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SUBMISSION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE AND KYOTO PROTOCOL

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NATIONAL INVENTORY REPORT 2018

SUBMISSION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON

CLIMATE CHANGE AND

KYOTO PROTOCOL

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NATIONAL INVENTORY REPORT 2018

Croatian greenhouse gas inventory for the period 1990-2016

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Executive summary

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 for the first commitment period 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. 5/17) 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, 61/17).

In this NIR, the inventory of the emissions and removals of the greenhouse gases (GHG) is reported for the period from 1990 to 2016. 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 twelve reviews so far, in-country review in 2004, 2007, 2008 and 2012 and centralized reviews in 2005, 2006, 2009, 2010, 2011, 2013, 2014 and 2016. 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 (NO_x), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2). The greenhouse gases covered by Montreal Protocol on the pollutants related to ozone depletion (freons) are reported in the framework of this protocol and therefore are excluded from this Report.

Greenhouse gas emission sources and sinks are divided into 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 Environment and Energy (MEE), 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. Committee for inter-sectorial coordination for national system for monitoring of GHG emission (National System Committee) is included in the approval process; its members provide their opinion on certain parts of the Inventory within the frame of their speciality. Members of the National System Committee are nominated by the authorized Ministries and others relevant Institutions upon the request of the MEE.

MEE 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;
- collection of activity data;
- 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;
- quantitative estimate of the calculation uncertainty 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 inventory submission until 2018.

ES.1.2.2. Background information on supplementary information required under article 7, paragraph 1, of the Kyoto Protocol

LULUCF

MEE, 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, MEE 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 MEE 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.1.2.3. Information on Kyoto Protocol units

Asigned Amount Units (AAUs)

Pursuant to Article 3(7bis), (8) and (8bis) of the Kyoto Protocol and Paragraph 2 of Annex I to document FCCC/SBSTA//2015/L.13, the assigned amount for the second commitment period is equal to the percentage inscribed in the third column of Annex B of the Annex to the Doha amendment of the aggregate anthropogenic carbon dioxide equivalent emissions of greenhouse gases in the base year multiplied by eight, taking into account Article 3(7bis) of the Kyoto Protocol and paragraph 2 of the Annex to document FCCC/SBSTA/2015/L.13.

The amount of the Assigned amount units (AAUs) for Croatia for the period from 2013 till 2020 is 162,271,086 t CO_2-eq.

Commitment period reserve

Parties are required by decision 11/CMP.1 under the Kyoto Protocol and Paragraph 18 of Decision 1/CMP.8 to establish and maintain a commitment period reserve as part of their responsibility to manage and account for their assigned amount. The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8. Table ES1.2-1 provides a calculation using both methods to calculate the commitment period reserve. The last column presents the commitment period reserve applicable for the second commitment period for the Croatia.

Table ES1.2-1: Commitment period reserve

	t CO_2-eq
Assigned amount for second commitment period	162,271,086
90 % of assigned amount	146,043,977
Emission from last submitted inventory	24,304,160
100% of most recently reviewed* inventory multiplied by 8	194,443,328
Commitment period reserve	146,043,977

Information from national registry

Changes to the national registry of HR in 2017 are presented in ES1.2-2.

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

Reporting Item	Description
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	The Standard Electronic Format report for 2017 has been submitted to the UNFCCC Secretariat electronically.
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	No discrepant transactions occurred in 2017.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2017.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2017.
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2017.
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.haop.hr/hr/tematska-podrucja/zrak-klima-tlo/klimatske-promjene in Croatian language and at https://ets-registry.webgate.ec.europa.eu/euregistry/HR/index.xhtml in English and Croatian language.
15/CMP.1 annex I.E paragraph 18 CPR Calculation	The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8 (Table ES1.2-2).

There has not been any issuance, acquisition, holding, transfer, cancellation, retirement and/or carry-over of CP2 AAUs, RMUs, ERUs, CERs, tCERs and lCERs in 2017.

Croatia has performed issuance and cancellation of CP1 ERUs in 2015 to account for the LULUCF activities in the first commitment period of the Kyoto protocol. Pursuant to Commission Delegated Regulation (EU) 2015/1844, CP1 AAUs have been exchanged in return for the CER and ERU units exchanged by the operators pursuant to Article 60 of the Regulation (EU) No 389/2013. Retirement transactions have been performed to account for the CP1 emissions.

