NIR 2015

NATIONAL INVENTORY REPORT 2015

CROATIAN GREENHOUSE GAS INVENTORY
FOR THE PERIOD 1990-2013

October 2015

CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE

NATIONAL INVENTORY REPORT 2015

SUBMISSION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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NATIONAL INVENTORY REPORT 2015

Croatian greenhouse gas inventory for the period 1990-2013

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CONTENT

LIST OF ABBREVIATIONS

AD	*- Activity Data*
ARKOD	*- Land parcel identification system*
CAA	*- Croatian Agricultural Agency*
CAEN	*- Croatian Agency for the Environment and Nature*
CBS	*- Central Bureau of Statistics*
CEM	*- Continuous Emission Monitoring*
CFC	*- Chlorofluorocarbons*
CHC	*- Croatian Centre for Horse Breeding*
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*

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ES.1. BACKGROUND INFORMATION ON GREENHOUSE GAS (GHG) INVENTORIES AND CLIMATE CHANGE

ES.1.1. BACKGROUND INFORMATION ON CLIMATE CHANGE

Climate change in Croatia over the period 1961-2010 has been determined by trends in annual and seasonal mean air temperature, mean minimum and mean maximum temperature; and in indices of temperature extremes; then in precipitation amounts and precipitation indices, as well as in dry and wet spells.

Trends in air temperature (mean, mean minimum and mean maximum temperature) in the last 50 years (1961-2010) show warming all over Croatia. Annual temperature trends are positive and significant, and the changes are higher on the mainland than at the coast and the Dalmatian hinterland. Observed warming can be seen in all indices of temperature extremes, with positive trends of warm temperature indices (warm days and nights as well as warm spell duration index) and with the negative trends of cold temperature indices (cold days and nights and cold spell duration index).

The hottest year 2007 was for 1.5 ° C warmer than the mean of the standard period 1961-1990., the coldest year 2005 was 0.1 ° C colder. During the decade 2001-2010, spatial mean air temperature in nine years was higher than the corresponding referent averages.

During the recent 50-year period (1961-2010) the annual precipitation amounts experienced prevailing insignificant trends that are increasing in the eastern lowland and decreasing elsewhere. The statistically significant decreases are found for the stations in the mountainous region of Gorski kotar and in the Istria peninsula (northern Adriatic) as well as in the southern coastal region.

Changes of trend in dry and wet spells in Croatia are presented by annual and seasonal of their maximum lengths. The most prominent feature of time trend is found for dry spells during autumn for which a spatially consistent statistically significant negative trend is found. For the rest of the seasons trends in dry spells of both categories are less consistent in magnitude and direction.

ES.1.2. BACKGROUND INFORMATION ON GREENHOUSE GAS (GHG) INVENTORIES

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 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 2013. The NIR is prepared in accordance with the UNFCCC reporting guidelines on annual Inventories as adopted by the COP by its Decision 24/CP.19. The methodologies used in the calculation of emissions are based on the 2006 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 eleven reviews so far, in-country review in 2004, 2008 and 2012 and centralized reviews in 2005, 2006, 2009, 2010, 2011, 2012, 2013 and 2014. 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), sulphur hexafluoride (SF_6), nitrogen fluoride (NF_3) and indirect greenhouse gases: carbon monoxide (CO), oxides of nitrogen (NOx), 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 five main sectors: Energy, Industrial Processes and 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.1.2.1. 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 Agency for the Environment and Nature (CAEN) 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. Commitee for inter-sectorial coordination for national system for monitoring of GHG emission (National System Commite) 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 Commitee are nominated by the authorized Ministries upon the request of the MENP.

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.

CAEN 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 2015 inventory submission.

ES.1.2.2. CRF REPORTER ISSUES

According to Decision 13/CP.20 of the Conference of the Parties to the UNFCCC, CRF Reporter version 5.0.0 was not functioning in order to enable Annex I Parties to submit their CRF tables for the year 2015. In the same Decision, the Conference of the Parties reiterated that Annex I Parties in 2015 may submit their CRF tables after 15/April, but no longer than the corresponding delay in the CRF Reporter availability. "Functioning" software means that the data on the greenhouse emissions/removals are reported accurately both in terms of reporting format tables and XML format.

CRF reporter version 5.10 still contains issues in the reporting format tables and XML format in relation to Kyoto Protocol requirements, and it is therefore not yet functioning to allow submission of all the information required under Kyoto Protocol.

Recalling the Conference of Parties invitation to submit as soon as practically possible, and considering that CRF reporter 5.10 allows sufficiently accurate reporting under the UNFCCC (even if minor inconsistencies may still exist in the reporting tables, as per the Release Note accompanying CRF Reporter 5.10), the present report is the official submission for the year 2015 under the UNFCCC. The present report is not an official submission under the Kyoto Protocol, even though some of the information included may relate to the requirements under the Kyoto Protocol.

ES.1.2.3. BACKGROUND INFORMATION ON SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1, OF THE KYOTO PROTOCOL

LULUCF

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

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

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

ES.1.2.4. INFORMATION ON KYOTO PROTOCOL UNITS

Information on Kyoto Protocol units are given in the table ES1.2-1.

Table ES1.2-1:Information on Kyoto Protocol units

Annual Submission Item	HR report
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	The Standard Electronic Format report for 2014 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 2014.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2014.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2014.
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2014.
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 in Croatian language and at http://www.azo.hr/GHGRegistry in English language. https://ets-registry.webgate.ec.europa.eu/euregistry/HR/index.xhtml
15/CMP.1 annex I.E paragraph 18 CPR Calculation	The Commitment Period Reserve is calculated in accordance with decision 11/CMP.1 (Annex Article 6.) as five times the most recently reviewed inventory (NIR 2014), which is calculated below. 100% × 26,449,617 × 5 = 132,248,085 t CO2-eq

ES.1.2.5. CHANGES IN NATIONAL SYSTEM

In 2015 Croatian Environment Agency changed its name to Croatian Agency for the Environment and Nature. There are no other changes regarding national system since NIR 2014.

ES.1.2.6. CHANGES IN NATIONAL REGISTRY

Changes in national registry are given in the table ES1.2-1.

Table ES1.2-1: 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	No change of cooperation arrangement occurred during the reported period.

Annual Submission Item	HR report
15/CMP.1 annex II.E paragraph 32.(c) Change to database or the capacity of national registry	An updated diagram of the database structure is attached as Annex A. Versions of the CSEUR released after 6.1.7.1 (the production version at the time of the last Chapter 14 submission) introduced changes in the structure of the database. These changes 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	Changes introduced since version 6.1.7.1 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 (see Annex B). Annex H testing was carried out in February 2015 and the test report is provided as part of this submission. 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	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change of security	No change of security measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(g) Change of list of publicly available information	Web site of Croatian part of Union Registry is regularly updated with FAQ, mandatory publicly available information and announcements that are available in Croatian and English.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No Change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change of data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change of test results	Changes introduced since version 6.1.7.1 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; the report is attached as Annex B. Annex H testing was carried out in February 2015 and the test report is provided as part of this submission.
The previous Annual Review recommendations	No recommendations were addressed form previous annual review.

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

In this chapter national emissions and removals for the Republic of Croatia are presented for the period from 1990 to 2013. 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 used to calculated CO_2 equivalent emissions are defined in Annex III of Decision 24/CP.19 Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention. Global worming potential values for certain gases (100- year time horizon) are presented below.

Gas	Global Warming Potential
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_20)	298
HFC-23	14800
HFC-32	675
HFC-125	3500
HFC-134a	1430
HFC-143a	4470
HFC-152a	124
HFC-227ea	3220
HFC-236fa	9810
CF_4	7390
C_2F_6	12200
C_3F_8	8830
SF_6	22800

Source: 24/CP.19

The results of the greenhouse gas (GHG) emission calculation are presented for the period from 1990 to 2013. Total emissions/removals of GHG and their trend in sectors are given in Tables ES.2-1, ES.2-2 and in Figure ES.2-1 while the contribution of the individual gases is given in Tables ES.2-3, ES.2-4 and Figure ES.2-2.

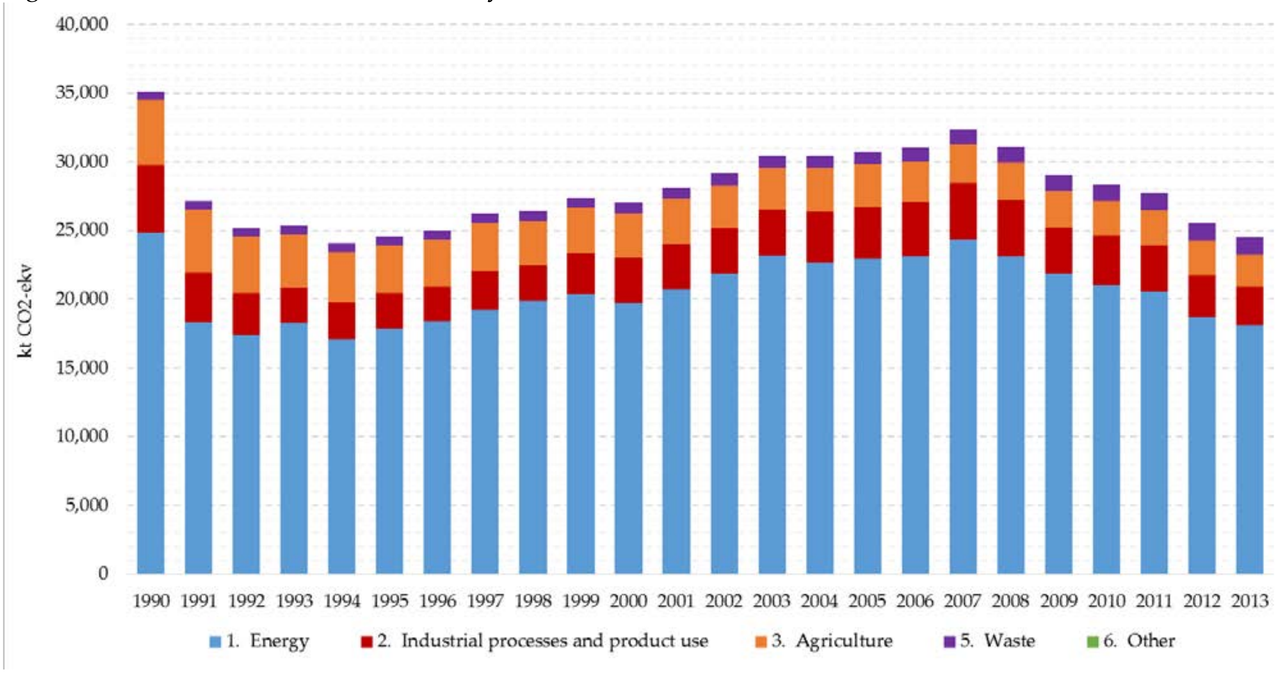
Table ES.2-1: Emissions/removals of GHG by sectors for the every five years from 1990 to 2005 (kt CO_2-eq)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2005
	CO_2 equivalent (kt)			
1. Energy	24,902.6	17,858.2	19,739.1	22,953.6
2. Industrial processes and product use	4,852.6	2,572.9	3,291.6	3,776.9
3. Agriculture	4,766.5	3,486.6	3,208.7	3,088.9
4. Land use, land-use change and forestry	-5,536.7	-8,431.5	-7,162.1	-6,996.6
5. Waste	594.2	673.5	799.8	909.9
6. Other	NO	NO	NO	NO
Total (including LULUCF)	**29,579.3**	**16,159.6**	**19,877.0**	**23,732.6**
Total (excluding LULUCF)	**35,116.0**	**24,591.1**	**27,039.1**	**30,729.3**

Table ES.2-2: Emissions/removals of GHG by sectors for the period from 2010-2013 (kt CO_2-eq)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	2012	2013	Change from base to latest reported year
	CO_2 equivalent (kt)				(%)
1. Energy	21,035.3	20,559.4	18,685.7	18,122.7	-27.2
2. Industrial processes and product use	3,591.3	3,361.9	3,092.0	2,812.6	-42.0
3. Agriculture	2,526.1	2,587.1	2,512.6	2,318.0	-51.4
4. Land use, land-use change and forestry	-6,260.3	-5,187.8	-5,036.4	-5,125.2	-7.4
5. Waste	1,173.3	1,211.0	1,214.8	1,239.5	108.6
6. Other	NO	NO	NO	NO	NO
Total (including LULUCF)	**22,065.7**	**22,531.5**	**20,468.7**	**19,367.6**	**-34.5**
Total (excluding LULUCF)	**28,326.1**	**27,719.3**	**25,505.1**	**24,492.8**	**-30.3**

Figure ES2-1: Trend of GHG emissions, by sectors



Tables ES.2-1, ES.2-2 and Figure 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 2013 excluding LULUCF has the Energy sector with 74.0 percent, followed by Industrial Processes and product use with 11.5 percent, Agriculture with 9.5 percent and Waste with 5.0 percent. This structure is with minor changes consistent through all the observed period from 1990 to 2013. In the year 2013, the total GHG emissions in Croatia was 24,492.8 kt CO_2-eq excluding LULUCF sector while the total emission was 19,367.6 kt CO_2-eq including the LULUCF sector which represents removals by sink from 20.9 percent in that year.

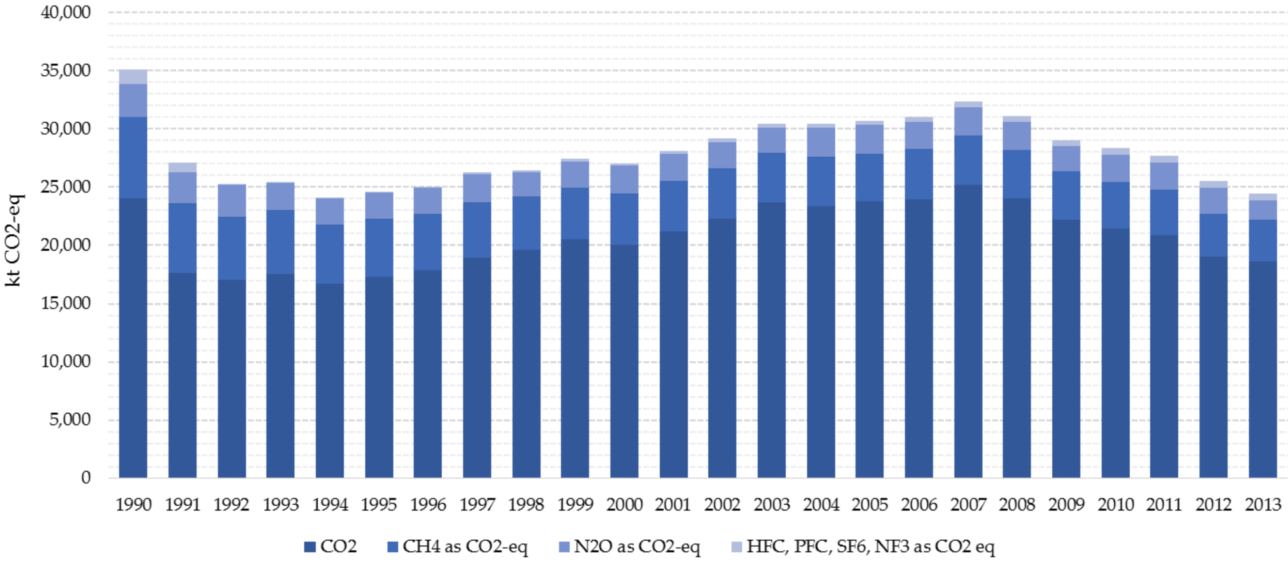
Table ES.2-3: Emissions/removals of GHG by gases for the every five years from 1990 to 2005 (kt CO_2-eq)

GREENHOUSE GAS EMISSIONS	1990	1995	2000	2005
	CO_2 equivalent (kt)			
CO_2 emissions without net CO_2 from LULUCF	24,074.3	17,326.5	20,073.7	23,753.5
CO_2 emissions with net CO_2 from LULUCF	18,530.9	8,878.4	12,743.6	16,746.5
CH_4 emissions without CH_4 from LULUCF	6,952.9	4,951.9	4,359.5	4,153.5
CH_4 emissions with CH_4 from LULUCF	6,954.1	4,959.5	4,456.4	4,156.2
N_2O emissions without N_2O from LULUCF	2,838.1	2,244.2	2,395.0	2,423.1
N_2O emissions with N_2O from LULUCF	2,843.6	2,253.3	2,466.1	2,430.7
HFCs	NO	57.3	199.2	386.1
PFCs	1,240.2	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO
SF_6	10.5	11.1	11.6	13.0
NF_3	NO	NO	NO	NO
Total (without LULUCF)	**35,116.0**	**24,591.1**	**27,039.1**	**30,729.3**
Total (with LULUCF)	**29,579.3**	**16,159.6**	**19,877.0**	**23,732.6**
Total (without LULUCF, with indirect)	**35,116.0**	**24,591.1**	**27,039.1**	**30,729.3**
Total (with LULUCF, with indirect)	**29,579.3**	**16,159.6**	**19,877.0**	**23,732.6**

Table ES.2-4: Emissions/removals of GHG by gases for the for the period from 2010-2013 (kt CO_2-eq)

GREENHOUSE GAS EMISSIONS	2010	2011	2012	2013	Change from base to latest reported year
	CO_2 equivalent (kt)				(%)
CO_2 emissions without net CO_2 from LULUCF	21,432.0	20,866.5	19,022.8	18,620.8	-22.65
CO_2 emissions with net CO_2 from LULUCF	15,160.5	15,637.4	13,911.1	13,482.0	-27.25
CH_4 emissions without CH_4 from LULUCF	4,036.7	3,914.6	3,688.9	3,581.0	-48.50
CH_4 emissions with CH_4 from LULUCF	4,038.5	3,933.2	3,727.8	3,582.9	-48.48
N_2O emissions without N_2O from LULUCF	2,304.4	2,365.7	2,219.2	1,706.6	-39.87
N_2O emissions with N_2O from LULUCF	2,313.8	2,388.4	2,255.6	1,718.3	-39.57
HFCs	544.0	563.1	565.0	577.7	0.00
PFCs	0.0	0.0	0.0	0.1	-100.00
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	0.00
SF_6	9.0	9.4	9.2	6.6	-37.03
NF_3	NO	NO	NO	NO	0.00
Total (without LULUCF)	**28,326.1**	**27,719.3**	**25,505.1**	**24,492.8**	**-30.25**
Total (with LULUCF)	**22,065.7**	**22,531.5**	**20,468.7**	**19,367.6**	**-34.52**
Total (without LULUCF, with indirect)	**28,326.1**	**27,719.3**	**25,505.1**	**24,492.8**	**-30.25**
Total (with LULUCF, with indirect)	**22,065.7**	**22,531.5**	**20,468.7**	**19,367.6**	**-34.52**

Figure ES.2-2: Trend of GHG emissions, by gases



Tables ES.2-3, ES.2-4 and Figure ES.2-2 represents the contribution of the individual gasses to total emissions and removals of the GHGs. The largest contribution to the GHGs emission in 2013 excluding LULUCF has CO_2 emission with 76.0 percent, followed by CH_4 with 14.6 percent, N_2O with 7.0 percent and HFCs, PFCs and SF6 with 2.4 percent.

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

ES.3.1. GREENHOUSE GAS EMISSIONS BY SECTORS

ENERGY SECTOR

Energy sector is the largest contributor to GHG emissions. In the year 2013, the GHG emission from Energy sector was 3.0 percent lower in relation to 2012 and 27.2 percent lower in relation to 1990. 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 (8 percent) while the contribution of energy in nitrous oxide (N_2O) emission is quite small (about 2 percent). Emissions from fossil fuel combustion comprise the majority (more than 90 percent) of energy-related emissions. Emission of individual subsectors is presented in the Table ES.3-1.

Table ES.3-1: Energy subsectors total emissions by gases for the period 1990-2013 (kt CO_2-eq)

GHG source and sink categories	1990	1995	2000	2005	2009	2011	2012	2013
1. Energy	**24,902.6**	**17,858.2**	**19,739.1**	**22,953.6**	**21,035.3**	**20,559.4**	**18,685.7**	**18,122.7**
A. Fuel combustion	20,610.3	14,598.3	17,034.1	20,228.1	18,579.2	18,247.1	16,707.6	16,209.3
1. Energy industries	7,189.5	5,243.2	5,839.4	6,880.9	5,931.0	6,178.5	5,524.2	5,132.2
2. Manufact. ind.	5,529.0	2,967.9	3,115.6	3,739.0	3,030.1	2,792.1	2,421.9	2,392.8
3. Transport	4,032.1	3,419.2	4,525.6	5,581.6	5,978.4	5,838.2	5,656.5	5,749.7
4. Other sectors	3,859.7	2,968.1	3,553.5	4,026.6	3,639.7	3,438.3	3,105.0	2,934.7
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions	4,292.3	3,259.8	2,705.0	2,725.5	2,456.1	2,312.3	1,978.0	1,913.4
1. Solid fuels	59.6	28.2	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
2. Oil and nat. gas	4,232.7	3,231.6	2,705.0	2,725.5	2,456.1	2,312.3	1,978.0	1,913.4
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	NO	NO

The largest part (31.7 percent) of the emissions are a consequence of fuel combustion in Transport, then the combustion in Energy industries (28.3 percent in 2013) and the combustion in small stationary energy sources, such as Commercial/Institutional, Residential and Agriculture/Forestry/Fishing (16.2

percent in 2013). Manufacturing Industries and Construction contribute to total emission from Energy sector with 13.2 percent, while Fugitive Emissions from Fuels contribute with about 10.6 percent.

INDUSTRIAL PROCESSES AND PRODUCT USE

In Industrial Processes sector, the key emission sources are Cement Production, Lime Production, Ammonia Production, Nitric Acid Production and Consumption of HFCs in Refrigeration and Air Conditioning Equipment, which all together contribute with 92.3 percent in total sectoral emission in 2013. 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 2013 emissions from industrial processes were decreased by 9.0 percent regarding 2012 and by 42.0 percent regarding 1990. Emission of individual subsectors is presented in the Table ES.3-2.

Table ES.3-2: Industrial processes subsectors total emissions by gases for the period 1990-2013 (kt CO_2-eq)

GHG source and sink categories	1990	1995	2000	2005	2010	2011	2012	2013
2. Industrial processes and product use	**4,852.6**	**2,572.9**	**3,291.6**	**3,776.9**	**3,591.3**	**3,361.9**	**3,092.0**	**2,812.6**
A. Mineral industry	1,280.9	760.0	1,423.1	1,785.4	1,432.3	1,220.1	1,191.1	1,291.4
B. Chemical industry	1,531.9	1,454.2	1,421.6	1,305.5	1,362.9	1,327.4	1,131.6	726.6
C. Metal industry	1,582.7	39.1	27.3	11.8	27.6	29.4	1.8	16.6
D. Non-energy products	413.3	217.8	175.4	241.6	184.5	179.8	151.0	151.6
E. Electronic Industry	NO	NO	NO	NO	NO	NO	NO	NO
F. Product uses as ODS subs.	NO	57.3	199.2	386.1	544.0	563.2	565.0	577.8
G. Other product manufacture	43.8	44.5	45.0	46.4	40.0	42.0	51.5	48.6
H. Other	NA	NA	NA	NA	NA	NA	NA	NA

AGRICULTURE

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 83 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 2012 and 2013. Compared to 2012, in 2013 CH_4 emission from Enteric fermentation decreased by 7.0 percent. As for Manure management emissions, CH_4 emission decreased in 2013 compared to 2012 by 1.8 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 2013 compared to 2012 by 8.4 percent. Overall, in the year 2013 the GHG emission from Agriculture sector decreased by 7.8 percent in comparison with 2012. Emission of individual subsectors is presented in the Table ES.3-3.

Table ES.3-3: Agriculture subsectors total emissions by gases for the period 1990-2013 (kt CO_2-eq)

GHG source and sink categories	1990	1995	2000	2005	2010	2011	2012	2013
3. Agriculture	**4,766.5**	**3,486.6**	**3,208.7**	**3,088.9**	**2,526.1**	**2,587.1**	**2,512.6**	**2,318.0**
A. Enteric fermentation	2,501.1	1,806.4	1,487.6	1,244.4	949.8	917.7	902.7	839.8
B. Manure management	676.7	480.4	404.6	392.9	352.0	338.6	324.2	318.4
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	1,538.7	1,153.5	1,255.6	1,366.2	1,144.3	1,232.4	1,189.2	1,089.7
E. Presc. burning of savannas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F. Field burning of agric. resid.	NO	NO	NO	NO	NO	NO	NO	NO
G. Liming	NO	NO	NO	14.5	13.5	14.5	9.6	9.6
H. Urea application	50.0	46.3	60.9	71.0	66.6	83.9	86.9	60.4
I. Other carbon-containing fert.	NA	NA	NA	NA	NA	NA	NA	NA
J. Other	NO	NO	NO	NO	NO	NO	NO	NO

LULUCF

The Low on Forest (Official Gazette No. 140/05, 82/06, 129/08, 80/10, 124/10, 25/12, 68/12, 148/13, 94/14) 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 (PiCAEN 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.3-4 shows the CO_2 removal trend in the forestry sector. Removal arisen in LULUCF sector contribute with 20.9% to the total emissions of CO_2 eq in Croatia in year 2013.

Table ES.3-4: Removal trends in LULUCF sector from 1990-2013 (kt CO_2-eq)

	1990	1995	2000	2005	2010	2011	2012	2013
LULUCF removals	-5,536.7	-8,431.5	-7,162.1	-6,996.6	-6,260.3	-5,187.8	-5,036.4	-5,125.2

WASTE

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 1990-2013. Increasing emissions are a consequence of greater quantities of waste, activities in Wastewater treatment and discharge 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, 46/15) include the assumed time-lags with respect to relevant EU legislation. CH_4 that is recovered and burned in a flare in the period 2004-2013 have been included in emission estimation. Emission of individual subsectors is presented in the Table ES.3-5. It should be emphasized that Solid Waste Disposal on Land contributes with 76.4 percent in total sectoral emission in 2013. Waste sector contributes to total GHG emissions with 5.0 percent in 2013.

Table ES.3-5: Waste subsectors total emissions by gases for the period 1990-2013 (kt CO_2-eq)

GHG source and sink categories	1990	1995	2000	2005	2010	2011	2012	2013
5. Waste	594.2	673.5	799.8	909.9	1,173.3	1,211.0	1,214.8	1,239.5
A. Solid waste disposal	288.8	363.4	481.1	600.2	881.1	919.7	937.6	947.2
B. Biolog.treatment of solid waste	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	8.2
C. Incineration of waste	0.5	0.5	6.3	0.2	0.0	0.1	0.1	0.0
D. Waste water treatment	304.9	309.5	312.4	309.6	292.2	291.3	277.2	284.0
E. Other	NO	NO	NO	NO	NO	NO	NO	NO

ES.3.2. GREENHOUSE GAS EMISSIONS BY GASES

ES.3.2.1. 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.3.2-1.

Table ES.3.2-1: CO_2 emission/removal by sectors from 1990-2013 (kt CO_2)

GHG source and sink categories	1990	1995	2000	2005	2010	2011	2012	2013
Energy	21,219.2	15,492.7	17,657.1	20,964.4	19,112.8	18,767.5	17,103.4	16,605.3
Industrial processes	2,804.6	1,787.0	2,349.6	2,703.5	2,239.1	2,000.7	1,822.8	1,945.6
Agriculture	50.0	46.3	60.9	85.5	80.1	98.3	96.5	70.0
LULUCF	-5,543.4	-8,448.1	-7,330.1	-7,007.0	-6,271.6	-5,229.1	-5,111.7	-5,138.9
Waste	0.54	0.54	6.15	0.16	0.05	0.05	0.08	0.04
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total CO_2 emission	**35,116.0**	**24,591.1**	**27,039.1**	**30,729.3**	**28,326.1**	**27,719.3**	**25,505.1**	**24,492.8**
Net CO_2 emission	**29,579.3**	**16,159.6**	**19,877.0**	**23,732.6**	**22,065.7**	**22,531.5**	**20,468.7**	**19,367.6**

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 89.2 percent in total CO_2 emission (presented as CO_2 emission without LULUCF). CO_2 emission from fuel combustion and fugitive emissions makes the largest part of CO_2 emission (89.2 percent). Emission by sub-sectors is presented in Table ES.3.2-2.

Table ES.3.2-2: CO_2 emission by sub-sectors from 1990-2013 (kt CO_2)

GHG source categories	1990	1995	2000	2005	2010	2011	2012	2013
Energy Industries	7,166.8	5,226.8	5,816.8	6,853.4	5,905.0	6,152.2	5,499.9	5,109.5
Manuf. Ind. and Const.	5,501.7	2,954.7	3,103.1	3,723.7	3,015.8	2,779.6	2,409.1	2,380.7
Transport	3,936.6	3,343.5	4,380.1	5,487.8	5,890.7	5,764.1	5,586.0	5,679.8
Other sectors	3,643.0	2,856.8	3,418.4	3,898.1	3,506.2	3,281.8	2,941.6	2,779.6
Fugitive emissions	971.1	1,110.9	938.6	1,001.3	795.2	789.8	666.9	655.6
Total CO_2 emission	**20,248.0**	**14,381.8**	**16,718.5**	**19,963.0**	**18,317.7**	**17,977.6**	**16,436.5**	**15,949.6**

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).

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 2013, the CO_2 emission from Transport sector contributed with 30.5 percent to the national total CO_2 emission. The largest part of the CO_2 emission from Transport sector arises from road transport (94.7 percent of CO_2 emission from transport sector in 2013) 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.

INDUSTRIAL PROCESSES AND PRODUCT USE

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.3.2-3.

Table ES.3.2-3: CO_2 emission from Industrial Processes and product use for the period from 1990-2013 (kt CO_2)

GHG source categories	1990	1995	2000	2005	2010	2011	2012	2013
Mineral industry	1,280.9	760.0	1,423.1	1,785.4	1,432.3	1,220.1	1,191.1	1,291.4
Chemical industry	771.9	770.8	724.4	664.6	594.7	571.3	478.9	486.0
Metal industry	338.6	38.4	26.8	11.8	27.6	29.4	1.8	16.6
Non-energy products and solvent use	413.3	217.8	175.4	241.6	184.5	179.8	151.0	151.6
Total CO_2 emission	**2,804.6**	**1,787.0**	**2,349.6**	**2,703.5**	**2,239.1**	**2,000.7**	**1,822.8**	**1,945.6**

The most significant CO_2 industrial processes emission sources are production of cement, ammonia and lime. In 2013, mineral industry contributes in total sectoral CO_2 emission with 66.4 percent and chemical industry with 25.0 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 2013 CO_2 emissions from industrial processes increased by 6.7 percent, regarding the year 2012.

ES.3.2.2. METHANE EMISSION (CH_4)

The major sources of methane (CH_4) emission are fugitive emission from production, processing, transportation and activities related with fuel use in Energy sector, Agriculture and Waste Disposal on Land. In Table ES.3.2-4, sectoral and total CH_4 emissions are reported.

Table ES.3.2-4: CH_4 emission in Croatia in the period from 1990-2013 (kt CH_4)

GHG source and sink categories	1990	1995	2000	2005	2010	2011	2012	2013
Energy	142.51	91.27	76.94	74.64	72.05	67.22	58.90	56.44
Industrial processes	0.38	0.24	0.14	0.16	0.12	0.08	0.01	0.01
Agriculture	114.16	82.53	68.35	58.18	45.69	44.23	43.42	40.71
LULUCF	0.05	0.30	3.88	0.11	0.07	0.75	1.56	0.08
Waste	21.07	24.03	28.94	33.17	43.61	45.06	45.23	46.09
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total CH_4 emission	**278.12**	**198.08**	**174.38**	**166.14**	**161.47**	**156.58**	**147.56**	**143.24**

Fugitive methane emission is mainly the result of exploration, production, processing, transportation and distribution of natural gas. The fugitive emission from oil and natural gas accounts with 35.1 percent in total methane emission. 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 treatment and discharge 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.3.2.3. NITROUS OXIDE EMISSION (N_2O)

The most important sources of N_2O emissions in Croatia are agricultural activities, nitric acid production, but as well, the N_2O emissions occur in energy sector and waste management. In Table ES.3.2-5 the N_2O emission is reported according to sectors.

Table ES.3.2-5: N_2O emission in Croatia for the period from 1990-2013 (kt N_2O)

GHG source and sink categories	1990	1995	2000	2005	2010	2011	2012	2013
Energy	0.41	0.28	0.53	0.41	0.41	0.37	0.37	0.36
Industrial Processes	2.64	2.39	2.44	2.25	2.67	2.64	2.33	0.95
Agriculture	6.25	4.62	4.83	5.20	4.38	4.64	4.46	4.13
LULUCF	0.02	0.03	0.24	0.03	0.03	0.08	0.12	0.04
Waste	0.22	0.24	0.24	0.27	0.28	0.28	0.28	0.29
Other	NO	NO	NO	NO	NO	NO	NO	NO
Total N_2O emission	**9.54**	**7.56**	**8.28**	**8.16**	**7.76**	**8.01**	**7.57**	**5.77**

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. 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. In the framework of the N_2O reduction measure analysis, the possibility for application of non-selective catalytic reduction device was considered, whereby the nitric acid production influence on N_2O emissions would be practically eliminated.

In Energy sector the emission was calculated on the basis of fuel consumption and adequate emission factors (IPCC). The 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.3.2.3. HALOGENATED CARBONS (HFC, PFC),SF_6 and NF_3 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, SF_6 and NF_3 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, SF_6 and NF_3 (provided by the MENP) was used for emission calculation which is presented in kt of CO_2-eq and showed in Table ES.3.2-6.

Table ES.3.2-6: HFCs, PFCs and SF_6 emission in the period from 1990-2013 (kt CO_2-eq)

	1990	1995	2000	2005	2010	2011	2012	2013
HFC, PFC and SF_6 emission	1,250.69	68.40	210.83	399.15	552.94	572.52	574.20	584.35

ES.4. OTHER INFORMATION (E.G. INDIRECT GHGS)

The photochemicaly active gases, carbon monoxide (CO), oxides of nitrogen (NOX) and non-methane volatile organic compounds (NMVOCs) indirectly contribute to the greenhouse gas effect. These are generally called indirect greenhouse gases or ozone precursors, because they are involved in creation and degradation of ozone which is also one of the greenhouse gases. Sulphur dioxide (SO2), as a precursor of sulphate and aerosols, is believed to contribute negatively to the greenhouse effect. Emissions of indirect GHGs have been taken from the draft of emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2013 Submission to the Convention on Long-range Transboundary Air Pollution’.The calculations of aggregated results for the emissions of indirect gases in the period 1990-2013 are given in table ES.4.1-1.

Table ES.4.1-1: Emissions of ozone precursors and SO_2 by sectors (kt)

GHG	Emissions (kt)								
	1990	1995	2000	2005	2009	2010	2011	2012	2013
NO_x Emission	**102.27**	**71.27**	**83.20**	**88.02**	**79.02**	**67.47**	**62.19**	**58.91**	**57.89**
Energy	99.23	68.26	77.31	85.33	77.28	65.42	60.17	56.50	55.75
Industrial Processes	3.00	2.80	3.00	2.60	1.60	2.00	1.40	1.30	1.20
Agriculture	NO	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	0.04	0.21	2.89	0.09	0.14	0.05	0.62	1.11	0.94
Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO Emission	**462.33**	**317.90**	**435.44**	**277.80**	**213.22**	**195.30**	**203.67**	**214.83**	**193.20**
Energy	420.59	283.02	314.14	256.98	207.73	192.77	185.15	178.21	159.59
Industrial Processes	40.60	27.90	30.90	18.20	0.80	0.90	0.80	0.60	0.70
Agriculture	NO	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	1.14	6.98	90.40	2.62	4.69	1.63	17.72	36.02	32.91
Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOC Emission	**131.95**	**75.29**	**80.89**	**73.73**	**61.37**	**59.8**	**58.26**	**55.26**	**53.27**
Energy	55.15	38.99	44.80	35.81	30.02	29.13	28.17	26.16	24.53
Industrial Processes	65.35	27.78	23.91	28.89	21.89	21.69	20.95	19.12	18.30
Agriculture	9.69	7.21	6.75	6.91	6.54	6.40	6.05	6.18	5.77
LULUCF	0.84	0.16	3.94	0.11	0.15	0.10	0.65	1.64	2.47
Waste	0.92	1.15	1.49	2.01	2.77	2.48	2.44	2.16	2.20
SO_2 Emission	**170.04**	**77.33**	**58.78**	**61.14**	**58.84**	**37.70**	**30.57**	**26.62**	**18.25**
Energy	168.36	76.27	57.82	60.40	58.49	37.43	30.26	26.41	18.24
Industrial Processes	1.68	1.06	0.96	0.74	0.35	0.27	0.31	0.21	0.01
Agriculture	NA	NA	NA	NA	NA	NA	NA	NA	NA
LULUCF	NA	NA	NA	NA	NA	NA	NA	NA	NA
Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Although Parties may now choose to report indirect CO_2, in accordance with paragraph 29 of the UNFCCC Inventory Reporting Guidelines, Croatia does not choose to report indirect CO_2 emissions from the atmospheric oxidation of CH_4, CO and NMVOCs, or indirect N_2O emissions arising from sources other than those in the agriculture and LULUCF sectors.

CHAPTER 1: INTRODUCTION

1.1. BACKGROUND INFORMATION ON GHG INVENTORIES AND CLIMATE CHANGE

1.1.1. Background information on climate change

Climate change in Croatia over the period 1961-2010 has been determined by trends in annual and seasonal mean air temperature, mean minimum and mean maximum temperature; and in indices of temperature extremes; then in precipitation amounts and precipitation indices, as well as in dry and wet spells.

Trends in air temperature (mean, mean minimum and mean maximum temperature) in the last 50 years (1961-2010) show warming all over Croatia. Annual temperature trends are positive and significant, and the changes are higher on the mainland than at the coast and the Dalmatian hinterland. Observed warming can be seen in all indices of temperature extremes, with positive trends of warm temperature indices (warm days and nights as well as warm spell duration index) and with the negative trends of cold temperature indices (cold days and nights and cold spell duration index).

The hottest year 2007 was for 1.5 ° C warmer than the mean of the standard period 1961-1990., the coldest year 2005 was 0.1 ° C colder. During the decade 2001-2010, spatial mean air temperature in nine years was higher than the corresponding referent averages.

During the recent 50-year period (1961-2010) the annual precipitation amounts experienced prevailing insignificant trends that are increasing in the eastern lowland and decreasing elsewhere. The statistically significant decreases are found for the stations in the mountainous region of Gorski kotar and in the Istria peninsula (northern Adriatic) as well as in the southern coastal region.

Changes of trend in dry and wet spells in Croatia are presented by annual and seasonal of their maximum lengths. The most prominent feature of time trend is found for dry spells during autumn for which a spatially consistent statistically significant negative trend is found. For the rest of the seasons trends in dry spells of both categories are less consistent in magnitude and direction.

1.1.2. Background information on greenhouse gas (GHG) inventories

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 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 2013. The NIR is prepared in accordance with the UNFCCC reporting guidelines on annual Inventories as adopted by the COP by its Decision 24/CP.19. The methodologies used in the calculation of emissions are based on the 2006 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, 2012, 2013 and 2014. 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 (NOx), 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 five main sectors: Energy, Industrial Processes and 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.

1.1.3. CRF Reporter issues

According to Decision 13/CP.20 of the Conference of the Parties to the UNFCCC, CRF Reporter version 5.0.0 was not functioning in order to enable Annex I Parties to submit their CRF tables for the year 2015. In the same Decision, the Conference of the Parties reiterated that Annex I Parties in 2015 may submit their CRF tables after 15/April, but no longer than the corresponding delay in the CRF Reporter availability. "Functioning" software means that the data on the greenhouse emissions/removals are reported accurately both in terms of reporting format tables and XML format.

CRF reporter version 5.10 still contains issues in the reporting format tables and XML format in relation to Kyoto Protocol requirements, and it is therefore not yet functioning to allow submission of all the information required under Kyoto Protocol.

Recalling the Conference of Parties invitation to submit as soon as practically possible, and considering that CRF reporter 5.10 allows sufficiently accurate reporting under the UNFCCC (even if minor inconsistencies may still exist in the reporting tables, as per the Release Note accompanying CRF Reporter 5.10), the present report is the official submission for the year 2015 under the UNFCCC. The present report is not an official submission under the Kyoto Protocol, even though some of the information included may relate to the requirements under the Kyoto Protocol.

1.1.4. 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.

1.1.5. Information on Kyoto units

Information on Kyoto Protocol units are given in the table 1.1-1.

Table 1.1-1: Information on Kyoto Protocol units

Annual Submission Item	HR report
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	The Standard Electronic Format report for 2014 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 2014.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2014.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2014.
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2014.
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 in Croatian language and at http://www.azo.hr/GHGRegistry in English language. https://ets-registry.webgate.ec.europa.eu/euregistry/HR/index.xhtml
15/CMP.1 annex I.E paragraph 18 CPR Calculation	The Commitment Period Reserve is calculated in accordance with decision 11/CMP.1 (Annex Article 6.) as five times the most recently reviewed inventory (NIR 2014), which is calculated below. 100% × 26,449,617 × 5 = 132,248,085 t CO2-eq

1.1.6. Changes in national system

In 2015 Croatian Environment Agency changed its name to Croatian Agency for the Environment and Nature. There are no other changes regarding national system since NIR 2014.

1.1.7. Changes in national registry

Changes in national registry are given in the table 1.1-2.

Table 1.1-2: 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	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database or the capacity of national registry	An updated diagram of the database structure is attached as Annex A. Versions of the CSEUR released after 6.1.7.1 (the production version at the time of the last Chapter 14 submission) introduced changes in the structure of the database. These changes 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	Changes introduced since version 6.1.7.1 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 (see Annex B). Annex H testing was carried out in February 2015 and the test report is provided as part of this submission. 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	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change of security	No change of security measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(g) Change of list of publicly available information	Web site of Croatian part of Union Registry is regularly updated with FAQ, mandatory publicly available information and announcements that are available in Croatian and English.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No Change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change of data integrity measures	No change of data integrity measures occurred during the reporting period.

Annual Submission Item	HR report
15/CMP.1 annex II.E paragraph 32.(j) Change of test results	Changes introduced since version 6.1.7.1 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; the report is attached as Annex B. Annex H testing was carried out in February 2015 and the test report is provided as part of this submission.
The previous Annual Review recommendations	No recommendations were addressed form previous annual review.

1.2. A DESCRIPTION OF THE NATIONAL INVENTORY ARRANGEMENTS

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 Agency for the Environment and Nature (CAEN) 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. Commitee for inter-sectorial coordination for national system for monitoring of GHG emission (National System Commite) 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 Commitee are nominated by the authorized Ministries upon the request of the MENP.

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.

CAEN 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 2015 inventory submission.

1.2.1. Institutional, legal and procedural arrangements

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.

1.2.2. Overview of inventory planning, preparation and management

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 CAEN 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 CAEN 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 CAEN 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.

1.2.3. Quality assurance, quality control and verification plan

<u>QA/QC PLAN</u>

According to Article 7. of the Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia, within the competence of CAEN 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: Annual Data Collection Plan (ADCP), QA/QC Plan, Category-specific QC checklist and Improvement Plan.

Annual data Collection Plan (ADCP) is main document for data collection which is the responsibility of Croatian Agency for the Environment and Nature (CAEN). It contains source categories, activity, activity data, data source and competent authority and is made for each sector. This document is prepared annually in collaboration between MENP, CAEN and National System Commitee.

QA/QC plan 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, internal audits, annual review and reporting on GHG registry and general and specific QA/QC procedures.

Improvement Plan is document which defines objectives related to the improvement of National Inventory. This document takes into account 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 • Documentation revision and supplement	QA/QC coordinator (CAEN)
Approval of QA/QC plan	CAEN
Implementation of QC procedures • Internal audit • Corrective and preventive activities • Reporting on performed internal audit	QA/QC coordinator (CAEN) Sectoral experts (CAEN), Project leader in NIR preparation (CAEN) Project Coordinator (Authorized Institution) Sectoral experts (Authorized Institution) QA/QC coordinator (Authorized Institution)
Reporting on QC procedures	Authorized Institution
Implementation of QA procedures	CAEN, MENP, National System Commitee

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 2013 in Waste sector is presented in Annex 5, Table A5-1. All data in the form of Inventory Data Record Sheets are also archived at CAEN.

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 CAEN, 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 CAEN submits complete Inventory and CRF tables to the MENP, which, upon receipt, approves the latter. National System Commitee is included in the approval process; its members provide their opinion on certain parts of the Inventory within the frame of their speciality. QA/QC coordinator documents all National System Commitee results/findings.

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).

TREATMENT OF CONFIDENTIALITY ISSUES

In Croatian GHG Inventory only data that refers to a single enterprise is in general confidential. In the National Inventory Report, for those activities, the activity data and emissions are aggregated on subsector level.

1.2.4. Changes in the national inventory arrangements since previous annual GHG inventory submission

Changes to institutional, legal and procedural arrangements (24/CP.19, 22. (a))

In 2015 Croatian Environment Agency changed its name to Croatian Agency for the Environment and Nature. There are no other changes regarding national system since NIR 2014.

Changes in staff and capacity (24/CP.19, 22. (b))

Authorised Institution for preparation of 2015 inventory submission stayed the same securing the long-term experience built up over the past years. There were few changes regarding sectoral experts. New sectoral expert for Agriculture and Waste is involved in NIR 2015. The expert for uncertainty and key sources analysis is changed as well as Project coordinator.

Changes to national entity with overall responsibility for the inventory (24/CP.19, 22. (c))

There are no changes to national entity with overall responsibility for the inventory.

Changes to the process of inventory planning (24/CP.19, 22.(d,e)/23./24.):

Due to unfunctionality of CRF Reporter the process of inventory planning was changed. National Inventory Report for 2015 was submitted in November 2015.

Changes to the process of inventory preparation (24/CP.19, 25./26.):

Due to the new reporting guidelines and the new CRF Reporter, changes in the Data collection programme were required. Due to unfunctionality of CRF Reporter the process of inventory preparation was postponed till the end of September.

Changes to the process of inventory management (24/CP.19, 27.):

There are no changes the process of inventory management.

1.3. INVENTORY PREPARATION, AND DATA COLLECTION, PROCESSING AND STORAGE

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 CAEN 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 CAEN 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 CAEN 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, 2013 and 2104. Issues recommended by the ERT have been included in this report as far as possible.

1.4. BRIEF GENERAL DESCRIPTION OF METHODOLOGIES (INCLUDING TIERS USED) AND DATA SOURCES USED

The methodologies from 2006 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 and NF_3. Emissions of indirect GHGs have been taken from the emission inventory report 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2013 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), sulphur hexafluoride (SF6) and nitrogen triflouride (NF_3) 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 (NOx) 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 2006 IPCC Guidelines provides methodology with default emission factors for different tiers. The emission estimates are divided into following sectors: Energy, Industrial Processes and 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 CAEN - 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 - CAEN - '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 - CAEN
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'
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

CRF Sector/Sub-sector	Type of data	Source of data
	Activity data on sewage sludge applied	- Voluntary survey of Food Company
LULUCF	Activity data on areas of different land use categories, annual increment and annual harvest and wildfires Activity data on crop production	- Ministry of Agriculture with assistance of public company "Hrvatske šume" - CAEN - CBS
Waste	Activity data on municipal solid waste disposed to different types of SWDSs	- MENP - CAEN
	Activity data on wastewater treatment and discharge	- State company Croatian Water (Hrvatske vode)
	Activity data on waste incineration	- CAEN

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.

Summary table with the key categories identified for the latest reporting year (by level and trend) on the basis of table 4.4 of volume 1 of the 2006 IPCC Guidelines is provided in table 1.5-1.

Table 1.5-1: Key categories summary table for 2013

Table								
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2013)								
A	B	C	D					E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification					Com.
1. Energy								
Fuel Combustion Activities - Energy Industries - Liquid Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i		
Fuel Combustion Activities - Manufacturing Industries and Construction - Liquid Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i		
Fuel Combustion Activities - Manufacturing Industries and Construction - Gaseous Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i		
Fugitive Emissions from Fuels - Oil and Natural Gas - Natural gas - CH4	CO2	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i		
Fugitive Emissions from Fuels - Oil and Natural Gas - Oil - CH4	CO2	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i		
Fugitive Emissions from Fuels - Oil and Natural Gas - Natural gas - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i		
Fuel Combustion Activities - Manufacturing Industries and Construction - Solid Fuels - CO2	CO2	Yes	L1e	T1e, T2e	L1i	T1i, T2i		

Table

Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2013)

A	B	C	D				E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification				Com.
Fuel Combustion Activities - Other Sectors - Solid Fuels - CO2	CO2	Yes		T1e, T2e		T1i, T2i	
Fugitive Emissions from Fuels - Oil and Natural Gas - Oil - CO2	CO2	Yes		T1e, T2e		T1i, T2i	
Fuel Combustion Activities - Other Sectors - Biomass - CH4	CH4	Yes	L2e			T2i	
Fuel Combustion Activities - Manufacturing Industries and Construction - Other Fossil Fuels - CO2	CO2	Yes		T2e		T2i	
Fugitive emissions from fuels - Solid Fuels - CH4	CH4	Yes		T2e		T2i	
Fuel Combustion Activities - Transport - Domestic Navigation - Liquid Fuels - CO2	CO2	Yes		T2e		T2i	
Fuel Combustion Activities - Transport - Railways - CO2	CO2	Yes				T2i	
Fuel Combustion Activities - Other Sectors - Solid Fuels - CH4	CH4	Yes				T2i	
Fuel Combustion Activities - Transport - Road transportation - CH4	CH4	Yes				T2i	
Fuel Combustion Activities - Transport - Road transportation - N2O	N2O	Yes				T2i	
Fuel Combustion Activities - Transport - Domestic Aviation - CO2	CO2	Yes				T2i	
Fuel Combustion Activities - Transport - Road transportation - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i	
Fuel Combustion Activities - Energy Industries - Solid Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
Fuel Combustion Activities - Energy Industries - Gaseous Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
Fuel Combustion Activities - Other Sectors - Gaseous Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
Fuel Combustion Activities - Other Sectors - Liquid Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i,	T1i, T2i	
2. Industrial processes and product use							
Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning - HFCs and PFCs	HFCs, PFCs	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i	
Chemical Industry - Ammonia Production - CO2	CO2	Yes	L1e	T2e	L1i	T2i	
Chemical industry - Nitric Acid Production - N2O	N2O	Yes	L1e	T1e, T2e	L1i	T1i, T2i	
Non-Energy Products from Fuels and Solvent Use - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
Metal Industry - Aluminium Production - PFCs	PFCs	Yes		T1e, T2e		T1i, T2i	
Chemical Industry - Petrochemical and Carbon Black Production - CO2	CO2	Yes		T1e, T2e		T1i, T2i	
Metal Industry - Ferroalloys Production - CO2	CO2	Yes		T1e, T2e		T1i, T2i	
Metal Industry - Aluminium Production - CO2	CO2	Yes		T2e		T2i	
Mineral industry - Cement Production - CO2	CO2	Yes	L1e	T1e, T2e	L1i	T1i, T2i	
Mineral Industry - Other Process Uses of Carbonates - CO2	CO2	Yes				T2i	
Mineral Industry - Lime Production - CO2	CO2	Yes				T2i	
Metal Industry - Iron and Steel Production - CO2	CO2	Yes				T2i	
Other Product Manufacture and Use - N2O	N2O	Yes				T2i	
3. Agriculture							
Enteric Fermentation - CH4	CH4	Yes	L1e, L2e	T1e, T2e	L1i,	T1i, T2i	
Direct N2O Emissions From Managed Soils - N2O	N2O	Yes	L1e, L2e		L1i,	T2i	
Indirect N2O Emissions from Managed soils - N2O	N2O	Yes	L1e, L2e		L1i, L2i	T2i	
Manure Management - CH4	CH4	Yes	L1e,	T2e	L1i,	T2i	
Manure Management - N2O	N2O	Yes	L1e,	T2e	L1i,	T1i, T2i	

Table							
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2013)							
A	B	C	D				E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification				Com.
Liming - CO2	CO2	Yes	L2e				
Urea Application - CO2	CO2	Yes				T2i	
4. Land use, land use change and forestry							
Forest Land Remaining Forest Land - CO2	CO2	Yes			L1i, L2i	T1i, T2i	
Land Converted to Settlements - CO2	CO2	Yes			L1i, L2i	T1i, T2i	
Harvested wood products - CO2	CO2	Yes			L1i, L2i	T2i	
Land Converted to Forest Land - CO2	CO2	Yes			L1i, L2i	T1i, T2i	
Cropland Remaining Cropland - CO2	CO2	Yes			L2i	T2i	
Land Converted to Cropland - CO2	CO2	Yes			L2i	T2i	
Direct N2O emissions from N mineralization/immobilization - N2O	N2O	Yes			L2i		
Land Converted to Grassland - CO2	CO2	Yes			L2i	T2i	
5. Waste							
Solid Waste Disposal - CH4	CH4	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i	
Wastewater Treatment and Discharge - CH4	CH4	Yes	L1e, L2e	T2e	L1i,	T2i	
Wastewater Treatment and Discharge - N2O	N2O	Yes	L2e	T2e		T2i	

Key category analysis is provided by CRF Application too. Although there are differences between the two analyses, a large key sources were identified in both analyses. Some categories in CRF analysis differed from categories which are provided in 2006 IPCC Guidelines for key category analysis so detailed comparison between both of them was not possible to make.

1.6. GENERAL UNCERTAINTY EVALUATION, INCLUDING DATA ON THE OVERALL UNCERTAINTY FOR THE INVENTORY TOTALS

The uncertainties associated with both annual estimates of emissions and emission trends over time are reported according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The uncertainties are estimated using Tier 1 and Tier 2 (Monte Carlo analysis) methods described by the IPCC, which provide estimates of uncertainties by pollutant. The uncertainties are estimated for both excluding LULUCF and including LULUCF due to the Good Practice Guidance for Land Use, Land-Use Change and Forestry.

According to the Tier 1 uncertainty analysis the total uncertainty including LULUCF is 55.10 percent.

According to the Tier 2 Monte Carlo analysis the total uncertainty including LULUCF for all source activities is estimated to be from -28.65 percent to +28.71 percent.

According to the Tier 1, the uncertainty introduced into the trend in total national emissions including LULUCF is estimated to be 17.16 percent.

According to the Tier 2 Monte Carlo analysis the total uncertainty introduced into the trend for all source activities including LULUCF is estimated to be from -23.52 percent to +23.57 percent.

The results of the Tier 1 approach and results of the Tier 2 approach are shown in Table A2.1-2 and A2.1-3 (Annex 2).

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 2.

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 2013.

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.

1.7. GENERAL ASSESSMENT OF COMPLETENESS

Croatian inventory consists of the emission estimates for the period from 1990-2013.

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.

CHAPTER 2: TRENDS IN GREENHOUSE GAS EMISSIONS

2.1. DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR AGGREGATED GHG EMISSIONS

The total GHG emissions in 2013, excluding removals by sinks, amounted 24,492.8 mil. t CO_2-eq (equivalent CO_2 emissions), which represents 30.3 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 2008-2013, emission has been reduced by 10.9 percent in 2011, 8.1 percent in 2012 and 21.3 percent in 2013, 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. 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 treatment and discharge, have the greatest impact on emission increase in Waste sector.

The main reasons of GHG emission decrease in 2013 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 2013, overall emissions from industrial processes dropped by 9.0 precent, regarding 2012 and by 30.9 precent, regarding 2008.

The results of the greenhouse gas (GHG) emission calculation are presented for the period from 1990 to 2013. Total emissions/removals of GHG and their trend in sectors are given in Tables 2.1-1, 2.1-2 and in Figure 2.1-1 while the contribution of the individual gases is given in Tables 2.1-3, 2.1-4 and Figure 2.1-2.

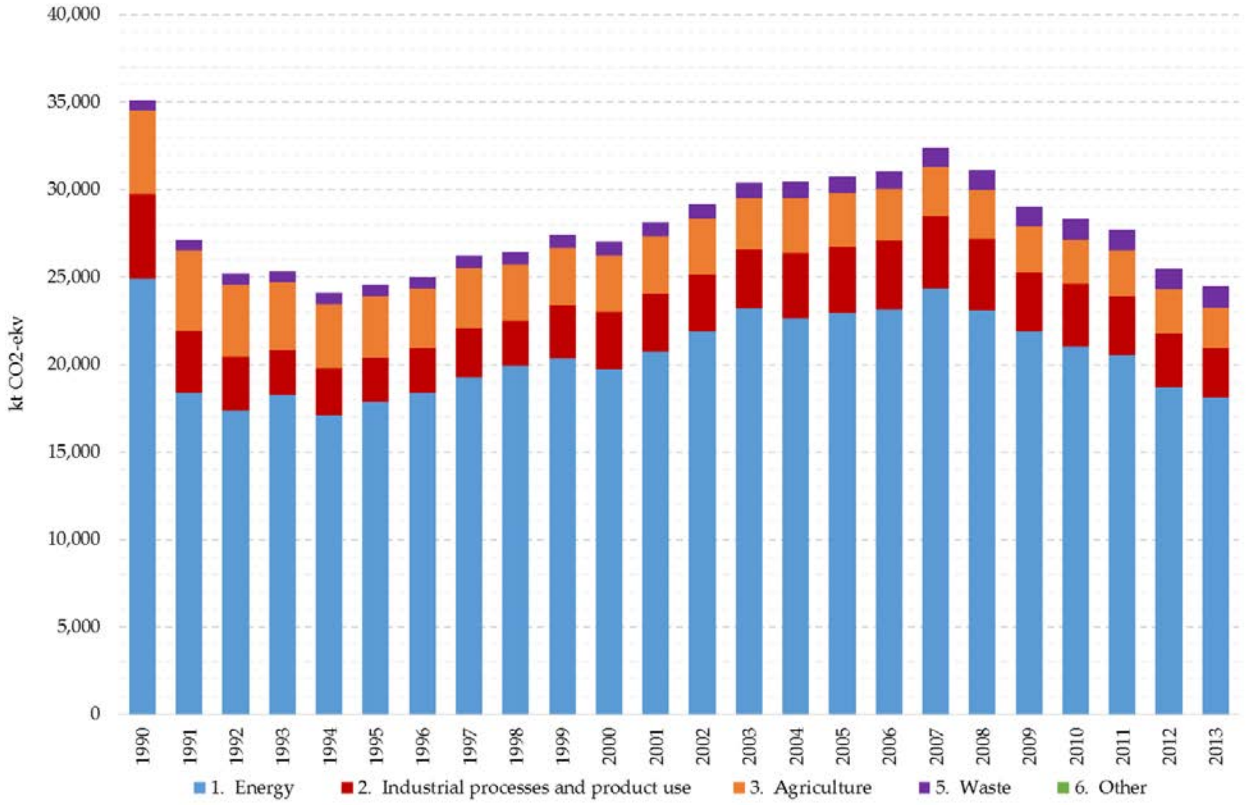
Table 2.1-1: Emissions/removals of GHG by sectors for the every five years from 1990 to 2005 (kt CO_2-eq)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2005
	CO_2 equivalent (kt)			
1. Energy	24,902.6	17,858.2	19,739.1	22,953.6
2. Industrial processes and product use	4,852.6	2,572.9	3,291.6	3,776.9
3. Agriculture	4,766.5	3,486.6	3,208.7	3,088.9
4. Land use, land-use change and forestry(5)	-5,536.7	-8,431.5	-7,162.1	-6,996.6
5. Waste	594.2	673.5	799.8	909.9
6. Other	NO	NO	NO	NO
Total (including LULUCF)	**29,579.3**	**16,159.6**	**19,877.0**	**23,732.6**
Total (excluding LULUCF)	**35,116.0**	**24,591.1**	**27,039.1**	**30,729.3**

Table 2.1-2: Emissions/removals of GHG by sectors for the period from 2010-2013 (kt CO_2-eq)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2010	2011	2012	2013	Change from base to latest reported year
	CO_2 equivalent (kt)				(%)
1. Energy	21,035.3	20,559.4	18,685.7	18,122.7	-27.23
2. Industrial processes and product use	3,591.3	3,361.9	3,092.0	2,812.6	-42.04
3. Agriculture	2,526.1	2,587.1	2,512.6	2,318.0	-51.37
4. Land use, land-use change and forestry	-6,260.3	-5,187.8	-5,036.4	-5,125.2	-7.43
5. Waste	1,173.3	1,211.0	1,214.8	1,239.5	108.59
6. Other	0.0	0.0	0.0	0.0	0.00
Total (including LULUCF)	**22,065.7**	**22,531.5**	**20,468.7**	**19,367.6**	**-34.52**
Total (excluding LULUCF)	**28,326.1**	**27,719.3**	**25,505.1**	**24,492.8**	**-30.25**

Figure 2.1-1: Trend of GHG emissions, by sectors



Tables 2.1-1, 2,1-2 and Figure 2.1-1 represents the contribution of the individual sectors to total emissions and removals of the GHGs. The largest contribution to the GHGs emission in 2013 excluding LULUCF has the Energy sector with 74.0 percent, followed by Industrial Processes and product use with 11.5 percent, Agriculture with 9.5 percent and Waste with 5.0 percent. This structure is with minor changes consistent through all the observed period from 1990 to 2013. In the year 2013, the total GHG emissions in Croatia was 24,492.8 kt CO_2-eq excluding LULUCF sector while the total emission was 19,367.6 kt CO_2-eq including the LULUCF sector which represents removals by sink from 20.9 percent in that year.

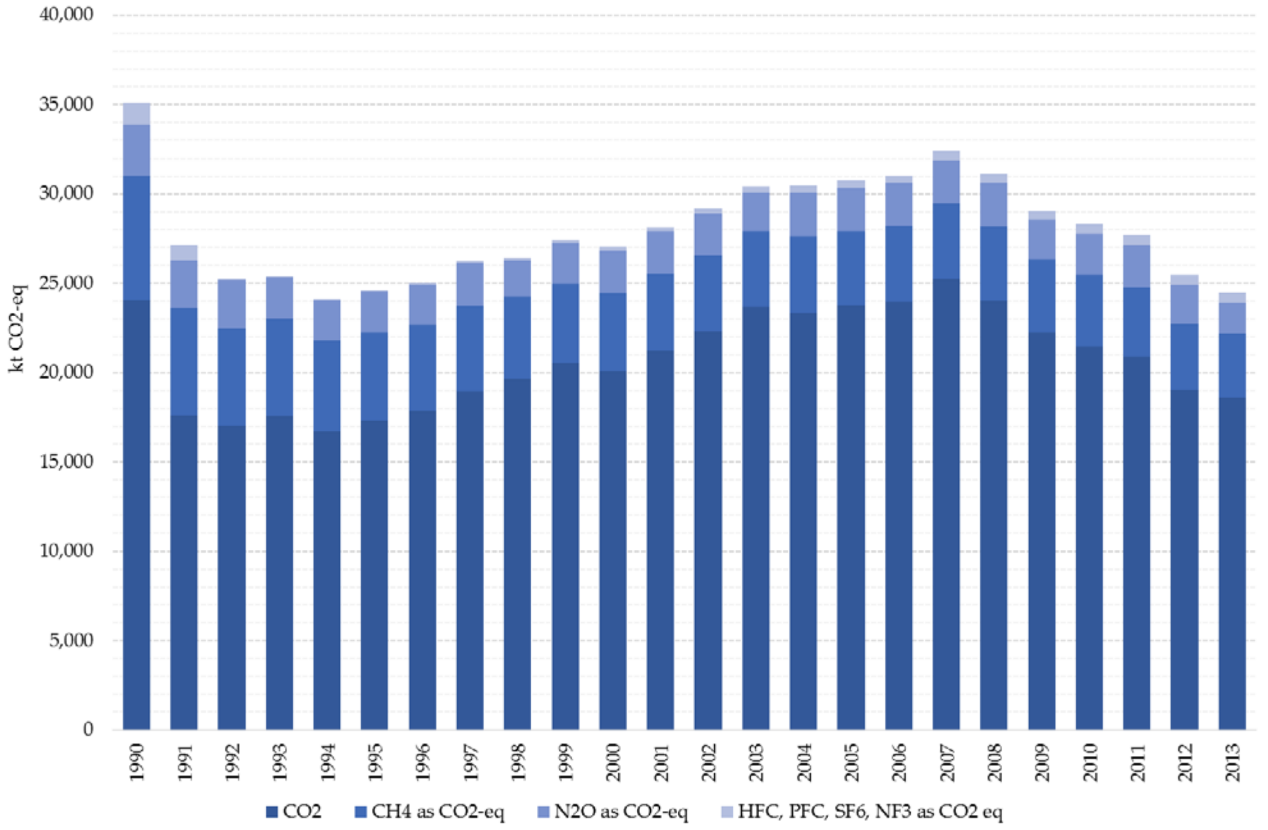
Table 2.1-3: Emissions/removals of GHG by gases for the every five years from 1990 to 2005 (kt CO_2-eq)

GREENHOUSE GAS EMISSIONS	1990	1995	2000	2005
	CO_2 equivalent (kt)			
CO_2 emissions without net CO_2 from LULUCF	24,074.3	17,326.5	20,073.7	23,753.5
CO_2 emissions with net CO_2 from LULUCF	18,530.9	8,878.4	12,743.6	16,746.5
CH_4 emissions without CH_4 from LULUCF	6,952.9	4,951.9	4,359.5	4,153.5
CH_4 emissions with CH_4 from LULUCF	6,954.1	4,959.5	4,456.4	4,156.2
N_2O emissions without N_2O from LULUCF	2,838.1	2,244.2	2,395.0	2,423.1
N_2O emissions with N_2O from LULUCF	2,843.6	2,253.3	2,466.1	2,430.7
HFCs	NO	57.3	199.2	386.1
PFCs	1,240.2	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO
SF_6	10.5	11.1	11.6	13.0
NF_3	NO	NO	NO	NO
Total (without LULUCF)	**35,116.0**	**24,591.1**	**27,039.1**	**30,729.3**
Total (with LULUCF)	**29,579.3**	**16,159.6**	**19,877.0**	**23,732.6**
Total (without LULUCF, with indirect)	**35,116.0**	**24,591.1**	**27,039.1**	**30,729.3**
Total (with LULUCF, with indirect)	**29,579.3**	**16,159.6**	**19,877.0**	**23,732.6**

Table 2.1-4: Emissions/removals of GHG by gases for the for the period from 2010-2013 (kt CO_2-eq)

GREENHOUSE GAS EMISSIONS	2010	2011	2012	2013	Change from base to latest reported year
	CO_2 equivalent (kt)				(%)
CO_2 emissions without net CO_2 from LULUCF	21,432.0	20,866.5	19,022.8	18,620.8	-22.65
CO_2 emissions with net CO_2 from LULUCF	15,160.5	15,637.4	13,911.1	13,482.0	-27.25
CH_4 emissions without CH_4 from LULUCF	4,036.7	3,914.6	3,688.9	3,581.0	-48.50
CH_4 emissions with CH_4 from LULUCF	4,038.5	3,933.2	3,727.8	3,582.9	-48.48
N_2O emissions without N_2O from LULUCF	2,304.4	2,365.7	2,219.2	1,706.6	-39.87
N_2O emissions with N_2O from LULUCF	2,313.8	2,388.4	2,255.6	1,718.3	-39.57
HFCs	544.0	563.1	565.0	577.7	0.00
PFCs	0.0	0.0	0.0	0.1	-100.00
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	0.00
SF_6	9.0	9.4	9.2	6.6	-37.03
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	**28,326.1**	**27,719.3**	**25,505.1**	**24,492.8**	**-30.25**
Total (with LULUCF)	**22,065.7**	**22,531.5**	**20,468.7**	**19,367.6**	**-34.52**
Total (without LULUCF, with indirect)	**28,326.1**	**27,719.3**	**25,505.1**	**24,492.8**	**-30.25**
Total (with LULUCF, with indirect)	**22,065.7**	**22,531.5**	**20,468.7**	**19,367.6**	**-34.52**

Figure 2.1-2: Trend of GHG emissions, by gases



Tables 2.1-3, 2.1-4 and Figure 2.1-2 represents the contribution of the individual gasses to total emissions and removals of the GHGs. The largest contribution to the GHGs emission in 2013 excluding LULUCF has CO_2 emission with 76.0 percent, followed by CH_4 with 14.6 percent, N_2O with 7.0 percent and HFCs, PFCs and SF6 with 2.4 percent.

