	NO	2.45	NO	NO	NO
1992	72.70	70.06	2.64	NO	2.64	NO	NO	NO
1993	72.89	70.06	2.83	NO	2.83	NO	NO	NO
1994	73.08	70.06	3.02	NO	3.02	NO	NO	NO
1995	73.27	70.06	3.21	NO	3.21	NO	NO	NO
1996	73.46	70.06	3.40	NO	3.40	NO	NO	NO
1997	73.65	70.06	3.59	NO	3.59	NO	NO	NO
1998	73.83	70.06	3.78	NO	3.78	NO	NO	NO
1999	74.02	70.06	3.97	NO	3.97	NO	NO	NO
2000	74.21	70.06	4.16	NO	4.16	NO	NO	NO
2001	74.23	70.28	3.94	NO	3.94	NO	NO	NO
2002	74.24	70.51	3.73	NO	3.73	NO	NO	NO
2003	74.25	70.74	3.52	NO	3.52	NO	NO	NO
2004	74.27	70.96	3.30	NO	3.30	NO	NO	NO
2005	74.28	71.19	3.09	NO	3.09	NO	NO	NO
2006	74.29	71.41	2.88	NO	2.88	NO	NO	NO
2007	74.31	71.64	2.66	NO	2.66	NO	NO	NO

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
2008	74.32	71.87	2.45	NO	2.45	NO	NO	NO
2009	74.33	72.09	2.24	NO	2.24	NO	NO	NO
2010	74.34	72.32	2.02	NO	2.02	NO	NO	NO
2011	74.36	72.51	1.85	NO	1.85	NO	NO	NO
2012	74.37	72.70	1.67	NO	1.67	NO	NO	NO

Table 7.5-2: Emissions of wetland in the period 1990-2012 in Gg CO_2

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	0.00	30.00	0.00	0.00	0.00
1991	30.17	NE	30.17	0.00	30.17	0.00	0.00	0.00
1992	31.89	NE	31.89	0.00	31.89	0.00	0.00	0.00
1993	33.60	NE	33.60	0.00	33.60	0.00	0.00	0.00
1994	35.32	NE	35.32	0.00	35.32	0.00	0.00	0.00
1995	37.04	NE	37.04	0.00	37.04	0.00	0.00	0.00
1996	38.76	NE	38.76	0.00	38.76	0.00	0.00	0.00
1997	40.47	NE	40.47	0.00	40.47	0.00	0.00	0.00
1998	42.19	NE	42.19	0.00	42.19	0.00	0.00	0.00
1999	43.91	NE	43.91	0.00	43.91	0.00	0.00	0.00
2000	45.63	NE	45.63	0.00	45.63	0.00	0.00	0.00
2001	36.33	NE	36.33	0.00	36.33	0.00	0.00	0.00
2002	34.40	NE	34.40	0.00	34.40	0.00	0.00	0.00
2003	32.46	NE	32.46	0.00	32.46	0.00	0.00	0.00
2004	30.53	NE	30.53	0.00	30.53	0.00	0.00	0.00
2005	28.59	NE	28.59	0.00	28.59	0.00	0.00	0.00
2006	26.66	NE	26.66	0.00	26.66	0.00	0.00	0.00
2007	24.72	NE	24.72	0.00	24.72	0.00	0.00	0.00
2008	22.79	NE	22.79	0.00	22.79	0.00	0.00	0.00
2009	20.86	NE	20.86	0.00	20.86	0.00	0.00	0.00
2010	18.92	NE	18.92	0.00	18.92	0.00	0.00	0.00
2011	17.32	NE	17.32	0.00	17.32	0.00	0.00	0.00
2012	15.73	NE	15.73	0.00	15.73	0.00	0.00	0.00

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):

$$\Delta \mathbf{C}_{\text{LW flood}} = \sum A_i \times (B_{after} - B_{before})_i$$

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

$$\Delta \mathbf{C}_{\text{LW flood}} = \sum A_i \times (B_{after} - B_{before})_i /20$$

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

- NA

7.5.8.CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

- NA

7.6.SETTLEMENTS 5.E

7.6.1.CATEGORY 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 221.98 kha in 1990 to 256.02 kha in 2012. Emissions from the change in the carbon stock in biomass and soil ranges from 204.28 to 513.42 Gg CO_2,

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 2012.

Table 7.6-1: Activity data of Settlements for 1990-2012 in kha

Year	5.E 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	212.98	190.89	22.09	0.23	14.33	7.54	NO	NO
1991	214.09	192.03	22.06	0.21	14.13	7.72	NO	NO
1992	215.21	193.18	22.03	0.20	13.93	7.90	NO	NO
1993	216.32	195.43	20.89	0.19	13.18	7.52	NO	NO
1994	217.43	197.63	19.80	0.24	12.42	7.14	NO	NO
1995	218.54	197.72	20.83	0.23	12.75	7.85	NO	NO
1996	219.66	198.86	20.80	0.22	12.55	8.03	NO	NO
1997	220.77	200.00	20.77	0.28	12.32	8.17	NO	NO
1998	221.88	201.14	20.74	0.38	12.07	8.30	NO	NO
1999	222.99	202.29	20.71	0.40	11.85	8.46	NO	NO

2000	224.11	203.43	20.68	0.55	11.57	8.55	NO	NO
2001	226.77	204.57	22.19	0.90	11.97	9.33	NO	NO
2002	229.43	205.72	23.71	1.11	12.43	10.17	NO	NO
2003	232.09	206.86	25.23	1.19	12.96	11.07	NO	NO
2004	234.74	208.00	26.74	1.49	13.38	11.87	NO	NO
2005	237.40	209.14	28.26	1.81	13.79	12.66	NO	NO
2006	240.06	210.29	29.78	2.12	14.20	13.45	NO	NO
2007	242.72	211.43	31.29	2.19	14.74	14.36	NO	NO
2008	245.38	212.57	32.81	2.46	15.18	15.18	NO	NO
2009	248.04	213.34	34.70	2.56	16.07	16.07	NO	NO
2010	250.70	214.09	36.61	2.74	16.93	16.93	NO	NO
2011	253.36	215.21	38.15	2.77	17.69	17.69	NO	NO
2012	256.02	216.32	39.70	2.91	18.40	18.40	NO	NO

Table 7.6-2: Emissions of Settlements 1990-2012 in Gg CO_2

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	240.31	NE	240.31	3.37	137.71	99.22	NO	NO
1991	250.75	NE	250.75	3.19	143.40	104.15	NO	NO
1992	251.11	NE	251.11	3.02	141.72	106.38	NO	NO
1993	208.57	NE	208.57	2.84	112.41	93.32	NO	NO
1994	208.50	NE	208.50	13.87	105.98	88.65	NO	NO
1995	270.71	NE	270.71	3.80	153.24	113.67	NO	NO
1996	241.19	NE	241.19	3.24	129.96	107.99	NO	NO
1997	243.32	NE	243.32	7.86	126.33	109.14	NO	NO
1998	259.88	NE	259.88	25.71	123.65	110.51	NO	NO
1999	249.35	NE	249.35	12.95	123.32	113.08	NO	NO
2000	278.29	NE	278.29	46.93	118.12	113.24	NO	NO
2001	319.14	NE	319.14	36.55	149.49	133.10	NO	NO
2002	353.04	NE	353.04	52.53	156.04	144.47	NO	NO
2003	352.54	NE	352.54	32.60	163.25	156.69	NO	NO
2004	393.40	NE	393.40	65.81	162.55	165.04	NO	NO
2005	403.04	NE	403.04	63.05	165.43	174.56	NO	NO
2006	406.80	NE	406.80	53.19	169.17	184.44	NO	NO
2007	423.89	NE	423.89	47.46	178.80	197.63	NO	NO
2008	462.86	NE	462.86	78.22	178.42	206.22	NO	NO
2009	471.71	NE	471.71	63.91	189.30	218.49	NO	NO
2010	490.95	NE	490.95	66.74	195.45	228.76	NO	NO
2011	489.64	NE	489.64	45.17	205.11	239.36	NO	NO
2012	522.90	NE	522.90	66.97	208.72	247.21	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 x 0.45 x 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 x 0.45 x 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 0.0256 tC/ha annually. The figure was used for all unsealed Croatian settlement area.

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. In case of Grassland converted to Settlement national value of 4.3 tC/ha in Grassland before LUC was used in estimation.

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.

In reporting period emissions ranged from 2.84 GgCO_2eq to 60.85 GgCO_2eq due to LUC from Forestland to Settlements.

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 0-20 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 0.19 kha to 2.91 kha.

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 25.78 to 131.01 GgCO_2 in the period 1990-2012.

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 166.8 to 279.0 GgCO_2 in the period 1990 to 2012.

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 2,142 ha to 15,212 ha in the years 1990-2012.

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 -21.8 to 0.2 GgCO_2 in annual cropland and -29.3 to 0.02 GgCO_2 in perennial cropland converted to settlements in the years 1990-2012.

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 15.5 to 110.2 GgCO_2 in annual cropland and 15.5 to 21.0 Gg CO_2 in perennial cropland converted to settlements in the years 1990-2012.

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 1,116.1 ha to 15,211.9 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 0.16 to -17.80 GgCO_2 during the period 1990-2012.

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 13.96 to 190.2 GgCO_2 in the period 1990-2012.

7.6.5. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

According to the Tier 2 method relative uncertainty for the total CO_2 eq in category Land converted to Settlements ranges between ± 89 and ± 156%. In Annex 5 comparison between the uncertainties calculated using Tier 1 and Tier 2 methods by categories and carbon pools is presented.

The Setllement 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

- Correction in previously wrongly presented part of the correction factor (value of 1.5%) for Settlement areas in Excel sheet. Instead of 0,015, value of 0.15 was introduced causing mistake in Settlement area in matrix
- All data in case of deforestation area in category Forest land converted to settlements were reviewed under the LULUCF project *"Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol"* regardless the ownership type and forest type. This is a reason that area converted from Forest land to Settlement differs than previously reported

7.6.8. CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Survey for existing data for the determination of biomass stocks and growth rates in Settlement area makes a part of newly developed LULUCF project proposal.

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	237.34	237.34	NO	NO	NO	NO	NO	NO
1991	250.40	250.40	NO	NO	NO	NO	NO	NO
1992	249.68	249.68	NO	NO	NO	NO	NO	NO
1993	248.82	248.82	NO	NO	NO	NO	NO	NO
1994	248.07	248.07	NO	NO	NO	NO	NO	NO
1995	247.28	247.28	NO	NO	NO	NO	NO	NO
1996	246.44	246.44	NO	NO	NO	NO	NO	NO
1997	245.76	245.76	NO	NO	NO	NO	NO	NO
1998	245.05	245.05	NO	NO	NO	NO	NO	NO
1999	238.13	238.13	NO	NO	NO	NO	NO	NO
2000	233.05	233.05	NO	NO	NO	NO	NO	NO
2001	236.05	236.05	NO	NO	NO	NO	NO	NO
2002	238.88	238.88	NO	NO	NO	NO	NO	NO
2003	241.59	241.59	NO	NO	NO	NO	NO	NO
2004	244.19	244.19	NO	NO	NO	NO	NO	NO
2005	244.41	244.41	NO	NO	NO	NO	NO	NO
2006	244.79	244.79	NO	NO	NO	NO	NO	NO
2007	243.95	243.95	NO	NO	NO	NO	NO	NO
2008	245.43	245.43	NO	NO	NO	NO	NO	NO
2009	244.48	244.48	NO	NO	NO	NO	NO	NO
2010	242.92	242.92	NO	NO	NO	NO	NO	NO
2011	239.97	239.97	NO	NO	NO	NO	NO	NO
2012	238.09	238.09	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 due to area consistency with the area of total Croatia and those of the other sub-categories. 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.

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 237.8 and 498.9 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. 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. DIRECT N_2O EMISSIONS FROM N FERTILIZATION (5(I))

N_2O emissions from N fertilization of cropland and grassland are reported in the agriculture sector. No fertilizers are applied to forest land,

7.9. N_2O EMISSIONS FROM DRAINAGE OF SOILS (5(II))

Drainage of soils did not occur in Croatia in period 1990-2012 and no data are reported.

7.10. N_2O EMISSIONS FROM DISTURBANCE ASSOCIATED WITH LAND-USE CONVERSION TO CROPLAND (5(III))

7.10.1. DESCRIPTION

N_2O emissions from Cropland remaining Cropland are included in the agriculture sector. Under this category according to the IPCC GPG, N_2O emissions associated with disturbance of cropland soils that are converted to other land use categories should be reported.

7.10.2. METHODOLOGICAL ISSUES

The annual release of N_2O due to the conversion of forestland to cropland was calculated using the IPCC default value (Tier 1) and equations 3.3.14 and 3.3.15:

$$N_2O_{net\text{-}min} - N = EF_1 \times \Delta C_{LCmineral} \times 1/(C/N \text{ ratio})$$

where:

EF_1 = the emission factor for calculating emissions of N_2O from N in the soil = 0.0125 kg N_2O-N/kg N (IPCC GPG default value)

$\Delta C_{LCmineral}$ = change in the carbon stock in mineral soils in forestland converted to cropland

C/N = ratio by mass of C to N in the soil organic matter = 12 (national value)

The annual release of N_2O due to conversion from Grassland to Cropland was performed using the same equations and values for changes in the carbon stock in mineral soils in grasslands converted to annual and perennial cropland and nationally determined value of 10 for C/N ratio.

7.10.3. CATEGORY-SPECIFIC RECALCULATIONS

- NA

7.11.CARBON EMISSIONS FROM AGRICULTURAL LIME APPLICATION (5(IV))

7.11.1. DESCRIPTION

The application of lime on agricultural soils was estimated for this year reporting for the first time. Data that are collected come from the sugar factories in Croatia in which lime has been produced as byproduct during the technological process of sugar production. Based on the available information, lime coming from sugar factories is only kind of lime that is so far applied on agricultural lands in Croatia. According to the information from fields, all lime that has been produced in one year has been applied on agricultural lands in the same year. Due to the fact that sugar factories in Croatia are placed in areas with acidic soils (in cities Osijek, Virovitica and Zupanja), and the fact that all produced lime is given for a free to local population, all quantities of lime produced are applied on soils. This has been practice in Croatia since 2005 and it is connected with improvements in sugar production introduced by sugar factories. Before that, lime produced in sugar factories was discharged into water sewerage system.
For the purposes of sugar purification, only kind of stone which is used in sugar factories in Croatia is limestone. Since there is no other kind of lime that is applied on agricultural soils in Croatia, in case of calcium magnesium carbonate NO is reported in CRF tables for whole reporting period.

Further investigation on this issue is foreseen in due time, See Chapter 7.3.8

7.11.2. METHODOLOGICAL ISSUES

Estimation due to liming was performed using the IPCC GPG 2003 equation 3.3.6 and emission factor of 12%.

7.11.3. CATEGORY-SPECIFIC RECALCULATIONS

- NA

7.12.BIOMASS BURNING (5(IV))

7.12.1. DESCRIPTION

Detailed analyses that were conducted within the LULUCF 1 project for the purposes of determining the areas affected by fires in the period 1990-2012 years included categories of forest land, grassland and cropland. Analyses were conducted on data and information primarily available in the Register on forest fires. This register was established in 2009 pursuant to the *Forest Act*[39] and at that time relevant Ordinance[40].
It contains all data and information on fires that occurred after 1990, in forests or land under the forest management. Additionally, it contains data and information on fires occurred on agricultural types of land

[39] Forest Act (OG 140/05), Article 40
[40] *Ordinance on the method of data collection, conducting the Register and requirements for using data on forest fires* (OG 126/06)

(cropland and grassland) when fires are connected with forests and/or lands under the forest management. It is estimated that more than 50% of all fires on agricultural types of land are connected with forests or land under the forest management. Although, data and information available in this register concerning fires on agricultural types of land can not be consider complete, at the moment, the Register is consider to be most reliable source of data and information about fires on agricultural lands in Croatia. This Register is currently running based on new legislative act[41] that prescribes methodology for data collection and its recording.
All data and information concerning areas affected by fires are presented as one of outcomes of LULUCF 1 project in a separate document[42].
Based on the conducted analyses it was determined that Cropland areas were not affected by fires in period 1990-2012. In case of Grassland, areas recorded in the Register was doubled in order to avoid underestimation of emissions in this category of land since it was estimated (expert judgement) that only 50% of grassland areas affected by fires are recorded in this Register.
The analyses in forest land category were conducted on all types of forests (including maquies and shrub forests) regardless the ownership type. Also, by this work all areas that were converted to/from forest land and areas in which natural spreading of forests were recorded in period 1990-2012 were covered. According to the available data and information during the period 1990-2012 fires did not occur in state forests that are managed by other legal bodies. Data and information presented in this report concerning fire emissions refer to state owned forests managed by Croatian forests Ltd and private forests.
Emissions are reported in CRF tables under corresponding categories of land.

For future work on Croatian LULUCF and KP reporting update of the Register has been recognized as relevant within the LULUCF 1 project, It has been recommended this to be performed through a separate project[43]. The completeness of the Registry and its upgrade in a way that fully meets requirements of LULUCF and KP reporting, as well as reporting to other international and national institutions, has been envisaged as a long term objective for Croatian reporting.

7.12.2. METHODOLOGICAL ISSUES

Data and information on fires that are available in the Registry on forest fires can be presented in two periods of time, depending on the methods used for data collection. The first period covers period from 1990 to November 2006. The second period covers period from November 2006 to 2012, when the Registry was officially established based on the *Forest Act*[44] and *Ordinance*[45] provisions. In the first period the methods of collecting data on forest fires were not legally prescribed, Croatian forests Ltd, led data and information on fires in paper forms as part of its internal procedures. These forms contained a variety of information (i,g, information about

[41] *Ordinance on the method of data collection, conducting the Register and requirements for using data on forest fires* (OG 175/13)
[42] Janeš,D.,G.Kovač,V.Grgesina,D.Pleskalt (2014): Identifying areas affected by fires according to requirements of Article 3.3 and 3.4 of the Kyoto protocol
[43] Ibid
[44] Ibid.
[45] Ibid.

fire location, type of vegetations affected by fires, causes of fires, type of fires, types of intervention, participants in fire fighting, burnt volume, etc,). In 2001 the internal database on forest fires was established in digital form in Croatian forests Ltd. This secured that data on fires are kept in paper and digital forms in the period from 2001 to 2008.

Recording the forest fires on maps has not been requested by national legislation so far. However, in many occasions sketches of areas affected by fires were kept. By 2005, the majority of the sketches were drawn up by hand on a topographic map presenting forest divisions into compartments and sub-compartments at a scale of 1: 25.000. After 2005, the mapping of areas affected by fires has been done using also global positioning system (GPS) on the fields (Figure 7.12-1, and Figure 7.12-2).

Although it is not officially prescribed, mapping of areas affected by fires (using GPS as one of possible tools for recording purposes) since 2009 makes a part of good practice in forest management in Croatia (Figure 7.12-3).

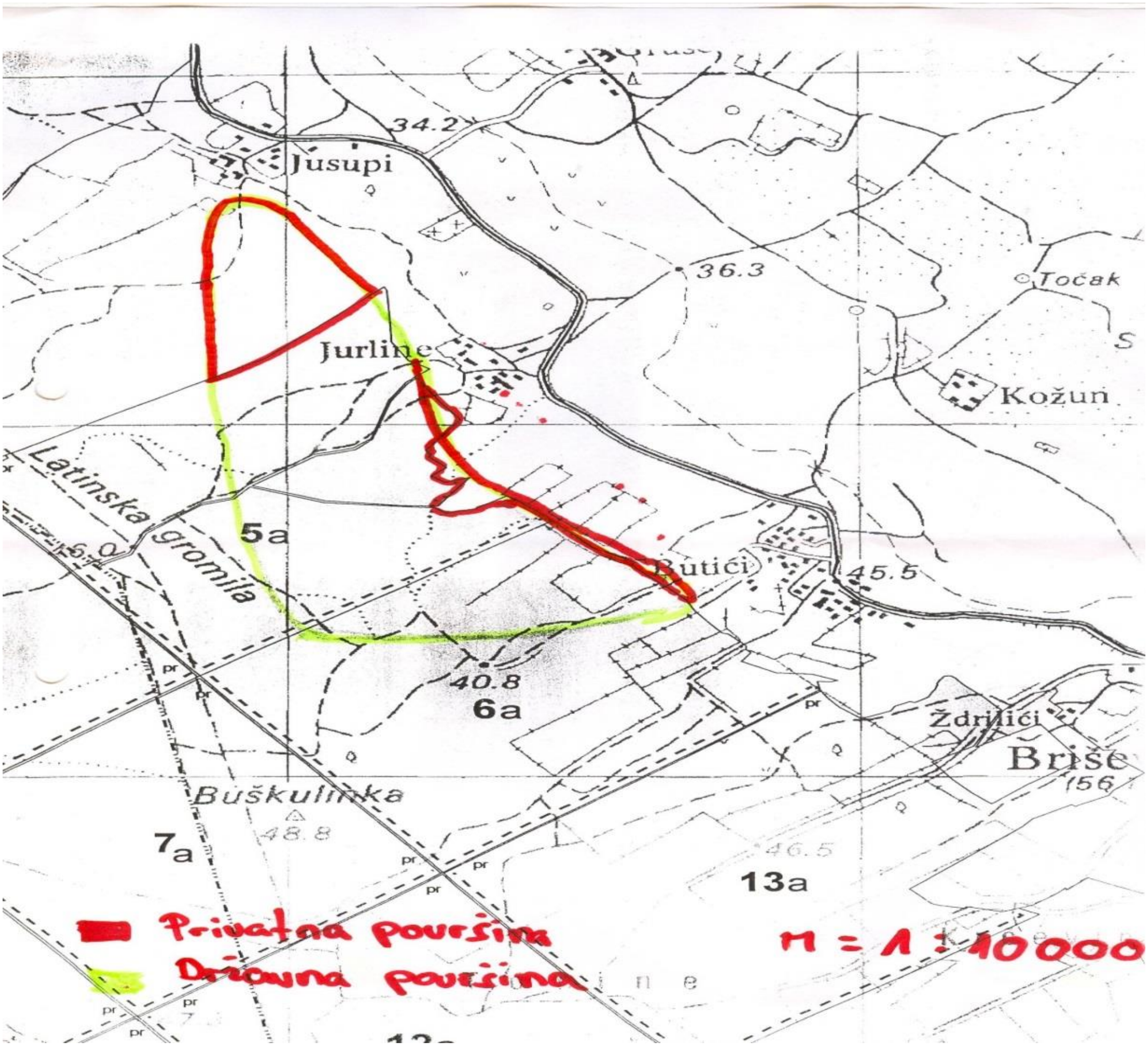


Figure 7.12-1: Map of areas affected by fires in 2006 (Forest district Split, Forest unit Zadar, Management unit Mustapstan (state owned forests marked in green (40,0 ha), private owned forests marked in red (10,0 ha))

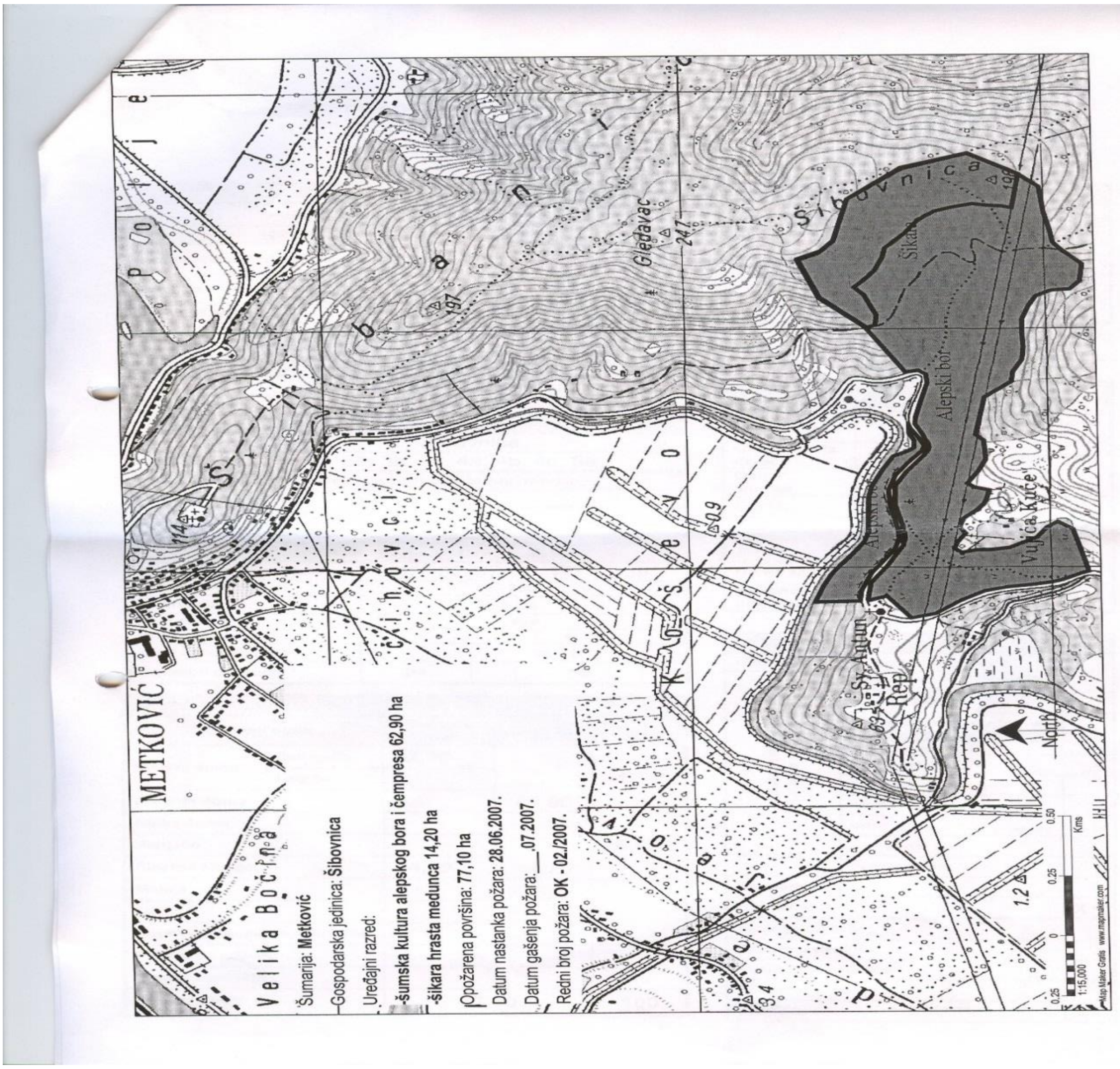


Figure 7.12-2: Map of state owned forests affected by fires in 2007 defined using GPS (Forest district Split, Forest unit Metković, Management unit Šibovnica; total affected area 77,10 ha)

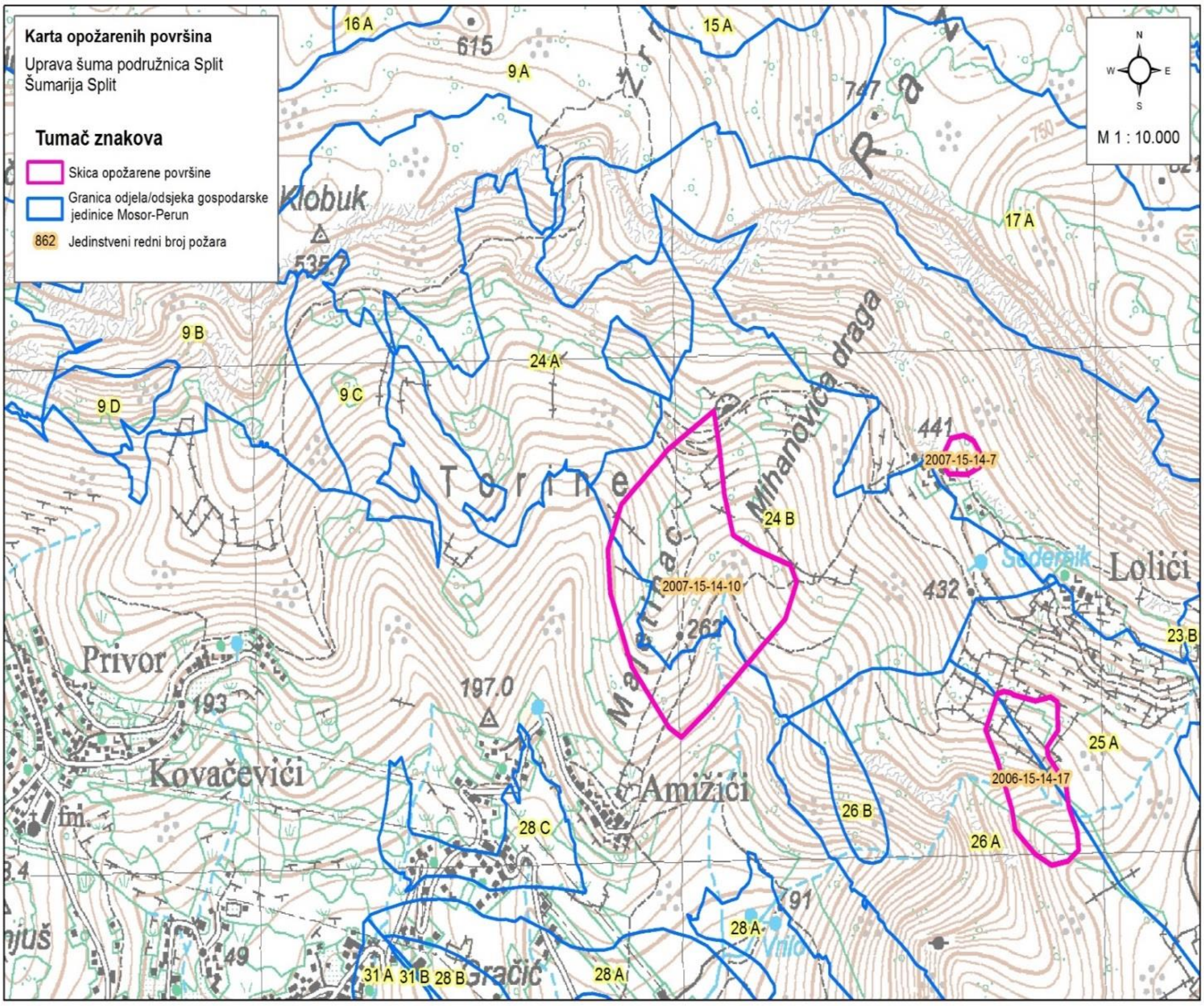


Figure 7.12-3: Map from unified GIS database on forest fires, Forest district Split, Forest unit Split, Management unit Mosor-Perun (state owned forests affected by fires (marked in pink) in 2006 and 2007; total affected area 18,43 ha)

In order to secure reporting on emissions due to forest fires separately for categories Forest land remaining Forest land and land converted to/from Forest land, each record on each single forest fire in Register in period 1990-2012 were checked. All data and information in Register were then compared with data, maps and information available in corresponding Forest management plans in order to determine whether the affected forest areas were recoded as forest or as land under the forest management (in Croatian circumstances this corresponds to Grassland category comparing to IPCC definitions). If the corresponding forest management plan was developed after 1990, additional checking was done by using forest management plan that was valid in period before 1990.