SEF report which is submitted together with this report contains the information on the transactions in the reporting period, the year 2017. Croatia did not have any holdings or performed any transactions involving CP2 Kyoto units in the reporting period.

Croatia did not conclude any transfers of its annual emission allocation to other Member States pursuant to Decision 406/2009/EC.

ES.1.2.4. Changes in national system

In 2016 Ministry of Environment and Nature Protection changed its name to Ministry of Environment and Energy. There are no other changes regarding national system since NIR 2016.

ES.1.2.5. Changes in national registry

Changes in national registry are given in the table ES1.2-3.

Table ES1.2-3: Changes in national registry

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	There has been no change of name or contact
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	The version of the EUCR released after 8.0.7 (the production version at the time of the last Chapter 14 submission) introduced minor 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. The database model is provided in Annex A. This document is considered confidential and is available upon request. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. This document is considered confidential and is available upon request. 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). No other change in the registry's conformance to the technical standards occurred for the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The mandatory use of hardware tokens for authentication and signature was introduced for registry administrators.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change in the list of publicly available information with regards to confidentiality of information occurred during the reporting period.
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 regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. This document is considered confidential and is available upon request. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission. Annex H technical standard testing is planned later in 2018 when new version of the Union Registry software will be available.
1/CMP.8 paragraph 23 PPSR account	Previous period surplus reserve (PPSR) account will be stablished in the Consolidated System of European Registries (CSEUR).

The Annexes A and B are considered as confidential and are available upon request.

ES.1.2.6. Information on minimization of activities

According to paragraph 24 of the Annex to Decision 15/CMP.1 Parties included in Annex II, and other Parties included in Annex I that are in a position to do so, shall incorporate information on how they give priority, in implementing their commitments based on relevant methodologies referred to in paragraph 8 of decision 31/CMP.1. Considerations of possible impact of the implementation of response measures form part of the fully transparent process of impact assessments or sustainability impact assessments for EU legislative proposals or trade agreements respectively, such as specific proposals on climate action or cross-border sectoral measures including energy, transport, industry and agriculture.

According to Article 4, paragraphs 8 and 9 of the Convention Croatia strives to implement Kyoto commitments in a way which minimize adverse impact on developing countries. In continuation information on implementation of policies and measures that minimise adverse social, environmental and economic impacts on non-Annex I Parties is provided.

a) Market imperfections, fiscal incentives, tax and duty exemptions and subsidies

The ongoing liberalization of energy market is in line with EU policies and directives. No significant market distortions have been identified. Consumption taxes for electricity and fossil fuels were harmonized recently. The main instrument addressing externalities is the emission trading under the EU ETS.

b) Removing subsidies associated with the use of environmentally unsound and unsafe technologies

In Republic of Croatia no subsidies for environmentally unsound and unsafe technologies have been identified.

c) Technological development of non-energy uses of fossil fuels

The Republic of Croatia has not participated actively in activities of this nature.

d) Carbon capture and storage technology development

The Republic of Croatia does not take part in any such activity.

e) Improvements in fossil fuel efficiencies

In 2014 The Third National Energy Efficiency Action Plan for the 2014- 2016 period has been drawn up in accordance with the template laid down by the European Commission, with which all EU Member States must comply. Measures for the period from 2014 to 2016 regarding energy efficiency are:

- supporting the use of renewable energy sources and energy efficiency by the Environmental Protection and Energy Efficiency Fund (the Fund),
- encouraging the use of renewable energy and energy efficiency through the Croatian Bank for Reconstruction and Development (HBOR),
- energy efficiency projects with repayment through savings (ESCOs),
- increasing energy efficiency in buildings
- energy audits in the industry,
- promoting energy efficiency in households and the services sector through project activities,
- labelling the energy efficiency of household appliances,
- metering and informative billing of energy consumption,
- eco-design of energy using products.

f) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies

As regard of above motioned activity the Republic of Croatia does not take part in any such activity.

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 2016. 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
CF4	7390
C2F6	12200
C3F8	8830
SF6	22800
	Source: 24/CP.19

The results of the greenhouse gas (GHG) emission calculation are presented for the period from 1990 to 2016. 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.