2.2. DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY SECTOR

<u>ENERGY SECTOR</u>

Energy sector is the largest contributor to GHG emissions. In the year 2013, the GHG emission from Energy sector was 3.0 percent lower in relation to 2012 and 27.2 percent lower in relation to 1990. 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 (8 percent) while the contribution of energy in nitrous oxide (N_2O) emission is quite small (about 2 percent). Emissions from fossil fuel combustion comprise the majority (more than 90 percent) of energy-related emissions. Emission of individual subsectors is presented in the Table 2.2-1.

Table 2.2-1: Energy subsectors total emissions by gases for the period 1990-2013 (kt CO_2-eq)

GHG source and sink categories	1990	1995	2000	2005	2010	2011	2012	2013
1. Energy	24,902.6	17,858.2	19,739.1	22,953.6	21,035.3	20,559.4	18,685.7	18,122.7
A. Fuel combustion	20,610.3	14,598.3	17,034.1	20,228.1	18,579.2	18,247.1	16,707.6	16,209.3
1. Energy industries	7,189.5	5,243.2	5,839.4	6,880.9	5,931.0	6,178.5	5,524.2	5,132.2
2. Manufact. ind.	5,529.0	2,967.9	3,115.6	3,739.0	3,030.1	2,792.1	2,421.9	2,392.8
3. Transport	4,032.1	3,419.2	4,525.6	5,581.6	5,978.4	5,838.2	5,656.5	5,749.7
4. Other sectors	3,859.7	2,968.1	3,553.5	4,026.6	3,639.7	3,438.3	3,105.0	2,934.7
5. Other	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions	4,292.3	3,259.8	2,705.0	2,725.5	2,456.1	2,312.3	1,978.0	1,913.4
1. Solid fuels	59.6	28.2	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
2. Oil and nat. gas	4,232.7	3,231.6	2,705.0	2,725.5	2,456.1	2,312.3	1,978.0	1,913.4

The largest part (31.7 percent) of the emissions are a consequence of fuel combustion in Transport, then the combustion in Energy industries (28.3 percent in 2013) and the combustion in small stationary energy sources, such as Commercial/Institutional, Residential and Agriculture/Forestry/Fishing (16.2 percent in 2013). Manufacturing Industries and Construction contribute to total emission from Energy sector with 13.2 percent, while Fugitive Emissions from Fuels contribute with about 10.6 percent.

INDUSTRIAL PROCESSES AND PRODUCT USE

In Industrial Processes sector, the key emission sources are Cement Production, Lime Production, Ammonia Production, Nitric Acid Production and Consumption of HFCs in Refrigeration and Air Conditioning Equipment, which all together contribute with 92.3 percent in total sectoral emission in 2013. 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 2013 emissions from industrial processes were decreased by 9.0 percent regarding 2012 and by 42.0 percent regarding 1990. Emission of individual subsectors is presented in the Table 2.2-2.

Table 2.2-2: Industrial processes subsectors total emissions by gases for the period 1990-2013 (kt CO_2-eq)

GHG source and sink categories	1990	1995	2000	2005	2010	2011	2012	2013
2. Industrial processes and product use	4,852.6	2,572.9	3,291.6	3,776.9	3,591.3	3,361.9	3,092.0	2,812.6
A. Mineral industry	1,280.9	760.0	1,423.1	1,785.4	1,432.3	1,220.1	1,191.1	1,291.4
B. Chemical industry	1,531.9	1,454.2	1,421.6	1,305.5	1,362.9	1,327.4	1,131.6	726.6
C. Metal industry	1,582.7	39.1	27.3	11.8	27.6	29.4	1.8	16.6
D. Non-energy products	413.3	217.8	175.4	241.6	184.5	179.8	151.0	151.6
E. Electronic Industry	NO	NO	NO	NO	NO	NO	NO	NO
F. Product uses as ODS subs.	NO	57.3	199.2	386.1	544.0	563.2	565.0	577.8
G. Other product manufacture	43.8	44.5	45.0	46.4	40.0	42.0	51.5	48.6
H. Other	NA	NA	NA	NA	NA	NA	NA	NA

AGRICULTURE

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 2012 and 2013. Compared to 2012, in 2013 CH_4 emission from Enteric fermentation decreased by 7.0 percent. As for Manure management emissions, CH_4 emission decreased in 2013 compared to 2012 by 1.8 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 2013 compared to 2012 by 8.4 percent. Overall, in the year 2013 the GHG emission from Agriculture sector decreased by 7.8 percent in comparison with 2012. Emission of individual subsectors is presented in the Table 2.2-3.

Table 2.2-3: Agriculture subsectors total emissions by gases for the period 1990-2013 (kt CO_2-eq)

GHG source and sink categories	1990	1995	2000	2005	2010	2011	2012	2013
3. Agriculture	**4,766.5**	**3,486.6**	**3,208.7**	**3,088.9**	**2,526.1**	**2,587.1**	**2,512.6**	**2,318.0**
A. Enteric fermentation	2,501.1	1,806.4	1,487.6	1,244.4	949.8	917.7	902.7	839.8
B. Manure management	676.7	480.4	404.6	392.9	352.0	338.6	324.2	318.4
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	1,538.7	1,153.5	1,255.6	1,366.2	1,144.3	1,232.4	1,189.2	1,089.7
E. Presc. burning of savannas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F. Field burning of agric. resid.	NO	NO	NO	NO	NO	NO	NO	NO
G. Liming	NO	NO	NO	14.5	13.5	14.5	9.6	9.6
H. Urea application	50.0	46.3	60.9	71.0	66.6	83.9	86.9	60.4
I. Other carbon-containing fert.	NA	NA	NA	NA	NA	NA	NA	NA
J. Other	NO	NO	NO	NO	NO	NO	NO	NO

LULUCF

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 (PiCAEN 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 2.2-4 shows the CO_2 emission/removal trend in the forestry sector. Emissions arisen in LULUCF sector contribute with 19.8% to the total emissions of CO_2-eq in Croatia in year 2013.

Table 2.2-4: Emission trends in LULUCF sector from 1990-2013 (kt CO_2-eq)

	1990	1995	2000	2005	2010	2011	2012	2013
LULUCF emissions	-5,536.7	-8,431.5	-7,162.1	-6,996.6	-6,260.3	-5,187.8	-5,036.4	-5,125.2

WASTE

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 1990-2013. Increasing emissions are a consequence of greater quantities of waste, activities in wastewater treatment and discharge 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, 46/15) include the assumed time-lags with respect to relevant EU legislation. CH_4 that is recovered and burned in a flare in the period 2004-2013 have been included in emission estimation. Emission of individual subsectors is presented in the Table 2.2-5. It should be emphasized that Solid Waste Disposal on Land contributes with 76.4 percent in total sectoral emission in 2013. Waste sector contributes to total GHG emissions with 5.0 percent in 2013.

Table 2.2-5: Waste subsectors total emissions by gases for the period 1990-2013 (kt CO_2-eq)

GHG source and sink categories	1990	1995	2000	2005	2010	2011	2012	2013
5. Waste	594.2	673.5	799.8	909.9	1,173.3	1,211.0	1,214.8	1,239.5
A. Solid waste disposal	288.8	363.4	481.1	600.2	881.1	919.7	937.6	947.2
B. Biolog.treatment of solid waste	IE,NA, NE	IE,NA, NE	IE,NA, NE	IE,NA, NE	IE,NA, NE	IE,NA, NE	IE,NA, NE	8.2
C. Incineration of waste	0.5	0.5	6.3	0.2	0.0	0.1	0.1	0.0
D. Waste water treatment	304.9	309.5	312.4	309.6	292.2	291.3	277.2	284.0
E. Other	NO	NO	NO	NO	NO	NO	NO	NO

CHAPTER 3: ENERGY (CRF SECTOR 1)

3.1. OVERVIEW OF SECTOR

3.1.1. Overview of the energy situation

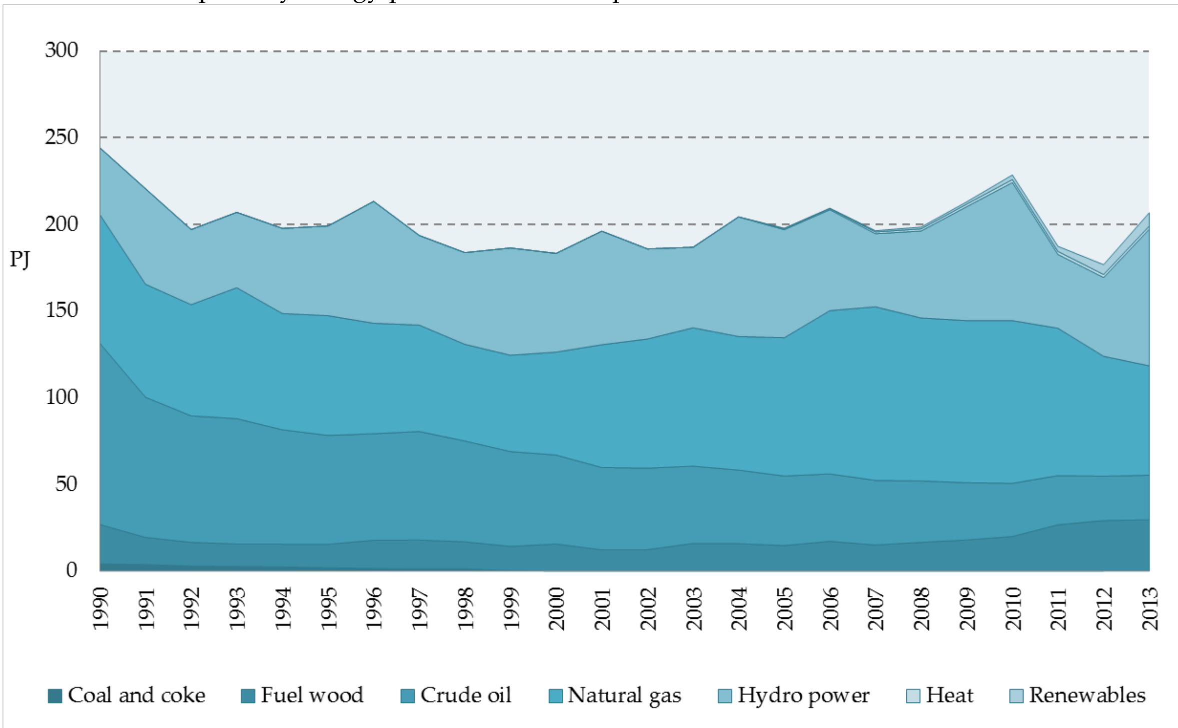
Primary sources of energy that are produced in Croatia are fuel wood, crude oil, natural gas, renewables and hydro power. Coal production stopped in 2000. Primary energy production for the 1990, 1995, 2000, 2005 and period from 2010 to 2013 is presented in the Table 3.1-1.

Table 3.1-1: Primary energy production

PJ	1990	1995	2000	2005	2008	2010	2011	2012	2013
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	19.96	26.74	29.17	29.6
Crude oil	104.54	62.81	51.35	40.11	35.42	30.69	28.37	25.62	25.7
Natural gas	74.27	69.12	59.4	79.76	94.05	93.88	85.02	69.19	63.1
Hydro power	38.55	51.75	56.93	62.40	50.19	79.71	42.59	45.45	78.9
Heat	-	-	-	0.61	1.25	1.71	1.73	1.71	1.7
Renewables	0.00	0.00	0.00	0.20	1.03	2.63	2.97	5.66	7.7
Total	**244.25**	**199.16**	**183.32**	**197.24**	**197.28**	**228.57**	**187.42**	**176.79**	**206.76**

Figure 3.1-1 presents the trends in the primary energy production from 1990 to 2013.

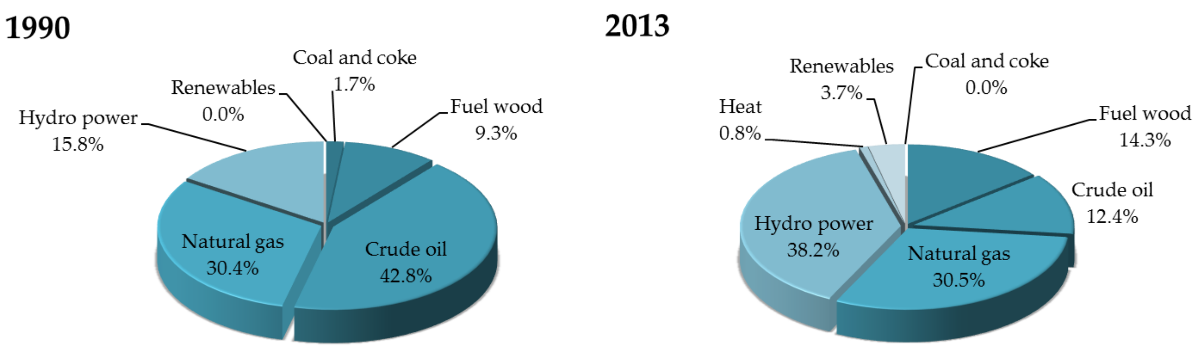
Figure 3.1-1: Trends in primary energy production for the period from 1990 to 2013



In 1990 primary energy production was about 244 PJ, which is 15.3% higher comparing to 2013. In 2013, the total primary energy production increased by 16.9% with relation to the 2012. Comparing to 2012, the energy production from renewable sources increased 1.4 times in 2012. The production of natural gas decreased 8.8% while production of crude oil increased by 0.4%, as well as fuel wood (0.5%). Hydro power utilization increased by 73.6%.

While in 1990 the share of crude oil in primary energy production was the highest one with 42.8%, in 2013 its' share was only 12.4%. In 2013, the share of natural gas (30.5%) was the highest one. It was followed by hydro power with the share of 38.1%. The comparison of shares in primary energy productions for the 1990 and 2013 are presented in Figure 3.1-2.

Figure 3.1-2: Shares of individual energy forms in the total production for the 1990 and 2013



Primary energy supply

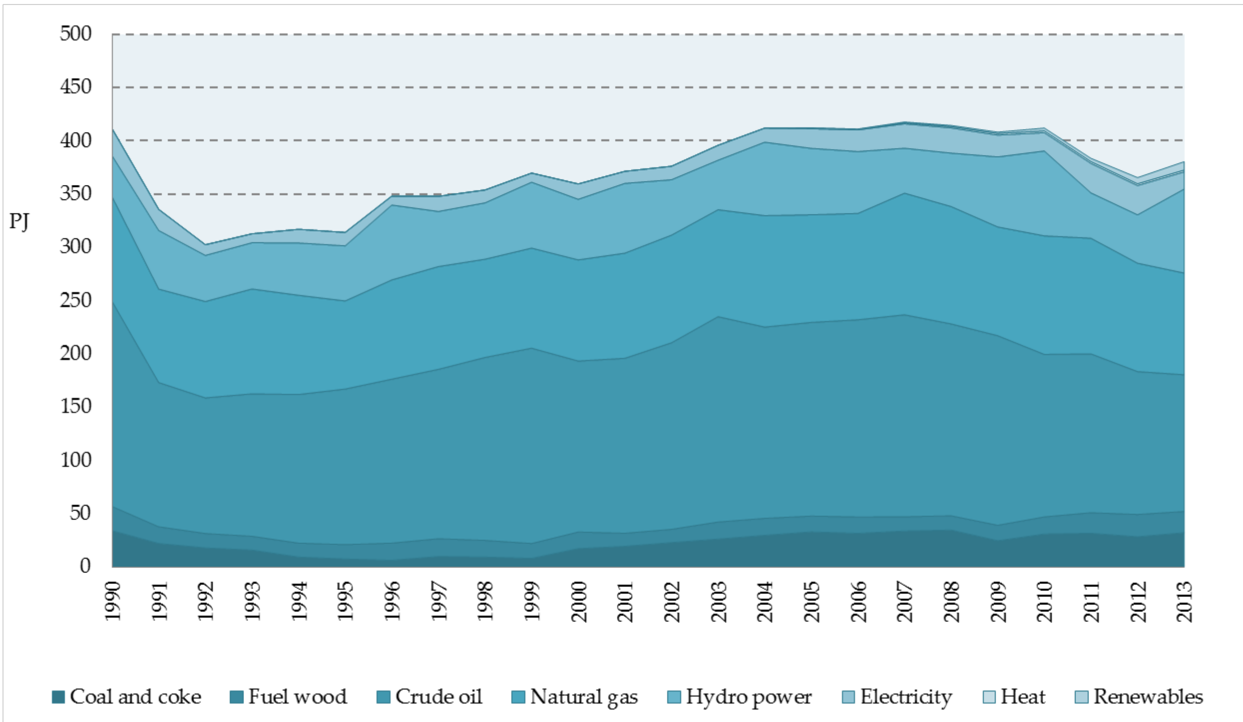
Total primary energy supply is determined by adding the import and subtracting the export of all primary and transformed energy forms to the total primary energy supply. Primary energy supply for the 1990, 1995, 2000, 2005 and period from 2010 to 2013 is presented in the Table 3.1-2.

Table 3.1-2: Primary energy supply

PJ	1990	1995	2000	2005	2008	2010	2011	2012	2013
Coal and coke	34.07	7.42	17.15	32.95	34.65	30.92	31.66	28.37	32.18
Fuel wood	22.68	13.52	15.64	14.77	13.38	16.05	19.23	20.88	19.84
Liquid fuels	192.6	146.03	160.52	181.88	180.15	152.54	149.16	134.17	128.37
Natural gas	98.22	82.77	94.98	101.06	110.22	111.37	108.60	101.78	95.54
Hydro power	38.55	51.75	56.93	62.40	50.19	79.71	42.59	45.45	78.88
Electricity	25.42	12.59	14.4	18.41	23.68	17.15	27.71	27.46	16.17
Heat	-	-	-	0.61	1.25	1.71	1.73	1.71	1.74
Renewables	0.00	0.00	0.00	0.20	0.97	2.24	2.97	5.72	7.8
Total	**411.54**	**314.08**	**359.62**	**411.67**	**413.24**	**411.69**	**383.65**	**365.54**	**380.52**

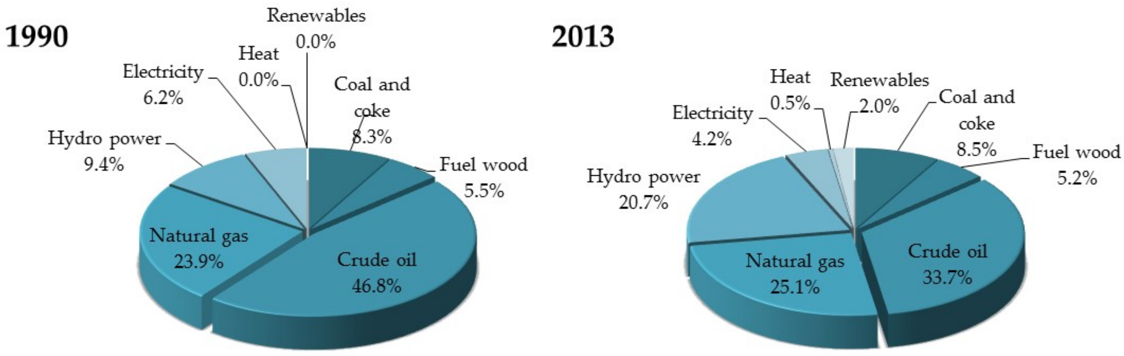
Figure 3.1-3 presents the trends in the primary energy supply from 1990 to 2013.

Figure 3.1-3: Trends in primary energy supply for the period from 1990 to 2013



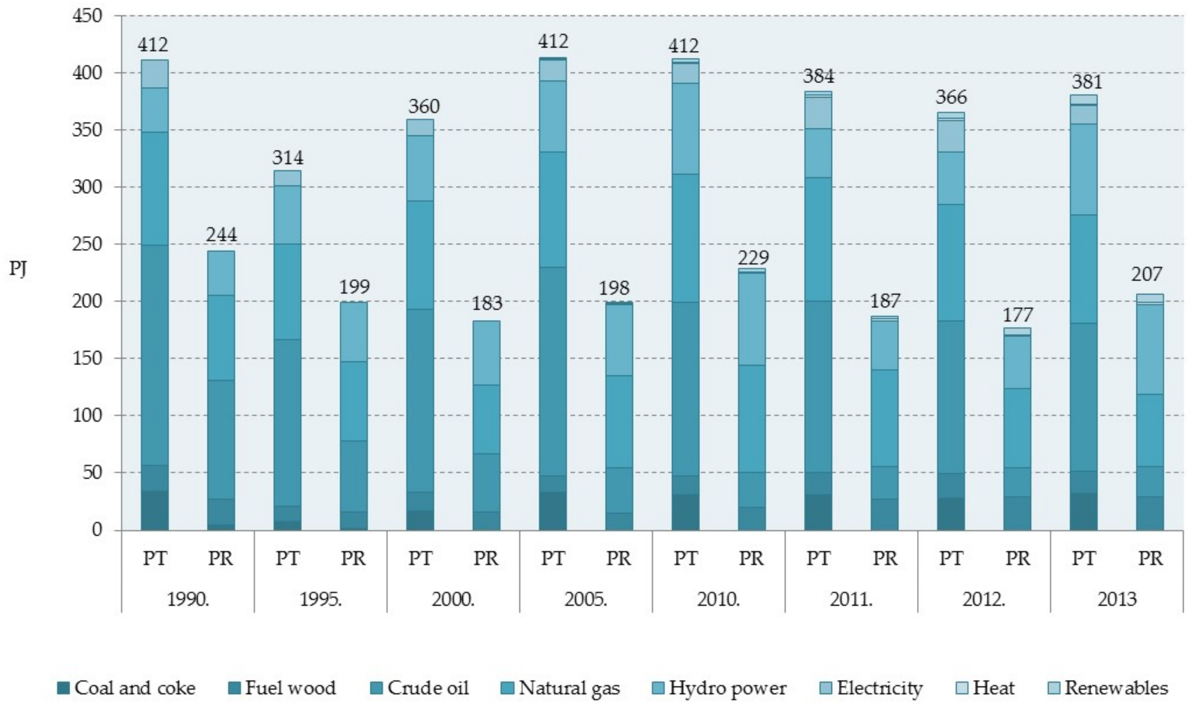
In 1990 primary energy supply was about 412 PJ, which is 7.5.% higher comparing to 2013. In 2013, the total primary energy supply increased by 3.9% with relation to the previous year. There was an increase in, fuel wood, renewable energy sources and hydro power while consumption of natural gas, liquid fuels and coal and coke decreased. Due to good hydrology conditions, hydro power energy supply increased by 73.6% with relation to the 2012. Figure 3.1-4 presents comparison of the shares of individual energy forms in the total primary energy supply for the 1990 and 2013.

Figure 3.1-4: Comparison of the shares of individual energy forms for the 1990 and 2013



Liquid fuels had the largest share in total primary energy supply in 1990 as well as in 2013 (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 54.3%. Total hydro power and fuel wood supply were fully covered from the territory of Croatia. The production of solid fuels stopped in 2000, thus all needs for coke and coal were satisfied from export.

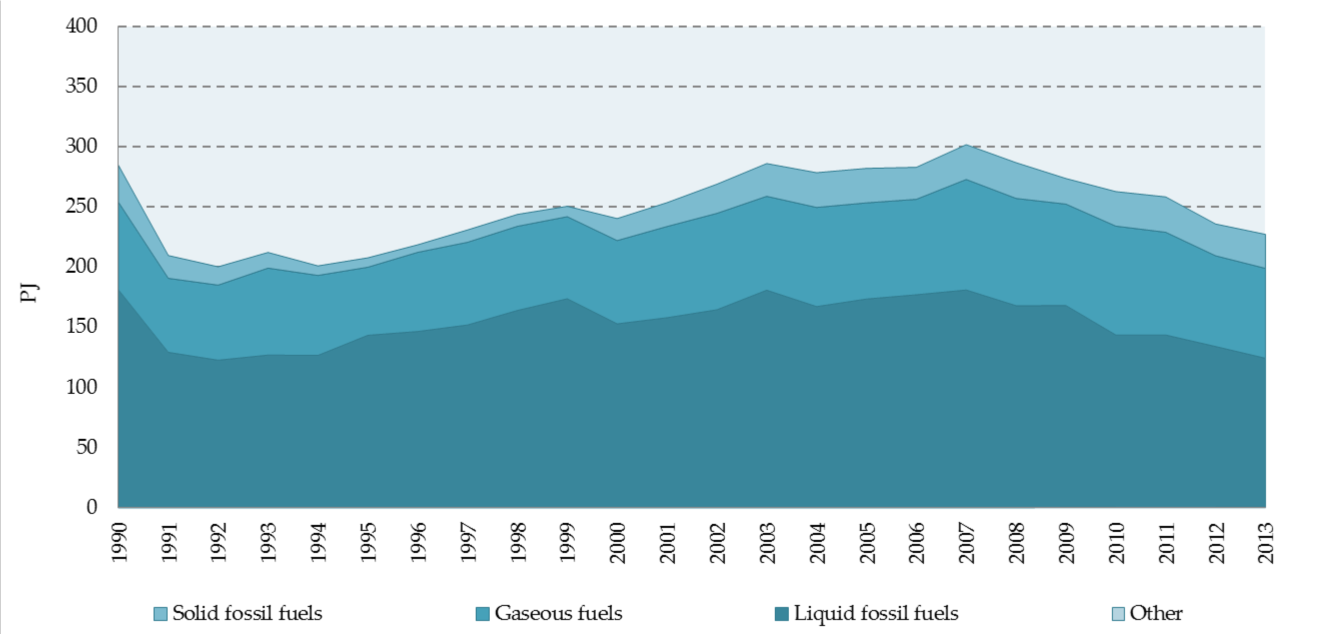
The basis for estimating the GHG emissions from Energy sector is the national energy balance. Data on production, imports, exports, stock change and consumption of fuels are reported both in natural units (kg or m3) and energy units (PJ). National energy balance for 2013 is presented in Annex 4. For easier comparison of data from energy balance the natural units are transformed to energy units using appropriate national net calorific values (Table 3.1-3).

Table 3.1-3: National net calorific values, CO2 emission factors and oxidation factors for 1990 and 2013

Fuel		DOV		CO_2 Emission factor (t CO2/TJ)	Oxidation factor (OF)
		Unit	2013		
Motorni benzin	Motor Gasoline	TJ/ kt	44,5900	69,30	1
Aviobenzin	Aviation Gasoline	TJ/ kt	44,5900	70,00	1
Kerozin (Mlazno gorivo)	Jet Kerosene	TJ/ kt	43,9600	71,50	1
Dizel i ekstra lako loživo ulje (plinsko ulje)	Gas/Diesel Oil	TJ/ kt	42,7100	74,10	1
Loživo ulje i srednje loživo ulje	Residual Fuel Oil	TJ/ kt	40,1900	77,40	1
Ukapljeni naftni plin	Liquefield Petroleum Gases	TJ/ kt	46,8900	63,10	1
Maziva	Lubricants	TJ/ kt	33,5000	73,30	1
Naftni koks	Petroleum Coke	TJ/ kt	31,0000	97,50	1
Petrolej	Petroleum	TJ/ kt	43,9600	73,30	1
Antracit	Anthracite	TJ/ kt	29,3100	98,30	1
Kameni ugljen-Industrija	*Other bituminouse coal Industry*	TJ/ kt	27,0486	94,60	1
Kameni ugljen-*Termoelektrane*	Other bituminouse coal *Thermal power plant*	TJ/ kt	24,9600	94,60	1
Ugljen za proizvodnju koksa (koksni ugljen)	Coking coal	TJ/ kt	28,2000	94,60	1
Mrki ugljen (smeđi ugljen) *Industrija*	Sub bituminouse coal *Industry*	TJ/ kt	16,7400	96,10	1
Lignit	Lignite	TJ/ kt	10,5000	101,00	1
Briketi kamenog ugljena	Brown coal briquettes	TJ/ kt	20,7000	97,50	1
Koks	Coke oven coke	TJ/ kt	29,3100	107,00	1
Prirodni plin	Natural Gas	$TJ/10^6m^3$	34,0000	56,10	1
Gradski plin	Gas Works Gas	$TJ/10^6m^3$	17,1000	44,40	1
Koksni plin	Coke Oven Gas	$TJ/10^6m^3$	38,7000	44,40	1

The structure of energy consumption of fossil fuels from 1990 to 2013 is shown in Figure 3.1-6.

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 (8 percent) while the contribution of energy in nitrous oxide (N_2O) emission is quite small (about 2 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 (NOx), 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.

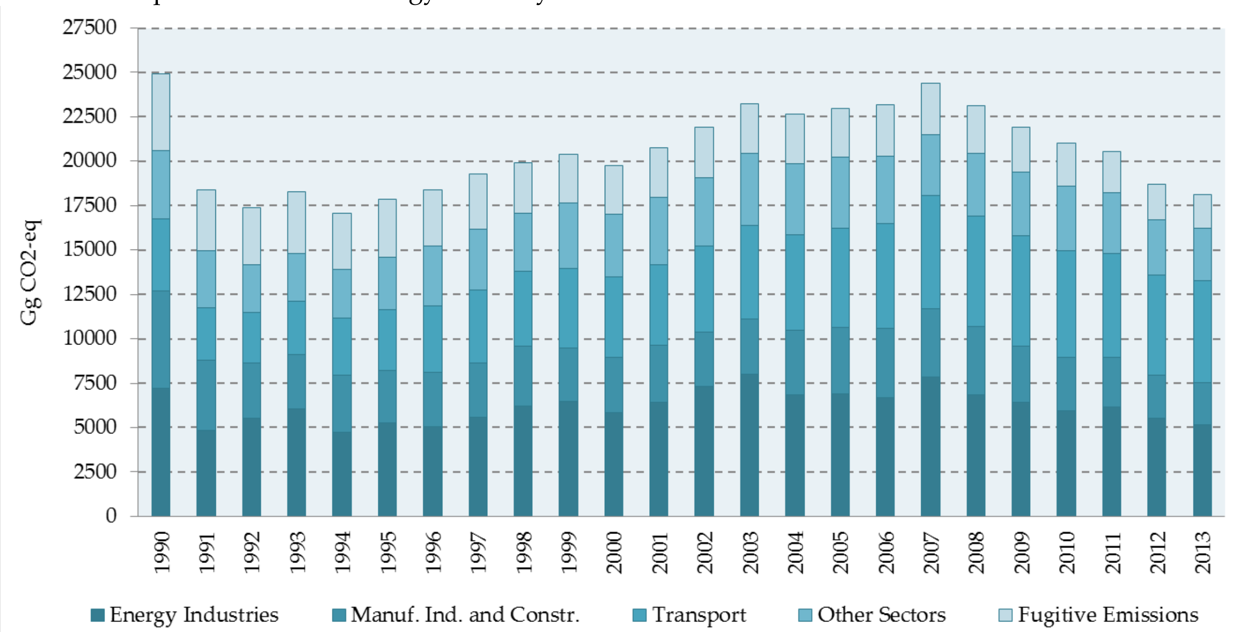
The fuel fugitive emission which is generated during production, transport, processing, storing and distribution of fossil fuels, is also estimated. These activities produce mainly the emission of CH_4, and smaller quantities of CO_2 and N_2O, NMVOC, CO and NOx.

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 (2013), is presented in the Table 3.1-4 while contribution of individual subsectors to GHG emission for the period 1990-2013 is presented in Figure 3.1-7.

Table 3.1-4: Contribution of individual subsectors to emission of greenhouse gases, for 2013

GHG categories	kt			Total	
	CO_2	CH_4	N_2O	CO_2-eq (kt)	%
ENERGY	16,605.25	56.44	0.36	18,122.71	100.00
A. Fuel combustion activities	15,949.64	6.13	0.36	16,209.29	89.44
1. Energy industries	5,109.51	0.13	0.07	5,132.17	28.32
a) Electricity and heat production	3,650.70	0.10	0.06	3,670.71	20.25
b) Petroleum refining	1,229.54	0.03	0.01	1,231.97	6.80
c) Manufacture of solid fuels	229.27	0.00	0.00	229.49	1.27
2. Manufacturing ind. and constr.	2,380.65	0.18	0.03	2,392.78	13.20
3. Transport	5,679.83	0.55	0.19	5,749.69	31.73
a) Civil aviation	103.98	0.00	0.00	104.87	0.58
b) Road transport	5,379.94	0.54	0.15	5,439.06	30.01
c) Railways	74.06	0.00	0.03	82.66	0.46
d) Navigation (domestic)	121.85	0.01	0.00	123.11	0.68
4. Other sectors	2,779.65	5.28	0.08	2,934.65	16.19
5. Other	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	655.61	50.31	0.00	1,913.42	10.56
1. Solid fuels	NO	NO	NO	NO	NO
2. Oil and natural gas	655.61	50.31	0.00	1,913.42	10.56
C. CO_2 transport and storage	NO	NO	NO	NO	NO

Figure 3.1-7: CO_2-eq emissions from Energy sector by subsectors in 1990-2013



The largest part (31.7 percent) of the emissions are a consequence of fuel combustion in Transport, then the combustion in Energy industries (28.3 percent in 2013) and the combustion in small stationary energy sources, such as Commercial/Institutional, Residential and Agriculture/Forestry/Fishing (16.2 percent in 2013). Manufacturing Industries and Construction contribute to total emission from Energy sector with 13.2 percent, while Fugitive Emissions from Fuels contribute with about 10.6 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.

Energy sector key sources

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 2013

Table							
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2013)							
A	B	C	D				E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification				Com.
1. Energy							
Fuel Combustion Activities - Energy Industries - Liquid Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
Fuel Combustion Activities - Manufacturing Industries and Construction - Liquid Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
Fuel Combustion Activities - Manufacturing Industries and Construction - Gaseous Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
Fugitive Emissions from Fuels - Oil and Natural Gas - Natural gas - CH4	CO2	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i	
Fugitive Emissions from Fuels - Oil and Natural Gas - Oil - CH4	CO2	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i	
Fugitive Emissions from Fuels - Oil and Natural Gas - Natural gas - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i	
Fuel Combustion Activities - Manufacturing Industries and Construction - Solid Fuels - CO2	CO2	Yes	L1e	T1e, T2e	L1i	T1i, T2i	
Fuel Combustion Activities - Other Sectors - Solid Fuels - CO2	CO2	Yes		T1e, T2e		T1i, T2i	
Fugitive Emissions from Fuels - Oil and Natural Gas - Oil - CO2	CO2	Yes		T1e, T2e		T1i, T2i	
Fuel Combustion Activities - Other Sectors - Biomass - CH4	CH4	Yes	L2e			T2i	
Fuel Combustion Activities - Manufacturing Industries and Construction - Other Fossil Fuels - CO2	CO2	Yes		T2e		T2i	
Fugitive emissions from fuels - Solid Fuels - CH4	CH4	Yes		T2e		T2i	
Fuel Combustion Activities - Transport - Domestic Navigation - Liquid Fuels - CO2	CO2	Yes		T2e		T2i	
Fuel Combustion Activities - Transport - Railways - CO2	CO2	Yes				T2i	
Fuel Combustion Activities - Other Sectors - Solid Fuels - CH4	CH4	Yes				T2i	
Fuel Combustion Activities - Transport - Road transportation - CH4	CH4	Yes				T2i	
Fuel Combustion Activities - Transport - Road transportation - N2O	N2O	Yes				T2i	
Fuel Combustion Activities - Transport - Domestic Aviation - CO2	CO2	Yes				T2i	
Fuel Combustion Activities - Transport - Road transportation - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i	
Fuel Combustion Activities - Energy Industries - Solid Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
Fuel Combustion Activities - Energy Industries - Gaseous Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
Fuel Combustion Activities - Other Sectors - Gaseous Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
Fuel Combustion Activities - Other Sectors - Liquid Fuels - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i,	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

<u>Ozone precursors and SO_2 emissions</u>

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 2013 was set up according to the EMEP/CORINAIR methodology. Emissions were obtained from the emission inventory report 'Republic of Croatia Informative Inventory Report for 2013, under Convention on Long-range Transboundary Air Pollution

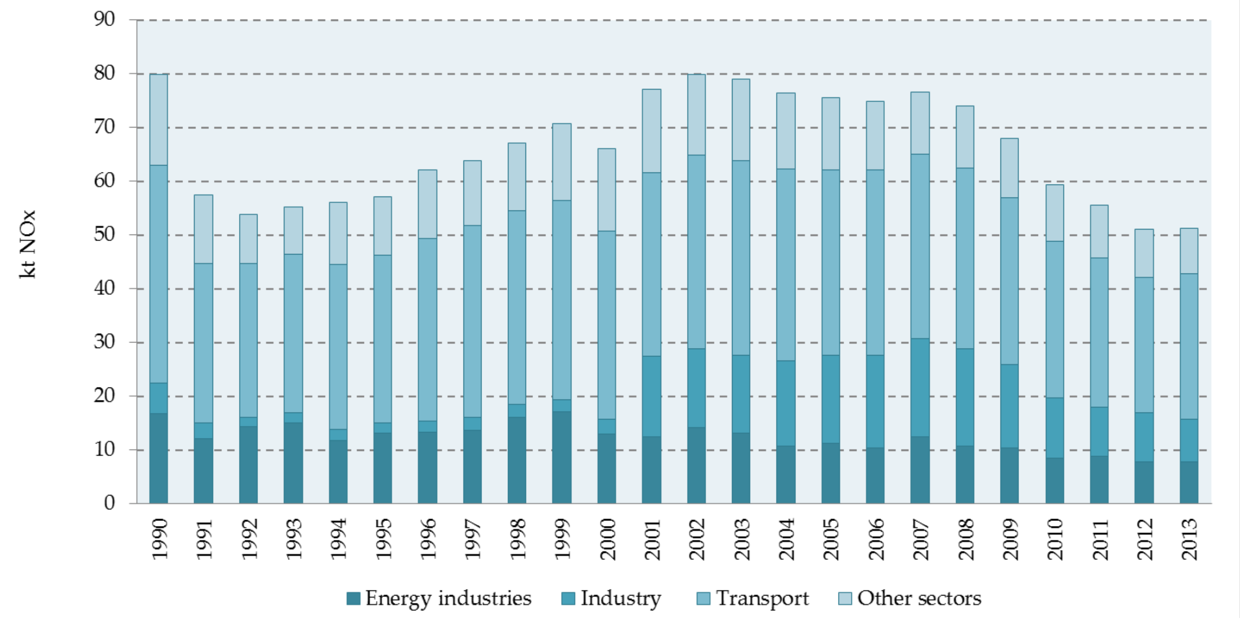
(CLRTAP)' which is Croatia's obligation in the framework of the Long-range Transboundary Air Pollution Convention according to the Act on Air Protection (OG 130/11).

<u>NO_X emissions</u>

The NO_X emission encompasses nitrogen monoxide and nitrogen dioxide emissions. The emissions are expressed as equivalents of NO_2. NO_X is a pollutant that causes acidification and eutrophication. Together with volatile organic compounds and other reactive gases in atmosphere, and in presence of solar radiation, NO_X takes part in ground ozone formation.

The emission of NO_X from Energy sector (Fuel Combustion Activities) in 2013 was 51.3 kt which is 0.6 percent higher than the year before and 36.0 percent lower compared to 1990. The NO_X emissions from Energy sector contribute with approximately 95 percent to national total NO_X emission. The structure of NO_X emission in Energy sector has not changed significantly in the period from 1990 to 2013 (Figure 3.1-8). The main source of NO_X emission is transport (52.7 percent of total emission). Small stationary energy sources accounted for 16.6 percent and emission from industry sectors accounted for 15.7 percent to the energy sector.

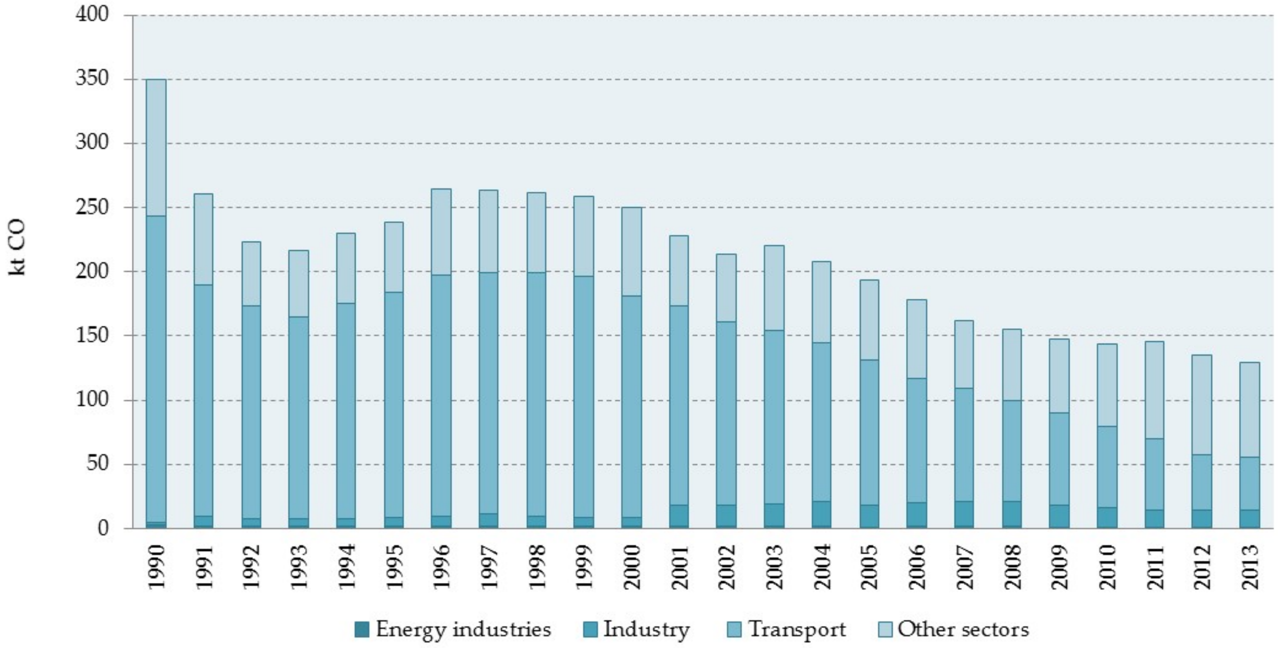
Figure 3.1-8: NOx emissions from Energy sector in the period 1990-2013



CO emissions

In 2013, the emission of CO from Fuel Combustion Activities was 129.7 kt which is 4.1 percent lower than in the year before and 62.9 percent lower compared to 1990, the year with maximum emission (349.5 kt) of CO in the observed period. The CO emissions from Energy sector in 2013 contribute with approximately 90 percent to national total CO emission. 31.8 percent of CO emission in Energy sector in 2013 was the result of incomplete fossil fuel combustion in Road transport sector and 57.3 percent in Commercial and Residential sector (Figure 3.1-9). Large combustion plants have automatic regulation of air throughput and combustion control, so CO emissions are low (about 0.9% of national total emission).

Figure 3.1-9: CO emissions from Energy sector in the period 1990-2013



NMVOC emissions

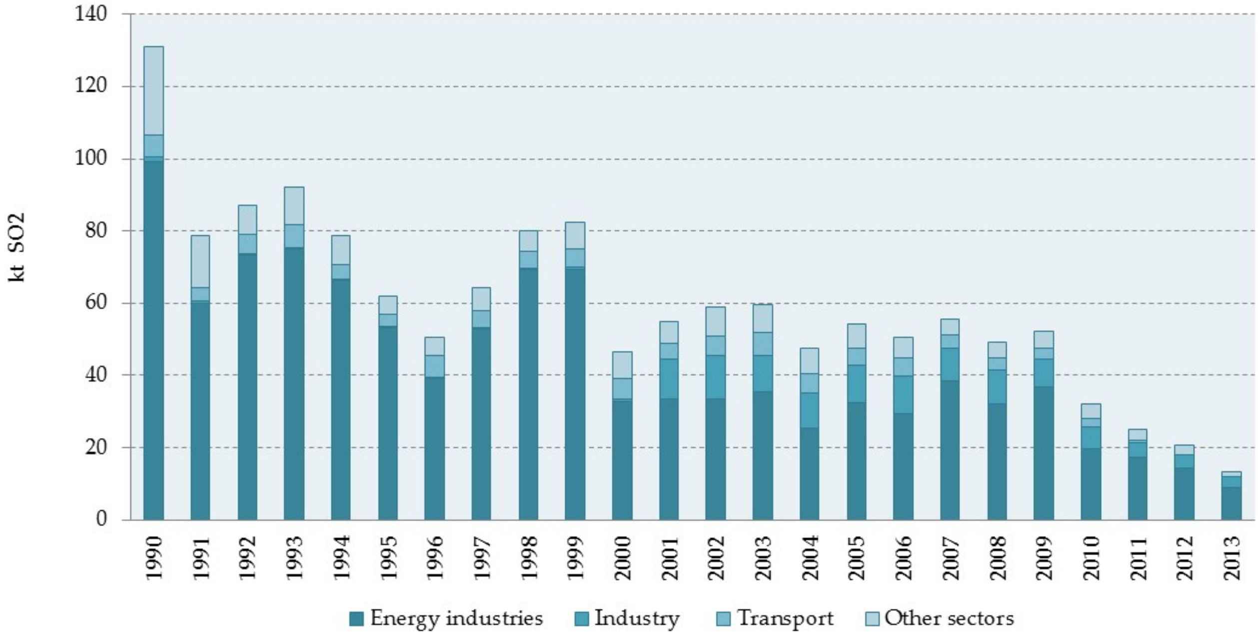
Non methane volatile organic compounds are important because they are precursors in formation of tropospheric ozone. Some of them may have undesirable ecotoxicological properties, for example benzene and xylene. Anthropogenic NMVOCs emissions from Energy sector (Fuel Combustion Activities) were 17.8 kt in 2013 which was 4.9 percent lower than the year before and 58.7 percent lower than 1990. The NMVOC emissions from Energy sector contribute with approximately 33 percent to national total NMVOC emission.

The structure of NMVOC emission from Energy sector has not changed significantly in the period from 1990 to 2013 (Figure 3.2-10). The main source of NMVOC emission is stationary combustion sectors accounted with 66.2 percent to the national total, mainly from the Commercial and Residential sector (54.7 percent).

SO_2 emissions

In accordance with the calculated results, the level of SO_2 emission from Fuel Combustion Activities in 2013 reached 13.3 kt which is approximately 91 percent of total national SO_2 emission. The trend shows that emissions of SO_2 have decreased by 36.2 percent compared to the emission in 2012 and decreased by 90.4 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 2013, 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. Emission trend for SO_2 in the period of 1990 to 2013 as well as the share of the particular sectors in total emission of SO_2 in Energy sector 1990 and 2013 is presented in Figure 3.1-10.

Figure 3.1-10: CO emissions from Energy sector in the period 1990-2013



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 2006 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	2010	2011	2012	2013
Fuel consumption (PJ)								
Ref. approach	284.6	207.7	240.4	282.0	262.8	258.4	235.8	227.2
Sect. approach	286.5	200.0	235.5	280.1	262.5	255.4	236.2	225.5
Rel. Diff.(%)	**0.67**	**-3.69**	**-2.05**	**-0.67**	**-0.12**	**-1.15**	**0.17**	**-0.74**
Ref. approach	19,535.2	13,978.1	16,885.9	20,242.6	18,627.7	18,126.4	16,235.1	16,056.7
Sect. approach	20,248.0	14,381.8	16,718.5	19,963.0	18,317.7	17,977.6	16,436.5	15,949.6
Rel. Diff. (%)	**-3.52**	**-2.81**	**1.00**	**1.40**	**1.69**	**0.83**	**-1.23**	**0.67**

The CO_2 emission calculated by Sectoral approach is lower in comparison to Reference approach. The difference is relatively small (less than 5 percent). The most important difference between sectoral and reference approach is in liquid fuels consumption (Table 3.2-2.).

Table 3.2-2: The fuel consumption and CO_2 emissions from liquid fuels combustion (Reference & Sectoral approach)

	1990	1995	2000	2005	2010	2011	2012	2013
Liquid fuel consumption (PJ)								
Ref. approach	181.10	143.31	152.82	173.49	143.28	143.38	133.67	123.88
Sect. approach	179.45	136.13	147.92	172.01	142.94	140.30	134.04	122.23
Rel. Diff.(%)	**-0.91**	**-5.01**	**-3.21**	**-0.85**	**-0.24**	**-2.15**	**0.27**	**-1.34**
Ref. approach	12,619.0	10,076.0	11,239.9	13,062.7	10,775.3	10,509.6	9,445.0	9,130.7
Sect. approach	13,118.7	10,452.7	11,088.2	12,763.4	10,469.4	10,369.1	9,648.8	9,022.6
Rel. Diff. (%)	**-3.81**	**-3.60**	**1.37**	**2.35**	**2.92**	**1.36**	**-2.11**	**1.20**

The Sectoral Approach is based on sectoral energy consumption data other hand Reference Approach is based on net quantities of fuel imported and produced in Croatia. Apparent consumption (in tonnes) is derived from imports and exports of primary fuels (crude oil, natural gas, coal3), secondary fuels (gasoline, diesel oil etc.) and stock changes. For crude oil, a single value for carbon content and net calorific value is applied, although these properties may vary depending on origin. For solid, gaseous, secondary liquid and other fuels, the same carbon content values and net calorific values are applied as in the Sectoral Approach.

The main cause of difference between Reference and Sectoral Approach is that the energy and carbon content of crude oil may vary over time. However, no data are available to quantify this effect.

In 2013 consumption of solid fuel and CO_2 emission are the same for both approaches while consumption of gaseous fuels is higher in sectoral approach for 0.03% due to consumption of gas works gas in sectoral approach while in reference approach is not accounted.

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:

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.

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 3.2-3.

Table 3.2-3: Fuel consumption and CO_2-eq emissions for International aviation and marine bunkers, from 1990 to 2013

	1990	1995	2000	2005	2010	2011	2012	2013
Liquid fuel consumption (TJ)								
Aviation bunkers	4,849.76	2,638.34	2,393.11	3,194.82	3,421.80	3,565.38	3,665.71	4,009.89
Marine bunkers	1,936.81	1,356.78	757.39	1,047.78	254.96	983.91	NO	NO
Total bunkers	**6,786.57**	**3,995.12**	**3,150.50**	**4,242.60**	**3,676.76**	**4,549.29**	**3,665.71**	**4,009.89**
CO_2-eq emission (kt)								
Aviation bunkers	347.99	189.31	171.72	229.24	245.53	255.83	263.03	292.06
Marine bunkers	148.72	104.13	58.21	80.62	19.83	76.73	NO	NO
Total bunkers	**496.71**	**293.44**	**229.92**	**309.86**	**265.36**	**332.56**	**263.03**	**292.06**

Total CO_2-eq from the international bunker in 2013 amounted to 292.06 kt which is 10% higher than in 2012 as a result of higher fuel consumption in the Aviation bunkers.

Marine bunkers

International marine bunkers are included in national energy balance for the period from 1994 to 2013, as separate data. Until the year 1994, international marine bunkers are based on expert estimation.

In 2013 review process ERT noticed some discrepancies between the fuel consumption data in IEA and CRF tables for marine bunkers. Comparison of this data are given in table 3.2-4.

Table 3.2-4: Comparison of fuel consumption data for marine bunkers for the period from 1990 to 2013

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 small differences. Errors in fuel consumption data in national report for the period from 1990 to 1994 and for 1996 are revised.

Aviation bunkers

In 2014 review process ERT noticed some discrepancies between the fuel consumption data in IEA and CRF tables for aviation bunker fuels. Differences occur due to different methodology of separating total fuel consumed in aviation sector for Inventory purposes and statistic purposes. In Croatian energy balance total fuel consumed in aviation sector is divided on the basis of fuel consumed by domestic and international carriers. For the Inventory purposes data are divided using drivers such as passengers carried to estimate amount of fuel which is actually consumed in international and domestic aviation. The differences in fuel consumption by energy statistics and inventory fuel consumption are given in table 3.2-5. Detailed methodology how total fuel consumption was divided on international and domestic is described in Chapter 3.2.6.2 Methodological issues of Transport sector.

Table 3.2-5: The differences in fuel consumption by energy statistics and inventory fuel consumption for the period from 1990 to 2013

Jet kerosene consumption (1000 t)	1990	1995	2000	2005	2010	2011	2012	2013
Energy statistics	NE	57.0	32.0	38.6	52.7	55.9	65.8	79.2
Inventory	110.32	60.02	54.44	72.68	77.84	81.11	83.39	91.12
Difference (1000 t)	-	3.02	22.44	34.08	25.14	25.21	17.59	11.92

3.2.3. Feedstocks and non-energy use of fuels

Non-energy fuel consumptions (fuels used as feedstock) and appropriate emissions, where one part or even the whole carbon is stored in product for a longer time and the other part oxidizes and goes to atmosphere, are described here. The feedstock use of energy carriers occurs in chemical industry (natural gas consumption for ammonia production, production of naphtha, ethane, paraffin and wax), construction industry (bitumen production), and other products such as motor oil, industrial oil, grease etc. As a result of non-energy use of bitumen in construction industry there is no CO_2 emission because all carbon is bound to the product.

3.2.4. Energy industries (CRF 1.A.1.)

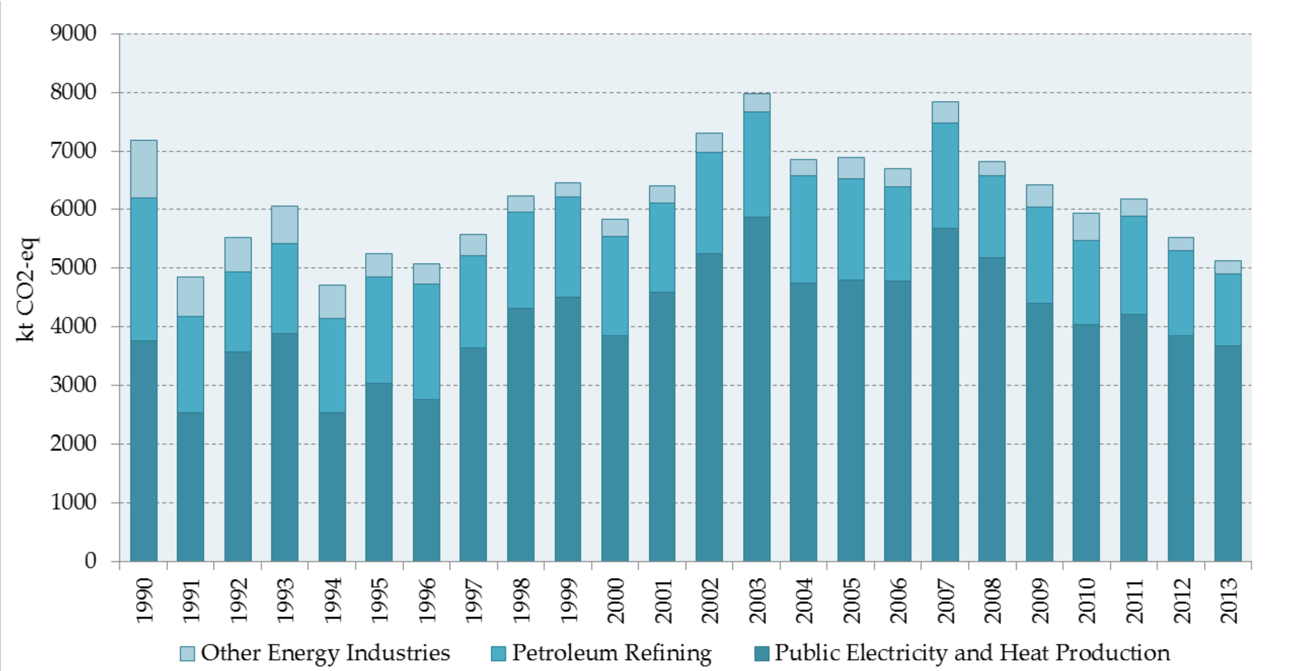
3.2.4.1. Category description

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 3.2-6 and Figure 3.2-1.

Table 3.2-6: The CO_2-eq emissions (kt) from Energy Industries

CO_2-eq emission (kt)	1990	1995	2000	2005	2010	2011	2012	2013
Public Electricity and Heat Production	3,768.15	3,028.75	3,840.22	4,794.78	4,037.19	4,216.15	3,849.45	3,671.03
Petroleum Refining	2,427.24	1,817.60	1,704.29	1,733.78	1,432.57	1,664.11	1,456.51	1,231.93
Other Energy Industries	994.00	396.72	295.02	352.52	461.45	298.40	218.41	229.48
Total Energy Industries	**7,189.38**	**5,243.07**	**5,839.53**	**6,881.09**	**5,931.21**	**6,178.67**	**5,524.37**	**5,132.44**

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 3,857.7 MW (including TPP Plomin and excluding NPP Krško). Total capacities serving the needs of the Croatian electric power system amount to 4,205.7 MW (with 50% of Krško capacities). Out of this amount, 1,671 MW is placed in thermal power plant, 2,286.7 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 3.2-7.

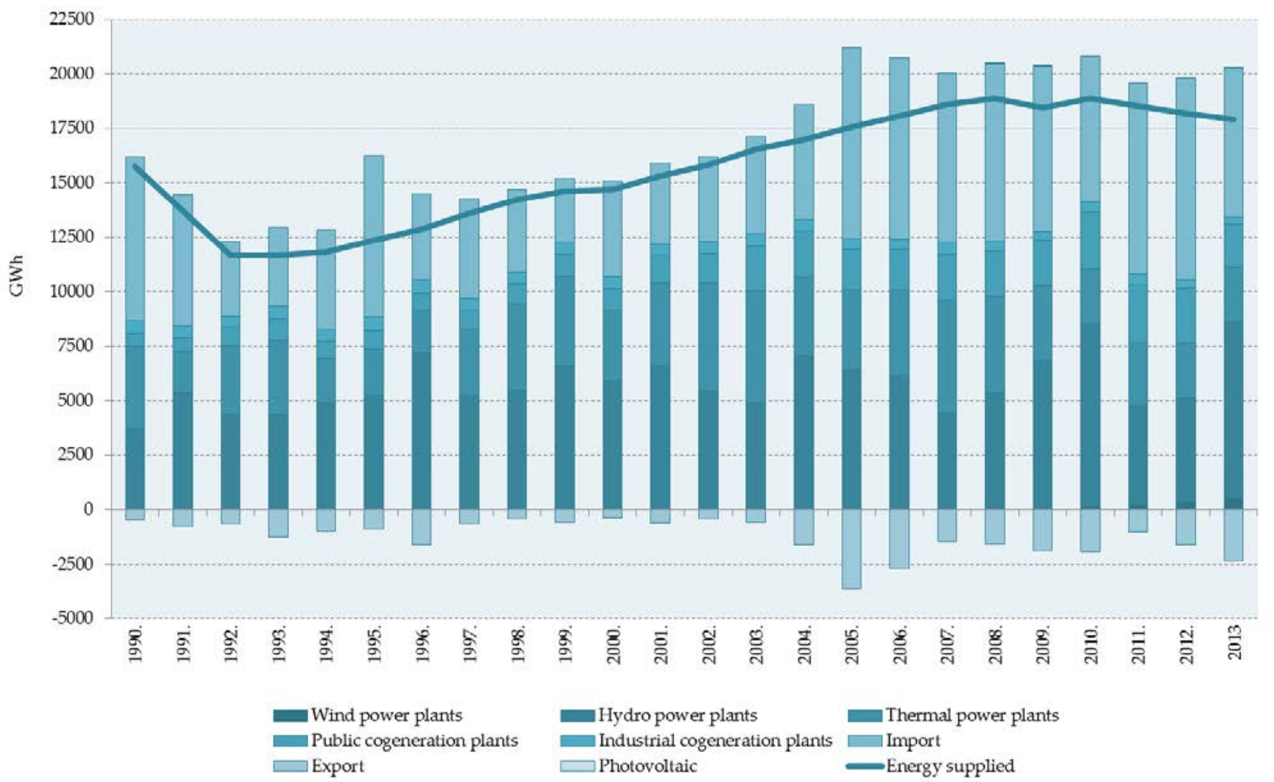
Table 3.2-7: Generating capacities of HPPs, TPPs and NPP Krško

	Available Power (MW) Net Output	**Fuel**
HPPs	2,186.7	-
NPP Krško*	348.00	uranium oxide (UO_2)
TPP Plomin 1	105.00	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)	89.00	fuel oil / natural gas / extra light oil
CPP Osijek	90.00	fuel oil / natural gas / extra light oil
CCGT Jertovec	74.00	natural gas / extra light oil
Total (HPPs+NPP+TPPs)	**4,205.70**	

* 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 2013 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 2013, the import of electricity was about 30 percent of total electricity consumption in Croatia. Electricity supply for the period from 1990 to 2013 is presented in Figure 3.2-2.