In case of emissions from fires in areas that are subject of conversion from Forest land to other categories of land, Croatia used notation key NO in CRF tables. In Croatia only conversion from Forest land to Settlement and Cropland category occurs. Based on the data available in the Register, there were no Cropland areas affected by fires in period 1990-2012. Additionally, since conversion from Forest land to Settlement happens in general for infrastructure purposes in Croatia, there are no GHG emissions due to biomass burning on these lands.

The controlled burning of managed forest is not carried out in Croatia.

The GHG emissions due to forest fires are reported in categories: *Forest land remaining Forest land*, *Grassland converted to Forestland and Grassland remaining Grassland* using equation 3.2.20, Tier 1 method and default values prescribed in IPCC GPG 2003. In case of Forest land remaining Forest land and Land converted to forest land a mean value of 19.8 t/ha biomass consumption was applied (BxC) and emission factor (D) prescribed in table 3.A.1.16 for CO_2 (1531), CH_4 (7.1) and N_2O (0.11) were used.
When estimating emissions in category Grassland remaining Grassland, value from Table 3.A.1.13 Savanna Grasslands (mid/late dry season burns) was used for biomass consumption, and emission factors of 1640 (CO_2), 2.4 (CH_4) and 0.2 (N_2O).

Estimates of non-CO_2 greenhouse gas emissions (CO, NO_x and NMHC) released in wildfires were estimated also according to Tier 1, equation 3.2.20, IPCC GPG 2003 using corresponding factors for biomass consumption and emission factors from Table 3.A.1.16.

$$L_{fire}\,(tGHG) = A \times B \times C \times D \times 10^{-6}$$

Where:

A = area burnt (ha)
B = mass of available fuel (kg d,m,/ha)
C = combustion efficiency, dimensionless
D = emission factor (g/kg dm)

In the category *Forest Land remaining Forest land*, the amount of CH_4 emissions ranged between 14.62 and 1,132.64 $GgCO_2$ equivalents, N_2O emissions ranged between 0.32 and 25.23 while CH_4 emissions ranged from 1.43 to 110.31 $GgCO_2$ equivalent in the reporting period, Emissions of these gases are significantly lower in category *Land converted to Forest land*.

7.12.3.CATEGORY-SPECIFIC RECALCULATIONS

- New estimation has been done based on the data gathered through activities of LULUCF 1 project

7.12.4. UNCERTAINTY AND TIME SERIES COSISTENCY

When performing uncertainty analyses in LULUCF sector, values presented in Table 7.12-1 were used in case of forest fires.

Table 7.12-1 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_2O (D)	75%	Default, IPCC GPG 2003

7.12.5. SECTOR SPECIFIC PLANNED IMPROVEMENTS

Through the conducted LULUCF project „*Improving Croatian reporting in the sector Land use, Land use change and Forestry (LULUCF) in the First commitment period of the Kyoto Protocol*" many data and information about forest fires are collected. Detailed analyses of recently available data (that are not at the moment used for NIR 2014 reporting) are foreseen in next period in order to check its quality and usefulness for switching to Tier 2 methodology in future LULUCF and KP reporting in case of emissions due to forest fires.

7.13. REFERENCES

Badjun, S. (1965) Physical and mechanical properties of Oakwood from forest district "Lubardenik" Lipovljani, *Drvna industrija* 16: 2-8.

Badjun, S. (1977) Comparative Wood Quality Appreciation, *Drvna industrija* 28: 125-131.

Croatian Bureau of Statistics (1999) Statistical Yearbook of the Republic of Croatia, *Croatian Bureau of Statistics*: 228

Croatian Bureau of Statistics (2011-2012) Statistical Yearbooks of the Republic of Croatia, *Croatian Bureau of Statistics*

Croatian Environment Agency (2013), http://www,azo,hr/CORINELandCover: 2-5

Croatian Forests (2006) Forest Management Area Plan of the Republic of Croatia 2006-2015, Public company "Croatian Forests"

Croatian Geological Institute (2012) Total nitrogen and organic carbon in soils of the Republic of Croatia, Croatian Environment Agency

Croatian Parliament (1993) Law on amendments to the Law on Forests Official Gazette No 76

Croatian Parliament (2009) Energy Development Strategy of the Republic of Croatia, Official Gazette No 130

Croatian Parliament (2012) Law on Energy, Official Gazette No 120

Environment Agency Austria (2012), National inventory report 2012, Submission under the UNFCCC and the Kyoto Protocol,
http://unfccc,int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/6598,php

Government of the Republic of Croatia (1993) The Regulation on amendments to the Law on Forests, Official Gazette No 14

Government of the Republic of Croatia (2007) Tariff system for the production of electricity from renewable energy sources and cogeneration, Official Gazette No 33

Government of the Republic of Croatia (2013) Draft strategy for management and disposal of property of the Republic of Croatia 2013-2017, http://www.duudi.hr/wp-content/uploads/2013/04/nacrt-Strategije.pdf : 43,

Govorčin S., T. Sinković, J. Trajković, B. Šefc (2011) Structural, technical and usable properties of some commercial wood species, Academy of Forestry Sciences: 647.

Horvat, I. (1957) Investigations on technical properties of Slavonian Oakwood, *Šumarski list* 81: 321-360.

Horvat, I. (1958) Investigations on technical properties of fir-wood (Abies Alba Mill,) from Gorski kotar, *Drvna industrija* 9: 2-10.

Horvat, I. (1969) Some physical and mechanical properties of beechwood from Gorski kotar Žumberak, Petrova gora, Senjsko bilo and Velebit, *Drvna industrija* 20: 183-194.

Janeš,D., G. Kovač, V. Grgesina, D. Pleskalt (2014): Identifying areas affected by fires according to requirements of Article 3.3 and 3.4 of the Kyoto Protocol

Ministry of Economy (2006) 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, http://www.plinacro.hr/default.aspx?id=44

Ministry of Regional Development, Forestry and Water management (2006) Regulations on the procedure for granting funds from fees for the use of beneficial functions of forests for work performed in private forests, Official Gazette No 66

Ministry of Regional Development, Forestry and Water management (2008) Ordinance on amendments to the Ordinance on the Register of forest owners, Official Gazette No 84

Ministry of Regional Development, Forestry and Water management (2010) Forest Resources Assessment Croatia 2010 (FRA 2010)

Republic of Bulgaria, Ministry of Environment and Water, Executive Environment Agency (2012), National inventory report 2012, Submission under the UNFCCC and the Kyoto Protocol, http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/6598.php

Section of Forestry and Wood Industry Association of Engineers and Technicians People's Republic of Croatia (1949), Small Forestry-technical Manual: 215

Sinković, T. (1991) Some physical properties of fir-wood from Gorski kotar, *Drvna industrija* 42: 17-21.

Sinković, T., S. Govorčin, T. Sedlar (2011) Comparison of Physical Properties of Untreated and Heat treated Beech and Hornbeam, *Drvna industrija* 62: 283-290.

Štajduhar, F. (1972) A contribution to Physical and mechanical properties investigation of Beechwood in Croatia, *Drvna industrija* 23: 43-59.

The Intergovernmental Panel on Climate Change (IPCC, 2003), Good Practice Guidelines for Land Use, Land-Use Change and Forestry, Institute for Global Environmental Strategies (IGES)

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 (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O).
CH_4 emissions as a result of disposal and treatment of MSW, CH_4 emissions from treatment of industrial wastewater and disposal of domestic and commercial wastewater in septic tanks, indirect N_2O emissions from human sewage and CO_2 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 Sustainable Waste Management Act [46], Strategy[47] and Plan[48]. The main act regulating waste management issues in the Republic of Croatia is the Sustainable Waste Management Act. There are a number of ordinances that have been adopted according to Sustainable Waste Management 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. Waste Framework Directive[49] is transposed by the new Sustainable Waste Management Actwhich is adopted in 2013.

Management of the different types of waste is arranged by the Strategy and Plan, which are harmonised by objectives of the waste hierarchy. The following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy: (a) prevention; (b) preparing for re-use; (c) recycling; (d) other recovery, e.g. energy recovery; and (e) disposal. 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

[46] Sustainable Waste Management Act (Official Gazette No. 94/13)

[47] Waste Management Strategy of the Republic of Croatia (OG 130/05)

[48] Waste Management Plan of the Republic of Croatia for 2007 - 2015 (OG 85/07, 126/10, 31/11)

[49] Waste Framework Directive 2008/98/EC

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. 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 GHGs should report required activity data for more accurate emissions estimation.

The total annual emissions of GHGs, expressed in Gg CO_2-eq, from waste management in the period 1990-2012 are presented in the Figure 8.1-1.

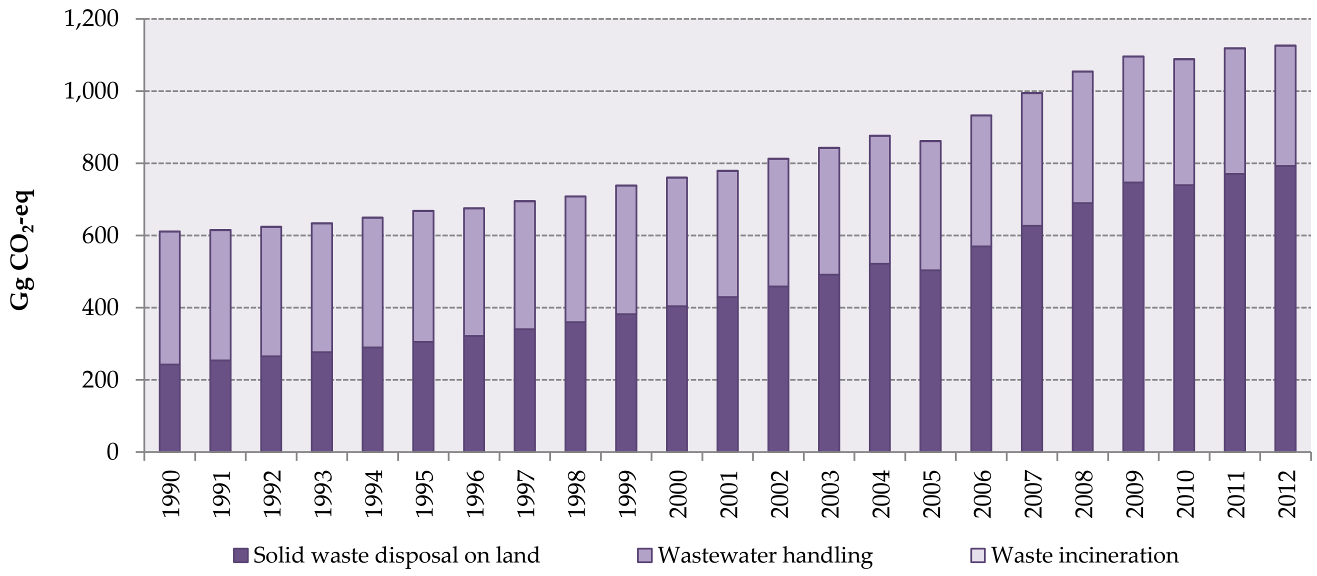


Figure 8.1-1: Emissions of GHGs from Waste sector (1990-2012)

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 2012[50]

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, L2i	T1e, T2e	T1i, T2i
CH_4 Emissions from Waste Water Handling	CH_4	L1e, L2e	L1i		

L1e - Level excluding LULUCF Tier1 L2e - Level excluding LULUCF Tier 2
L1i - Level including LULUCF Tier1 L2i - Level including LULUCF Tier 2
T1e - Trend excluding LULUCF Tier 1 T2e - Trend excluding LULUCF Tier 2
T1i - Trend including LULUCF Tier 1 T2i - Trend including LULUCF Tier 2

[50] 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 2009. Starting with 2009 there is a decrease in quantities registered, caused primary 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 2012 was 1.67 million tonnes, which is in average 391 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.

In the annual reports on municipal waste, produced by the CEA, validated data on municipal waste production (collection by waste code) is available since 2007, and the data on types of municipal waste landfilled (by waste code) is available since 2010 (Croatian waste catalogue is harmonized with European list of waste). Municipal waste by definition is waste from households and waste which, because of its nature and composition, is similar to waste produced by households, with exception of the industrial, agricultural and forestry waste. Inventory includes emissions related to the disposal of MSW on solid waste disposal sites (SWDSs). Efforts have been made in order to collect the necessary data and information on organic industrial waste (including sludge from waste water treatment) disposed in SWDSs.

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 (Official Gazette No. 117/07 , 111/11, 17/13, 62/13) and Ordinance on the waste management (Official Gazette No. 23/14), which are 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 302 official landfills registered in the Republic of Croatia since 2005, remediation processes for all the locations are either in planning phase, ongoing or completed. In 2012, the municipal waste was actively landfilled at 142 official sites (thereof 63 are managed, 41 are unmanaged deep and 38 are unmanaged shallow SWDSs); 90 SWDSs have been closed (thereof 28 are managed, 9 are unmanaged deep and 53 are unmanaged shallow SWDSs) and the waste removed completely from 70 closed managed SWDSs.

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 CH_4 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 Sustainable Waste Management 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 SWDSs for the period 1990-1998 has been evaluated from available relevant data compiled into Report; Fundurulja, D., Mužinić, M. (2000) *Estimation of the Quantities of Municipal Solid Waste in the Republic of Croatia in the period 1990 – 1998 and 1998 – 2010*, Zagreb. 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 period 2010-2012 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 almost all of 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" SWDSs. "Official" SWDSs do not necessarily fall under managed SWDS category as defined by IPCC (site management activities carried out in "Official" SWDSs 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 SWDSs 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 the period 2010 - 2012 (adjustment the country-specific to IPCC SWDS classification), the set of criteria was defined by working group, using the data for 2009 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 SWDSs in the period 1990-2012 are reported in the Table 8.2-2.

Table 8.2-2: The total annual generated and disposed MSW on different types of SWDS (1990-2012)

Year	MSW_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)
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
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
2012	1,670	0.83	870	397	116

* 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 CH_4 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 1990-2012. 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 1990-2012, are reported in the Table 8.2-3.

Table 8.2-3: Total weighted average MCF (1990-2012)

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
2012	0.892

The quantity of CH_4 emitted during decomposition process is directly proportional to the fraction of degradable organic carbon (DOC), which is defined as the carbon content of different types of organic biodegradable wastes such as paper and textiles, garden and park waste, food waste, wood and straw waste. 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:*

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)	2005-2012
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 degrades[51] 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 (without energy recovery) in the period 2004-2012 have been included in emission estimation and subtracted from generated CH_4. Information on recovered CH_4 in the period 2004-2012 is presented in the table 8.2-5.

Table 8.2-5: Recovered CH_4 (2004-2012)

Year	Recovered CH_4 (Gg)
2004	0.242
2005	2.723
2006	1.615
2007	1.370

[51] 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.

Table 8.2-5: Recovered CH_4 (2004-2012), cont.

Year	Recovered CH_4 (Gg)
2008	1.123
2009	1.234
2010	3.814
2011	4.397
2012	4.802

The most of managed SWDSs 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 CH_4 from land disposal of MSW in the period 1990-2012 are presented in the Figure 8.2-1.

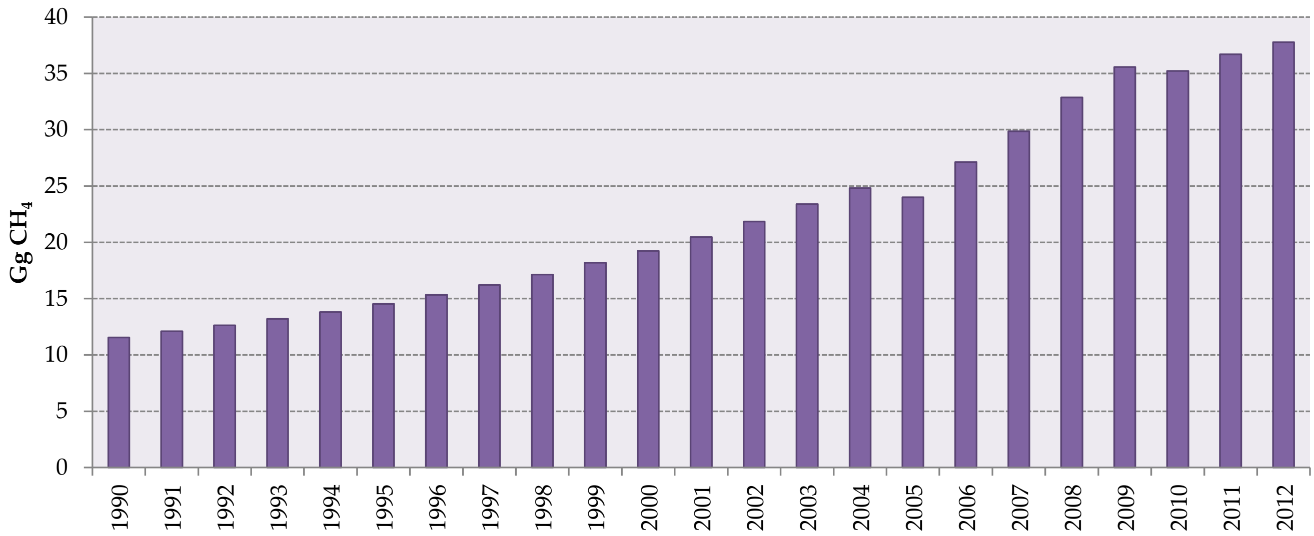


Figure 8.2-1: Emissions of CH_4 from Solid Waste Disposal on Land (1990-2012)

8.2.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

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

In addition, SWDSs in Croatia are classified into several categories, according to applied waste management activities, legality, volume 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. CH_4 emissions from solid waste disposal on land were estimated using Tier 2 method which is a *good practice*. The uncertainty of activity data is very high due to high discrepancy between various data sources. Basic country-specific activity data for CH_4 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

There are no source-specific recalculations for this subsector.

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 SWDSs (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. It will be solved through the project of the CEA: Creating a uniform methodology for the analysis of the composition of MSW, determine the average composition of MSW in the Republic of Croatia and the projection of the amount of MSW. The first output of the project that would include analysis and evaluation of the current situation, development of a uniform methodology for determining the composition of MSW and performed partly the field research with the purpose of determining the composition of MSW are planned at the end of 2014.
- 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.
- to collect the necessary data and information on organic industrial waste (including sludge from waste water treatment) disposed in SWDSs.

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. 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 CH_4 emissions. Anaerobic process is applied in some industrial wastewater treatment. Data for 3 industries with the largest potential for wastewater methane emissions (Manufacture of food products and beverages, Manufacture of pulp, paper and paper products and Manufacture of chemicals and chemical products) were considered. 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.

CH_4 emissions from treatment of industrial, domestic and commercial wastewater and indirect N_2O emissions from human sewage are included in emission estimates for the period 1990-2012.

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 proposed by *Revised 1996 IPCC Guidelines*,.

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 2003-2012. Insufficient data have been assessed by interpolation method. Submitted data on sludge treatment show that aerobic processes are used. Fraction of DOC removed as sludge is reported to be zero for entire period 1990-2012.

Data for CH_4 emission calculation for the period 1990-2012 are presented in the Table 8.3-1.

Table 8.3-1: Data for CH_4 emission calculation from Domestic and Commercial Wastewater (1990-2012)

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	21,902.04	2,450,000	53.66
2011	21,865.31	2,450,000	53.57
2012	21,878.26	2,300,000	50.32

* 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 1990-2012.

There is no sufficient information on fraction of wastewater type treated by a particular type of system.

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 1990-2012.

Default value for maximum methane producing capacity (Bo) of 0.6 kg CH_4/kg BOD, proposed by *2000 IPCC Good Practice Guidance,* has been used for emission calculation for entire period 1990-2012.

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 1990-2012.

The resulting annual emissions of CH_4 from Domestic and Commercial Wastewater in the period 1990-2012 are presented in the Figure 8.3-1.

Figure 8.3-1: Emissions of CH_4 from Domestic and Commercial Wastewater (1990-2012)

8.3.2.2. Industrial wastewater

Methane emissions from industrial wastewater have been calculated using the IPCC Tier 1 methodology proposed by *Revised 1996 IPCC Guidelines,*

Data on industrial output (tonne/yr) for 3 industries with the largest potential for wastewater methane emissions (Manufacture of food products and beverages, Manufacture of pulp, paper and paper products and Manufacture of chemicals and chemical products) were provided by Croatian Chamber of Economy. Insufficient data were assessed by interpolation/extrapolation method.

Data on industrial output for the period 1990-2012 are presented in the Table 8.3-2.

Table 8.3-2: Data on industrial ouput (1990-2012)

Year	Total industrial output (tonne)		
	Manufacture of food products and beverages	Manufacture of pulp, paper and paper products	Manufacture of chemicals and chemical products
1990	5,315,793*	339,150*	3,318,280*
1991	5,351,454*	353,635*	3,255,152*
1992	5,387,114*	368,120*	3,192,024*
1993	5,422,775*	382,605*	3,128,896*
1994	5,458,436*	453,729	3,065,768*
1995	5,494,097*	412,203	3,147,255
1996	5,529,757*	371,798	2,915,042
1997	5,446,749	425,155	2,957,173
1998	5,824,329	416,693	2,370,884
1999	5,544,368	461,676	2,773,894
2000	5,658,938	540,973	2,907,306
2001	3,131,009	542,469	2,414,577
2002	3,335,776*	568,227	2,325,925
2003	3,544,664*	544,932	2,342,540
2004	3,757,680	566,745	2,784,861
2005	4,969,306	468,791	3,066,741
2006	5,455,702	538,793	2,939,226
2007	5,179,332	583,172	3,282,811
2008	5,173,879	595,836	3,127,388
2009	4,332,625	406,574	2,369,124
2010	4,246,800	427,943	2,400,562
2011	4,402,599	405,122	2,347,350
2012	4,316,793	373,123	2,103,609

* insufficient data on industrial output (tonne/yr) were assessed by extrapolation/interpolation method:

- manufacture of food products and beverages: data for the period 1990-1996 were assessed by extrapolation method taking into account the pattern from 1997 to 2000; data for 2002 and 2003 were assessed by interpolation method;
- manufacture of pulp, paper and paper products: data for the period 1990-1994 were assessed by extrapolation method taking into account the pattern from 1994 to 2000;
- manufacture of chemicals and chemical products: data for the period 1990-1994 were assessed by extrapolation method taking into account the pattern from 1995 to 2000.

Data on wastewater output (m^3/yr) for 3 industries with the largest potential for wastewater methane emissions (Manufacture of food products and beverages, Manufacture of pulp, paper and paper products and Manufacture of chemicals and chemical products) were taken from Statistical Yearbooks. Data for 1997 are insufficient and assessed by interpolation. Data for the period 1990-1993 are available in different (aggregated) form. These data also assessed by extrapolation to enable usage of same methodology during the time series. Data on wastewater output for the period 1990-2012 are presented in the Table 8.3-3.

Table 8.3-3: Data on wastewater ouput (1990-2012)

Year	Total wastewater output (m^3)		
	Manufacture of food products and beverages	Manufacture of pulp, paper and paper products	Manufacture of chemicals and chemical products
1990	7,237,300	3,207,500	2,875,490
1991	7,127,770	3,079,150	2,883,241
1992	7,018,240	2,950,800	2,890,992
1993	6,908,710	2,822,450	2,898,743
1994	5,911,000	679,000	2,115,000
1995	6,157,000	5,224,000	1,806,000
1996	5,274,000	3,817,000	6,896,000
1997	6,470,590	2,309,050	2,929,747
1998	9,348,000	1,130,000	1,571,000
1999	9,759,000	1,065,000	2,371,000
2000	4,914,000	1,169,000	2,189,000
2001	4,715,000	1,808,000	1,577,000
2002	5,630,000	132,000	3,619,000
2003	5,037,000	3,695,000	4,936,000
2004	4,767,000	2,213,000	3,519,000
2005	6,440,000	681,000	1,864,000
2006	5,045,000	1,692,000	3,375,000
2007	4,941,000	1,646,000	1,624,000
2008	2,570,000	1,574,000	1,007,000
2009	2,553,000	1,766,000	1,332,000
2010	3,086,000	2,508,000	1,437,000
2011	2,279,000	171,000	728,000
2012	2,084,000	1,881,000	471,000

No country-specific data are available for degradable organic component, DOC (kg COD/m^3 wastewater) and wastewater produced (m^3/tonnes of product). Average values calculated using default values for different industry type, proposed by *IPCC Good Practice Guidance* (Table 5.4), has been used for emission calculation for entire period 1990-2012 (Table 8.3-4).

Table 8.3-4: Data on degradable organic component and wastewater produced (1990-2012)

Parameter	Manufacture of food products and beverages	Manufacture of pulp, paper and paper products	Manufacture of chemicals and chemical products
DOC (kg COD/m^3 wastewater)*	4.66	9.00	3.00
Wastewater produced (m^3/tonne product)**	15.55	162.00	67.00

* following default values for DOC (kg COD/m^3 wastewater) have been used:

- manufacture of food products and beverages: Alcohol Refining: 11; Beer&Malt: 2.9; Coffee: 9; Dairy products: 2.7; Fish processing: 2.5; Meat&Poultry: 4.1; Sugar refining: 3.2; Vegetables, fruits&juices: 5.0; Wine&vinegar: 1.5 (average = 4.66 kg COD/m^3 wastewater);
- manufacture of pulp, paper and paper products: Pulp&Paper (combined): 9.00 kg COD/m^3 wastewater;
- manufacture of chemicals and chemical products: Organic chemicals: 3.00 kg COD/m^3 wastewater.

** following default values for wastewater produced (m^3/tonne product) have been used:

- manufacture of food products and beverages: Alcohol Refining: 24; Beer&Malt: 6.3; Coffee: NA; Dairy products: 7; Fish processing: NA; Meat&Poultry: 13; Sugar refining: NA; Vegetables, fruits&juices: 20; Wine&vinegar: 23 (average = 15.5 m^3/tonne product);
- manufacture of pulp, paper and paper products: Pulp&Paper (combined): 162.00 m^3/tonne product;
- manufacture of chemicals and chemical products: Organic chemicals: 67.00 m^3/tonne product.

Submitted data on sludge treatment show that aerobic processes are used. Fraction of DOC removed as sludge is reported to be zero for entire period 1990-2012.

Organic wastewater from industrial sources (kg COD/yr) for the period 1990-2012 are presented in the Table 8.3-5.

Table 8.3-5: Organic wastewater from industrial sources (1990-2012)

Year	Organic wastewater from industrial sources (kg COD/yr)			Total organic wastewater (kg COD/yr)
	Manufacture of food products and beverages	Manufacture of pulp, paper and paper products	Manufacture of chemicals and chemical products	
1990	384,830,928	494,480,700	666,974,280	1,546,285,908
1991	387,412,545	515,599,830	654,285,552	1,557,297,927
1992	389,994,161	536,718,960	641,596,824	1,568,309,945
1993	392,575,778	557,838,090	628,908,096	1,579,321,964
1994	395,157,395	661,536,882	616,219,368	1,672,913,645
1995	397,739,012	600,991,974	632,598,255	1,631,329,241
1996	400,320,628	542,081,484	585,923,442	1,528,325,554
1997	394,311,342	619,875,990	594,391,773	1,608,579,105
1998	421,645,826	607,538,394	476,547,684	1,505,731,904
1999	401,378,361	673,123,608	557,552,694	1,632,054,663
2000	409,672,529	788,738,634	584,368,506	1,782,779,669
2001	226,665,918	790,919,802	485,329,977	1,502,915,697
2002	241,489,797	828,474,966	467,510,925	1,537,475,688
2003	256,612,012	794,510,856	470,850,540	1,521,973,408
2004	272,033,068	826,314,210	559,757,061	1,658,104,339
2005	359,747,391	683,497,278	616,414,941	1,659,659,610
2006	394,959,469	785,560,194	590,784,426	1,771,304,089

Table 8.3-5: Organic wastewater from industrial sources (1990-2012), cont.

Year	Organic wastewater from industrial sources (kg COD/yr)			Total organic wastewater (kg COD/yr)
	Manufacture of food products and beverages	Manufacture of pulp, paper and paper products	Manufacture of chemicals and chemical products	
2007	374,951,975	850,264,776	659,845,011	1,885,061,762
2008	374,557,194	868,728,888	628,604,988	1,871,891,070
2009	313,655,582	592,784,892	476,193,924	1,382,634,398
2010	307,442,357	623,940,894	482,512,962	1,413,896,213
2011	318,721,230	590,667,876	471,817,350	1,381,206,456
2012	312,509,464	544,013,334	422,825,409	1,279,348,207

No country-specific data are available for fraction of wastewater treated. Default value (0.57), proposed by *Revised 1996 IPCC Guidelines* (Table 6-9), has been used for emission calculation for entire period 1990-2012.

There is no sufficient information on fraction of wastewater type treated by a particular type of system.

No country-specific data are available for methane conversion factor (MCF). Due to the fact that wastewaters are mostly handled aerobically, MCF is assessed to be 0.01 according to expert judgement (comparison with the other countries). This value has been used for emission calculation for entire period 1990-2012.

Default value for maximum methane producing capacity (Bo) of 0.25 kg CH_4/kg COD, proposed by *2000 IPCC Good Practice Guidance,* has been used for emission calculation for entire period 1990-2012.

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 1990-2012.

The resulting annual emissions of CH_4 from Industrial Wastewater in the period 1990-2012 are presented in the Figure 8.3-2.

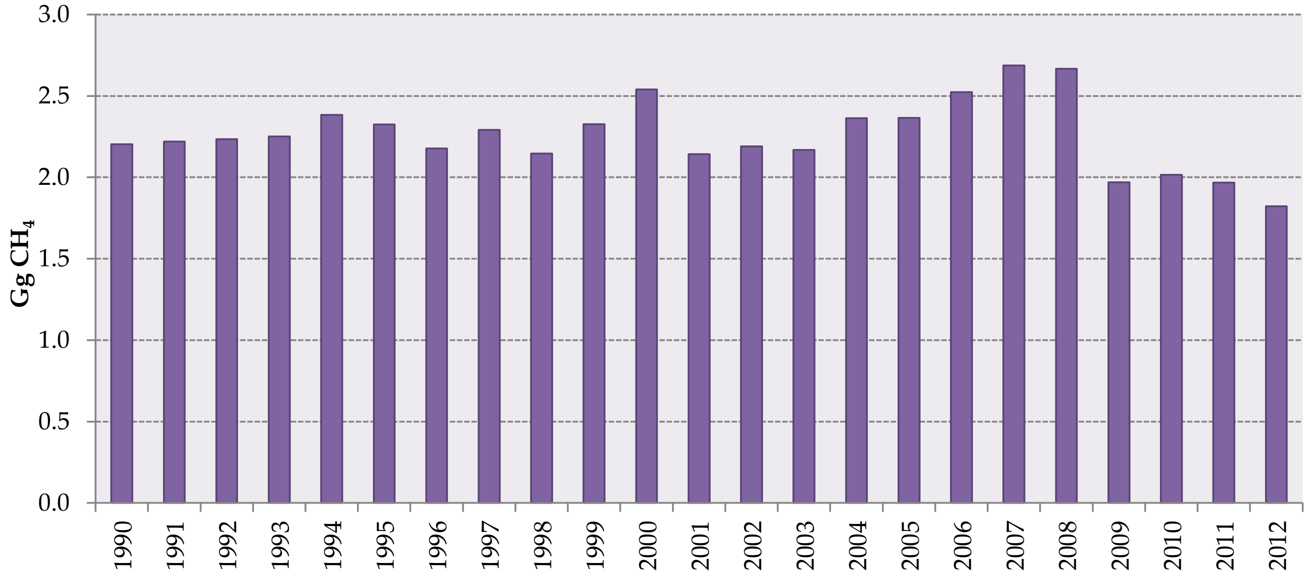


Figure 8.3-2: Emissions of CH_4 from Industrial Wastewater (1990-2012)

8.3.2.3.Human sewage

Indirect nitrous oxide (N_2O) emissions from human sewage have been calculated using the IPCC Tier 1 methodology proposed by *Revised 1996 IPCC Guidelines.*

The population estimate of the Republic of Croatia for the period 1990-2012 were taken from Statistical Yearbook. Croatian data on the annual per capita Protein intake value (PIV), for the period 1992-2009, 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 the period 2010-2012. Data on Population and PIV for the period 1990-2012 are presented in the Table 8.3-6.

Table 8.3-6: Data on Population and PIV (1990-2012)

Year	Population	Protein intake (kg/person/yr)
1990	4,778,000	22.71
1991	4,513,000	22.43
1992	4,470,000	22.52
1993	4,641,000	21.46
1994	4,649,000	21.97
1995	4,669,000	23.54
1996	4,494,000	23.18
1997	4,572,500	22.89

Table 8.3-6: Data on population and PIV (1990-2012), cont.

Year	Population	Protein intake (kg/person/yr)
1998	4,501,000	22.67
1999	4,554,000	24.05
2000	4,381,000	24.05
2001	4,305,494	25.81
2002	4,305,384	27.41
2003	4,305,725	27.63
2004	4,310,861	27.63
2005	4,312,487	28.84
2006	4,313,530	29.93
2007	4,311,967	30.44
2008	4,309,796	30.40
2009	4,302,847	30.84
2010	4,289,857	30.87
2011	4,280,622	31.07
2012	4,267,558	31.27

Fraction of nitrogen in protein ($FRAC_{NPR}$) which equals 0.16 kg N/kg protein, proposed by *Revised 1996 IPCC Guidelines*, has been used for emission calculation for entire period 1990-2012.
Default emission factor (EF) which equals 0.01 kg N_2O-N/kg sewage-N produced, proposed by *Revised 1996 IPCC Guidelines*, has been used for emission calculation for entire period 1990-2012.

The resulting annual emissions of N_2O from Human Sewage in the period 1990-2012 are presented in the Figure 8.3-3.

Figure 8.3-3: Emissions of N_2O from Human Sewage (1990-2012)

8.3.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainties contained in CH_4 emissions estimates from Domestic and Commercial Wastewater and Industrial 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 extrapolation/interpolation methodology, which represents additional uncertainty in the estimations.
The uncertainties contained in N_2O emissions estimates from Humane sewage are related primarily to applied default emission factor and extrapolated values for protein intake.

Activity data and emission factor uncertainty for CH_4 emission from Domestic and Commercial Wastewater and Industrial Wastewater was calculated in detail using Monte-Carlo analysis.
Uncertainty estimate associated with activity data for CH_4 and N_2O emission calculation amounts 50 percent, based on expert judgements. Uncertainty estimate associated with CH_4 and N_2O 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, Industrial 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. CH_4 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

<u>Domestic and Commercial Wastewater:</u>
The new BOD value (Gg /yr) for the period 2010-2012 have been provided by state company Croatian Water (Hrvatske vode). Thereupon, CH_4 emissions have been recalculated for 2010 and 2011.

Industrial Wastewater:

New set of data for CH_4 emissions from industrial wastewater treatment (industrial production in tonne/yr) for 3 industries with the largest potential for wastewater methane emissions (Manufacture of food products and beverages, Manufacture of pulp, paper and paper products and Manufacture of chemicals and chemical products) have been included. Thereupon, CH_4 emissions have been recalculated for the period 1990-2011.

Human Sewage

New data for Population in country have been provided at the Statistical Yearbook 2013, Release on 9 December 2013 (Revision of estimates the population of Croatia since 2001 to 2010). Updated data have been provided for 1997 and for the period 2000-2011. Thereupon, N_2O emissions have been recalculated for 1997 and for the period 2001-2011.

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 CH_4 emission calculation:

- assumptions of parameters which default values are used
  - wastewater treated ratio for industrial and domestic/commercial wastewater – more information on fraction of wastewater type treated by a particular type of system; more information on wastewater flows and treatment system, in order to consider all potential anaerobic treatment systems and discharge pathways;
  - methane conversion factor for industrial and domestic/commercial wastewater
  - maximum methane producing capacity for industrial and domestic/commercial wastewater
  - DOC in kg COD/m^3 wastewater of industries with the largest potential for CH_4 emission
  - wastewater produced in m^3/tonne product for industries with the largest potential for CH_4 emission
- investigation whether DOC removed as sludge for industrial and domestic/commercial wastewater are there - improve quantity and quality of data on sludges produced and data on management of sludges which are to be reported to Environmental Pollution Register;
- more detailed background information related to the sources of AD and EFs are necessary in order to improve transparency. It is necessary to

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

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 - 2012 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.

CO_2 emissions from incineration of clinical waste are included in emission estimates for the period 1990-2012. CO_2 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 CO_2 emission calculation from incineration of hazardous waste are used for the period 2007-2010 and data for CO_2 emission calculation from incineration of plastic are used for the period 2007-2009.

In regard to N_2O 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, N_2O emissions have not been estimated.

8.4.2. METHODOLOGICAL ISSUES

CO_2 emissions from incineration of waste have been calculated using the IPCC Tier 1 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 2004-2012 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 1990-2012.

Data on incineration of hazardous waste for the period 2007-2012 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 and 2012.

Data on incineration of plastics for 2007 and 2008 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 the period 2010-2012.

Data for CO_2 emission calculation from Waste Incineration (without energy recovery) for the period 1990-2012 are presented in the Table 8.4-1.

Table 8.4-1: Incinerated waste (without energy recovery) (1990-2012)

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

Table 8.4-1: Incinerated waste (without energy recovery) (1990-2012), cont.

Year	Incinerated waste (tonnes)		
	Hospital waste	Hazardous waste	Plastics
2008	196.64	28.64	13.23
2009	49.19	28.64	13.23
2010	54.40	32.60	0.00
2011	57.45	0.00	0.00
2012	93.10	0.00	0.00

Quantities of incinerated waste without energy recovery were not increased significantly in 2007, but CO_2 emission increased. The reason is accessibility of more detailed data on types of incinerated waste. CO_2 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- 2012, 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 and 2012. Also, the total quantity of plastics has been incinerated with energy recovery in the period 2010-2012.

The resulting annual emissions of CO_2 from Waste Incineration in the period 1990-2012 are presented in the Figure 8.4-1.

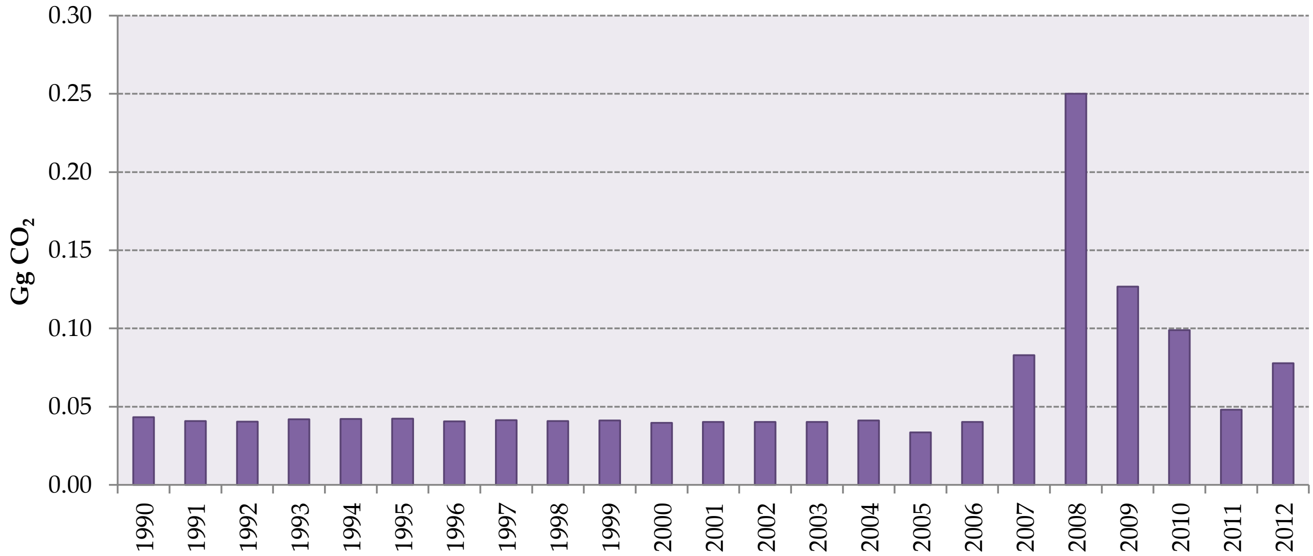


Figure 8.4-1: Emissions of CO_2 from Waste Incineration (1990-2012)

8.4.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainties contained in CO_2 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 CO_2 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 order to estimate N_2O emissions from waste incineration.

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 1990-2012 are presented in Table 8.5-1.

Table 8.5-1: Emissions from Waste (1990-2012)

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	39.72	0.77
	1991		12.09		253.95	41.30	1.02
	1992		12.63		265.23	42.50	1.14
	1993		13.20		277.15	43.74	1.19
	1994		13.82		290.13	44.68	1.29
	1995		14.54		305.26	45.74	1.32
	1996		15.32		321.80	47.68	1.36
	1997		16.20		340.30	48.98	1.35
	1998		17.13		359.75	50.84	1.42
	1999		18.18		381.84	51.75	1.43
	2000		19.24		404.11	53.18	1.53
	2001		20.47		429.83	55.16	1.56
	2002		21.85		458.90	56.49	1.60
	2003		23.39		491.15	58.29	1.64
	2004		24.82		521.32	59.53	1.73
	2005		24.01		504.14	58.54	1.65
	2006		27.14		569.87	61.10	1.83
	2007		29.86		627.08	63.08	1.92
	2008		32.87		690.17	65.49	2.20
	2009		35.57		746.97	68.19	2.55
	2010		35.21		739.50	67.97	2.57
	2011		36.71		770.89	68.93	2.71
	2012		37.76		793.02	70.45	3.01
Domestic and Commercial Wastewater	1990	CH_4	11.30	21	237.25	38.85	0.75
	1991		11.21		235.33	38.28	0.94
	1992		11.11		233.41	37.40	1.00
	1993		11.02		231.49	36.54	0.99
	1994		10.93		229.57	35.35	1.02
	1995		10.84		227.65	34.11	0.99
	1996		10.77		226.16	33.51	0.95
	1997		10.70		224.67	32.34	0.89
	1998		10.63		223.18	31.54	0.88
	1999		10.56		221.69	30.05	0.83
	2000		10.49		220.20	28.98	0.84
	2001		10.37		217.74	27.94	0.79
	2002		10.26		215.37	26.51	0.75
	2003		10.15		213.08	25.29	0.71
	2004		10.09		211.92	24.20	0.70
	2005		10.02		210.39	24.43	0.69
	2006		9.96		209.06	22.42	0.67
	2007		9.91		208.15	20.94	0.64
	2008		9.77		205.21	19.47	0.65
	2009		9.69		203.59	18.58	0.69

Table 8.5-1: Emissions from Waste (1990-2012), cont.

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg CO_2-eq)	Percent in Waste	Percentage in Total Country Emission
	2010		9.66		202.83	18.64	0.70
	2011		9.64		202.49	18.11	0.71
	2012		9.06		190.21	16.90	0.72
Industrial Wastewater	1990	CH_4	2.20	21	46.27	7.58	0.15
	1991		2.22		46.60	7.58	0.19
	1992		2.23		46.93	7.52	0.20
	1993		2.25		47.26	7.46	0.20
	1994		2.38		50.06	7.71	0.22
	1995		2.32		48.82	7.31	0.21
	1996		2.18		45.74	6.78	0.19
	1997		2.29		48.14	6.93	0.19
	1998		2.15		45.06	6.37	0.18
	1999		2.33		48.84	6.62	0.18
	2000		2.54		53.35	7.02	0.20
	2001		2.14		44.97	5.77	0.16
	2002		2.19		46.01	5.66	0.16
	2003		2.17		45.55	5.41	0.15
	2004		2.36		49.62	5.67	0.16
	2005		2.37		49.67	5.77	0.16
	2006		2.52		53.01	5.68	0.17
	2007		2.69		56.41	5.67	0.17
	2008		2.67		56.02	5.32	0.18
	2009		1.97		41.38	3.78	0.14
	2010		2.01		42.31	3.89	0.15
	2011		1.97		41.33	3.70	0.15
	2012		1.82		38.28	3.40	0.15
Human Sewage	1990	N_2O	0.27	310	84.57	13.85	0.27
	1991		0.25		78.91	12.84	0.32
	1992		0.25		78.46	12.57	0.34
	1993		0.25		77.64	12.25	0.33
	1994		0.26		79.62	12.26	0.35
	1995		0.28		85.67	12.84	0.37
	1996		0.26		81.19	12.03	0.34
	1997		0.26		81.56	11.74	0.32
	1998		0.26		79.52	11.24	0.31
	1999		0.28		85.38	11.57	0.32
	2000		0.26		82.13	10.81	0.31
	2001		0.28		86.60	11.11	0.31
	2002		0.30		91.99	11.32	0.32
	2003		0.30		92.73	11.01	0.31
	2004		0.30		92.84	10.60	0.31
	2005		0.31		96.92	11.25	0.32
	2006		0.32		100.63	10.79	0.32
	2007		0.33		102.31	10.29	0.31
	2008		0.33		102.13	9.69	0.33
	2009		0.33		103.44	9.44	0.35
	2010		0.33		103.21	9.49	0.36
	2011		0.33		103.66	9.27	0.36

Table 8.5-1: Emissions from Waste (1990-2012), cont.

Source	Year	GHG	Emission (Gg)	GWP[1]	Emission (Gg CO_2-eq)	Percent in Waste	Percentage in Total Country Emission
	2012		0.34		104.01	9.24	0.39
Waste Incineration	1990	CO_2	0.043	1	0.043	0.007	0.0001
	1991		0.041		0.041	0.007	0.0002
	1992		0.040		0.040	0.006	0.0002
	1993		0.042		0.042	0.007	0.0002
	1994		0.042		0.042	0.006	0.0002
	1995		0.042		0.042	0.006	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	0.005	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	0.004	0.0001
	2007		0.083		0.083	0.008	0.0003
	2008		0.250		0.250	0.024	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
	2012		0.078		0.078	0.007	0.0003

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

8.6. REFERENCES

Central Bureau of Statistics, *Statistical Yearbooks (1990-2012)*

Croatian Environment Agency (2006) *Cadastre of Emission to Environment (KEO) Reporting Forms - regarding to hazardous waste*, Zagreb

Croatian Environment Agency,*Cadastre of Waste - Municipal Solid Waste, Report 2006, Report 2007, Report 2008, Report 2009, Report 2010, Report 2011,Report 2012*, Zagreb

Croatian Environment Agency (2013) Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2012* Submission to the Convention on Long-range Transboundary Air Pollution, EKONERG Ltd., Zagreb

Croatian Water Ltd. (2013) *Report: Data for methane emission calculations from domestic and commercial wastewater*, Zagreb

Diaz, L.F. et al. (1996) *Solid Waste Management for Economically Developing Countries, ISWA*

Government of the Republic of Croatia (2005) *Croatian Waste Management Strategy*

FAOSTAT: Statistical Database, http://www.fao.org

FCCC/ARR/2013/HRV *Report of the individual review of the annual submission of Croatia submitted in 2013, 21 March 2014*

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

IPCC (2000) *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, Japan

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

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

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

Ministry of Environmental and Nature Protection (2006) *Guidelines Development for starting implementation of Waste Management Plan in the Republic of Croatia*, LIFE04 TCY/CRO/000028, EKONERG Ltd., Zagreb

Ministry of Environmental and Nature Protection (2013) *National Inventory Report 2013, Croatian greenhouse gas inventory for the period 1990 – 2011*, EKONERG Ltd., Zagreb

Ministry of Environmental and Nature Protection (2010) *Fifth National Communication of the Republic of Croatia under the United Nations Framework Convention on Climate Change (UNFCCC)*, Zagreb

Ministry of Environmental and Nature Protection (2007) *Waste Management Plan in the Republic of Croatia (2007-2015)*, Zagreb

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 1990-2011 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 *Report of the individual review of the annual submission of Croatia submitted in 2013*)

Recalculations are performed in the following sectors:

- Energy
  - Feedstock and non-energy use
  - Reference Approach
  - Civil aviation
  - Railways
  - Road transport
  - Manufacturing Industries and Construction – Petrochemical production
  - Fugitive emissions from oil, natural gas and other sources
- Industrial Processes
  - Lime production
  - Limestone and dolomite use
  - Nitric acid production
  - Consumption of halocarbons and SF_6
- Solvent and Other Product Use
- Agriculture
  - CH_4 emissions from Enteric fermentation in domestic livestock
  - CH_4 emissions from Manure management,
  - N_2O emissions from Manure management
  - N_2O emissions from Agricultural soils
  - Indirect N_2O emissions from nitrogen used in agriculture
- LULUCF
  - Emissions/removals from Forest land remaining forest land and Land converted to Forest land
  - Emissions/removals from Cropland remaining Cropland and Land converted to Cropland
  - Emissions/removals from Grassland remaining Grassland and Land converted to Grassland

  - Emissions/removals from Land converted to Settlements
- Waste
  - 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

Fugitive emissions from coal mining and handling (1.B.1.a)

- Recalculations were made because activity data on production of coal were duplicated for the period from 1990 – 1999.

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 1991-2011.

Mineral Products (2.A.); Limestone and Dolomite Use (2.A.3.)

New data have been obtained from several manufacturers for the entire reporting period (limestone use 1990-2011; dolomite use 2000-2011). Therefore, recalculations for this subsector have been performed for the period 1990-2011.

Chemical Industry (2.B.); Nitric Acid Production (2.B.2.)

New data on nitric acid production and plant-specific emission factors have been provided by the manufacturer. Therefore, emission recalculations have been performed for the entire reporting period.

Consumption of Halocarbons and SF_6 (2.F.); Refrigeration and Air Conditioning Equipment (2.F.1.)

New data for the year 2011 were provided for HFC-134a used in Transport Refrigeration, HFC-410a and HFC-407c used in Industrial Refrigeration, HFC-410a and HFC-407c used in Stationary Air-Conditioning and HFC-134a used in Mobile Air-Conditioning. Recalculations were made respectively.

Consumption of Halocarbons and SF_6 (2.F.); Fire Extinguishers (2.F.3.)

New data were provided for gases HFC-236fa for 2008, HFC-227ea and HFC-125 for 2011. Recalculations were made respectively.

Solvent and Other Product Use

Solvent and Other Product Use (3.B.C.D.)

Activity data for NMVOC emission calculation for the period 2001-2011 has been updated according to the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2012* Submission to the Convention on Long-range Transboundary Air Pollution'. Therefore, CO_2 emissions have been recalculated for the period 2001-2011 in this report.

Agriculture

CH_4 Emissions from Enteric Fermentation in Domestic Livestock (4.A.)

Methane emissions from Enteric fermentation were recalculated:

- for the 1995-2011 period due to changes in activity data (number of horses and mules/asses)
- for the 1990-2011 period due to change in dairy cattle population, live animal weights and milk yield AD
- for the 1990-2007 period due to change of usage of default emission factors from those for developing to those for developed countries

CH_4 Emissions from Manure management (4.B.)

Emissions were recalculated for the 1995-2011 period due to changes in activity data (number of horses and mules/asses).
Emissions were also recalculated for the entire 1990-2011 period due to reconciliation of the discrepancy regarding the usage of IPCC default EFs for developing countries for the period 1990-2007 and default EFs for developed countries for the period 2008-2011 for the estimation of emissions from manure management (sheep, goats, horses, mules and assess, swine and poultry). EFs for developed countries will be used for the entire timeseries as a short term replacement until national factors are developed.

N_2O Emissions from Manure management (4.B.)

Emissions were recalculated:

- for the 1995-2011 period due to changes in activity data (number of horses and mules/asses)
- for the entire 1990-2011 due to changes in activity data on dairy cattle population
- for the entire 1990-2011 due to changes in that fractions of manure N per AWMS for swine. ERT pointed out that fractions of manure N per AWMS for swine which are presented in the table 6.4- are not correct, because the sum of the fractions for liquid systems (29 per cent), pasture, range and paddock (27 per cent) and other systems (45 per cent) amounts to 101%. NIR team would like to reiterate that this is an error present both in Revised 1996 IPCC Guidelines, p.4.101, table 4-21) and in the original reference document used by the Guidelines. Croatian NIR team changed the percentage values to address this issue by lowering all AWMS fractions percentage for swine by 0.33% and 0.34, respectively.
- for the 1990-2007 period due to reconciliation of the discrepancy regarding the usage of IPCC default EFs for developing countries for the period 1990-2007 and default EFs for developed countries for the period 2008-2011 for the estimation of emissions from manure management (sheep, goats, horses, mules and assess, swine and poultry). EFs for developed countries will be used for the entire timeseries as a short term replacement until national factors are developed.

Agricultural soils (4.D.)

Direct emission from Agricultural soils (4.D.1.)

<u>N_2O emissions from animal manure and liquid/slurry</u>
Recalculations were performed for the 1995-2011 time period due to updated activity data (change in AD source) regarding the number of animals (horses, mules/asses).

<u>N_2O emissions due to cultivation of organic soils</u>
Recalculations were performed for the entire time period 1990-2011 due to updated activity data regarding the area of histosols in the Republic of Croatia.

N_2O emissions originating from biological fixation of nitrogen and crop residue
Recalculations were performed for the year 1992 and 2011 due to the change in activity data for maize (1992) and vetches (2011) crops.

N_2O emissions due to application of sewage sludge
Recalculations were performed for the years 2009-2011 due to the new activity data.

Nitrous oxide from animal manure and liquid/slurry
Recalculations were performed for the years 1990-2011 due to change of fraction of Manure Nitrogen per AWMS for swine and due to updated activity data (change in AD source) regarding the number of animals (dairy cattle).

Direct N_2O emission from pasture, range and paddock manure (CRF 4.D.2.)

Emissions were recalculated:

- for the 1995-2011 period due to changes in activity data (number of horses and mules/asses)
- for the entire 1990-2011 due to changes in activity data on dairy cattle population
- for the entire 1990-2011 due to changes in that fractions of manure N per AWMS for swine.
- for the 1990-2007 period due to reconciliation of the discrepancy regarding the usage of IPCC default EFs for developing countries for the period 1990-2007 and default EFs for developed countries for the period 2008-2011 for the estimation of emissions from manure management (sheep, goats, horses, mules and assess, swine and poultry). EFs for developed countries will be used for the entire timeseries as a short term replacement until national factors are developed.

Indirect N_2O emission from nitrogen used in agriculture (4.D.3.)

Since direct N_2O emissions were recalculated due to the changes in activity data for application of sewage sludge, recalculations of indirect N_2O emissions were performed for the same time period. For detailed explanation, see Chapter 6.6.1.5.

Emissions were also recalculated:

- for the 1995-2011 period due to changes in activity data (number of horses and mules/asses)
- for the entire 1990-2011 due to changes in activity data on dairy cattle population
- for the entire 1990-2011 due to changes in that fractions of manure N per AWMS for swine.
- for the 1990-2007 period due to reconciliation of the discrepancy regarding the usage of IPCC default EFs for developing countries for the period 1990-2007 and default EFs for developed countries for the period 2008-2011 for the estimation of emissions from manure management (sheep, goats, horses, mules and assess, swine and poultry). EFs for developed countries will be used for the entire timeseries as a short term replacement until national factors are developed.

LULUCF

CO_2 emissions/removals in Forest land remaining Forest land (5 A 1)

For this year submission Croatia applied new values for R/S factor in its estimation and estimation has been performed using the per ha values for increment and harvest that corresponds to total forest areas while in last year's report estimation was done using the per/ha values for each type of ownership and finally summing them up.

Area under the forest fires were corrected subtracing the areas under the Land converted to forest land that were affected by fires

CO_2 emissions/removals in Land converted to Forest land (5 A 2)

Emissions due to fires on these areas are estimated

CO_2 emissions/removals in Cropland remaining Cropland (5 B 1) and Land converted to Cropland (5 B 2)

Based on new available data, organic soils emissions are calculated for annual and perennial cropland using the new data on areas. Also, emissions due to liming since 2005 are added to soil emissions and new CBS data for cropland areas in 2010 and 2011 were used.

CO_2 emissions/removals in Grassland remaining Grassland (5 C 1) and Land converted to Grassland (5 C 2)

Recalculations performed under this category of land are connected with new defined area under organic soil and adding the emissions due to fires.

CO_2 emissions/removals in Land converted to Settlements (5 E 2)

Correction in previously incorrectly presented part of the correction factor (value of 1.5%) for Settlement areas in Excel sheet. Instead of 0.015, value of 0.15 was introduced causing mistake in Settlement area in matrix

Waste

Wastewater Handling (6.B.)

Domestic and Commercial Wastewater:

The new BOD value (Gg /yr) for the period 2010-2012 have been provided by state company Croatian Water (Hrvatske vode). Thereupon, CH_4 emissions have been recalculated for 2010 and 2011.

Industrial Wastewater:

New set of data for CH_4 emissions from industrial wastewater treatment (industrial production in tonne/yr) for 3 industries with the largest potential for wastewater methane emissions (Manufacture of food products and beverages, Manufacture of pulp, paper and paper products and Manufacture of chemicals and chemical products) have been included. Thereupon, CH_4 emissions have been recalculated for the period 1990-2011.

Human Sewage

New data for Population in country have been provided at the Statistical Yearbook 2013, Release on 9 December 2013 (Revision of estimates the population of Croatia since 2001 to 2010). Updated data have been provided for 1997 and for the period 2000-2011. Thereupon, N_2O emissions have been recalculated for 1997 and for the period 2001-2011.

10.1.1.2. Consistency with good practice guidance

Energy

Road transportation (1.A.3.b)

- Emissions of CO_2 from LPG and CNG were recalculated for the period 1990-2010 in the course of the ERT review in 2013.

-Recalculations are made foe CH4 and N2O emissions due to new COPERT IV version 10.0

10.1.1.3New methods

LULUCF

For this year submission Croatia applied new values for R/S factor in its estimation and estimation has been performed using the per ha values for increment and harvest that corresponds to total forest areas while in last year's report estimation was done using the per/ha values for each type of ownership and finally summing them up.

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.

LULUCF

Settlement (5 E) - area

Correction in previously incorrectly presented part of the correction factor (value of 1.5%) for Settlement areas in Excel sheet. Instead of 0.015, value of 0.15 was introduced causing mistake in Settlement area in matrix

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 2013 (Resubmission, v2.3) and current submission (NIR 2014), on the level of the different greenhouse gases.