Figure 3.2-2: Electricity supply for the period from 1990 to 2013



In this subsector there are few types of plants:

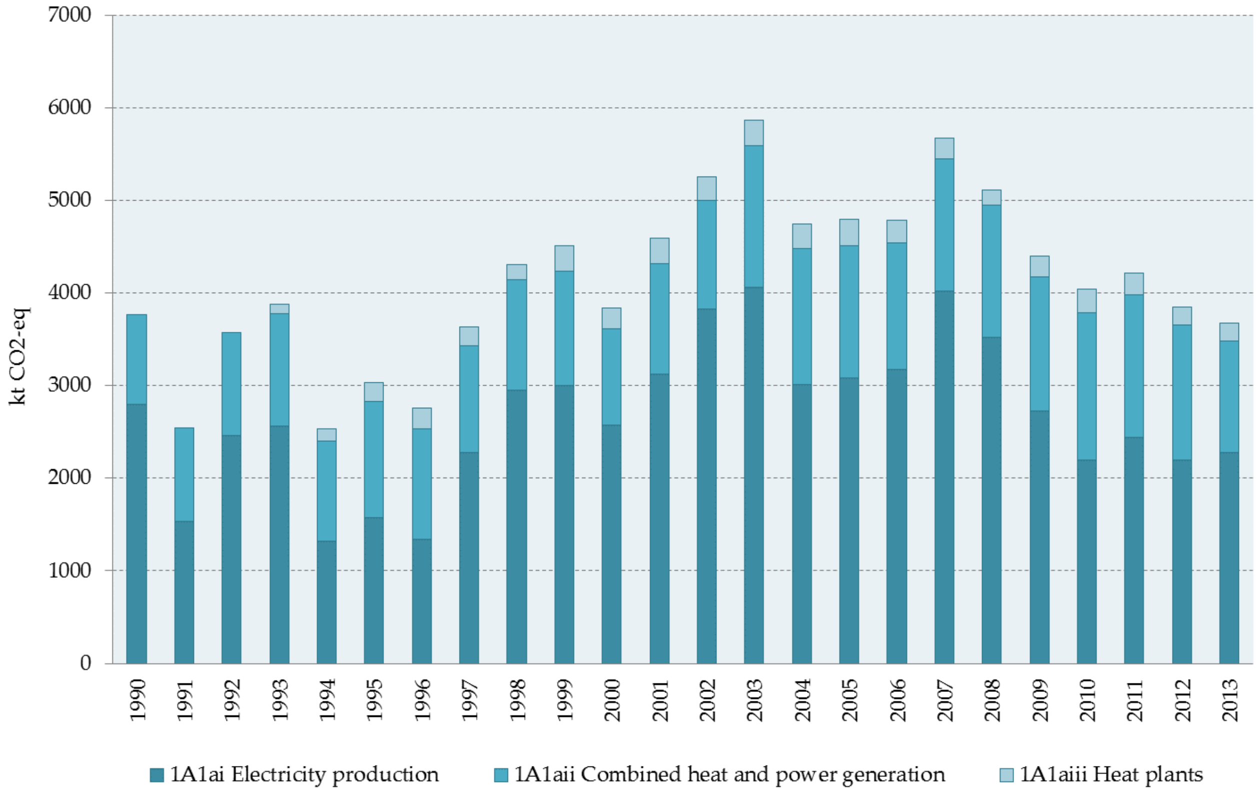
- Thermal Power Plants (TPPs), which produce only electricity
- Public Cogeneration Plants (PCPs), which produce combined heat and electricity
- Public Heating Plants (PHPs), which produce only heat.

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 2013.

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

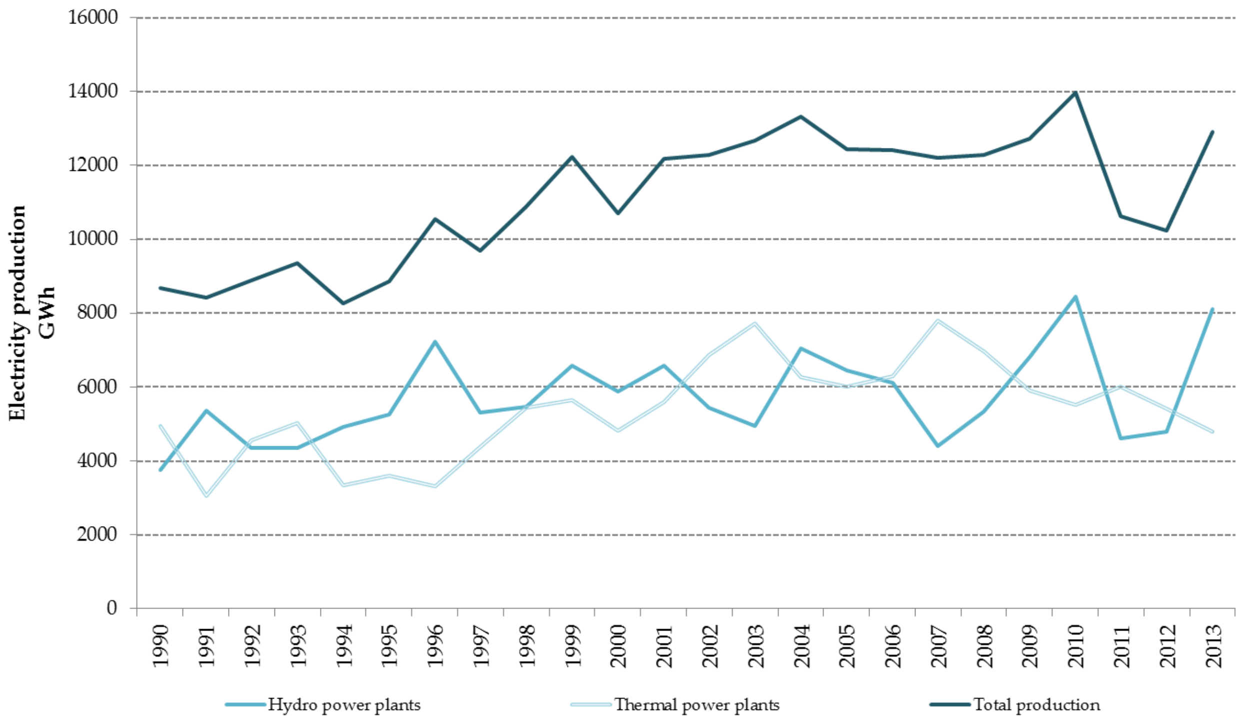


Production of electricity has increasing trend through the years, from 8 TWh (1990) to 13 TWh (2010) but CO_2 emission does not follow this trend. Approximately 53 percent of electricity is generated in hydro power plants (HPP), but this percent depends on hydrological conditions during the year. If 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 2013 is presented in Figure 3.2-4. In 2013, the total electricity production was 1.5 percent lower than in the former year. Decrease in energy consumption from thermal power plants and public cogeneration plants are mostly due to favourable hydrological conditions which leaded to increase in electricity production from hydro power by 68.8 percent (Table 3.2-8).

Table 3.2-8: Differences between electricity production in 2012 and 2013

ENERGY BALANCE	Electricity, GWh		Difference	Difference
	2012	2013	2013-2012	%
Production	10,557.4	13,431.0	2,873.6	27.2
Hydro power plants	4,801.2	8,105.8	3,304.6	68.8
Wind power plants	328.7	517.3	188.6	57.4
Photovoltaic	2.4	11.3	8.9	370.8
Thermal power plants	2,513.1	2,501.2	-11.9	-0.5
Public cogeneration plants	2,529.2	1,968.8	-560.4	-22.2
Industrial cogeneration plants	382.8	326.6	-56.2	-14.7
Import	9,230.8	6,845.3	-2,385.5	-25.8
Export	-1,601.8	-2,354.8	-753.0	47.0
Total consumption	**18,186.4**	**17,921.5**	**-264.9**	**-1.5**

Figure 3.2-4: Domestic production of electricity by sources for the period from 1990 to 2013



Fuel consumption, net calorific values and emission factors used for estimating GHG emissions for the years 1990, 2000, 2005, 2010 and for period 2011-2013 are presented in Tables A3-1 to A3-3 of the Annex 3.

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 3.2-9.

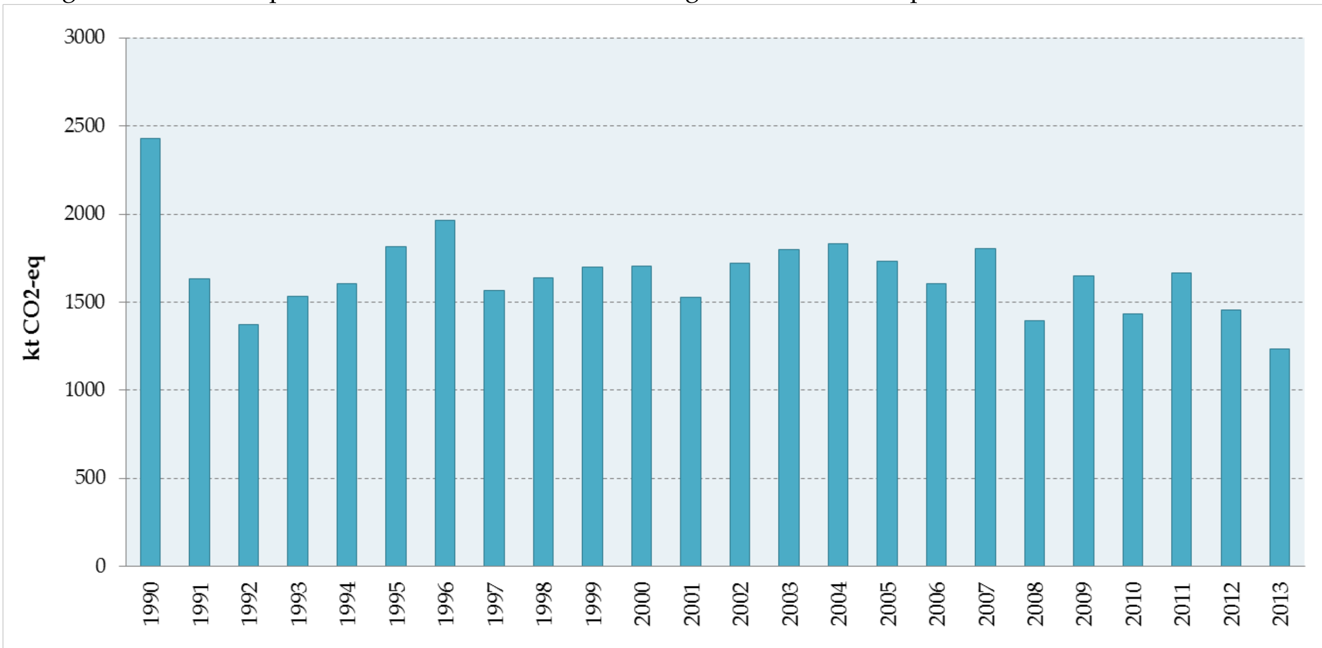
Table 3.2-9: Processing Capacities of Oil and Lube Refineries

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, net calorific values and emission factors used for estimating GHG emissions are presented in Table A2-4 of the Annex 3.

Figure 3.2-5: CO_2-eq emissions from Petroleum Refining subsector for the period from 1990 to 2013



<u>Manufacturing of Solid Fuels and Other Energy Industries (CRF 1.A.1.c)</u>

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.

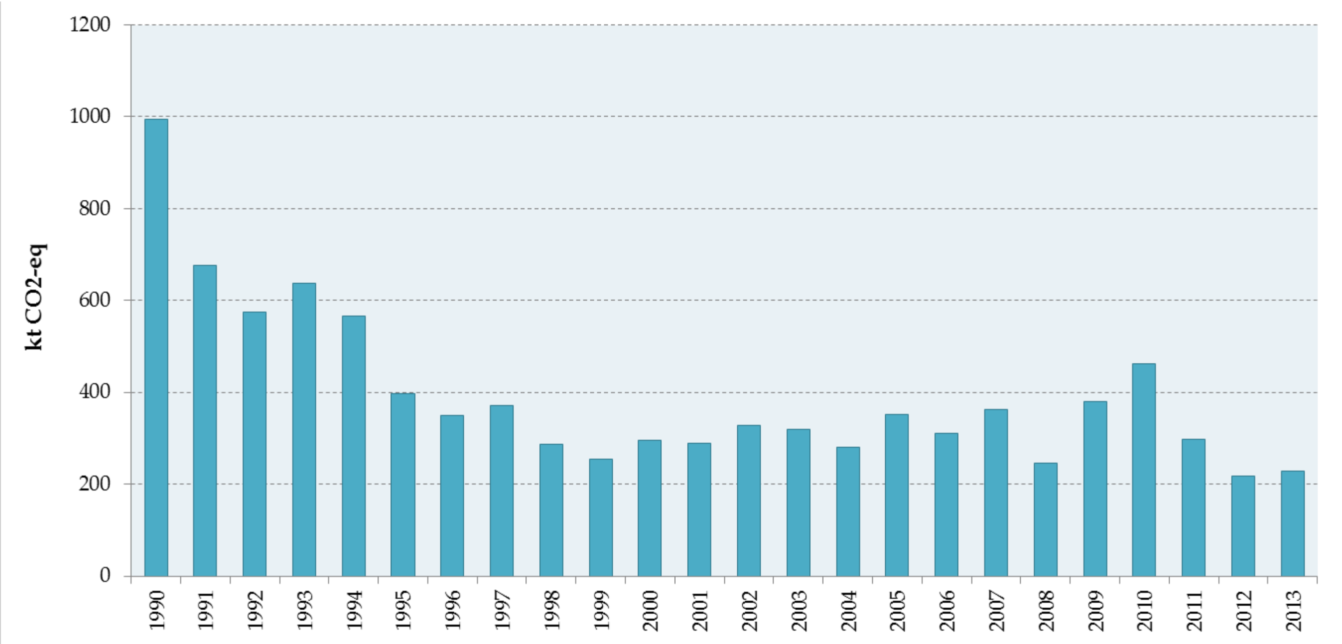
Natural gas is produced from 17 on-shore gas fields and 9 off-shore gas fields, which covers about 67.7 percent of total domestic demand in 2012. The largest share of gas is coming from fields Molve and Kalinovac. They include the units for processing and preparation of gas for transportation to Central Gas Stations (CGS) Molve I, II and III. Their capacities are:

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

The underground gas storage Okoli was designed with the nominal capacity of 553 million 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 2013 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 2013



Fuel consumption, net calorific values and emission factors used for estimating GHG emissions from Manufacturing of Solid Fuels and Other Energy Industries are presented in the Tables A3-5 to A3-7 of the Annex 3.

3.2.4.2. Methodological issues

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 (2006 IPCC Guidelines for National GHG Inventories). It is assumed that combustion process is 100 percent efficient, so oxidation factor was 1.

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 2006 IPCC Guidelines for National GHG Inventories. 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.

3.2.4.3. 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 5 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 2006 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.

Time-series consistency

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

3.2.4.4. Category-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, 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.

3.2.4.5. Category-specific recalculations

For emission calculation new 2006 IPCC Gudelines was used instead of old ones. Recalculations are mainly made because of new emission factors which are given in 2006 IPCC Guidelines.

3.2.4.6. Category-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 are 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.

3.2.5. Manufacturing industries and construction (1.A.2)

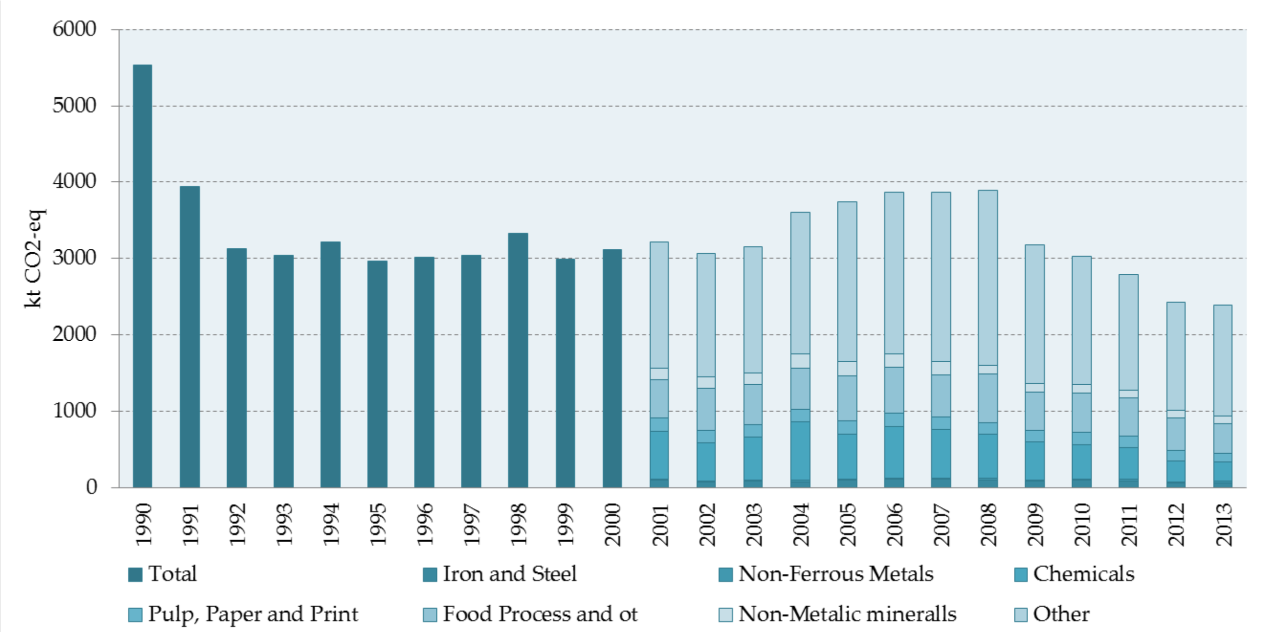
3.2.5.1. Category description

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 2013. The total GHG emission from Manufacturing Industries and Construction is given in the Table 3.2-10 and Figure 3.2-7.

Table 3.2-10: The CO_2-eq emissions (kt) from Manufacturing Industries and Construction

	1990	1995	2000	2005	2010	2011	2012	2013
Iron and Steel Industry	IE	IE	IE	89.16	93.13	84.26	51.17	58.50
Non-Ferrous Metals	IE	IE	IE	21.25	14.02	18.56	19.75	19.96
Chemicals	IE	IE	IE	581.70	450.18	418.19	280.05	253.46
Pulp, Paper and Print	IE	IE	IE	175.00	162.15	148.78	127.12	113.79
Food Proc., Bev. and Tobac.	IE	IE	IE	594.22	515.38	497.10	430.87	389.05
Non-metallic minerals	IE	IE	IE	192.57	115.46	112.30	100.05	96.60
Other	IE	IE	IE	2,085.16	1,679.80	1,512.94	1,412.88	1,461.42
Total Manuf. Ind. and Cons.	**5,529.04**	**2,967.87**	**3,115.63**	**3,739.05**	**3,030.11**	**2,792.12**	**2,421.88**	**2,392.78**

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.

3.2.5.2. 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 2001-2013 (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 (2006 IPCC Guidelines for National GHG Inventories).

Fuel consumption, net calorific values and emission factors used for estimating GHG emissions from Manufacturing Industries and Construction by fuels are shown in Tables A3-8 and A3-9 of the Annex 3.

3.2.5.3. 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 5 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 2006 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 5 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.

3.2.5.4. Category-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.

3.2.5.5. Category-specific recalculations

For emission calculation new 2006 IPCC Gudelines was used instead of old ones. Recalculations are mainly made because of new emission factors which are given in 2006 IPCC Guidelines.

3.2.5.6. Category-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.

3.2.6. Transport (1.A.3)

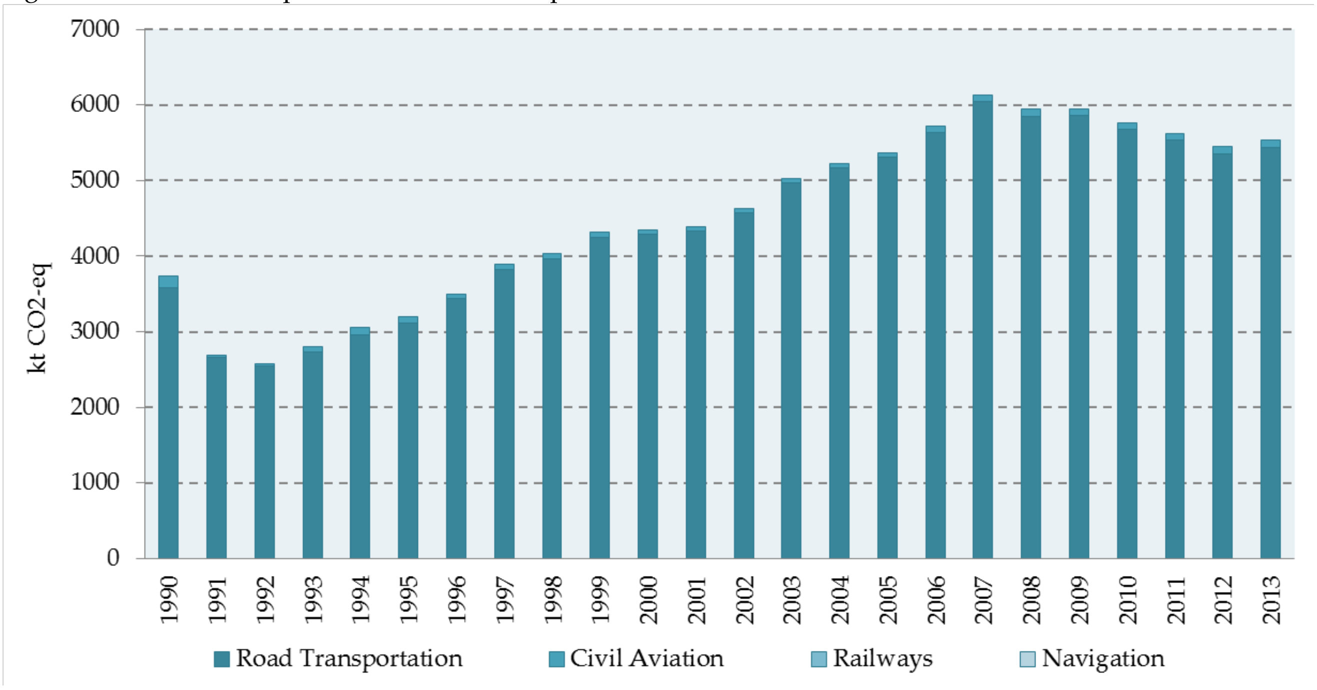
3.2.6.1. Category description of Transport sector

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 3.2-11 and Figure 3.2-8.

Table 3.2-11: The CO_2-eq emissions (kt) from sector Transport

	1990	1995	2000	2005	2010	2011	2012	2013
Civil Aviation	157.62	80.13	55.98	67.85	82.58	91.58	96.39	104.87
Road Transport	3,585.17	3,120.14	4,285.67	5,304.27	5,677.55	5,534.50	5,359.46	5,439.06
Railways	153.50	118.55	96.39	107.74	100.67	93.25	87.60	82.66
Navigation	135.78	100.34	87.52	101.69	117.56	118.86	113.09	123.11
Total Transport	**4,032.07**	**3,419.16**	**4,525.56**	**5,581.55**	**5,978.36**	**5,838.19**	**5,656.55**	**5,749.69**

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 2013 was 31.7%. CO_2-eq emissions from the transport sector in 2013 amounted to 5,749.7 kt, which is 1.7% higher than in 2013 as a result of more 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 2013 and contributed to the CO_2-eq emissions from the transport sector with 94.6%. In 2013, the Navigation sector was contributed to the CO_2-eq emissions with 2.1%, Civil aviation (domestic) with 1.8% and Railways with 1.4% and (Figure 2.3-8).

In comparison with 1990, CO_2-eq emissions from the transport sector were increased by 30% 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 2013 was amounted to 104.87 kt, which is 8.1% higher than in 2012, as a result of fuel jet kerosene consumption increase. In comparison with 1990, CO_2-eq emission was by 50.3% 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 22.2 percent in 2013 and 10.2 percent in 1990. In the period from 1990 to 2013 emissions from road transportation rised by 65.9 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 2013 was amounted to 82.66 kt, which is 6.1% lower than in 2011 as a result of decrease of fuel diesel consumption. In comparison with 1990, CO2-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 CO2-eq from the sub-sectors Navigation in 2012 was amounted to 111.2 kt, which is for 5.6% lower than in 2012 as a result of increase in fuel consumption. In comparison with 1990, CO_2-eq was decreased by 53.8% as a result of decrease in navigation traffic and consequently decreases in fuel consumption.

3.2.6.2. 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.

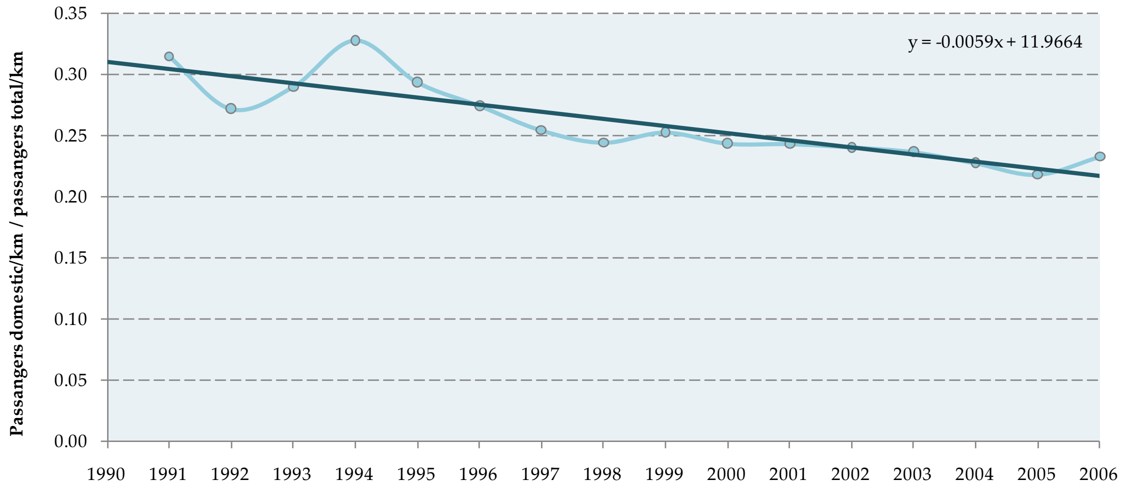
Emissions from domestic aviation estimate by using drivers such as ratio of domestic/international passengers, taking into account average km traveled for passengers on domestic/international routes. So, total jet kerosene consumption from Energy balance was divided to domestic and international aviation according to average km traveled per passenger on domestic/international routes (Table 3.2-12). Data were obtained from Statistical yearbooks and Energy balance.

Table 3.2-12: Estimation of civil aviation drivers

	1990	1995	2000	2005	2010	2011	2012	2013
Total jet kerosene (10^3 t)	160.0	85.0	72.0	93.0	103.3	109.4	113.3	123.8
Passangers carried - Total (10^3)		679.0	1,072.0	2,099.	1,861.	2,078.	1,960.9	1,812.0
Passangers carried – intern. (10^3)		346.0	712.0	1,633.	1,418.	1,571.	1,460.0	1,349.1
Passangers carried – domastic (10^3)		333.0	360.0	466.0	443.0	507.0	500.9	462.9
Passangers kilometers- total (10^6)		444.0	763.0	1,989.	1,510.	1,591.	1,451.0	1,451.0
Passangers kilometers-inter. (10^6)		317.0	656.0	1,842.	1,370.	1,430.	1,292.0	1,292.0
Passangers kilometers-dom. (10^6)		127.0	107.0	147.0	140.0	161.0	159.0	159.0
Passangers domestic/km		381.4	297.2	315.5	316.0	317.6	317.4	343.5
Passangers international/km		916.2	921.3	1,128.	966.1	910.2	884.9	957.6
Passangers intern.+domastic		1,297.6	1,218.6	1,443.	1,282.	1,227.	1,202.4	1,301.2
share domestic	0.31	0.29	0.24	0.22	0.25	0.26	0.26	0.26
Jet kerosene in domestic aviation (kt)	49.68	24.98	17.56	20.32	25.46	28.29	29.91	32.68
Jet kerosene in intern. aviation(kt)	110.3	60.02	54.44	72.68	77.84	81.11	83.39	91.12

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, 2010 and for period 2011 - 2013 are shown in Table A3-11 Annex 3.

In 2013 and 2014 ARR ERT recommended that Cratia should improve the accurancy and transparency of its reporting in its next NIR by adopting an approach in accoridinance with IPCC good practice guidance, such as using aviation fuel use survays, sales statistics and origin-destination statistic to obtain actual jet kerosene consumption figures for domestic and international aviation. In 2014 Croatia lunched the project ''Development of methodologies for data assessments of emissions from transport with integral impact assessment sector on the environment - phase 1. information on activities for aviation and railways''. Through this project data on LTO Cycles in domestic and international transport was gathered for the period from 1990 to 2013. In cooperation with domestic airline companies and Croatian jet kerosene supplier only data on fuel sold was available, data on fuel used in domestic and international transport was not available for all airline companies. For only one airline company which is in EU ETS system data on actual fuel consumption on domestic and international routes was available. Croatian fuel supplier has only data on fuel sold to domestic and in international carriers. So it is decided that current approach is for now only way for dividing fuel consumed on domestic and international routes.

In 2014 new projects named ''Technical assistance in the business statistics development, preparation of documents on the data quality and improving the data collection system'' by Energy Institute Hrvoje Požar was lunched. This projects were launched in the framework of the IPA 2009

Programme and covered the area of energy statistics and improvement of methodologies of data collection in the final energy consumption sectors: households, services and transport. The aim of projects is to determine the energy consumption indicators based on the survey of energy consumption and according to EUROSTAT's list of variables and models for calculating energy efficiency. One of result will be to determine actual consumption on domestic and international routes. It is expected that results of this project for the period from 1990 to 2014 will be available at the end of 2015. If data will available as it was predicted it is planned to use those data in National Inventory Report for 2016 as well as data on LTO cycles.

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 2006 IPCC guidance. Amounts of all types of liquid and gaseous fuels consumed for the whole period from 1990 to 2013 were extracted from national energy balances. Emissions factors used for calculating CO_2 emissions from liquid fuels are from 2 IPCC guidelines.

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 balances 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.

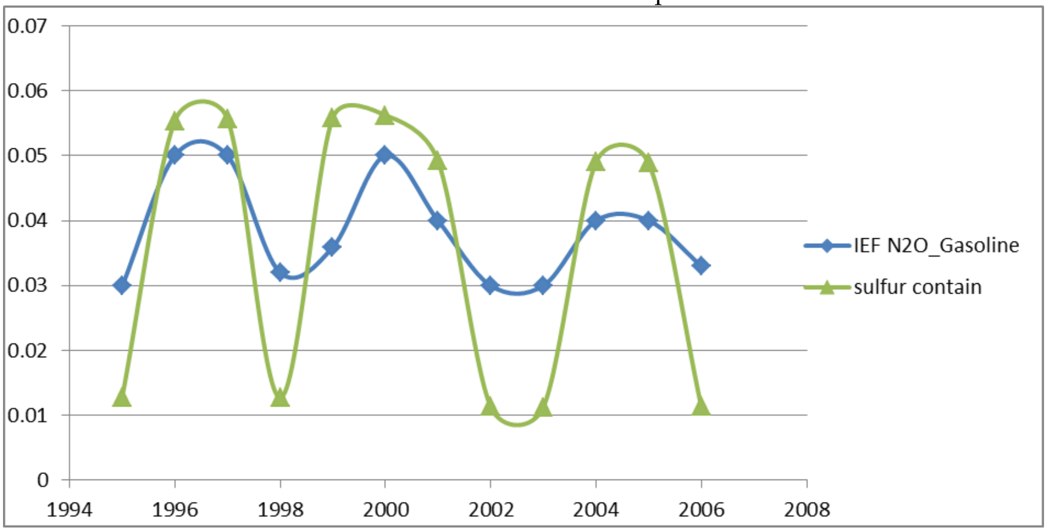
Two assumptions/adjustments are applied in the COPERT model:

- 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, 2010 and for period 2011 – 2013 are presented in the Table A2-10 of the Annex 3. Comparing the total number of vehicles in 2013 with the number of vehicles in 1990 it can be notice the increase by 24.2 percent. The increase was largely the result of increase in the number of passenger cars by 16.5 percent, constituting 82.2 percent of the total number of road vehicles in 2013. Other classes of vehicles were also increased in this period: the number of Light Duty vehicles increased by 50.6 percent, Heavy Duty vehicles included buses decreased by 4.2 percent, motorcycles and mopeds by 79.5 percent. It is important to emphasize that number of registered vehicles gradually decreased in the period 2008-2013 due to economic crisis, where number of passenger cars which have a highest share in total number of vehicles decreased by 14.4 percent.

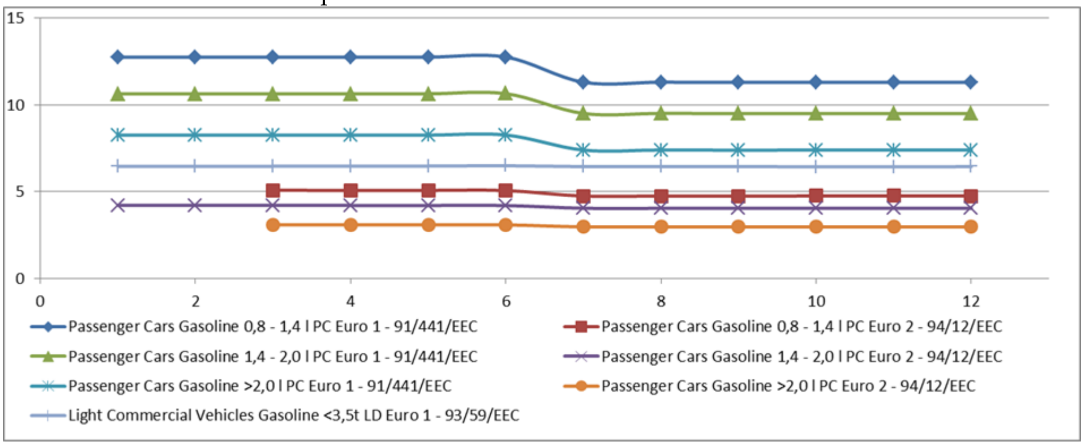
During review of NIR 2014, ERT noticed the fluctuation in the IEF values for the time period 1995-2006 for N_2O emissions. Fluctuations occur only in Sector Passenger cars , subsector Gasoline 0,8-1,4 l, 1,4-2,0 l and >2,0 l, Technology PC Euro 1. These fluctuations are direct in line with fluctuations 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 N_2O and fluctuations on sluphur content of the fuel



For conformation of this statement, N_2O emission calculation with constant sulfur contain for Passenger Euro I Gasoline vehicles was performed. Obtained IEF for N_2O did not have fluctuations (see figure 3.2-11).

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

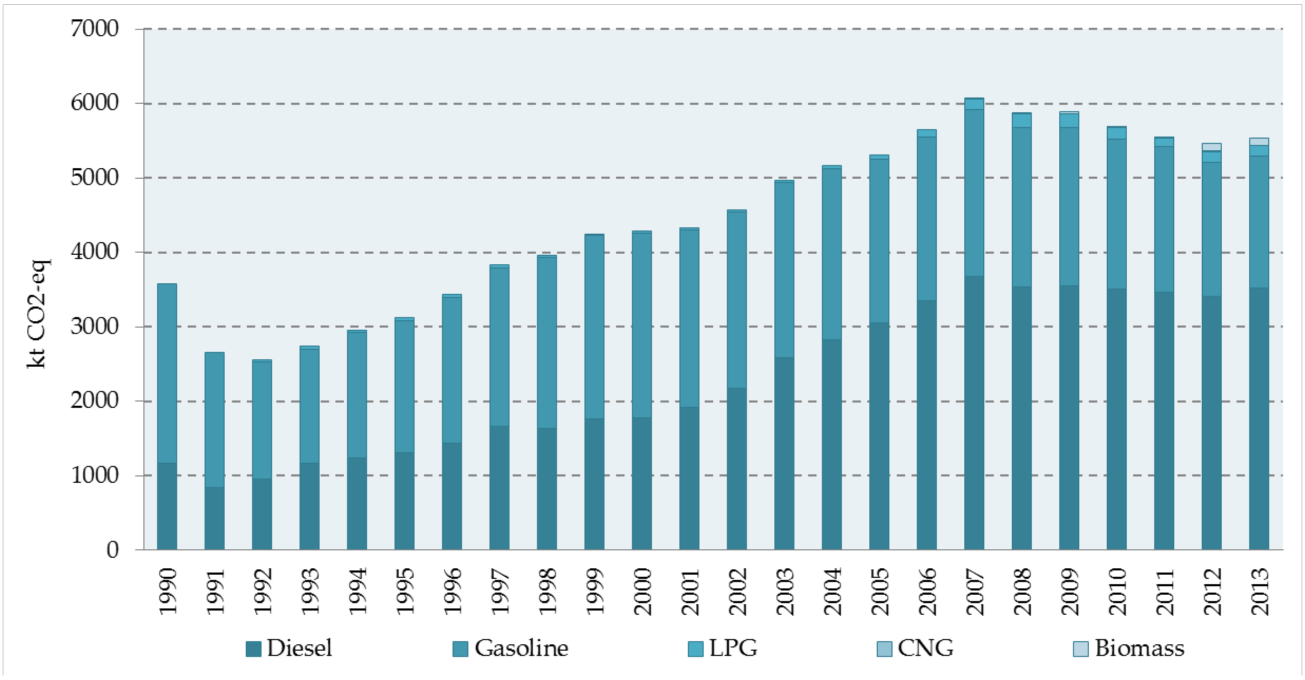


Amounts of fuels consumed, their net calorific values and appropriate GHG emission factors and GHG emissions in the sub-sector Road transport for the years 1990, 2000, 2005, 2010 and for period 2011 - 2013 are shown in Table A3-12 Annex 3.

The CO_2-eq from the sub-sectors Road transport in 2013 amounted to 5,439.06 kt, which is 1.5 percent more than in 2012 as a result of increase in fuel consumption. In comparison with 1990, CO_2-eq increased by 34.1 percent as a result of grow in diesel fuel consumption (by 3.0 times compared to 1990). At the same time gasoline consumption was decreased by 25.6%.

Trends of CO_2-eq emissions for fossil fuel type consumed in road transport for the period from 1990 to 2013 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 2013



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.

In 2014 Croatia lunched the project ''Development of methodologies for data assessments of emissions from transport with integral impact assessment sector on the environment - phase 1. information on activities for aviation and railways''. Through this project data on type of engine for locomotives were gathered for the period from 1999 to 2013 so default emission factors for CH_4 and N_2O were modified depending on the engine design.

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, 2010 and for period 2011 - 2013 are shown in the Table A3-13 of the Annex 3.

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, 2010 and for period 2011 - 2013 are shown in the Table A2-14 of the Annex 3.

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 estimated uncertainty of data from energy balance is below 5 percent. The accuracy of data on net calorific values, which are also taken from national energy balance, is high.

There are more uncertainties in data on international marine and aviation bunkers. Nevertheless, possible errors in estimated values do not significant 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 2006 IPCC Guidelines.

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.

3.2.6.4. Category-specific QA/QC and verification

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

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

Source-specific quality check in road transportation included comparison of results of emission calculation obtained independently with Tier 1 (top-down) and Tier 2/3 (COPERT model) approach for CO2 emissions from liquid fuels. This is in line with recommendation from the IPCC good practice guidance. The difference between these two approaches is 0.57 percent for combined CO2 emissions from gasoline and diesel oil in 2013, 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 (1990-2013) 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.

3.2.6.5. Category-specific recalculations

For emission calculation new 2006 IPCC Gudelines was used instead of old ones. Recalculations are mainly made because of new emission factors which are given in 2006 IPCC Guidelines.

3.2.6.6. Category-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.

3.2.7. Other sectors (CRF 1.A.4)

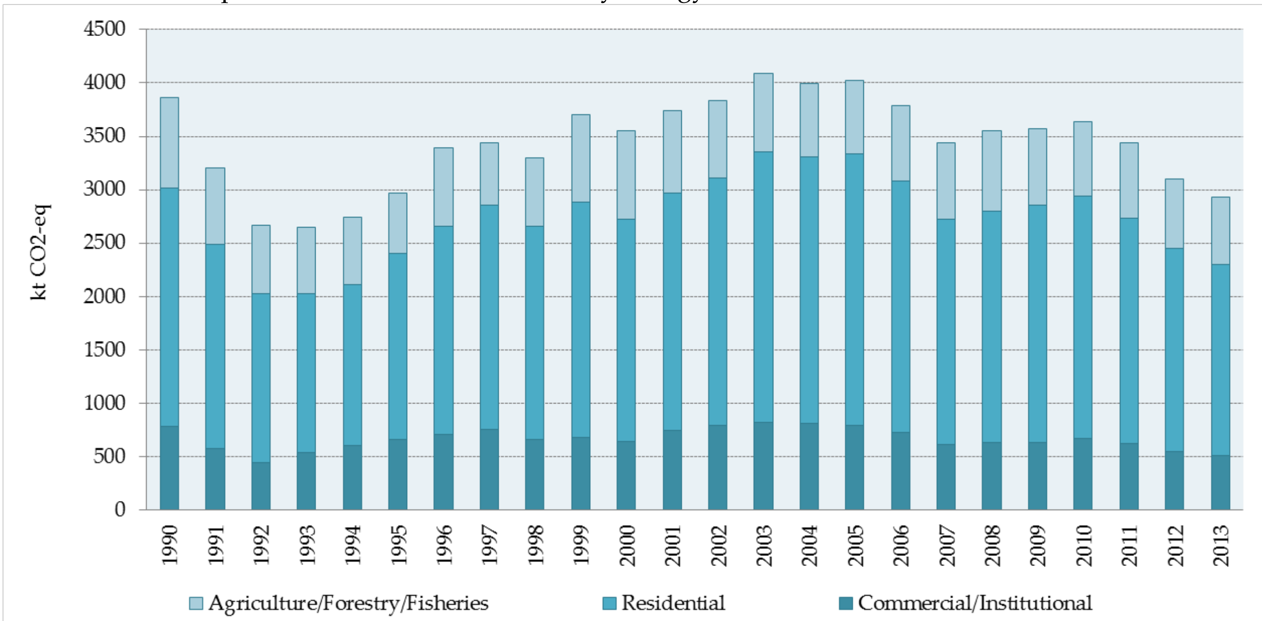
3.2.7.1. Category description

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 3.2-12 and Figure 3.2-13.

Table 3.2-13: The CO_2-eq emissions (kt) from Small Stationary Energy Sources

	1990	1995	2000	2005	2010	2011	2012	2013
Commercial/Institutional	782.76	664.66	643.95	792.74	674.23	620.95	545.77	512.07
Residential	2,236.84	1,738.14	2,075.87	2,538.45	2,264.33	2,117.16	1,906.39	1,784.09
Agric./Fores/Fishing	840.06	565.29	833.67	695.43	701.18	700.16	652.85	638.49
Total	**3,859.66**	**2,968.09**	**3,553.50**	**4,026.62**	**3,639.74**	**3,438.26**	**3,105.01**	**2,934.65**

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.

3.2.7.2. 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 2006 IPCC Guidelines. Values for fraction of carbon which oxidizes were taken from 20066 IPCC Guidelines as recommended.

The fuel consumption and GHG emissions for Commercial/Institutional, Residential and Agriculture/Forestry/Fishing are presented in Tables A3-15, A3-16 and A3-17 of the Annex 3.

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 estimated uncertainty of data from energy balance is below 5 percent. The accuracy of data on net calorific values, which are also taken from national energy balance, is high.

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 2006 IPCC Guidelines.

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.

3.2.7.4. Category-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.

3.2.7.5. Category-specific recalculations

For emission calculation new 2006 IPCC Gudelines was used instead of old ones. Recalculations are mainly made because of new emission factors which are given in 2006 IPCC Guidelines.

3.2.7.6. Category-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.

3.3. FUGITIVE EMISSIONS FROM SOLID FUELS AND OIL AND NATURAL GAS AND OTHER EMISSIONS FROM ENERGY PRODUCTION (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)

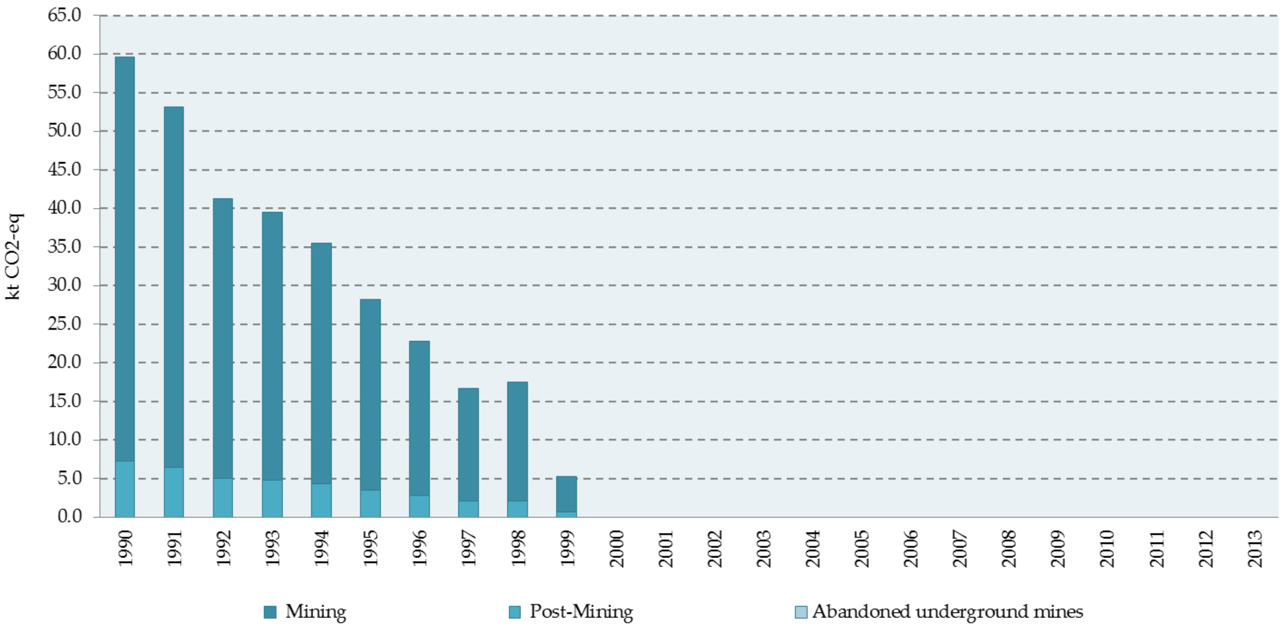
3.3.1.1. Category description

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 2006 IPCC Guidelines. Used emission factors are an average value of the range proposed in the IPCC Guidelines. For underground mines, for mining activities emission factor of 18.0 m^3CH_4/t was used and for Post-mining activities 2.5 m^3CH_4/t was used. Conversion factor amounted 0.67 kt CH_4 /million m^3.

In 2006 IPCC Guidelines new activity Abandoned underground coal mines is included. Numbers of abandoned mines and technology of closing were gathered for the period from 1951 till 2013. For the period from 1901 to 1950 were not available. According to 2006 IPCC Guidelines it is good practice to include mines that are known to be fully flooded in databases and other records used for inventory development, but they should be assigned an emission of zero as the emissions from such mines are negligible (2006 IPCC, page 4.23) so data on abandoned mines are given in table 3.3-1.

Table 3.3-1: Number of abandoned underground mines with closing technology for the period 1901-2013

Period	Number of abandoned underground mines	Closing technology		CH_4 emission
		Closing technology	Number of mines	
1901-1925	-	Fully Flooded Mines	-	-
		Partially Flooded Mines	-	-
		Unflooded	-	-
1926-1950	-	Fully Flooded Mines	-	-
		Partially Flooded Mines	-	-
		Unflooded	-	-
1951-1975	35	Fully Flooded Mines	35	0
		Partially Flooded Mines	-	-
		Unflooded	-	-
1976-1999	8	Fully Flooded Mines	8	0
		Partially Flooded Mines	-	-
		Unflooded	-	-
2000-2013	1	Fully Flooded Mines	1	0
		Partially Flooded Mines	-	-
		Unflooded	-	-

The coal production data and emissions of methane from mining and post-mining activities are shown in Table A3-18, Annex 3.

3.3.1.3. Uncertainties and time-series consistency

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.

Time-series consistency

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

3.3.1.4. Category-specific QA/QC 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. Category-specific recalculations

For emission calculation new 2006 IPCC Gudelines was used instead of old ones. Recalculations are mainly made because of new emission factors which are given in 2006 IPCC Guidelines.

3.3.1.6. Category-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. Oli and natural gas (CRF 1.B.2)

3.3.2.1. 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 3.3-2.

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

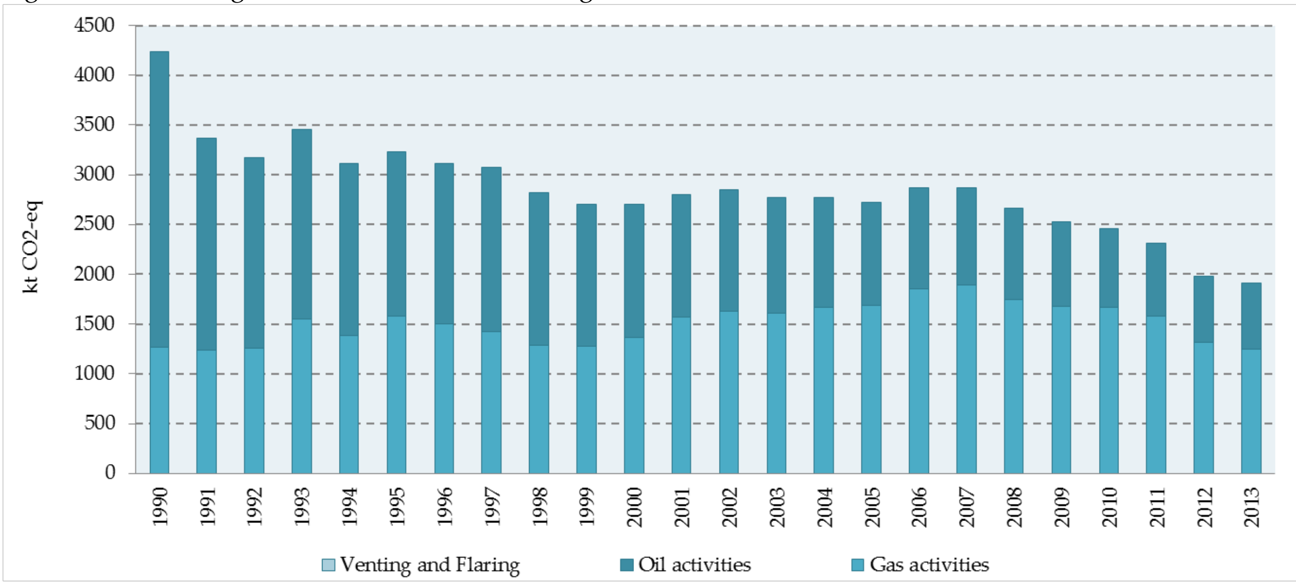
CO_2 emission (kt)	1990	1995	2000	2005	2010	2011	2012	2013
Central Gas Station MOLVE	415.949	739.268	633.016	691.245	487.261	509.038	429.194	429.194

The total GHG fugitive emission from oil and natural gas systems are shown in the Table 3.3-3 and Figure 3.3-2.

Table 3.3-3: The CO_2-eq emissions (kt) from oil and gas systems

	1990	1995	2000	2005	2010	2011	2012	2013
Oil activities	2,967.45	1,650.91	1,336.09	1,041.76	793.48	731.70	660.62	661.64
Gas activities	1,265.21	1,580.70	1,368.91	1,683.76	1,662.59	1,580.61	1,317.43	1,251.77
Venting and Flaring	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
Total	**4,232.66**	**3,231.61**	**2,705.00**	**2,725.51**	**2,456.07**	**2,312.32**	**1,978.05**	**1,913.42**

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.

The activity data and emission factors used to calculate fugitive emissions from oil and gas are shown in Table A3-19 and A3-20, Annex 3

Fugitive emission of ozone precursors and SO2

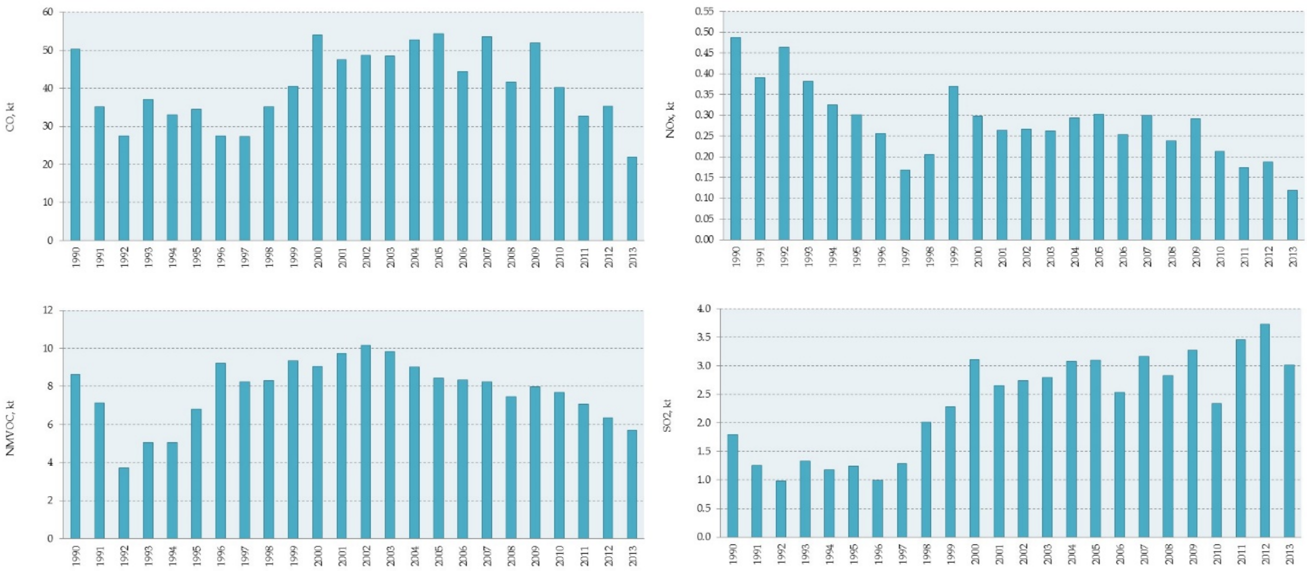
Emissions of indirect GHGs for whole time period (1990-2013) was set up according to the EMEP/CORINAIR methodology. Emissions were obtained from the emission inventory report 'Republic of Croatia Informative Inventory Report for 2013, under Convention on Long-range Transboundary Air Pollution (CLRTAP)' 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 3.3-4 and Figure 3.3-3.

Table 3.3-4: The fugitive emissions of ozone precursors and SO_2 from fugitive emissions sector

Emissions (kt)	1990	1995	2000	2005	2010	2011	2012	2013
CO emission	50.32	34.52	54.07	54.42	40.12	32.65	35.37	21.98
NO_x emission	0.49	0.30	0.30	0.30	0.21	0.17	0.19	0.12
NMVOC emission	8.64	6.80	9.06	8.45	7.67	7.06	6.35	5.70
SO_2 emission	1.80	1.24	3.11	3.10	2.33	3.46	3.73	3.02

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



3.3.2.2. Methodological issues

<u>Fugitive emission of CH_4</u>

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 in developing countries and countries with economies in transition (2006 IPCC Guidelines, pages 4.55-4.62). 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.

The emission factors used for calculation are taken from 2006 IPPC Guidance (Table 4.2.5).

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 3.

3.3.2.3. Uncertainties and time-series consistency

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.

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 (±5 percent).

Time-series consistency

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

3.3.2.4. Category-specific QA/QC and verification

For fugitive emissions from oil and gas operations a Tier 1 method was applied and emission factor is value proposed in the 2006 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. Category-specific recalculations

For emission calculation new 2006 IPCC Gudelines was used instead of old ones. Recalculations are mainly made because of new emission factors which are given in 2006 IPCC Guidelines.

3.3.2.6. Category-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 2) is necessary. On long term basis, inventory team is planning apply Tier 2 approach for calculation of fugitive emissions from oil and natural gas operations.

3.4. CO_2 TRANSPORT AND STORAGE (CRF 1.C)

CO_2 transport and CO_2 storage is not occurring in Croatia.

CHAPTER 4: INDUSTRIAL PROCESSES AND PRODUCT USE (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, glass and ammonia. 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 *2006 IPCC Guidelines*, 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[1] prescribes obligation and procedure for emissions monitoring, which comprise estimation and/or reporting of all anthropogenic emissions and removals. According to the

[1] Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia (OG 87/12)

requirement, sources of abovementioned greenhouse gases are responsible to report required activity data for more accurate emissions estimation.

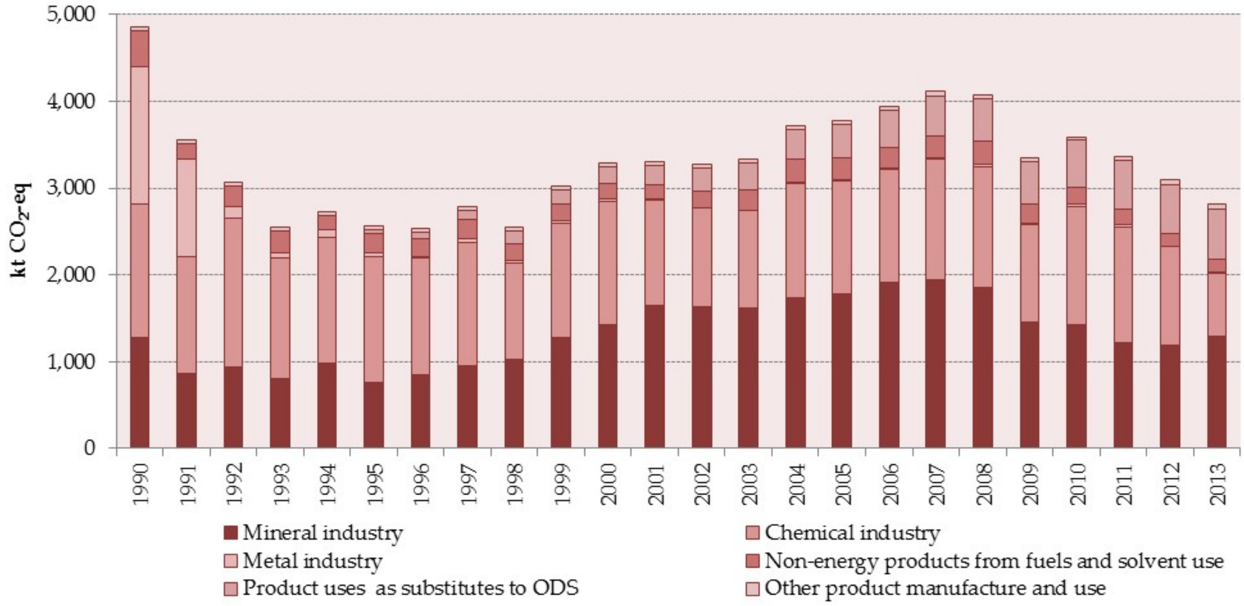
Emission factors used for calculation of emissions are, in most cases, default emission factors according to *2006 IPCC Guidelines*, mainly due to a lack of plant-specific emission factors. Country-specific emission factors for cement and lime production as well as plant-specific emissions factor for 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 *2006 IPCC Guidelines*, 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 2013 still considerably lower than in 2008.

The total annual emissions of GHGs, expressed in kt CO_2-eq, from Industrial Processes and Product Use in the period 1990-2013 are presented in the Figure 4.1-1.

Figure 4.1-1: Emissions of GHGs from Industrial Processes and Product Use (1990 - 2013)



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 2013[2]

Table							
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2013)							
A	B	C	D				E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification				Com.
Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning - HFCs and PFCs	HFCs, PFCs	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i	
Chemical Industry - Ammonia Production - CO2	CO2	Yes	L1e	T2e	L1i	T2i	
Chemical industry - Nitric Acid Production - N2O	N2O	Yes	L1e	T1e, T2e	L1i	T1i, T2i	
Non-Energy Products from Fuels and Solvent Use - CO2	CO2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
Metal Industry - Aluminium Production - PFCs	PFCs	Yes		T1e, T2e		T1i, T2i	
Chemical Industry - Petrochemical and Carbon Black Production - CO2	CO2	Yes		T1e, T2e		T1i, T2i	
Metal Industry - Ferroalloys Production - CO2	CO2	Yes		T1e, T2e		T1i, T2i	
Metal Industry - Aluminium Production - CO2	CO2	Yes		T2e		T2i	
Mineral industry - Cement Production - CO2	CO2	Yes	L1e	T1e, T2e	L1i	T1i, T2i	
Mineral Industry - Other Process Uses of Carbonates - CO2	CO2	Yes				T2i	
Mineral Industry - Lime Production - CO2	CO2	Yes				T2i	
Metal Industry - Iron and Steel Production - CO2	CO2	Yes				T2i	
Other Product Manufacture and Use - N2O	N2O	Yes				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

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

MINERAL INDUSTRY

4.2. *CEMENT PRODUCTION (2.A.1)*

4.2.1. Category description (e.g. characteristics of sources)

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.

4.2.2. 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, *2006 IPCC Guidelines*).

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 - 2013)

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	1,880,328	99,587	2,019,513	0.501	0.301
2013	2,093,282	102,641	2,239,841	0.521	0.319

[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 - 2013)

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
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
2013	0	533	274,777	413	9819	1,640

The resulting emissions of CO_2 from Cement Production in the period 1990 - 2013 are presented in the Figure 4.2-1.

Figure 4.2-1: Emissions of CO2 from Cement Production (1990 - 2013)

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). In 2013 the cement production started increase slightly (8,0 percent compared to 2012). Accordingly, CO_2 emissions in 2013 was 12,2 percent higher than in 2012.

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 - 2013)

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

Year	Cement production / tonnes	
	Portland	Aluminate
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	2,155,356	100,195
2013	2,333,113	103,215

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, NMVOC and NH_3 have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2013* Submission to the Convention on Long-range Transboundary Air Pollution'.

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 2 percent, based on expert judgements. Uncertainty estimate associated with emission factors amounts to 2 percent, accordingly to values reported in *2006 IPCC Guidelines* (detailed in Annex 1).

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

4.2.4. Category-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 and Other Product Use. 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.

4.2.5. Category-specific recalculations

Recalculations were made according to applied *2006 IPCC Guidelines.*

4.2.6. Category-specific planned improvements

Data included in emissions estimation should be in full compliance with the data included in the EU ETS reports.

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

4.3. LIME PRODUCTION (2.A.2)

4.3.1. Category description (e.g. characteristics of sources)

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:

$CaCO_3$ (limestone) + Heat $\rightarrow$ CaO (quicklime) + $CO_2\uparrow$

$CaCO_3{*}MgCO_3$ (dolomite) + Heat $\rightarrow$ CaO*MgO (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 canceled 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.

4.3.2. 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.

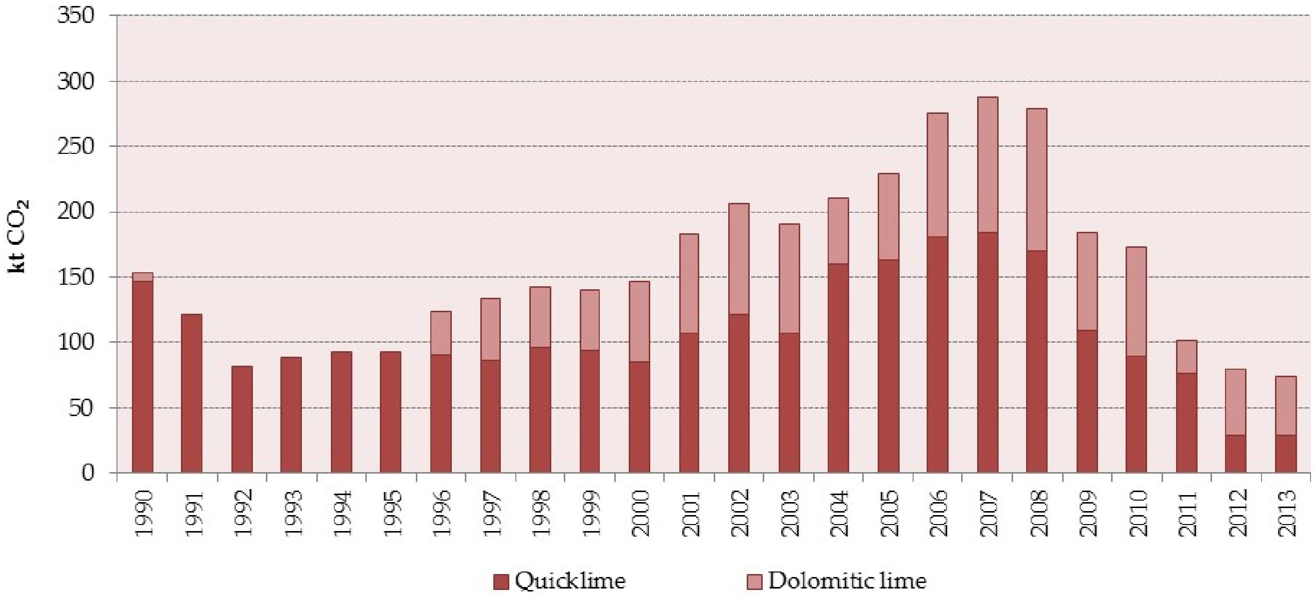
The data for quicklime and dolomitic lime production were cross-checked with lime production data from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Table 4.3-1: Lime production and emission factors (1990 - 2013)

Year	Quicklime		Dolomitic lime	
	Production	EF (t CO_2/t lime)	Production	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	44,752	0.654	59,334	0.879
2013	44,921	0.654	52,857	0.849

The resulting emissions of CO_2 from Lime Production in the period 1990 - 2013 are presented in the Figure 4.3-1.

Figure 4.3-1: Emissions of CO_2 from Lime Production (1990 - 2013)



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 canceled the production of quicklime and started the production of dolomitic lime. The total production of lime in 2012 decreased by 23 precent compared to 2011, while the total production of lime in 2013 decreased by 9 precent compared to 2012. CO_2 emission decreased by 9 precent in 2013 compared to 2012.

Emissions of SO_2, CO, NO_x, NMVOC and NH_3 have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2013* Submission to the Convention on Long-range Transboundary Air Pollution'.

4.3.3. 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 percent, based on expert judgements. Uncertainty estimate associated with emission factors amounts to 2 percent, accordingly to values reported in *2006 IPCC Guidelines* (detailed in Annex 1).

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

4.3.4. Category-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.

4.3.5. Category-specific recalculations

Recalculations were made according to applied *2006 IPCC Guidelines.*

4.3.6. Category-specific planned improvements

Data included in emissions estimation should be in full compliance with the data included in the EU ETS reports.

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

4.4. GLAS PRODUCTION (2.A.3)

4.4.1. Category description (e.g. characteristics of sources)

The major glass raw materials which emit CO_2 during the melting process are limestone ($CaCO_3$), dolomite $CaMg(CO_3)_2$ and soda ash (Na_2CO_3).

In practice, glass makers do not produce glass only from raw materials, but use a certain amount of recycled scrap glass (cullet). Most operations will use as much cullet as they can obtain, sometimes with restrictions for glass quality requirements.

During the reporting period, in operation were two factories of glass in Croatia; one of them producing container glass and the other producing flat glass.

4.4.2. Methodological issues

Calculation of CO_2 emissions from glass production is accomplished by applying an emission factor in tonnes of CO_2 released per tonne of carbonate consumed, according to *2006 IPCC Guidelines*.

The data for carbonate consumed as well as glass production were collected by survey of glass manufacturers. The activity data for glass production (see Table 4.4-1) were cross-checked with glass production data from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining.

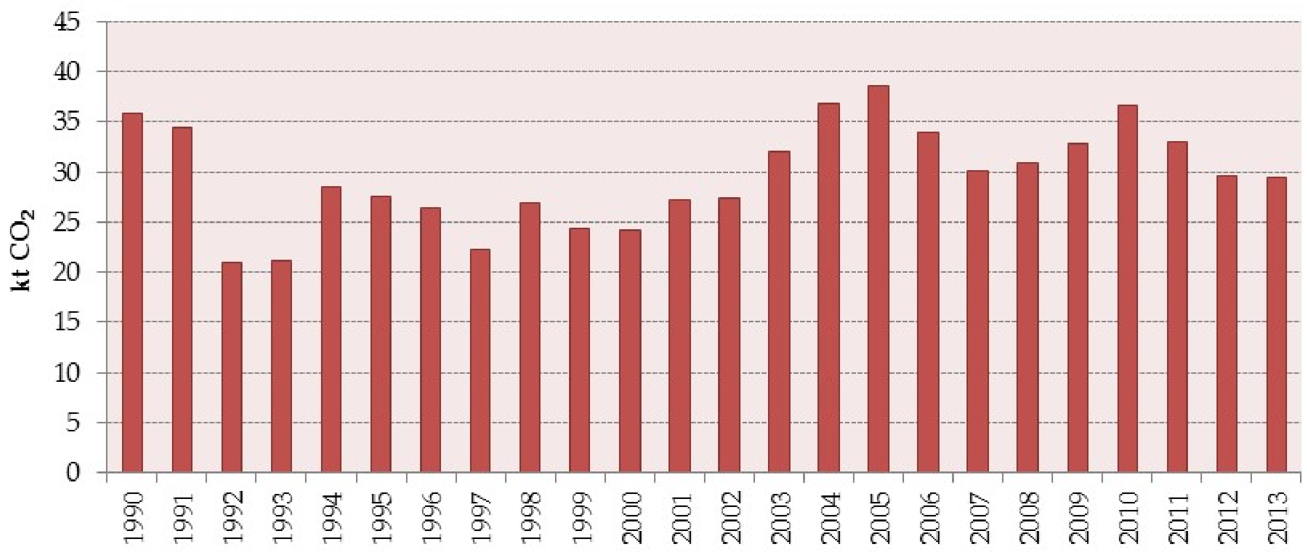
Table 4.4-1: Glass production (1990 - 2013)

Year	Glass production / tonnes
1990	275,490
1991	252,940
1992	143,900
1993	134,410
1994	162,220
1995	166,810
1996	153,760
1997	127,320
1998	148,330
1999	136,260
2000	139,060
2001	150,340
2002	158,540
2003	186,970
2004	210,650
2005	227,810
2006	228,670
2007	237,500
2008	255,070
2009	280,920
2010	295,170
2011	320,470

Year	Glass production / tonnes
2012	300,110
2013	303,060

The resulting emissions of CO_2 from Glass Production in the period 1990 - 2013 are presented in the Figure 4.4-1.

Figure 4.4-1: Emissions of CO_2 from Glass Production (1990 - 2013)



Emissions of SO_2, CO, NO_x, NMVOC and NH_3 have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2013* Submission to the Convention on Long-range Transboundary Air Pollution'.

4.4.3. 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 percent, based on expert judgements. Uncertainty estimate associated with emission factors amounts to 2 percent, accordingly to values reported in *2006 IPCC Guidelines* (detailed in Annex 1).

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

4.4.4. Category-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 3 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.

4.4.5. Category-specific recalculations

Recalculations were made according to applied *2006 IPCC Guidelines*.

4.4.6. Category-specific planned improvements

Data included in emissions estimation should be in full compliance with the data included in the EU ETS reports.

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

4.5. OTHER PROCESS USES OF CARBONATES (2.A.4)

4.5.1. 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 2000-2013 also include significant limestone use in desulphurization process in

Thermal Power Plant (TPP) Plomin 2 . Also, emissions from the use of lithium carbonate (Li_2CO_3) in glass production during 2010, have been included in this sub-sector.

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.

4.5.2. 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 . A 100 percent purity of raw material was assumed for the purpose of calculations (*2006 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 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.

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 (*2006 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).

Data for the use of limestone, dolomite, soda ash and lithium carbonate are shown in Table 4.5-1.

Table 4.5-1: Data for the use of limestone, dolomite, soda ash and lithium carbonate (1990 - 2013)

Year	Limestone use (tonnes)	Dolomite and other tes* use (tonnes)	Soda ash use (tonnes)
1990	0	12,098	0
1991	0	10,018	0
1992	0	9,173	13,753
1993	677	7,632	10,020
1994	676	15,722	12,960
1995	575	6,541	17,053
1996	731	8,323	13,367
1997	784	0	13,776
1998	826	0	10,956
1999	529	0	12,862
2000	6,969	585	14,037
2001	9,126	623	14,747
2002	12,445	850	16,355
2003	14,404	1,180	14,696
2004	13,324	1,360	15,705
2005	12,099	12,567	14,315
2006	12,042	15,564	16,185
2007	11,395	15,776	16,861
2008	15,955	15,778	15,172
2009	12,148	16,171	13,985
2010	22,337	13,579	18,959
2011	44,010	13,821	21,386
2012	34,192	55,752	21,233
2013	13,157	46,134	12,345

* Li_2CO_3 from glass production, used in 2010

The resulting emissions of CO_2 from Limestone and Dolomite Use in the period 1990 - 2013 are presented in the Figure 4.5-1. The resulting emissions of CO_2 from Soda Ash Use in the period 1990 - 2013 are presented in the Figure 4.5-2.

Figure 4.5-1: Emissions of CO_2 from Limestone and Dolomite Use (1990 - 2013)

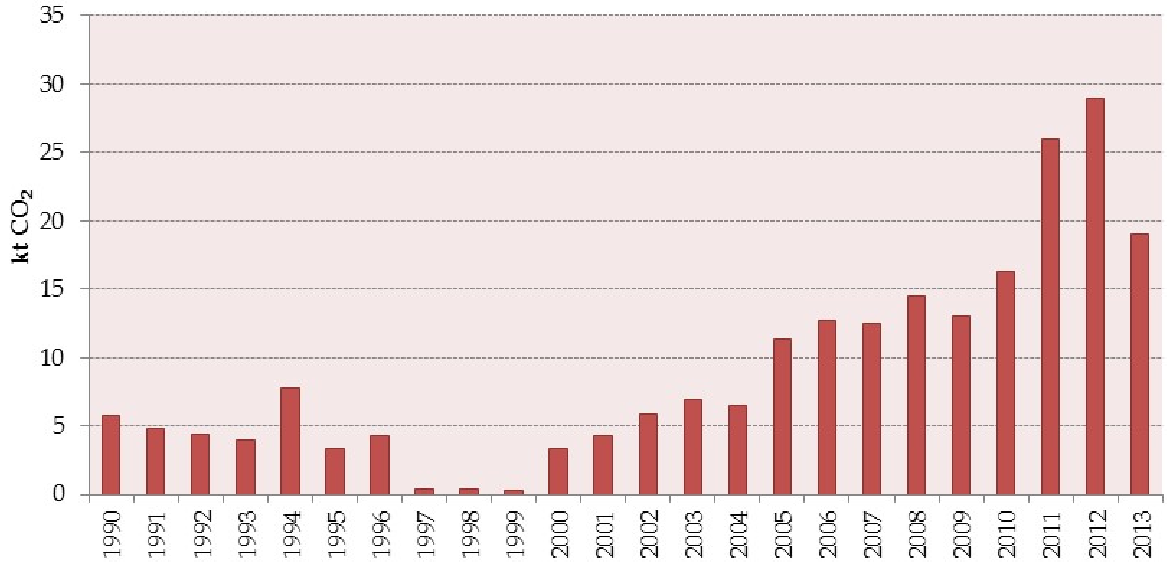
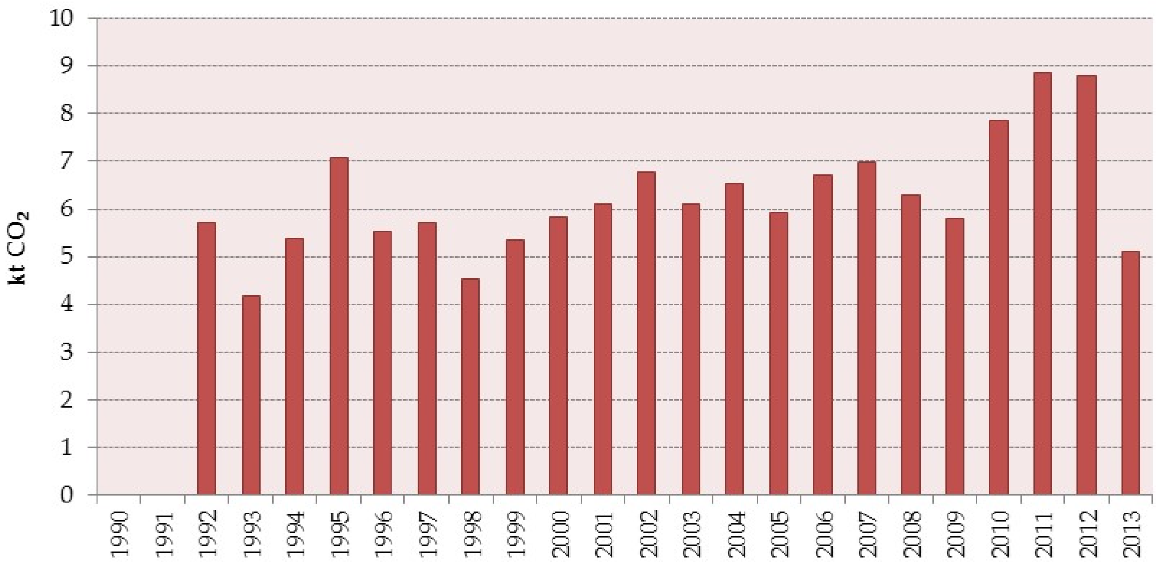


Figure 4.5-2: Emissions of CO_2 from Soda Ash Use (1990 – 2013)



4.5.3. Uncertainties and time-series consistency

Uncertainty estimate associated with activity data amounts to 7.5 percent, based on expert judgements. Uncertainty estimate associated with emission factors amounts to 5 percent, accordingly to values reported in *2006 IPCC Guidelines* (detailed in Annex 1).

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

4.5.4. Category-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.

4.5.5. Category-specific recalculations

Recalculations were made according to applied *2006 IPCC Guidelines*.

4.5.6. Category-specific planned improvements

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.

CHEMICAL INDUSTRY

4.6. AMMONIA PRODUCTION (2.B.1)

4.6.1. Category description (e.g. characteristics of sources)

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.

4.6.2. Methodological issues

For purposes of ammonia production in Croatia, natural gas is used as both feedstock and fuel. CO_2 emission occurring from natural gas used as feedstock and fuel has been calculated for this subsector. Tier 3 method are used for CO_2 emission calculation (*2006 IPCC Guidelines*).

Data on consumption and composition of natural gas (see Table 4.6-1) were collected by survey of ammonia manufacturer (Fertilizer Company). Consumption of natural gas for ammonia production process 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 4.6-1: Consumption and composition of natural gas in Ammonia Production (1990 - 2013)

Year	Natural gas ption (m^3)	Natural gas ption (m^3)	Natural gas ption (GJ)	Carbon content the fuel (kg C/GJ)
	Feedstock	Fuel	Total	
1990	242,905,233	158,223,414	13,879,452	15.182
1991	230,492,226	161,579,316	13,701,332	15.218
1992	299,567,927	199,801,218	17,272,679	15.235
1993	238,269,046	173,831,568	14,238,900	14.824
1994	239,717,137	176,937,060	14,179,159	15.062
1995	232,773,362	199,321,324	14,759,490	15.080

Year	Natural gas ption (m^3)	Natural gas ption (m^3)	Natural gas ption (GJ)	Carbon content the fuel (kg C/GJ)
	Feedstock	Fuel	Total	
1996	254,116,356	172,383,212	14,459,188	15.114
1997	277,311,935	189,155,505	15,815,579	15.043
1998	207,973,360	145,686,203	11,991,181	15.044
1999	262,772,017	190,298,670	15,383,109	15.060
2000	266,433,375	201,566,239	15,873,611	15.045
2001	214,441,408	159,621,843	12,733,861	15.103
2002	193,045,364	135,705,657	11,221,259	15.078
2003	216,859,822	161,406,178	12,934,806	15.084
2004	264,367,950	186,992,167	15,394,088	15.006
2005	259,004,302	185,607,918	15,126,597	15.034
2006	253,861,433	177,659,494	14,738,166	15.049
2007	280,232,850	192,990,286	16,036,586	14.995
2008	284,633,920	194,654,319	16,255,540	15.005
2009	238,983,580	169,381,100	13,854,588	15.000
2010	249,994,075	222,816,769	16,013,630	15.082
2011	253,619,204	221,162,101	16,148,262	15.048
2012	263,268,440	169,827,600	14,948,743	15.106
2013	263,512,934	175,534,988	15,199,839	15.110

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

Carbon oxidation factor of the fuel amount of 1 is used for the entire period.

CO_2 recovered (see Table 4.6-2) for downstream use (i.e. urea, NPK, dry ice) is substracted from the CO_2 emission.

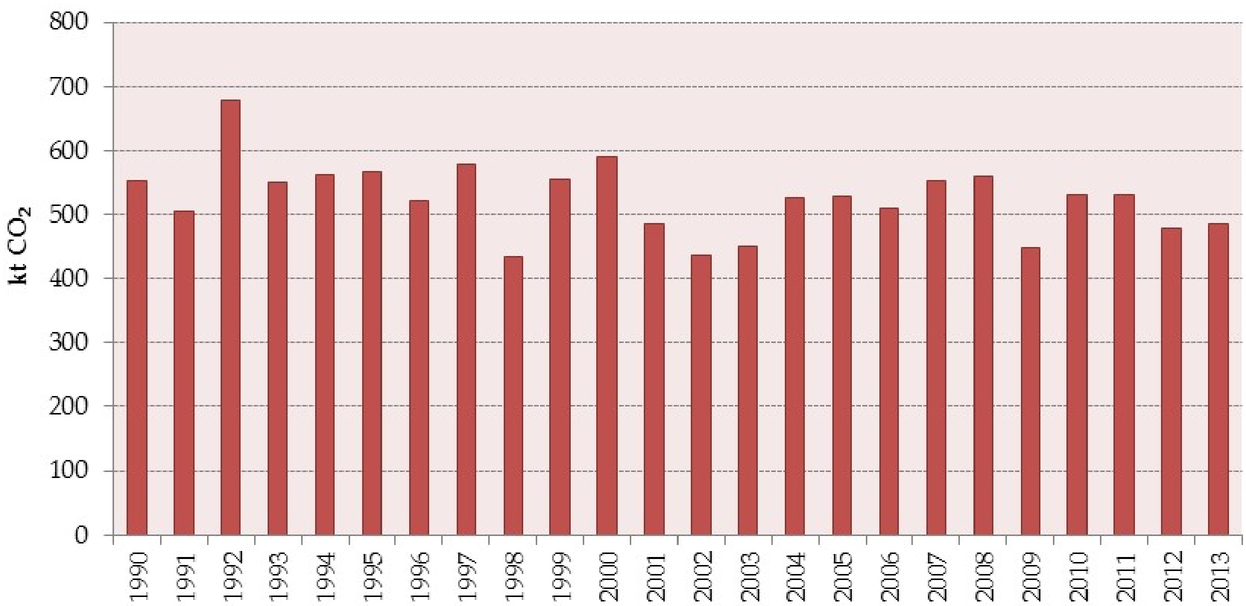
Table 4.6-2: CO_2 recovered for downstream use (1990 - 2013)

Year	R_{CO2} - urea (t)	R_{CO2} - NPK (t)	R_{CO2} - dry ice,)	R_{CO2} - total (t)
1990	208,896.5	5,049.0	6,568.0	220,513.5
1991	248,296.1	5,323.0	6,568.0	260,187.1
1992	273,809.1	3,182.0	8,772.0	285,763.1
1993	211,675.7	2,740.0	8,872.0	223,287.7
1994	213,692.4	2,089.0	5,421.0	221,202.4
1995	241,286.6	1,146.0	7,022.0	249,454.6
1996	270,528.1	1,411.0	7,984.0	279,923.1
1997	283,199.6	1,476.0	9,948.0	294,623.6
1998	219,196.8	558.0	8,543.0	228,297.8
1999	284,156.1	1,071.0	8,820.0	294,047.1

Year	R_{CO2} - urea (t)	R_{CO2} - NPK (t)	R_{CO2} - dry ice, (t)	R_{CO2} - total (t)
2000	274,579.2	983.0	9,155.0	284,717.2
2001	211,607.7	825.0	7,414.0	219,846.7
2002	179,355.8	817.0	4,204.0	184,376.8
2003	254,133.6	0.0	10,933.0	265,066.6
2004	305,753.6	0.0	15,806.0	321,559.6
2005	291,590.8	0.0	13,051.0	304,641.8
2006	291,445.2	0.0	12,911.0	304,356.2
2007	312,432.4	0.0	16,167.4	328,599.8
2008	323,920.0	0.0	11,708.3	335,628.3
2009	306,615.5	0.0	8,132.1	314,747.6
2010	332,935.0	0.0	20,618.6	353,553.6
2011	338,136.4	0.0	21,854.9	359,991.3
2012	325,986.3	0.0	23,076.3	349,062.6
2013	332,779.0	0.0	23,373.1	356,152.1

The resulting emissions of CO_2 from Ammonia Production in the period 1990 - 2013 are presented in the Figure 4.6-1.

Figure 4.6-1: Emissions of CO_2 from Ammonia Production (1990 – 2013)



Tier 1 method are used for CH_4 and N_2O emission calculation (see Table 4.6-3). Default emission factors of 1.0 kg CH_4/TJ and 0.1 kg N_2O/TJ are used (*2006 IPCC Guidelines*).

Table 4.6-3: CH_4 and N_2O emissions from Ammonia Production (1990 - 2013)

Year	CH_4 from fuel (kt)	N_2O from fuel (kt)
1990	0.005475	0.000547
1991	0.005647	0.000565
1992	0.006911	0.000691
1993	0.006006	0.000601
1994	0.006021	0.000602
1995	0.006808	0.000681
1996	0.005844	0.000584
1997	0.006413	0.000641
1998	0.004940	0.000494
1999	0.006461	0.000646
2000	0.006837	0.000684
2001	0.005434	0.000543
2002	0.004632	0.000463
2003	0.005519	0.000552
2004	0.006378	0.000638
2005	0.006315	0.000631
2006	0.006068	0.000607
2007	0.006540	0.000654
2008	0.006602	0.000660
2009	0.005747	0.000575
2010	0.007547	0.000755
2011	0.007522	0.000752
2012	0.005862	0.000586
2013	0.006077	0.000608

4.6.3. Uncertainties and time-series consistency

According to *2006 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 *2006 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 of CO_2 emission estimate associated with activity data amounts to 2 percent, based on information provided by manufacturer. Uncertainty of CO_2 emission estimate associated with emission factor amounts to 2 percent, accordingly to value recommended in *2006 IPCC Guidelines* (detailed in Annex 1).

Uncertainty of CH_4 emission estimate associated with activity data amounts to 5 percent, based on information provided by manufacturer. Uncertainty of CH_4 emission estimate associated with emission factor amounts to 50 percent, accordingly to value recommended in *2006 IPCC Guidelines* (detailed in Annex 1).

Uncertainty of N_2O emission estimate associated with activity data amounts to 5 percent, based on information provided by manufacturer. Uncertainty of N_2O emission estimate associated with emission factor amounts to 200 percent, accordingly to value recommended in *2006 IPCC Guidelines* (detailed in Annex 1).

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

4.6.4. Category-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 and Product Use. 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.

4.6.5. Category-specific recalculations

Recalculations were made according to applied *2006 IPCC Guidelines*.

4.6.6. Category-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).

4.7. *NITRIC ACID PRODUCTION (2.B.2)*

4.7.1. Category description (e.g. characteristics of sources)

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. Abatement technology is installed at the plant since 2013. Nitric acid is used in the manufacture of fertilizers.

4.7.2. Methodological issues

Emissions of N_2O from nitric acid production have been calculated by multiplying annual nitric acid production by plant-specific EFs using Tier 2 methodology. 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[3] (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). Data on nitric acid production (see Table 4.3-4), 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 4.7-1: Nitric acid production (1990 - 2013)

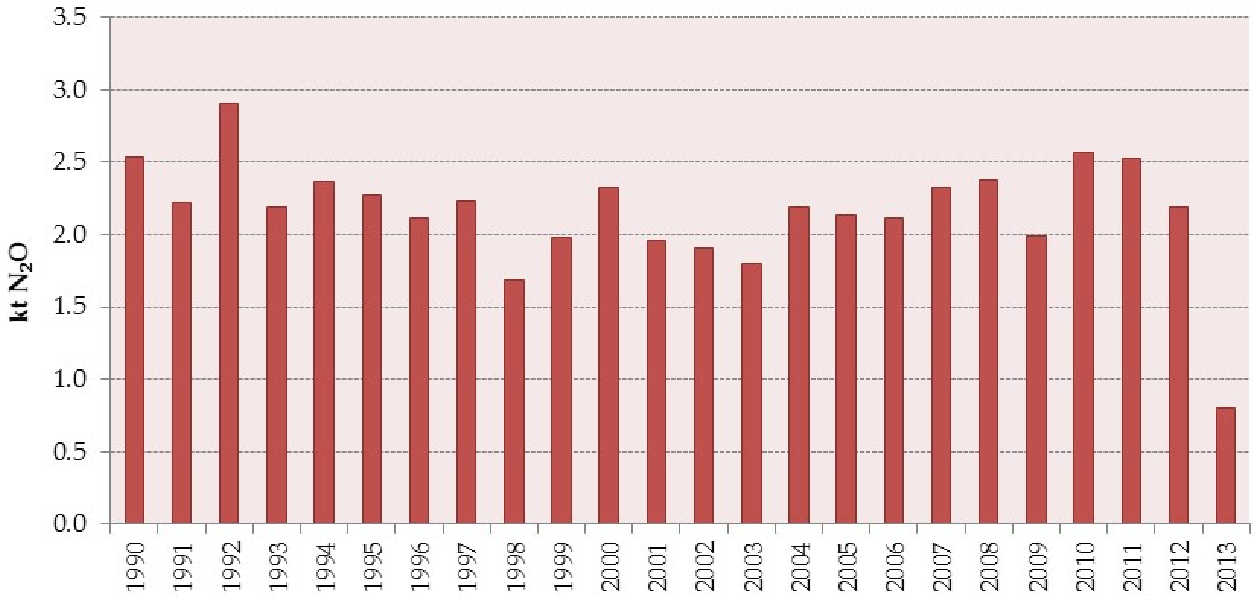
Year	Nitric acid production UNIT 1 (tonnes)	Nitric acid production UNIT 2 (tonnes)	Nitric acid production TOTAL (tonnes)
1990	206,962	125,497	332,459

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

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
2013	186,777	110,768	297,545

The resulting emissions of N_2O from Nitric Acid Production in the period 1990 - 2013 are presented in the Figure 4.7-1.

Figure 4.7-1: Emissions of N_2O from Nitric Acid Production (1990 - 2013)



4.7.3. 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 2 percent, based on information provided by manufacturer. Uncertainty estimate associated with emission factors amounts to 20 percent for 1990 and 2 percent for 2013, based on expert judgements and information provided by manufacturer (detailed in Annex 1).

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

4.7.4. Category-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 and Product Use. 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.

4.7.5. Category-specific recalculations

Recalculations were made according to applied 2006 IPCC Guidelines.

4.7.6. Category-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.

4.8. ADIPIC ACID PRODUCTION (2.B.3)

This category does not exist in Croatia.

4.9. CAPROLACTAM, GLYOXAL AND GLYOXYLIC ACID PRODUCTION (2.B.4)

This category does not exist in Croatia.

4.10. CARBIDE PRODUCTION (2.B.5)

This category does not exist in Croatia.

4.11. TITANIUM DIOXIDE PRODUCTION (2.B.6)

This category does not exist in Croatia.

4.12. SODA ASH PRODUCTION (2.B.7)

This category does not exist in Croatia.

4.13. PETROCHEMICAL AND CARBON BLACK PRODUCTION ADIPIC ACID PRODUCTION (2.B.8)

4.13.1. Category description (e.g. characteristics of sources)

The production of other chemicals such as carbon black and some petrochemicals (methanol, ethylene, ethylene dichloride, …) can be sources of CH_4 emissions. Although most CH_4 sources from industrial processes individually are small, collectively they may be significant.

4.13.2. Methodological issues

Emissions of CO_2 and CH_4 from the petrochemical and carbon black production have been calculated using Tier 1 methodology, by multiplying an annual production of each chemical with related emission factor provided by *2006 IPCC Guidelines.*

The annual production of chemicals (see Table 4.13-1) was extracted from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Emissions of CO_2 and CH_4 from Petrochemical and Carbon Black Production in the period 1990 - 2013 are reported in the Table 4.13-2.

Table 4.13-1: Annual production of chemicals (1990 - 2013)

Year	Carbon black (tonnes)	Ethylene (tonnes)	Ethylene de	Methanol (tonnes)
1990	30,624	72,631	72,653	0.00
1991	18,783	66,871	68,325	0.00
1992	13,479	68,318	92,089	0.00
1993	17,123	68,634	79,608	0.00
1994	21,468	65,285	97,528	0.00
1995	27,185	67,547	84,374	0.00
1996	26,735	64,782	48,631	0.00
1997	24,214	63,554	26,264	0.00
1998	24,087	60,148	31,308	0.00
1999	20,627	60,295	47,686	0.00
2000	20,029	38,918	71,364	0.00
2001	21,180	46,632	64,442	0.00
2002	19,416	43,554	0	0.00
2003	21,295	41,252	0	3.72
2004	20,272	49,886	0	3.80
2005	18,498	50,263	0	2.93
2006	26,264	48,824	0	2.95
2007	23,724	45,438	0	2.03
2008	16,904	43,045	0	2.00
2009	3,976	38,797	0	1.00
2010	0	36,271	0	0.87
2011	0	23,323	0	1.92
2012	0	0	0	3.17
2013	0	0	0	1.01

Table 4.13-2: Emissions of CO_2 and CH_4 from Petrochemical and Carbon Black Production (1990 - 2013)

Year	Carbon black		Ethylene		Ethylene de		Methanol	
	CO_2 (kt)	CH_4 (kt)	CO_2 (kt)	CH_4 (kt)	CO_2 (kt)	CH_4 (kt)	CO_2 (kt)	CH_4 (kt)
1990	80.235	0.002	125.652	0.218	13.877	NA	0.000	0.000000
1991	49.211	0.001	115.687	0.201	13.050	NA	0.000	0.000000
1992	35.315	0.001	118.190	0.205	17.589	NA	0.000	0.000000
1993	44.862	0.001	118.737	0.206	15.205	NA	0.000	0.000000
1994	56.246	0.001	112.943	0.196	18.628	NA	0.000	0.000000
1995	71.225	0.002	116.856	0.203	16.115	NA	0.000	0.000000
1996	70.046	0.002	112.073	0.194	9.289	NA	0.000	0.000000
1997	63.441	0.001	109.948	0.191	5.016	NA	0.000	0.000000
1998	63.108	0.001	104.056	0.180	5.980	NA	0.000	0.000000
1999	54.043	0.001	104.310	0.181	9.108	NA	0.000	0.000000
2000	52.476	0.001	67.328	0.117	13.631	NA	0.000	0.000000
2001	55.492	0.001	80.673	0.140	12.308	NA	0.000	0.000000
2002	50.870	0.001	75.348	0.131	0.000	NA	0.000	0.000000
2003	55.793	0.001	71.366	0.124	0.000	NA	0.002	0.000009
2004	53.113	0.001	86.303	0.150	0.000	NA	0.003	0.000009
2005	48.465	0.001	86.955	0.151	0.000	NA	0.002	0.000007
2006	68.812	0.002	84.466	0.146	0.000	NA	0.002	0.000007
2007	62.157	0.001	78.608	0.136	0.000	NA	0.001	0.000005
2008	44.288	0.001	74.468	0.129	0.000	NA	0.001	0.000005
2009	10.417	0.000	67.119	0.116	0.000	NA	0.001	0.000002
2010	0.000	0.000	62.749	0.109	0.000	NA	0.001	0.000002
2011	0.000	0.000	40.349	0.070	0.000	NA	0.001	0.000004
2012	0.000	0.000	0.000	0.000	0.000	NA	0.002	0.000007
2013	0.000	0.000	0.000	0.000	0.000	NA	0.001	0.000002

4.13.3. Uncertainties and time-series consistency

Uncertainty estimate associated with activity data for CO_2 and CH_4 emissions for all chemicals amounts to 7.5 percent based on expert judgements.

Uncertainty estimate associated with default emission factors for CO_2 and CH_4 emissions for methanol and ethylene amounts to 30 percent, based on expert judgements (detailed in Annex 1).

Uncertainty estimate associated with default emission factor for CO_2 emission for ethylene dichloride amounts to 20 percent, based on expert judgements (detailed in Annex 1).

Uncertainty estimate associated with default emission factors for CO_2 emission for carbon black amounts to 15 percent, based on expert judgements. Uncertainty estimate associated with default emission factors for CH_4 emission for carbon black amounts to 85 percent, based on expert judgements. (detailed in Annex 1)

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

4.13.4. Category-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.

4.13.5. Category-specific recalculations

Recalculations were made according to applied 2006 IPCC Guidelines.

4.13.6. Category-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.

4.14. FLUOROCHEMICAL PRODUCTION (2.B.9)

This category does not exist in Croatia.

METAL INDUSTRY

4.15. IRON AND STEEL PRODUCTION (2.C.1)

4.15.1. 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.

4.15.2. 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 *2006 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[4].

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 Industry to avoid double-counting. These emissions are included in Energy sector because Coke Oven Coke used in blast furnace is given in energy balance.

Steel Production

There are two steel manufacturers in Croatia. Steel production by one manufacturer was halted in 2009. In 2012, steel production by second manufacturer was considerably reduced, while in 2013 it was increased.

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

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

(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:

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

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 4.15-1. 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 4.15-2).

Table 4.15-1: Consumption of main carbon donors (input materials) in EAFs (1990 - 2013)

Year	Scrap iron	Steel scrap	EAF carbon es (tonnes)	EAF charge tonnes)	Petroleum nnes)
1990	2,500	173,588	1,180	121	0
1991	13,221	119,396	982	106	600
1992	17,866	96,221	927	88	327
1993	23,557	60,799	627	63	253
1994	14,892	56,777	550	122	68
1995	10,559	41,661	346	27	0
1996	12,858	38,966	312	12	191
1997	18,233	61,114	468	7	369
1998	31,968	84,281	698	100	246
1999	11,743	72,647	557	78	127
2000	7,845	70,363	462	67	58
2001	7,003	55,100	375	60	118
2002	5,324	29,121	213	292	115
2003	15,934	29,777	223	240	215
2004	20,409	76,594	417	737	274
2005	7,818	77,641	286	745	99
2006	5,510	87,978	331	886	177
2007	4,523	85,054	351	967	97
2008	31,421	130,815	713	1,418	399
2009	25,531	26,293	333	4	376
2010	82,659	38,797	649	283	1,550
2011	83,790	25,331	396	973	1,637
2012	1,233	0	5	16	0
2013	44,632	570	221	394	0

Table 4.15-2: Consumption of other carbon donors (input materials) and reducing fuels in EAFs (1990 - 2013)

Year	Lime (tonnes)	Other carbon (tonnes)	Natural gas	Diesel oil	Liquefied m gases
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	30	40,266	0	0
2013	1,875	1,212	2,061,350	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[5] (Table 4.15-3) and reducing fuels[6] (Table 4.15-4) have been used.

Table 4.15-3: EF for carbon donors (input materials) in EAFs (1990 - 2013)

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 4.15-4: EF and net calorific values for reducing fuel in EAFs (1990 - 2013)

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

[5] 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

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

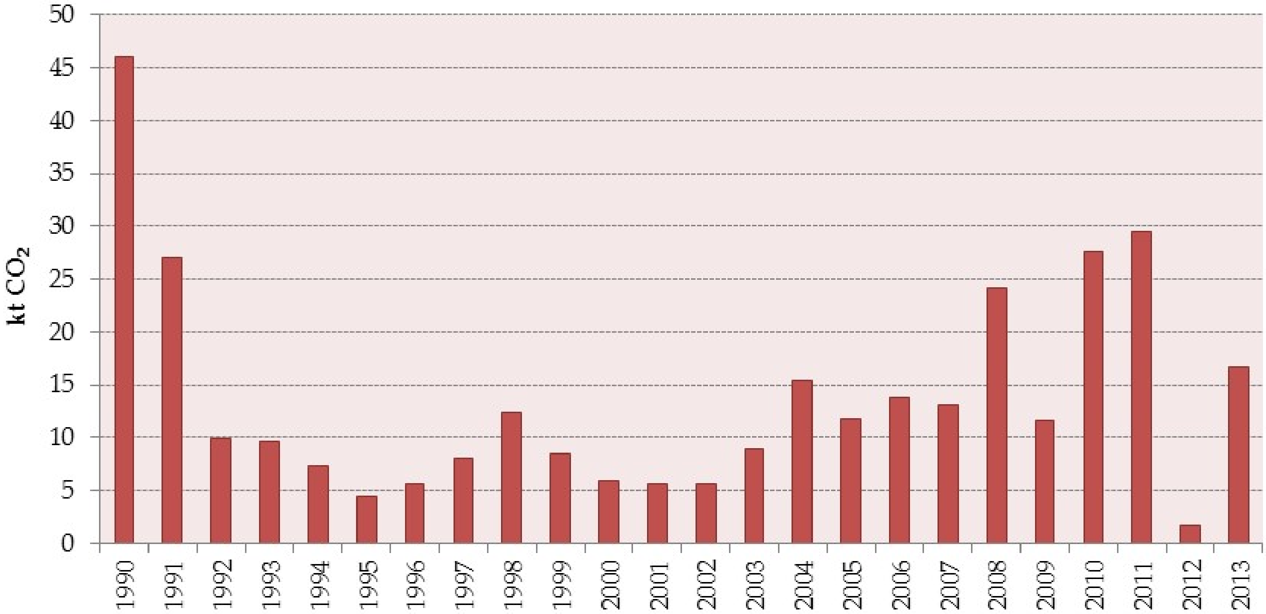
The activity data for steel production (see Table 4.15-5) were collected by bottom up analysis from two steel manufacturers.

Table 4.15-5: Steel production (1990 - 2013)

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
2007	76,252
2008	138,865
2009	46,264
2010	103,427
2011	95,907
2012	5,896
2013	57,806

The resulting emissions of CO_2 from Steel Production in the period 1990 - 2013 are presented in the Figure 4.15-1. CO_2 emissions from limestone and dolomite use are included in total CO_2 emissions for this category.

Figure 4.15-1: Emissions of CO_2 from Steel Production (1990 - 2013)



CO_2 emissions fluctuated over the period. It is mainly a result of discontinuous operation, which requires increasing consumption of input materials.

4.15.3. Uncertainties and time-series consistency

Uncertainty estimate associated with activity data amounts to 10 percent for 1990 and 5 percent for 2013, based on expert judgements. Uncertainty estimate associated with emission factors amounts to 10 percent for 1990 and 5 percent for 2013, accordingly to values reported in *2006 IPCC Guidelines* and based on expert judgement (detailed in Annex 1).

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

4.15.4. Category-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.

4.15.5. Category-specific recalculations

Recalculations were made according to applied 2006 IPCC Guidelines.

4.15.6. Category-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.

4.16. FERROALLOYS PRODUCTION (2.C.2)

4.16.1. 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.

4.16.2. Methodological issues

Emissions of CO_2 and CH_4 from the ferroalloys production have been calculated using Tier 1 methodology, by multiplying an annual production of each type of ferroalloys (ferromanganese, siliconmanganese and ferrochromium) with related emission factor provided by *2006 IPCC Guidelines* (1.3 t CO_2/t ferromanganese; 1.4 t CO_2/t siliconmanganese; 1.3 t CO_2/t ferrochromium; 1.2 t CH_4/t ferroalloys).

The annual production of ferroalloys (see Table 4.4-1) was extracted from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining. 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.

Table 4.16-1: Ferroalloys production (1990 - 2013)

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

Emissions of CO_2 and CH_4 from Ferroalloys Production in the period 1990 - 2003 are reported in the Table 4.16-2.

Table 4.16-2: Emissions of CO_2 and CH_4 from Ferroalloys Production (1990 - 2013)

Year	CO_2 emissions (kt)			CH_4 emissions
	Ferromanganese	Silicon ese	Ferrochromium	Ferroalloys
1990	26.70	67.99	79.12	0.156
1991	16.97	53.71	94.70	0.149
1992	0.00	35.80	72.88	0.098
1993	0.00	12.01	36.44	0.044
1994	0.73	30.90	41.22	0.065
1995	0.00	0.00	33.91	0.031
1996	0.00	0.00	13.73	0.013
1997	0.06	0.58	31.50	0.030
1998	0.07	0.98	15.42	0.015
1999	0.08	0.38	17.95	0.017
2000	0.04	0.46	20.48	0.019
2001	0.06	0.42	0.47	0.001
2002	0.04	0.27	0.00	0.000
2003	0.08	0.92	0.00	0.001

4.16.3. 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 10 percent , based on expert judgements. Uncertainty estimate associated with default emission factors amounts to 25 percent, accordingly to values reported in *2006 IPCC Guidelines* and based on expert judgements (detailed in Annex 1).

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

4.16.4. Category-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.

4.16.5. Category-specific recalculations

Recalculations were made according to applied 2006 IPCC Guidelines.

4.16.6. Category-specific planned improvements

Ferroalloys production fluctuated over the period and was halted in 2003, which has consequently decreased the possibility to recheck activity data. There is no plan for improvements for this category. Due to this fact, Tier 1 methodology is used for emissions calculation.

4.17. ALUMINIUM PRODUCTION (2.C.3)

4.17.1. 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.

4.17.2. 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[7].

The resulting emission of CO_2 from Aluminium Production in 1990 amounted to about 111 kt CO_2. In 1991 about 76 kt 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 *2006 IPCC Guidelines*. Default emission factors equal 1.7 kg/tonne Al for CF_4 and 0.17 kg/tonne Al for C_2F_6 (Side Worked Prebaked Anodes). 820 kt CO_2-eq of CF_4 and 116 kt CO_2-eq of C_2F_6 were emitted in 1990. 563 kt CO_2-eq of CF_4 and 80 kt 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.

[7] 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.

4.17.3. 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 *2006 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 2 percent, based on expert judgements. Uncertainty estimate associated with default emission factor for CO_2 emissions amounts to 10 percent, accordingly to values reported in *2006 IPCC Guidelines* and based on expert judgements (detailed in Annex 1).

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 2 percent, based on expert judgements. Uncertainty estimate associated with default emission factor for PFCs emissions amounts to 25 percent, accordingly to values reported in *2006 IPCC Guidelines* and based on expert judgements (detailed in Annex 1).

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

4.17.4. Category-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.

4.17.5. Category-specific recalculations

This category does not exist in Croatia - primary aluminium production in Croatia was halted in 1991.

4.17.6. Category-specific planned improvements

There is no planned improvements - primary aluminium production in Croatia was halted in 1991.

4.18. MAGNESIUM PRODUCTION (2.C.4)

This category does not exist in Croatia.

4.19. LEAD PRODUCTION PRODUCTION (2.C.5)

This category does not exist in Croatia.

4.20. ZINC PRODUCTION (2.C.6)

This category does not exist in Croatia.

NON-ENERGY PRODUCTS FROM FULES AND SOLVENT USE (CRF 2.D)

4.21. LUBRICANT AND PARAFIN WAX USE (2.D.1)

4.21.1. Category description

Lubricants and paraffin wax are mostly used in industrial and transportation applications. These are subdivided into motor oils, industrial oils and greases, waxes, etc. which differ in terms of physical characteristics and commercial applications.

4.21.2. Methodological issues

Emissions of CO_2 from lubricant and paraffin wax use have been calculated using Tier 1 methodology, by multiplying an annual consumption of each type of lubricant or wax with related default emission and ODU factors provided by *2006 IPCC Guidelines*.

The annual consumption of lubricants and paraffin waxes (see Table 4.21-1) was extracted from Energy Balance.

Table 4.21-1: Consumption of lubricants and paraffin waxes (1990 - 2013)

Year	Lubricants ıffin waxes (TJ)	Naphtha (TJ)	Bitumen (TJ)	LPG (TJ)	Ethane (TJ
1990	8,309	7,683	3,349	0	0
1991	7	3,126	2,374	0	0
1992	7,080	3,096	2,036	0	0
1993	8,971	3,096	1,480	0	0
1994	5,383	268	1,805	0	0
1995	9,183	224	1,363	0	0
1996	5,668	0	3,518	0	0
1997	6,269	0	3,705	0	0
1998	4,711	0	4,154	0	0
1999	1,642	0	3,963	0	3,709
2000	1,494	0	3,551	0	3,662
2001	1,773	0	3,149	0	3,089
2002	1,727	0	4,596	0	2,862
2003	1,868	0	7,249	0	2,673
2004	1,991	0	8,261	0	3,146
2005	1,951	0	6,834	0	3,127
2006	1,946	0	6,693	0	3,009
2007	1,910	0	6,693	0	2,820
2008	1,905	0	8,077	220	2,706
2009	1,761	0	6,831	75	2,332
2010	1,487	1,021	4,228	0	2,124
2011	1,464	1,034	4,740	0	1,386
2012	1,347	1,043	4,322	0	0
2013	1,323	896	4,623	0	0

Emissions of CO_2 from Lubricant and Paraffin Wax Use in the period 1990 - 2013 are presented in the Table 4.21-2.

Table 4.21-2: Emissions of CO_2 from Lubricant and Paraffin Wax Use (1990 - 2013)

Year	Lubricants ıffin waxes (kt CO_2)	Naphtha (kt CO_2)	Bitumen (kt CO_2)	LPG (kt CO_2)	Ethane (kt CO_2)
1990	112.68	54.03	0.00	0	0.00
1991	45.84	38.31	0.00	0	0.00
1992	45.41	32.85	0.00	0	0.00
1993	45.41	23.88	0.00	0	0.00
1994	3.93	29.12	0.00	0	0.00

Year	Lubricants ıffin waxes (kt CO_2)	Naphtha (kt CO_2)	Bitumen (kt CO_2)	LPG (kt CO_2)	Ethane (kt CO_2)
1995	3.29	21.99	0.00	0	0.00
1996	0.00	56.75	0.00	0	0.00
1997	0.00	59.78	0.00	0	0.00
1998	0.00	67.02	0.00	0	0.00
1999	0.00	63.94	0.00	0	45.70
2000	0.00	57.29	0.00	0	45.11
2001	0.00	50.80	0.00	0	38.06
2002	0.00	74.15	0.00	0	35.26
2003	0.00	116.96	0.00	0	32.93
2004	0.00	133.28	0.00	0	38.76
2005	0.00	110.26	0.00	0	38.53
2006	0.00	107.99	0.00	0	37.07
2007	0.00	107.99	0.00	0	34.74
2008	0.00	130.31	2.78	220	33.34
2009	0.00	110.20	0.95	75	28.73
2010	14.98	68.21	0.00	0	26.17
2011	15.17	76.48	0.00	0	17.08
2012	15.30	69.72	0.00	0	0.00
2013	13.15	74.58	0.00	0	0.00

4.21.3. Uncertainties and time-series consistency

Uncertainty estimate associated with activity data for CO_2 emissions calculation resulting by consumption of all types of lubricants and waxes amounts to 5percent, based on expert judgements.

Uncertainty estimate associated with default CO_2 emission factors for all types of lubricants and waxes amounts to 50 percent, based on expert judgements (detailed in Annex 1).

4.21.4. Category-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.

4.21.5. Category-specific recalculations

Recalculations were made according to applied 2006 IPCC Guidelines.

4.21.6. Category-specific planned improvements

There is no plan for improvements.

4.22. OTHER (2.D.3)

4.22.1. Category description

This category includes following sub-categories:

- Solvent use
- Road paving with asphalt
- Asphalt roofing
- Urea based catalytic converters

4.22.2. Methodological issues

Solvent use

Estimation of NMVOC emissions from Solvent Use (provided by EMEP-CORINAIR Emission Inventory Guidebook) has been carried out by estimating the amount of solvent containing products consumed. Emissions of NMVOC have been taken from the emission inventory report 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 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.

Following categories are included in the NMVOC emission estimation:

- Domestic solvent use including fungicides (NFR 2.D.3.a)

- Coating applications (NFR 2.D.3.d)
- Degreasing (NFR 2.D.3.e)
- Dry cleaning (NFR 2.D.3.f)
- Chemical products (NFR 2.D.3.g)
- Printing (NFR 2.D.3.h)
- Other solvent and product use (NFR 2.D.3.i)
- Other solvent and product use (NFR 2.G)

CO_2 emissions from Solvent Use 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.

The resulting emissions of CO_2 and from Solvent Use in the period 1990 - 2013 are presented in the Table 4.5-3.

Table 4.5-3: Emissions of CO2 from Solvent Use (1990 - 2013)

Year	CO_2 emission (kt CO_2)
1990	122.957
1991	82.494
1992	56.579
1993	56.733
1994	57.668
1995	55.864
1996	59.117
1997	61.031
1998	56.905
1999	48.899
2000	48.421
2001	49.843
2002	56.710
2003	54.868
2004	59.484
2005	59.692

Year	CO_2 emission (kt CO_2)
2006	63.049
2007	66.543
2008	65.652
2009	49.252
2010	48.134
2011	44.459
2012	41.172
2013	39.212

Road paving with asphalt and Asphalt roofing

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 2013 Submission to the Convention on Long-range Transboundary Air Pollution'.

Urea based catalytic converters

This source category encompasses CO_2 emissions from the use of urea containing in diesel engines with SCR-catalysts in road transportation (Euro V/VI).

Emissions of CO_2 from urea based catalytic converters have been calculated using Tier 1 methodology, by multiplying amount of urea-based additive consumed for use in catalytic converters and the mass fraction of urea in the urea-based additive.

Emissions of CO_2 from Urea Based Catalytic Converters in the period 1990 - 2013 are presented in the Table 4.5-4.

Table 4.5-4: Emissions of CO2 from Urea Based Catalytic Converters (1990 – 2013)

Year	CO_2 emission (kt CO_2)
1990	1.746
1991	1.251
1992	1.426
1993	1.740
1994	1.842
1995	1.956
1996	2.157
1997	2.487
1998	2.451
1999	2.636
2000	2.659
2001	2.865
2002	3.258

Year	CO_2 emission (kt CO_2)
2003	3.865
2004	4.233
2005	4.555
2006	4.997
2007	5.495
2008	5.277
2009	5.300
2010	5.243
2011	5.180
2012	5.079
2013	5.254

4.22.3. Uncertainties and time-series consistency

Lubricant and paraffin wax use

Uncertainty estimate associated with activity data for CO_2 emissions calculation amounts to 5 percent, based on expert judgements.

Uncertainty estimate associated with default emission factors for CO2 emissions calculation amounts to 50 percent, based on expert judgements (detailed in Annex 1).

Solvent use

Uncertainty estimate associated with default emission factors for CO_2 emissions calculation amounts to 50 percent, based on expert judgements (detailed in Annex 1).

Urea based catalytic converters

Uncertainty estimate associated with activity data for CO_2 emissions calculation amounts to 5 percent, based on expert judgements.

Uncertainty estimate associated with default emission factors for CO_2 emissions calculation amounts to 5 percent, based on expert judgements (detailed in Annex 1).

4.22.4. Category-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.

4.22.5. Category-specific recalculations

Recalculations were made according to applied 2006 IPCC Guidelines.

4.22.6. Category-specific planned improvements

There is no plan for improvements.

4.23. ELECTRONICS INDUSTRY (CRF 2.E)

This category does not exist in Croatia.

4.24. REFRIGERATION AND AIR CONDITIONING (2.F.1)

4.24.1. Category description

Refrigeration and air conditioning accounts for the majority of emissions in this subsector. 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, PFC-116 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 Commercial Refrigeration, Domestic Refrigeration, Industrial Refrigeration, Transport Refrigeration, Mobile Air-Conditioning and Stationary Air-Conditioning.

Refrigerants used are R-23, R-134a, PFC-14, PFC-116, 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 centre.

Several regional centres 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 centres 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.

4.24.2. Methodological issues

Emissions of HFCs used in Refrigeration and Air Conditioning Equipment have been calculated for the period 1995-2013, since there was no use of these substances prior to 1995.

Tier 2 methodology is used for HFCs emission calculation. For some gases, as HFC-23 (used in 2010, 2011 and 2013), PFC-14 (used in 2010), PFC-218 (used in the period 2009-2012) and PFC-116 (used in 2013) Tier 1a methodology is used for emission calculation due to the missing data on average annual stocks.

Calculation of HFCs emission by Tier 2 methodology are based on the data on the amount of HFCs in operating systems (average annual stocks) for Commercial Refrigeration (HFC-125, HFC-134a, HFC-143a), Domestic Refrigeration (HFC-134a), Industrial Refrigeration (HFC-32, HFC-125, HFC-134a, HFC-143a), Transport Refrigeration (HFC-134a), Mobile Air-Conditioning (HFC-134a) and Stationary-Air Conditioning (HFC-32, HFC-125, HFC-134a).

Default emission factors proposed by *2006 IPCC Guidelines* have been used for emission calculation.

Data on import and export of HFCs and PFCs, which were used for emission calculation by means of Tier 1a methodology, have been compiled by the MENP.

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 because the equipment generally comes to the market already filled with gas.

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

Emissions of HFCs used in Refrigeration and Air Conditioning Equipment in the period 1995-2013 are reported in the Table 4.24-1.

Table 4.24-1: Emissions of HFCs used in Refrigeration and Air Conditioning Equipment (t) (1990-2013)

Source/Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003
2.F.1. Refrigeration and Air Conditioning Equipment									
Commercial Refrigeration									
HFC-125	1.58	2.67	3.27	4.85	5.15	5.94	6.24	7.43	8.02
HFC-134a	0.14	0.24	0.30	0.44	0.47	0.54	0.57	0.68	0.73
HFC-143a	1.87	3.16	3.86	5.73	6.08	7.02	7.37	8.78	9.48
Domestic Refrigeration									
HFC-134a	0.03	0.06	0.14	0.18	0.20	0.23	0.27	0.29	0.33
PFC-14	NO	NO	NO	NO	NO	NO	NO	NO	NO
PFC-218	NO	NO	NO	NO	NO	NO	NO	NO	NO
PFC-116	NO	NO	NO	NO	NO	NO	NO	NO	NO

Source/Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003
Industrial Refrigeration									
HFC-23	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-32	0.55	0.66	0.90	1.20	1.48	1.96	2.26	2.41	2.53
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-143a	NO	NO	NO	NO	NO	NO	NO	NO	NO
Transport Refrigeration									
HFC-134a	24.44	26.48	29.90	32.50	39.00	44.85	55.51	66.95	80.89
Mobile Air-Conditioning									
HFC-134a	2.47	8.38	16.80	25.03	33.57	42.60	45.33	51.14	54.93
Stationary Air-Conditioning									
HFC-32	0.30	0.50	0.96	1.24	1.67	2.02	2.33	2.49	2.72
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

Table 4.24-1: Emissions of HFCs used in Refrigeration and Air Conditioning Equipment (t) (1990-2013), cont.

Source/Gas	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
2.F.1. Refrigeration and Air Conditioning Equipment										
Commercial Refrigeration										
HFC-125	9.21	9.90	10.49	11.68	11.88	11.98	13.07	15.44	15.84	16.04
HFC-134a	0.84	0.90	0.95	1.06	1.08	1.09	1.19	1.40	1.44	1.46
HFC-143a	10.88	11.70	12.40	13.81	14.04	14.16	15.44	18.25	18.72	18.95
Domestic Refrigeration										
HFC-134a	0.42	0.45	0.41	0.32	0.30	0.29	0.29	0.29	0.28	0.28
PFC-14	NO	NO	NO	NO	NO	NO	0.026	NO	NO	NO
PFC-218	NO	NO	NO	NO	NO	0.258	0.008	0.017	0.031	NO
PFC-116	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.060
Industrial Refrigeration										
HFC-23	NO	NO	NO	NO	NO	NO	0.066	0.036	NO	0.067
HFC-32	2.99	3.58	3.81	3.97	4.09	4.36	4.71	4.94	5.06	5.33
HFC-125	3.08	3.69	3.96	4.14	4.27	4.56	4.92	5.16	5.28	5.58
HFC-134a	2.25	2.66	2.83	2.83	2.91	3.00	3.41	3.58	3.66	3.91
HFC-143a	NO	0.01	0.04	0.06	0.07	0.08	0.08	0.08	0.08	0.10
Transport Refrigeration										
HFC-134a	94.02	105.1	113.7	124.8	133.1	134.8	144.3	145.9	146.5	147.5
Mobile Air-Conditioning										
HFC-134a	61.49	68.37	80.91	89.28	97.14	97.50	107.4	107.7	108.0	108.7
Stationary Air-Conditioning										
HFC-32	3.13	3.50	3.83	4.09	4.20	4.22	4.33	4.40	4.48	4.59
HFC-125	3.23	3.60	3.94	4.20	4.31	4.34	4.45	4.53	4.60	4.71
HFC-134a	2.39	2.55	2.73	2.86	2.99	2.99	3.12	3.17	3.22	3.30

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

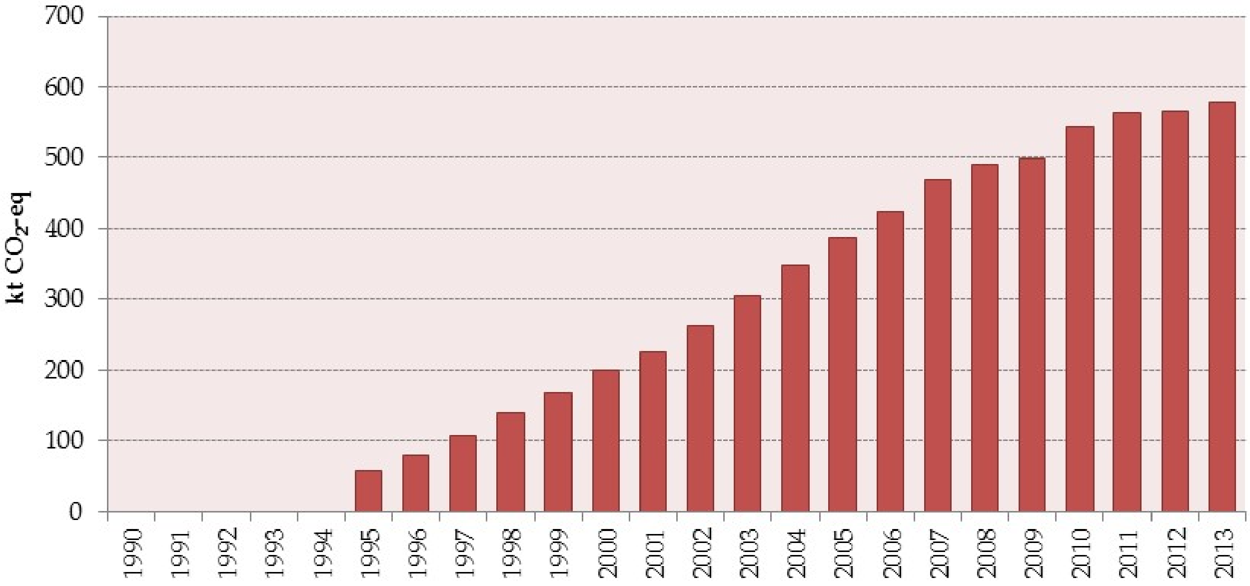
Croatia) data about all refrigeration equipment using HCFC was collected. Because of that, quantities of installed HFC are not so huge. In many hotels, industry and commercial refrigeration HCFC 22 based equipment is still in use.

Also, according to actual economic situation, import and placing of transport refrigeration was decreased on the Croatian market.

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.

Emissions of HFCs and PFCs used in Refrigeration and Air Conditioning Equipment in the period 1990-2013 are presented in the Figure 4.24-1.

Figure 4.24-1: Emissions of HFCs and PFCs used in Refrigeration and Air Conditioning Equipment (1990 - 2013), (kt CO_2-eq)



4.24.3. Uncertainties and time-series consistency

Activity data and emission factor uncertainties were calculated in detail using Monte-Carlo analysis. Uncertainty estimate associated with calculation of HFCs and PFCs emissions amounts to 50 percent for activity data and 50 percent for emission factor, based on expert judgements (detailed in Annex 1).

4.24.4. Category-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 and Product Use. 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 4.24.6).

4.24.5. Category-specific recalculations

Recalculations were made according to applied 2006 IPCC Guidelines.

4.24.6. Category-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 and PFCs 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.

4.25. FOAM BLOWING AGENTS (2.F.2); FIRE PROTECTION (2.F.3); AEROSOLS (2.F.4); SOLVENTS (2.F.5)

4.25.1. Category description

These categories encompasses consumption of HFCs in Foam Blowing Agents (HFC-152a), Fire Protection (HFC-125, HFC-227ea and HFC-236fa) and Aerosols/Metered Dose Inhalers (HFC-134a). The category Solvents does not exist in Croatia. All data on HFCs have been compiled by the MENP.

4.25.2. Methodological issues

Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 have been calculated for the period 1995-2013, since there was no use of these substances prior to 1995.

Tier 2 methodology is used for HFCs emission calculation in 2.F.3 and 2.F.4. Tier 1a methodology is used for emission calculation in 2.F.2 due to the missing data on average annual stocks.

Default emission factors proposed by *2006 IPCC Guidelines* have been used for emission calculation. Calculation of HFCs emission by Tier 2 methodology are based on the data on the amount of HFCs in operating systems (average annual stocks) for Fire Protection (HFC-125, HFC-227ea and HFC-236fa) and Aerosols/Metered Dose Inhalers (HFC-134a). Data on import and export of HFCs are used for emission calculation by means of Tier 1a methodology for Foam Blowing Agents (HFC-152a).

Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 in the period 1995-2013 are reported in the Table 4.25-1.

Table 4.25-1: Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 (t) (1990 - 2013)

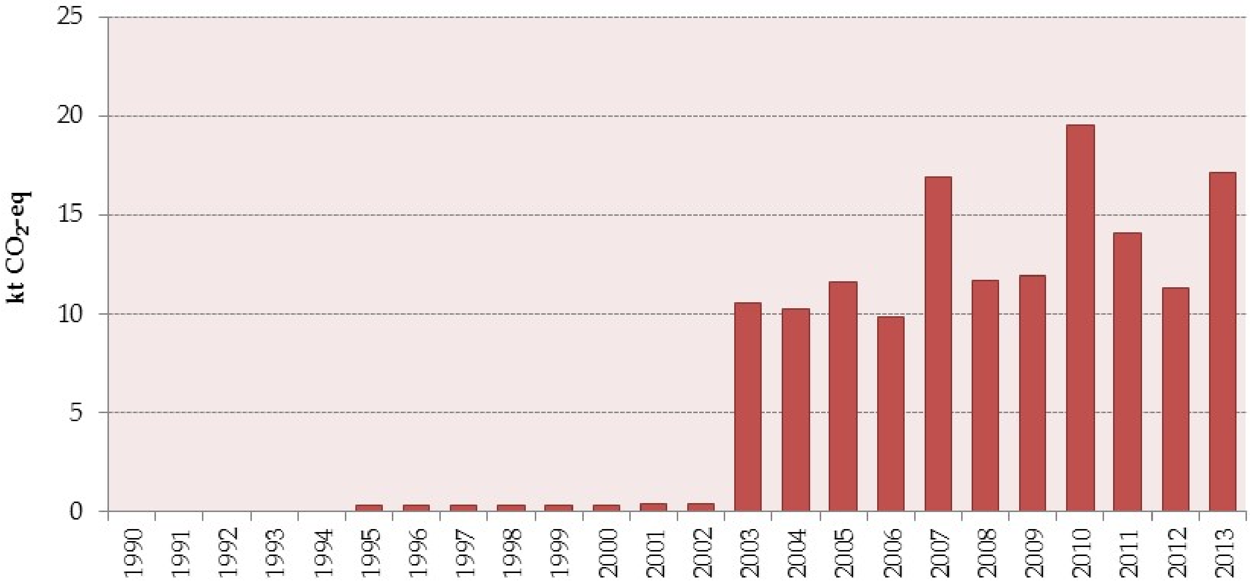
Source/Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003
2.F.2 Foam Blowing Agents									
HFC-152a	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F.3 Fire Protection									
HFC-125	NO	NO	NO	NO	NO	NO	NO	NO	0.01
HFC-227ea	0.04	0.04	0.04	0.04	0.04	0.04	0.06	0.06	0.06
HFC-236fa	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F.4 Aerosols									
HFC-134a	NO	NO	NO	NO	NO	NO	NO	NO	7.05

Table 4.25-1: Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 (t) (1990 - 2013), cont.

Source/Gas	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
2.F.2 Foam Blowing Agents										
HFC-152a	NO	NO	0.40	0.40	NO	0.24	36.09	NO	NO	NO
2.F.3 Fire Protection										
HFC-125	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.06	0.06	0.13
PFC-227ea	0.06	0.07	0.15	0.32	0.39	0.48	0.56	0.68	0.91	1.00
PFC-236fa	NO	NO	0.04	0.08	0.12	0.00	0.00	0.05	0.05	0.06
2.F.4 Aerosols										
HFC-134a	6.84	7.74	5.85	9.73	5.51	6.07	7.80	6.13	3.13	6.40

Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 in the period 1990 - 2013 are presented in the Figure 4.25-1.

Figure 4.25-1: Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 (kt CO_2-eq), (1990 - 2013)



4.25.3. Uncertainties and time-series consistency

Uncertainty estimate associated with calculation of HFCs emissions amounts to 50 percent for activity data and 50 percent for emission factor, based on expert judgements (detailed in Annex 1).

4.25.4. Category-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.

4.25.5. Category-specific recalculations

Recalculations were made according to applied 2006 IPCC Guidelines.

4.25.6. Category-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 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.

OTHER PRODUCT MANUFACTURE AND USE (CRF 2.G)

4.26. ELECTRICAL EQUIPMENT (2.G.1)

4.26.1. Category description

This category encompasses consumption of SF_6 in electrical equipment. Data on SF_6 have been compiled by the MENP.

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.

4.26.2. Methodological issues

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 (Tier 2 methodology, *2006 IPCC Guidelines*) 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).

Emissions of SF_6 used in Electrical Equipment in the period 1990-2013 are presented in the Table 4.26-1.

Table 4.26-1: Emissions of SF_6 (kt CO_2-eq), (1990 - 2013)

Year	Emission of SF_6 (kt CO_2-eq)
1990	10.45
1991	10.33
1992	10.42
1993	10.53
1994	10.64
1995	11.12
1996	11.57
1997	11.43
1998	11.99
1999	11.99
2000	11.62
2001	11.69
2002	12.01
2003	12.28
2004	12.57
2005	13.03
2006	13.01
2007	13.05
2008	11.98
2009	8.03
2010	8.95
2011	9.37
2012	9.21
2013	6.58

4.26.3. Uncertainties and time-series consistency

Uncertainty estimate associated with calculation of SF_6 emissions amounts to 50 percent for activity data and 50 percent for emission factor, based on expert judgements (detailed in Annex 1).

4.26.4. Category-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.

4.26.5. Category-specific recalculations

Recalculations were made according to applied 2006 IPCC Guidelines.