Table 10.2-1: Differences between NIR 2013 (Resubmission, v2.3) and NIR 2014 (Resubmission, v2.1), for 1990-2011 due to recalculations

GHG		1990	1991	1992	1993	1994	1995	1996	1997
CO_2 (Gg) Incl. LULUCF	NIR 2013	16,907.29	9,248.03	8,125.62	8,570.35	7,977.96	8,116.78	8,997.28	10,579.83
	NIR 2014	16,808.10	9,179.43	8,065.06	8,514.18	7,910.30	8,051.28	8,936.80	10,632.83
	Difference %	***-0.59***	***-0.74***	***-0.75***	***-0.66***	***-0.85***	***-0.81***	***-0.67***	***0.50***
CO_2 (Gg) Excl. LULUCF	NIR 2013	23,338.72	17,352.45	16,708.08	17,165.18	16,490.29	17,201.66	17,834.25	18,861.38
	NIR 2014	23,339.56	17,361.43	16,714.83	17,170.51	16,498.33	17,213.76	17,845.37	18,938.63
	Difference %	***0.00***	***0.05***	***0.04***	***0.03***	***0.05***	***0.07***	***0.06***	***0.41***
CH_4 (Gg CO_2-eq) Incl. LULUCF	NIR 2013	3,478.98	3,227.33	2,911.46	3,055.34	2,838.18	2,794.63	2,787.83	2,869.44
	NIR 2014	3,709.44	3,496.50	3,203.23	3,382.68	3,137.97	3,088.87	3,082.54	3,137.92
	Difference %	***6.62***	***8.34***	***10.02***	***10.71***	***10.56***	***10.53***	***10.57***	***9.36***
CH_4 (Gg CO_2-eq) Excl. LULUCF	NIR 2013	3,466.48	3,214.84	2,908.61	3,031.14	2,827.19	2,792.76	2,780.30	2,857.55
	NIR 2014	3,696.55	3,483.61	3,199.53	3,358.02	3,126.61	3,086.83	3,074.49	3,125.79
	Difference %	***6.64***	***8.36***	***10.00***	***10.78***	***10.59***	***10.53***	***10.58***	***9.39***
N_2O (Gg CO_2-eq) Incl. LULUCF	NIR 2013	3,948.46	3,764.28	3,660.05	3,135.72	3,197.10	3,058.51	3,058.53	3,351.45
	NIR 2014	3,962.69	3,802.43	3,740.95	3,235.18	3,281.19	3,144.73	3,157.34	3,436.93
	Difference %	***0.36***	***1.01***	***2.21***	***3.17***	***2.63***	***2.82***	***3.23***	***2.55***
N_2O (Gg CO_2-eq) Excl. LULUCF	NIR 2013	3,940.75	3,756.74	3,654.89	3,125.84	3,190.41	3,054.07	3,052.97	3,345.06
	NIR 2014	3,954.37	3,794.27	3,734.94	3,224.40	3,273.95	3,140.10	3,151.15	3,430.09
	Difference %	***0.35***	***1.00***	***2.19***	***3.15***	***2.62***	***2.82***	***3.22***	***2.54***
HFCs (Gg CO_2-eq)	NIR 2013	0.00	NO	NO	NO	NO	49.37	68.32	90.87
	NIR 2014	0.00	NO	NO	NO	NO	49.37	68.32	90.87
	Difference %	***NO***	***NO***	***NO***	***NO***	***NO***	***0.00***	***0.00***	***0.00***
PFCs (Gg CO_2-eq)	NIR 2013	936.56	642.44	NO	NO	NO	NO	NO	NO
	NIR 2014	936.56	642.44	NO	NO	NO	NO	NO	NO
	Difference %	***0.00***	***0.00***	***NO***	***NO***	***NO***	***NO***	***NO***	***NO***
SF_6 (Gg CO_2-eq)	NIR 2013	10.95	10.83	10.92	11.04	11.16	11.66	12.13	11.98
	NIR 2014	10.95	10.83	10.92	11.04	11.16	11.66	12.13	11.98
	Difference %	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
Total (Gg CO_2-eq) Incl. LULUCF	NIR 2013	25,282.26	16,892.92	14,708.06	14,772.45	14,024.40	14,030.94	14,924.08	16,903.57
	NIR 2014	25,427.75	17,131.63	15,020.17	15,143.08	14,340.62	14,345.90	15,257.13	17,310.53
	Difference %	***0.58***	***1.41***	***2.12***	***2.51***	***2.25***	***2.24***	***2.23***	***2.41***
Total (Gg CO_2-eq) Excl.LULUCF	NIR 2013	31,693.47	24,977.30	23,282.50	23,333.20	22,519.04	23,109.52	23,747.97	25,166.85
	NIR 2014	31,938.00	25,292.59	23,660.22	23,763.97	22,910.04	23,501.71	24,151.46	25,597.35
	Difference %	***0.77***	***1.26***	***1.62***	***1.85***	***1.74***	***1.70***	***1.70***	***1.71***

Table 10.2-1: Differences between NIR 2013 (Resubmission, v2.3) and NIR 2014 (Resubmission, v2.1), for 1990-2011 due to recalculations, cont.

GHG		1998	1999	2000	2001	2002	2003	2004	2005
CO_2 (Gg) Incl. LULUCF	NIR 2013	11,427.31	11,978.86	12,308.54	12,845.52	13,729.35	15,559.48	15,138.48	15,326.56
	NIR 2014	11,492.44	12,095.04	12,457.27	13,109.42	14,044.02	15,950.09	15,565.91	15,858.45
	Difference %	***0.57***	***0.97***	***1.21***	***2.05***	***2.29***	***2.51***	***2.82***	***3.47***
CO_2 (Gg) Excl. LULUCF	NIR 2013	19,623.64	20,535.28	20,093.24	21,033.98	22,108.03	23,528.66	23,152.39	23,485.16
	NIR 2014	19,634.03	20,545.30	20,099.51	21,040.76	22,110.86	23,534.14	23,159.42	23,501.38
	Difference %	***0.05***	***0.05***	***0.03***	***0.03***	***0.01***	***0.02***	***0.03***	***0.07***
CH_4 (Gg CO_2-eq) Incl. LULUCF	NIR 2013	2,721.95	2,714.26	2,833.20	2,932.58	3,000.02	3,120.72	3,197.44	3,182.71
	NIR 2014	2,970.36	2,954.16	3,058.58	3,146.49	3,197.70	3,289.63	3,404.57	3,334.66
	Difference %	***9.13***	***8.84***	***7.95***	***7.29***	***6.59***	***5.41***	***6.48***	***4.77***
CH_4 (Gg CO_2-eq) Excl. LULUCF	NIR 2013	2,699.66	2,712.86	2,782.50	2,922.21	2,994.80	3,096.30	3,196.39	3,181.58
	NIR 2014	2,947.58	2,952.52	3,009.21	3,135.28	3,192.32	3,264.79	3,403.35	3,333.13
	Difference %	***9.18***	***8.83***	***8.15***	***7.29***	***6.60***	***5.44***	***6.47***	***4.76***
N_2O (Gg CO_2-eq) Incl. LULUCF	NIR 2013	2,891.51	3,221.04	3,299.73	3,343.97	3,268.45	3,117.84	3,482.87	3,495.63
	NIR 2014	2,974.63	3,286.07	3,349.26	3,389.41	3,309.33	3,142.83	3,522.99	3,512.33
	Difference %	***2.87***	***2.02***	***1.50***	***1.36***	***1.25***	***0.80***	***1.15***	***0.48***
N_2O (Gg CO_2-eq) Excl. LULUCF	NIR 2013	2,882.91	3,217.39	3,284.97	3,337.92	3,263.04	3,107.52	3,477.37	3,489.59
	NIR 2014	2,965.14	3,282.16	3,334.75	3,382.37	3,303.68	3,131.65	3,517.32	3,505.92
	Difference %	***2.85***	***2.01***	***1.52***	***1.33***	***1.25***	***0.78***	***1.15***	***0.47***
HFCs (Gg CO_2-eq)	NIR 2013	118.19	142.62	170.68	193.42	225.11	263.03	300.11	333.47
	NIR 2014	118.19	142.62	170.68	193.42	225.11	263.03	300.11	333.47
	Difference	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
PFCs (Gg CO_2-eq)	NIR 2013	NO	NO	NO	NO	NO	NO	NO	NA,NO
	NIR 2014	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 2013	12.57	12.57	12.18	12.26	12.59	12.87	13.17	13.66
	NIR 2014	12.57	12.57	12.18	12.26	12.59	12.87	13.17	13.66
	Difference %	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
Total (Gg CO_2-eq) Incl. LULUCF	NIR 2013	17,171.53	18,069.35	18,624.33	19,327.75	20,235.52	22,073.93	22,132.08	22,352.02
	NIR 2014	17,568.18	18,490.46	19,047.97	19,850.99	20,788.75	22,658.44	22,806.75	23,052.56
	Difference %	***2.31***	***2.33***	***2.27***	***2.71***	***2.73***	***2.65***	***3.05***	***3.13***
Total (Gg CO_2-eq) Excl.LULUCF	NIR 2013	25,336.97	26,620.72	26,343.57	27,499.78	28,603.57	30,008.37	30,139.44	30,503.46
	NIR 2014	25,677.51	26,935.17	26,626.34	27,764.08	28,844.55	30,206.48	30,393.36	30,687.55
	Difference %	***1.34***	***1.18***	***1.07***	***0.96***	***0.84***	***0.66***	***0.84***	***0.60***

Table 10.2-1: Differences between NIR 2013 (Resubmission, v2.3) and NIR 2014 (Resubmission, v2.1), for 1990-2011 due to recalculations, cont.

GHG		2006	2007	2008	2009	2010	2011
CO_2 (Gg) Incl. LULUCF	NIR 2013	15,633.76	17,261.78	15,920.15	13,906.62	13,407.12	13,820.03
	NIR 2014	16,234.86	17,910.58	16,657.39	14,675.57	14,314.59	14,750.96
	Difference %	***3.84***	***3.76***	***4.63***	***5.53***	***6.77***	***6.74***
CO_2 (Gg) Excl. LULUCF	NIR 2013	23,716.52	24,999.12	23,755.72	21,982.48	21,288.79	20,869.29
	NIR 2014	23,733.88	25,018.34	23,770.70	21,991.10	21,330.41	20,918.00
	Difference %	***0.07***	***0.08***	***0.06***	***0.04***	***0.20***	***0.23***
CH_4 (Gg CO_2-eq) Incl. LULUCF	NIR 2013	3,472.53	3,632.10	3,614.82	3,600.75	3,640.28	3,588.11
	NIR 2014	3,592.32	3,721.08	3,635.55	3,635.36	3,688.15	3,633.50
	Difference %	***3.45***	***2.45***	***0.57***	***0.96***	***1.31***	***1.26***
CH_4 (Gg CO_2-eq) Excl. LULUCF	NIR 2013	3,471.04	3,627.09	3,610.99	3,598.84	3,638.97	3,581.30
	NIR 2014	3,590.46	3,715.35	3,631.17	3,633.41	3,686.79	3,626.13
	Difference %	***3.44***	***2.43***	***0.56***	***0.96***	***1.31***	***1.25***
N_2O (Gg CO_2-eq) Incl. LULUCF	NIR 2013	3,545.90	3,610.67	3,578.14	3,325.78	3,379.99	3,495.76
	NIR 2014	3,557.56	3,599.14	3,570.79	3,330.08	3,403.37	3,514.82
	Difference %	***0.33***	***-0.32***	***-0.21***	***0.13***	***0.69***	***0.55***
N_2O (Gg CO_2-eq) Excl. LULUCF	NIR 2013	3,539.26	3,602.70	3,569.91	3,317.47	3,371.29	3,485.11
	NIR 2014	3,550.56	3,590.45	3,562.02	3,321.70	3,394.63	3,503.60
	Difference %	***0.32***	***-0.34***	***-0.22***	***0.13***	***0.69***	***0.53***
HFCs (Gg CO_2-eq)	NIR 2013	365.45	405.94	424.16	435.68	472.25	475.94
	NIR 2014	365.45	405.94	424.42	435.68	472.25	484.91
	Difference %	***0.00***	***0.00***	***0.06***	***0.00***	***0.00***	***1.88***
PFCs (Gg CO_2-eq)	NIR 2013	NA,NO	NA,NO	NA,NO	0.20	0.03	0.01
	NIR 2014	NA,NO	NA,NO	NA,NO	0.20	0.03	0.01
	Difference %	***NO***	***NO***	***NO***	***0.00***	***0.00***	***0.00***
SF_6 (Gg CO_2-eq)	NIR 2013	13.64	13.68	12.55	8.39	9.32	9.82
	NIR 2014	13.64	13.68	12.55	8.39	9.32	9.82
	Difference %	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
Total (Gg CO_2-eq) Incl. LULUCF	NIR 2013	23,031.29	24,924.18	23,549.83	21,277.43	20,908.99	21,389.67
	NIR 2014	23,763.82	25,650.43	24,300.69	22,085.29	21,887.71	22,394.01
	Difference %	***3.18***	***2.91***	***3.19***	***3.80***	***4.68***	***4.70***
Total (Gg CO_2-eq) Excl.LULUCF	NIR 2013	31,105.91	32,648.53	31,373.34	29,343.07	28,780.65	28,421.47
	NIR 2014	31,253.98	32,743.77	31,400.86	29,390.49	28,893.42	28,542.46
	Difference %	***0.48***	***0.29***	***0.09***	***0.16***	***0.39***	***0.43***

The change in the 1990-2011 trend for the greenhouse gas emissions compared to the NIR 2013 (Resubmission, v2.3) is presented in Table 10.2-2. It can be concluded that the trend in the total national emissions increased by 3.03 percent including LULUCF and decreased by 7.31 percent excluding LULUCF comparing NIR 2013 (Resubmission, v2.3) and NIR 2014 (Resubmission, v2.1). The largest absolute changes in emission trends are recorded for CO_2, HFC and total CO_2-eq, described in Table 10.2-2.

Table 10.2-2: Differences between NIR 2013 (Resubmission, v2.3) and NIR 2014 (Resubmission, v2.1) for the emission trends 1990-2011

GHG	Trend (absolute)		
CO_2-eq (Gg)	NIR 2013	NIR 2014	*Difference*
CO_2 emissions including net CO_2 from LULUCF	-3,500.18	-2,057.14	-1,443.03
CO_2 emissions excluding net CO_2 from LULUCF	-2,049.93	-2,421.57	371.63
CH_4	172.49	-70.42	242.90
N_2O	-569.46	-450.77	-118.68
HFCs	472.25	0.00	472.25
PFCs	0.00	0.00	0.00
SF_6	0.00	-1.14	1.14
Total (including LULUCF)	**-4,373.26**	**-3,033.74**	**-1,339.52**
Total (excluding LULUCF)	**-2,912.82**	**-3,395.54**	**482.71**

Table 10.2-2: Differences between NIR 2013 (Resubmission, v2.3) and NIR 2014 (Resubmission, v2.1) for the emission trends 1990-2011, cont.

GHG	Trend (percent)		
CO_2-eq (Gg)	NIR 2013	NIR 2014	*Difference*
CO_2 emissions including net CO_2 from LULUCF	-22.38	-20.86	-1.52
CO_2 emissions excluding net CO_2 from LULUCF	-8.77	-17.50	8.73
CH_4	3.21	-1.09	4.30
N_2O	-15.14	-17.14	2.00
HFCs	100.00	100.00	0.00
PFCs	-100.00	-100.00	0.00
SF_6	28.82	-12.36	41.18
Total (including LULUCF)	**-21.76**	**-18.73**	**-3.03**
Total (excluding LULUCF)	**-9.44**	**-16.76**	**7.31**

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. This national regulation has been replaced by Regulation (EU) No 525/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC. 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 flow between collaborating institutions 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. The work on the protocols has started at the end of 2013 and will be finished by first half of 2014.

Secondly, Committee for inter-sectorial coordination for national system was established by Governments decision in 2014 and it 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 accredited verification 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.

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. 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.

Cross-cutting planned improvements

Category	Recommendation	NIR 2014	NIR 2015	Long-term
KC analysis	Include more explanation of how the key category analysis is used to prioritize the development and improvement of the inventory, including methodological choices	•		
Inventory management	Ensure that the inventory management system functions in such a way as to allow the provision of timely responses to the ERT	•		
Inventory management	Improve transparency by providing in the table references to specific sections of the NIR (e.g. paragraph numbers) to indicate where such recommendations are covered		•	

Sector-specific planned improvements

Energy

Category	Recommendation	NIR 2014	NIR 2015	Long-term
Comparison of the reference approach with the sectoral approach and international statistics	(1) Report details including the quantifiable information of an analysis of the fuels behind the discrepancy (2) Examine the reasons for discrepancies in comparison with IEA data and explain the results of such investigations.	•		

International bunker fuels	Provide a more detailed explanation of the drivers underlying the high inter-annual variation in the estimated CO_2 emissions	•		
Feedstocks and non-energy use of fuels	Provide more detail on feedstocks and the non-energy use and allocation of fuels	•		
Stationary combustion: solid, liquid and gaseous fuels – CO_2	(1) Apply country-specific factors to estimate emissions for the main fuel types (2) If country-specific factors are not available, include the implementation timeline for the plan to apply country specific factors to estimate emissions for the main fuel types		•	
Road transportation: all fuels–CO_2	Use a tier 1 approach to estimate CO_2 emissions from road transportation for all fuels	•		
Coal mining and handling : solid fuels – CH_4	Revise the estimates of CH_4 emissions for this category and clearly document the revision, including the AD used and the sources of the EFs used, and improve QA/QC procedures	•		
Oil and natural gas: liquid and gaseous fuels – CO_2, CH_4 and N_2O	(1) Take steps towards reporting emissions from venting and flaring separately and describe the progress made in its NIR (2) Estimate CH_4 emissions from transmission and distribution using a higher-tier method			•

Other (mobile): liquid fuels – CO2, CH4 and N2O	(1) Report mobile fuel combustion (military) under other (mobile). (2) If data are not available, use the notation key "IE" to report the emissions	•		

Industrial Processes and Solvent use

Category	Recommendation	NIR 2014	NIR 2015	Long-term
Sector overview	Continue to improve the information on recalculations	•		
Ammonia production – CO2	Provide more detailed and specific explanation with regard to the approach used for the split between natural gas used as fuel and natural gas used as feedstock review its emission estimation methodology for this category and provide clearer justification of its IEF estimation	•		
Ferroalloys production – CO2	Obtain AD for ferroalloys production to replace the interpolated data			•
Consumption of halocarbons and SF6 – HFCs	Continue conducting surveys on the status of disposal of refrigeration and air conditioning equipments and include the results in its NIR			•
	Further improve the reporting by conducting the necessary surveys to obtain AD for the estimation of actual emissions of HFC-152a for the entire time series			•
	Continue its effort to report emissions from import and export separately in future inventory submissions		•	
Solvent and other product use	Either provide clear information to justify that N_2O emission from fire extinguishers and other activities do not occur – in which case change the notation key from "NE" to "NO", or conduct the necessary surveys and report emissions accordingly	•		

Agriculture

Category	Recommendation	NIR 2014	NIR 2015	Long-term
Sector overview	(1) Estimate CH4 emissions from enteric fermentation (for all animals except cattle) and CH4 and N2O emissions from manure management (for sheep, goats, horses, mules/asses, and poultry), applying the default EFs for developed countries for all years of the time series in its next annual submission (2) Apply the correct notation keys in the reporting on the agriculture sector (3) Include in the NIR background information on the evaluation of AD compiled by CSB and the Croatian Horse Breeding Centre; information on how time-series consistency is ensured if different sources of data have been chosen; data sources for and information on the representativeness of the yearly average milk yields; clear references to equations, parameters and EFs in order to improve transparency of documentation (4) Apply new study results to estimte emissions from enteric fermentation (cattle) and manure management (cattle and swine) as soon as new project results are available (5) Report all relevant parameters and fractions related to the AD and the calculation of N2O emissions from Nfixing crops and crop residues in CRF table 4.F		•	
Enteric fermentation – CH4	(1) Improve the sector-specific routine QC procedures, especially at the stage of data transfer from the calculation sheet to the CRF tables (2) Updates a list of sector-specific improvements and implement the improvement on schedule		•	
Manure management – CH4	(1) Apply a tier 2 method in its CH4 emission estimates in NIR 2015 reflecting the result of new projects to develop tier 2 estimates with country-specific EFs and AWMS distribution (2) Continue its efforts to develop country-specific values for the estimation of CH4 emissions from manure management and apply new study results for emission calculation in NIR 2015		•	

Manure management – N2O	(1) Starts with the works as soon as possible in order to include the refined estimates based on country-specific N excretion values and AWMS data (2) Revises its calculation using country-specific data as soon as new study results are available (3) Ensure the consistency of the multiplication of the number of swine by the N excretion value per swine in CRF table 4.B(b) and the sum of N excreted in all AWMS		•	
Agricultural soils – N2O	Provide information on the start of the application of sewage sludge to agricultural land from 2005 onwards and on the non-occurrence of slurry discharge from domestic septic tanks on agricultural land		•	

LULUCF and KP-LULUCF

Category	Recommendation	NIR 2014	NIR 2015	Long-term
Sector overview	(1) Provide estimates for all land-use categories and pools in line with the IPCC good practice guidance for LULUCF (2) Include land areas for all land-use categories in the CRF tables (3) Improve the transparency of the reporting by providing additional explanation of and reference materials for expert judgements and assumptions, by reporting emissions from organic soils separately from emissions from mineral soils for all subdivisions under cropland and by reporting litter separately from soils for the converted land-use categories (4) Review the use of the notation keys in the CRF tables and improve the QC of the CRF tables (5) Implement the planned improvements, particularly those envisaged to be completed for the next annual submission, and provide detailed information on any progress made and the likely timing of completion of the other planned improvements	•	•	
Forest land remaining forest	(1) Provide a justification for the assumption that the dead organic matter, litter and soil are not net sources (2) Report emissions and removals for all forest types and carbon pools	•	•	•

land – CO_2	(3) Determine the area of wildfires on maquia and scrub forests and estimate emissions and removals from the area and the subsequent regrowth of biomass and dead organic matter (4) Make efforts to advance and complete the implementation of the Croatian National Forest Inventory, use the results to improve the LULUCF sector inventory			
Land converted to forest land– CO_2	Complete the assessment carried out concerning whether this land-use change is natural or humaninduced and whether the land is managed or unmanaged, as well as the exact year of the event of the land-use change	•	•	
Land converted to cropland land – CO_2	Use a higher tier approach to estimate carbon stock changes in perennial cropland remaining perennial cropland			•
Activities under Article 3, paragraph 3, of the Kyoto Protocol	Implement the planned improvement to ensure the identification and traceability of afforestation, reforestation and deforestation land and provide detailed information thereon	•	•	
Afforestation and reforestation	Estimate afforestation and reforestation for all land areas, using the more precise method proposed by the Party, for its next annual submission	•	•	
Deforestation	Estimate deforestation for all land areas, using the more precise method proposed by the Party, for its next annual submission	•	•	
Forest management	Provide the justification in the NIR of the Party's assumption that the dead organic matter, litter and soil are not net sources Estimate emissions and removals from all managed forest types	•		

Waste

Category	Recommendation	NIR 2014	NIR 2015	Long-term
Sector overview	Strengthen QA/QC procedures to avoid errors and provide more detailed information on sector-specific QA/QC activities		•	
Solid waste disposal on land – CH_4	Provide information on the type of waste disposed to solid waste disposal sites and ensure that all types of solid waste, including industrial waste, sludge and construction and demolition waste, disposed to solid waste disposal sites are considered in the emission estimation		•	
Wastewater handling – CH_4	Provide more information on wastewater flows and treatment systems			•
	Provide and explain the data used in the estimation to estimate CH_4 emissions from industrial wastewater treatment	•		
Waste incineration- add gases N_2O	Identify the technologies applied in the incineration of hazardous waste and estimate and report the associated N_2O emissions		•	

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 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.

Under the Article 3, paragraph 3 of the Kyoto Protocol (KP) Croatia reports emissions and removals from afforestation (A) and deforestation (D) activities, while Reforestation (R) does not happen in Croatia. Under the Article 3.4 of the KP Croatia elected activity Forest management (FM) for the estimation of emissions and removals by sink.

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.).

Table 11.1-1: The relationship between KP activities and reported UNFCCC land categories

UNFCCC			KP	
Land use category	**Subcategories**		**Activities**	**Article**
Forest Land	*Land converted to Forest land*	*Grassland converted to Forest land*	Afforestation	3.3
Cropland	*Land converted to Cropland*	*Forest land converted to perennial Cropland*	Deforestation	
Settlements	*Land converted to Settlements*	*Forest land converted to Settlements*		

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
Minimum land area	0.05 - 1 ha	0.1 ha
Minimum crown cover	10 - 30 %	10 %
Minimum tree height	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 forests**.

For this year reporting and based on ERT's request, Croatia performed estimation for all types of forests (including maquies and shrub forests) that meets thresholds for defining forests under the Kyoto protocol (see also subchapters 7.2-3 and 7.2.2.1.).

Based on the *Forest Act*[52] (Article 4), forests represent also forest nurseries and seed orchards in cases when they 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. Thus, these areas are also included under the LULUCF and KP reporting.

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 and these areas are not subject of this reporting.

According to the same legislative act, areas covered by garigues and scrub forests (degraded stages of maquies and shrub forests) also belongs to forest category. However, since these types of forests are not able to reach thresholds defined by Croatia under the KP, these areas are excluded from the estimation and are not subject of reporting under the KP.

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 CO_2) per year, or to 1.325 Mt C (4.858 Mt CO_2) for the whole commitment period.

[52] Forest Act (OG 140/05, 82/06, 129/08, 80/10, 124/10, 25/12, 68/12, 148/13, 94/14)

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 1990–2012 based on definitions presented further in this subchapter. Applied definitions are as follows:

11.1.3.1. Definition and identification of Afforestation/Reforestation areas since 1990.

Following request given by the ERT in ARR 2012 to trace and identify all lands under the Article 3.3 and Article 3.4 of the KP, Croatia conducted special survey under the framework of project "*Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol"(*abbreviated LULUCF 1).

In the part of survey that concerns identification and traceability of areas that were subject of afforestation, by the survey both types of afforestation as defined by IPCC GPG were covered: afforestation by seeding and planting and afforestation due to human induced promotion of natural seed sources. The survey was performed in all areas under the forest management as defined by KP regardless the ownership and forest types.

According to Article 25 of the Ordinance on forest management[53], afforestation in national circumstances is the activity within the forest regeneration and it refers to establishment of forests (afforestation) on non-forest land and also to establishment of plantations of fast growing species. Forest regeneration is a part of the Forest Management plans/programs (FMAPs) and thus afforestation done by seeding and planting is clearly human induced.

When performing the survey the Approach 3 and *wall to wall* mapping was applied collecting the data and information about areas afforested through seeding and planting regardless the ownership and forest types. A special Questionnaire was designed for this purpose. Data and information requested by questionnaire were collected at two levels of forestry administrations:

1. The level of Forest Administration such as: **a)** the name of Forest Administration **b)** the name of regional Forest office **c)** the name of management unit (FMU) **d)** FMU code
2. The level of regional forest office providing the data and information at the time of afforestation **e)** Period of validity of forest management program **f)** Year of afforestation **g)** Compartment code **h)** Sub-compartment code **i)** sub-compartment size area **j)** size of sub-compartment area afforested
3. The level of regional forest office providing the data and information at present time such as **k)** Period of validity of forest management plan/program **l)** Compartment code **m)** Sub-compartment code **n)** size of sub-compartment area afforested **o)** GIS afforested area

[53] Ordinance on forest management (OG 111/2006, 141/08)

The questionnaire was designed in order to check all previously reported data by Croatia under the KP, and in order to develop a unique map of areas afforested in Croatia through seeding and planting in period 1990-2012 (Figure 11.1-1).

Data and information collected at the level of Forest administration and level of regional forests offices were merged with GIS layer of forest management types in order to perform final checks using the topographical map (1:25000) from 1970s, new topographical maps, Croatian base map 1: 5000 and old management maps. An example of performed checks is presented in Figure 11.1-2.

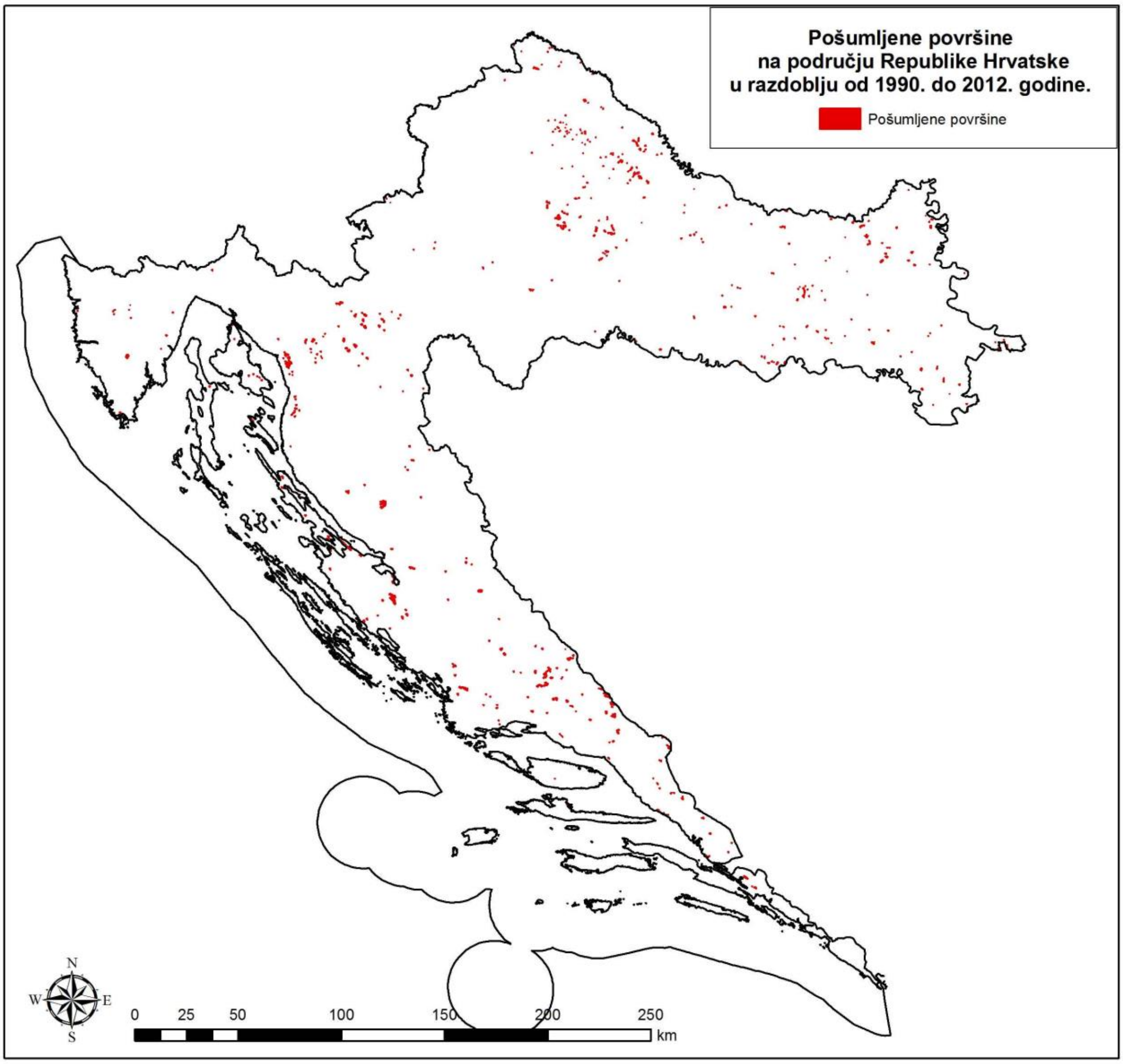


Figure 11.1-1: Areas afforested in Croatia through seeding and planting in period 1990-2012 (marked in red)

When performing this work, all areas that were previously reported as *afforestation* areas and for which was found mismatch with IPCC GPG definition of term *afforestation* in fully, exclusion from the areas eligible for KP reporting was done.