4.26.6. Category-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 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 should be 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.

4.27. SF6 AND PFCS FROM OTHER PRODUCT USE (2.G.2)

This category does not exist in Croatia.

4.28. N_2O FROM PRODUCT USES (2.G.3)

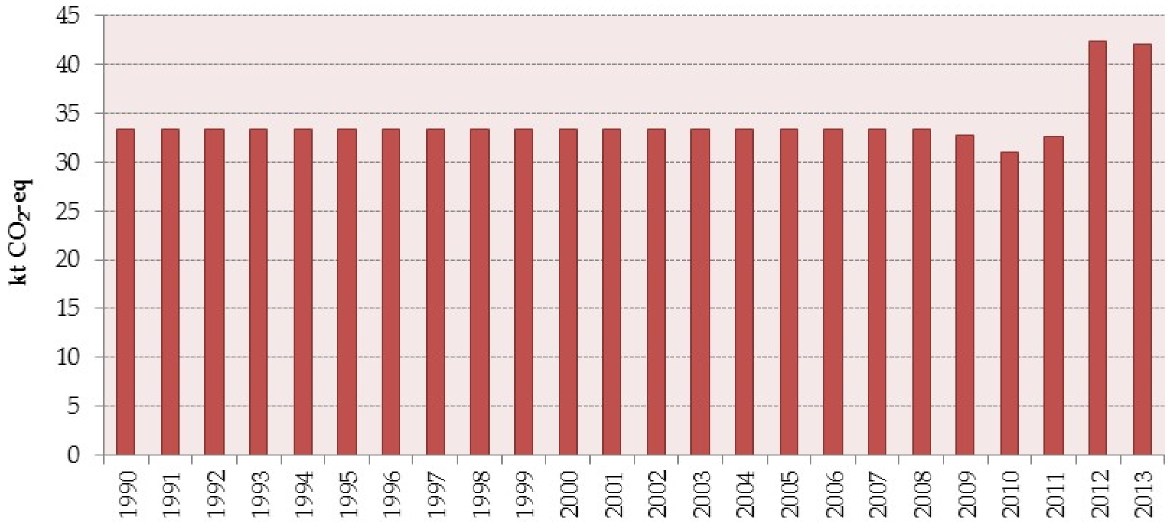
4.28.1. Category description

This category encompasses use of N_2O for anaesthesia and use of N_2O for aerosol cans. According to available data, there is no use of N_2O in fire extinguishers or other uses. Data are obtained by producers and distributors of N_2O in Croatia.

4.28.2. Methodological issues

N_2O emissions have been calculated by multiplying annual quantity of N_2O used for anaesthesia and aerosol cans with default emission factor proposed by *2006 IPCC Guidelines*. 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. Emissions of N_2O from Product Use in the period 1990 - 2013 are presented in the Figure 4.28-1.

Figure 4.28-1: Emissions of N_2O from Product Use (kt CO_2-eq), (1990 - 2013)



4.28.3. Uncertainties and time-series consistency

Uncertainty estimate associated with calculation of N_2O emissions amounts to 50 percent for activity data and 50 percent for emission factor, based on expert judgements (detailed in Annex 1).

4.28.4. Category-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.

4.28.5. Category-specific recalculations

Recalculations were made according to applied 2006 IPCC Guidelines.

4.28.6. Category-specific planned improvements

Data for N_2O use in anaesthesia, aerosol cans, fire extinguishers and other uses should be checked and revised for the entire reporting period.

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

CHAPTER 5: AGRICULTURE (CRF SECTOR 3)

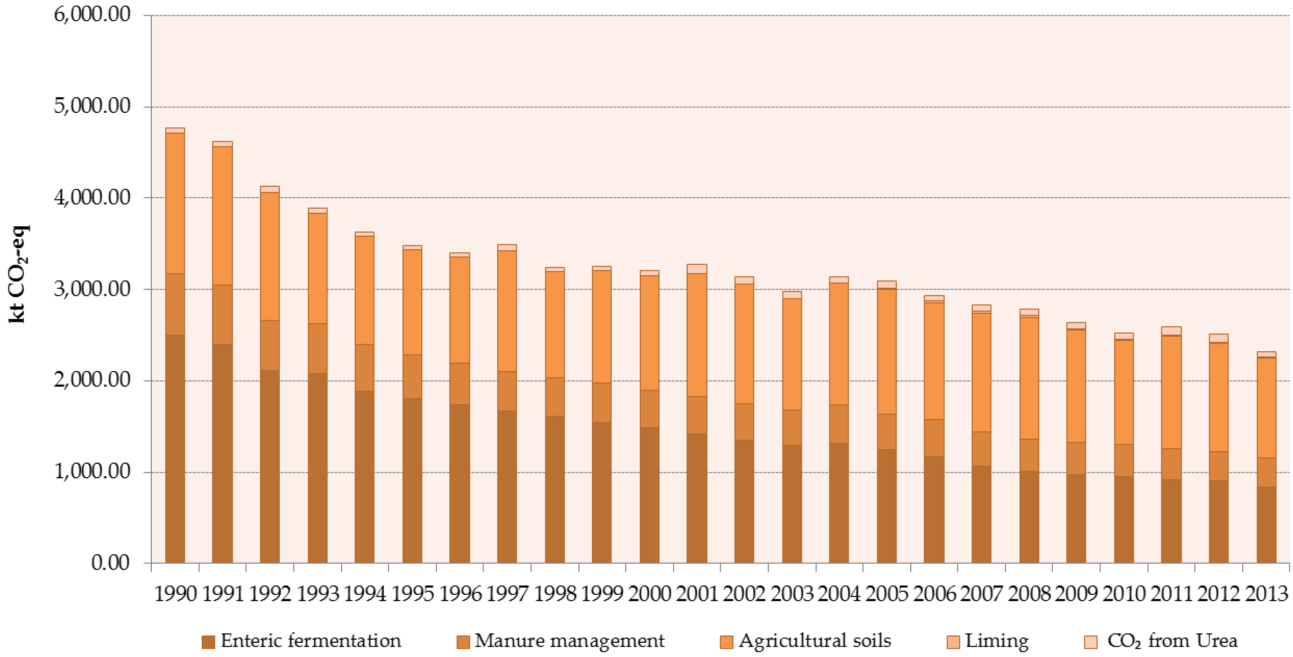
5.1. OVERVIEW OF SECTOR

The agricultural activities contribute directly to the emission of greenhouse gases through various processes. The following main 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)
- Liming and urea application (CO_2)

The total emission in 2013 caused by agricultural activities was 2,317.95 kt CO_2-eq, which represents 9.46 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 5.1-1). 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 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 5.1-1: 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 5.1-1 and Table 5.1-2 show the total emission from Agriculture by gases and by emission sources for the period 1990-2012.

Table 5.1-1: Emission of greenhouse gases from agriculture by gas

Year	Methane emission kt CH_4			Nitrous oxide emission kt N_2O			Carbon dioxide emission kt CO_2		
	Enteric fermentation	Manure management	Total	Manure management	Agricultural soils	Total	Liming	Urea	Total
1990	100.04	14.11	**114.16**	1.09	5.16	**6.25**	NO	50.02	**50.02**
1991	96.05	13.57	**109.62**	1.04	5.09	**6.13**	NO	50.95	**50.95**
1992	84.47	11.62	**96.09**	0.85	4.73	**5.58**	NO	65.51	**65.51**
1993	82.96	11.66	**94.62**	0.86	4.08	**4.94**	NO	52.14	**52.14**
1994	75.59	10.90	**86.49**	0.78	3.97	**4.76**	NO	47.57	**47.57**
1995	72.26	10.28	**82.53**	0.75	3.87	**4.62**	NO	46.29	**46.29**
1996	69.30	9.93	**79.22**	0.72	3.89	**4.60**	NO	52.44	**52.44**
1997	66.57	9.58	**76.15**	0.67	4.41	**5.09**	NO	68.39	**68.39**
1998	64.28	9.30	**73.58**	0.67	3.88	**4.55**	NO	44.25	**44.25**
1999	61.78	9.33	**71.11**	0.68	4.10	**4.78**	NO	50.49	**50.49**
2000	59.51	8.85	**68.35**	0.62	4.21	**4.83**	NO	60.87	**60.87**
2001	56.78	8.79	**65.57**	0.64	4.52	**5.16**	NO	92.09	**92.09**
2002	53.97	8.53	**62.50**	0.62	4.41	**5.02**	NO	80.76	**80.76**
2003	51.51	8.60	**60.11**	0.60	4.11	**4.70**	NO	71.79	**71.79**
2004	52.43	9.03	**61.46**	0.66	4.48	**5.14**	NO	75.94	**75.94**
2005	49.78	8.40	**58.18**	0.61	4.58	**5.20**	14.49	70.97	**85.46**
2006	46.63	8.80	**55.43**	0.63	4.31	**4.93**	17.48	63.19	**80.67**
2007	42.40	8.18	**50.58**	0.58	4.38	**4.96**	16.60	72.72	**89.32**
2008	40.15	7.68	**47.83**	0.55	4.48	**5.02**	20.78	75.83	**96.60**
2009	38.94	7.82	**46.76**	0.55	4.11	**4.66**	11.92	65.04	**76.96**
2010	37.99	7.70	**45.69**	0.54	3.84	**4.38**	13.47	66.58	**80.05**
2011	36.71	7.52	**44.23**	0.50	4.14	**4.64**	14.45	83.86	**98.31**
2012	36.11	7.31	**43.42**	0.47	3.99	**4.46**	9.60	86.85	**96.45**
2013	33.59	7.11	**40.71**	0.47	3.66	**4.13**	9.60	60.39	**69.99**

Table 5.1-2: Emission of greenhouse gases from agriculture in CO_2-eq

Year	Methane emission kt CO_2-eq			Nitrous oxide emission kt CO_2-eq			Carbon dioxide emission kt CO_2-eq			kt CO_2-eq
	Enteric fermentation	Manure management	Total	Manure management	Agricultural soils	Total	Liming	Urea	Total	TOTAL EMISSION
1990	2,501.11	352.87	**2,853.98**	323.85	1,538.65	**1,862.50**	NO	50.02	**50.02**	**4,766.50**
1991	2,401.35	339.22	**2,740.56**	310.12	1,515.65	**1,825.78**	NO	50.95	**50.95**	**4,617.29**
1992	2,111.66	290.47	**2,402.14**	254.54	1,409.00	**1,663.53**	NO	65.51	**65.51**	**4,131.18**
1993	2,074.08	291.43	**2,365.51**	257.67	1,215.41	**1,473.08**	NO	52.14	**52.14**	**3,890.74**
1994	1,889.85	272.39	**2,162.24**	233.38	1,184.27	**1,417.66**	NO	47.57	**47.57**	**3,627.46**
1995	1,806.40	256.97	**2,063.37**	223.41	1,153.48	**1,376.89**	NO	46.29	**46.29**	**3,486.55**
1996	1,732.48	248.13	**1,980.61**	214.07	1,158.10	**1,372.17**	NO	52.44	**52.44**	**3,405.23**
1997	1,664.27	239.39	**1,903.66**	201.04	1,314.37	**1,515.41**	NO	68.39	**68.39**	**3,487.46**
1998	1,606.95	232.44	**1,839.39**	199.90	1,154.93	**1,354.84**	NO	44.25	**44.25**	**3,238.47**
1999	1,544.56	233.17	**1,777.73**	201.64	1,223.19	**1,424.82**	NO	50.49	**50.49**	**3,253.04**
2000	1,487.63	221.24	**1,708.87**	183.33	1,255.60	**1,438.93**	NO	60.87	**60.87**	**3,208.67**
2001	1,419.43	219.78	**1,639.21**	190.95	1,348.08	**1,539.04**	NO	92.09	**92.09**	**3,270.34**
2002	1,349.15	213.24	**1,562.39**	183.69	1,313.76	**1,497.45**	NO	80.76	**80.76**	**3,140.60**
2003	1,287.71	215.02	**1,502.73**	177.78	1,224.12	**1,401.89**	NO	71.79	**71.79**	**2,976.42**
2004	1,310.74	225.71	**1,536.45**	196.57	1,335.35	**1,531.91**	NO	75.94	**75.94**	**3,144.30**
2005	1,244.38	210.04	**1,454.43**	182.82	1,366.16	**1,548.99**	14.49	70.97	**85.46**	**3,088.88**
2006	1,165.80	220.03	**1,385.83**	186.63	1,283.83	**1,470.46**	17.48	63.19	**80.67**	**2,936.96**
2007	1,059.90	204.51	**1,264.41**	173.00	1,304.37	**1,477.37**	16.60	72.72	**89.32**	**2,831.11**
2008	1,003.82	191.90	**1,195.71**	162.79	1,334.01	**1,496.80**	20.78	75.83	**96.60**	**2,789.11**
2009	973.54	195.58	**1,169.11**	163.18	1,224.49	**1,387.67**	11.92	65.04	**76.96**	**2,633.75**
2010	949.79	192.45	**1,142.24**	159.53	1,144.32	**1,303.85**	13.47	66.58	**80.05**	**2,526.14**
2011	917.70	187.96	**1,105.66**	150.43	1,232.45	**1,382.88**	14.45	83.86	**98.31**	**2,586.85**
2012	902.73	182.84	**1,085.57**	140.65	1,189.24	**1,329.89**	9.60	86.85	**96.45**	**2,511.92**
2013	839.85	177.79	**1,017.63**	140.63	1,089.70	**1,230.33**	9.60	60.39	**69.99**	**2,317.95**

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 5.1-3):

Table 5.1-3: Key categories in agriculture sector based on the level and trend assessment in 2013[8]

Table								
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2013)								
A	B	C	D					E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification					Com.
Enteric Fermentation - CH4	CH4	Yes	L1e, L2e	T1e, T2e	L1i,		T1i, T2i	
Direct N2O Emissions From Managed Soils - N2O	N2O	Yes	L1e, L2e		L1i,		T2i	
Indirect N2O Emissions from Managed soils - N2O	N2O	Yes	L1e, L2e		L1i, L2i		T2i	
Manure Management - CH4	CH4	Yes	L1e,	T2e	L1i,		T2i	
Manure Management - N2O	N2O	Yes	L1e,	T2e	L1i,		T1i, T2i	
Liming - CO2	CO2	Yes	L2e					
Urea Application - CO2	CO2	Yes					T2i	

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

ENTERIC FERMENTATION

5.2. CH_4 EMISSIONS FROM ENTERIC FERMENTATION IN DOMESTIC LIVESTOCK (CRF 3.A.)

5.2.1. Category description

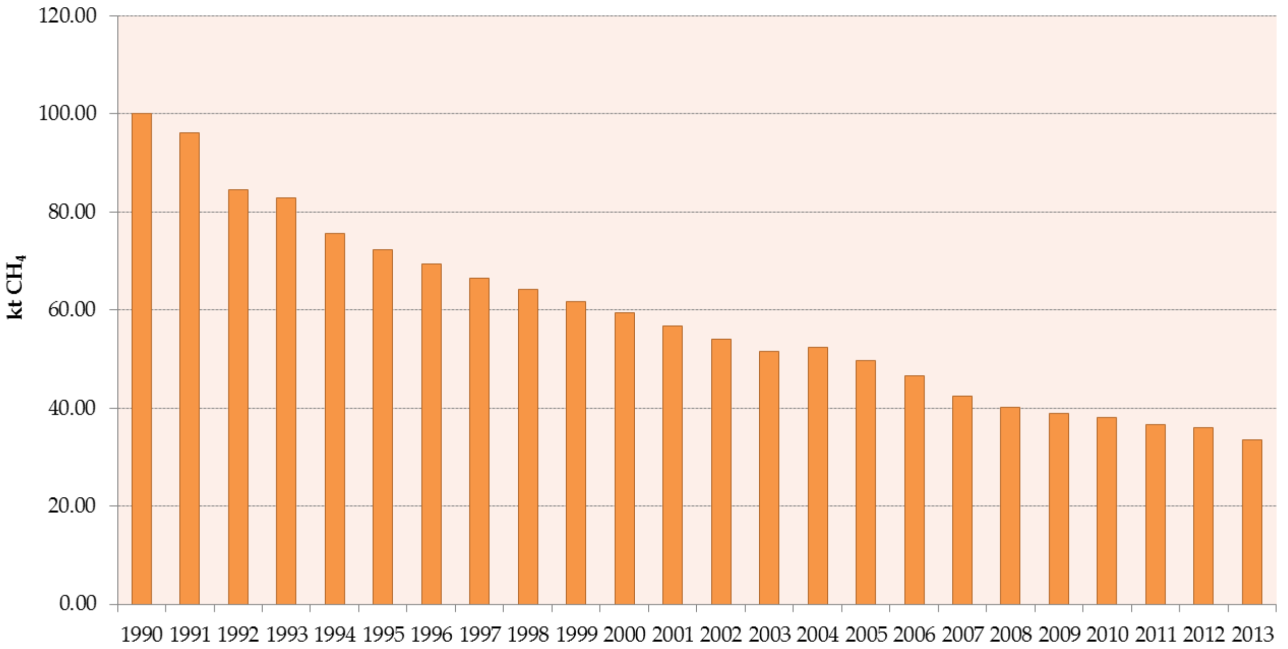
Methane is a direct product of animal metabolism generated during the digestion process. The greatest producers of methane are ruminants (cows, other cattle and sheep). The amount of methane produced and excreted depends on the animal digestive system and the amount and type of the animal feed. Estimates 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 56% of total CH_4 emission from Enteric fermentation in 2013, followed by non dairy cattle representing about 26%. Jointly, cattle are responsible for around 82% of total CH_4 emission from Enteric fermentation.

Figure 5.2-1 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

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

the war period in the early 1990s (up to 1996). The decrease is recorded for each animal category (see Table 5.2.2).

Figure 5.2-1: CH_4 emission from Enteric fermentation



5.2.2. Methodological issues

The IPCC Tier 2 methodology has been used to calculate methane emission from enteric fermentation for all livestock (sub)categories except goats and mules&asses that defaulted to Tier 1 methodolody. National emission factors for animal species were developed with the assistance of experts from the Faculty of Agriculture, University of Zagreb. Data on detailed livestock subcategories was collected and populations segregated for cattle, swine and poultry[9]. Development of national emission factors marks a significant change and improvement of the inventory.

The main two sources regarding the number of animals produced annually (NAPA) are the Central Bureau of Statistics (CBS) and FAO database. See Table 5.2-1 for detailed information. Numbers on dairy cattle category was also provided by CAA for the years 2008-2013. Animal number for the rest of the dataset (years 1990 to 2007) was extrapolated based on the 2008-2013 numbers, based on the

[9] Poultry is not a source of CH_4 emissions from Enteric Fermentation, however average annual population is a shared activity data with other source categories (Manure Management).

expert opinion of Croatian agency for the environment and nature. National data (provided by Croatian CBS and CAA) are considered to be the most accurate source. For animal categories where national data was not available, FAO data was considered an adequate replacement source. The number of animals produced annually (NAPA) is reported in Table 5.2-2. Conversion of NAPA to annual average population (AAP) was performed using Equation 10.1 (2006 IPCC Guidelines for National Greenhouse Gas Inventories) and expert judgement data provided by expert from the Faculty of Agriculture, University of Zagreb, as detailed in Table 5.2-3. NAPA to AAP conversion was performed on the most detailed segretation level for which data was available, before the livestock categories were reclassified.

Cattle classification used 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

Swine classification used for Tier 2 is as follows:

- Market swine (nursery, finishers, fattening pigs)
- Breeding swine (sows, gilts, breeding boars)

Table 5.2-1: Sources of activity data regarding animal population

Animal category	CBS	FAO	Croatian Agricultural Agency	Extrapolation
Dairy cattle			2008-2013	1990-2007
Other cattle	1990-2013			
Sheep	1990-2013			
Goats	1990-1991; 1999-2013	1992-1998		
Horses	1990-1994		1995-2013	
Mules/assess	1990-1991	1992-1994	1995-2013	
Swine	1990-2013			
Poultry	1990-2013			

Table 5.2-2: Number of animals produced annualy in the period from 1990 – 2013

Year	*Animal number / 1000 heads*							
	Dairy cattle	Total Non-dairy	Sheep	Goats	Horses	Mules/ asses	Total Swine	Total 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	1182	10160
2013	181	276	620	69	21	3	1110	9307

Table 5.2-3: Livestock categories and "days alive" estimate used for NAPA to AAP conversion for year 2013

Disagregated Livestock categories	Days alive	Disagregated Livestock categories	Days alive
Market swine (nursery, finishers, fattening pigs)		**Poultry**	
0-20 kg	70 days	Layers	365 days
20-50 kg	112 days	Broilers	51 days
50-80 kg	160 days	Turkeys	240 days
80-110 kg	202 days	Geese	180 days
110+ kg	365 days	Ducks	180 days
		Other	365 days

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 1990-2013, 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 (1995-2013) and mules/asses (1995-2013). 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, swine and poultry 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 5.2-4 contains information on how CBS categories for cattle were reclassified into the appropriate IPCC categories. Over time, it is expected that this CBS categorization will be uniform across the dataset.

Table 5.2-4: Cattle classification into main IPPC subcategories

IPPC categories	CBS categories		
	1990-1999	2000-2006	2007-2013
Mature non-dairy cattle	▪ 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 cattle	▪ 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)

Existing Tier 2 calculation emission for cattle was updated from 1996 to 2006 IPCC Guidelines methodology with the assistance of the experts from the Faculty of Agriculture, University of Zagreb, changing previously used default data form 1996 IPCC guidelines with national values (see Table 5.2-5). 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 2010-2013. Average value of national live animal weights dataset for the years 2010-2013 was used for cattle categories.

Table 5.2-5: National data used in emission factor calculation for cattle for 2013

Animal	weight (kg)	Cfi	Ca	WG (kg/day)	fat (%)	$C_{pregnancy}$	DE (%)	Ym
mature dairy	562.82	0.386	0.009	0.00	4.00	0.10	61.00	0.064
mature non-dairy	529.06	0.322	0.097	0.00	-	-	50.00	0.070
young	301.64	0.322	0.000	0.40	-	-	75.00	0.040

Milk yield per cow per day for the period from 1990-2013 is presented in Table 5.2-5. AD set on milk yield per cow was provided by CAA for the years 2008-2013, while the rest of the data set (1990-2007) was extrapolated based on CAA data and expert judgement of Croatian agency for the environment and nature.

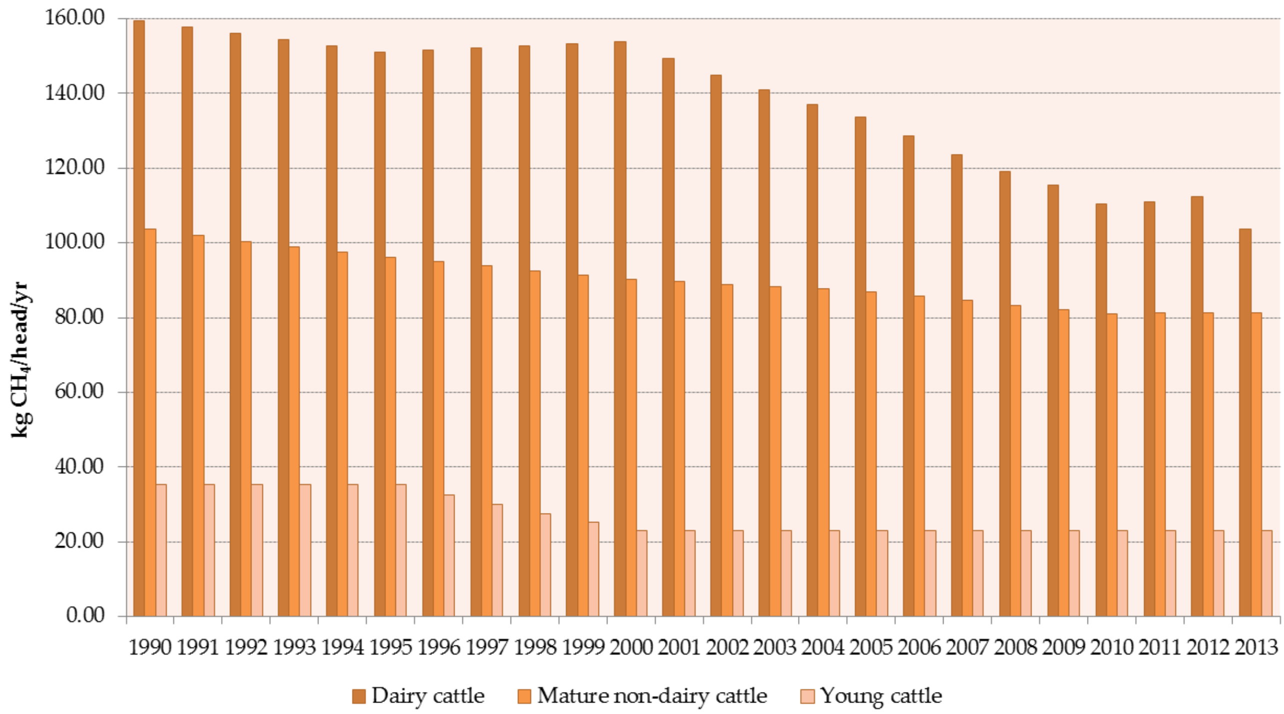
Table 5.2-5: Milk yield per cow

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Milk yield (kg/day)	6.27	6.38	6.50	6.61	6.73	6.85	6.98	7.10	7.23	7.36	7.49

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Milk yield (kg/day)	7.63	7.77	7.91	8.05	8.19	8.34	8.49	8.64	8.91	8.87	9.03	9.38	8.37

Emission factors for mature non-dairy, young and dairy cattle is presented in Figure 5.2-2.

Figure 5.2-2: Enteric fermentation emission factors used for dairy cattle



For other animals (sheep, horses, swine) national emission factors were also developed for key years in the data series and then interpolated for the time periods between key years. For goats, mules and asses default emission factors for developed countries were used for the entire data series. See Table 5.2-6.

Table 5.2-6: National enteric fermentation emission factors for each animal category (except cattle) for year 2013

Animal Category	Methodology used	EF / kg per head per year
		2013
Sheep	Tier2	7.76 (country specific)
Goats	Tier1	5.00 (default)
Horses	Tier2	10.64 (country specific)
Mules/asses	Tier1	10.00 (default)
Swine	Tier2	1.37 (country specific)
Poultry	-	Not estimated

5.2.3. Uncertainties and time-series consistency

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%.

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.

5.2.4. 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.

5.2.5. Category-specific recalculations

Emissions were recalculated for the entire 1990-2013 period due to changes in methodology (2006 IPCC guidelines) and national EF for all animal categories.

5.2.6. Category-specific planned improvements

Planned improvements which are assumed to be mid-term or long-term goals (over 1 year) are:

- 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 and investigation into existing and additional annual population subcagetorization for animal species that present a significant share in emissions. This applies particulary to improvement to swine subcategorization to prevent overestimation of emissions
- Continued investigation of activity data (livestock population numbers) with the purpose of gathering more detailed activity data, particularly of sheep annual population subcategorization.
- Continued improvements and verifications of parameters for Tier 2 emission calculation for historical years, particulary for cattle subcategories.

MANURE MANAGEMENT

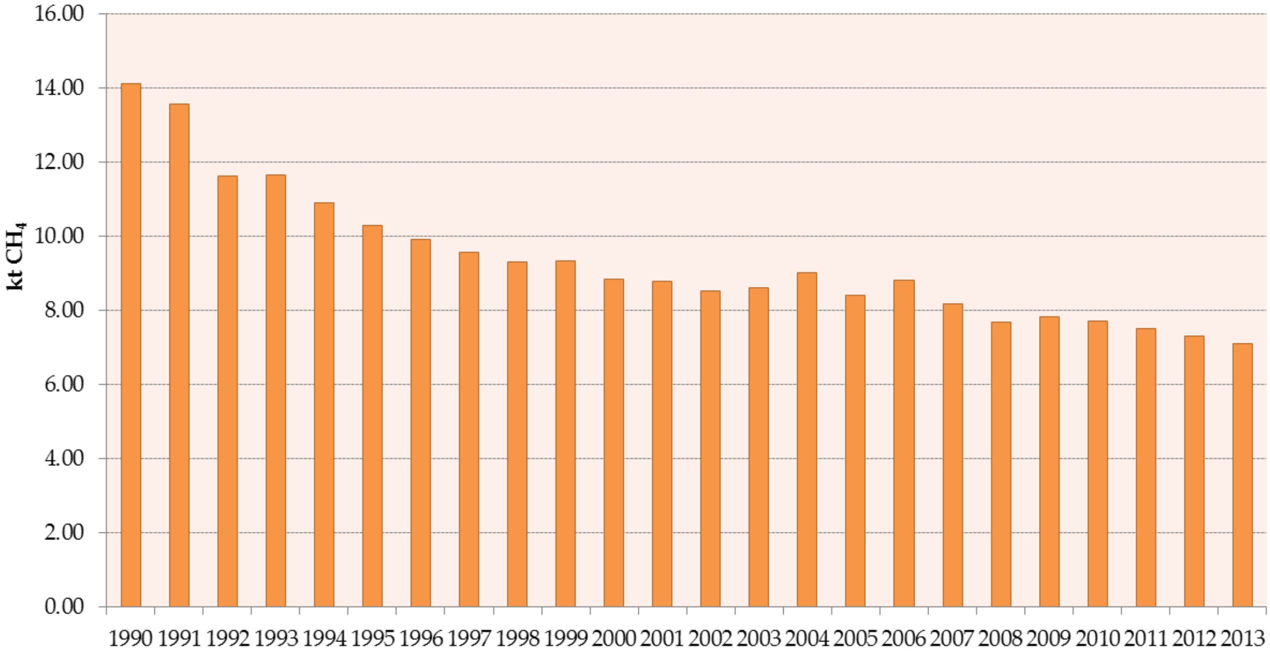
5.3. MANURE MANAGEMENT – CH4 EMISSIONS (CRF 3.B.1.)

5.3.1. Category description

Management of livestock manure produces both methane (CH_4) and nitrous oxide (N_2O) emissions. CH_4 produced during the storage and treatment of manure, and from manure deposited on pasture is estimated, and the main factors affecting CH4 emissions are the amount of manure produced and the portion of the manure that decomposes anaerobically. This occurs most readily when large numbers of animals are managed in a confined area and where manure is disposed of in liquid-based systems.

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. Methane emission from Manure management for the period from 1990 to 2013 is presented in Figure 5.3-1. The emission trend depends on the animal population trend.

Figure 5.3-1: CH_4 emission from Manure management



5.3.2. Methodological issues

The 2006 IPCC methodology, Tier 2 method 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 Chapter 5.2.2 and Table 5.2-2 for additional information. National emission factors were developed for all animal species with the assistance of experts from the Faculty of Agriculture, University of Zagreb.

Table 5.3-1: National manure management emission factors for each animal category for the year 2013

Animal Category	EF / kg per head per year
Cattle	
Dairy cattle	16.90
Othery cattle	8.09
Sheep	0.118
Goats	0.123
Horses	1.33
Mules/asses	1.33
Swine	
Market swine	2.58
Breeding swine	3.92
Poultry	0.03

5.3.3. Uncertainties and time-series consistency

Uncertainty estimate associated with activity data amounts to minimal ±10% and maximum of ±30%, based on expert judgments and values for default EF from 2006 IPCC Guidelines. The expert judgment 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 30% based on expert judgment.

5.3.4. 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.

5.3.5. Category-specific recalculations

Emissions were recalculated for the entire 1990-2012 period due to changes in methodology (2006 IPCC guidelines 2006) and EF for all animal categories.

5.3.6. Category-specific planned improvements

Planned improvements for the Enteric Fermentation source will also improve emissions calculation from Manure management sector. Please refer to chapter 5.2.6 for the planned improvements for Enteric Fermentation.

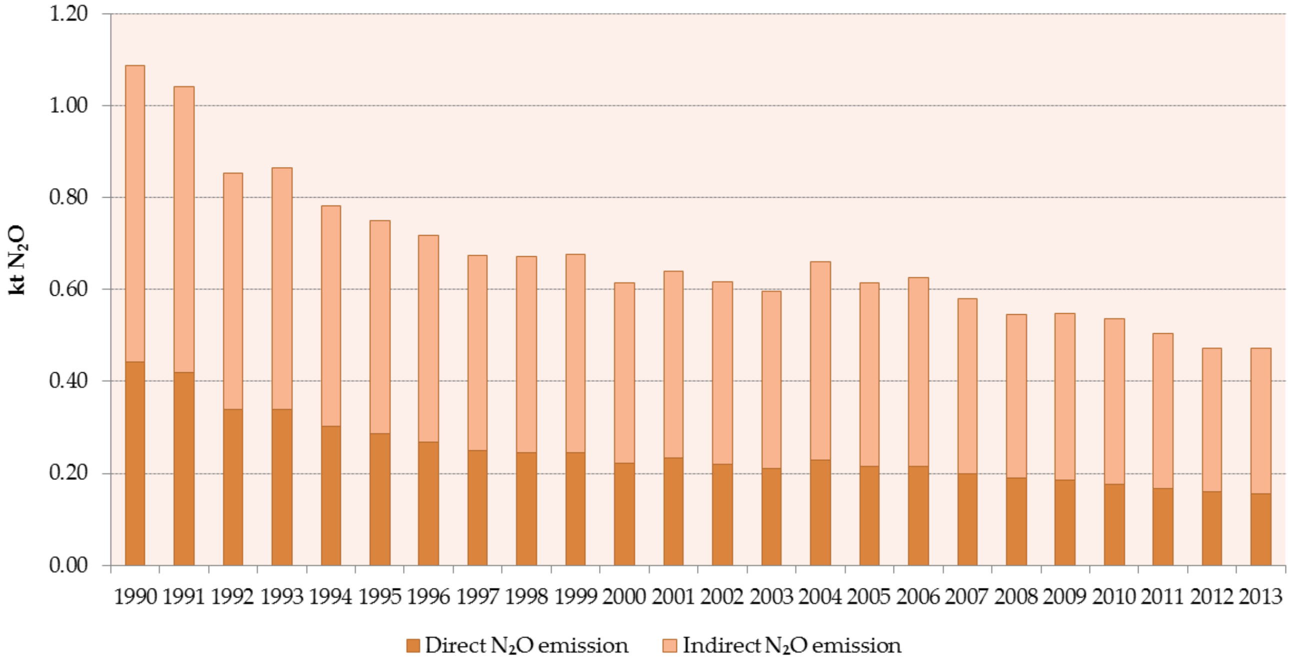
5.4. MANURE MANAGEMENT – N_2O EMISSIONS (CRF 3.B.2.)

5.4.1. Category description

Management of livestock manure produces both methane (CH4) and nitrous oxide (N_2O) emissions. N_2O is produced during the storage and treatment of manure before it is applied to land or otherwise used for feed, fuel, or construction purposes. The emission of N_2O from manure during storage and treatment depends on the nitrogen and carbon content of manure, and on the duration of the storage and type of treatment. Direct N_2O emissions occur via combined nitrification and denitrification of nitrogen contained in the manure. Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NOx.

There are two emission pathways of nitrous oxide (N_2O) as a result of manure management. Direct N_2O emissions via combined nitrification and denitrification of nitrogen contained in the manure, dependant on storage and treatment types and methods. 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. Second pathway is indirect emission from volatile nitrogen losses that occur in the forms of ammonia and NOx,. and losses through runoff and leaching into soils. Nitrous oxide (N_2O) emissions from Manure management for the period from 1990 to 2013 are presented in Figure 5.4-1.

Figure 5.4-1: N_2O Emissions from Manure management



5.4.2. Methodological issues

Direct N_2O Emissions from Manure Management

The 2006 IPCC methodology (Tier 2) has been used. Emissions were calculated using equation 10.25 (2006 IPCC Guidelines), with country-specific data: nitrogen excretion rates (Nex) for all animal categories and fraction of Nex for each livestock category (T) managed in each manure management system (S) usage data ($MS_{(T,S)}$), presented in Table 5.4-1 for the last inventory year. Country-specific data was developed with the assistance of experts from the Faculty of Agriculture, University of Zagreb for each year in the data series (calculated for key years and then interpolated for the time periods between key years), marking a significant improvement in this source category of the inventory.

Default emission factors (Table 10.21 of 2006 IPCC Guidelines) were used for the final estimate calculation of direct N_2O emissions.

The emission trend depends on the animal population trend. Activity data regarding livestock population are the same as for the calculation of CH_4 emission from Enteric fermentation and Manure management.

Table 5.4-1: Manure management emission factors for each animal category and AWMS for the year 2013

Livestock Type	Nitrogen Excretion Nex kg/head/(yr)	Fraction of Manure Nitrogen per AWMS (%/100)					
		Anaerob. lagoon	Liquid system	Solid storage and drylot	Pasture range and paddock	Digester	Other systems
Dairy Cattle	87.84	5.00	49.7	39.30	2.00	3.00	1.00
Other Cattle	50.32	0.00	34.7	56.30	5.00	3.00	1.00
Sheep	8.04	0.00	0.00	17.20	82.80	0.00	0.00
Goats	16.61	0.00	0.00	6.80	88.40	0.00	4.80
Horses	41.79	0.00	0.00	30.00	70.00	0.00	0.00
Mules	39.42	0.00	0.00	10.00	90.00	0.00	0.00
Market swine	9.78	2.00	83.26	11.74	0.00	3.00	0.00
Breeding swine	30.99	1.60	74.24	20.16	1.00	3.00	0.00
Layers	0.55	0.00	12.00	87.00	1.00	0.00	0.00
Broilers	0.40	0.00	1.00	98.00	1.00	0.00	0.00
Turkeys	1.60	0.00	0.00	98.00	1.40	0.00	0.60
Ducks	0.76	0.00	1.00	93.00	5.00	0.00	1.00
Other poultry	1.21	0.00	10.00	80.00	5.00	0.00	5.00

Indirect N_2O Emissions from Manure Management

Tier 1 methodology (Equation 10.26, 2006 IPCC guidelines) has been used. Volatized N in forms of NH_3 and NO_x was calculated for each manure management systems from all livestock categories, summing all N losses. Final N_2O emissions were the estimated using Equation 10.27 (2006 IPCC guidelines), using default emission factors (Table 11.3, 2006 IPCC guidelines).

5.4.3. Uncertainties and time-series consistency

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 estimated to be ±25%. Uncertainty of emission factors is within the range -50% to +100%.

5.4.4. 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

5.4.5. Category-specific recalculations

Emissions were recalculated for the entire 1990-2012 period due to changes in methodology (2006 IPCC guidelines 2006) , also accounting for new country specific data for all animal categories and manure management systems.

5.4.6. Category-specific planned improvements

Short term goals (1 year) are as follows:

Planned improvements which are assumed to be mid-term or long-term goals (over 1 year) are:

- Continued improvements of fractions for N excretion for livestock categories (primarily cattle and swine) in manure management systems with the purpose of further verification of source data.
- Developing estimations of FracleachMS for Tier2 estimates of indirect emission.

RICE CULTIVATION

5.5. RICE CULTIVATION (CRF 3.C.)

5.5.1. Category description

Anaerobicy 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

AGRICULTURAL SOILS

5.6. DIRECT N_2O EMISSION FROM MANAGED SOILS (CRF 3.D.1.)

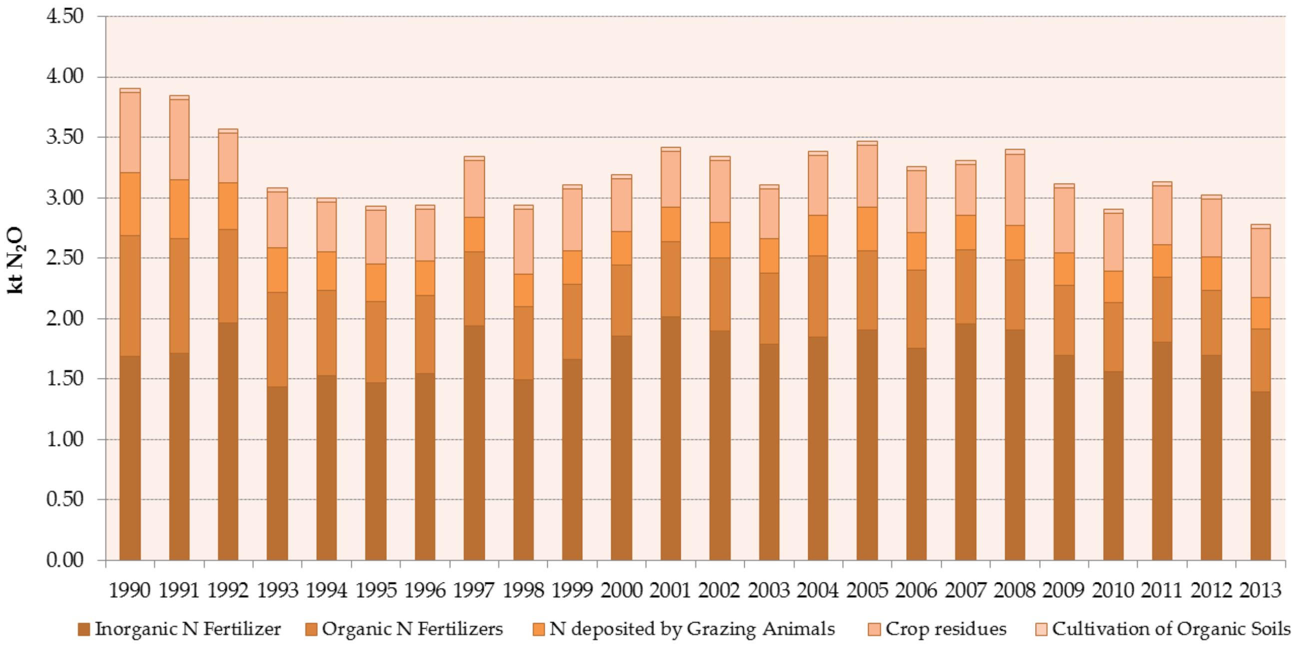
5.6.1. Category description

Direct N_2O emissions from agricultural soils include total amount of nitrogen applied to soils through human induced N aditions and/or change od practices. Specific N sources estimated are as follows:

- Inorganic N Fertilizers (3.D.1.1)
- Organic N Fertilizers (3.D.1.2)
  - Animal Manure applied to Soils (3.D.1.2.a.)
  - Sewage Sludge applied to Soils (3.D.1.2.b.)
- Urine and Dung deposited by Grazing Animals (3.D.1.3)
- Crop Residues (3.D.1.4)
- Mineralization/Immobilization Associated with Loss/Gain of Soil Organic Content (3.D.1.5)
- Cultivation of Organic Soils (3.D.1.6)

Direct Emissions of N_2O from Managed Soils for the period from 1990 to 2013 are shown in Figure 5.6-2.

Figure 5.6-2: Direct N_2O emissions from Agricultural soils



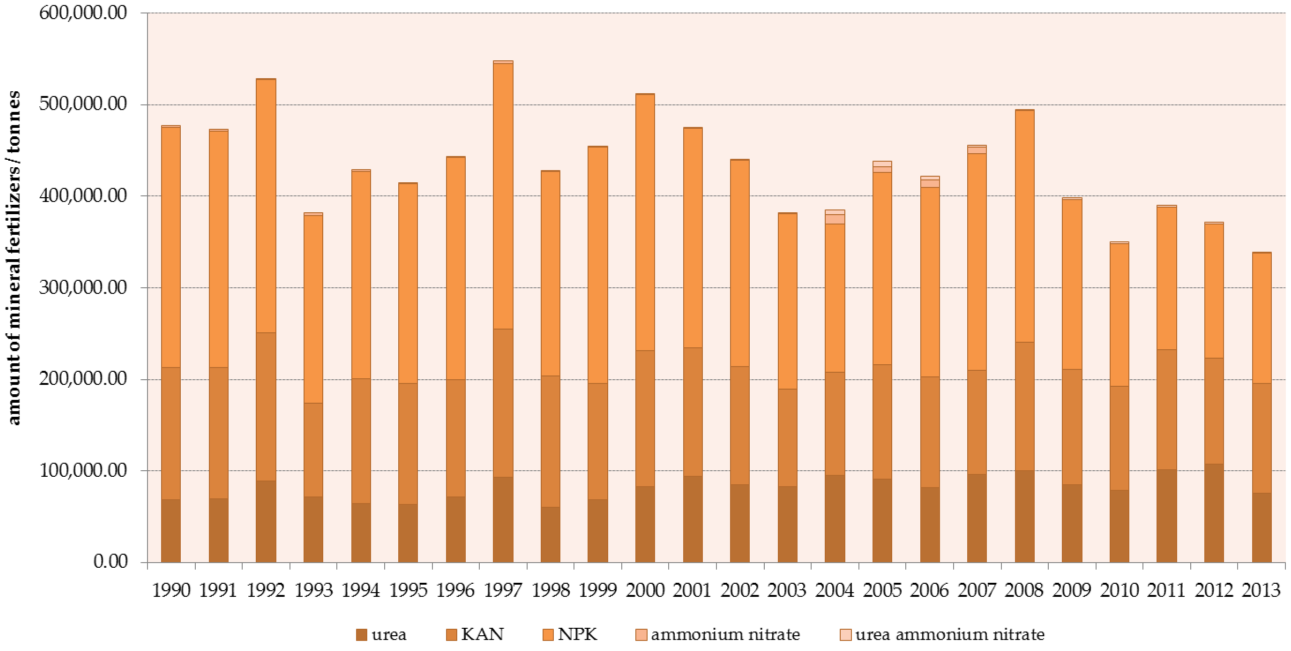
5.6.2. Methodological issues

In order to calculate emission from Agricultural Soils, the IPCC methodology (Tier 1) has been used. Emission factors were taken from the 2006 *IPCC Guidance.*

Inorganic N Fertilizers (3.D.1.1)

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 1992-2013. 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 1990-2012 is presented in Figure 5.6-3 while the nitrogen applied in the same period is shown in Table 5.6-1.

Figure 5.6-3: Mineral fertilizers applied to soil in the period from 1990-2013



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 5.6-1: Nitrogen from applied inorganic fertilizers in the period 1990-2013

Year	Nitrogen applied / tonnes					
	Urea	Calcium ammonium nitrate	NPK	Ammonium nitrate	Urea ammonium nitrate	TOTAL
1990	68,209	144,556	261,794	2,153	0	107,413
1991	69,472	143,124	258,292	2,007	0	108,715
1992	89,334	161,189	276,713	843	0	124,818
1993	71,099	102,754	205,052	3,145	0	91,359
1994	64,868	135,955	226,090	1,639	0	96,911
1995	63,128	132,226	218,533	835	0	93,416
1996	71,509	128,314	241,928	244	0	98,389
1997	93,256	161,515	289,936	2,749	0	123,352
1998	60,339	143,669	222,759	1,018	0	95,246
1999	68,846	126,746	257,479	702	0	105,621
2000	82,999	147,858	279,536	125	0	118,005
2001	93,893	139,985	240,620	819	0	128,343
2002	85,003	129,147	225,254	289	0	120,469
2003	82,418	106,579	191,836	13	0	113,621
2004	94,970	112,896	161,585	10,262	5,268	117,579
2005	90,721	125,113	209,990	6,643	5,609	121,309
2006	81,332	121,063	206,965	8,103	4,634	111,802
2007	96,273	113,891	235,688	7,190	2,496	124,661
2008	100,165	139,864	252,931	0	1,965	121,148
2009	84,941	126,257	184,776	0	2,458	108,011
2010	78,222	114,386	155,934	0	1,660	99,526
2011	100,979	130,936	155,712	0	2,012	114,579
2012	107,081	116,027	146,454	0	2,207	107,869
2013	75,150	120,149	142,468	0	1,049	88,509

Organic N Fertilizers (3.D.1.2)

Estimated amounts of organic N inputs applied to soils other than grazing animals was calculated using Equation 11.3 from 2006 IPCC Guidlelines for National Greenhouse Gas Inventories. Applied animal manure and sewage sludge were accounted for.

Animal Manure applied to Soils (3.D.1.2.a.)

The estimate is based on the amount of N in solid and liquid manure/slurry which is annually used for crop fertilization, calculated using the Equation 11.4 from the 2006 IPCC Guidlelines for National Greenhouse Gas Inventories. In the Republic of Croatia, manure is not used as fuel, feed or for construction, so adjustment of annual amount of animal manure in regards to these fractions was not necessary.

Sewage Sludge applied to Soils (3.D.1.2.b.)

Sufficient activity data was provided for the period 2005-2013, 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 agency for the environment and nature. 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.

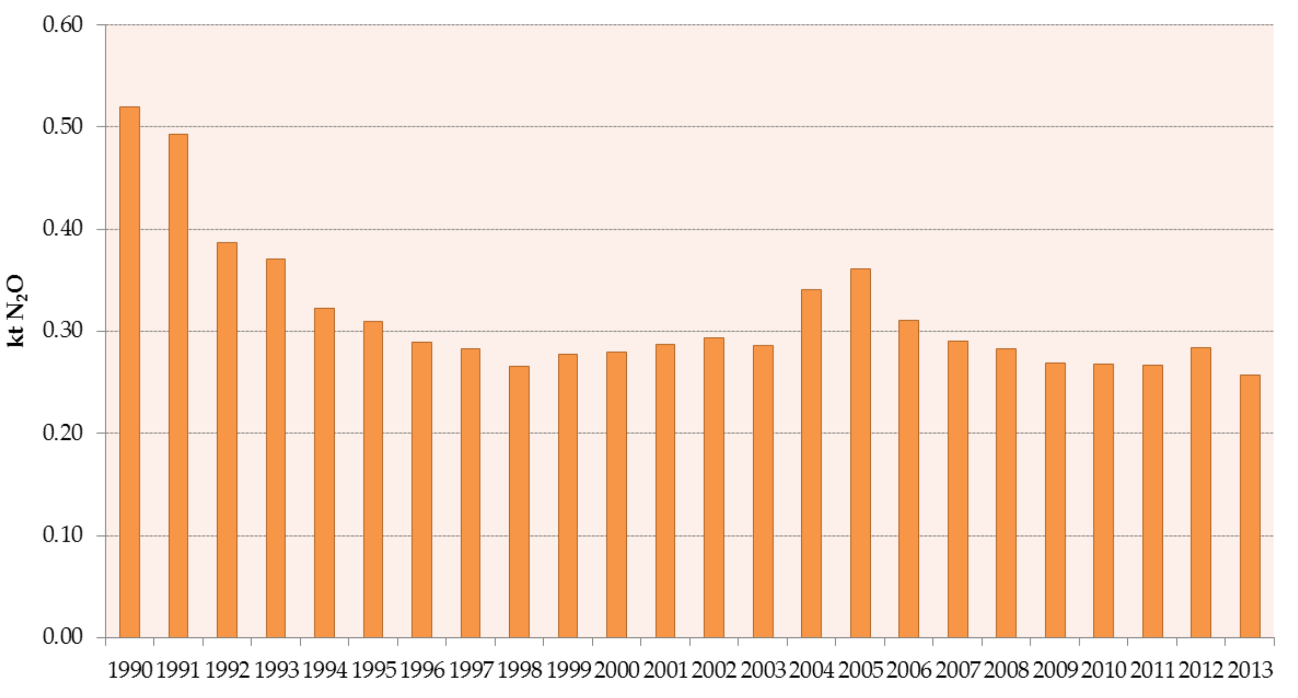
Table 5.6-2: Amount of sludge and nitrogen percentage applied

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	3.89%
2010	434	3.89%
2011	683	3.89%
2012	956	3.89%
2013	1567	3.89%

Urine and Dung deposited by Grazing Animals (3.D.1.3)

Annual amount of N input deposited on pasture, range and paddock soils by grazing animals. Equation 11.5 from 2006 IPCC Guidelines for National Greenhouse Gas Inventories was used for the estimation calculation. Data on N deposited was obtained from the Direct N2O emission from Manure Management (see Chapter 5.3.2.2 for details) using country-specific data on nitrogen excretion rates for each livestock species. Emissions of N_2O follow the trend of livestock number and is are shown in Figure 5.6-4.

Figure 5.6-4: N_2O emissions due to urine and dung deposited by grazing animals 1990-2013



Crop Residues (3.D.1.4)

Tier 1 method using Equation 11.6 from 2006 IPCC Guidlelines for National Greenhouse Gas Inventories was used in calculation of nitrous oxide emission from crop residues. The estimate is based on the amount of crop residues including N-fixing crops returned to soils annualy. The data on crop production were obtained from the Central Bureau of Statistics, FAO database and for certain years by extrapolation (see Table 5.6-3). 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. FAO data on harvested area was used for all crops. 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. 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.

Activity data related to crop production and harvest data is presented in Table 5.6-4.

Table 5.6-3: Data sources regarding crop production

Crop	CBS	FAO	Extrapolation*
Soyabeans	1990-2013		
Beans, dry	1990-2013		
Cow peas, dry	2008-2013	1992-2007	1990-1991
Lentils		1992-2013	1990-1991
Peas, dry	2008-2013	1992-2007	1990-1991
Vetches		1992-2013	1990-1991
Clover	1990-2013		
Alfaalfa	1990-2013		
Wheat	1990-2013		
Maize	1990-1991, 1994-2013	1992-1993	
Potatoes	1990-2013		
Sugar beets	1990-2013		
Tobacco	1990-2013		
Sunflowers	1990-2013		
Rape seed	1990-2013		
Tomatoes	1990-2011		
Barley	1990-2013		
Oats	1990-1991; 2000-2013	1992-1999	
Cabbages and other brassicas	1990-2013		
Garlic**	1990-2013		
Onions**	1990-2013		
Rye	1990-2013		
Sorghum	1990-1997***, 2012-2013	1998-2011	
Watermelons	1990-2013		

**Extrapolation was based on data for the period 1992-1995.*

***CBS provides aggregated data for garlic & onions. FAO data was used to calculate yearly ratios of garlic and onions in the total, aggregated number.*

****CBS did not obtain sorghum production data from 1997 to 2012*

Table 5.6-4: Production and harvest data crops in the period from 1990 – 2013

Year	Production of crops / tonnes/ ha															
	Wheat		Maize		Potatoes		Sugar beets		Tobacco		Sunflowers		Rape seed		Tomatoes	
	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha
1990	1,602,435	219,260	1,950,011	408,194	610,236	85,670	1,205,928	19,855	12,394	7,709	52,982	17,765	33,200	9,016	54,742	7,019
1991	1,495,625	217,356	2,387,533	403,502	658,687	82,152	1,244,439	20,165	10,460	7,584	46,430	18,585	22,816	9,416	48,601	6,749
1992	658,019	168,865	1,537,663	370,205	480,079	60,758	525,189	17,500	11,651	8,377	40,413	18,153	24,183	11,743	35,262	4,318
1993	886,921	211,845	1,671,819	373,166	507,898	64,754	537,196	14,717	9,585	7,635	42,723	17,564	28,665	13,010	39,771	4,784
1994	750,330	198,381	1,686,922	370,517	563,285	66,356	591,819	16,043	8,613	6,659	26,474	17,871	28,341	13,889	46,276	4,956
1995	876,507	227,044	1,735,854	354,059	692,216	66,458	690,707	18,804	8,548	6,798	37,066	19,385	24,472	10,982	46,958	4,778
1996	741,235	200,852	1,885,515	361,268	666,020	65,537	906,246	20,896	11,272	7,735	28,526	18,849	11,661	7,651	49,019	4,901
1997	833,508	208,377	2,183,144	371,273	620,032	63,189	931,186	22,919	11,339	7,274	36,138	16,946	11,181	5,356	48,085	5,141
1998	1,020,045	241,734	1,982,545	377,818	664,753	64,931	1,233,322	29,287	12,133	7,445	62,206	28,642	21,967	8,949	62,003	5,765
1999	558,217	169,280	2,135,452	384,184	728,646	66,374	1,113,969	27,847	10,051	6,490	72,374	41,996	32,581	16,234	70,816	6,408
2000	865,260	235,939	1,190,238	388,639	198,243	65,232	482,211	20,985	9,714	5,678	53,956	25,715	29,436	12,886	26,081	6,634
2001	811,674	239,856	1,733,003	406,153	242,709	65,641	964,880	23,757	10,502	5,500	42,985	25,336	22,456	10,319	27,272	6,801
2002	822,650	233,699	1,956,418	408,877	266,055	64,640	1,183,445	25,149	10,905	5,489	62,965	26,835	25,585	13,041	25,988	6,867
2003	506,212	205,998	1,279,617	405,947	164,051	63,097	677,569	27,327	9,680	5,748	69,253	28,211	28,596	15,524	22,942	7,055
2004	801,424	214,508	1,931,627	413,764	247,057	16,043	1,260,444	26,560	10,293	5,394	68,973	28,381	31,392	14,299	25,938	1,200
2005	601,748	146,253	2,206,729	318,972	273,409	18,903	1,337,750	29,370	9,579	5,131	78,006	49,769	41,275	20,149	28,930	1,192
2006	804,601	175,551	1,934,517	296,195	274,529	16,759	1,559,737	31,881	10,851	4,940	81,614	35,308	19,996	8,413	29,027	1,550
2007	812,347	175,045	1,424,599	288,549	296,302	17,355	1,582,606	34,316	12,639	6,005	54,303	20,615	39,330	13,069	48,040	1,682
2008	858,333	156,536	2,504,940	314,062	255,554	15,000	1,269,536	22,000	12,866	5,897	119,872	38,631	62,942	22,372	32,358	1,226
2009	936,076	180,376	2,182,521	296,910	270,251	14,000	1,217,041	23,066	13,348	6,062	82,098	27,366	80,424	28,723	37,419	1,229
2010	681,017	168,507	2,067,815	296,768	178,611	10,950	1,249,151	23,832	8,491	4,119	61,789	26,412	33,047	16,339	33,648	945
2011	782,499	149,797	1,733,664	305,130	167,524	10,881	1,168,015	21,723	10,643	5,905	84,960	30,041	49,483	17,563	35,798	1,054
2012	999,681	186,949	1,297,590	299,161	151,278	10,232	919,230	24,000	11,787	6,000	90,019	33,534	26,406	9,893	25,418	800
2013	998,940	204,506	1,874,372	288,365	162,501	10,234	1,050,715	20,245	9,834	6,095	130,576	40,805	47,827	17,972	28,504	743

Table 5.6-4: Production and harvest data crops in the period from 1990 – 2013 (cont.)

Year	Production of crops / tonnes/ ha															
	Barley		Oats		Cabbages and other brassicas		Garlic		Onions		Rye		Sorghum		Watermelons	
	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha
1990	196,554	31,663	62,287	16,528	135,637	11,791	11,830	3,290	40,309	8,172	15,840	3,053	2,185	32	20,938	2.054
1991	185,695	33,003	53,851	16,875	129,437	11,337	10,471	3,163	38,488	7,837	14,069	2,974	1,858	47	17,941	2.023
1992	106,811	32,873	45,262	17,582	75,981	7,745	6,744	2,304	28,717	5,082	6,069	2,252	633	140	8,062	682
1993	125,671	36,605	41,074	17,204	88,933	8,559	7,345	2,439	31,081	5,417	6,273	2,453	678	147	8,014	767
1994	107,810	36,225	42,425	18,493	104,178	8,788	9,346	2,543	40,896	5,955	7,146	2,963	618	136	16,045	1.141
1995	103,281	32,518	38,237	15,763	125,874	8,858	9,384	2,419	43,010	5,842	5,051	1,930	559	133	21,384	1.382
1996	88,091	31,034	39,529	16,290	131,563	8,767	8,967	2,400	39,274	5,852	5,517	2,043	466	109	26,901	1.867
1997	108,496	33,759	46,796	18,142	143,549	9,011	9,002	2,460	43,776	6,033	5,009	1,959	547	128	25,450	1.847
1998	143,510	42,737	56,110	21,669	144,298	9,247	10,624	2,651	51,662	6,578	5,530	2,146	540	130	60,243	2.599
1999	124,890	44,517	56,823	24,124	160,170	9,701	10,277	2,670	55,633	6,797	6,246	2,446	485	118	53,437	2.890
2000	179,652	46,363	61,604	20,377	36,887	9,679	2,553	2,671	14,166	7,026	7,236	2,931	466	131	25,802	3.069
2001	192,067	51,172	71,632	20,527	35,570	9,898	3,069	2,619	18,000	7,258	10,796	3,186	571	136	25,837	3.204
2002	206,478	50,653	74,187	19,217	40,357	10,072	2,908	2,631	17,385	7,228	9,207	3,470	626	150	28,210	3.458
2003	160,203	53,833	53,025	19,940	38,814	10,338	2,609	2,547	15,393	7,145	5,967	3,192	396	180	16,988	3.112
2004	237,603	67,538	73,462	20,000	36,127	5,000	2,888	1,000	17,523	2,500	8,994	2,900	527	185	24,237	900
2005	162,530	50,341	49,470	21,185	53,399	2,278	3,741	1,200	22,059	1,627	4,737	1,848	600	200	28,852	900
2006	215,262	59,159	66,630	24,914	52,851	1,909	3,445	900	20,381	1,400	5,487	2,008	800	300	26,549	1.000
2007	225,265	59,000	56,150	27,967	43,582	2,088	5,250	880	31,097	1,000	4,364	1,731	1,200	400	30,193	1.200
2008	279,106	65,536	65,328	19,873	62,820	3,123	5,100	930	30,601	1,000	4,079	1,367	760	217	35,608	1.223
2009	243,609	59,584	62,297	20,901	77,004	3,325	5,105	570	30,529	1,000	2,860	998	1,130	455	44,175	1.614
2010	172,359	52,524	48,190	19,280	45,654	1,639	3,659	440	26,704	800	2,507	1,035	1,000	390	23,313	897
2011	193,961	48,318	77,223	25,344	36,877	1,899	2,728	540	19,569	1,100	2,949	871	1,280	400	19,902	765
2012	235,778	56,905	94,542	28,514	23,014	1,276	2,805	410	20,128	700	2,426	846	1,300	384	20,226	681
2013	201,339	53,796	60,178	21,656	30,980	1,242	2,989	433	21,441	767	2,955	1,019	1,388	365	23,004	565

Table 5.6-4: Production and harvest data crops in the period from 1990 – 2013 (cont.)

Year	Production of crops / tonnes/ ha															
	Soyabeans		Beans, dry		Cow peas, dry		Lentils		Peas, dry		Vetches		Clover		Alfaalfa	
	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha
1990	55,461	17,611	18,437	8,769	1,790	153	219	97	535	3,578	1,888	759	225,466	47,548	252,563	34.493
1991	56,365	19,380	21,949	8,438	1,521	149	199	94	554	3,392	2,005	755	226,546	46,260	251,486	34.083
1992	46,129	26,220	15,961	5,980	895	186	155	78	812	5,980	2,125	871	129,747	44,972	142,613	33.672
1993	49,456	21,424	17,588	6,514	1,651	270	180	90	337	3,000	2,160	706	136,012	43,684	137,225	33.262
1994	44,127	20,435	20,596	6,958	441	120	167	86	400	2,899	2,509	741	155,087	42,396	162,457	32.852
1995	34,319	15,018	21,844	6,733	400	100	92	78	853	2,915	2,400	720	143,910	41,108	158,557	32.441
1996	35,896	16,423	20,221	6,975	368	101	123	89	611	2,787	2,207	729	165,973	39,820	188,462	32.031
1997	39,469	16,030	20,527	7,521	373	109	135	89	577	800	2,237	785	157,559	38,532	179,669	31.620
1998	77,458	34,015	21,003	5,946	384	86	139	90	746	3,900	2,305	621	158,516	37,244	201,778	31.210
1999	115,853	46,336	22,291	6,581	400	100	148	65	824	500	2,400	720	167,266	35,956	223,387	30.800
2000	65,299	47,484	2,657	6,511	300	57	143	60	650	300	2,400	720	100,179	34,668	85,575	30.389
2001	91,841	41,621	4,421	6,470	400	100	130	61	739	298	2,300	700	115,709	33,380	98,305	29.979
2002	129,470	47,897	5,163	6,519	400	100	152	63	886	400	2,690	705	131,103	32,092	107,815	29.568
2003	82,591	49,860	4,967	6,475	400	100	105	61	1,335	500	1,851	700	51,890	30,804	72,056	29.158
2004	97,923	37,131	4,459	6,137	400	100	106	56	1,100	624	1,840	643	124,813	29,516	103,555	28.748
2005	119,602	48,211	6,041	1,774	338	65	108	58	893	448	1,363	624	125,460	28,228	147,272	28.337
2006	174,214	62,810	4,058	1,864	400	100	140	100	715	326	2,400	750	121,411	26,940	162,694	27.927
2007	90,637	46,506	2,503	4,451	400	100	100	92	670	374	2,300	700	111,675	25,652	137,291	27.516
2008	107,558	35,789	3,263	2,147	1,149	100	41	41	870	351	2,996	625	176,089	24,364	196,244	27.106
2009	115,159	44,292	2,460	1,947	1,468	120	74	41	955	372	2,000	775	147,763	23,347	174,274	26.544
2010	153,580	56,456	1,641	1,276	1,197	70	29	16	340	221	1,838	700	119,968	20,472	177,652	27.207
2011	147,271	58,896	1,059	1,232	1,939	71	82	56	696	252	1,700	700	105,075	21,176	153,240	25.126
2012	96,718	54,000	472	788	1,863	80	100	11	404	139	1,600	650	83,817	20,720	124,055	24.803
2013	111,316	47,156	1,480	1,097	1,378	80	80	44	189	154	1,700	660	82,844	16,783	177,857	25.694

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. Higher fluctuations in trend have also 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.

Default crop specific factors were used from the Table 11.2 of 2006 IPCC Guidelines for the emission calculation, except for dry matter fraction where a c

ombination of sources were used, as presented in the Table 5.6-5. Dry matter fraction needed to be incorporated so that adjustments for moisture contents could be made.

Table 5.6-5: Dry matter fraction for crops

Crop	dry matter fraction
Soyabeans	0.86
Beans, dry	0.895
Cow peas, dry	0.85
Lentils	0.85
Peas, dry	0.87
Vetches	0.85
Clover	0.85
Alfaalfa	0.85
Wheat	0.86
Maize	0.86
Potatoes	0.30
Sugar beets	0.25
Tobacco	0.89
Sunflowers	0.92
Rape seed	0.90
Tomatoes	0.063
Barley	0.86
Oats	0.92
Cabbages and other brassicas	0.135
Garlic	0.354
Onions, dry	0.142
Rye	0.900
Sorghum	0.910
Watermelons and melons	0.850

- GPG default values
- Expert judgement (Faculty of Agriculture)
- Valeus from Slovenian NIR
- Values from Portuguese NIR
- Values from Hungarian NIR

Mineralization/Immobilization Associated with Loss/Gain of Soil Organic Content (3.D.1.5)

Emission from this activity were reported in 4 (III) Please see Chapter 4. for explanation of this source.

Cultivation of Organic Soils (3.D.1.6)

Cultivation of soils with high content of organic material causes the release of a long term bounded N. Activity data regarding the area of histosols in the Republic of Croatia have been obtained from the Croatian agency for the environment and nature, based on information available from ARKOD (Croatian Land Parcel Identification System – *LPIS*). Resulting total histosol area amounts to 2685.49 ha. According to CAEN expert judgment this value is accurate on a national level and can be used for each year in the entire period from 1990-2013.

5.6.3. Uncertainties and time-series consistency

Uncertainty estimates are based on expert judgement and IPCC values on default EF. Uncertainty of activity data is ±30% 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 ±30% for mineral fertilizers, N-fixing crops and crop residues, ±50% for animal manure, while for histosols is up to ±500% (using default EF IPCC value). 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.

5.6.4. 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.

5.6.5. Category-specific recalculations

Emissions from all sources from managed soils were recalculated for the entire 1990-2012 period due to change in methodology (use of 2006 IPCC Guidelines).

5.6.6. Category-specific planned improvements

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.
- Replacing FAO harvested area AD of crops with national source.

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.

5.7. N_2O EMISSIONS FROM MANAGED SOILS (CRF 3.D.2.)

5.7.1. Category description

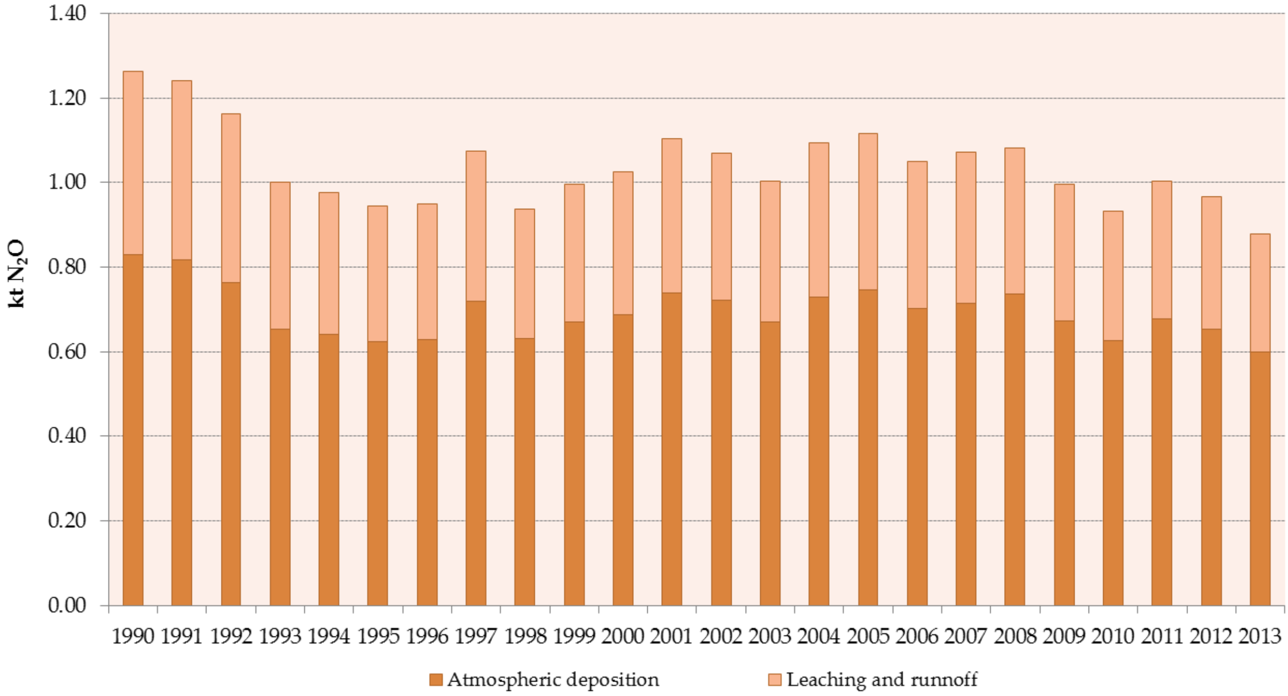
Calculations of indirect N_2O emission from nitrogen used in agriculture are based on two pathways. These are:

- volatilization and subsequent atmospheric deposition of NH_3
- leaching and runoff of the nitrogen that is applied to or deposited on soils

Volatilisation of N as NH_3 and oxides of N (NOx), and the deposition of these gases and their products NH_4^+ and NO_3^- onto soils and the surface of lakes and other waters. Leaching and runoff from land of N from synthetic and organic fertiliser additions, crop residues, mineralisation of N associated with loss of soil C in mineral and drained/managed organic soils through land-use change or management practices, and urine and dung deposition from grazing animals. Some of the inorganic N in or on the soil, mainly in the NO_3^- form, may bypass biological retention mechanisms in the soil/vegetation system by transport in overland water flow (runoff) and/or flow through soil macropores or pipe drains.

Indirect emissions of N_2O from managed soils for the period from 1990 to 2013 are shown in Figure 5.6-5.

Figure 5.6-5: Indirect N_2O emissions from Managed Soils



5.7.2. Methodological issues

<u>Atmospheric deposition due to volatilization</u>

N_2O emissions from atmospheric deposition of N volatilised from managed soil were estimated using Tier 1 methodology, using Equation 11.9 from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, using default emission factors and fractions.

<u>Nitrogen leaching and run-off</u>

N_2O emissions resulting from nitrogen from fertilizers and other agricultural inputs that is lost through leaching and run-off were estimated using Tier 1 methodology, using Equation 11.10 from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, using default emission factors and fractions.

5.7.3. Uncertainties 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.

Uncertainty estimate associated with activity data amounts to a maximum of ±30 percent (see Chapters 5.3.2.3 and 5.5.1.3, *Uncertainties and time-series consistency* for N_2O emissions from Manure Mangement and Direct N_2O Emissions from Agricultural Soils). Uncertainty estimate associated with emission factors amounts to 400 percent, according to information on default factors uncertainty range provided in the *IPCC Guidelines.* Indirect N_2O emissions have been calculated using the same method and data sets for every year in the time series

5.7.4. Category-specific QA/QC and verification

There is no category-specific information, QA/QC for this category is shared and presented in Chapters 5.3.2.4 and 5.5.1.4. (N_2O emissions from Manure Mangement and Direct N_2O Emissions from Agricultural Soils, respectively).

5.7.5. Category-specific recalculations

Emissions from all sources from managed soils were recalculated for the entire 1990-2012 period due to change in methodology (use of 2006 IPCC Guidelines).

5.7.6. Category-specific planned improvements

Planned improvements in this category are shared with the planned improvements for the N_2O Emissions from Manure Management (Chapter 5.3.2) and Direct emission from agricultural soils (Chapter 5.5.1).

PRESCRIBED BURNING OF SAVANNAS

5.8. PRESCRIBED BURNING OF SAVANNAS (CRF 3.E)

5.8.1. 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.

FIELD BURNING OF AGRICULTURAL RESIDUES

5.9. FIELD BURNING OF AGRICULTURAL RESIDUES (CRF 3.F.)

5.9.1. 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.

LIMING

5.10. LIMING (CRF 3.G.)

5.10.1. Category description

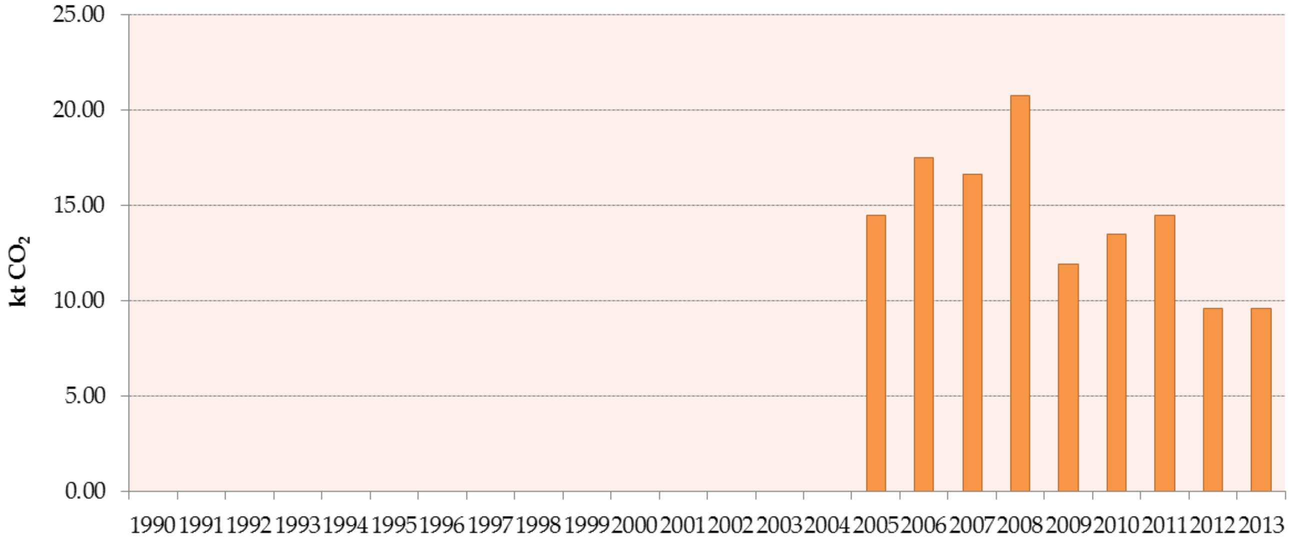
The application of lime on agricultural soils was estimated for NIR 2014 for the first time. Data that are collected come from the sugar factories in Croatia in which lime has been produced as byproduct during the technological process of sugar production. Based on the available information, lime coming 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 farmers, 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 a 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.

Due to the missing data for 2013, it was assumed that same quantity of lime has been produced and applied on agriccultural soils in 2013 as in year 2012 since quantities of sugar that can be produced by each sugar factory in Croatia are regulated by legislative act.

CO_2 emisisons form liming for the period from 1990 to 2013 are presented in Figure 5.10-1. Further investigation on this issue is foreseen in due time, See Chapter 6.5.6

Figure 5.10-1: Direct CO_2 emissions from Liming



5.10.2. Methodological issues

Estimation due to liming was performed using the 2006 Guidelines equation 11.12 and emission factor of 12%.

5.10.3. Uncertainties 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.

5.10.4. Category-specific QA/QC and verification

There is no category specific QA/QC information for liming. It has been included in overall QA/QC system of the Croatian GHG inventory.

5.10.5. Category-specific recalculations

In NIR 2015 no recalulcations were performed for the estimation of emissions due to liming.

5.10.6. Category-specific planned improvements

For NIR 2016 additional efforts will be made in order to collect relevant data and perform estimation of emissions for years 2013 and 2014.

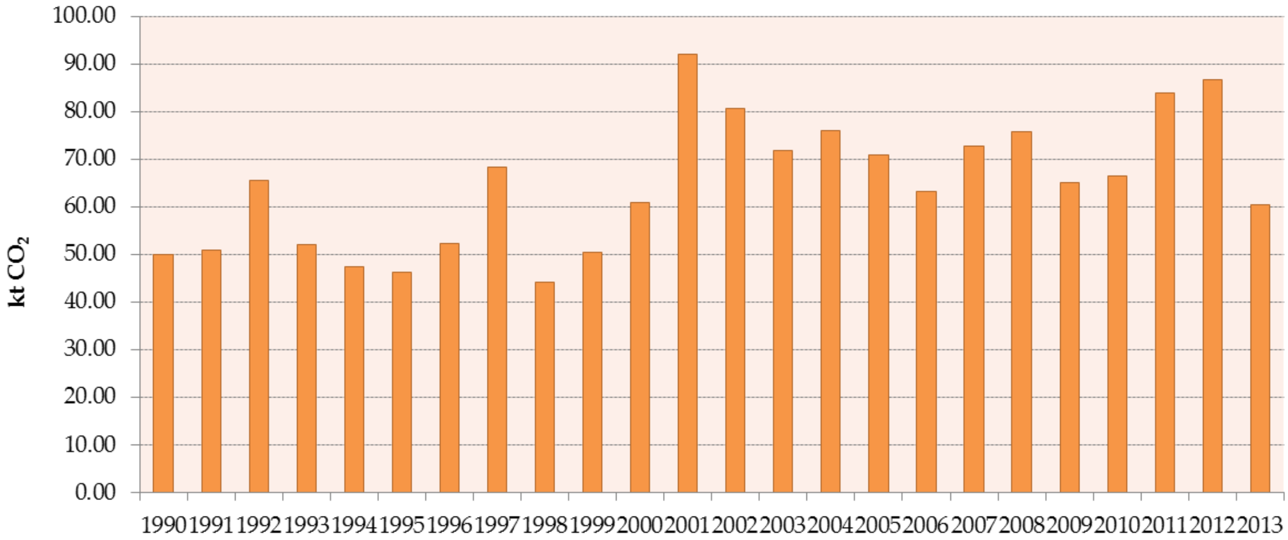
UREA APPLICATION

5.11. UREA APPLICATION (CRF 3.H.)

5.11.1. Category description

In addition to direct N_2O emissions from managed soils, adding urea during fertilization results in conversion of ($CO(NH_2)_2$) into ammonium (NH_4^+), hydroxyl ion (OH^-), and bicarbonate (HCO_3^-), in the presence of water and urease enzymes. Similar to the soil reaction following addition of lime, bicarbonate that is formed evolves into CO_2 and water. This source category is included because the CO_2 removal from the atmosphere during urea manufacturing is estimated in the Industrial Processes and Product Use Sector (IPPU Sector). Emission of CO_2 from urea application for the period from 1990 to 2013 is shown in Figure 5.9-1.

Figure 5.9-1: Direct CO_2 emissions from Urea Application



5.11.2. Methodological issues

CO_2 emissions resulting from nitrogen from fertilizers and other agricultural inputs that is lost through leaching and run-off were estimated using Tier 1 methodology, using Equation 11.13 from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, using default emission factors.

Activity data for applied urea was taken from common dataset used for Direct N_2O emission from Agricultural Soils emission estimates for inorganic N Fertilizers. See Chapter 5.5.1.2 for details. Entire proportion of urea and urea ammonium nitrate solutions was assumed to be urea for conversion of CO_2-C emissions to CO_2, according to good practice guidance provided by 2006 IPCC Guidelines.

5.11.3. Uncertainties and time-series consistency

Uncertainty estimate associated with activity data amounts to a maximum of ±30 percent (see Chapters 5.3.2.3 and 5.5.1.3, Uncertainties and time-series consistency for N_2O emissions from Manure Mangement and Direct N2O Emissions from Agricultural Soils). Uncertainty estimate associated with emission factors amounts to ±50 percent, according to information on default factors uncertainty range provided in the IPCC Guidelines. Emissions have been calculated using the same method and data sets for every year in the time series.

5.11.4. Category-specific QA/QC and verification

There is no category-specific information, QA/QC for this category is shared and presented in Chapter 5.5.1.4. (Direct N_2O Emissions from Agricultural Soils).

5.11.5. Category-specific recalculations

This is a new category for NIR 2015, no recalulcations were performed.

5.11.6. Category-specific planned improvements

In addition to planned improvement shared with Direct N_2O emissions from Agricultural Soils (see Chapter 5.5.1.6)., planned improvement which are assumed to be mid-term or long-term goals (over 1 year) is development of proportion estimates of urea in applied urea solutions AD.

CHAPTER 6: LAND USE, LAND-USE CHANGE AND FORESTRY (CRF SECTOR 4)

6.1. OVERVIEW OF LULUCF SECTOR

According to the methodology prescribed by the IPCC Good Practice Guidance for LULUCF (GPG 2006), 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 2006 Guidelines, 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 6.1-1.

Table 6.1-1: Key category analyse for LULUCF sector based on the level and trend assessment for 2013

Table							
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2013)							
A	B	C	D				E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification				Com.
Forest Land Remaining Forest Land - CO2	CO2	Yes			L1i, L2i	T1i, T2i	
Land Converted to Settlements - CO2	CO2	Yes			L1i, L2i	T1i, T2i	
Harvested wood products - CO2	CO2	Yes			L1i, L2i	T2i	
Land Converted to Forest Land - CO2	CO2	Yes			L1i, L2i	T1i, T2i	
Cropland Remaining Cropland - CO2	CO2	Yes			L2i	T2i	
Land Converted to Cropland - CO2	CO2	Yes			L2i	T2i	
Direct N2O emissions from N mineralization/immobilization - N2O	N2O	Yes			L2i		
Land Converted to Grassland - CO2	CO2	Yes			L2i	T2i	

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

The completeness of the estimated emissions/removals is presented in Table 6.1-2.

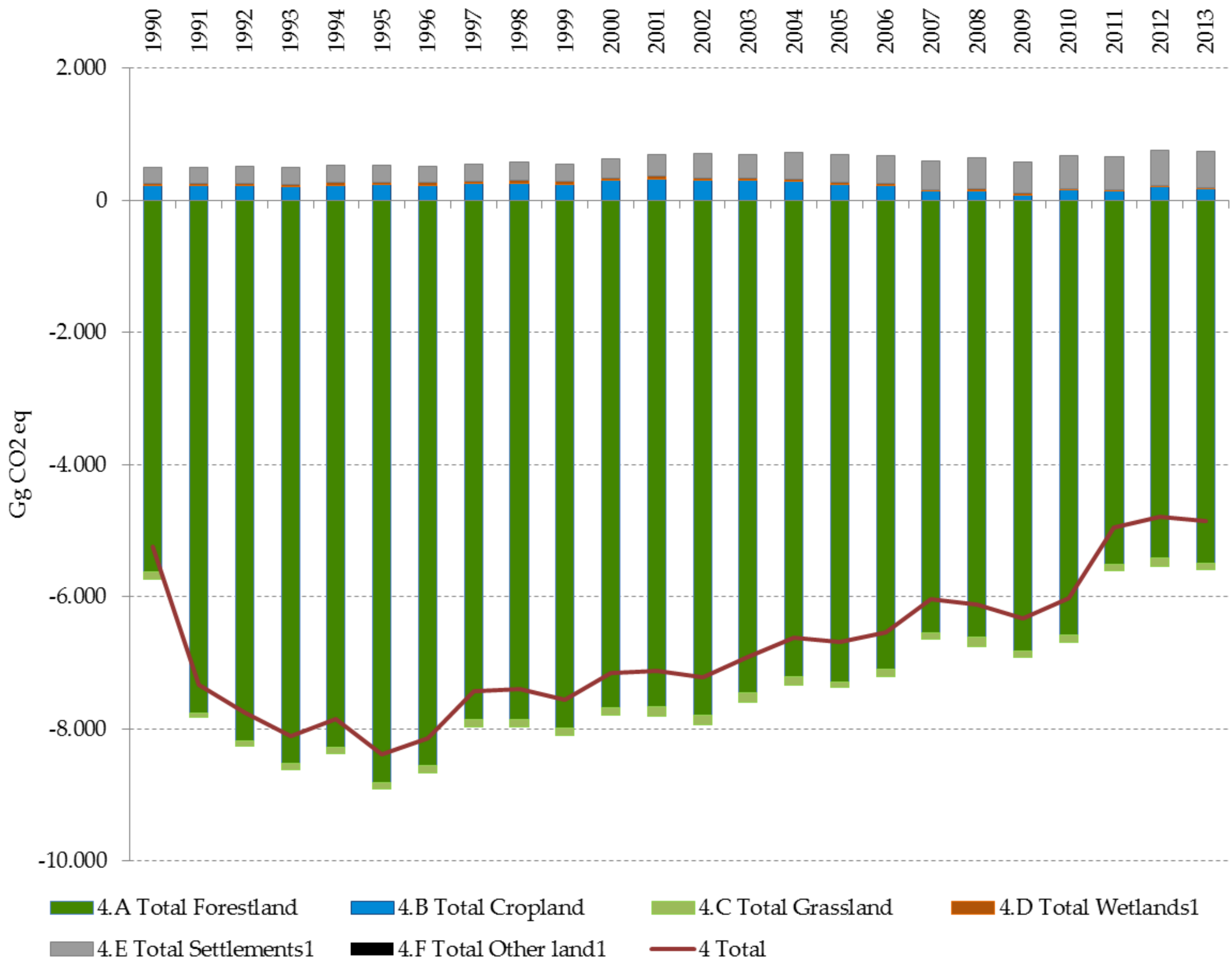
Table 6.1-2: Reported LULUCF categories - status of emission estimates

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

6.1.1. Emission trends

As it can be concluded from the above reported figures and Figure 6.1-1, 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.

Figure 6.1-1: Emission/removal trend for LULUCF



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

[*] Excluding emissions from fires

6.1.2. 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[10] 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

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

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 Chapter 6.4.2.2. 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 than 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 methodology. 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 previous reports before this survey was not conducted.

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 recognized for each type of forest ownership.

For representing LUC in other categories of land, IPCC 2006 Guidelines 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 6.1-4). 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 6.1-3 presents land use data and land use changes in the reporting period.

Table 6.1-3: Land use and LUC for Croatia for the years 1990-2013

Area in kha	1990	2013	2013-1990
4.A Forest land - Total	2,314	2,353	39
4.A1. Forest land remaining forest land	2,310	2,310	0
4.A1a Forest land remaining forest land -coniferous	200	203	3
4.A1b Forest land remaining forest land -deciduous	1,678	1,678	0
4.A1c Forest land remaining forest land -out of yield	433	430	-2
4.A2 LUC in Forest land	4	42	39
4.A2.1a Annual cropland in forest land	0	1	1
4.A2.1b Perennial cropland in forest land	0	0	0
4.A2.2 Grassland in forest land	4	41	38
4.A2.3 Wetlands in forest land	0	0	0
4.A2.4 Settlement in forest land	0	0	0
4.A2.5 Other land in forest land	0	0	0
4.B Cropland - Total	1,624	1,535	-88
Cropland annual	1,479	1,414	-65
Cropland perennial	145	121	-23
4.B1. Cropland remaining cropland	1,616	1,519	-98
4.B1a Annual cropland remaining annual cropland	1,472	1,399	-73
4.B1b Perennial cropland remaining perennial cropland	143	119	-24
4.B1c LUC perennial cropland in annual cropland	0.43	0.17	0
4.B1d LUC annual cropland in perennial cropland	0.89	0.18	-1
4.B2 LUC in cropland	7	17	10
4.B2.1a Forest land in annual cropland	0	0	0
4.B2.1b Forest land in perennial cropland	0	1.38	1

Area in kha	1990	2013	2013-1990
4.B2.2a Grassland in annual cropland	6.7	14.5	8
4.B2.2b Grassland in perennial cropland	0.6	1.0	0
4.B2.3a Wetlands in annual cropland	0	0	0
4.B2.3b Wetlands in perennial cropland	0	0	0
4.B2.4a Settlements in annual cropland	0	0	0
4.B2.4b Settlements in perennial cropland	0	0	0
4.B2.5a Other land in annual cropland	0	0	0
4.B2.5b Other land in perennial cropland	0	0	0
4.C Grassland	1,211	1,216	5
4.C1. Grassland remaining grassland	1,179	1,141	-38
4.C2. LUC in grassland	32	75	43
4.C2.1 Forest land in grassland	0	0	0
4.C2.2a Annual cropland in grassland	29.1	68.8	40
4.C2.2b Perennial cropland in grassland	2.8	6.3	4
4.C2.3 wetlands in grassland	0	0	0
4.C2.4 Settlements in grassland	0	0	0
4.C2.5 Other land in grassland	0	0	0
4.D Wetlands	72	74	2
4.D1. Wetlands remaining wetlands	70	73	3
4.D2. LUC in wetlands	2	1	-1
4.D2.1 Forest land in wetlands	0	0	0
4.D2.2a Annual cropland in wetlands	2	1	-1
4.D2.2b Perennial cropland in wetlands	0	0	0
4.D2.3 Grassland in wetlands	0	0	0
4.D2.4 Settlements in wetlands	0	0	0
4.D2.5 Other land in wetlands	0	0	0
4.E Settlements	213	259	46
4.E1 Settlements remaining Settlements	191	215	24
4.E2 LUC in Settlements	22	44	21
4.E2.1 Forest land in Settlements	0	4	4
4.E2.2a Annual cropland in Settlements	13	18	5
4.E2.2b Perennial cropland in Settlements	1	2	1
4.E2.3 Grassland in Settlements	8	20	12
4.E2.4 Wetlands in Settlements	0	0	0
4.E2.5 Other land in Settlements	0	0	0
4.F Other land	226	222	-3
4.F1 Other land remaining other land	226	222	-3
4.F2 LUC in Other land	0	0	0
4.F2.1 Forest land in Other land	0	0	0
4.F2.2a Annual cropland in Other land	0	0	0
4.F2.2b Perennial cropland in Other land	0	0	0
4.F2.3 Grassland in Other land	0	0	0
4.F2.3 Wetlands in Other land	0	0	0
4.F2.5 Settlements in other land	0	0	0
Total area Croatia	5,659.40	5,659.40	0

Table 6.1-4 Land use matrixes

Category	FL	CL	GL	WL	SL	OL
FL	**2,314.001**				0.000	
CL		**1,623.401**	0.833	0.226	0.377	
GL	0,000	0.366	**1,209.693**		0.377	
WL				**72.094**		
SL					**212.226**	
OL						**225.806**
1990 calculated	**2,314.001**	**1,623.767**	**1,210.526**	**72.320**	**212.980**	**225.806**
1990 reported	2,314.001	1,623.767	1,210.526	72.320	212.980	225.806
FL	**2,314.001**				0.000	
CL		**1,620,030**	2.991	0.189	0.556	
GL	0.213	0.103	**1,209.653**		0.556	
WL				**72.320**		
SL					**212.980**	
OL						**225.806**
1991 calculated	**2,314.214**	**1,620.133**	**1,212.644**	**72.509**	**214.093**	**225.806**
1991 reported	2,314.214	1,607.072	1,212.644	72.509	214.093	238.867
FL	**2,314.214**				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						**238.867**
1992 calculated	**2,314,377**	**1,603.489**	**1,214.763**	**72.699**	**215.206**	**238.867**
1992 reported	2,314,.77	1,604.209	1,214.763	72.699	215.206	238.148
FL	**2,314.377**				0.000	
CL		**1,600.387**	3.076	0.189	0.556	
GL	0.298	0.103	**1,213.805**		0.556	
WL				**72.99**		
SL					**215.206**	
OL						**238.148**
1993 calculated	**2,314.675**	**1,600.490**	**1,216.881**	**72.888**	**216.318**	**238.148**
1993 reported	2,314.675	1,601.345	1,216.881	72.888	216.318	237.293
FL	**2,314.615**				0.059	
CL		**1,597.622**	3.007	0.189	0.527	
GL	0.259	0.103	**1,215.992**		0.527	
WL				**72.888**		
SL					**216.318**	
OL						**237.293**
1994 calculated	**2,314.874**	**1,597.726**	**1,218.999**	**73.077**	**217.431**	**237.293**
1994 reported	2,314.874	1,598.482	1,218.999	73.077	217.431	236.536
FL	**2,314.871**				0,003	
CL		**1,594.730**	3.008	0.189	0.555	
GL	0.232	0.103	**1,218.109**		0.555	
WL				**73.077**		
SL					**217.431**	

Category	FL	CL	GL	WL	SL	OL
OL						236.536
1995 calculated	2,315.102	1,594.833	1,221.118	73.267	218.544	236.536
1995 reported	2,315.102	1,595.619	1,221.118	73.267	218.544	235.751
FL	2,315.102				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						235.751
1996 calculated	2,315.390	1,591.911	1,223.236	73.456	219.657	235.751
1996 reported	2,315.390	1,592.756	1,223.236	73.456	219.657	234.906
FL	2,315.311				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						234.906
1997 calculated	2,315.508	1,589.218	1,225.354	73.645	220.769	234.906
1997 reported	2,315.508	1,589.892	1,225.354	73.645	220.769	234.231
FL	2,315.403				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						234.231
1998 calculated	2,315.663	1,586.316	1,227.472	73.834	221.882	234.231
1998 reported	2,315.663	1,587.029	1,227.472	73.834	221.882	233.519
FL	2,315.631				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						233.519
1999 calculated	2,315.962	1,583.309	1,229.591	74.024	222.995	233.519
1999 reported	2,315.962	1,590.224	1,229.591	74.024	222.995	226.604
FL	2,315.794				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						226.604
2000 calculated	2,316.038	1,586.728	1,231.709	74.213	224.108	226.604
2000 reported	2,316.038	1,591.808	1,231.709	74.213	224.108	221.524
FL	2,315.684				0.354	
CL		1,589.340	1.302	0.013	1.152	
GL	0.254	1.135	1,229.168		1.152	

Category	FL	CL	GL	WL	SL	OL
WL				**74.213**		
SL					**224.108**	
OL						**221.524**
2001 calculated	**2,315.937**	**1,590.475**	**1,230.470**	**74.226**	**226.767**	**221.524**
2001 reported	2,315.937	1,587.474	1,230.470	74.226	226.767	224.525
FL	**2,315.710**				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						**224.525**
2002 calculated	**2,316.009**	**1,585.969**	**1,,229.232**	**74.239**	**229.426**	**224.525**
2002 reported	2,316.009	1,583.141	1,229.232	74.239	229.426	227.353
FL	**2,315.914**				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						**227.353**
2003 calculated	**2,316.198**	**1,581.518**	**1,227.993**	**74.253**	**232.086**	**227.353**
2003 reported	2,316.198	1,578.807	1,227.993	74.253	232.086	230.064
FL	**2,315,851**				0.305	
CL	0.03234	**1,575,925**	1.692	0.0131667	1.177	
GL	0,619	1.135	**1,225.062**		1.177	
WL	0.000			**74.253**		
SL	0.000				**232.086**	
OL	0.000					**230.073**
2004 calculated	**2,316,502**	**1,577.060**	**1,226.754**	**74.266**	**234.745**	**230.073**
2004 reported	2,316.502	1,574.474	1,226.754	74.266	234.745	232.660
FL	**2,316.137**				0.335	
CL	0.061	**1,569.255**	4.043	0.013	1.162	
GL	2.985	1.135	**1,221.472**		1.162	
WL	0.000			**74.266**		
SL	0.000				**234.745**	
OL	0.000					**232.629**
2005 calculated	**2,319.183**	**1,570.390**	**1,225.516**	**74.279**	**237.404**	**232.629**
2005 reported	2,319.183	1,570.140	1,225.516	74.279	237.404	232.878
FL	**2,318.830**				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	0.000			**74,.279**		
SL	0,.000				**237.404**	
OL	0.000					**232,.843**
2006 calculated	**2,321.703**	**1,566.222**	**1,224.277**	**74.292**	**240.063**	**232.843**
2006 reported	2,321.703	1,565.807	1,224.277	74.292	240.063	233.258
FL	**2,321.478**				0.078	

Category	FL	CL	GL	WL	SL	OL
CL	0.082	**1,559.436**	5.067	0.013	1.290	
GL	3.880	1.135	**1,217.972**		1.290	
WL	0.000			**74.292**		
SL	0.000				**240.063**	
OL	0.000					**233.322**
2007 calculated	**2,325.440**	**1,560.571**	**1,223.038**	**74.305**	**242.723**	**233.322**
2007 reported	2,325.440	1,561.473	1,223.038	74.305	242.723	232.420
FL	**2,325.031**				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	0.000			**74.305**		
SL	0.000				**242.723**	
OL	0.000					**232.468**
2008 calculated	**2,326.865**	**1,558.567**	**1,221.800**	**74.318**	**245.382**	**232.468**
2008 reported	2,326.865	1,557.140	1,221.800	74.318	245.382	233.896
FL	**2,326.259**				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	0,.000			**74.318**		
SL	0.000				**245.382**	
OL	0.000					**234.260**
2009 calculated	**2,330.709**	**1,551.497**	**1,220.561**	**74.332**	**248.041**	**234.260**
2009 reported	2,330.709	1,552.806	1,220.561	74.332	248.041	232.951
FL	**2,330.360**				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	0.000			**74.332**		
SL	0.000				**248.041**	
OL	0.000					**232.958**
2010 calculated	**2,335.167**	**1,546.907**	**1,219.322**	**74.345**	**250.701**	**232.958**
2010 reported	2,335.167	1,548.473	1,219.322	74.345	250.701	231.392
FL	**2,334.976**				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	0.000			**74.345**		
SL	0.000				**250.701**	
OL	0.000					**231.419**
2011 calculated	**2,341.021**	**1,541.159**	**1,218.084**	**74.358**	**253.360**	**231.419**
2011 reported	2,341.021	1,544.139	1,218.084	74.358	253.360	228.439
FL	**2,340.776**				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	0.000			**74.358**		
SL	0.000				**253.360**	
OL	0.000					**228.276**
2012 calculated	**2,345.803**	**1,538.086**	**1,216.845**	**74.371**	**256.019**	**228.276**

Category	FL	CL	GL	WL	SL	OL
2012 reported	2,345.803	1,539.806	1,216.845	74.371	256.019	226.557
FL	**2,345.636**				1.240	
CL	0.326	**1,530.513**	7.996	0.013	1.284	
GL	6.816	1.135	**1,207.610**		1.284	
WL	0.000			**74.371**		
SL	0.000				**254.870**	
OL	0.000					**226.306**
2013 calculated	**2,352.777**	**1,531.647**	**1,215.606**	**74.384**	**258.678**	**226.306**
2013 reported	2,352.777	1,535.472	1,215.606	74.384	258.678	222.482

6.2. LAND-USE DEFINITIONS AND THE CLASSIFICATION SYSTEMS USED AND THEIR CORRESPONDENCE TO THE LAND USE, LAND-USE CHANGE AND FORESTRY CATEGORIES

6.2.1. Forest Land

Definitions applied within this inventory regarding the Forest land are consistent with the 2006 Guidelines 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 (as presented in Croatian NIR 2014, 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 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.

6.2.2. Cropland (4.B)

Based on the IPCC 2006 Guidelines 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).

6.2.3. Grassland (4.C)

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.

6.2.4. Wetlands (4.D)

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.

6.2.5. Settlement (4.E)

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.

6.3. INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USE DATABASES USED FOR THE INVENTORY PREPARATION

6.3.1. Forest Land (4.A)

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[11] 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 2014 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

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

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 6.3-2). 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 6.3-3.

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 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 6.3-4 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 and 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 6.3-5 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 species, 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 6.3-6 shows that compartment 7 of the management unit "Krivsko ostrvo" is divided into 3 sub-compartments.

Figure 6.3-2: Spatial division of the Republic of Croatia on forest districts

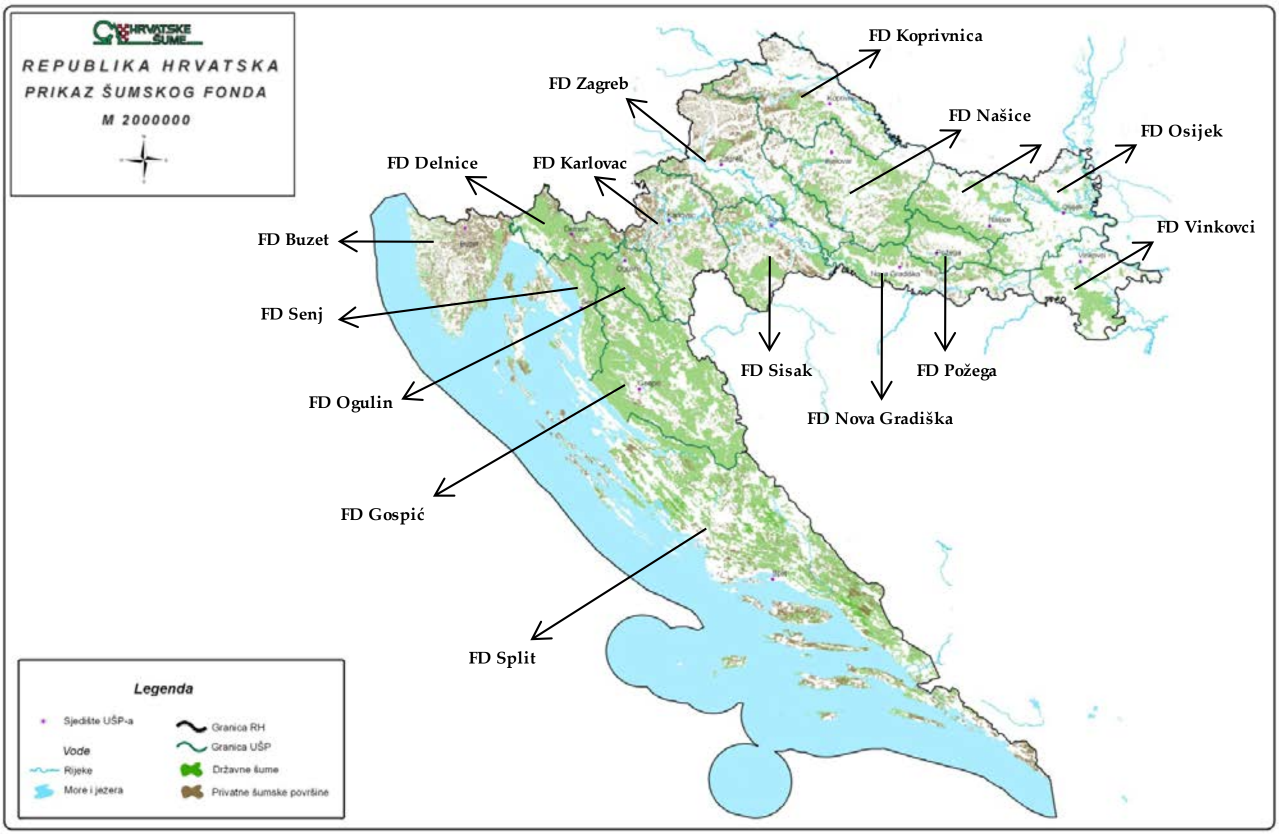


Figure 6.3-3: Division of forest district "Vinkovci" on related forest units (example, UŠP refers to FD)

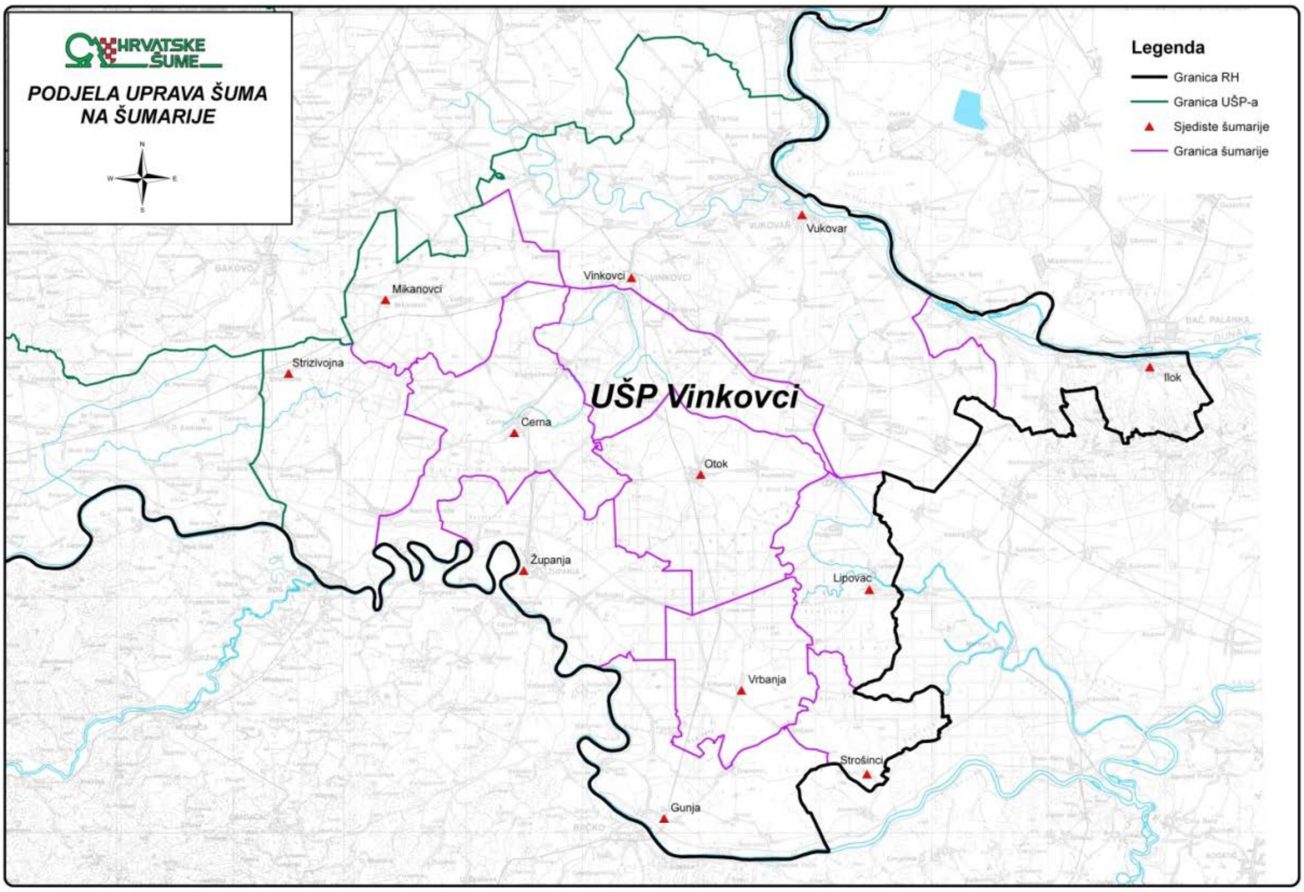


Figure 6.3-4: Area of a forest unit "Cerna" with the spatial division on related management units (example)

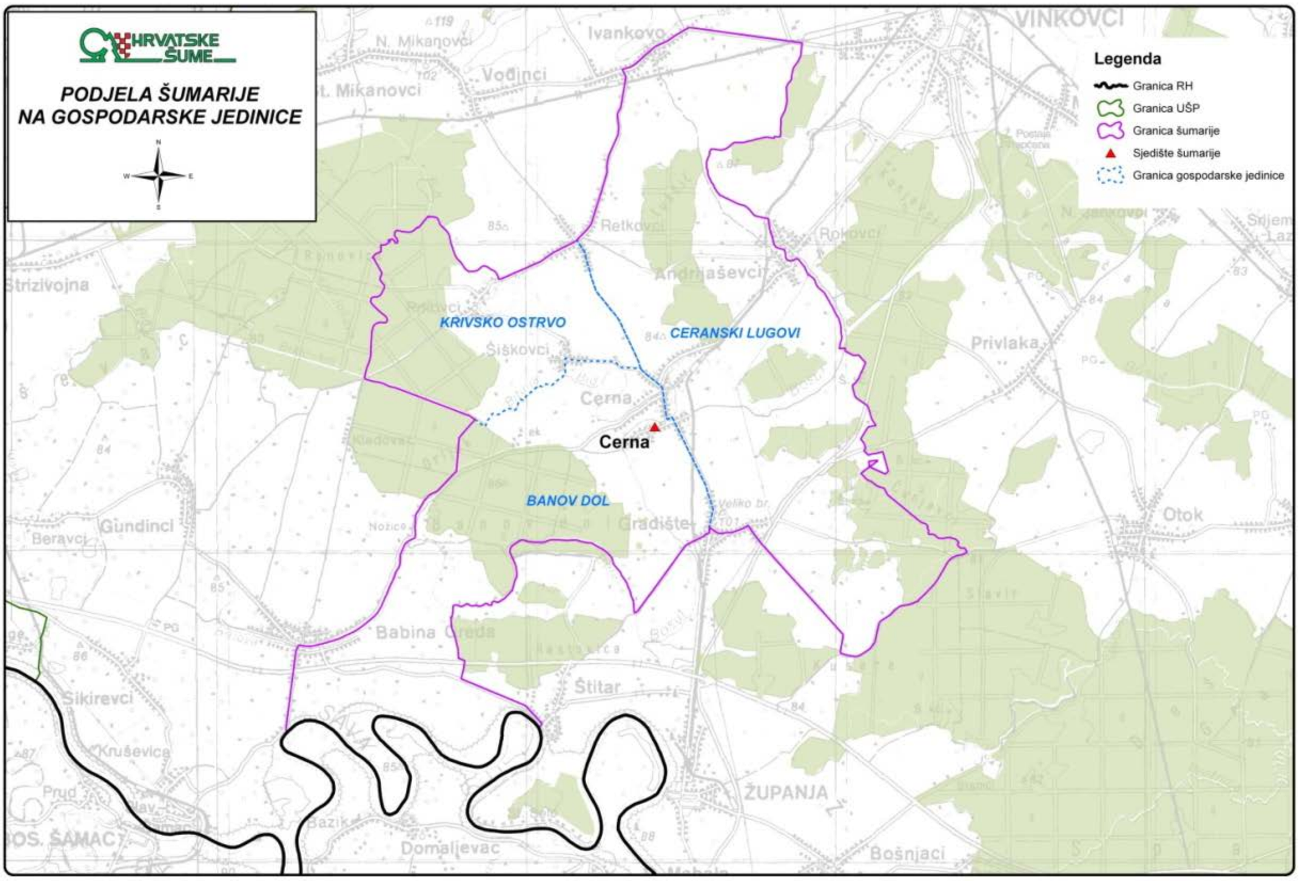


Figure 6.3-5: Area of a management unit "Krivsko ostrvo" divided into compartments (example)

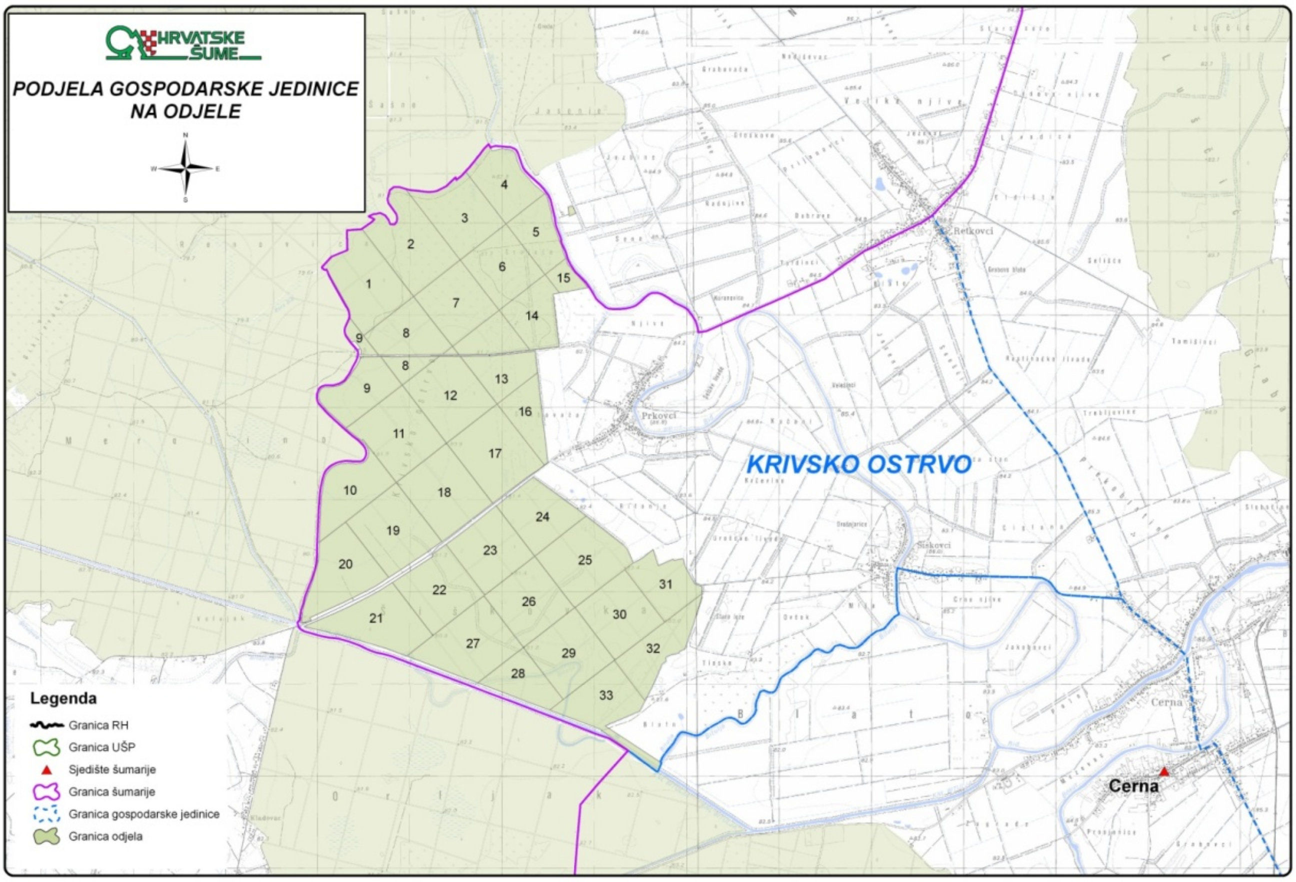
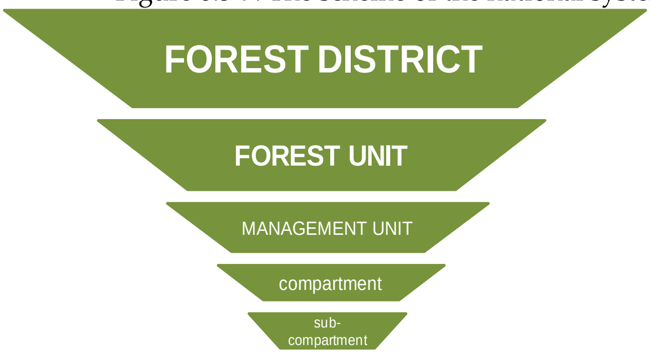


Figure 6.3-6: Compartment area divided into sub-compartments (example)

Short scheme of the system's structure is presented in Figure 6.3-7.

Figure 6.3-7: The scheme of the national system's structure



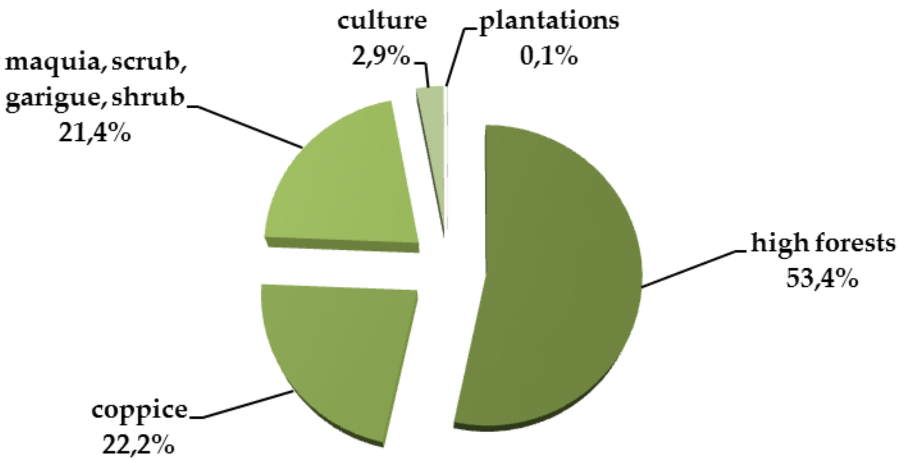
Therefore, it should be emphasized again that the basic unit for forest management in Croatia is the sub-compartment for which, based on field measurements on a 0.05 ha grid and the analysis of the related results, data on area, land category, growing stock and increment on diameter class (above 10 cm 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 6.3-8: The share of categories of land under the forest management (LUFM)



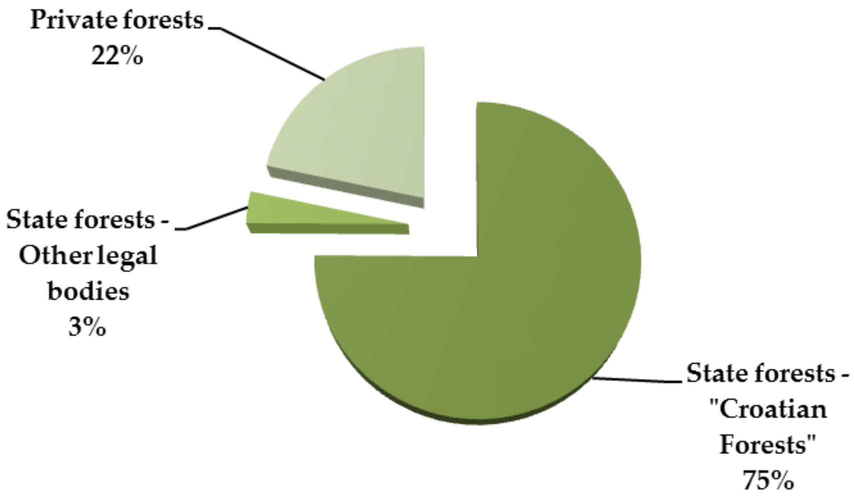
Based on the forest stands, forest land with tree cover is divided as follows:

- high forests
- Plantations
- Forest cultures
- Coppice
- Maquia
- Shrub
- Garigue

- Scrub.

Their share in the forest land with tree cover is shown in Figure 6.3-9.

Figure 6.3-9: 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).

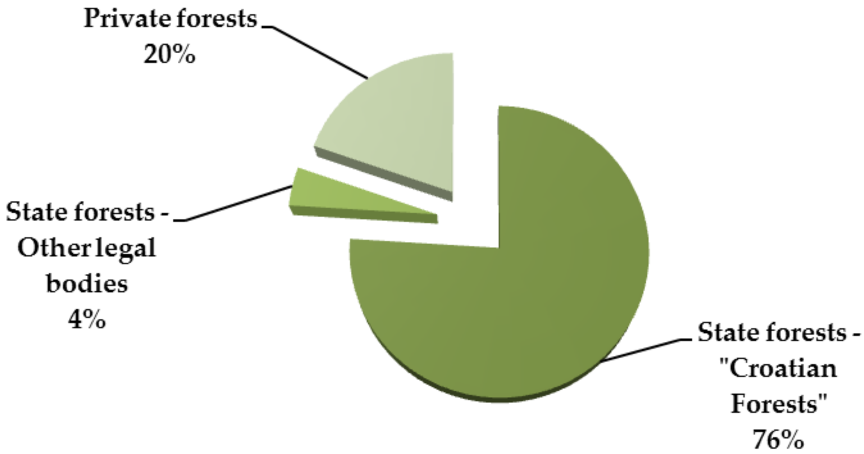
Based on the ownership, there are two types of forests in Croatia:

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 6.3-10).

Figure 6.3-10: 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
- 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 6.3-11: The share of growing stock in state and private forests, year 2006

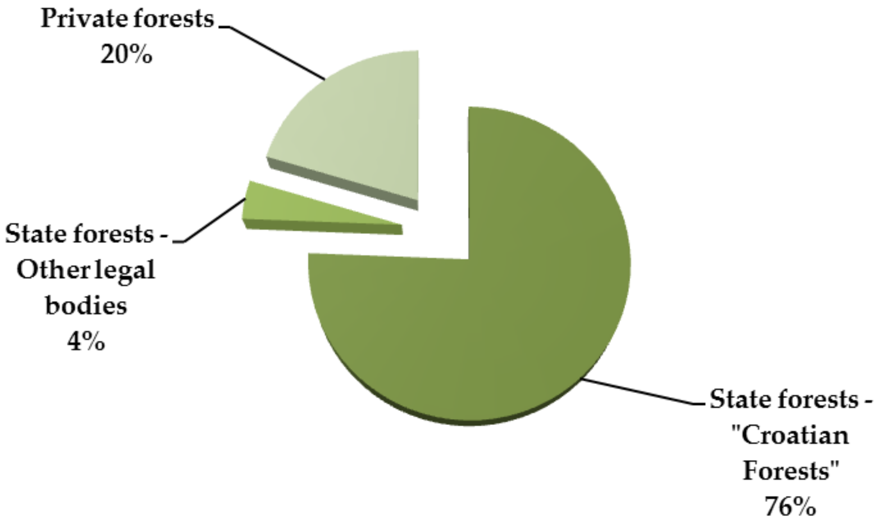
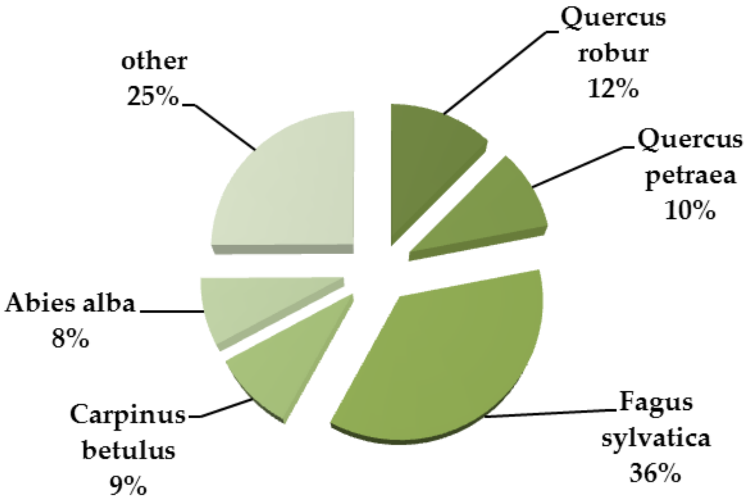


Figure 6.3-12: Share of main species in total growing stock, year 2006



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:

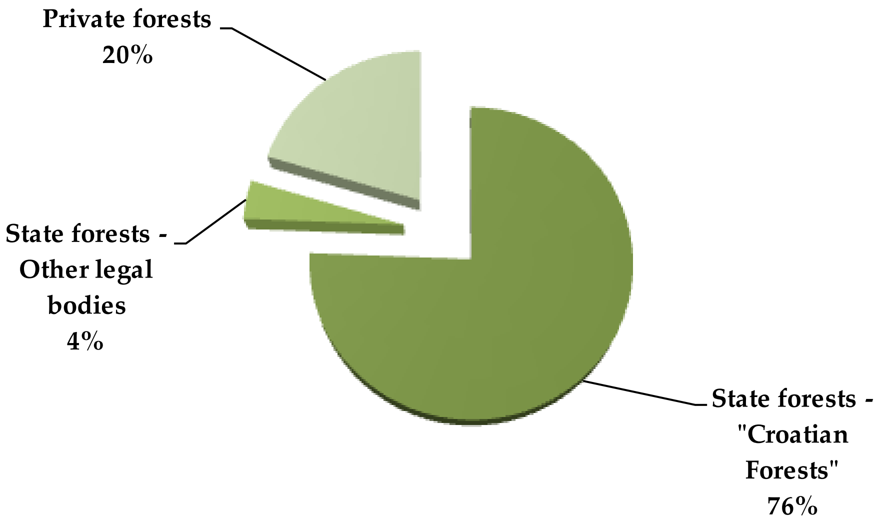
- Extracting the sub-compartment at 143,000 ha
- Measurements of breast diameters at 69,000 sample plots of the 5% sample trees
- Measurements of breast diameters at 25,000 sample plots of the 2% sample trees

- 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[12], 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 6.3-13.

Figure 6.3-13: 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 6.4). 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).

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

6.3.2. Cropland (4.B)

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[13].

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 1:5,000, 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

[13] Croatian Agency for Environment and Nature, Corine Land Cover database. See list of References

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.

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.

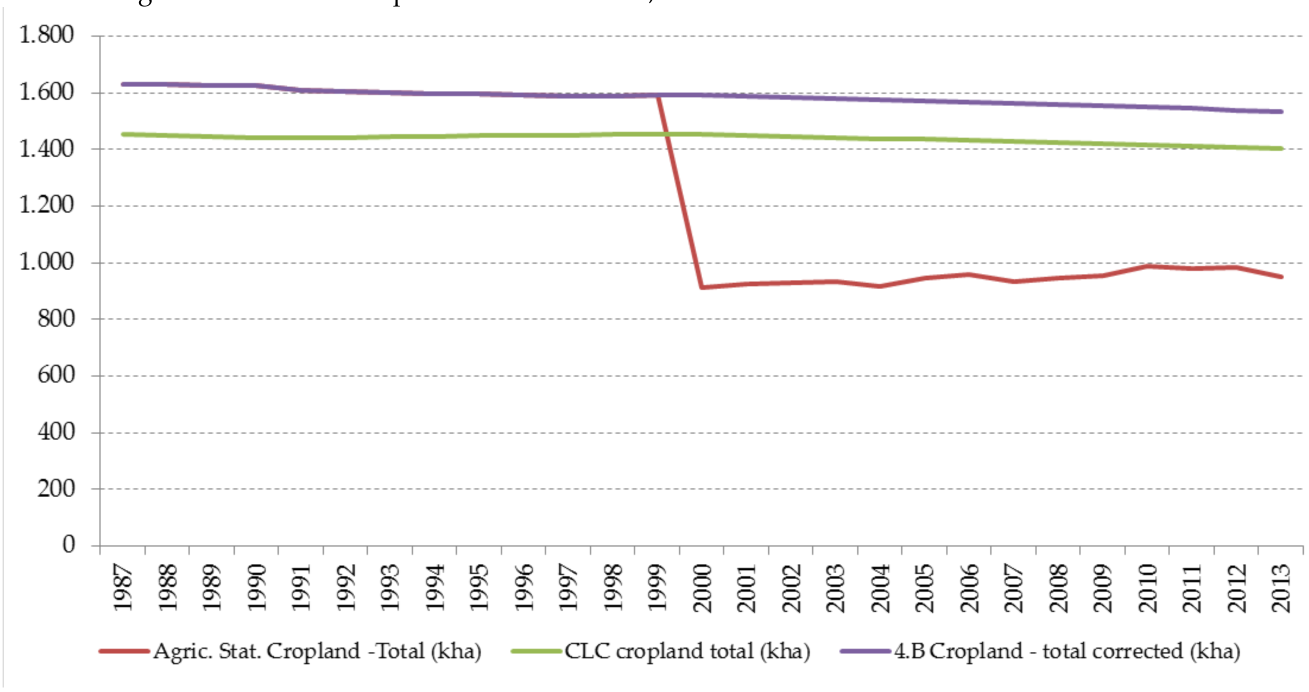
The main purpose of this revision was the methodological harmonisation of data and methods of estimating data for the mentioned period. The methodology is fully harmonised with the EUROSTAT recommendations''[14].

Applying the new EUROSTAT methodology and the interview method on private family farms in its statistical work after 2005, the CBS needed to focus only on categories of utilized agricultural area that was used for production in a year in question and actually utilized arable land in a year in question. Collecting data in such a way, the CBS completely omitted records on the traditionally less managed or unmanaged areas in Croatia that were not used in year of question (mostly grassland areas such as meadows and pastures). Before the new methodology was applied, these areas were recorded as unutilized agricultural land (and were traced based on the cadastral data), subcategory that does not exist within the new methodology. Comparison between data gathered using official definitions in CBS work before and after 2005 shows difference of more than 1,0 million ha in grassland areas and explains the difference between the CBS data series for the period 1990-1999 and the period 2000-2010.

The area data adjustment after 2000 for the necessity of this report due to the changes in the CBS data collection approach and application of new EUROSTAT methodology is presented in Figure 6.3-14.