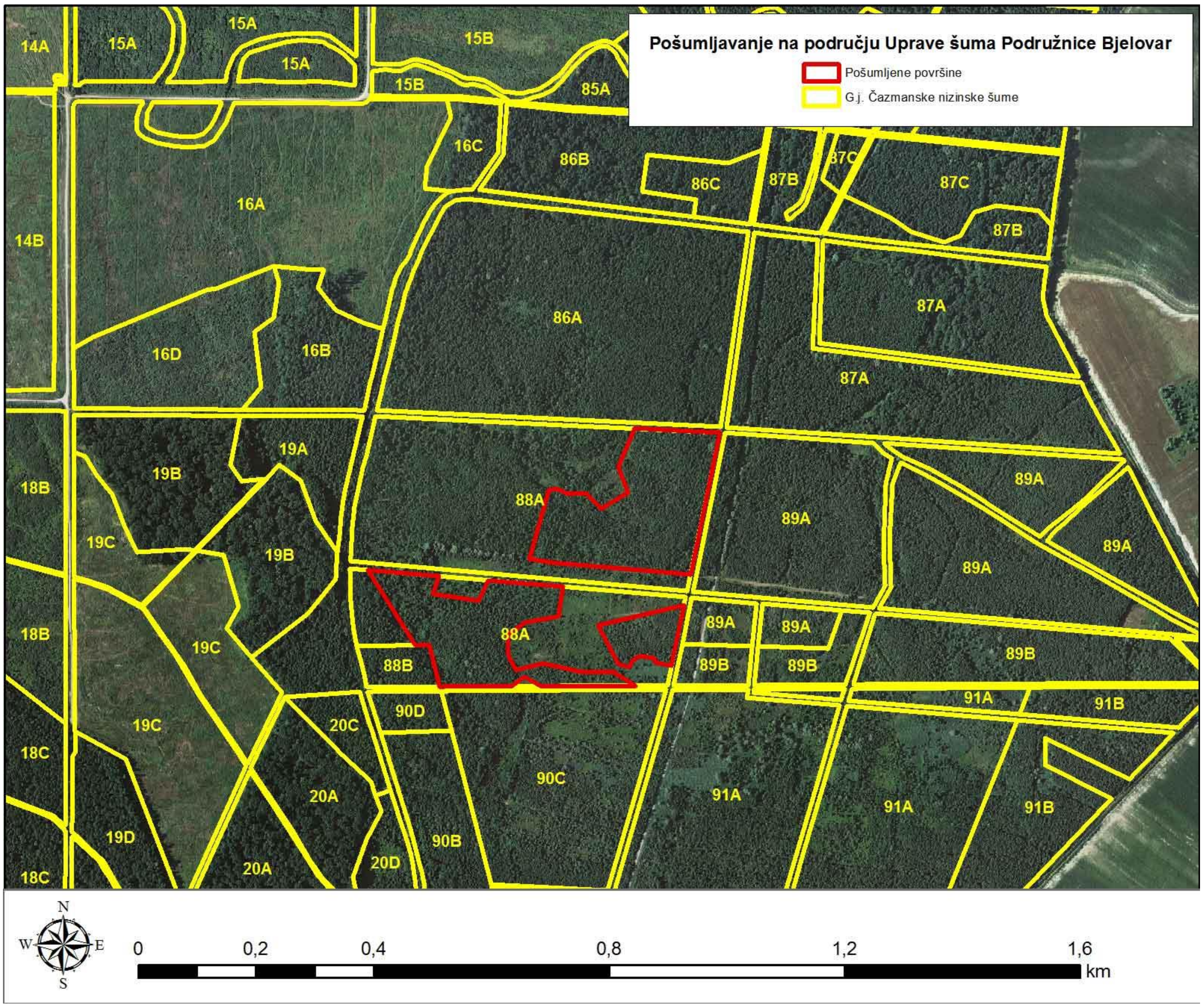


Figure 11.1-2 An example of afforested area registered on forest managemenet map with orto-photo background layer showing present state of areas (Forest Administration Bjelovar, FMU Cazmanske nizinske sume, sub-compartments 88 a and b, year of afforestation 1993., afforested area 10,01 ha)

Croatia believes that collecting the data on the level of a part of area of sub-compartment on which afforestation was actually successful, complete and detailed analyses of afforestation through seeding and planting was performed.

Afforestestation due to human induced promotion of natural seed sources were performed for all type of forests and forests ownership. Performed analyses differed depending on forest ownership. In case of state owned forest managed by Croatian forests Ltd. Approach 3 and *wall to wall* mapping was performed as presented below.

For the extraction of vector layer surface in ESRI .shp format of forests expanded by spreading of seeds on new areas software packages ESRI's ArcEditor 10, QGIS Desktop 2.4 and AutoCAD Map 3D with raster design module were used.
Spatial vector and raster data associated with official "HS fond" (contains all data on parameters relevant for forest sector) database of "Croatian forests Ltd" were used as an input data. Areas and boundaries (polygons) of the compartments/sub-compartments of every single FMU were taken into analyses. Additionally in the analyses were used a vector layer of forest boundaries obtained by using GIS methods from old topographic maps in scale 1: 25000. Raster data that are used during the analyses were primarily topographic maps 1: 25000 whose content corresponds to situation in period 1971 – 1980, digital ortho-photo raster data from period 1998-2006, and recent data from digital ortho-photo in 2012.

Performed GIS analysis is presented in nine steps on the example of one Forest Administration (Našice). Small methodological difference should be noted when interpreting analyses taking into consideration whether analyses is performed in even aged forests (all nine steps necessary to identify area increase) and uneven aged forests (steps four and seven not needed).

Step 1: Forest management maps presenting areas on sub-compartment level and maps showing boundaries of Forest Administration were used (Figure 11.1-3)

Step 2: All areas that do not comply with KP definition of forests (i.e. garigues and scrubs) as well as forest area that are not grown naturally (cultures, plantations) were identified in order to be removed from the analyses (Figure 11.1-4)

Step 3: All areas that are not cover by forests are detected in order to be removed from the maps and future analyses (Figure 11.1-5)

Step 4: All area covered with forests older than 24 years are identified and removed from the analyses (in case of even aged forest, Figure 11.1-6) because they were forests already in 1990

Step 5: Forest areas that remain after conducting steps 1-4 were then overlapped with topographical maps (1:25000) from 1980 on which vector layer of forests were created using the GIS methods for this purpose. The result of the overlap was a vector layer presenting forest area that were not forest before 1990 (Figure 11.1-7)

Step 6: In this step correction in areas was made due to difference in scale of maps used (i.e. basis for present forest management maps is cadastre and its maps in scale 1:2000 or 1:2880 or digital orto-photo in scale of 1:5000 while forest areas in 1980 are presented in topographical maps in scale of 1:25000). After overlapping with topographical maps correction was made removing all areas that were not forests (Figure 11.1-8)

Step 7: In this step all areas that were younger than 24 years and which are growing on areas that were registered as forest area even before 1990 were identified in order to be removed from the analyses. This step was needed because some of areas went through natural regeneration before 1990 without adequate result and were subject of replanting and were not detected on topographical maps. (Figure 11.1-9)

Step 8: Areas that were remaining after steps 1-7 were conducted were subject of final control which was done using the state orto-photo from 2012. Due to use of different maps with different scales it was not possible to get full compliance among cadastral and forest management maps and there were cases in which remained identified areas were actually arable land or unfertile land and not forests. For this reason in this step of analyses, all these areas were checked on the level of regional forest offices on the site (Figure 11.1-10)

Step 9: Areas identified as a subject of human induced promotion of natural seed sources on level of each of 16 Forests Administrations were merged in order to present these areas on a single map (figure (11.1-11)

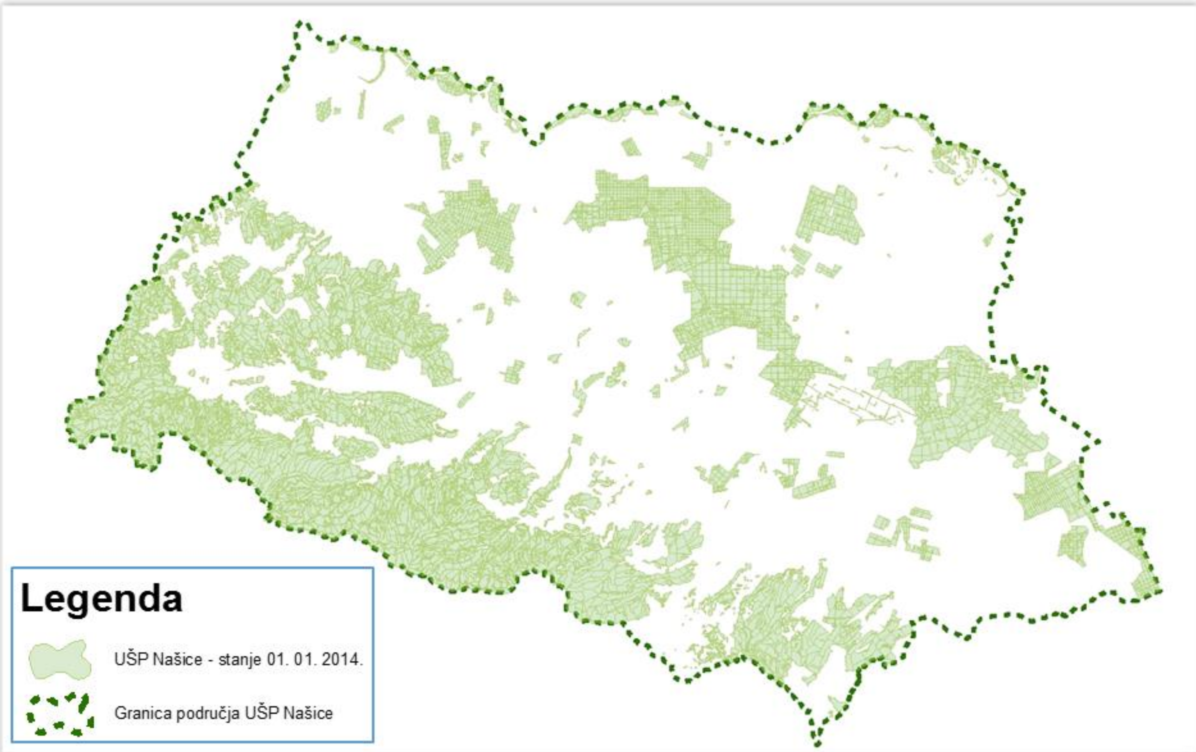


Figure 11.1-3: Forest Administration Našice (boundary of Administration marked in green dots, forests area according to national definitions in 2014 marked in green)

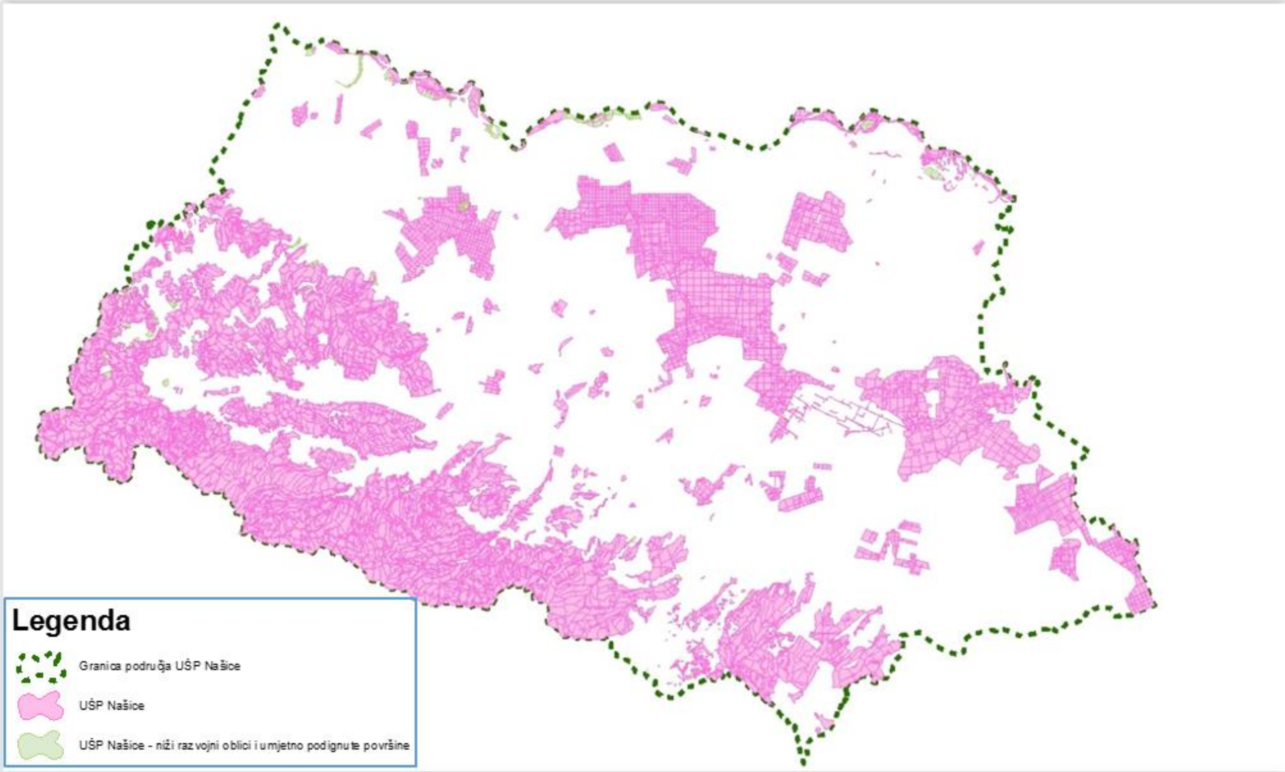
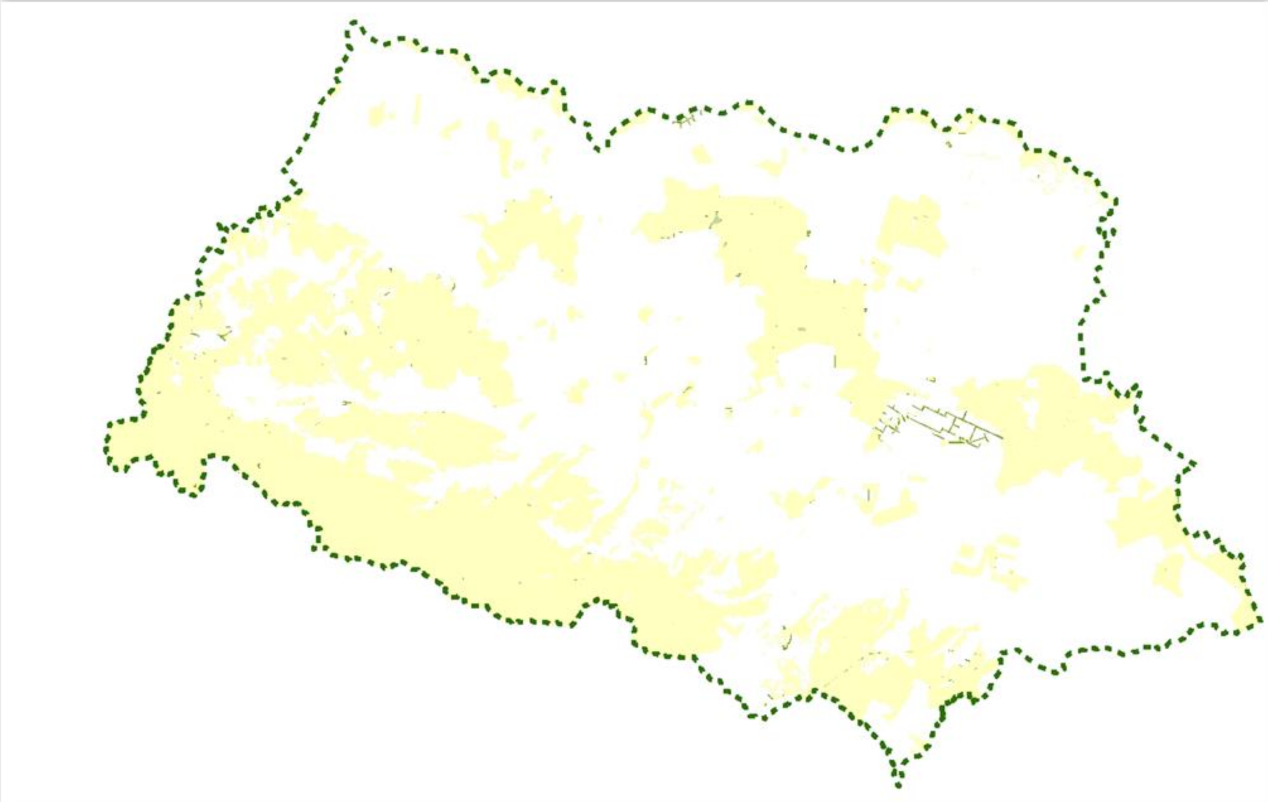


Figure 11.1-4: Forest Administration Našice (boundary of Administration marked in green dots, forests area according to KP definition of forests marked in pink, area not complying with KP definition of forests marked in green)



FFigure 11.1-5: Forest Administration Našice (boundary of Administration marked in green dots, forests area marked in yellow, non-stocked forest area (i.e. clearings) marked in green)

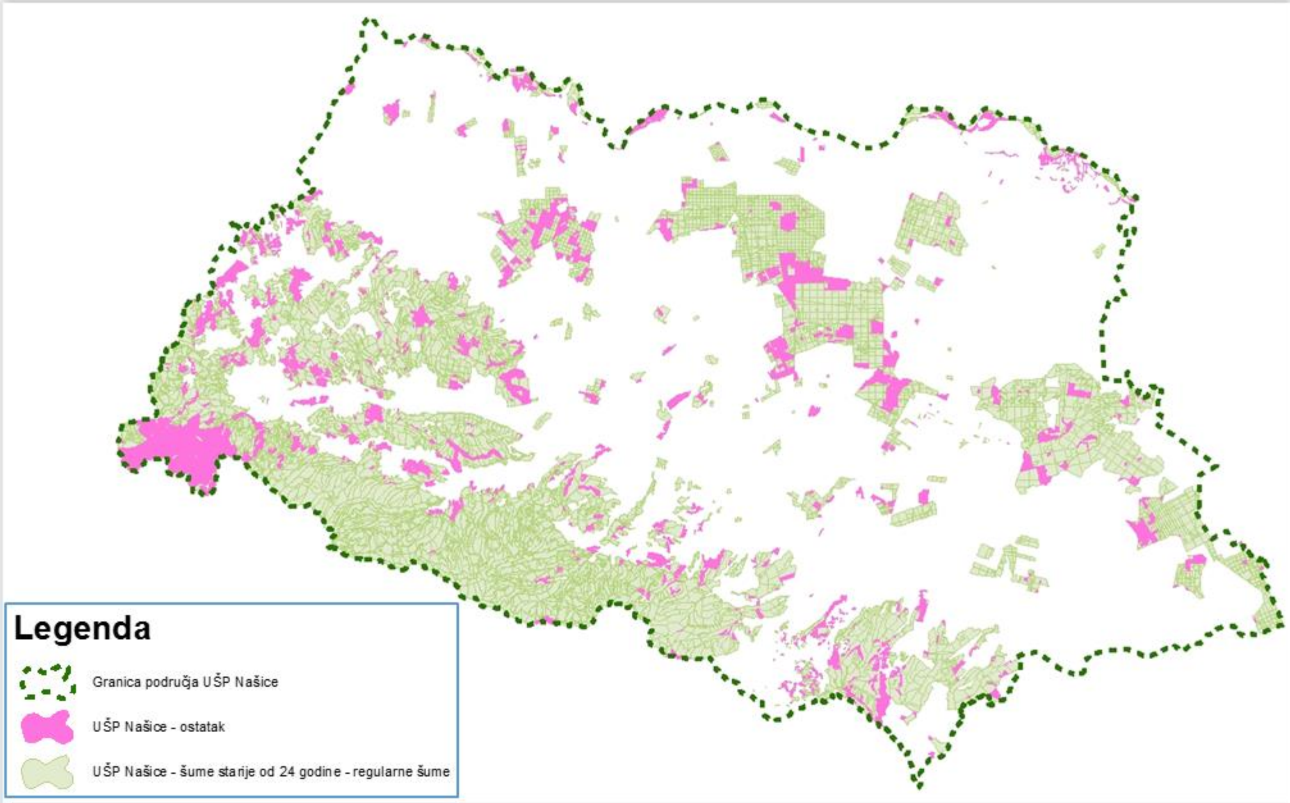


Figure 11.1-6: Forest Administration Našice (boundary of Administration marked in green dots, forests older that 24 years marked in green, remaining forest area marked in pink)

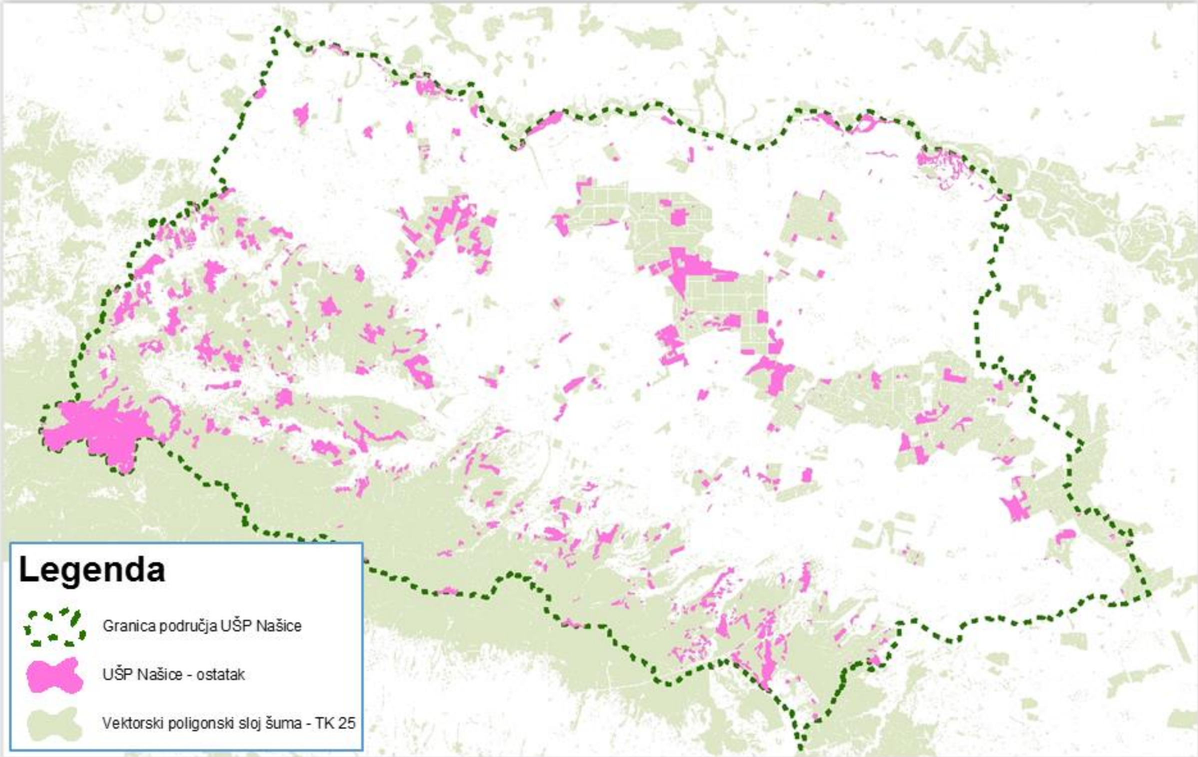


Figure 11.1-7: Forest Administration Našice (boundary of Administration marked in green dots, forests according to polygons of forests from topographical map marked in green, remaining forest area marked in pink)

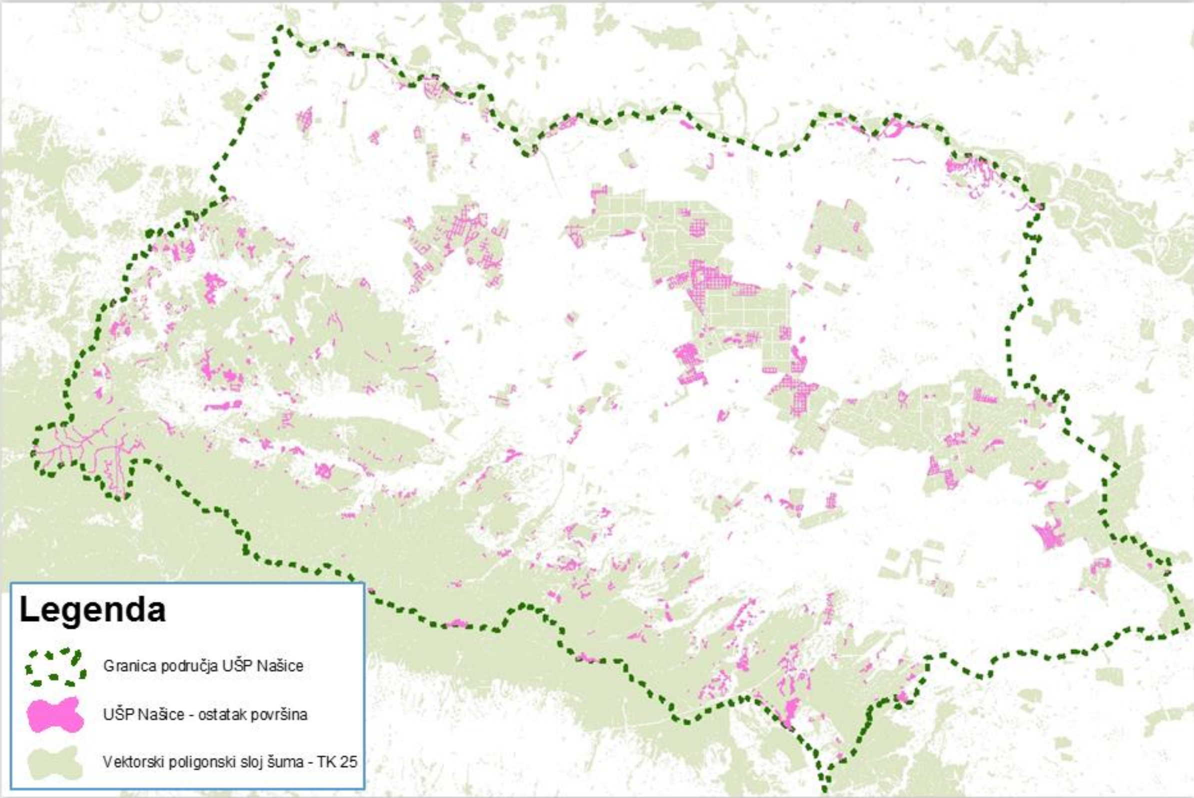


Figure 11.1-8: Forest Administration Našice (boundary of Administration marked in green dots, forests according to topographical map marked in green, remaining forest area after overlapping with topographical map marked in pink)

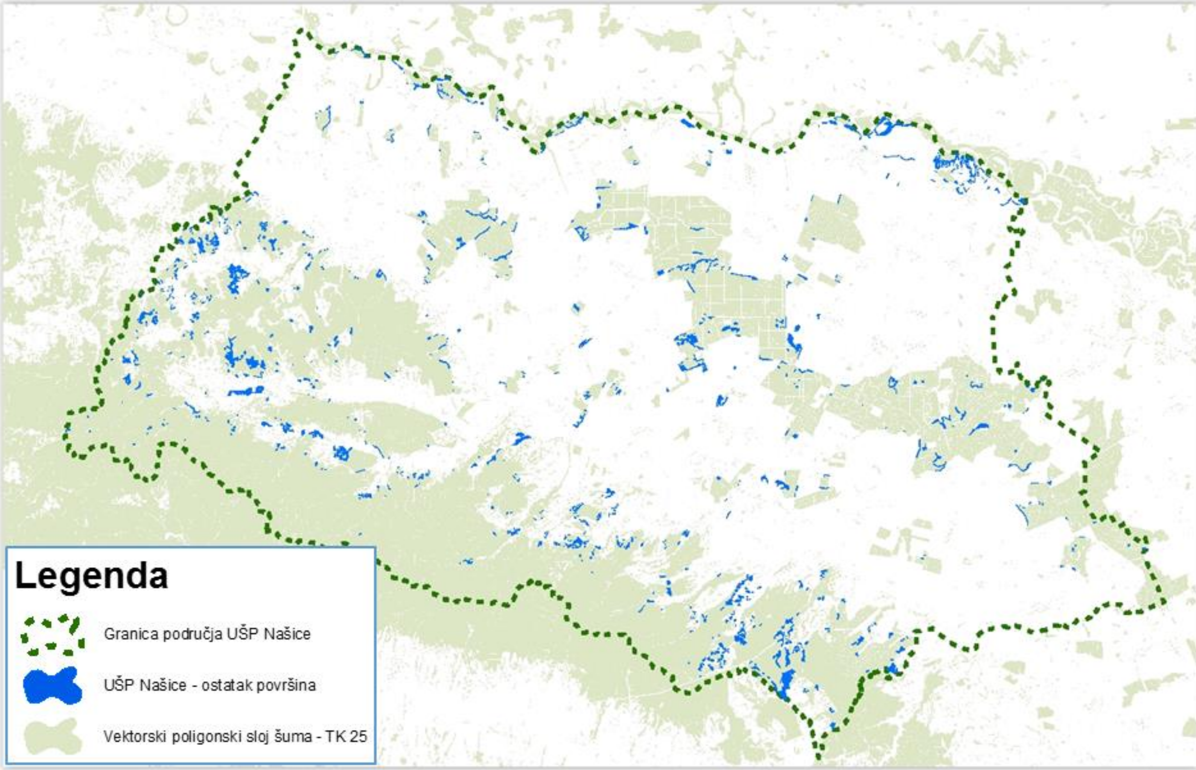


Figure 11.1-9: Forest Administration Našice (boundary of Administration marked in green dots, forests according to topographical map marked in green, remaining forest area after conducting step No. 6 marked in blue)

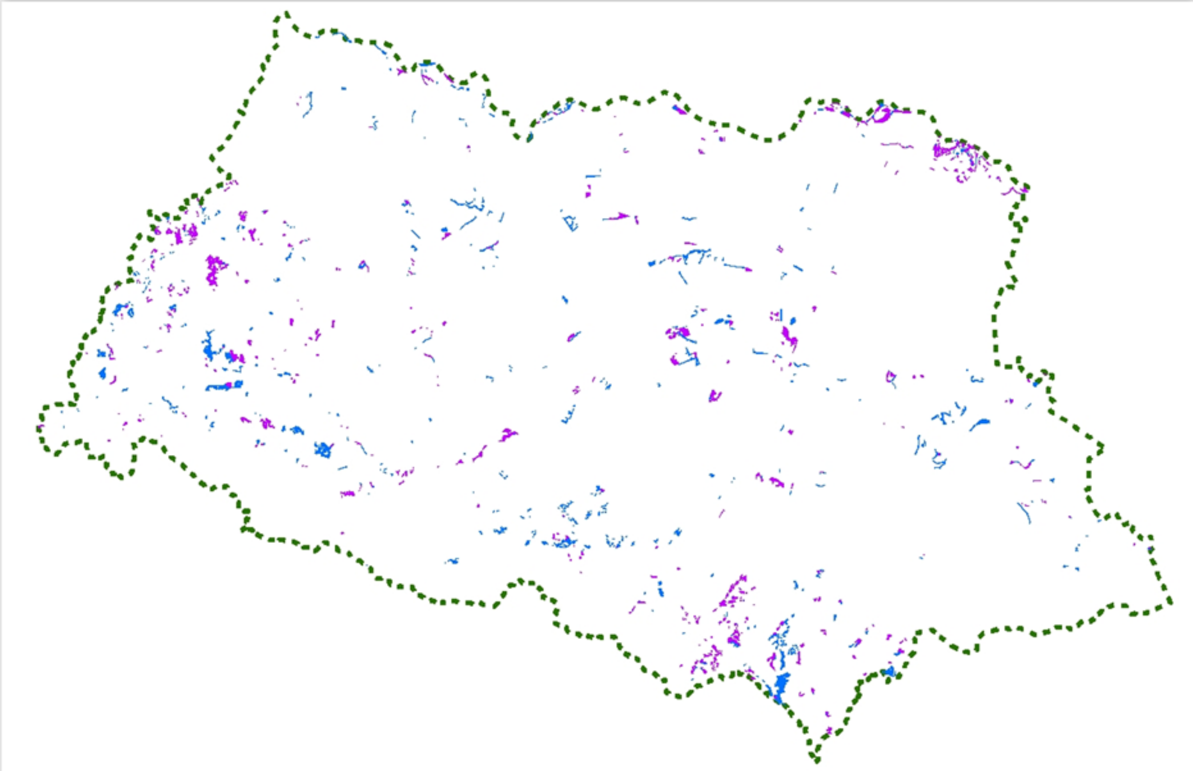


Figure 11.1-9: Forest Administration Našice (boundary of Administration marked in green dots, forest areas younger than 24 years marked in blue, remaining forest area marked in purple)

Figure 11.1-10: Forest Administration Našice (boundary of Administration marked in green dots, areas identified as not forests after step No 8. marked in red, areas identified as afforested after steps No1-No8 were performed marked in green).