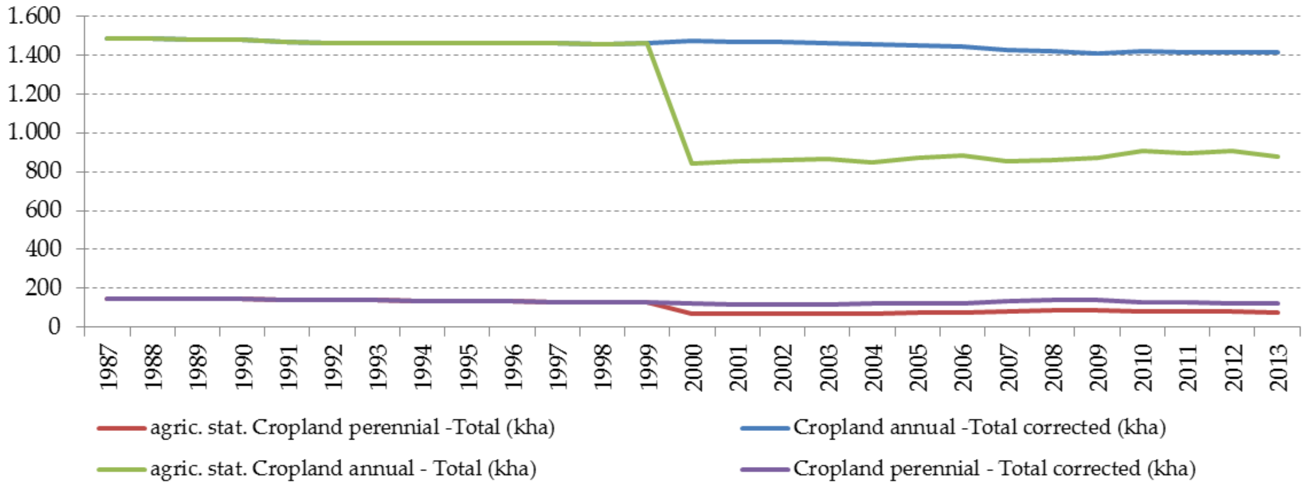
[14] Statistical Yearbook of the Republic of Croatia 2012. See list of References

Figure 6.3-14: 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 6.3-15: Area of annual and perennial cropland in Croatia after adjustments 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.

6.3.3 Grassland (4.C)

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.

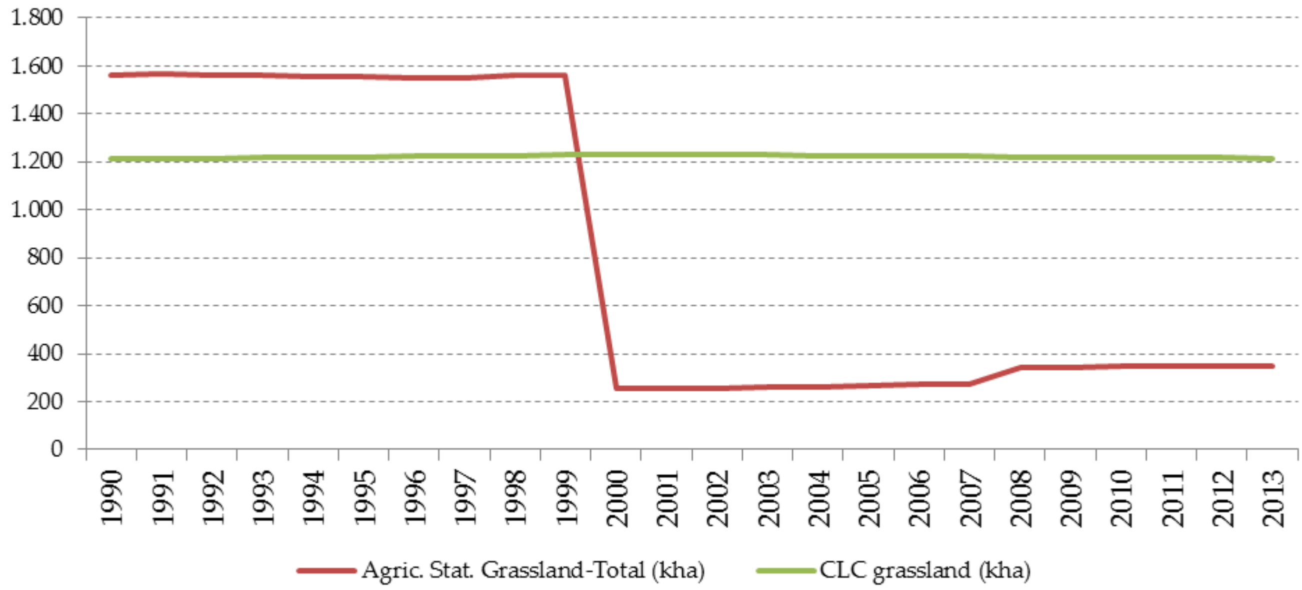
The complete examination of CBS data demonstrated its inadequateness related to the total area of Croatia. The adjustment of CBS data with CLC data for the time series since 2000 had the same results, leading to the exceedance of the total area of Croatia. At the same time, self-standing CLC data fitted 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 6.3.2.

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 6.3-16)

Figure 6.3-16: Total grassland area in Croatia according to the CBS data and 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 2001-2013 by 1.2 kha annually.

6.3.4. Wetlands (4.D)

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.

6.3.5. Settlements (4.E)

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.

6.3.6. Other Land (4.F)

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 145 and 162 kha in the reporting period.

Total area of other land is reported according to the IPCC 2006 Guidelines as the difference between the area of all land use categories except other land and the total area of Croatia, which ranges between 221 and 239 kha.

Table 6.9-1 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 unfavourable 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 4.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.

6.4. FOREST LAND (CRF CATEGORY 4.A)

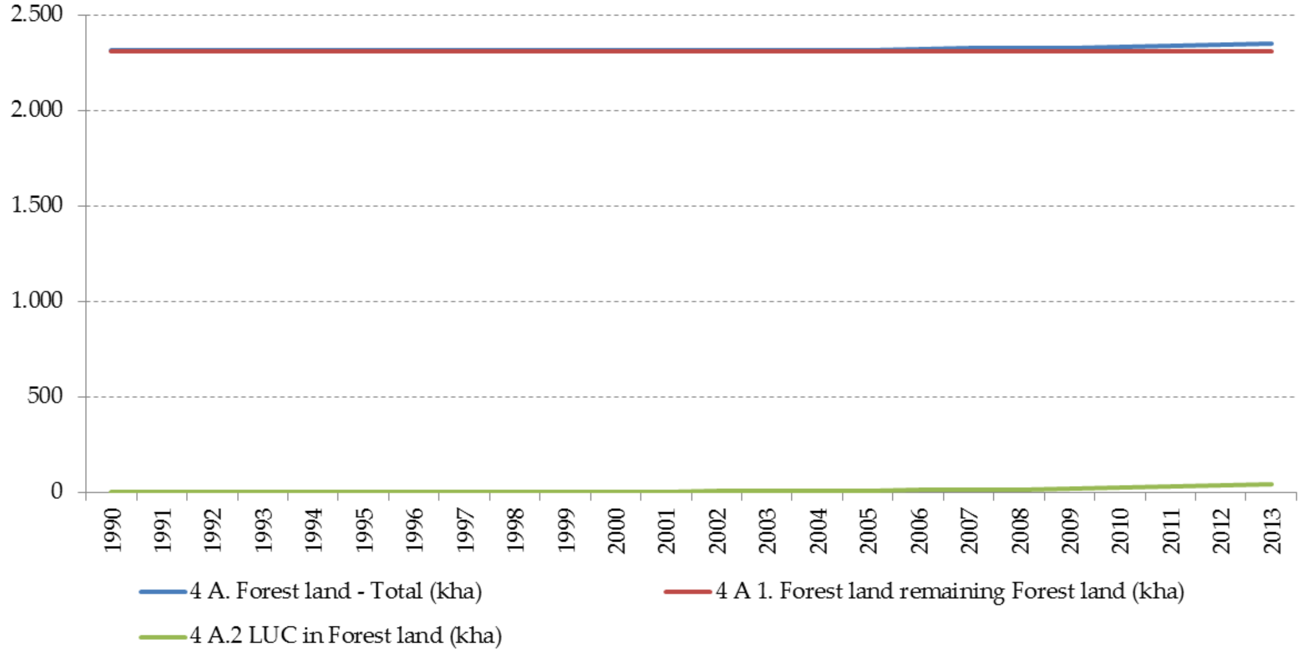
6.4.1. Description

Under this land category, CO_2 emissions/removals from soil and living biomass[15] 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 6.4.1 and detailed description of conducted survey is presented in Chapter 6.14. Emissions due to fires are presented in table 6.4.2. Since salvage logging data are included in harvest data, in CRF table notation key IE has been used in case of CO_2 emissions.

Figure 6.4-1 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.

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

Figure 6.4.-1: Trend of forest land and LUC to forest land in conversion period of 20 years (1990-2013) in kha*



* forest land area including forests out of yield

CO_2 removals from forest land remaining forest land in 2013 are -5,290.75 kt CO_2 and from Land converted to Forest land -200.75 kt CO_2. Therefore, the share of removals from land conversion in total Forest land removals makes only 3.8%. Annual emissions/removals from each land use category to forest land are presented in Table 6.4-1.

Table 6.4.-1: Emissions/Removals of CO_2 in Forest land category (kt CO_2)

Year	4.A Forest land - Total	4.A.1 Forest land remaining Forest land	4.A.2 Land converted to Forest land	4.A.2.1 Cropland converted to Forest land	4.A.2.2 Grassland converted to Forest land	4.A.2.3 Wetland converted to Forest land	4.A.2.4 Settlement converted to Forest land	4.A.2.5 Other land converted to Forest land
1990	-5,628.11	-5,588.83	-39.2798	0.00	-39.28	NO	NO	NE
1991	-7,758.27	-7,722.01	-36.26	0.00	-36.26	NO	NO	NE
1992	-8,186.62	-8,149.86	-36.76	0.00	-36.76	NO	NO	NE
1993	-8,528.92	-8,493.05	-35.88	0.00	-35.88	NO	NO	NE
1994	-8,281.22	-8,243.94	-37.27	0.00	-37.27	NO	NO	NE

Year	4.A Forest land - Total	4.A.1 Forest land remaining Forest land	4.A.2 Land converted to Forest land	4.A.2.1 Cropland converted to Forest land	4.A.2.2 Grassland converted to Forest land	4.A.2.3 Wetland converted to Forest land	4.A.2.4 Settlement converted to Forest land	4.A.2.5 Other land converted to Forest land
1995	-8,814.07	-8,775.88	-38.19	0.00	-38.19	NO	NO	NE
1996	-8,565.32	-8,526.88	-38.44	0.00	-38,.44	NO	NO	NE
1997	-7,868.69	-7,828.66	-40.03	0.00	-40.03	NO	NO	NE
1998	-7,856.58	-7,816.72	-39.86	0.00	-39.86	NO	NO	NE
1999	-7,986.62	-7,946.35	-40.27	0.00	-40.27	NO	NO	NE
2000	-7.,683.24	-7,640.88	-42.37	0.00	-42.37	NO	NO	NE
2001	-7,672.26	-7,629.29	-42.97	0.00	-42.97	NO	NO	NE
2002	-7,791.63	-7,748.04	-43.59	0.00	-43.59	NO	NO	NE
2003	-7,462.63	-7,417.71	-44.92	0.00	-44.92	NO	NO	NE
2004	-7,211.81	-7,167.16	-44.65	0.73	-45.38	NO	NO	NE
2005	-7,291.19	-7,270.70	-20.49	1.28	-21.78	NO	NO	NE
2006	-7,108.06	-7,071.57	-36.49	0.77	-37.26	NO	NO	NE
2007	-6,550.79	-6,513.40	-37.39	0.75	-38.14	NO	NO	NE
2008	-6,609.15	-6,522.51	-86,.64	-0.50	-86.14	NO	NO	NE
2009	-6,824.05	-6,751.57	-72.48	-0.49	-71.98	NO	NO	NE
2010	-6,583.46	-6,477.43	-106.03	-1.19	-104.84	NO	NO	NE
2011	-5,509.41	-5,390.54	-118.87	-3.65	-115.22	NO	NO	NE
2012	-5,411.54	-5,230.12	-181.42	-2.89	-178.53	NO	NO	NE
2013	-5,491.49	-5,290.75	-200.75	-5.04	-195.70	NO	NO	NE

Table 6.4.-2: CO_2 emissions from wildfires

Year	Area burnt (ha)	CO_2 emission CO_2 equivalent (kt)	CH_4 emission CO_2 equivalent (kt)	N_2O emission CO_2 equivalent (kt)
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
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
2013	615	19.10	1.431	0.94

6.4.2. Methodological issues

6.4.2.1 Forest land remaining forest land (4.A.1)

The dataset required for presenting the biomass carbon stock change encompasses the entire period from 1990-2013 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 Guidelines 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 Croatia without taking into consideration type of ownership.

Since the War period, in Croatia there is an active process of returning previously confiscated forests to private owners[16] 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 2.12 from IPCC 2006 Guidelines.

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 6.4-3.

Table 6.4-3: 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[17] and share of species in total growing stock in Croatia[18], 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 (mo/VWET) were used except in

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

[17] Scientific papers of Badjun, Horvat,Sinković, Govorčin, Štajduhar. See list of References

[18] Forest Management Area Plan of the Republic of Croatia 2006-2015. See list of References

case of hornbeam wood density where value for wood density in absolute dry were used and corrected by the shrinkage factor of 17.1% [19].

In case of common 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 common fir appears on silicate or limestone[20]. Since there is no exact data about area of common fir on silicate and limestone, mean value of 0.387 t d.m/m^3 was used when calculating contribution of common 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[21] 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[22].

The detailed overview of the approach is shown below:

$$\mathbf{\Delta C_B = \Delta C_G - \Delta C_L}$$

$$\Delta C_G = \Sigma_{i,j} (A_{i,j} \times I_V \times BEF_1 \times D_1 \times (1+R) \times CF)$$

Where:

ΔC_B	=	annual change in carbon stocks in biomass, tonnes C yr^{-1}
ΔC_G	=	annual increase in carbon stocks due to biomass growth, C yr^{-1}
ΔC_L	=	annual decrease in carbon stocks due to biomass losses, C yr^{-1}

ΔC_G	=	annual increase in carbon stocks due to biomass growth in forest land remaining forest land by vegetation type and climatic zone, tonnes C yr^{-1}
A	=	area of land remaining in the same land-use category, ha
i	=	ecological zone (i=1 to n)
j	=	climate domain (j=1 to n)
I_V	=	average net increment for specific vegetation type, m^{3}ha^{-1}yr^{-1}

[19] Scientific paper of Sinković, Govorčin and Sedlar. See list of References
[20] Scientific paper of Horvat. See list of References
[21] Scientific paper of Govorčin, Sinković, Trajković, Šefc. See list of References
[22] Mali šumarsko-tehnički priručnik. See list of References

BEF_1	=	biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to above ground biomass growth for specific vegetation type, tonnes above-ground biomsss growth (m^3 annual increment)$^{-1}$
D_1	=	basic wood density
R	=	ration of below-ground biomass to above-ground biomass for a specific vegetation type, in tonne d. m. below ground biomass (tonne d. m. above-ground biomass)$^{-1}$
CF	=	carbon fraction of dry matter (tonne d.m)$^{-1}$
ΔC_L	=	$L_{wood\text{-}removals}+L_{fuelwood}+L_{disturbance}$
$L_{wood\text{-}removals}$	**=**	**Σ H x BEF_R x D_R x (1+R) x CF**

Where:

ΔC_L	=	annual decrease in carbon stocks due to biomass losses inforest land remaining forest land
H	=	annual wood removal, roundwood, m^3yr^{-1}
BEF_R	=	biomass expansion factor for conversion for wood removal (m^3 of removals)$^{-1}$
D_R	=	basic wood density
R	=	ration of below-ground biomass to above-ground biomass for a specific vegetation type, in tonne d. m. below ground biomass (tonne d. m. above-ground biomass)-1
$L_{fuelwood}$	=	annual biomass loss due to fuelwood removals, tonnes C yr^{-1} (Equation 2.13)
$L_{disturbance}$	=	annual biomass loss due to fuelwood removals, tonnes C yr_{-1} (Equation 2.14)

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 Tier 1 approach assuming that there are no changes in the dead wood stock in all managed forests.

B) Changes in the carbon stock in the dead organic matter - litter

As regarding the calculation of carbon stock change in this pool, Croatia uses IPCC GPG Tier 1 approach assuming that there are no changes in the litter stock in all managed forests.

C) Soil

There was no change regarding the forest management in the past 20 years. Because of that it is assumed that the average carbon stock in Croatian soils is stable following the approach of the IPCC GPG 2006 Tier 1 methodology.

6.4.2.2 Land converted to forest land (4.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 1990-2013.

The related definition of Land Converted to forest land is provided in Chapter 6.2.1. 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[23] as one of outcomes of the project. Detailed description of conducted work will be presented in KP Chapter in NIR 2016.

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

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

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 1990-2013. 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.

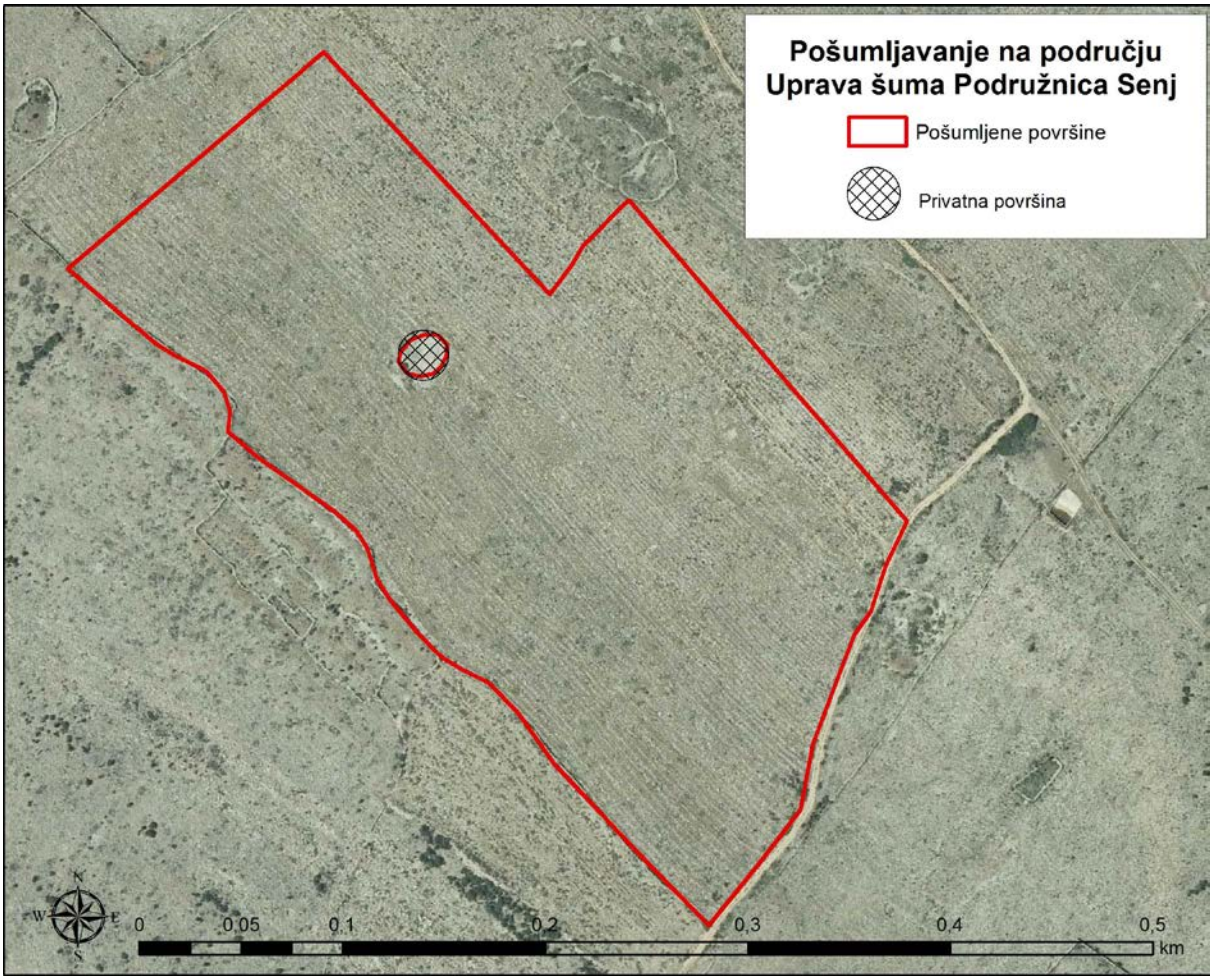
In case of afforestation in private forests generated through planting and seeding measures, analyses conducted through LULUCF 1 project proved that in period 1990-2012 in private forests no afforestation has occurred through planting and seeding measures. This was expected outcome, since according to the Ordinance[24] 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*[25], 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.

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

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

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 6.4-1)

Figure 6.4.-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 6.4-4. After the LULUCF 1 project was finalized, new recording system was introduced in database systems of Croatian forests Ltd. in order to support UNFCCC and KP reporting in field of forestry.

Table 6.4-4: 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
2013	296.62	29.12	6,815.74

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 afforestation 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 Croatian NIR 2014, Chapter 11.1.3.

Conducted survey confirmed that beyond the increase of forest area in state owned forests managed by Croatian 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 1990-2013.

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 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 when performing survey.

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 2006 Guidelines 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 2006 Guidelines 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 2006 Guidelines 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 method26 for the soil carbon content determination since this method has been found more accurate than previously used wet combustion method. For the estimation national value for C/N ratio (10) was used in case of Grassland mineral soils that are converted to Cropland.

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

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 6.5.2.1). 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 6.4-5 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.

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

Table 6.4-5: Annual change in carbon stock in living biomass and soil for Land converted to forest land

kt 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
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
2013	56.57	-32.79	23.78	30.97	54.75

6.4.3. 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. New uncertainy estimate was performed for NIR 2015.

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 6.4-6 and 6.4-7. 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 6.4-6 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 2006
R/S (Root to Shoot ratio) for coniferous in Forestland	Range 0,12-0,49	Default, IPCC 2006
R/S (Root to Shoot ratio) for deciduous in Forestland	Range 0,17-0,30	Default, IPCC 2006
R/S (Root to Shoot ratio) for coniferous in afforestated areas	42%	Default, IPCC 2006
BEF 1 for coniferous	Range 1-1.3	Default, IPCC 2006
BEF 1 for deciduous	Range 1.1-1.3	Default, IPCC 2006
BEF 2 for coniferous	Range 1.15-4.2	Default, IPCC 2006
BEF 2 for deciduous	Range 1.15-3.2	Default, IPCC 2006
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

Inputs	Uncertainty	Source of information
Belowground biomass at LUC areas to and from aCL	75%	Default, IPCC 2006
pCL aboveground biomass	75%	Default, IPCC 2006
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 2006
Emission factor for organic Cropland soils	90%	Default, IPCC 2006
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 2006
Organic soil area	30%	Expert judgment
Soil C stock in Grassland	61.2%	Empirical data
Emission factor for organic Grassland soils	90%	Default, IPCC 2006
C/N ratio grassland soils	10.6%	Empirical data
Yield biomass at LUC areas to and from Grassland	75%	Default, IPCC 2006
Area of Wetland	1%	Expert judgment
LUC area aCL-WL	300%	Expert judgment
LUC area pCL-WL	300%	Expert judgment
Soil C stock in Wetlands	67%	Empirical data
Area of Settlement	30%	Expert judgment
LUC area FL-SL	2%	Expert judgment
LUC area aCL-SL	300%	Expert judgment
LUC area pCL-SL	300%	Expert judgment
LUC area GL-SL	200%	Expert judgment
Biomass growth in pCL-SL	50%	Expert judgment
Soil C stock in Settlements	65.4%	Empirical data

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.

Regarding the Forest land remaining forest land, the relative uncertainty of CO_2 equivalent emission/removal ranges between ±50 and ±196 % and it is calculated using the uncertainties for emission factors and area presented in Tables 6.4-6. In case of LUC to Forest land uncertainty of CO_2 equivalent is calculated to ranges between ±189% and ± 269%.

6.4.4. 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

a. 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

b. 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).

6.4.5. Category-specific recalculations

Recalculations needed in this category of land coming due to use of new 2006 IPCC Guidelines and some improvements done by Croatia (See Chapter 10). Data and information will be provided in NIR 2016.

6.4.6. Category-specific planned improvements

- Further investigation on BEFs is part of a new project proposal within the LULUCF sector

Improvements are to be implemented in timeframe as it is presented in Chapter 10.

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.

6.5. CROPLAND (CRF CATEGORY 4.B)

6.5.1. Description

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

Cropland area ranged from 1,535.47 kha to 1,623.77kha in the period 1990-2013. Emissions from the change in carbon stock in biomass and soil ranged from 80.61 ktCO_2 to 326.43 ktCO_2 for the period 1990-2013.

Annual LUCs to Cropland occurs from the Forest land and Grassland category.

Tables 6.5-1 and 6.5-2 present the land use change and removals/emissions from land use change to cropland in the period 1990-2013.

Table 6.5-1: Activity Data of Cropland from 1990 to 2013 in kha*

Year	4.B Total Cropland	4.B.1 Cropland remaining cropland	4.B.1.a Annual cropland remaining annual cropland	4.B.1.b Perennial cropland remaining perennial cropland	4.B.1.c Perennial cropland converted to annual cropland	4.B.1.d Annual cropland converted to perennial cropland	4.B.2 Land converted to Cropland	4.B.2.2.a Grassland converted to annual cropland	4.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	1,59741	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	038	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
2008	1,558.39	1,545.92	1,407.50	137.86	0.26	0.30	12.48	10.87	0.74
2009	1,551.55	1,540.33	1,399.85	139.98	0.24	0.26	11.22	10.15	0.70
2010	1,548.47	1,535.06	1,405.82	128.80	0.22	0.22	13.42	11.59	0.79
2011	1,544.14	1,529.52	1,400.82	128.29	0.20	0.20	14.62	12.55	0.86
2012	1,539.81	1,524.05	1,403.10	120.58	0.19	0.19	15.75	13.51	0.94
2013	1,535.47	1,518.61	1,399.47	118.80	0.17	0.18	16.86	14.46	1.01

Table 6.5-2: Emissions (+) / removals (-) of CO_2 in Cropland from 1990 to 2013 (kt CO_2 equivalent)

Year	4.B Total Cropland	4.B.1 Cropland remaining cropland	4.B.2 Land converted to cropland	4.B.2.1 Forestland converted to cropland	4.B.2.2 Grassland converted to cropland	4.B.2.3 Wetlands converted to cropland	4.B.2.4 Settlements converted to cropland	4.B.2.5 Other land converted to cropland	N2O in CO2 eq
1990	222.83	194.50	28.33	0.00	23.48	NO	NO	NO	4.86
1991	218.97	190.85	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	213.09	186.94	26.15	0.00	21.81	NO	NO	NO	4.35
1994	228.53	203.36	25.17	0.00	20.99	NO	NO	NO	4.18
1995	233.49	209.30	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

Year	4.B Total Cropland	4.B.1 Cropland remaining cropland	4.B.2 Land converted to cropland	4.B.2.1 Forestland converted to cropland	4.B.2.2 Grassland converted to cropland	4.B.2.3 Wetlands converted to cropland	4.B.2.4 Settlements converted to cropland	4.B.2.5 Other land converted to cropland	N2O in CO2 eq
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	285.02	255.42	29.59	0.74	23.59	NO	NO	NO	5.26
2005	246.22	199.30	32.43	0.25	26.38	NO	NO	NO	5.79
2006	225.43	172.44	35.51	0.02	29.17	NO	NO	NO	6.32
2007	136.64	75.49	44.55	5.72	31.96	NO	NO	NO	6.87
2008	146.53	82.87	42.88	0.71	34.75	NO	NO	NO	7.42
2009	80.61	17.02	51.66	6.09	37.54	NO	NO	NO	8.02
2010	157.07	97.29	46.32	-2.60	40.34	NO	NO	NO	8.58
2011	138.41	71.66	52.30	-0.94	43.94	NO	NO	NO	9.30
2012	211.17	149.25	52.32	-5.24	47.55	NO	NO	NO	10.01
2013	180.86	113.13	58.14	-3.73	51.16	NO	NO	NO	10.71

6.5.2. Methodological issues

6.5.2.1. Cropland Remaining Cropland (4.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[27]) 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 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 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 ago x 0.033 x biomass carbon stock at harvest)*

* *Excluding perennial cropland areas lost due to land use changes*

For the annual carbon accumulation rate in perennial cropland the IPCC default value of 2.1 tC/ha annually was used.

For the aboveground biomass carbon stock at harvest, the IPCC 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 Tier 1 method for LUCs with partly country specific EFs and using below equation:

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:

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

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

ΔC_{Growth} = Carbon accumulation rate of perennial cropland = 2.1 t C/ ha annually (IPCC 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 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[28]), as well as expansion factors from the Austrian Expert Panel for Soil Fertility[29]. The related biomass of strew, leaves or other aboveground plant parts has been determined using the expansion factor from Austria also.

In order to provide an estimate of the belowground biomass the estimated aboveground biomass in annual cropland was multiplied with the root/shoot ratio. Root/shoot ratios of the United States Department of Agriculture were applied for this purpose following examples from other countries. The explanation for the use of this root/shoot ratio was found fitting for Croatia too (all the mentioned countries belong to the temperate region).

For each year from the period 2000-2010 the weighted mean value of the total biomass per ha was calculated on the basis of yields of individual crops and the corresponding areas 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 Guidelines Tier 1 method for LUCs with partly country specific EFs and using below presented equation:

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

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

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 default value) (accounted only for the year of LUC)

C_{After} = carbon stock immediately after conversion is 0 t C/ ha (IPCC 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 2013 was 1,518.61 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 2,571 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 6.11).

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[30] 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 0.18 kha to 0.89 kha from 1990 to 2013.

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 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)

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

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

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 kt of carbon annually respectively.

For estimating CO_2 emissions from organic soils in the Cropland Remaining Cropland category the IPCC GPG 2.26 equation was applied:

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

Where:

$\Delta C_{CC\ Organic}$= CO_2 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 default value)

6.5.2.2. Land Use Change to Cropland (4.B.2)

6.5.2.2.1. 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 1990-2013. 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:

- 10 tC/ha – for perennial Cropland (IPCC)

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

- 38.69 tC/ha when calculating losses due to conversion of deciduous forests to perennial Cropland
- 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.

6.5.2.2.2. Grassland Converted to Cropland (4.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, 14.46 kha of grassland area were converted to cropland in 2013. 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 kt CO_2 and in 2012 in emissions of 58.14 kt CO_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 6.5.2.1.

To calculate the annual change in carbon stock of grassland living biomass converted to annual and perennial cropland the IPCC GPG Tier 1 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 1.33 ktCO_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 64.41 ktCO_2 for the period 1990-2013.

6.5.2.2.3. 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 11.8.

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

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 croplad and 12 in case of forest land converted to cropland)

6.5.3. Uncertainties and time-series consistency

The uncertainty values for total CO_2 eq in category Land converted to Cropland ranges from ±1977% to ±2075% using uncertainties for emission factors and area as it is presented Table 6.4-6. In regards to Cropland remaining Cropland, uncertainty for total CO_2 eq ranges between ±880% and ±840%.

In Annex 1 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.

6.5.4. Category-specific QA/QC and verification

The calculation of data for this category was included in the overall QA/QC system of the Croatian GHG inventory.

6.5.5. Category-specific recalculations

Recalculations needed in this category of land coming due to use of new 2006 IPCC

Guidelines and some improvements done by Croatia (See Chapter 10). Data and information will be provided in NIR 2016.

6.5.6. 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)"

6.6. GRASSLAND (CRF CATEGORY 4.C)

6.6.1. Description

In this category only emissions/removals from the grassland management (Grassland Remaining Grassland and Land Converted to Grassland) were considered. For the purpose of this report a combination of the IPCC GPG Tier 1 and Tier 2 approach was used to calculate the carbon stock changes.

The grassland area ranged from 1,210.53 kha to 1,231.71 kha in the period 1990-2013. Removals from the change in carbon stock in biomass and soil ranges from 76.80 ktCO_2 to 148.78 ktCO_2 in period 1990-2013.

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 6.6-1 and 6.6-2 show the land use change and removals/emissions from LUC to grassland in the period from 1990 to 2013.

Table 6.6-1: Activity Data of Grassland in the period 1990-2013 in kha

Year	4.C Grassland - Total	4.C.1 Grassland remaining grassland	4.C.2 Land converted to grassland	4.C.2.1 Forest land converted to grassland	4.C.2.2 Cropland converted to grassland	4.C.2.2.a Annual cropland converted to grassland	4.C.2.2.b Perennial cropland converted to grassland	4.C.2.3 Wetlands converted to grassland	4.C.2.4 Settlements convertet to grassland	4.C.2.5 Other land converted to grassland
1990	1,210.53	1,178.66	31.87	NO	31.87	29.11	2.76	NO	NO	NO
1991	1,212.64	1,179.42	33.23	NO	33.23	30.43	2.80	NO	NO	NO
1992	1,214.76	1,180.23	34.53	NO	34.53	31.70	2.83	NO	NO	NO
1993	1,216.88	1,180.91	35.98	NO	35.98	33.10	2.88	NO	NO	NO
1994	1,219.00	1,181.65	37.35	NO	37.35	34.43	2.92	NO	NO	NO
1995	1,221.12	1,182.39	38.72	NO	38.72	35.76	2.96	NO	NO	NO
1996	1,223.24	1,183.08	40.16	NO	40.16	37.15	3.00	NO	NO	NO
1997	1,225.35	1,183.90	41.46	NO	41.46	38.42	3.04	NO	NO	NO
1998	1,227.47	1,184.66	42.81	NO	42.81	39.73	3.08	NO	NO	NO
1999	1,229.59	1,185.32	44.27	NO	44.27	41.14	3.13	NO	NO	NO
2000	1,231.71	1,186.14	45.57	NO	45.57	42.32	3.25	NO	NO	NO
2001	1,230.47	1,185.23	45.24	NO	45.24	42.01	3.23	NO	NO	NO
2002	1,229.23	1,184.21	45.02	NO	45.02	41.80	3.22	NO	NO	NO
2003	1,227.99	1,183.14	44.85	NO	44.85	41.63	3.22	NO	NO	NO
2004	1,226.75	1,181.85	44.91	NO	44.91	41.68	3.23	NO	NO	NO
2005	1,225.52	1,178.20	47.32	NO	47.32	43.86	3.46	NO	NO	NO
2006	1,224.28	1,174.72	49.56	NO	49.56	45.89	3.67	NO	NO	NO
2007	1,223.04	1,170.05	52.99	NO	52.99	49.01	3.99	NO	NO	NO
2008	1,221.80	1,167.60	54.19	NO	54.19	50.09	4.10	NO	NO	NO
2009	1,220.56	1,162.51	58.06	NO	58.06	53.59	4.46	NO	NO	NO
2010	1,219.32	1,156.32	63.00	NO	63.00	58.09	4.91	NO	NO	NO
2011	1,218.08	1,150.95	6713	NO	67.13	61.76	5.37	NO	NO	NO
2012	1,216.85	1,146.74	70.10	NO	70.10	64.37	5.73	NO	NO	NO
2013	1,215.61	1,146.74	70.10	NO	70.10	64.37	5.73	NO	NO	NO

Table 6.6-2: Emissions (+) / removals (-) of CO_2 in Grassland 1990-2013 (kt CO2 equivalent)

Year	4.C Grassland - Total	4.C.1 Grassland remaining grassland	4.C.2 Land converted to grassland	4.C.2.1 Forest land converted to grassland	4.C.2.2 Cropland converted to grassland	4.C.2.3 Wetlands converted to grassland	4.C.2.4 Settlements convertet to grassland	4.C.2.5 Other land converted to grassland
1990	-103.97	2.07	-106.04	NO	-106.04	NO	NO	NO
1991	-76.80	2.07	-78.86	NO	-78.86	NO	NO	NO
1992	-83.63	2.07	-85.70	NO	-85.70	NO	NO	NO
1993	-86.55	2.07	-88.61	NO	-88.61	NO	NO	NO

1994	-94.08	2.07	-96.15	NO	-96.15	NO	NO	NO
1995	-99.94	2.07	-102.01	NO	-102.01	NO	NO	NO
1996	-104.68	2.07	-106.75	NO	-106.75	NO	NO	NO
1997	-113.41	2.07	-115.48	NO	-115.48	NO	NO	NO
1998	-117.99	2.07	-120.06	NO	-120.06	NO	NO	NO
1999	-121.64	2.07	-123.71	NO	-123.71	NO	NO	NO
2000	-110.96	2.07	-113.03	NO	-11303	NO	NO	NO
2001	-148.78	2.07	-150.85	NO	-150.85	NO	NO	NO
2002	-145.24	2.07	-147.31	NO	-147.31	NO	NO	NO
2003	-143.30	2.07	-145.37	NO	-145.37	NO	NO	NO
2004	-137.97	2.07	-140.04	NO	-140.04	NO	NO	NO
2005	-91.05	207	-93.12	NO	-93.12	NO	NO	NO
2006	-103.91	2.07	-105.97	NO	-105.97	NO	NO	NO
2007	-88.74	2.07	-90.81	NO	-90.81	NO	NO	NO
2008	-14685	2.07	-148.92	NO	-148.92	NO	NO	NO
2009	-98.32	2.07	-100.39	NO	-100.39	NO	NO	NO
2010	-110.91	2.07	-112.98	NO	-112.98	NO	NO	NO
2011	-94.55	2.07	-96.62	NO	-96.62	NO	NO	NO
2012	-134.54	2.07	-136.61	NO	-136.61	NO	NO	NO
2013	-103.50	2.07	-136.61	NO	-136.61	NO	NO	NO

6.6.2. 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).

6.6.2.1. Grassland Remaining Grassland (4.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 2006).

The area of grassland remaining grassland in 2013 amounts to 1,146.74 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 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 ktCO_2 annually for the period 1990-2013.

According to expert judgment liming does not occur in the grassland category.

6.6.2.2. Land use change to Grassland (4.C.2)

6.6.2.2.1. Forest land converted to Grassland (4.C.2.1)

There has not been conversion from the Forestland to Grassland in the last decades

6.6.2.2.2. Cropland converted to Grassland (4.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, 70.10 kha of Cropland area were converted into Grassland in year 2013. 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 -106.04 kt CO_2 and in year 2013 in removal of 136.61 ktCO_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 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 126.0 to 297.9 ktCO_2 in Cropland converted to Grassland, while emissions in case of perennial Cropland converted to Grassland in range of 3.63 to 8.24 ktCO_2 in period 1990-2013.

6.6.3. Uncertainties and time-series consistency

The uncertainty values for total CO_2 eq in category Land converted to Grassland ranges from ±554% to ±708% using uncertainties for emission factors and area as it is presented in table 6.4-6. In regards to Grassland remaining Grassland uncertainty for total CO_2 eq is around ±94%.

In Annex 1 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.

6.6.4. Category-specific QA/QC and verification

The calculation of the data for category 4.C was included in overall QA/QC system of the Croatian GHG inventory.

6.6.5. Category-specific recalculations

Recalculations needed in this category of land coming due to use of new 2006 IPCC Guidelines and some improvements done by Croatia (See Chapter 10). Data and information will be provided in NIR 2016.

6.6.6. 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.

6.7. WETLANDS (CRF CATEGORY 4.D)

6.7.1. Description

In this category only emissions/removals from the sub-categories "Land Converted to Wetland" were considered.

Due to lack of information it was assumed that the carbon stock in biomass, dead organic matter and soil of surface waters was 0.

Peat extraction does not occur in Croatia.

The wetland area ranged from 72.32 ha in 1990 to 74.37 ha in 2013.

The land use change and removals/emissions from the IPCC land use categories to wetland in the period 1990-2013 are presented in Tables 6.7-1 and 6.7-2.

Table 6.7-1: Activity data of wetland in the period 1990-2013 in kha

Year	4.D Total Wetland	4.D.1 Wetland remaining Wetland	4.D.2 Land converted to Wetland	4.D.2.1 Forest land converted to Wetland	4.D.2.2 Cropland converted to Wetlands	4.D.2.3 Grassland converted to Wetlands	4.D.2.4 Settlements converted to Wetlands	4.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
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	7434	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
2013	72.89	0.00	1.67	NO	1.67	NO	NO	NO

Table 6.7-2: Emissions of wetland in the period 1990-2013 in ktCO2

Year	4.D Total wetland	4.D 1 Wetland remaining Wetland	4.D.2 Land converted to Wetland	4.D.2.1 Forest land converted to Wetland	4.D.2.2 Cropland to converted Wetlands	4.D.2.3 Grassland to converted Wetlands	4.D.2.4 Settlements to converted Wetlands	4.D.2.5 Other land to converted 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
2013	14.13	NE	14.13	0.00	14.13	0.00	0.00	0.00

6.7.2. Methodological issues

6.7.2.1. Land Use Change to Wetland (4.D.2)

Based on analyzed data it was concluded that no conversion occurred from other land use categories to wetland except from cropland.

6.7.2.2. Cropland Converted to Wetland (4.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 7.10 was applied.

The annual change in carbon stocks of living biomass in cropland converted to wetland (t C/a):

$\Delta C_{LW\,flood} = \sum A_i \times (B_{after} - B_{before})_i$

A_i = area of land converted annually to flooded land from original land use *i*, ha yr^{-1}

B_{Before} = living biomass in land immediately before conversion to wetland: **1)** for annual cropland 5.7 t C /ha; **2)** for perennial cropland 63 t C / ha (IPCC default value)

B_{After}= living biomass in land immediately before conversion to wetland (default = 0 t C/ha a)

Changes in carbon stocks in soil of cropland converted to wetland

$\Delta C_{LW\,flood} = \sum A_i \times (B_{after} - B_{before})_i /20$

A_i = area of land converted to flooded land for a transition period of 20 years, ha

B_{Before} = carbon stock in soil immediately before conversion to wetland:**1)** for annual cropland 46.4 t C /ha a, and **2)** for perennial cropland 77.8 t C / ha a (See Chapter 6.4.1.)

B_{After} =carbon stock in soil immediately after conversion to wetland (default = 0 t C/ha

6.7.3. Uncertainties and time-series consistency

According to the Tier 2 method uncertainty for the total CO_2eq in category Land converted Wetland ranges between ±176 and ±355%. Uncertainties for emission factors and areas used in this estimation are presented in table 6.4-6. 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.

6.7.4. Category-specific QA/QC and verification

The calculation of the data for category 4.D was included in overall QA/QC system of the Croatian GHG inventory.

6.7.5. Category-specific recalculations

- NA

6.7.6. Category-specific planned improvements

- NA

6.8. SETTLEMENTS (CRF CATEGORY 4.E)

6.8.1. Description

In this category only emissions/removals from sub-categories “Land converted to Settlements” were considered.

It was assumed that dead wood and litter do not occur in the settlements area.

The settlements area ranges from 212.98 kha in 1990 to 258.68 kha in 2013. Emissions from the change in the carbon stock in biomass and soil ranges from 240.31 to 534.71kt CO_2.

Annual LUCs to Settlements occur from the subcategories Forest Land, Cropland (annual and perennial) and Grassland.

Tables 6.8-1 and 6.8-2 show the land use change and removals/emissions from LUC to Settlements in the period 1990 to 2013.

Table 6.8-1: Activity data of Settlements for 1990-2013 in kha

Year	4.E Total Settlement	4.E.1 Settlement remaining settlement	4.E.2 Land converted to settlement	4.E.2.1 Forest land converted to settlement	4.E.2.2 Cropland converted to settlement	4.E.2.3 Grassland converted to settlement	4.E.2.4 Wetland converted to settlement	4.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	19203	22.06	0.21	14.13	7.72	NO	NO
1992	215.23	193.18	22.05	0.23	13.93	7.90	NO	NO
1993	216.32	194.32	22.00	0.19	13.73	8.08	NO	NO
1994	217.43	195.46	21.97	0.24	13.51	8.23	NO	NO
1995	218.54	196.60	21.94	0.23	13.31	8.41	NO	NO
1996	219.66	197.75	21.91	0.22	13.11	8.58	NO	NO
1997	220.77	198.89	21.88	0.28	12.87	8.73	NO	NO
1998	221.88	200.03	21.85	0.38	12.62	885	NO	NO
1999	222.99	201.17	21.82	0.40	12.41	9.02	NO	NO
2000	224.11	202.32	21.79	0.55	12.13	9.11	NO	NO
2001	226.77	203.46	23.31	0.90	12.52	9.89	NO	NO
2002	229.43	204.60	24.82	1.11	12.99	10.72	NO	NO
2003	232.09	205.75	26.34	1.19	13.51	11.63	NO	NO
2004	234.74	206.89	27.86	1.49	13.94	12.43	NO	NO

2005	237.40	208.03	29.37	1.81	14.35	13.22	NO	NO
2006	240.06	209.17	30.89	2.12	14.76	14.01	NO	NO
2007	242.72	210.32	32.41	2.19	15.30	14.92	NO	NO
2008	247.28	211.46	35.82	2.56	16.63	16.63	NO	NO
2009	246.15	212.23	33.92	2.46	15.73	15.73	NO	NO
2010	250.70	212.98	37.72	2.74	17.49	17.49	NO	NO
2011	253.36	214.09	39.27	2.77	18.25	18.25	NO	NO
2012	256.02	215.21	40.81	2.91	18.95	18.95	NO	NO
2013	258.68	215.17	43.51	4.15	19.68	19.68	NO	NO

Table 6.8-2: Emissions of Settlements 1990-2013 in kt CO2

Year	Total Settlement	4.E.1 Settlement remaining settlement	4.E.2 Land converted to Settlement	4.E.2.1 Forest land converted to Settlement	4.E.2.2 Cropland converted to Settlement	4.E.2.3 Grassland converted to Settlement	4.E.2.4 Wetland converted to Settlement	4.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	251.47	NE	251.47	2.84	140.03	108.60	NO	NO
1994	260.78	NE	260.78	13.89	136.87	110.01	NO	NO
1995	252.79	NE	252.79	3.81	136.33	112.64	NO	NO
1996	252.84	NE	252.84	3.24	134.71	114.89	NO	NO
1997	254.85	NE	254.85	7.74	131.07	116.04	NO	NO
1998	271.45	NE	271.45	25.63	128.40	117.42	NO	NO
1999	260.85	NE	260.85	12.80	128.06	119.99	NO	NO
2000	289.31	NE	289.31	46.29	122.87	120.15	NO	NO
2001	330.11	NE	330.11	35.86	154.23	140.01	NO	NO
2002	364.64	NE	364.64	52.49	160.78	151.37	NO	NO
2003	363.97	NE	363.97	32.38	168.00	163.59	NO	NO
2004	404.34	NE	404.34	65.10	167.30	171.94	NO	NO
2005	413.93	NE	413.93	62.29	170.17	181.46	NO	NO
2006	417.75	NE	417.75	52.49	173.91	191.35	NO	NO
2007	435.50	NE	435.50	47.42	183.55	204.53	NO	NO
2008	474.00	NE	474.00	77.72	183.17	213.12	NO	NO
2009	482.95	NE	482.95	63.50	194.05	225.40	NO	NO
2010	502.38	NE	502.38	66.52	200.20	235.66	NO	NO
2011	501.34	NE	501.34	45.22	209.86	246.27	NO	NO
2012	534.71	NE	534.71	67.13	213.47	254.11	NO	NO
2013	545.56	NE	67.13	213.47	254.11	0.00	NO	NO

6.8.2. Methodological issues

6.8.2.1. 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 23,251 coniferous trees and 143,203 deciduous trees in unsealed area of City of Zagreb. Default annual carbon accumulation rate from the IPCC GPG (Table 8.2) 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 8.2).

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 ktCO_2eq to 213,47 ktCO_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 6.2). 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.

6.8.2.1.1. Forest Land Converted to Settlements (4.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 4.15 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 2.84 to 213.47 ktCO_2 in the period 1990-2013.

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 2.9 to 45.1 ktCO_2 in the period 1990 to 2013.

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.

6.8.2.1.2. Cropland Converted to Settlements (4.E.2.2)

The area in conversion status from cropland to settlements for the time period of 20 years ranged from 12.13 ha to 19.68 ha in the years 1990-2013.

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 -5.61 to 22.28 ktCO_2 in annual cropland and -1.53 to -5.61 ktCO_2 in perennial cropland converted to settlements in the years 1990-2013.

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 87.84 to 142.55 ktCO_2 in annual cropland and 16.75 to 27.19 kt CO_2 in perennial cropland converted to settlements in the years 1990-2012.

6.8.2.1.3. Grassland Converted to Settlements (4.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 4.97 to 18.20 ktCO_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 94.25 to 246.03 ktCO_2 in the period 1990-2013.

6.8.3. 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 ±88 and ±192%. In Annex 1 comparison between the uncertainties calculated using Tier 1 and Tier 2 methods by categories and carbon pools is presented.

The Settlements 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.

6.8.4. Category-specific QA/QC and verification

The calculation of the data for category 4.E was included in overall QA/QC system of the Croatian GHG inventory.

6.8.5. Category-specific recalculations

Recalculations needed in this category of land coming due to use of new 2006 IPCC Guidelines and some improvements done by Croatia (See Chapter 10). Data and information will be provided in NIR 2016.

6.8.6. Category-specific planned improvements

Survey for existing data for the determination of biomass stocks and growth rates in Settlement area makes a part of a developed LULUCF project proposal.

6.9. OTHER LAND (CRF CATEGORY 4.F)

In this category only the total area of land was considered. There was no conversion from other land use categories to other land.

6.9.1. Description

Table 6.9-1: Activity Data for Other Land, kha

Year	4.E Total Other land	4.E.1 Other land remaining other land	4.E.2 Land converted to Other land	4.E.2.1 Forest and converted to Other land	4.E.2.2 Cropland converted to Other land	4.E.2.3 Cropland converted to Other land	4.E.2.4 Wetland converted to Other land	4.E.2.5 Settlement converted to Other land
1990	225.81	225.81	NO	NO	NO	NO	NO	NO
1991	238.87	238.87	NO	NO	NO	NO	NO	NO
1992	238.15	238.15	NO	NO	NO	NO	NO	NO
1993	237.29	237.29	NO	NO	NO	NO	NO	NO
1994	236.54	236.54	NO	NO	NO	NO	NO	NO
1995	235.75	235.75	NO	NO	NO	NO	NO	NO
1996	234.91	234.91	NO	NO	NO	NO	NO	NO
1997	234.23	234.23	NO	NO	NO	NO	NO	NO
1998	233.52	233.52	NO	NO	NO	NO	NO	NO
1999	226.60	226.60	NO	NO	NO	NO	NO	NO
2000	221.52	221.52	NO	NO	NO	NO	NO	NO
2001	224.52	224.52	NO	NO	NO	NO	NO	NO
2002	227.35	227.35	NO	NO	NO	NO	NO	NO
2003	230.06	230.06	NO	NO	NO	NO	NO	NO
2004	232.66	232.66	NO	NO	NO	NO	NO	NO
2005	232.88	232.88	NO	NO	NO	NO	NO	NO
2006	233.26	233.26	NO	NO	NO	NO	NO	NO
2007	232.42	232.42	NO	NO	NO	NO	NO	NO
2008	233.90	233.90	NO	NO	NO	NO	NO	NO
2009	232.95	232.95	NO	NO	NO	NO	NO	NO
2010	231.39	231.39	NO	NO	NO	NO	NO	NO
2011	228.44	228.44	NO	NO	NO	NO	NO	NO
2012	226.56	226.56	NO	NO	NO	NO	NO	NO
2013	222.48	222.48	NO	NO	NO	NO	NO	NO

6.9.2. Methodological issues

6.9.3. Uncertainties and time-series consistency

This category of land was not subject of uncertainty estimates in LULUCF sector.

6.9.4. Category-specific QA/QC and verification

The calculation of the data for category 4.F was included in overall QA/QC system of the Croatian GHG inventory

6.9.5. Category-specific recalculations

NA

6.9.6. Category-specific planned improvements

NA

6.10. DIRECT N_2O EMISSIONS FROM N INPUTS TO MANAGED SOILS (CRF CATEGORY 4 I)

N_2O emissions from N fertilization of cropland and grassland are reported in the agriculture sector. No fertilizers are applied to forest land.

6.11. EMISSIONS AND REMOVALS FROM DRAINAGE AND REWETTING AND OTHER MANAGEMENT OF ORGANIC AND MINERAL SOILS (CRF CATEGORY 4 II)

Drainage of soils did not occur in Croatia in period 1990-2013 and no data are reported.

6.12. DIRECT N2O EMISSIONS FROM N MINERALIZATION/IMMOBILIZATION ASSOCIATED WITH LOSS/GAIN OF SOIL ORGANIC MATTER RESULTING FROM

CHANGE OF LAND USE OR MANAGEMENT OF MINERAL SOILS (CRF CATEGORY 4 III)

6.12.1. 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 are reported.

6.12.2. 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 equation 11.8.:

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

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.

6.12.3. Category-specific recalculations

- NA

6.13. INDIRECT N_2O EMISSIONS FROM MANAGED SOILS (CRF CATEGORY 4 IV)

N_2O indirect emissions are calculated in the agriculture sector. N_2O indirect emissions associated with disturbance of cropland soils that are converted to other land use categories are not estimated.

6.14. BIOMASS BURNING (CRF CATEGORY 4 V)

6.14.1. Description

Detailed analyses that were conducted within the LULUCF 1 project for the purposes of determining the areas affected by fires in the period 1990-2013 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*[31] and at that time relevant Ordinance[32].

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 (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[33] 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[34].

Based on the conducted analyses it was determined that Cropland areas were not affected by fires in period 1990-2012. These areas were not affected by fires in 2013. 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 1990-2013 were covered. According to the available data and information during the period 1990-2013 fires did not occur in state forests that are managed by

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[31] Forest Act (OG 140/05), Article 40

[32] *Ordinance on the method of data collection, conducting the Register and requirements for using data on forest fires* (OG 126/06)

[33] *Ordinance on the method of data collection, conducting the Register and requirements for using data on forest fires* (OG 175/13)

[34] 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

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[35]. 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.

6.14.2. 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* [36]and *Ordinance*[37] 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 (e.g. information about 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 6.14-1, and Figure 4.14-2).

[35] Ibid
[36] Ibid
[37] Ibid

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 6.14-3).

Figure 6.14-1: 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))

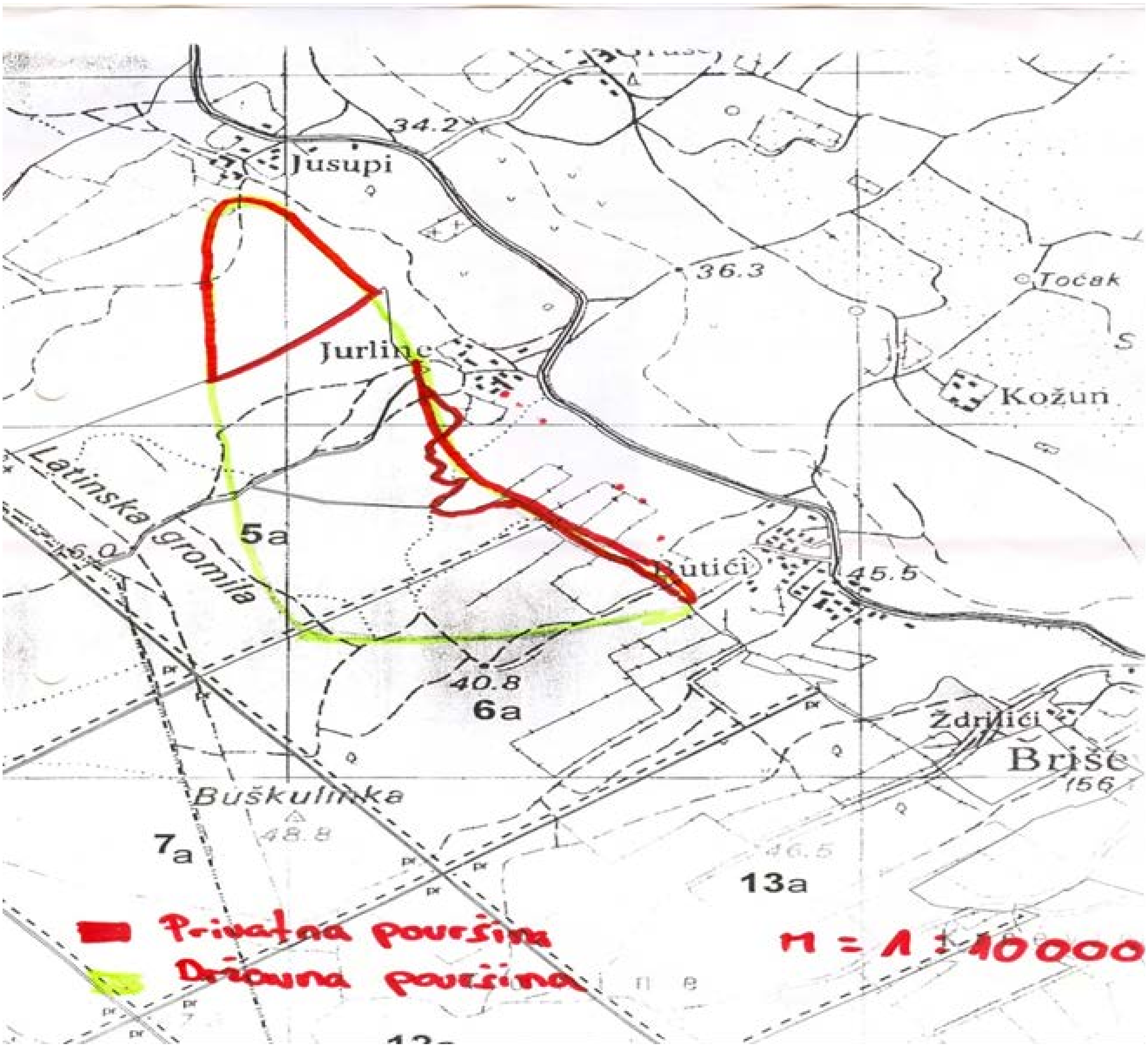
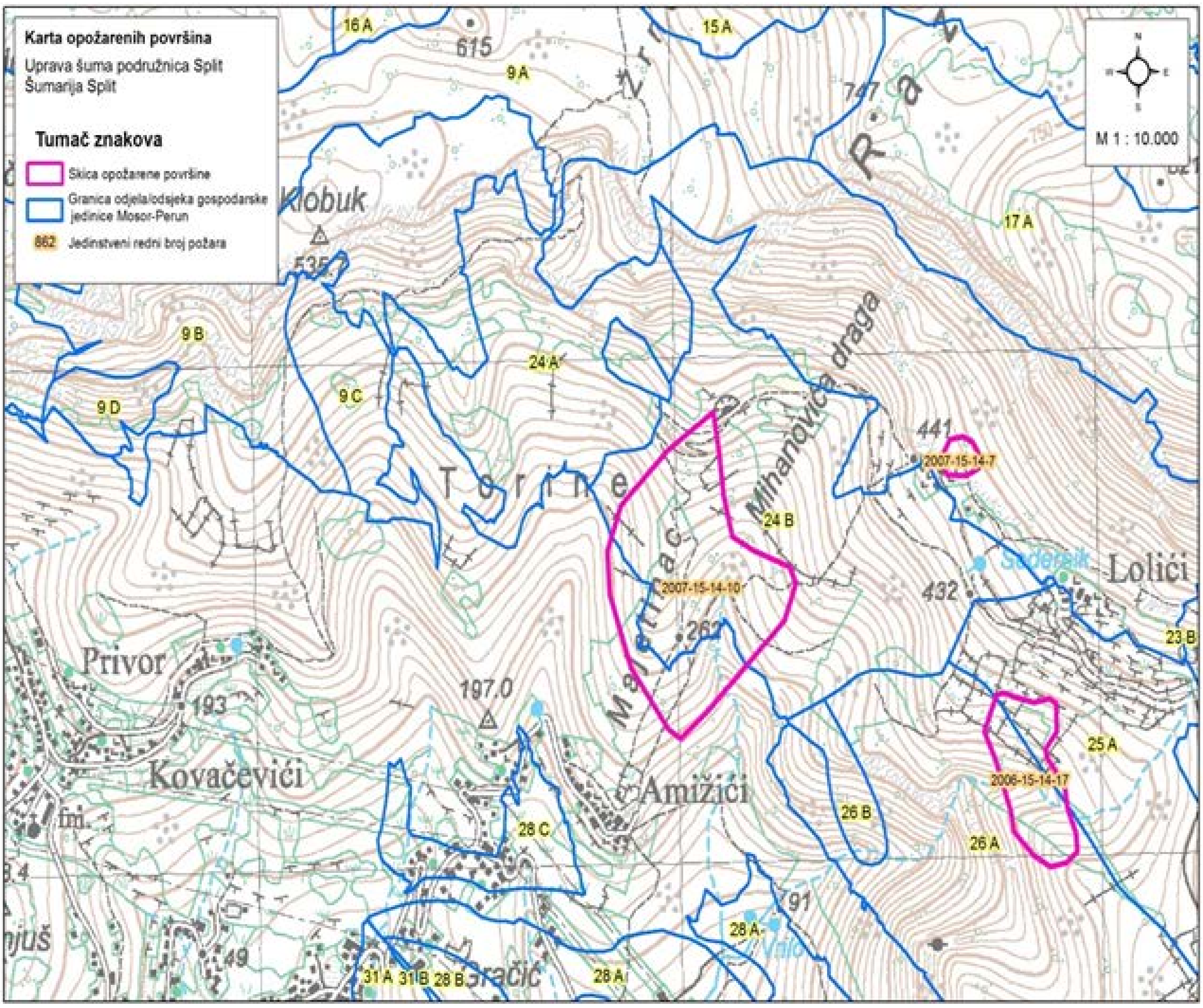


Figure 6.14-2: Map of state owned forests affected by fires in 2007 defined using GPS (Forest district Split, Forest unit Metković, Management unit Šibovnica; total affected area 77.10 ha)

Figure 6.14-3: 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 1990-2013 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 1990-2013. 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 and Grassland converted to Forestland using equation 2.27, Tier 1 method and default values prescribed in IPCC 2006 Guidelines. 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 2.5 for CO_2 (1531), CH4 (7.1) and N_2O (0.11) were used.

When estimating emissions in category Grassland remaining Grassland, value from Table 2.4 Savanna Grasslands (mid/late dry season burns) was used for biomass consumption, and emission factors of 1,640 (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 2.27, IPCC GPG 2006 using corresponding factors for biomass consumption and emission factors from Tables 2.4, 2.5, 2.6.

$$Lfire\ (tGHG) = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

Where:

A = area burnt (ha)

M_B = mass of fuel available available for combustion (tonnes ha^{-1})

C_f = combustion factor, dimensionless

G_{ef} = emission factor (g kg^{-1} dry matter burnt)

In the category Forest Land remaining Forest land, the amount of CH_4 emissions ranged between 14.62 and 1,132.64 ktCO_2 equivalents, N_2O emissions ranged between 0.33 and 25.23 while CH_4 emissions ranged from 1.42 to 110.30 ktCO_2 equivalent in the reporting period. Emissions of these gases are significantly lower in category Land converted to Forest land.

6.14.3. Uncertainties and time-series consistency

When performing uncertainty analyses in LULUCF sector, values presented in Table 6.14-1 were used in case of forest fires. In regards to the forest fire emissions', N_2O emission uncertainty it is calculated to ranges between ±49 and ±61% and between ±54% and ±132% for CH_4 emission.

Table 6.14-1 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 2006
Quantity of wood burnt down*Burning efficiency (B*C)	75%	Default, IPCC 2006
Emission factor for CO_2 (D)	75%	Default, IPCC 2006
Emission factor for CH_4 (D)	75%	Default, IPCC 2006
Emission factor for N_2O (D)	75%	Default, IPCC 2006

6.14.4. Category-specific QA/QC and verification

Emission estimation due to fires are included in overall QA/QC system in LULUCF sector.

6.14.5. Category-specific recalculations

Recalculations needed are result of using 2006 Guidelines. Relevant data and information will be provided in NIR 2016.

6.14.6. Category-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 2015 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.

CHAPTER 7: WASTE (CRF SECTOR 5)

7.1. *OVERVIEW OF SECTOR*

Waste management activities, such as disposal and biological treatment of solid waste, incineration of waste as well as wastewater treatment and discharge, can produce emissions of GHGs including methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O).

CH_4 and N_2O emissions as a result of disposal and biological treatment of solid waste, CO_2 and N_2O emissions resulting from incineration of waste (without energy recovery), CH_4 emissions from treatment of industrial and domestic and commercial wastewater and indirect N_2O emissions from wastewater treatment effluent 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 [38], Strategy[39] and Plan[40]. 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. Waste Framework Directive[41] is transposed in the area of waste management into the Croatian legislation by the new Sustainable Waste Management Act which is adopted in 2013.