After analyses were done, forests area that are identified as a result of afforestation due to human induced natural promotion of seed sources in state owned forests were presented in below map (Figure 11.1-11)

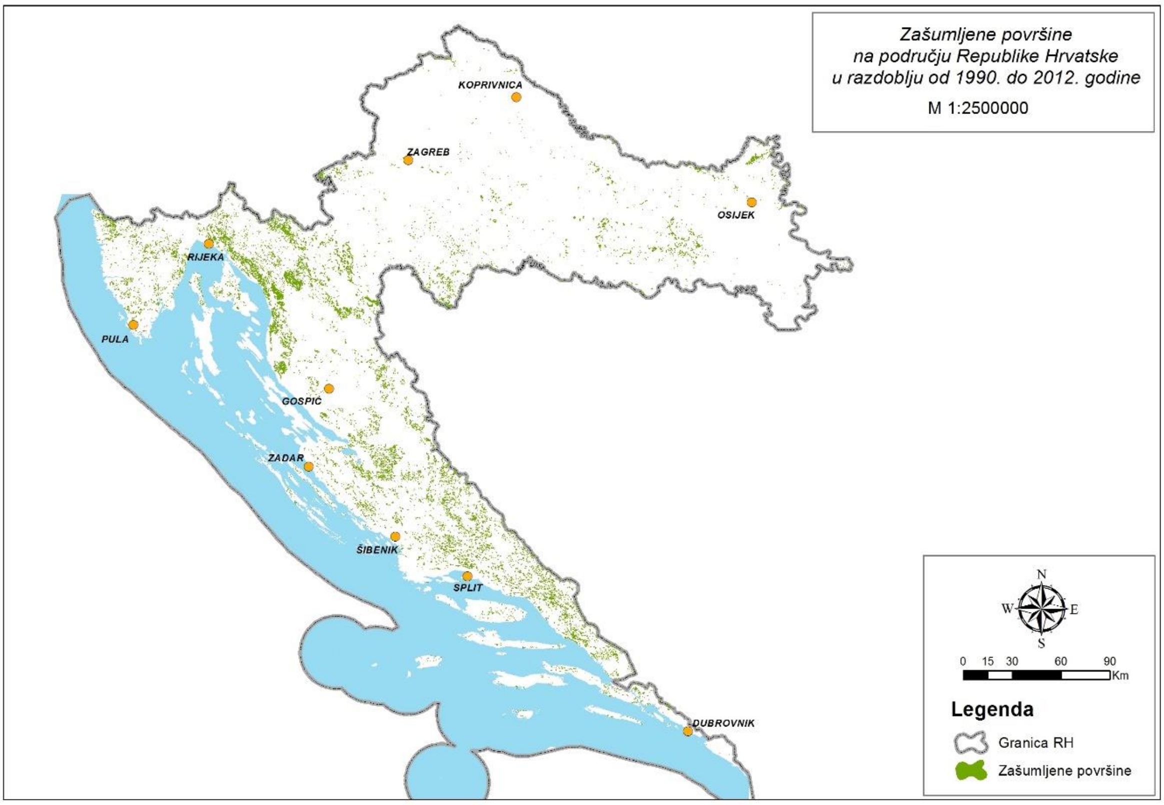


Figure 11.1-11: Identified afforested areas as a result of human induced promotion of seed sources in period 1990-2012 in state owned forests (areas marked in green)

Regarding the identification of afforested lands due to human induced promotion of seed sources in private forests it was not possible to conduct survey on the same way as for state owned forests managed by Croatian forests Ltd. These forests are mostly managed as uneven aged forests, their area is not in fully covered with official forest management programs (only 50% of area) at this time and there is no sufficient number of quality data and information on their previous state. Using the results of conducted survey in state owned forests proxy estimate was done. In order to determine category from which conversion to private forests happened, data and information from 10% of private forests covered by forest management programs were taken and expanded to whole area of private forests.

Reforestation, as defined by Kyoto, does not exist in Croatia due to strict legal provisions.

11.1.3.2 Definition and identification of Deforested areas since 1990.

According to the Croatian *Forest Act*[54], deforestation implies clear cutting of forest in order that the area can be used for other non-forestry purposes. It has to be performed in accordance with the spatial planning documents or provisions of the Decree on procedures and criteria for easement establishment on a forest or forest land owned by the Republic Croatia to cultivation of perennial crops[55]. 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 *Forest Act* (Articles 32, 35, 51, 51a and 52). 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.

Based on the recommendations given by the ERT in ARR 2012, Croatia carried out a special survey in order to trace and identify all deforested areas regardless ownerships and types of forests. The work was performed in the framework of the LULUCF 1 project.
All data and information concerning deforested areas are presented in a separate document[56] as one of outcomes of the LULUCF 1 project.

During the period 1990-2012 deforestation did not occur in state forests that are managed by other legal bodies in Croatia than Croatian Forests according to the data and information gained through the conducted survey. This was expected outcome since forests belonging to this type of ownership have rigorous or some degree of protection under the provisions of Law on nature protection. Consequently, data and information presented in this report concerning deforested areas and corresponding emissions refer to state owned forests managed by Croatian forests Ltd and private forests.

When performing the survey under the LULUCF 1 project Approach 3 and *wall to wall* mapping was applied in identification and traceability of areas that were subject of deforestation activity in period 1990-2012.
For a start, in case of state owned forests, all permits officially issued by the Ministry of Agriculture for the purposes of extraction of forests from forest management area in Croatia and its conversion to other land use were collected and then checked in order to secure that areas which were deforested were forest according to the thresholds set by Croatia for KP reporting purposes. Issuing of permits for exclusion of forests from forest management plans and its use for purposes other than for forest management has been regulated by provisions of *Forest Act*. Then, data and information recorded in each single permit that referred to forest area according to the KP definition had to be checked on a level of forest sub-compartment in each single management unit verifying that deforestation allowed by permit was actually executed on the field. In this work were used:

[54] Ibid
[55] OG 12/2008, Article 1.
[56] D. Janeš, G. Kovač, A. Durbešić (2014), Identification of deforested areas in Croatia according to the requirements of Article 3.3 of the Kyoto Protocol

- old scanned and recently digitized map of forest management units
- Croatian base map 1: 5000
- topographic maps 1:25 000
- digital ortho-photo
- digital cadastral maps

In order to avoid situation that some of deforested areas are not identified because they were not subject of permitting (i.e. due to War disturbance), additional checking was performed on fields on a level of single management unit. Identified deforested areas not covered by permitting had to be officially mapped and registered for the purposes of this reporting.

An example on identified deforested area presented in different maps is shown in Figures 11.1.-12.

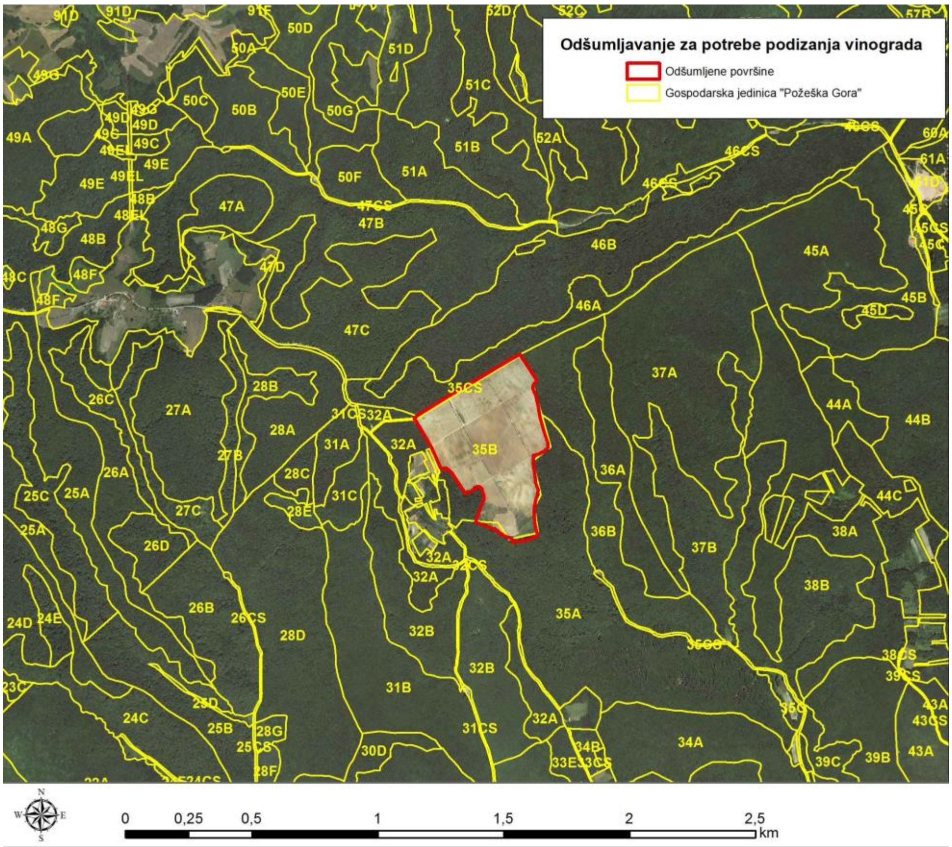


Figure 11.1-12: Map of forest management unit with deforested area marked in red (Forest Administration Požega, Management unit Pozeska gora, total deforested area 22.47 ha)

Areas deforested in period 1990-2012 in private forests were identified on the level of forest sub-compartment in each single forest office by using maps of forest management units or by using cadastral maps in cases where forest management program for private forests has not been developed yet. Areas had to be officially registered and in cases that they were not mapped before, this had to be performed for the purposes of this reporting.

When collecting data and information on deforested areas (regardless the ownership type) regional forest offices had to provide all information and data requested by specially designed Questionnaire for the purposes of KP reporting besides of mapping the deforested areas. Data and information requested by questionnaire are: **a)** the name of Forest Administration **b)** the name of Forest office **c)** the name of management unit (FMU) **d)** FMU code **e)** Information about the ownership **f)** Year of deforestation **g)** Compartment code **h)** Sub-compartment code **i)** sub-compartment size area **j)** size of sub-compartment area deforested **k)** Management type **l)** Growing stock deforested **m)** Reason for deforestation. In part of questionnaire that refers to management type additional data were collected providing information about species of coniferous and deciduous types of forests and information about maquies and shrub. Also, part of questionnaire that refers to growing stock deforested was further subdivided into coniferous and deciduous part.

The whole process was performed in several steps on different levels of Croatian forests Ltd. administration. Results of work performed on complete forest management area are presented in Table 11.1-3 and Figure 11.1-13.

Table 11.1-3: Area deforested in Croatia in period 1990-2012 (ha)

Year	Deciduous	Coniferous	Maquies and shrub	Total
1990	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00
1994	23.79	34.56	0.96	59.31
1995	0.00	3.01	0.00	3.01
1996	0.00	0.00	0.00	0.00
1997	3.68	8.02	66.80	78.50
1998	55.84	48.92	0.00	104.76
1999	27.56	0.48	4.39	32.43
2000	143.60	23.22	1.43	168.25
2001	50.65	28.44	275.24	354.33
2002	85.42	109.16	32.90	227.48
2003	46.50	19.08	29.89	95.47
2004	136.89	52.02	158.63	347.54
2005	106.17	37.50	221.13	364.80
2006	51.24	17.59	283.43	352.26
2007	56.38	39.21	129.56	225.15
2008	122.57	69.80	217.18	409.55
2009	92.52	18.77	494.68	605.97
2010	69.00	57.12	223.25	349.37
2011	18.37	19.03	154.14	191.54
2012	49.54	94.32	101.01	244.87
Total	1,139.72	680.25	2,394.62	4,214.59

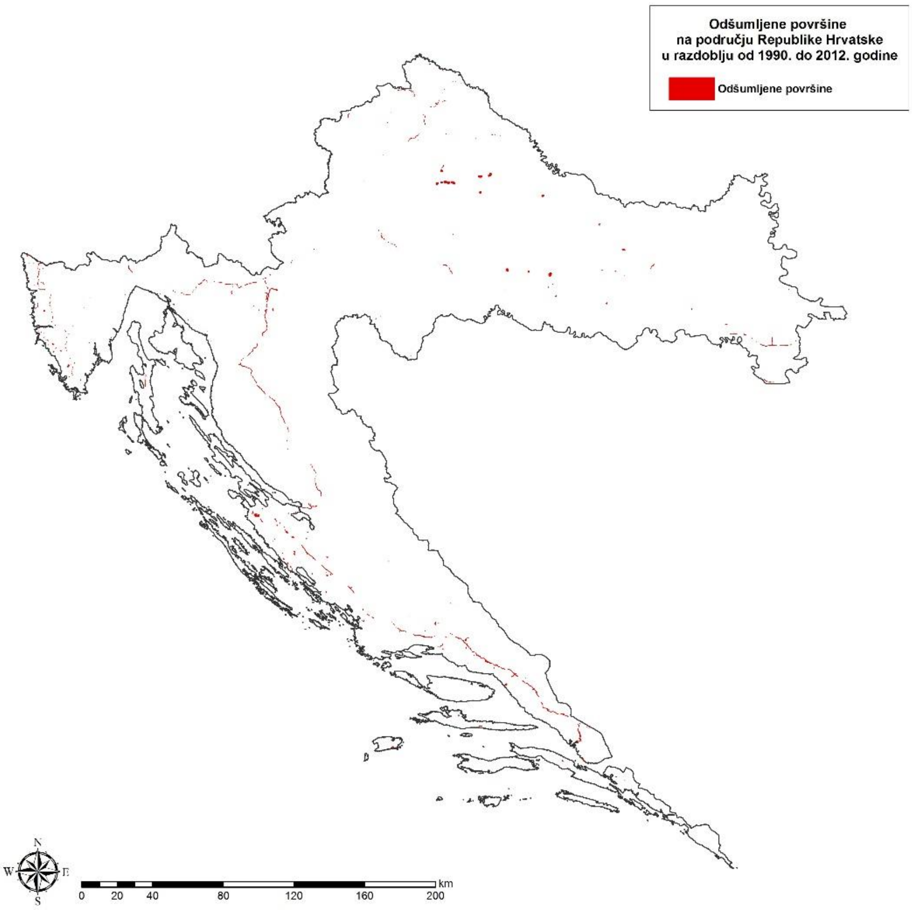


Figure 11.1-14: The spatial distribution of deforested land in period 1990-2012 (areas marked in red)

11.1.3.3. Definition and identification of Forest Management areas since 1990.

According to the national legislation, *forest management* has been interpreted in a same way as described in the IPCC GPG 2003. However, definition of *forest area* in the national context has a broader framework than that defined by Croatia within selected values for the purposes of reporting under the Kyoto Protocol. By the national framework forest land with tree cover (*forests*) and without tree cover (*land under the forest management*) constitutes one forest management area which is sustainable managed based on the FMAPs regardless the ownership type, purposes, forest stands etc. (see Chapter 7.2.2.1. for detail explanation).

Therefore, the area under the forest management according to the criteria set for KP reporting is not identical to forest management area in the national framework (Figure 11.1-15).

Croatian forest land area reported under *forest management* for the purposes of KP reporting refers to the area of **high forests, cultures, plantations, coppice, maquies and shrub forests**.

All forests fulfilling the definition of forests as defined in Table 11.1-2 are managed. Area of these forests is eligible area under *forest management* activity, since the entire Croatian forest area is defined as managed forest lands.

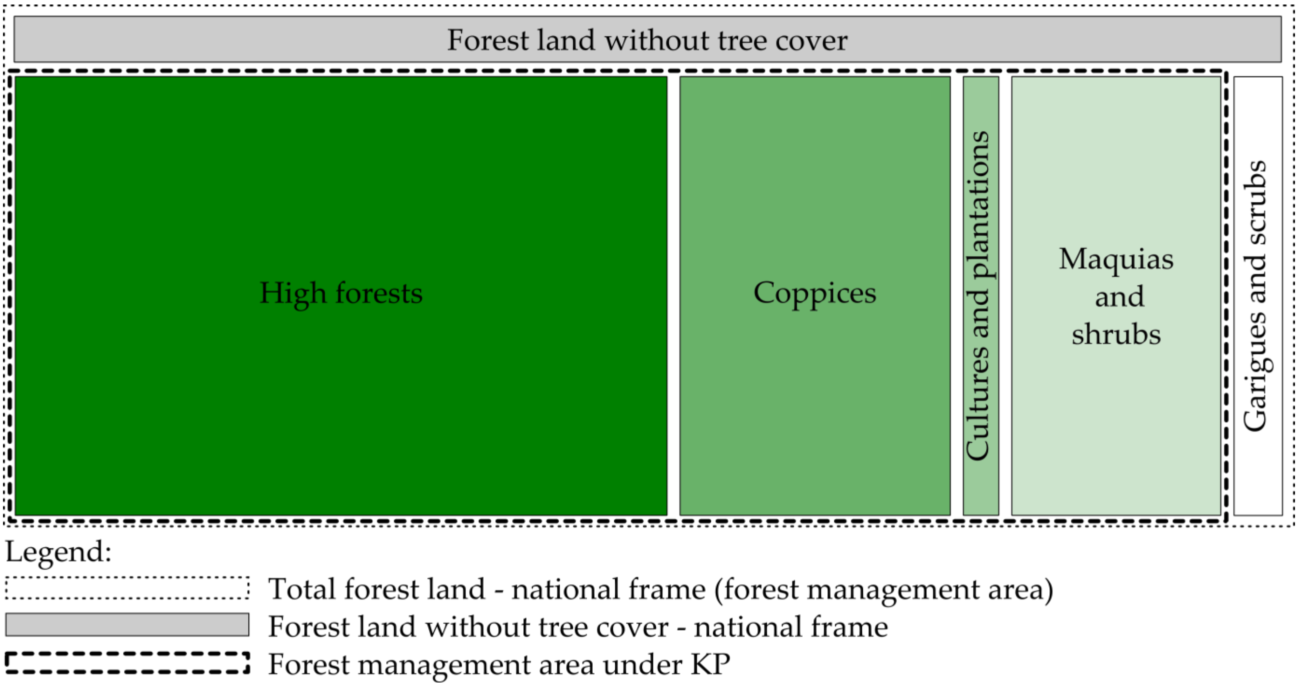


Figure 11.1-15: Forest management area under the KP and within the national framework (based on the relative share of forest types in total forest management area in Croatia)

Based on the results of conducted survey under the LULUCF 1 project, all areas detected as afforested and deforested in period 1990-2012 were subtracted from the forest land area to estimate the FM area.

For the complete analyses the forest area increase on basis of afforestations that happened before 1.1.1990 needed to be determined since some of these areas were already included in FM areas and emissions/removals were accounted under single years from period 1990-2012. One of reason causing this was that in 1993 a regulation57 by the Croatian law gave the obligation to Croatian forests to take over all existing forest meeting the forest definition that were not registered as forests before 1993 into the forest land (including the forests managed by holdings or enterprises). The background for this law was that all forest area in Croatia should be under forest management plans. As a result of this regulation also mature forests were for the first time counted as forest land under the new forest management plans.

[57] 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)

All these areas previously reported under FM that were detected by the described current survey as afforested due to human induced promotion of natural seed sources that happened before 1990, were shifted from the years were they were previously reported for the first time to the FM area in 1990.

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 (maquies and shrub)).

11.2.2. METHODOLOGY USED TO DEVELOP THE LAND TRANSITION MATRIX

Activity matrices are presented for 2012, 2011, 2010, 2009 and 2008 (Tables 11.2-1, 11.2-2, 11.2-3, 11.2-4 and 11.2-5) based on the results of conducted survey under LULUCF 1 project and as it was presented in points 11.1.3.1-11.1.3.3 of this Chapter.
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.
Based on the *Forest Act* and *Forest Ordinance*[58] afforestation works have to be prescribed by the *Forest Management Plan for management units (*FMAP*).* According to the Articles 31, 32 and 51, 51a and 52 of *Forest Act*, deforestation is strictly regulated and allowed in very limited circumstances for all forest under forest management regardless the types of forests and ownership.

[58] OG 111/06, OG 141/08,

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 act[59], 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 – Forest Administrations (organizational and territorial units). This division was established in 1996. Forest Administrations consist of Forest offices, currently of 169 altogether. The single Forest office 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 assessed. Based on the FMAPs total area of forest land in Croatia is known. Also, based on the strict national legislation, forestland converted to settlement and cropland categories is well known. Also, the grassland area converted to forestland is well known due to the fact that afforesttation 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, category that was facing with area decrease during the reporting period was grassland.

In order to identify and trace forest areas in accordance with provisions of decision 15/CMP.1 and requirements set in ARR 2012, Croatian Ministry of Environmental and Nature Protection initiated the project "*Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol*". The survey conducted through the project addressed the issue of increase of forest area in a way that:

1. Forest area increase on basis of afforestations that happened before 1.1.1990 was determined (e.g. in 1993 a regulation[60] 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 counted these lands under Art. 3.4 FM.
2. Afforestation and the former land use after 1.1.1990 and direct human induced LUC were identified. These areas are counted under Art. 3.3 AR
3. Afforestation not direct human induced were examined. There is no afforestation in Croatia that can be considered as not direct human induced

[59] Ordinance on Forest Management (OG 111/06 (Article 63), OG 141/08)

[60] 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)

With conducted survey all forests types and forests ownerships were covered. Results influenced in changes in data on forest areas previously reported under the Article 3.3 and 3.4 of the KP. New area figures are presented in Tables 11.2-1 to 11.2-5.

Table 11.2-1: Land transition matrix for year 2008, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2008
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	13.85							13.85
	D		2.41						2.41
Article 3.4 activities	FM		0.41	2,299.65					2,300.06
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		1.83	0.00	0.00	0.00	0.00	0.00	3,341.24	3,343.08
TOTAL (end of 2008)		15.69	2.82	2,299.65	0.00	0.00	0.00	3,341.24	5,659.40

Table 11.2-2: Land transition matrix for year 2009, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2009
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	15.69							15.69
	D		2.82						2.82
Article 3.4 activities	FM		0.61	2,299.04					2,299.65
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		4.45	0.00	0.00	0.00	0.00	0.00	3,336.79	3,341.24
TOTAL (end of 2009)		20.14	3.43	2,299.04	0.00	0.00	0.00	3,336.79	5,659.40

Table 11.2-3: Land transition matrix for year 2010, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2010
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	20.14							20.14
	D		3.43						3.43
Article 3.4 activities	FM		0.35	2,298.69					2,299.04
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		4.81	0.00	0.00	0.00	0.00	0.00	3,331.98	3,336.79
TOTAL (end of 2010)		**24.94**	**3.78**	**2,298.69**	**0.00**	**0.00**	**0.00**	**3,331.98**	**5,659.40**

Table 11.2-4: Land transition matrix for year 2011, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2011
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	24.94							24.94
	D		3.78						3.78
Article 3.4 activities	FM		0.19	2,298.50					2,298.69
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		6.04	0.00	0.00	0.00	0.00	0.00	3,325.94	3,331.98
TOTAL (end of 2011)		**30.99**	**3.97**	**2,298.50**	**0.00**	**0.00**	**0.00**	**3,325.94**	**5,659.40**

Table 11.2-5: Land transition matrix for year 2012, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2012
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	30.99							30.99
	D		3.97						3.97
Article 3.4 activities	FM		0.24	2,298.26					2,298.50
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		5.03	0.00	0.00	0.00	0.00	0.00	3,320.91	3,325.94
TOTAL (end of 2012)		**36.02**	**4.21**	**2,298.26**	**0.00**	**0.00**	**0.00**	**3,320.91**	**5,659.40**

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.
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 51 of the Ordinance[61] as part of the FMAP 2006-2015 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
- Risk forest fire map
- Beneficial function forest map with detected larger settlements, industrial plants, agricultural areas, transport corridor

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.

In order to comply with the ERT findings presented in ARR 2012 regarding the traceability and identification of lands as defined in paragraphs 6(a), 6(b), 6(e), 8(c), 9(a), 9(c) and 9(d) of the annex to decision 15/CMP.1, separate project was designed. Through surveys conducted within the framework of project "*Improving*

*Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol"(*abbreviated LULUCF 1) Croatia managed to identify and trace lands that should be reported under paragraphs 3.3 and 3.4 of the Kyoto Protocol (see points 11.1.3.1-11.1.3.3 of the report). The survey was conducted on complete forest areas that meet Croatian thresholds for forests defined under the KP regardless the ownership and forest types (this includes maquies and shrub areas). All data and information concerning the conducted survey are presented in a separate document[62] as one of outcomes of the LULUCF 1 project.

To conduct this work detailed analyses of spatial data and all relevant data available in official forest database *HS Fond* were performed consulting during the analyse forest management plans and programs valid in previous periods and making field checks in forms of site visits on a level of forest sub-compartment when it was needed.

All identified areas belonging to ARD areas were incorporated into a GIS database of Croatian forests Ltd. as geospatial ESRI Shapefile (.shp) files. These are a polygon layers with accompanying descriptive (attribute) data projected in HTRS96/TM coordinate system. Through descriptive data layers polygons can be linked to existing databases of Croatian forests Ltd.
Therefore, all reported ARD areas are geographically explicitly determined (Figure 11.1-1, Figure 11.1-11 and Figure 11.1-14) and traced as it is described in part of.

In case of geographical identification on afforested areas and its traceability in private and state forests that area managed by other legal bodies than Croatian Forests it should be emphasized that performed work proved 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).

Examples of areas registered as areas subject of ARD activities are presented in Figure 11.2.1 and Figure 11.2-2.

---

[61] Ordinance on Forest Management (OG 111/06 and 141/08)
[62] D. Janeš & all: Separation of areas under the Article 3.3 and 3.4 of the Kyoto Protocol

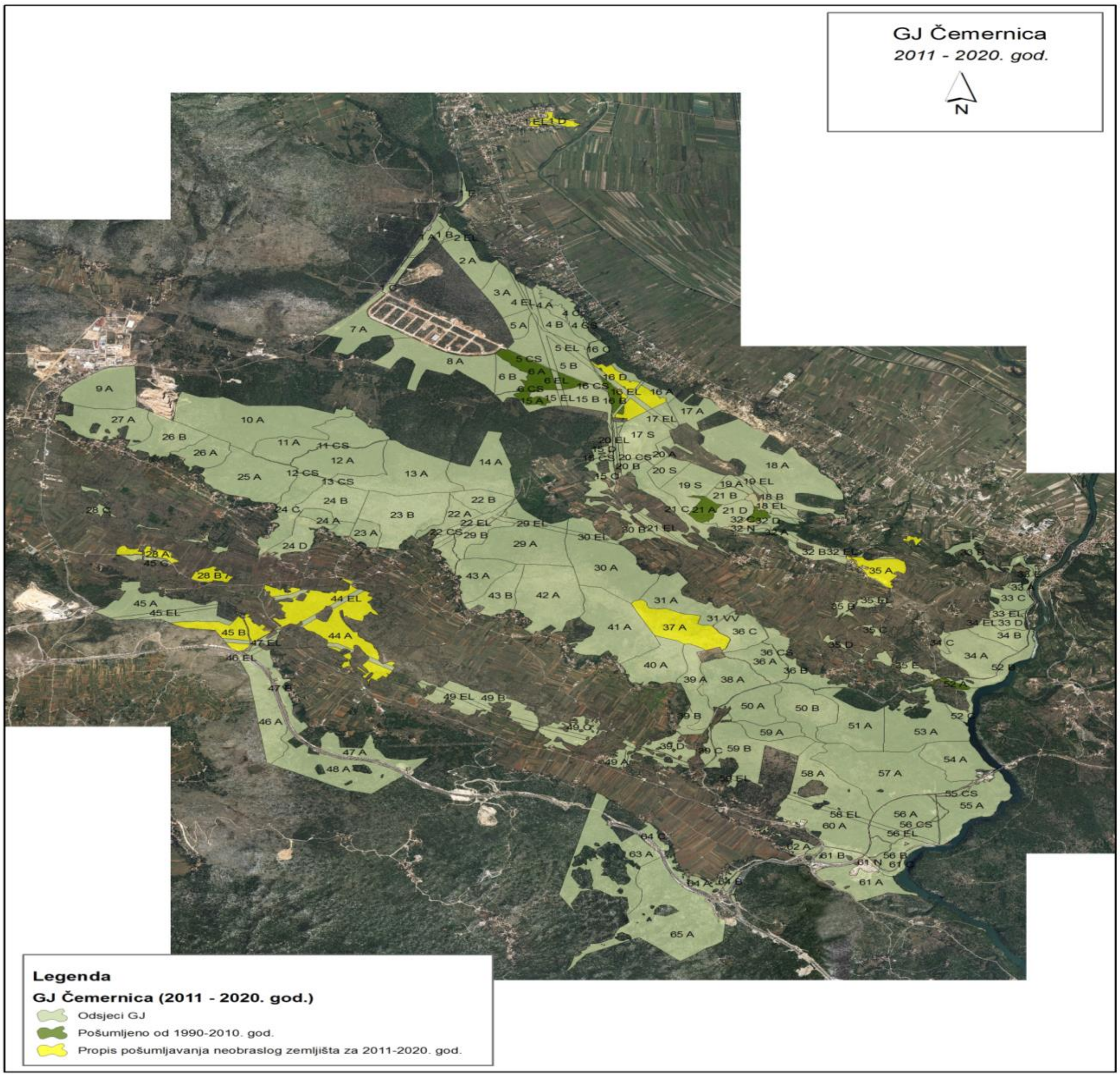


Figure 11.2-1: A map of one forest district in Croatia presenting areas that are afforestated in period 1990-2010 (marked green) and areas that are foreseen for the afforestation in period 2011-2020 (marked yellow)

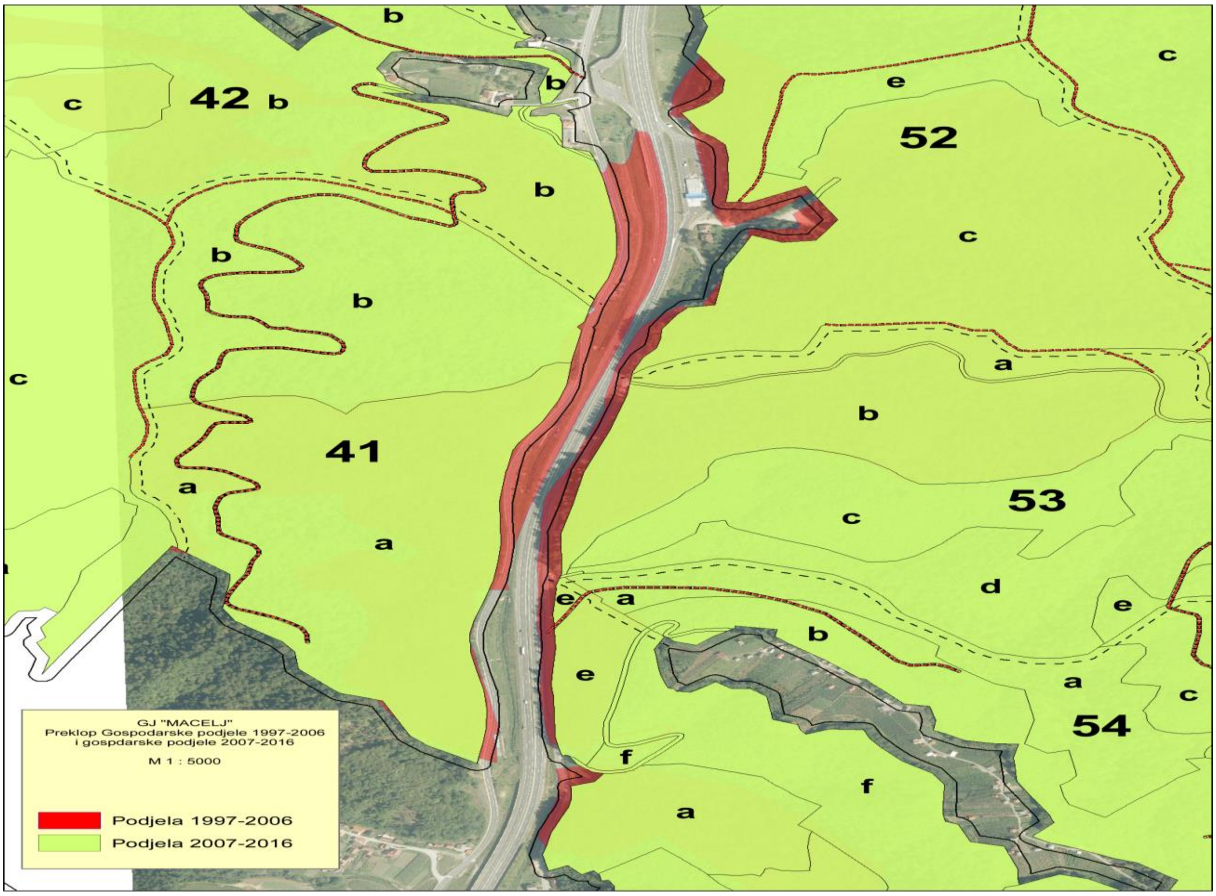


Figure 11.2-2 A map of the area with traced changes in the territory (area which was excluded from forest land in period 1997-2006 presented in red and situation in FMAP 2006-2015 presented in green)

11.3. ACTIVITY-SPECIFIC INFORMATION

Data used in the calculations are attained from FMAPs. The data were divided based on forest type and reported as *Deciduous*, *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

Methods and assumptions for estimating carbon stock changes in forests on areas under the Article 3.3 (*afforestation/reforestation* and *deforestation*) and Article 3.4 (*forest management*) of the Kyoto Protocol follow those applied for the UNFCCCC reporting (see chapter 7.2.2).

In order to comply with recommendations given by the ERT, emissions due to forest fires are reported separately for FM and ARD areas since this year of reporting. This has been performed using officially submitted data from Croatian Forests Ltd gained through the activities of LULUCF project *"Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol"*(abbreviated LULUCF 1).

GHG Emissions on FM areas are estimated using the IPCC GPG 2003 values for *Other temperate forests*. When estimating emissions form fires in afforested areas, values for biomass consumption and emission factors that also refer to *Other temperate forests* (IPCC GPG 2003, table 3A.1.16 and table 3A.1.13) are used. Estimate of emissions from wildfires cover also *Out of yield forests* (maquies and shrub) but high forest biomass losses are used in estimation which represents overestimation of emissions under this type of forests. Additionally, due to the officially prescribed methodology of data collection, it was not possible to distinguish areas affected by fires in case of maquies and shrub forests from scrub areas (degraded forms of shrub forests). Therefore, areas of scrub forests affected by fires make part of areas of maquies and shrub forests and estimation was done using the same values as for high forests. Maquies and shrub forest have significantly lower C stocks, so this approach represents another source of emission overestimation in Croatian reporting in case of fires.

Detailed description of method used to perform estimation has been described in Chapter 7.12.2.

CO_2 emissions from biomass burning in areas subject to Article 3.3 and Article 3.4 are included in CRF tables 5(KP-I)A.1.1 *Losses* and 5(KP-I)B.1 *Losses*, accordingly.

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 (GPG 2003). The activity data obtained refer to living biomass and soil as follows:

- For afforestation – afforested area
- For deforestation – deforested area and related volume felled

As regarding the afforestation, all units of land were not harvested since the beginning of the First commitment period.

Biomass

To determine the changes in biomass carbon stocks in ARD areas in Croatia, results and outcomes of the conducted survey under the LULUCF 1 project were used as presented below:

4. During the reporting period, afforestation by seeding and planting as well as supporting natural spreading of forests through human decision, did not happen in area of state owned forests managed by other legal bodies.
5. In private forests only afforestation due to human decision to support natural spreading of forests on new areas occurred during the reporting period (see also Chapter 7.2.4.2)
6. In case of state owned forests managed by Croatian forests Ltd. afforestation through seeding and planting activities occurred. Also, natural spreading of forests on new areas were recorded as result of human decision to support increase of forest's areas
7. Afforestation that occurred in state owned and private forests refers to conversions from grassland and cropland (annual and perennial) to forest land

For the purposes of estimation, below presented values according to the type of conversion (from Grassland or Cropland) and type of forests were used:

6. Average annual increments from the IPCC GPG 2003 were used for the aboveground biomass in natural regeneration
7. Values for the *Temperate forest* in age class ≤ 20 years and ≥ 20 years were applied.
8. The applied values are the same for both age classes (3 tdm/ha annually (for coniferous), 4 tdm/ha (for deciduous), and 0.5 tdm/ha (for maquies and shrub)
9. Mean values of the average Root to Shoot ratio from IPCC GPG were used (0.46 (for coniferous), 0.43 (for deciduous). Regarding the maquies and shrub forests conservative approach was applied using the lowest value (0.26) from the range defined for *Other forests/woodland*
10. IPCC GPG default value of 0.5 tC/ t dm for the Carbon fraction was used for all types of forests

Based on the above mentioned factors, average biomass growth was calculated to be 2.19 tC/ha annually in case of coniferous forests. This constant value was used for all afforested coniferous 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 the second age class since 1990) were calculated by multiplying the average biomass stock of the second age class by the area of the second age class. The same procedure was used when calculating gains in case of deciduous and maquies and shrub forests. Values of 2.86 tC/ha and 0.32 tC/ha as average biomass growth for deciduous and maquies and shrub forests were used accordingly.

When determining biomass growth of each forest type, average values for annual increment in AGB were used for deciduous and coniferous forests, and lowest value from the range defined in GPG 2003 for maquies and shrub forests.

In order to calculate the biomass carbon stock losses as a result of grassland and cropland conversions to the forestland, the nationally determined value of 4.29 tC/ ha annually for grassland category and 5.67 tC/ha annually for annual Cropland category were used. When estimating carbon stock losses due to conversion of perennial Cropland to forestland IPCC GPG value of 63.0 tC/ha annually was used.

As regarding D areas, the losses in living tree biomass per ha are calculated in the year of D using national information such as average harvested volume in period 1990-2012 by forest type and wood densities and also IPCC GPG 2003 values as presented in Table 11.3-1.

Table 11.3-1: Volume harvested on deforested areas according to the forest types (m^3/ha)

Forest type	Average harvested volume (m3/ha)	Wood density (tdm/m3)	BEF 2	**R/S**	CF (tC/t d.m)$^{-1}$
Deciduous	137,97	0,56	1,4	**0,26**	0,5
Coniferous	102,86	0,39	1,3	**0,32**	
Out of yield (maqies and shrub)	14,34	0,68	1,15	**0,26**	

Regarding the maquies and shrub forests, conservative approach was applied when using value of 1.15 as a lowest value from a range defined for *Temperate coniferous* species in IPCC GPG. Also, in case of R/S factor Croatia used value of 0,26 from the range defined for *Other forests Woodlands* in GPG 2003 (0,26 – 1,1) although it is considered that R/S factor in maquies and shrub forests is much higher since these forests come in Mediterranean parts of Croatia with dry climate and in order to survive they have to struggle for water and because of it is known by studies that they have very large roots.

BEF 2 and R/S factor for deciduous and coniferous forests are used from GPG 2003 based on estimation of aboveground biomass (t/ha) which is calculated using on national level derived values for average growing stocks and wood densities of each forest type.

In period 2008-2012 harvesting rates were as presented in below Table 11.3.-2.

Table 11.3-2: Volume harvested on deforested areas according to the forest types (m^3/ha)

	2008	2009	2010	2011	2012
Deciduous	114,45	42,38	180,28	182,80	180,74
Coniferous	123,04	48,43	20,22	14,08	12,12
Out of yield (maquies and shrub)	16,34	13,05	14,68	14,53	4,10

Based on nationally determined average values of deforested volume by each forest type, below presented values of carbon stock in total biomass (AGB+BGB) are determined to be:

1.67,90 tC/ha for deciduous forests
2.34,83 tC/ha for coniferous forests
3.7,09 tC/ha for Out of yield forests (maquies and shrub)

Approach 3. was applied when identifying all deforested forest areas in Croatia in period 1990-2012. Based on the analyse conducted through the project "Improving Croatian Reporting in the Land use, Land use change and Forestry Sector in the First Commitment Period of the Kyoto Protocol" (abbreviated: LULUCF 1) it is know that deforestation happens in Mediterranean (on 50,3% of all deforested areas with the 26,6 m3/ha average volume deforested) and continental part of Croatia (on 49,7% of all deforested areas with the 180,1 m3/ha average volume deforested). Most of harvested coniferous species belongs to younger coniferous forests (more than 55% of volume deforested refers to young Aleppo pine forests). This makes a reason that carbon stock in coniferous forest is relatively small.
This is also in line with stipulation of Forest Law (Article 57) which determines that conversion of forest land to cropland category of land can be performed primarily on: 1) land under the forests management (land without tree cover) 2) forest land with woody (scrub) vegetation and 3) young forests.

When calculating gains due to biomass growth on deforested area, below presented values were used:

1. 0.19 tC/ha - for annual plants in area of Settlement (nationally determined)
2. 0.0256 tC/ha – for perennial plants in area of Settlement (nationally determined)
3. 2.10tC/ha – for perennial Cropland (IPCC GPG)
Description of the underlying methods and assumptions can be found in related part of the report (Chapters 7.6.4.1 and 7.3.2.1)

A)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.

B) 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 (complete organic humus layer (O_l, O_f, O_h)). 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.

C) Soil

The estimates of the soil carbon stock changes at ARD areas follow the equation below:

$$\Delta C_{LFMineral} = [\,(SOC_{ref} - SOC_{before\ ARD}) \times A_{ARD}]/T_{ARD}$$

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 due to afforestation activity. Conversion that happens in the Croatian case refers to grassland and perennial cropland converted to forestland with following soil C stocks:

- Grassland: 70.6 tC/ha
- Forestland: 84.5 tC/ha
- Annual Cropland: 46.4 tC/ha
- perennial Cropland: 77.8 tC/ha

Soil removal factors determined in this cases were 0.695 tC/ha, 0.191 tC/ha and 0.336 tC/ha annually.

The values of soil carbon stock determined through national scientific investigation were used in order to estimate the carbon stock changes in soil due to conversion Forest land to perennial Cropland. Estimation with following soil C stocks:

- Forestland: 84.5 tC/ha

- perennial Cropland: 77.8 tC/ha

Soil emission factor determined in this case is -0.336 tC/ha annually.

For determination of soil carbon stock changes due to deforestation activity to settlement the used values of soil carbon stocks are presented below, and emission factor was calculated to be -4.1 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 Chapters 7.3.2.1 and 7.6.4.1.1 and Chapter 7.2.4. Methodological issues.

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, coppice, maquies and shrub forests.

Based on the ERT recommendations given in 2012 during the In country review, CO2 emissions/removals in period 2008 – 2012 are estimated using the per ha values for increment and harvest for all types of forest ownerships. Difference comparing to last year submission refers to the fact that for this year submission, estimation has been performed using the per ha values for increment and harvest that corresponds to all forest areas while in last year's report estimation vas done using the per/ha values for each type of ownership and finally summing them up. Additionally, for this submission Croatia performed estimation for maquies and shrub forests. Also, for this year reporting correction in previously used R/S factors has been performed. This is a main reason that removals for this year reporting differs to removals reported in NIR 2013. Increment and harvest data are divided per broadleaved and coniferous species.

11.3.1.2. Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

<u>Omitting GHG emissions/removals</u>

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

With respect to ensuring determination of harvesting or future deforestation of afforested land, country wide forest management plans secure that all forest management activities are prescribed and therefore known. Each of these plans define all measures and activities for the period of its validity (10 years), and they also give a description of the measures that are required in the following 10 years period. Based on the legislation[63] execution of each activity prescribed under forest management plans must be recorded on yearly basis (which refers also to afforested areas) and at the end of forest management plan officially registered by the Ministry of Agriculture. Following national forest legislation[64] only pre-commercial thinning is defined as possible harvesting operation in forests of first age class. In case of second age class forests no harvesting operation occurred during the First commitment period. These legislative acts and forest management practices related to first and second age classes forests on afforested areas, allows Croatia to report units of land harvested since the beginning of the commitment period, if this occurred. Since so far harvesting has not been performed on afforested area, Croatia uses notation key NO in CRF tables.

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 N_2O 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. N_2O emissions from drainage of soils

Drainage of soils does not occur in Croatia.

Table 5(KP-II)3. N_2O emissions from disturbance associated with land use conversion to cropland.

The annual release of N_2O due to the conversion of forestland to cropland was calculated using the IPCC default value (Tier 1) and equations 3.3.14 and 3.3.15:

$$N_2O_{\textbf{net-min}} - N = EF_1 \times \Delta C_{\textbf{LCmineral}} \times 1/(C/N \text{ ratio})$$

where:

EF_1 = the emission factor for calculating emissions of N_2O from N in the soil = 0.0125 kg N_2O-N/kg N (IPCC GPG default value)

$\Delta C_{\textbf{LCmineral}}$ = change in the carbon stock in mineral soils in forestland converted to cropland

C/N = ratio by mass of C to N in the soil organic matter = 12 (national value)

[63] Ordinance on Forest management, Articles 64 and 70

[64] Forest Act, Article 28

Table 5(KP-II)4. Carbon emissions from lime application

No lime is applied to forests and perennial cropland from D activities, 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.

Omitting carbon pools

Croatia performs estimation in the aboveground and belowground biomass and soil pools for Article 3.3 and estimation in the aboveground and belowground biomass for Article 3.4. 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 areas

As for afforestation areas and the **dead wood carbon pool**, it is considered that conversion of Grassland and Cropland to Forestland cannot generate carbon stock changes in terms of losses of dead wood, especially in the long-term. Generally, afforestation by seeding and planting has been performed only in state owned forests on the land under forest management that is without tree cover. Based on the IPCC GPG definitions of categories of land 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. The same apply to areas converted from Grassland and annual Cropland category due to human decision to support natural spreading of forests.

When determining the carbon stocks in forest soils, it is considered that the whole litter layer is included when samples were taken for an analysis. This is the conclusion of a group of soil experts, which is based on the fact that soil samples were taken at different time intervals throughout the area of forest soils in Croatia that is geographically very different (lowlands, mountainous and karst area). Therefore, the **litter** carbon stock changes at ARD lands are included in the reported soil C stock changes. This expert judgement is in line with the provisions of new legislative act that prescribes monitoring on agricultural lands[65].

Emissions on deforested areas are estimated based on harvest volumes of living and already dead trees (dead wood, being part of the amount of harvested biomass) expanded to tree biomass following the equations in the IPCC GP. All that biomass/dead wood is assumed to be oxidized in the year of D – so the worst case (complete instant oxidation of the harvested biomass in the year of D) was assumed and there is no reason to calculate any further decay at site. Due to the assessment systems and data used DW and fine woody debris component of litter are part of the biomass and soil pool, so they cannot be assessed a second time in order to avoid double accounting. Dead wood removed is part of the stock which is assessed as being removed due to deforestation.

Due to forest management practices in Croatia there are two types of dead wood – dead wood that refers to wood thicker than 7 cm which is removed from the forests and wood thinner than 7 cm (wood residues) which is left in the forest to decay after harvest operations. Dead wood reported as IE in CRF tables refers actually to dead wood removed from the forests and thicker than 7 cm.

Leaving wood residues thinner than 7 cm into the forests presents one of operations regularly performed in harvest and forest management practices in Croatia. However, deforestation is not regular operation under the forest management practices and as such it has been strictly and separately regulated by the law. Deforestation in Croatia happens due to conversion of Forest land to Cropland and Settlement category of land. Conversion to Settlement category has been performed mainly due to important infrastructural works (i.e. high ways constructions) and in case of Cropland category due to cultivation of vineyards, orchards or olive gardens. Both types of conversion require removal of all wood components including the wood residues in order to have successful conversion of forest land to cropland or settlement category (i.e. land requires tillage in case of orchards and wood residues would present obstacle to that work). Hence, when deforestation activity has been performed normal practice of leaving wood residues thinner than 7 cm into the forests is not and cannot be applied. As it was reported in Chapter 11.1.3.2 Approach 3 has been applied when identifying land subject to deforestation activity and only land on which deforestation was actually happened was reported according to the corresponding year of conversion. Consequently, there is no situation that wood have been cut and deforestation performed without real conversion to other types of land. This means that there are no situations on which wood residues are left on site due to failure to conduct planned conversion.

All presented above means that notation key NO should have been used when reporting emissions/removals of dead wood thinner than 7 cm. However, since there is no option to use two notation keys (IE and NO needed) at the same time in CRF tables, Croatia decided to use IE notation key since dead wood volume extracted from forests exists while there are no dead wood volume of wood residues remaining in the forests.

FM areas

a)Omitted pools of dead wood, litter and soil in subcategory Out of yield forests (maquies and shrub forests)

According to the national definition[66], maquies and shrub forests are forests where besides the trees, bushes are presented in the same crown layer.

---

[65] Ministry of Agriculture (2014), Ordinance on monitoring of agricultural lands (OG 43/14), Article 14

[66] Ordinance on Forest management (OG 111/06), Article 13

This type of forest in Croatia has been formed from typical Sub-Mediterranean and Eu-mediterranean species in theses 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, afforestation (using primarily pioneer tree species) and sporadic activities with the purpose of converting these forests to the form of high forests (i.e. according to the FMAP 2006-2015 conversion to high form of forests and reconstruction of maquies and shrub forests is prescribed to be executed on more than 10 000 ha in 10 year period). The main role of these forests is protective, so this is the reason that, accordinig to the national legislation, there is no biomass harvest in maquis and shrub forests, but sporadic measures of planting to convert such forests into higher form of forests.

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 would require more time and resources than the exploitation of wood in the high forests, and makes them not 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.

According to the measures in energy sector adopted by the Croatian Government and Parliament[67] (i.e. completion of gas pipelines for Dalmatia (Mediterranean region) and supporting measures to the production of electricity that originates form wind farms and solar panels both of which are most suitable for this region), and increase of prices of wood for heating it can be expected that consumption of wood will be even less in Mediterranean part of Croatia and that also in the future there will be no demand for wood consumption that originates from maquies and shrub forests. Additionally, it is not expected that legal framework by which maquies and shrub forests are defined and managed as protective forests with no harvest, will be changed in the future.

There is no harvest in these forest but sporadic planting measure and the pressure from animals decreased due to the depopulation of rural areas.

Croatia believes that presented arguments prove that these changes in maquies and shrub forests consequently are connected to an increase in the input of **dead wood** from natural mortality due to the increase in biomass. Additionally, Croatia believes that dead wood stock can only increase with times as a result of forest fires and the fact that these forests grow mainly in Mediterranean part of Croatia which is due

[67]Energy 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

to climate conditions most frequently disturbed by forest fires. Although these forests have very good ability to regenerate themselves after the fires, in cases of long lasting fires when biomass is lost, all biomass burnt has to be cut when preparing forest area for restoration. In these cases all biomass is left on the side to decay.

According to the Article 32 of Forest Act[68] removal of peat, litter and humus is strictly prohibited and its usage in exceptional situations is regulated by Article 33. For the same arguments as provided for dead wood (steady increase in biomass in these forests due to the lack of harvest and planting measures and less pressure from agricultural animals), litterfall and consequently the **litter pool** and the **soil pool** under the maquies and shrub forests are not a source of emissions, but a C sink.

a) Omitted pools in subcategories *Decidous* and *Coniferous forest*

b.1) Dead wood

According to the Croatian report for FAO *Forest Resources Assessment* 2005 (FRA 2005)[69] 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.
Furthermore, based on the available data on growing stocks and harvest which prove steadily increase in the standing stocks in Croatia (Table 11.3-2) 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.

Table 11.3-2: Growing stock, harvest, increment and forest areas in Croatia

	2008	2009	2010	2011	2012

[68] Ibid

[69] FAO, Forest Resources Assessment Croatia 2005 (FRA 2005), (http://www.fao.org/forestry/8405-0ae983caa45ca038755a439ceae4f532e.pdf)carbon

Growing stock (m³/ha)					
Deciduous	211.5	212.6	213.7	214.7	215.8
Coniferous	247.4	249.4	251.5	253.5	255.6
Out of yield forests	35*	35	35	35	35
Harvest (m³/ha)					
Deciduous	2.707	2.620	2.709	3.014	3.050
Coniferous	3.759	3.625	3.445	4.001	3.988
Out of yield forests	NO**	NO	NO	NO	NO
Increment (m³/ha)					
Deciduous	5.604	5.576	5.549	5.522	5.495
Coniferous	5.527	5.564	5.601	5.637	5.674
Out of yield forests	0.2	0.2	0.2	0.2	0.2
FM area (kha)					
Deciduous	1,662.16	1,662.06	1,662.00	1,661.98	1,661.93
Coniferous	201.87	201.85	201.79	201.78	201.68
Out of yield forests	435.62	435.13	434.90	434.75	434.65

*According to the expert judgement growing stock ranges between 20 to 50 m³/ha in these forests

**Not occurring (NO)

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)

As a consequence of War, areas polluted with mines are still present in Croatia. Although continued work has been conducted for de-mining purposes, according to the data available at Croatian Mine Action Centre (CMAC) there are still more than 61 kha[70] of areas polluted with mines.
According to the data delivered by Croatian Forests Ltd., forest areas polluted with mines were more than 243 kha in year 1997 and more than 54 kha in 2011 and 49 kha in 2012. Figures presented here refer to forest according to the Croatian thresholds chosen in defining forests for reporting under the Kyoto protocol. Due to safety reasons regular forest management activities have not been conducted on forest areas estimated to be 2.5 times bigger than area officially proclaimed as mine polluted. In these forest areas no forest work has been performed as long as they are under mines. De-mined forest areas are subject to official procedure prescribed by Forest Act[71] and special audit has to be performed and new Forest management plan for the corresponding forest unit has to be developed. By this plan all activities that need to be conducted in ten year period are prescribed. However, due to safety reasons activities defined by the plan on de-mined areas are usually executed slower than activities in forest areas that are not mine polluted.

[70] Croatian Mine Action Centre, http://www.hcr.hr/hr/minSituac.asp
[71] OG (140/05,82/06,129/08,80/10,124/10, 25/12, 68/12, 148/13), Article 21

Comparing to the total forest management area in Croatia it means that in year 1997. 12% of forest area was not accessible for managing and around 5.5% in years 2011 and 2012.
Forest areas polluted with mines are determined using official maps available at the CMAC and overlapping it with official forest maps present at Croatian forest Ltd.
Croatia believes that due to above presented facts that prevent removal of dead wood from forests and the implementation of needed thinning operations areas polluted with mines or that are de-mined, dead wood stock increases and consequently carbon stock in this pool is increasing.

Before it was approved, Forest management plan for the Republic of Croatia in period 2006-2015 (FMAP 2006-2015) was subject of official approval of other relevant institutions in Croatia. Requirements of the Ministry of Environment (Nature Protection Directorate) to ensure that a constant number (3-5 trees/ha) of old and dry, standing and fallen trees, especially trees with hollows are left on logging sites, are incorporated into the FMAP 2006-2015.
Additionally, according to the Article 26 of Forest Act, all forest management plans that need to be developed for forest incorporated in one of areas protected under the Law of Nature Protection (i.e national park), have to be approved by the Ministry of Environment and in order to be in line with the requirements of nature protection. Securing biological diversity through leaving certain number of dead trees on logging sites is one of constant requirement requested by the Ministry of Environment.

Since Forest Act was published in 2005 according to the Article 8, Croatian Forests Ltd and private forest owners are obliged to manage forests by maintaining and enhancing biological and landscape diversity and promote the protection of forest ecosystems in a way that due attention must be given to other species in the ecosystem that are associated with dry and dead trees through leaving the required number of old dead wood, hollow and decayed trees, in spatial distribution and number which preserves biological biodiversity.

Since 2002 Croatian Forests Ltd disposes with FSC (Forest Stewardship Council) certificate for forest management which proves that forests are managed according to strict environmental, social and economic standards. Since the first certificate was gained, certificate has been renewed on regular basis every 5 years. According to the available information, FSC certificate refers to more than 2.0 million ha of Croatian forests and land under the forest management[72].
In order to secure compliance with FSC requirements and national legislation 3-5 dead wood/ha have to be left on the logging sites since year 2002.