[38] Sustainable Waste Management Act (OG 94/13)

[39] Waste Management Strategy of the Republic of Croatia (OG 130/05)

[40] Waste Management Plan of the Republic of Croatia for 2007 - 2015 (OG 85/07, 126/10, 31/11, 46/15)

[41] Waste Framework Directive 2008/98/EC

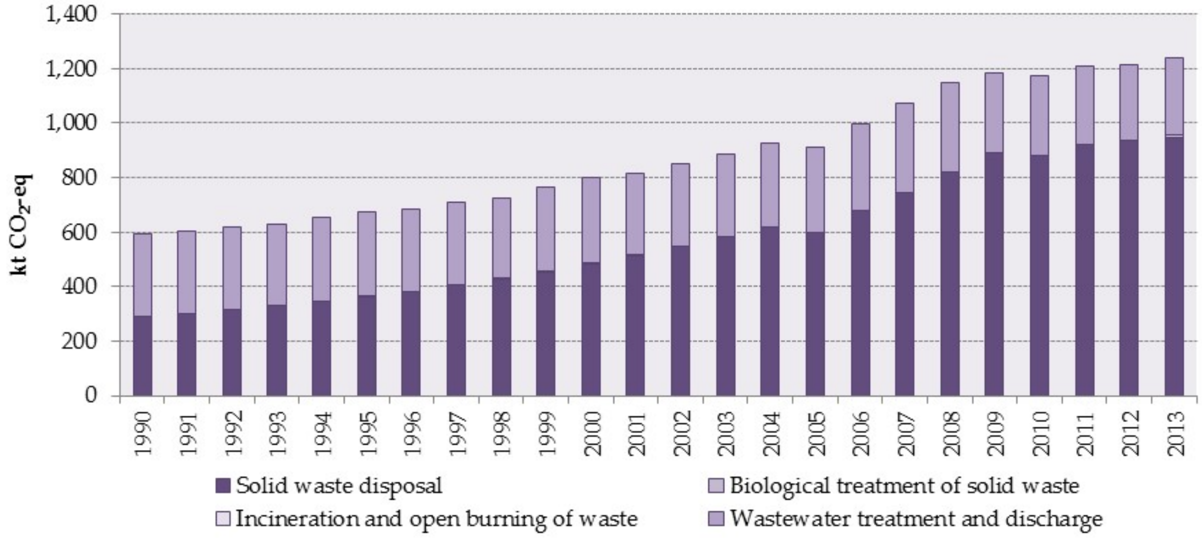
Management of the different types of waste is arranged by the Strategy and Plan, which are harmonised by objectives of the waste hierarchy. The following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy: (a) prevention; (b) preparing for re-use; (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 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[42] 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 kt CO_2-eq, from waste management in the period 1990 - 2013 are presented in the Figure 7.1-1.

[42] Regulation on the Greenhouse Gases Emissions Monitoring, Policy and Measures for Climate Change Mitigation in the Republic of Croatia (OG 87/12)

Figure 7.1-1: Emissions of GHGs from Waste sector (1990 - 2013)



In Waste sector, two source categories represent key source category regardless of LULUCF (detailed in Table 7.1-1):

Table 7.1-1: Key categories in Waste sector based on the level and trend assessment in 2013[43]

Table							
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2013)							
A	B	C	D				E
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification				Com.
Solid Waste Disposal - CH4	CH4	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i	
Wastewater Treatment and Discharge - CH4	CH4	Yes	L1e, L2e	T2e	L1i,	T2i	
Wastewater Treatment and Discharge - N2O	N2O	Yes	L2e	T2e		T2i	

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

7.2. *SOLID WASTE DISPOSAL (CRF 5.A)*

7.2.1. Category description

Generation of municipal solid waste 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.

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

The quantity of generated and disposed industrial waste was increased in the period from 2010 to 2013. 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 the Strategy and the Plan, include the assumed time-lags with respect to relevant EU legislation.

The total amount of municipal and industrial waste (including biodegradable industrial waste and sludge from wastewater treatment) generated in Croatia in 2013 was 1.72 million tonnes, which is in average 405 kg per capita. The amounts of separately collected fractions from municipal and industrial 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, produced by the CAEN, validated data on municipal and industrial waste production (collection by waste code) is available since 2007, and the data on types of municipal and industrial waste landfilled (by waste code) is available since 2010 (Croatian waste catalogue is harmonized with European list of waste). Inventory includes emissions related to the disposal of municipal and industrial waste on solid waste disposal sites (SWDSs). Efforts have been made in order to collect the necessary data and information on organic industrial waste (including biodegradable industrial waste and sludge from wastewater treatment) disposed on SWDSs.

There has been no systematic monitoring of the composition of municipal and industrial waste. The report “Analysis and assessment of the situation in the municipal waste management field” was done in the framework of the project “Creating a uniform methodology for the analysis of the composition of solid waste, determine the average composition of solid waste in the Republic of Croatia and the projection of the amount of solid waste”(CAEN, 2014 – 2015). This report contains data on waste composition for 2014.

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[44] and Ordinance on the waste management[45], 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 303 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 2013, the municipal and industrial waste was actively landfilled at 141 official sites (thereof 73 are managed, 22 are unmanaged deep and 46 are unmanaged shallow SWDSs); 92 SWDSs have been closed (thereof 31 are managed, 53 are unmanaged deep and 8 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. Several 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 and industrial waste on landfills.

7.2.2. Methodological issues

A method used to calculate CH_4 emissions according to *2006 IPCC Guidelines* is First Order Decay (FOD) method. The quantity of disposed municipal solid waste is taken into account from 1955 onwards. The quantity of disposed biodegradable industrial waste and sludge from wastewater treatment is taken into account for the period 2010 - 2013.

[44] Ordinance on the methods and conditions for the landfill of waste, categories and operational requirements for waste landfills (OG 117/07 , 111/11, 17/13, 62/13)

[45] Ordinance on the waste management (OG 23/14)

7.2.2.1. Activity data and data sources description

Main data supplier for activity data in Waste sector is CAEN. According to the Sustainable Waste Management Act, CAEN is responsible for maintaining the Waste Management Information System. The CAEN 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[46] adopted according to Environment Protection Act, the CAEN 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 CAEN. CAEN is cooperating with competent offices in counties and with companies collecting municipal and industrial waste 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 waste production per capita. Quality of municipal data is gradually improving as scales are installed at landfills, but still large amount of municipal and industrial waste is not being weighted, which usually lead to overestimation of collected and disposed quantities.

Main source for activity data on municipal and industrial waste is Environmental Pollution Register database and Landfill Inventory database, operated by CAEN from 2005 onwards.

Historical data for the total amount of generated and disposed municipal solid waste 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.

[46] Ordinance on the Environmental Pollution Register (OG 35/08)

Total annual municipal solid waste generated in 1955, 1960, 1970 and 1980 (MSW_T) and fractions of municipal solid waste disposed at SWDS (MSW_F) are reported in the Table 7.2-1.

Table 7.2-1: MSW_T and MSW_F in 1955, 1960, 1970 and 1980

Year	MSW_T (kt)	MSW_F (fraction)
1955	492	0.27
1960	594	0.32
1970	740	0.41
1980	920	0.50

Total annual municipal solid waste 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 municipal solid waste in 1999 were evaluated by interpolation method. Data for the quantity of disposed municipal solid waste in 2000 were obtained from *Report of Environment Condition*, Ministry of Environmental and Nature Protection. Data for the quantity of disposed municipal solid waste 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 municipal solid waste for the period 2001 to 2004 were assessed by interpolation method. Data for the quantity of disposed municipal solid waste 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 municipal solid waste (reporting destination of municipal solid waste). Data on the quantity of disposed municipal solid waste for the period 2010-2013 was obtained from the Environmental Pollution Register - reports delivered by the operators of active landfills. Data on the quantity of disposed biodegradable municipal solid waste for 2013 was obtained from the Waste Management Information System.- reports on landfills and waste disposal. Data on the quantity of generated and disposed industrial waste for the period 2010 - 2013 was obtained from the Environmental Pollution Register.

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 CAEN or the update is done upon receiving the information on individual landfill from other sources. Data on remediation status is requested by CAEN 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 municipal solid waste was disposed on unmanaged shallow SDWSs in the period 1955-1979 (according to recommendation for developing countries provided by 2006 *IPCC Guidelines*). It has been assumed that municipal solid waste 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 municipal solid waste disposed on all three IPCC categories (managed, unmanaged deep and unmanaged shallow) has been made by applying a factor of increasing disposed municipal solid waste on managed and unmanaged deep SWDS in the amount of 25 % compared to 1998 (according to expert judgement). Distribution of quantity of municipal solid waste 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 municipal solid waste 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 municipal solid waste disposed on managed, unmanaged deep and unmanaged shallow SWDS for the period 2007 to 2009 have been assessed by interpolation method.

In the process of defining managed and unmanaged landfills for 2013 (adjustment the country-specific to IPCC SWDS classification), the set of criteria was defined by working group using the data for the first half of 2014 available at Waste Management Information System (according the information on remediation activities, landfill depth, fences, aligning, compacting or covering).

In the process of defining managed and unmanaged landfills for industrial waste for the period 2010 - 2013 (adjustment the country-specific to IPCC SWDS classification), also the set of criteria was defined by working group, using the data for the first half of 2014 available at Waste Management Information System (according the information on remediation activities, landfill depth, fences, aligning, compacting or covering).

Data from Waste Management Information System used for SWDSs classification were collected using the reports on landfills and waste disposal and vary significantly in quality and quantity than partial information from 2009 that have been used for the classification of landfills in the previous period.

The total annual quantity of municipal and industrial biodegradable solid waste and sludge which is generated and disposed on different types of SWDSs in the period 1990 - 2013 are reported in the Table 7.2-2.

Table 7.2-2: The total annual quantity of municipal and industrial biodegradable solid waste and sludge which is generated and disposed on different types of SWDSs (1990 - 2013)

Year	Generated solid waste (kt)	Fraction of disposed solid waste	Solid waste disposed on managed SWDSs (kt)	Solid waste disposed on unmanaged SWDSs (≥5m) (kt)	Solid waste disposed on unmanaged SWDSs (<5m) (kt)
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	0.98	1,030	461	109
2011	1,645	0.96	1,045	437	102
2012	1,670	0.84	874	411	116
2013	1,723	0.84	989	405	59

7.2.2.2. 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) for the moderately degraded waste, proposed by *2006 IPCC Guidelines*, 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 1990-2013. Proportion of waste (by weight) for each type of SDWS are multiplied by corresponding default MCF proposed by *2006 IPCC Guidelines.*

The total weighted average MCF, that is obtained by summing of weighted average MCF for each type of SWDS, for the period 1990 - 2013, are reported in the Table 7.2-3.

Table 7.2-3: The total weighted average MCF (1990 - 2013)

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	0.906
2012	0.892
2013	0.920

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 *2006 IPCC Guidelines*.

Composition of waste and DOC are presented in the Table 7.2-4.

Table 7.2-4: Composition of waste and DOC

Waste stream	Percent in the solid waste (1955-1997)	Percent in the solid waste (1998-2004)	2005-2013
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 2006 IPCC Guidelines* the recommended default values for DOC_f is 0.5 which means that approximately 50 percent of total DOC actually degrades and converts to landfill gas. According to expert judgement, a mean value between 50 and 60 percent (i.e. 55 percent) was taken into account for DOC_f, in order to CH_4 emissions estimation from SWDSs.

The CH_4 fraction (F) is taken to be 0.5, according to proposed value by *2006 IPCC Guidelines* .

Collection of data on the quantity of landfill gas captured/flared/recovered was done on the basis of request from CAEN 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 2004-2013 have been included in emission estimation and subtracted from generated CH_4. Information on recovered CH_4 in the period 2004 - 2013 is presented in the Table 7.2-5.

Table 7.2-5: Recovered CH_4 (2004 - 2013)

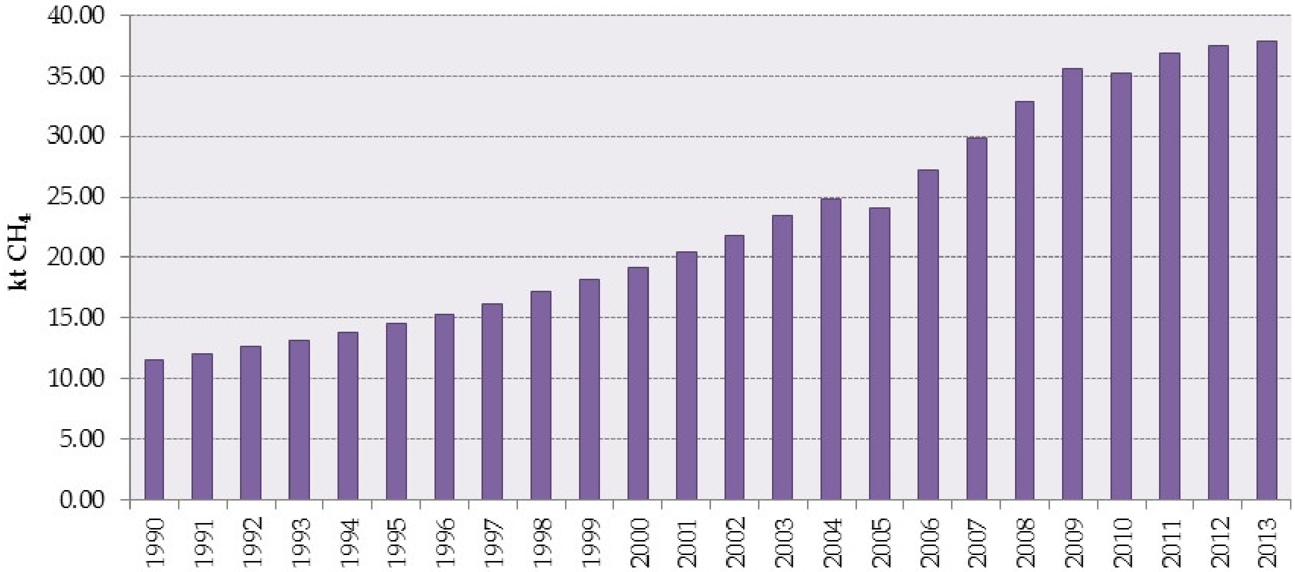
Year	Recovered CH_4 (kt)
2004	0.242
2005	2.723

Year	Recovered CH_4 (kt)
2006	1.615
2007	1.370
2008	1.123
2009	1.234
2010	3.814
2011	4.397
2012	5.179
2013	6.465

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 disposal of solid waste in the period 1990 - 2013 are presented in the Figure 7.2-1.

Figure 7.2-1: Emissions of CH4 from Solid Waste Disposal (1990 - 2013)



7.2.3. Uncertainties and time-series consistency

The uncertainties contained in CH_4 emissions estimates are related primarily to assessment of historical data for quantity of solid waste 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). 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. Also, comparison were made with data on waste composition for 2014 from the report "Analysis and assessment of the situation in the municipal waste management field", which was done in the framework of the project "Creating a uniform methodology for the analysis of the composition of solid waste, determine the average composition of solid waste in the Republic of Croatia and the projection of the amount of solid waste"(CAEN, 2014 – 2015).

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 *2006 IPCC Guidelines* (detailed in Annex 1).

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

7.2.4. Category -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 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.

7.2.5. Category specific recalculations

Recalculations were made according to applied *2006 IPCC Guidelines.*

7.2.6. Category -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 solid waste composition and periodic analysis of waste composition at major landfills. It is enabled through the project of the CAEN: Creating a uniform methodology for the analysis of the composition of solid waste, determine the average composition of solid waste in the Republic of Croatia and the projection of the amount of solid waste. Output of the project includes analysis and evaluation of the current situation, development of a uniform methodology for determining the composition of solid waste and research with the purpose of determining the composition of solid waste.
- modification of Environmental Pollution Register and Landfill Inventory database regarding to solid waste 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 detailed information on organic industrial waste (biodegradable industrial waste and sludge from wastewater treatment) disposed on SWDSs for entire period.

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.

7.3. BIOLOGICAL TREATMENT OF SOLID WASTE (CRF 5.B)

7.3.1. Category description

According to *2006 IPCC Guidelines*, CH_4 and N_2O emissions resulting from composting and anaerobic digestion of organic waste at biogas facilities are included in this category.

CH_4 and N_2O emissions from composting of municipal and industrial solid waste, sludge and other organic waste are included in emissions estimates only for the year 2013. Data for previous years are not available. Data on the total amount of CH_4 recovered are not available for entire period 1990 - 2013.

CH_4 emissions from anaerobic digestion of municipal and industrial solid waste, sludge and other organic waste at biogas facilities are included in emission estimates only for the year 2013. Data for previous years are not available. Data on the total amount of CH_4 recovered are not available for entire period 1990 - 2013.

7.3.2. Methodological issues

7.3.2.1. Composting

C emissions from composting of organic waste have been calculated using the IPCC Tier 1 methodology proposed by *2006 IPCC Guidelines*, by multiplying the total composted waste (tonnes) with default values for CH_4 emission factor (4 kg CH_4/t waste treated). The amount of CH_4 recovered should be included into emission calculation (currently not available).

The resulting emission of CH_4 from Composting in 2013 amounted to about 0.164 kt.

N_2O emissions from composting of organic waste have been calculated using the IPCC Tier 1 methodology proposed by *2006 IPCC Guidelines*, by multiplying the total composted waste (tonnes) with default values for N_2O emission factor (0.3 kg N_2O/t waste treated).

The resulting emission of N_2O from Composting in 2013 amounted to about 0.012 kt.

7.3.2.2. Anaerobic Digestion at Biogas Facilities

C emissions from anaerobic digestion of organic waste at biogas facilities have been calculated using the IPCC Tier 1 methodology proposed by *2006 IPCC Guidelines*, by multiplying the total digested waste (tonnes) with default values for CH_4 emission factor (1 kg CH_4/t waste treated). The amount of CH_4 recovered should be included into emission calculation (currently not available).

The resulting emission of CH_4 from Anaerobic Digestion at Biogas Facilities in 2013 amounted to about 0.019 kt.

7.3.3. Uncertainties and time-series consistency

The uncertainties contained in C_4 and N_2O emissions estimates from composting and anaerobic digestion of organic waste at biogas facilities are related primarily to assess activity data for entire period and applied default emission factors.

Uncertainty estimate associated with activity data for the year 2013 for composting and anaerobic digestion of organic waste at biogas facilities amounts 50 percent, based on expert judgements.

Uncertainty estimate associated with CH_4 emission factor for composting of organic waste amounts 100 percent, according to the provided uncertainty assessment in *2006 IPCC Guidelines* (detailed in Annex 1). Uncertainty estimate associated with N_2O emission factor for composting of organic waste amounts 110 percent, according to the provided uncertainty assessment in *2006 IPCC Guidelines* (detailed in Annex 1).

Uncertainty estimate associated with CH_4 emission factor for anaerobic digestion of organic waste at biogas facilities amounts 400 percent, according to the provided uncertainty assessment in *2006 IPCC Guidelines*(detailed in Annex 1).

7.3.4. Category -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.

7.3.5. Category -specific recalculations

Recalculations were made according to applied *2006 IPCC Guidelines.*

7.3.6. Category -specific planned improvements

Improvements in the sub-sector Biological Treatment of Solid Waste are related primarily to aggregation of accurate data for CH_4 and N_2O emission calculations for entire period 1990 - 2013.

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

7.4. INCINERATION AND OPEN BURNING OF WASTE (CRF 5.C)

7.4.1. Category description

According to *2006 IPCC Guidelines,* CO_2, CH_4 and N_2O emissions resulting from incineration of waste 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 CAEN 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[47] 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 CAEN coordinates activities relating to data quality assurance and control.

Data for the period 2008 - 2013 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 and N_2O emissions from incineration of industrial waste and CO_2 emission from incineration of clinical waste are included in emission estimates for the period 1990 - 2013. There is no open burning of waste - it is prohibited by law.

7.4.2. Methodological issues

CO_2 emissions from incineration of industrial and clinical waste have been calculated using the IPCC Tier 1 methodology proposed by *2006 IPCC Guidelines,* by multiplying the total incinerated waste with default values for fraction of carbon content, fraction of fossil carbon and oxidation factor.

[47] Ordinance on the establishment of the pollutant emission register (OG 35/08)

N_2O emissions from incineration of industrial waste have been calculated using the IPCC Tier 1 methodology proposed by *2006 IPCC Guidelines*, by multiplying the total incinerated waste with default emission factor.

Data on incineration of industrial waste for the period 1990 - 2013 have been provided by CAEN. Default values for fraction of carbon content (0.5), fraction of fossil carbon (0.9) and oxidation factor (1.0), proposed by *2006 IPCC Guidelines*, have been used for emission calculation. There was no incineration of industrial waste without energy recovery in the period 2009 - 2013.

Data for quantity of incinerated clinical waste for the period 1990 - 2013 were obtained by CAEN. Default values for fraction of carbon content (0.6), fraction of fossil carbon (0.4) and oxidation factor (1.0), proposed by *2006 IPCC Guidelines*, have been used for emission calculation for entire period 1990 - 2013.

Data for CO2 and N2O emission calculation from Incineration of Waste (without energy recovery) for the period 1990 - 2013 are presented in the Table 7.4-1.

Table 7.4-1: Incinerated waste (without energy recovery) (1990 - 2013)

Year	Incinerated waste (tonne)	
	Industrial waste	Clinical waste
1990	250.00	140.00
1991	250.00	140.00
1992	250.00	140.00
1993	250.00	140.00
1994	250.00	140.00
1995	250.00	140.00
1996	250.00	140.00
1997	1031.00	140.00
1998	2167.74	140.00
1999	2580.45	140.00
2000	3652.49	141.50
2001	3967.23	155.58
2002	2205.96	158.45
2003	400.00	162.64
2004	120.00	173.20
2005	4.50	175.70
2006	350.00	187.56
2007	285.00	204.89
2008	315.78	165.00
2009	0.00	185.17
2010	0.00	54.40
2011	0.00	57.45

Year	Incinerated waste (tonne)	
	Industrial waste	Clinical waste
2012	0.00	93.10
2013	0.00	48.00

The resulting annual emissions of CO_2 from Incineration of Waste in the period 1990 - 2013 are presented in the Figure 7.4-1. The resulting annual emissions of N_2O from Incineration of Waste in the period 1990 - 2008 are presented in the Figure 7.4-2.

Figure 7.4-1: Emissions of CO_2 from Incineration of Waste (1990 - 2013)

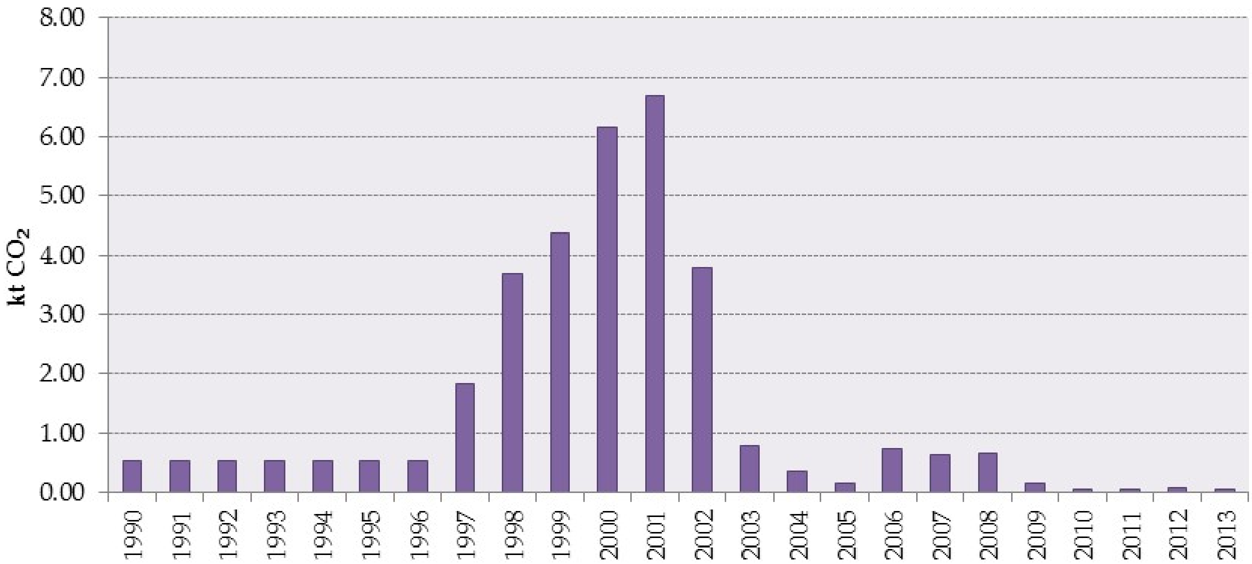
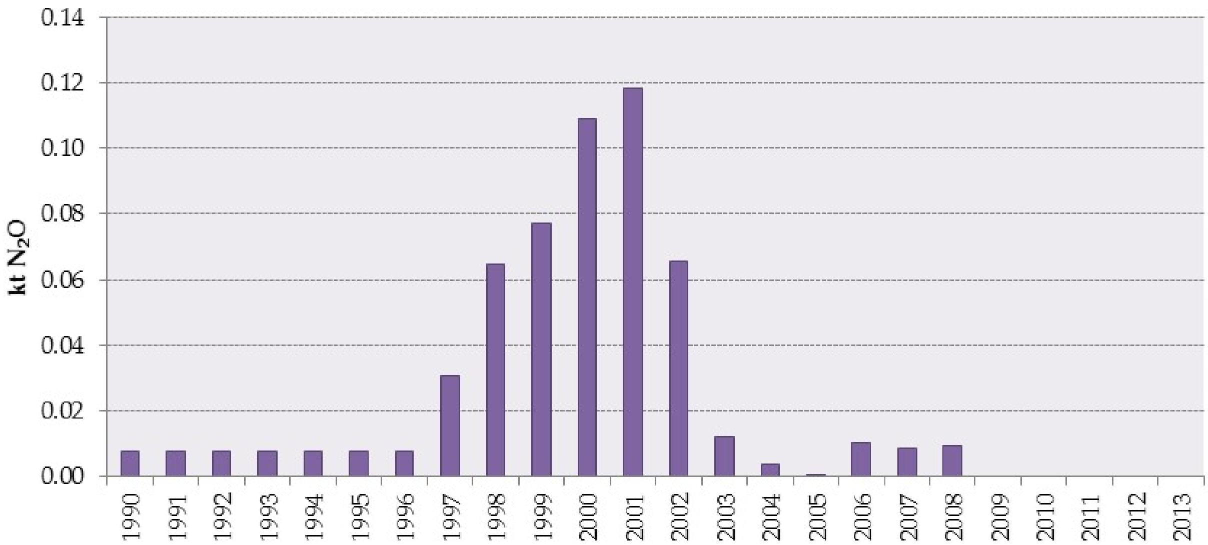


Figure 7.4-2: Emissions of N_2O from Waste Incineration (1990 - 2013)



7.4.3. Uncertainties and time-series consistency

The uncertainties contained in CO_2 and N_2O emissions estimates from incineration of waste are related primarily to assess activity data and applied default emission factors.

Uncertainty estimate associated with activity data for industrial and clinical waste amounts 50 percent, based on expert judgements.

Uncertainty estimate associated with CO_2 emission factor for incineration of industrial and clinical waste amounts 30 percent, according to the provided uncertainty assessment in *2006 IPCC Guidelines* (detailed in Annex 1).

Uncertainty estimate associated with N_2O emission factor for incineration of industrial waste amounts 200 percent, according to the provided uncertainty assessment in *2006 IPCC Guidelines* (detailed in Annex 1).

7.4.4. Category -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.

7.4.5. Category specific recalculations

Recalculations were made according to applied *2006 IPCC Guidelines.*

7.4.6. Category -specific planned improvements

Improvements in the sub-sector Waste Incineration are related primarily to aggregation of accurate data for CO_2 and N_2O emission calculations from incineration of different types of waste as well as detailed information on technology applied for the incineration.

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

7.5. WASTEWATER TREATMENT AND DISCHARGE (CRF 5.D)

7.5.1. Category description

Aerobic biological process is used mostly in wastewater treatment. Disposal of domestic 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 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 CAEN coordinates activities relating to data quality assurance and control.

CH_4 emissions from treatment of industrial and domestic wastewater and N_2O emissions from wastewater treatment effluent are included in emission estimates for the period 1990 - 2013.

7.5.2. Methodological issues

7.5.2.1. Domestic wastewater

Methane emissions from domestic 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 *2006 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 for years between those years have been assessed by interpolation method. Also, insufficient data for 2013 have been assessed accordingly data for 2012. 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 - 2013.

Data for CH_4 emission calculation for the period 1990 - 2013 are presented in the Table 7.5-1.

Table 7.5-1: Data for CH_4 emission calculation from Domestic Wastewater (1990 - 2013)

Year	DOC (kg BOD/1000persons/yr)	Population*	Total organic product (kt 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

Year	DOC (kg BOD/1000persons/yr)	Population*	Total organic product (kt DC/yr)
2011	21,865.31	2,450,000	53.57
2012	21,878.26	2,300,000	50.32
2013	21,669.57	2,300,000	49.84

* 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 litres/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 - 2013.

There is no sufficient information on fraction of wastewater type treated by a particular type of system.

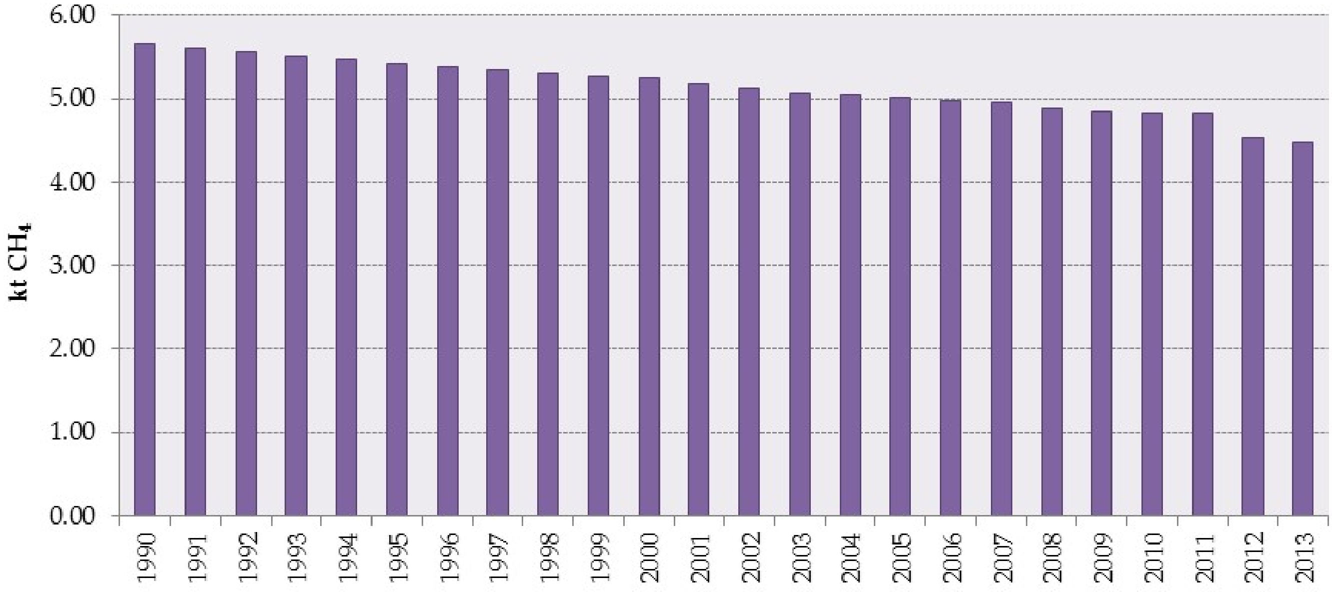
No country-specific data are available for methane conversion factor. Default value for anaerobic systems (MCF=1), proposed by *2006 IPCC Guidelines*, has been used for emission calculation for entire period 1990 - 2013.

Default value for maximum methane producing capacity (Bo) of 0.6 kg CH_4/kg BOD, proposed by *2006 IPCC Guidelines* , has been used for emission calculation for entire period 1990 - 2013.

No data are available for amount of methane recovered or flared. Default value of zero, proposed by *2006 IPCC Guidelines,* has been used for emission calculation for entire period 1990 - 2013.

The resulting annual emissions of CH_4 from Domestic Wastewater in the period 1990 - 2013 are presented in the Figure 7.5-1.

Figure 7.5-1: Emissions of CH_4 from Domestic Wastewater (1990 - 2013)



7.5.2.2. Industrial wastewater

Methane emissions from industrial wastewater have been calculated using the IPCC Tier 1 methodology proposed by *2006 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 - 2013 are presented in the Table 7.5-2.

Table 7.5-2: Data on industrial output (1990 - 2013)

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

Year	Total industrial output (tonne)		
	Manufacture of food products and beverages	Manufacture of pulp, paper and paper products	Manufacture of chemicals and chemical products
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
2013	4,923,120	464,916	1,883,015

* insufficient data on industrial output (tonne/yr) were assessed by extrapolation or 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 1990-1993 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 - 2013 are presented in the Table 7.5-3.

Table 7.5-3: Data on wastewater output (1990 - 2013)

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
2013	2,692,000	1,744,000	483,000

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 *2006 IPCC Guidelines* (Table 5.4), has been used for emission calculation for entire period 1990 - 2013 (Table 7.5-4).

Table 7.5-4: Data on degradable organic component and wastewater produced (1990 - 2013)

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 - 2013.

Organic wastewater from industrial sources (kg COD/yr) for the period 1990 - 2013 are presented in the Table 7.5-5.

Table 7.5-5: Organic wastewater from industrial sources (1990 - 2013)

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

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	
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
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
2013	356,403,798	677,847,528	378,486,015	1,412,737,341

No country-specific data are available for fraction of wastewater treated. Default value (0.57), proposed by *2006 IPCC Guidelines* (Table 6-9), has been used for emission calculation for entire period 1990 -2013.

There is no sufficient information on fraction of wastewater type treated by a particular type of system.

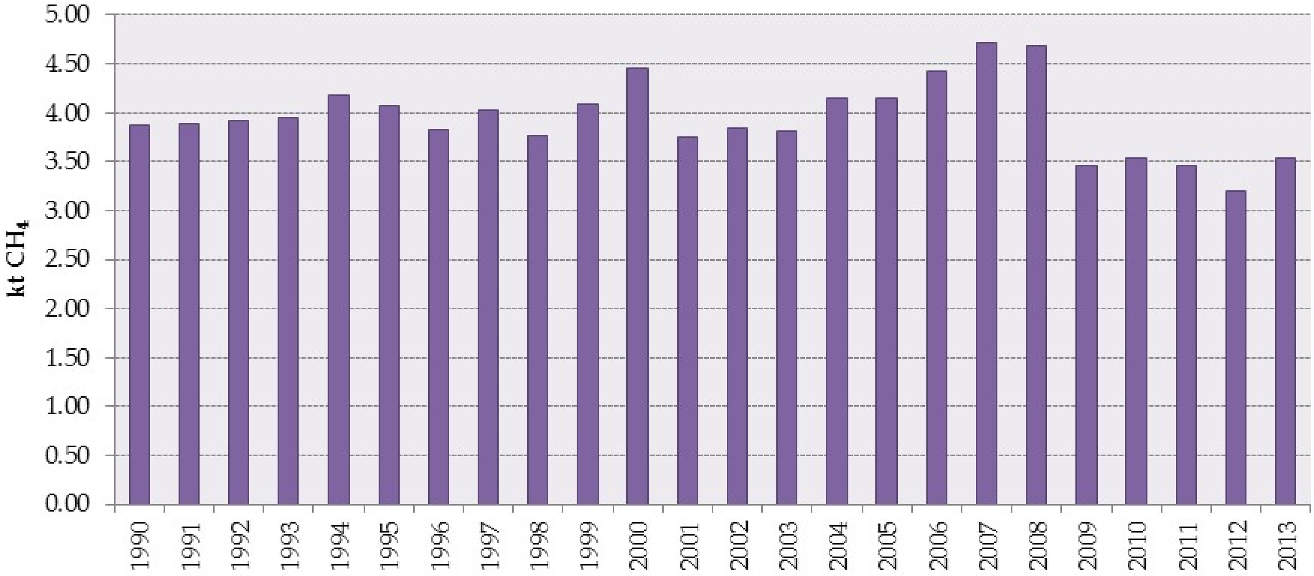
No country-specific data are available for methane conversion factor (MCF). Due to the fact that wastewaters are mostly handled aerobically, MCF is assessed to be 0.01 according to expert judgement (comparison with the other countries). This value has been used for emission calculation for entire period 1990 - 2013.

Default value for maximum methane producing capacity (Bo) of 0.25 kg CH_4/kg COD, proposed by *2006 IPCC Guidelines* , has been used for emission calculation for entire period 1990 - 2013.

No data are available for amount of methane recovered or flared. Default value of zero, proposed by *2006 IPCC Guidelines,* has been used for emission calculation for entire period 1990 - 2013.

The resulting annual emissions of CH_4 from Industrial Wastewater in the period 1990 - 2013 are presented in the Figure 7.5-2.

Figure 7.5-2: Emissions of CH_4 from Industrial Wastewater (1990 - 2013)



7.5.2.3. Nitrous oxide emissions from wastewater

Indirect nitrous oxide (N_2O) emissions from wastewater treatment effluent have been calculated using the IPCC Tier 1 methodology proposed by *2006 IPCC Guidelines.*

The population estimate of the Republic of Croatia for the period 1990 - 2013 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 2010-2013. Data on Population and PIV for the period 1990 - 2013 are presented in the Table 7.5-6.

Table 7.5-6: Data on population and PIV (1990 - 2013)

Year	Population	Protein intake (kg/person/yr)
1990	4,778,000	21.39
1991	4,513,000	21.43
1992	4,470,000	21.72
1993	4,641,000	20.99
1994	4,649,000	21.79
1995	4,669,000	23.54
1996	4,494,000	23.32
1997	4,572,500	23.10
1998	4,501,000	22.85

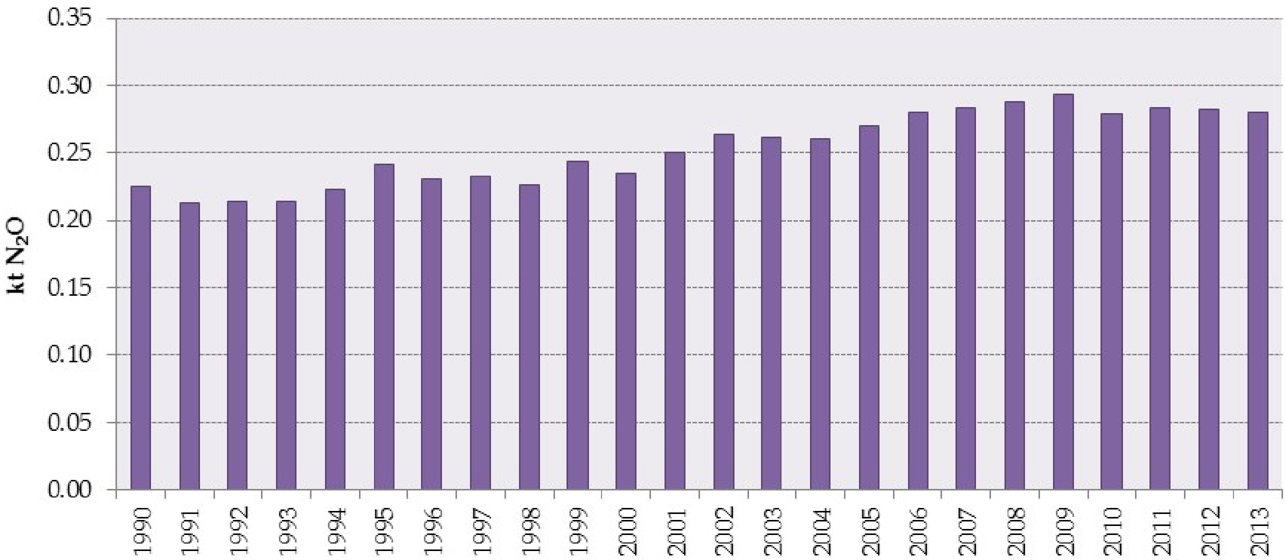
1999	4,554,000	24.31
2000	4,381,000	24.35
2001	4,305,494	26.39
2002	4,305,384	27.81
2003	4,305,725	27.63
2004	4,310,861	27.45
2005	4,312,487	28.51
2006	4,313,530	29.53
2007	4,311,967	29.93
2008	4,309,796	30.40
2009	4,302,847	31.03
2010	4,289,857	29.53
2011	4,280,622	30.08
2012	4,267,558	30.02
2013	4,255,689	29.96

Fraction of nitrogen in protein ($FRAC_{NPR}$) which equals 0.16 kg N/kg protein, proposed by *2006 IPCC Guidelines,* has been used for emission calculation for entire period 1990 - 2013.

Default emission factor (EF) which equals 0.01 kg N_2O-N/kg sewage-N produced, proposed by *2006 IPCC Guidelines,* has been used for emission calculation for entire period 1990 - 2013.

The resulting annual N_2O Emissions from Wastewater in the period 1990 - 2013 are presented in the Figure 7.5-3.

Figure 7.5-3: N_2O Emissions from Wastewater (1990 - 2013)



7.5.3. Uncertainties and time-series consistency

The uncertainties contained in CH_4 Emissions from Domestic 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 from Wastewater are related primarily to applied default emission factor and extrapolated values for protein intake.

Activity data and emission factor uncertainty for CH_4 Emissions from Domestic and Industrial Wastewater was calculated in detail using Monte-Carlo analysis.

Uncertainty estimate associated with activity data for CH_4 Emissions from Domestic and Industrial Wastewater amounts 30 percent, based on expert judgements. Uncertainty estimate associated with CH_4 emission factor amounts 30 percent, accordingly to provided uncertainty assessment in *2006 IPCC Guidelines.*

Uncertainty estimate associated with activity data for N_2O Emissions from Wastewater amounts 50 percent, based on expert judgements. Uncertainty estimate associated with N_2O emission factor amounts 50 percent, accordingly to provided uncertainty assessment in *2006 IPCC Guidelines* (detailed in Annex 1).

CH_4 Emissions from Domestic and Industrial Wastewater and N_2O Emissions from Wastewater have been calculated using the same method for every year in the time series. Different source of information were used for data sets.

7.5.4. Category -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 treatment and discharge represent key source category in Waste sector. CH_4 emissions from Wastewater treatment and discharge estimated using Tier 1 method. The uncertainty is high due to assessment of insufficient data and applied default emission factors. Investigation will be performed with a view to collect more accurate data.

7.5.5. Category -specific recalculations

Recalculations were made according to applied 2006 IPCC Guidelines.

7.5.6. Category -specific planned improvements

Improvements in the sub-sectors Domestic 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 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 wastewater;
  - maximum methane producing capacity for industrial and domestic 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 wastewater are there - improve quantity and quality of data on sludge produced and data on management of sludge 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.

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

CHAPTER 8: OTHER (CRF SECTOR 6)

UNFCCC Reporting Guidelines (Decision 24/CP.19) paragraph 29 indicates that Annex I Parties should report and explicitly describe the details of emissions from each country-specific source of gases which are not part of the IPCC Guidelines.

Among CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3, no emissions and removals are reported in Other sector.

CHAPTER 9: INDIRECT CO_2 AND NITROUS OXIDE EMISSIONS

9.1. DESCRIPTION OF SOURCES OF INDIRECT EMISSIONS IN GHG INVENTORY

Although Parties may now choose to report indirect CO_2, in accordance with paragraph 29 of the UNFCCC Inventory Reporting Guidelines, Croatia does not choose to report indirect CO_2 emissions from the atmospheric oxidation of CH_4, CO and NMVOCs, or indirect N_2O emissions arising from sources other than those in the agriculture and LULUCF sectors.

Information on the following precursor gases: carbon monoxide (CO), nitrogen oxides (NO_X) and non-methane volatile organic compounds (NMVOCs), as well as sulphur oxides (SO_2) are given in the Chapter 9.2.

9.2. METHODOLOGICAL ISSUES

The photochemicaly active gases, carbon monoxide (CO), oxides of nitrogen (NOX) and non-methane volatile organic compounds (NMVOCs) indirectly contribute to the greenhouse gas effect. These are generally called indirect greenhouse gases or ozone precursors, because they are involved in creation and degradation of ozone which is also one of the greenhouse gases. Sulphur dioxide (SO2), as a precursor of sulphate and aerosols, is believed to contribute negatively to the greenhouse effect. Emissions of indirect GHGs have been taken from the draft of emission inventory report 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2013 Submission to the Convention on Long-range Transboundary Air Pollution'.The calculations of aggregated results for the emissions of indirect gases in the period 1990-2013 are given in table 9.2-1.

Table 9.2-1: Emissions of ozone precursors and SO_2 by sectors (kt)

GHG	Emissions (kt)								
	1990	1995	2000	2005	2009	2010	2011	2012	2013
NO_x Emission	**102.27**	**71.27**	**83.20**	**88.02**	**79.02**	**67.47**	**62.19**	**58.91**	**57.89**
Energy	99.23	68.26	77.31	85.33	77.28	65.42	60.17	56.50	55.75
Industrial Processes	3.00	2.80	3.00	2.60	1.60	2.00	1.40	1.30	1.20
Agriculture	NO	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	0.04	0.21	2.89	0.09	0.14	0.05	0.62	1.11	0.94
Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO Emission	**462.33**	**317.90**	**435.44**	**277.80**	**213.22**	**195.30**	**203.67**	**214.83**	**193.20**
Energy	420.59	283.02	314.14	256.98	207.73	192.77	185.15	178.21	159.59
Industrial Processes	40.60	27.90	30.90	18.20	0.80	0.90	0.80	0.60	0.70
Agriculture	NO	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	1.14	6.98	90.40	2.62	4.69	1.63	17.72	36.02	32.91
Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOC Emission	**131.95**	**75.29**	**80.89**	**73.73**	**61.37**	**59.8**	**58.26**	**55.26**	**53.27**
Energy	55.15	38.99	44.80	35.81	30.02	29.13	28.17	26.16	24.53
Industrial Processes	65.35	27.78	23.91	28.89	21.89	21.69	20.95	19.12	18.30
Agriculture	9.69	7.21	6.75	6.91	6.54	6.40	6.05	6.18	5.77
LULUCF	0.84	0.16	3.94	0.11	0.15	0.10	0.65	1.64	2.47
Waste	0.92	1.15	1.49	2.01	2.77	2.48	2.44	2.16	2.20
SO_2 Emission	**170.04**	**77.33**	**58.78**	**61.14**	**58.84**	**37.70**	**30.57**	**26.62**	**18.25**
Energy	168.36	76.27	57.82	60.40	58.49	37.43	30.26	26.41	18.24
Industrial Processes	1.68	1.06	0.96	0.74	0.35	0.27	0.31	0.21	0.01
Agriculture	NA	NA	NA	NA	NA	NA	NA	NA	NA
LULUCF	NA	NA	NA	NA	NA	NA	NA	NA	NA
Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

9.3. UNCERTAINTIES AND TIME-SERIES CONSISTENCY

For detailed information refer to 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2013 Submission to the Convention on Long-range Transboundary Air Pollution'.

9.4. CATEGORY-SPECIFIC QA/QC AND VERIFICATION

For detailed information refer to 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2013 Submission to the Convention on Long-range Transboundary Air Pollution'.

9.5. CATEGORY-SPECIFIC RECALCULATIONS

For detailed information refer to 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2013 Submission to the Convention on Long-range Transboundary Air Pollution'.

9.6. CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

For detailed information refer to 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2013 Submission to the Convention on Long-range Transboundary Air Pollution'.

CHAPTER 10: RECALCULATIONS AND IMPROVEMENTS

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

The key differences between the previous and latest submission of CRF tables for the time series 1990-2012 are described in each chapter of Inventory. Difference between emissions NIR 2014 and NIR 2015 for 1990 are shown in the Table 10.1-1 while for 2012 are shown in Table 10.1-2.

Table 10.1-1: Difference between emissions estimated in NIR 2015 and NIR 2014 for 1990

Difference between NIR 2015 and NIR 2014 submission for 1990	CO_2 [(1)]	CH_4	N_2O	HFCs, PFCs, SF6, NF3	Total
	CO_2 equivalent (kt)				
Total (net emissions)[(1)]	2,379.22	3,256.05	-1,155.06	303.17	4,783.38
1. Energy	-15.04	2,107.16	13.40		2,105.52
A. Fuel combustion (sectoral approach)	-346.34	37.56	13.52		-295.27
B. Fugitive emissions from fuels	331.30	2,069.60	-0.12		2,400.79
2. Industrial processes and product use	781.52	-4.74	3.17	303.17	1,083.11
A. Mineral industry	-24.53	NO	NO		-24.53
B. Chemical industry	305.86	-8.64	-30.21		267.01
C. Metal industry	86.91	NO	NO		394.48
D. Non-energy products from fuels and solvent use	331.02	NO	NO		296.30
3. Agriculture	50.02	1,153.37	-1,119.60		83.79
A. Enteric fermentation	0.00	1,058.00	0.00		1,058.00
B. Manure management	0.00	95.37	-126.91		-31.54
C. Rice cultivation	0.00	NO	0.00		NO
D. Agricultural soils	0.00	NO	-992.69		-992.69
E. Prescribed burning of savannas	0.00	NO	NO		NO
F. Field burning of agricultural residues	0.00	NO	NO		NO
G. Liming	NO	NO	NO		NO
H. Urea application	50.02	0	0		50.02
4. Land use, land-use change and forestry[(1)]	1,644.48	-0.29	0.26		1,644.45
A. Forest land	1,944.74	-0.30	0.41		1,944.85
B. Cropland	-17.32	NO	-0.19		-17.51
C. Grassland	16.68	0.01	0.03		16.73
D. Wetlands	0.00	NO	NO		0.00
E. Settlements	0.00	NO	NO		0.00
G. Harvested wood products	NO	NO	NO		NO
5. Waste	0.49	0.55	-17.56		-16.51
Total CO_2 equivalent emissions without land use, land-use change and forestry					**3,138.93**
Total CO_2 equivalent emissions with land use, land-use change and forestry					**4,783.38**

Table 10.1-2: Difference between emissions estimated in NIR 2015 and NIR 2014 for 2012

Difference between NIR 2015 and NIR 2014 submission for 2012	CO_2(1)	CH_4	N_2O	HFCs, PFCs, SF6, NF3	Total
	CO_2 equivalent (kt)				
Total (net emissions)(1)	1,293.29	257.03	-1,065.74	-0.39	563.54
1. Energy	-349.14	101.90	9.75		-237.49
A. Fuel combustion (sectoral approach)	-512.71	23.29	9.86		-479.56
B. Fugitive emissions from fuels	163.57	78.61	-0.11		242.07
2. Industrial processes and product use	146.52	-0.29	16.23	-0.39	241.41
A. Mineral industry	18.44	NO	NO		18.44
B. Chemical industry	-24.38	-0.29	-26.10		-50.77
C. Metal industry	1.44	NO	NO		1.44
D. Non-energy products from fuels and solvent use	46.77	NO	NO		-4.54
3. Agriculture	96.45	55.57	-1,034.11		-882.09
A. Enteric fermentation		70.63			70.63
B. Manure management		-15.06	-149.83		-164.89
C. Rice cultivation		NO			NO
D. Agricultural soils		NO	-884.28		-884.28
E. Prescribed burning of savannas		NO	NO		NO
F. Field burning of agricultural residues		NO	NO		NO
G. Liming	9.60				NO
H. Urea application	86.85				86.85
4. Land use, land-use change and forestry(1)	1,503.71	-9.36	13.72		1,508.07
A. Forest land	1,808.47	-9.71	13.32		1,812.09
B. Cropland	-6.75	NO	-0.39		-7.14
C. Grassland	-2.19	0.34	0.78		-1.06
D. Wetlands	0.00	NO	NO		0.00
E. Settlements	11.81	NO	NO		11.81
G. Harvested wood products	-307.63				-307.63
5. Waste	0.00	109.22	-20.02		89.20
Total CO_2 equivalent emissions without land use, land-use change and forestry					**-944.53**
Total CO_2 equivalent emissions with land use, land-use change and forestry					**563.54**

10.2. IMPLICATIONS FOR EMISSION LEVELS

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 2014)

In 2015 Inventory for emission calculation new 2006 IPCC Guidelines was used instead of old ones. Recalculations are mainly made because of new emission factors and new methods which are given in 2006 IPCC Guidelines. Detailed information on reasons for recalculations of the base year and of year 2013 referred to in Article 7(1)(e) of Regulation (EU) No 525/2013 are given in table 10.2-1..

10.3. IMPLICATIONS FOR EMISSION TRENDS, INCLUDING TIME-SERIES CONSISTENCY

In 2015 Inventory for emission calculation new 2006 IPCC Guidelines was used instead of old ones. Recalculations are mainly made because of new emission factors and new methods which are given in 2006 IPCC Guidelines.

10.4. PLANNED IMPROVEMENTS, INCLUDING IN RESPONSE TO THE REVIEW PROCESS

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 plan, Improvements 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 plan and Annual data collection plan. 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.

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 Table 10.4-2 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.

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 Table 10.4-1 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.

Table 10.4-1: Recommendations from the last ARR with the status of implementation

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter NIR
Cross-cutting, Completeness	CO_2 emissions from incineration of plastic waste in the period 1990–2006	Table 3	Implemented. New data for incineration of industrial waste are included in CO_2 emission calculation for entire period.	7.4.2
	N_2O emissions from hazardous waste incineration in the period 1990–2010	Table 3	Implemented. New data for incineration of industrial waste are included in CO_2 emission calculation for entire period.	7.4.2
Cross-cutting, Key category analysis	Include more explanation in the NIR of how the key category analysis is used to prioritize the development and improvement of the inventory	Table 4	Recommendation is implemented in Improvement plan as short term issue	
Energy, Sector overview	Improve the transparency of reporting under feedstock and non-energy use of fuel with regards to natural gas used as fuel in ammonia production	21	Transparency improved. All non energy natural gas consumption is relocated to Industrial processes	3.2.3.
Energy, Sector overview	Take steps to ensure consistency of AD in the areas of fuel use in manufacturing industries and construction and in the type of AD used for the estimation of CO_2 emissions from gas transmission estimation of CO_2 emissions from gas transmission	22	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, for the period from 2001 to 2013	3.2.5
Energy, Comparison of the reference approach with the sectoral approach and international statistic	Provide a more detailed and transparent explanation for the observed CO_2 emission differences between the reference approach and the sectoral approach	24	Implemented	3.2.1.
Energy, Comparison of the reference approach with the sectoral approach and international statistic	Take steps to resolve the issue regarding the allocation of natural gas used as fuel as non-energy in the energy balance to improve the accuracy of the reporting	24	Implemented	3.2.4.
Energy, International bunker fuels	Compare the aviation bunker fuels of IEA and CRF tables and explain any discrepancies observed	26	Implemented	3.2.2.

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter NIR
Energy, International bunker fuels	Provide a detailed explanation of the factors contributing to decreases in bunker fuel consumption and associated CO2 emissions	26	Implemented	3.2.2.
Energy, Feedstocks and non-energy use of fuels	Carry through with the measures to collect data of the natural gas actually used as a fuel for the period 1990–2013 and report the data in its next annual submission	27	Not implemented. According to 2006 IPCC guidelines data from non energy fuel consumption are reported under IP sector. In energy sector only data from energy balance was used	3.2.3.
Energy, Stationary combustion: solid, liquid and gaseous – CO2, CH4 and N2O	Take steps to obtain and use plant-specific CO2 EFs to improve accuracy of the emission estimates	28	Recommendation is implemented in Improvement plan as long term issue	3.2.4.6.
Energy, Civil aviation liquid fuels – CO2	Improve the accuracy and transparency of reporting in the NIR by adopting an approach in accordance with the IPCC good practice guidance such as using aviation fuel use surveys, sales statistics and origin-destination statistics to obtain the actual jet kerosene consumption figures for domestic and international aviation	31	Implemented	3.2.6.1.
Energy, Road transportation: liquid and gaseous fuels – CO2	Improve the transparency of its reporting in road transportation by providing sufficient explanations in the NIR about the methodology used in estimating emissions from gaseous fuels	32	Implemented	3.2.6.1. and Annex 3, A3-12:1A3 b
Energy, Coal mining and handling: solid fuels –CH4	Use the actual coal production figures for estimating emissions	33	In the implementation process. Data on actual coal production are collected and will be implemented in next submission	
Energy, Oil and natural gas: gaseous fuels – CH4 and CO2	Take steps to use the gas pipeline length as the AD for CO2 emissions calculation	34	According to 2006 Guidelines new methodology was used to determine CO2 emissions	3.3.2.
Energy, Other (mobile): liquid fuels – CO2, CH4 and N2O	Indicate in the NIR the category under which military fuel use has been included	35	Not implemented. Recommendation will be implemented in next Inventory submission	
IPPU, Ammonia production - CO2	Review the emission estimation methodology.	39	Implemented, Tier 3 methodology is used for CO2 emission estimation.	4.6.2

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter NIR
IPPU, Ferroalloys production - CO2	Increase the transparency and accuracy of CO2 emission estimates.	40	Tier 1 methodology is used, because only data on ferroalloys production is enough accurate.	4.16.2
IPPU, Consumption of halocarbons and SF6	Conduction of survey on the status of disposal of refrigeration and air-conditioning equipment.	41	Not implemented yet. Recommendation will be implemented in medium-term.	4.24.1
IPPU, Lime production - CO2	Recalculation of approximate data on lime production from one factory in 2012.	44	Implemented	4.3.2
IPPU, Other production (glass) - CO2	Report the emission from glass production in a separate section.	45	Implemented	4.4
Agriculture, Sector overview	Provide detailed explanations in the NIR on the data sources and recalculations	47	According to 2006 Guidelines new methodology was used to calculate emissions - all emissions were recalculated as a a consequence. Recommendation on AD explanation is implemented in Improvement plan as long term issue.	-
Agriculture, Sector overview	Continue its effort to develop country-specific EFs to estimate CH4 emissions from enteric fermentation and CH4 and N2O emissions from manure management	48	Implemented. Additional improvements in Improvement plan as long term issue.	5.2.2, 5.3.2.,5.4.2
Agriculture, Sector overview	Improve the agricultural information provided in the inventory and explain the national conditions more thoroughly in the NIR	49	Partially implemented. Additional improvements are a part of Improvement plan as long term issue.	-
Agriculture, Enteric fermentation – CH4	Improve the transparency of recalculations and provide the references for AD for milk production	50	Recommendation is implemented in Improvement plan as long term issue	5.2.6
Manure management – CH4 and N2O	Implement the results of the research project	52	EF Implemented. Additional improvements in Improvement plan as long term issue.	5.3
Other (agricultural soils) – N2O	Correct the error in the nitrogen content of sludge and improve the QA/QC activity for the data received from CEA	59	Implemented	-
LULUCF, sector overview	Adequately explain recalculations to improve transparency in the sector	61	Not implemented. Recommendation will be implemented in next Inventory submission	
	Improve the transparency of the NIR and CRF tables by reporting DOM separately in forest land converted to	64	Recommendation is recognized as a long term goal in Improvement plan	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter NIR
	settlements and by separating litter from the soils pool			
Forest land remaining forest land – CO_2	Make significant efforts to use the results of CRONFI to improve the LULUCF sector inventory	66	Not implemented. Recommendation will be implemented in next Inventory submission	
Land converted to forest land – CO2	Make significant efforts to use the results of CRONFI to improve DOM estimates for the category land converted to forest	67	Not implemented. Recommendation will be implemented in next Inventory submission	
	Report the correct notation key in the CRF tables	68	Implemented	
Cropland remaining cropland – CO2	Implement the tier 2 approach to perennial cropland remaining perennial cropland	69	Recommendation is recognized as a long term goal in Improvement plan	
Land converted to cropland – CO2	Improve the cropland biomass estimates to enable it to implement a tier 2 method for estimating cropland biomass in this category	70	Recommendation is recognized as a long term goal in Improvement plan	
	Work towards using a higher tier method for reporting estimates for DOM in this category	71	Recommendation is recognized as a long term goal in Improvement plan	
Land converted to grassland – CO2	Improve cropland biomass estimates to enable the implementation of a tier 2 method for estimating cropland biomass in this category	72	Recommendation is recognized as a long term goal in Improvement plan	
Settlements – CO2	Improve cropland biomass estimates to enable the implementation of a tier 2 method for estimating cropland biomass in this category	73	Recommendation is recognized as a long term goal in Improvement plan	

Table 10.4-2: Indication on timeline of implementation

Cross-cutting planned improvements

Category	Recommendation	NIR 2015	NIR 2016	Long-term
Cross-cutting, Completeness	CO2 emissions from incineration of plastic waste in the period 1990–2006	•		
	N2O emissions from hazardous waste incineration in the period 1990–2010	•		
	Include more explanation in the NIR of how the key category analysis is used to prioritize the development and improvement of the inventory		•	

Sector-specific planned improvements

Energy

Category	Recommendation	NIR 2015	NIR 2016	Long-term
Sector overview	Improve the transparency of reporting under feedstock and non-energy use of fuel with regards to natural gas used as fuel in ammonia production	•		
Sector overview	Take steps to ensure consistency of AD in the areas of fuel use in manufacturing industries and construction and in the type of AD used for the estimation of CO2 emissions from gas transmission estimation of CO2 emissions from gas transmission			•
Comparison of the reference approach with the sectoral approach and international statistic	Take steps to resolve the issue regarding the allocation of natural gas used as fuel as non-energy in the energy balance to improve the accuracy of the reporting	•		
International bunker fuels	Compare the aviation bunker fuels of IEA and CRF tables and explain any discrepancies observed	•		

Category	**Recommendation**	**NIR 2015**	**NIR 2016**	**Long-term**
International bunker fuels	Provide a detailed explanation of the factors contributing to decreases in bunker fuel consumption and associated CO2 emissions	●		
Feedstocks and non-energy use of fuels	Carry through with the measures to collect data of the natural gas actually used as a fuel for the period 1990–2013 and report the data in its next annual submission	●		
Stationary combustion: solid, liquid and gaseous – CO2, CH4 and N2O	Take steps to obtain and use plant-specific CO2 EFs to improve accuracy of the emission estimates			●
Civil aviation liquid fuels – CO2	Improve the accuracy and transparency of reporting in the NIR by adopting an approach in accordance with the IPCC good practice guidance such as using aviation fuel use surveys, sales statistics and origin-destination statistics to obtain the actual jet kerosene consumption figures for domestic and international aviation	●	●	
Road transportation: liquid and gaseous fuels – CO2	Improve the transparency of its reporting in road transportation by providing sufficient explanations in the NIR about the methodology used in estimating emissions from gaseous fuels	●		
Coal mining and handling: solid fuels –CH4	Use the actual coal production figures for estimating emissions		●	
Oil and natural gas: gaseous fuels – CH4 and CO2	Take steps to use the gas pipeline length as the AD for CO2 emissions calculation			●

Category	Recommendation	NIR 2015	NIR 2016	Long-term
Other (mobile): liquid fuels – CO_2, CH_4 and N_2O	Indicate in the NIR the category under which military fuel use has been included		•	

Industrial Processes and Product Use

Category	Recommendation	NIR 2015	NIR 2016	Long-term
Ammonia production - CO_2	Review the emission estimation methodology..	•		
Ferroalloys production - CO_2	Increase the transparency and accuracy of CO_2 emission estimates.	•		
Consumption of halocarbons and SF_6	Conduction of survey on the status of disposal of refrigeration and air-conditioning equipment.			•
Lime production - CO_2	Recalculation of approximate data on lime production from one factory in 2012.	•		
Other production (glass) - CO_2	Report the emission from glass production in a separate section.	•		

Agriculture

Category	Recommendation	NIR 2015	NIR 2016	Long-term
Sector overview	Provide detailed explanations in the NIR on the data sources and recalculations	•		

Sector overview	Continue its effort to develop country-specific EFs to estimate CH4 emissions from enteric fermentation and CH4 and N2O emissions from manure management	•		
Sector overview	Improve the agricultural information provided in the inventory and explain the national conditions more thoroughly in the NIR	•		•
Enteric fermentation – CH4	Improve the transparency of recalculations and provide the references for AD for milk production			•
Manure management – CH4 and N2O	Implement the results of the research project	•		
Other (agricultural soils) – N2O	Correct the error in the nitrogen content of sludge and improve the QA/QC activity for the data received from CAEN	•		

LULUCF

Category	**Recommendation**	**NIR 2015**	**NIR 2016**	**Long-term**
Sector overview	Adequately explain recalculations to improve transparency in the sector		•	
Sector overview	Improve the transparency of the NIR and CRF tables by reporting DOM separately in forest land converted to settlements and by separating litter from the soils pool			•
Forest land remaining forest land – CO2	Make significant efforts to use the results of CRONFI to improve the LULUCF sector inventory		•	

Category	Recommendation	NIR 2015	NIR 2016	Long-term
Land converted to forest land – CO2	Make significant efforts to use the results of CRONFI to improve the LULUCF sector inventory		•	
Land converted to forest land – CO2	Report the correct notation key in the CRF tables	•		
Cropland remaining cropland – CO2	Implement the tier 2 approach to perennial cropland remaining perennial cropland			•
Land converted to cropland – CO2	Improve the cropland biomass estimates to enable it to implement a tier 2 method for estimating cropland biomass in this category			•
Land converted to cropland – CO2	Work towards using a higher tier method for reporting estimates for DOM in this category			•
Land converted to grassland – CO2	Improve cropland biomass estimates to enable the implementation of a tier 2 method for estimating cropland biomass in this category			•
Settlements – CO2	Improve cropland biomass estimates to enable the implementation of a tier 2 method for estimating cropland biomass in this category			•