The area and number of protected areas in Croatia increase during the years. According to the Protected Areas Register of the Ministry of Environmental and Nature Protection 1.7% of Croatian terrestrial area is

[72] Croatian Forests Ltd, http://split.hrsume.hr/index.php/hr/component/content/article/1-latest-news/472-10-godina-fsc-certifikata-u-hrvatskim-umama

protected in categories of strict reserve and national park[73]. In these protected categories forests make significant part.
Taking into account a fact that any economic activity and commercial use of natural resources are prohibited in these protected areas[74], it can be assumed that dead wood stock increases in forests within these protected categories. Consequently carbon stock in dead wood pool also increases.

Croatia believes that arguments provided on requirements of national legislation and international standard regarding the dead wood pool prove that dead wood stock in Croatia increases year by year and that carbon stock in dead wood consequently also increases.

Further, Croatia believes that reporting under the dead wood carbon stock pool performed by neighbouring countries (Slovenia, Hungary) and country with partially similar ecological conditions (Greece)[75] claiming that dead wood pool is not source of emissions in their countries or presenting exact data proving this, give additional support to Croatian claim that dead wood pool is not source of emissions due to similarities in ecological conditions with these countries.

b.2) Litter

According to the recent scientific paper[76] carbon stock in litter pool in penduculate oak forests increases with the forest age and reaches its maximum (10.34 tC/ha) in age of 137 years.
According to the FMAP 2006-2015[77] forests of penduculate oak has the biggest area in its fifth (100 years) and sixth age class (120 years). Since Ordinance on Forest management[78] prescribes cutting of penduculate oak forests in age of 140 years, this means that continues accumulation of carbon stock in litter pool will occur in these forests.

Since oak is one of main species in Croatian forests (12% of total growing stock in Croatia comes from this specie[79]) and there is no changes in management practices in any type of forests in Croatia, Croatia assumes that carbon stock in litter pool increases in all forests.

---

[73] State Institute for Nature Protection, http://www.dzzp.hr/eng/protected-areas/protected-areas-in-croatia/protected-areas-in-croatia-—national-categories-1137.html
[74] Law on Nature Protection (OG 80/13), Articles 112 and 113
[75] UNFCCC, National Inventory Submissions 2013, http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/7383.php
[76] Ostrogović, M. Z. (2013) *Carbon stocks and carbon balance in even-aged forest of penduculate oak (Quercus robur L.) forest in river Kupa basin*, table 38, page 58
[77] FMAP 2006-2015, table 93, page 293
[78] OG (OG 111/06, 141/08), Article 24
[79] FMAP 2006-2015, table 72, page 276

In addition, the assessments show that biomass stocks in the Croatian Forests increased steadily in the last decades. It is evident that litterfall is higher in forests with higher biomass. In parallel, harvest increased in the last decades in the Croatian forest which is associated with a higher flux of dead biomass from harvest residues (e.g. branches, stemwood parts, stumps, roots) to the soil. Also, this trend is connected with an increase in litterfall to soil.

Additionally, 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 very 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.

b.3) Soil

Within the reporting period, there was no change in the forest management.
At this moment Croatia does not dispose with the literature data or scientific investigation which supports that soil pool under the Forest management is not a source of emissions.
However, based on the data and information provided above that prove carbon stock increases in biomass, dead wood and litter pool, an increase in these pools is correlated with an increase of the C input to the mineral soil and consequently with an increase of carbon stock in soil. Consequently, it can be also assumed this pool is not a source of emission.

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.

11.3.1.4. Changes in data and methods since the previous submission (recalculations)

Recalculation made since last report:

1.ARD and FM areas are reported according to results of conducted survey through LULUCF 1 project. According to the conducted analyses increase of forests area that happened before 1990 were identified under the specific years and shifted and reported as FM area in 1990. In period 1990-2012 it was determined increase of forest area that amounts of 249,127.02 ha in this case. This was a reason of changes in reported FM areas for this year reporting when comparing to NIR 2013 report.

2.Previously reported ARD areas were checked under the LULUCF 1 project and based on the conducted surveys areas previously reported as afforested due to seeding and planting were checked and only areas that had successful afforestation were reported. Additionally, increase of area due to human induced promotion of natural seed sources was defined. Consequently, afforested area differs than reported in NIR 2013. In NIR 2013 Croatia reported 19.63 kha of areas afforestsed until 2010, and 2.08 kha afforestsed in 2011. This referred only to afforested area due to seeding and planting measures that were conducted by Croatian forests Ltd. while Croatia did not dispose at that time with the information about afforested areas due to human induced promotion of natural seed sources. Additionally, Croatia was reporting that mentioned type of afforestation was mainly performed with coniferous species and emissions/removals were calculated using the values for coniferous species only. Conducted detailed survey in case of afforestation done by seeding and planting shown that only 4,917.62 ha can be considered as afforested since in some of areas afforestation was not successful. Additionally, detailed data about forests types that was successfully afforested were collected. Now it is known that 1,295.11 ha were successfully afforested with deciduous species and 3,622.51 with coniferous species. Performed analyses confirmed that this type of afforestation happens only in case of state owned forests and refers to conversion of grassland to forest land as it was informed in previous Croatian reports.

Regarding the afforestation due to human induced promotion of natural seed sources, conducted analyses showed that this refers to all types of forests (deciduous, coniferous and Out of yield forests (maquies and shrub)). Also, it was noticed that this afforestation happens as a result of conversion of Cropland (annual and perennial) as well as Grassland category to Forest land. All these information were used when performing estimation of emissions/removals and were reason for difference between values reported for afforested areas this year and in NIR 2013.

Regarding the deforestation, detailed survey done through the LULUCF 1 project also shown difference in areas reported as deforested in NIR 2014 in comparison with data reported in NIR 2013.

While in NIR 2013, Croatia reported deforestation on 12.22 kha since 2010 and 0.17 kha in 2011, conducted survey shown that only 3.97 kha should be considered as deforested until 2011 and only 0.24 kha in 2012. The reason for this difference in area reported as deforested is the fact that previously Croatia was reporting deforestation on areas that do not match thresholds for forests as defined by Croatia under the Kyoto protocol (i.e. garigues and scrub). Additionally, all areas on which harvest was performed due to development of communications within the forests, as well as forests breaks were reported as deforested areas which needed to be corrected.

Deforestation that was recorded through conducted survey refers not only to conversion to settlement area but also to perennial Cropland and it occurs in all forest types (coniferous, deciduous an Out of yield forests (maquies and shrub)). All these information were used when performing estimation of emissions/removals and were reason for difference between values reported for deforested areas this year and in NIR 2013.

3. 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 type

4. Estimation performed for maquies and shrub forests using conservative approach and using lowest values defined in IPCC GPG for parameters relevant for estimation

5. Separate estimation of emissions due to forest fires were performed according to the areas defined as FM and ARD

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 CO_2 eq emissions for ARD activities are determined in range of ± 247 to ± 681% in period 2008-2012. In the same period uncertainty of total CO_2 eq emissions for AR activities are determined in range of ± 151 to ± 158% and in case of D activities range is between ± 190 and ± 197%. In regards to FM, uncertainty was determined to ranges between ± 65 and ± 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 2008-2012, Croatia reports afforestation, deforestation and Forest management activities. Reforestation activity has not been performed in Croatia during the reporting period.

11.4 ARTICLE 3.3

In the period 1990-2012, afforestation activities resulted in net removals while deforestation presented a net source. The data are presented in Table 11.4-1.

Table 11.4-1: Emissions/removals of Article 3.3 activities [Gg CO_2]

Year	2008	2009	2010	2011	2012
Total	**-5.56**	**-1.50**	**-41.55**	**-76.13**	**-122.69**
			Afforestation		
Biomass*	-43.33	-19.41	-40.06	-39.35	-89.81
Dead wood	NO	NO	NO	NO	NO
Litter	IE	IE	IE	IE	IE
Soil	-41.25	-53.07	-65.97	-81.38	-94.83
			Deforestation		
Biomass*	41.76	31.32	21.93	1.48	16.58
Dead wood	IE	IE	IE	IE	IE
Litter	IE	IE	IE	IE	IE
Soil	37.26	39.65	42.55	43.13	45.37

*Refers to above and belowground biomass

In period 2008-2012 mentioned activities altogether resulted in removals by sink.

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. As it is stated before, survey performed under the LULUCF 1 project proved that no afforestation by seeding and planting was performed on areas of state owned forests managed by other legal bodies and private forests. Afforestation by seeding and planting in Croatia has been performed only in state owned forests managed by Croatian forests Ltd. in period 2008-2012 based on forest management plans.

Regarding the afforestation due to natural spreading of forests on new areas, Croatia claims this afforestation is result of human induced promotion of natural seed sources in its entire territory. According to the conducted survey in all Croatian forests regardless the ownership and forest types within the framework of LULUCF 1 project, this type of afforestation does not occur in state owned forests that are managed by other legal bodies. This was expected outcome because forests belonging to this type of ownership are under strict or some kind of protection under the provisions of Law on nature protection, and their area is well known, fixed and can not be changed without very complex legal procedure which implies involvement of many institutions in Croatia.

Conducted survey on state owned forests managed by Croatian forests Ltd. regarding the afforestation due to natural spreading of forests on new areas showed that this increase of forest areas happens only from Grassland category of land. As it is presented in Figure 11.1-1 area under the Forest Management plans of Croatian Forest Ltd. encompasses not only area covered by forests but also land without tree cover. The part of area without tree cover which is defined as productive forest land according to national legislation belongs to the grassland category according to the IPCC definitions of land categories.
Basic principle of silviculture science in Croatia is implemented in a way that growth of new young forests is secured primarily through natural spreading of forests seeds coming from older trees that grow on the area. This principle is considered to be the most important part of forest management practices in Croatia by which sustainability of all aspects in forest management as well as sustainability of forests ecosystems are secured. According to the Article 36 of the Forest Act even aged forests in Croatia has to be grown naturally using the shelterwood compartment system while uneven aged forest has to be grown naturally using the group selection method of cutting with rotation period that can not be shorter than 5 years. When performing this work in even aged and uneven aged forests due attention has to be given to the seed crop of the main species. Felling of forest trees needs to be performed after the year with a full and good seed crop securing natural spreading of seed on forest areas as a first precondition of natural regeneration of forests in Croatia.
Consequently, natural spreading of forests by promoting seed spreading on grassland without tree cover (that are under the forest management plans and under supervision of Croatian forests Ltd.) makes integral part of practices on which forests are grown in Croatian and can be considered as human decision to promote natural spreading of forests and as such these areas should be reported as afforested.

In privately owned forests, the total observed natural spreading of forest is recorded on categories of grassland (82.1%), annual Cropland (16.3%) and perennial Cropland (1.6%). As a part of officially prescribed procedure required under the FSC rules, foresters are obliged to get permission of private owners to record their forest area in official forest management programs if the forest is identified as a new forest during the development of forest management program. Only the areas that are officially agreed by the land owners to stay as forests are recorded in the forest management programs and are consequently direct human induced AR areas. Once the area has been recorded as forests it falls under the provisions of *Forest Act* and can not be changed to other land use categories without strict legal procedures.

For other area of private forests that are so far not covered by official management programs (around 50% of private forests) Croatia claims that increase of forest area in these forests is also result of human decision to land use changes based on the information provided below.

According to the official data[80] 105 Settlements in Croatia had no inhabitants in 2001 which makes 1.55% of total settlement area in Croatia. In the same year 2489 Settlements (2.44%) had less than 100 inhabitants. These figures increased in 2011 when Croatia had 150 Settlements (2.22%) without inhabitants and 2653 Settlements (2.66%) with less than 100 inhabitants[81]. According to the same sources of information in same period number of inhabitants increased in area of main town from 25.42% to 26.19% although the total number of inhabitants in Croatia decreased for more than 3%. Based on these arguments and fact that in year 2012 total agricultural plant production was decreased for 12.3% comparing to production in 2011 and that employment in agriculture sector decreased for 3.1% comparing to the same year[82], Croatia believes that depopulation of rural areas and abandonment of agricultural practises on agricultural land is a result of human decision caused with economical situation in the country. Additionally, as a consequence of increased demand for use of woody biomass and its prices (total revenues from exports of wood products (excluding furniture) increased from 3.0% in 2011 to 3.4% in 2012[83]), Croatia is sure that all private owners on which land new forests grow will decide to claim them as forest during the official registration of forest areas in the development process of forest management programs.

Since depopulation of rural areas started from late 40-ies in last century (Figure 11.4-1) the fact is that in many cases abounded agricultural land is covered by several decades old forests which are still register as agricultural land in cadastral due to its tardiness[84].

[80] Statistical Yearbook (2011), page 57
[81] Statistical Yearbook (2012), page 57
[82] Ministry of Agriculture (2013), Annual report on the state of agriculture in 2012, http://www.mps.hr/default.aspx?id=9567, pages 4-5
[83] Statistical Yearbook (2012), page 293
[84] Janeš &all (2014) Separation of areas under the Article 3.3 and 3.4 of the Kyoto Protocol, page 15

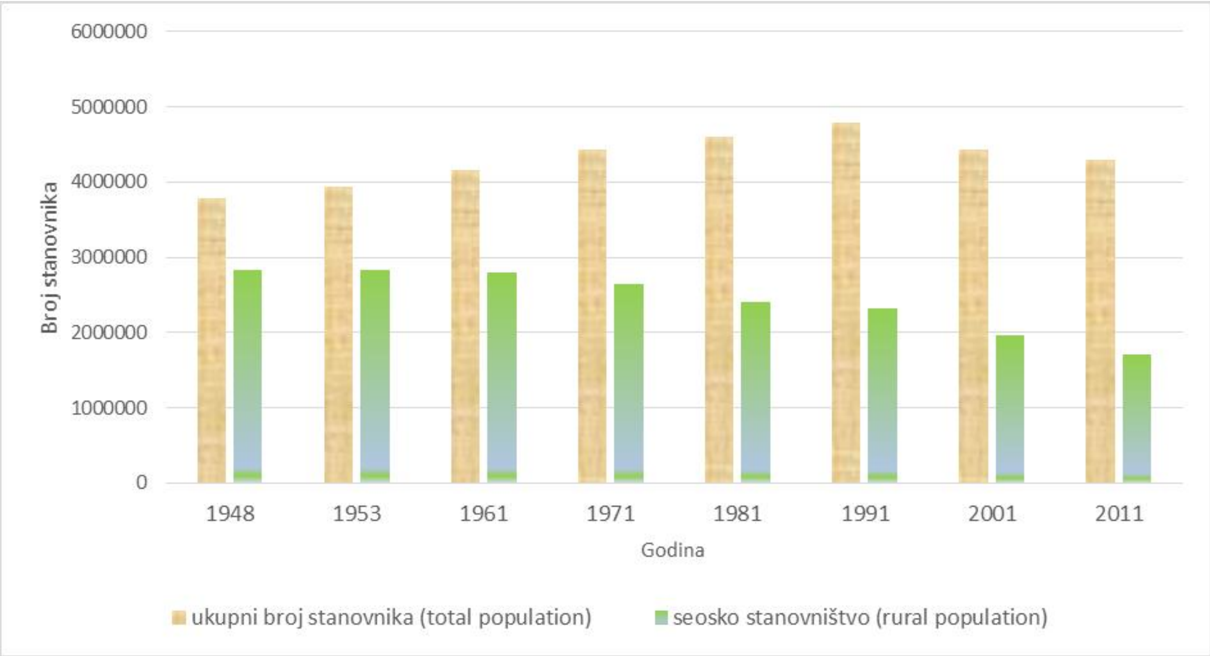


Figure 11.4-1 Total and number of inhabitants in rural areas in Croatia in period 1948-2011

Based on the experiences gained so far in development of programs for private forests when all private owners on which land new forests appeared as a result of natural spreading of forests decided to register this land as forest land, it is expected this trend will continue in case of remaining new private forest areas.

Additionally, due to the fact that conversion of abounded agricultural land that is already covered with forests again to agricultural purposes is very demanding and financially expensive (especially in cases of several decades old forests) it is much easier to register these areas as new forests.

According to the Forest Act[85], Article 62 all private and physical persons conducting business activity in Croatia are obliged to pay 0.0265% of their yearly profit (so called *green tax*) to the state budget for purposes of managing of forests (state and private owned). This financial means have to be shared among private forest owners, Croatian forests Ltd. and other legal bodies that manage forests according to their share of areas in total forest area in Croatia.[86] This financial means must be used in private forests for activities that are prescribed by Forest Act such as pre-commercial thinning and thinning. Since private owners can have benefit from these activities selling the wood gained through these activities, Croatia believes that this *green tax* also contributes that private owners decide to register their abounded agricultural land covered with forests as forests.

Croatia believes that above presented expectation is realistic also since new policy of the EU concerning rural development requires that special measures for forestry sector will be defined under programs for rural

[85] OG 94/14

[86] Regulations on the procedure for granting funds from fees for the use of beneficial functions of forests for work performed in private forests (OG 66/06, 25/11), Article 3

development in period 2014-2020. Under its rural development program[87] Croatia also defined many measures for forestry sector that are of interest of private forest owners.
It is believed that activities of Croatian union of Private Forest Owners[88] (in which 35 Private forest associations from whole Croatia are joined) will contribute to the awareness of relevance of forestry sector and possibilities that are available to private forest owners at EU and national level so that private owners on which areas forests are naturally spread will decide to keep them as forests.

Therefore, all increase of forest areas in private forests that come from Cropland and Grassland categories of land due to natural spreading of forests on new areas should be and are reported as afforestation activity under the Article 3.3 of the Kyoto protocol.

Deforestation requires land use change and relies on a strict legal frame as mentioned before. 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.

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 Articles 35 and 51 of the Low on Forests. 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 Articles 10 and 28 of the *Low on Forests* and the *Ordinance 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.

---

87 Ministry of Agriculture (2014), Program of rural development of the Republic Croatia 2014-2020 (draft).
88 http://www.hsups.hr/udruge.html

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	Net emissions/removals (Gg CO_2)				
Forest management	2008	2009	2010	2011	2012
	-8.616,04	-8.787,25	-8.546,74	-7.652,23	-7.507,01

11.5.4. INFORMATION ON THE EXTENT TO WHICH GHG REMOVALS BY SINKS OFFSET THE DEBIT INCURRED UNDER ARTICLE 3.3.

According to the estimation performed for activities subject of Article 3.3 of the Kyoto protocol, removals by sink achieved through afforestation activities are higher than emissions incurred due to deforestation activities during the period 2008-2012. Consequently, there are no debits that should be offset from the GHG removals by sink in this period.

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 Forest management and Afforestation activities are consider 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	CO2	Forest land remaining forest land	Yes	No other criteria.	No.
Afforestation and Reforestation	CO2	Conversion to forest land	Yes	NO	NO
Deforestation	CO2	Conversion to cropland, Conversion to settlements	No	NO	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 2013 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 2013.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2013.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2013.
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2013.
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 16.1.2013. From 17.1.2013. Croatian registry is part of

Annual Submission Item	**HR report**
	Union Registry and is in operational status with EUTL and 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. http://www.azo.hr/RegistarUnije and https://ets-registry.webgate.ec.europa.eu/euregistry/HR/index.xhtml Croatia was obliged to join to the EU Emission Trading Scheme (ETS) form 1.1.3013. because of the accession to the European Union.
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 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. This national regulation has been replaced by Regulation (EU) No 525/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC.

New national Plan for Air Protection, Ozone Layer Protection and Climate Change Mitigation for the period 2013-2017 was prepared and published (Official Gazette No. 139/2013). The plan will stipulate concrete measures to improve performance of national system. It is planned to prepare and carry out several capacity building projects, related to improvements in emissions estimates in all IPCC sectors and specifically related for completeness reporting in LULUCF sector. This projects will start in 2014. Based on the one comprehensive project predicted within the plan in LULUCF sector in order to improve corresponding reporting, several smaller projects are developed. So far two projects were approved for the implementation, and additional new project proposal has been developed.

Committee for inter-sectorial coordination for national system was established by Governments decision in 2014. Committee will perform 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.

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	No change of name or contact information of the registry administrator occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(b) Change of cooperation arrangement	Croatian registry is part of Union Registry and is in operational status with EUTL and ITL form 17.1.2013. therefore, Change of cooperation arrangement are described for the Union registry. Croatian registry joint to Union Registry which successfully has been implemented CSEUR platform in 2012. The 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20 June 2012. During the go-live process, all relevant transaction and holdings data were migrated to the CSEUR platform and the individual connections to and from the ITL were re-established for each Party. The Consolidated System of EU registries were certified on 1 June 2012 and went to production on 20 June 2012. A complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. This description includes: • Readiness questionnaire • Application logging • Change management procedure • Disaster recovery • Manual Intervention • Operational Plan • Roles and responsibilities • Security Plan • Time Validation Plan • Version change Management The documents above were provided in last submission by EU member states.

Annual Submission Item	HR report
15/CMP.1 annex II.E paragraph 32.(c) Change to database or the capacity of national registry	Croatian registry is part of Union Registry from 17.1.2013. therefore, changes to database or capacity of national registry are described for the Union registry. Iteration 5 of the national registry released in January 2013 and Iteration 6 of the national registry released in June 2013 introduces changes in the structure of the database. Changes introduced in release 5 and 6 of the national registry were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. No change 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	Croatian registry is part of Union Registry from 17.1.2013. therefore, change of conformance to technical standards are described for the Union registry. Changes introduced in release 5 and 6 of the national registry were limited and only affected EU ETS functionality. However, each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production. Annex H testing was carried out in February 2014. No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change of discrepancies procedures	Croatian registry is part of Union Registry from 17.1.2013. therefore, no change of discrepancies procedures occurred during the reporting period for the Union registry.
15/CMP.1 annex II.E paragraph 32.(f) Change of security	Croatian registry is part of Union Registry from 17.1.2013. therefore, no change of security occurred during the reporting period for the Union registry. Croatia has implemented its own internal procedures and instructions which includes: • Verification of information and documents required for the account opening in the Union Registry (document number: 75-13-1754/33) • Communication’s channels in Union Registry (document number: 74-13-15/33)

Annual Submission Item	HR report
15/CMP.1 annex II.E paragraph 32.(g) Change of list of publicly available information	Web site of Croatian part of Union Registry is regularly updated. FAQ are available in Croatian and English. Croatian web site is more comprehensive than English, but general informations are available in both languages.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	The new internet address of the Croatian part of Union Registry is : https://ets-registry.webgate.ec.europa.eu/euregistry/HR/index.xhtml
15/CMP.1 annex II.E paragraph 32.(i) Change of data integrity measures	Croatian registry is part of Union Registry from 17.1.2013. therefore, no change of data integrity measures occurred during the reporting period for the Union registry.
15/CMP.1 annex II.E paragraph 32.(j) Change of test results	Croatian registry is part of Union Registry from 17.1.2013. therefore, change of test result are described for the Union registry. Changes introduced in release 5 and 6 of the national registry were limited and only affected EU ETS functionality. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission. Annex H testing was carried out in February 2014.

Annual Submission Item	HR report
The previous Annual Review recommendations	**1.IAR/2013/HRV/2/1** P2.4.1.1. SIAR recommends that the party make the required information publicly available, as soon the national registry has performed a Kyoto Protocol unit transaction. (par 132) Croatian registry web site has all required information publicly available. Due to no performed Kyoto protocol unit transaction, account information, holding and transactions informations cannot be published. **1.IAR/2013/HRV/2/1** P2.4.2.1. SIAR recommends that the Party includes all public information, including complete account information and complete holding and transaction information, directly on the website of the national registry or via a link from the registry website to another website controlled by the Party. National administrator of Croatian part of Union registry starts to open accounts in 2013. All public informations, including complete account information and complete holding and transaction information are publicly available on link: http://www.azo.hr/Izvjesca28

<table>
<tr><td colspan="2">Croatian registry is part of Union Registry from 17.1.2013. therefore, the following table is in the response to the previous Annual Review recommendations for the Union registry submitted as a second addendum to Chapter 14: 'Information on changes in national registry' of the Annual Inventory Submission for the reporting year 2012</td></tr>
<tr><td>Recommendation description</td><td>Response</td></tr>
<tr><td>The assessor recommends that following major changes, the party provide a data model which contains all DES required entities complete with descriptions in its annual NIR.</td><td>The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. Since the successful certification of the registry on 1 June 2012, Iteration 4 of the registry, introduced in October 2012, added a limited number of new entities, none of them relating to DES entities.

A data model was attached which more clearly shows the relevant entities "RECONCILIATIONS", "NOTIFICATIONS", "RESPONSES"," INTERNAL AUDIT LOG" and "MESSAGE LOG." As specified in the DES (Section VII. Data Logging Specifications/E. Message Archive), a copy of messages sent and received is stored in standalone files in one of two managed servers in the hosting environment. For that reason, the Message Archive is not shown in the model. The "MESSAGE LOG" object holds the location of the entire message, for each Message_ID.

Since the successful certification of the registry on 1 June 2012, there has been no change in the capacity of the registry or change of its infrastructure.</td></tr>
</table>

The assessor strongly recommends that the Party test each release thoroughly against the DES as part of each major release cycle and provide the results of such tests in its annual NIR.	The consolidated EU system of registries successfully completed a full certification procedure in June 2012. Notably, this procedure includes connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the Data Exchange Standard (DES). This included a full Annex H test. All tests were executed successfully and led to successful certification on 1 June2012 The October 2012 release (version 4.0) was only a minor iteration and changes were limited to EU ETS functionality and had no impact on Kyoto Protocol functions in the registry. The test script previously provided reflects this. However, each major release of the registry is subject to both regression testing and tests related to new functionality. These tests include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production.

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 GHG emissions by 5 percent in the period 2008-2012 in comparison to base year emissions and harmonization and implementation of European Union climate and energy legislative framework.

It should be emphasized that in the last five years Croatian economy had suffered from recession and that economic stagnation continued in 2014. 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. 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 2013-2017 was prepared and adopted in 2013 (Official Gazette No. 139/2013)

In regard to long-term planning Croatia has adopted framework document for Low-Emission Development Strategy which was sponsored by the UNDP Croatia. This document represents a roadmap for transition to low-carbon society till 2050. Next step is to prepare Low-Carbon Development Strategy as stipulated by Regulation (EU) No 525/2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC.

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 fees 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 CO_2 emissions (approximately 21.5 million EUR).

Another market instrument which was implemented in Croatia in 2013 is emissions trading system as part of 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 fully or partially, depending on activity, 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 1990-2012 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 below[89].

During the six year period from 2007 to 2012 primary energy production in Croatia was decreasing at an average annual rate of 2.1 percent. This trend was recorded in the production of crude oil and natural gas, whereas the production of other primary forms of energy increased. The production of crude oil and natural gas decreased annually on average by 7.2 percent and 7.1 percent respectively. Hydrological conditions in 2012 were such that in the course of a six-year period there was an increase at an average annual rate of 1.5 percent.

The fastest growing production was that of renewable energy with an average annual growth rate of 47 percent in the period 2007-2012.

In 2012, total energy import in Croatia decreased by 3.5 percent compared to the previous year. The import of crude oil, coal, coke and petroleum products decreased, while the import of natural gas, electricity, fuel wood and biomass increased. The import of crude oil fell by 18.1 percent, of coal and coke by 17.6 percent and petroleum products by 0.9 percent. The import of natural gas increased by 55 percent, the import of electricity increased by 5.7 percent, whereas the import of fuel wood and biomass increased by 8.3 percent. During the period from 2007 till 2012, energy import in Croatia decreased at an average annual rate of 4.4 percent.

[89] Source: Annual Energy Report Energy in Croatia 2012, Ministry of Economy

In the period from 2007 till 2012, the total primary energy supply decreased at an average annual rate of 2.7 percent. In this period, there was a decrease in the consumption of liquid fuels, coal and coke, and natural gas, whereas the share of consumption of other energy forms in the total consumption increased. The consumption of liquid fuels decreased at an average annual rate of 6.7 percent, of coal and coke at an average rate of 3.4 percent annually and of natural gas at an average annual rate of 2.3 percent. The consumption of renewable energy sources increased at an average rate of 48.3 percent annually, and of fuel wood and solid biomass at an average rate of 8.9 percent annually. The consumption of heat from heat pumps increased at an average annual rate of 11.2 percent, whereas the consumption of the imported electricity increased at an average rate of 3.7 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 47 percent in the period 2007-2012.

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 331.8 million HRK (approximately 44 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 16.6 percent in the period 1995-2012 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. New (third) NAPEnU is under preparation.

In the field of energy efficiency in the buildings 2012 brings several changes in regulations directly affecting energy use in buildings trends. Changes in Law on end use energy efficiency (OG 152/08 and 55/12) fully implement Directive 2006/32/EC on energy efficiency and energy services, Directive 2009/125/EC on establishing a framework for setting of ecodesign requirements for energy related products and Directive 2010/31/EU on the energy performance of buildings (recast) in part relating to energy certification of the buildings and regular HVAC systems inspections. New regulation supersedes Ordinance on energy certification of the buildings and Ordinance on energy audits of the buildings with Ordinance on energy audits and energy certification of the buildings (OG 81/2012); Ordinance on requirements and criteria for persons performing energy audits and energy certification of the buildings (OG 113/08 and 89/09) is replaced by new Ordinance on requirements and criteria for persons performing energy audits of the buildings and energy certification of the buildings (OG 81/12).

In general consumption sector, where buildings have single largest energy use - households and services drop in final energy use is 3.8 percent compared to 2011. Final energy consumption in buildings in 2012 is 107.20 PJ, representing 43.3 percent of total energy consumption in 2012 which is 247.53 PJ. Total consumption in general sector in 2012 is 121,95 PJ.

Energy certification of the buildings, or appraisal and classifi cation 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.

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 2012 the share of transport sector consumption in the final consumption rose from 21% to 34%, 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, in greater capacity utilization (load factor increase) and in implementation of more energy efficient engines and vehicles, as well as appropriate driving regimes.

Since year 2007 when maximum fuel consumption in Croatia amounting 91,07 PJ was achieved, continuous reduction in consumption to 86,6 PJ in 2010, 84,97 PJ in 2011, respectively 84,02 PJ in 2012 has been recorded. The main reason for this negative trend is derived from the global economic - financial crisis which hit Croatia in second half of 2008, which generated lesser need for mobility, and thus lower fuel consumption.

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 which started in 2013.

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.