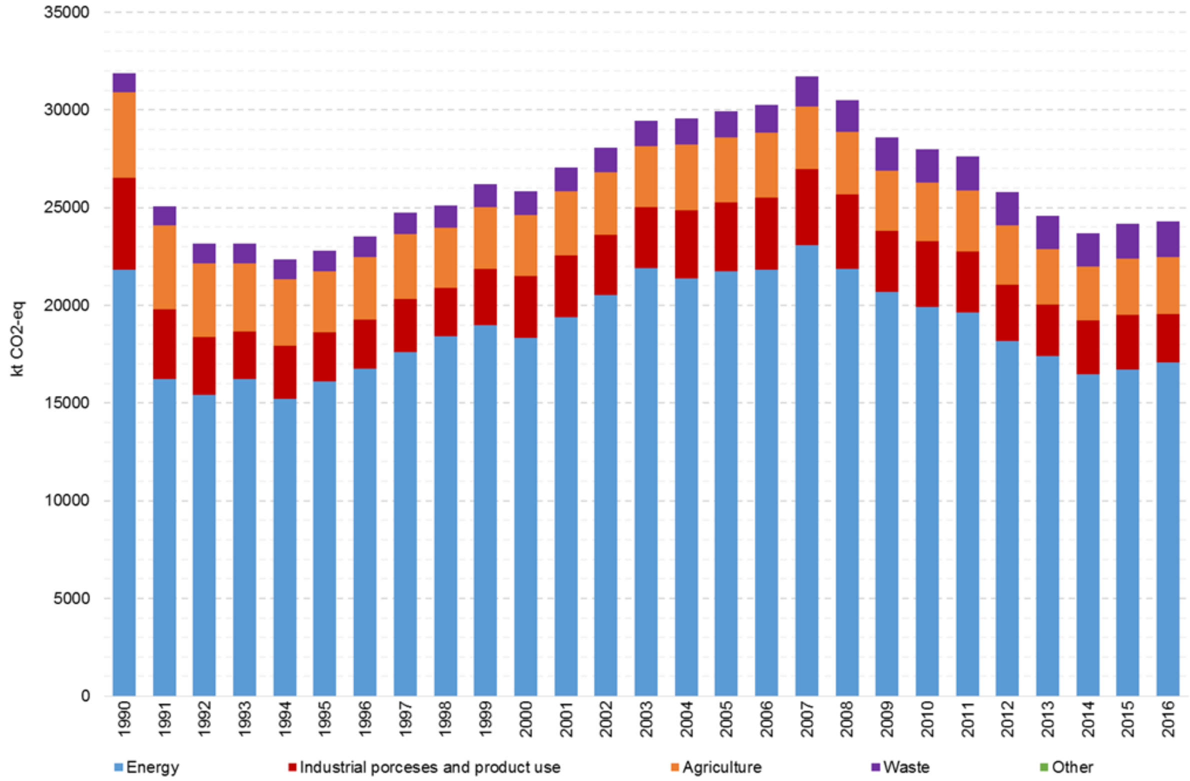
Table ES.2-1: Emissions/removals of GHG by sectors for the every five years from 1990 to 2010 (kt CO_2-eq)

Greenhouse gas source and sink categories	1990	2000	2005	2010
1. Energy	21,831.8	18,350.8	21,730.6	19,903.9
2. Industrial processes and product use	4,680.6	3,154.1	3,545.3	3,356.6
3. Agriculture	4,398.3	3,131.4	3,320.8	3,029.8
4. Land use, land-use change and forestry	-6,613.6	-7,404.1	-7,651.0	-7,010.5
5. Waste	983.4	1,194.9	1,337.3	1,695.4
6. Other	NO	NO	NO	NO
Total (with LULUCF)	25,280.6	18,427.0	22,282.9	20,975.3
Total (without LULUCF)	31,894.2	25,831.1	29,934.0	27,985.7

Table ES.2-2: Emissions/removals of GHG by sectors for the every five years from 2011 to 2016 (kt CO_2-eq)

Greenhouse gas source and sink categories	2011	2012	2013	2014	2015	2016
1. Energy	19,634.8	18,187.4	17,415.7	16,459.8	16,728.0	17,074.4
2. Industrial processes and product use	3,125.9	2,879.7	2,601.3	2,761.9	2,769.7	2,460.2
3. Agriculture	3,120.8	3,037.2	2,848.4	2,742.0	2,875.2	2,930.9
4. Land use, land-use change and forestry	-5,989.4	-5,713.5	-6,268.1	-6,292.5	-5,370.8	-5,422.2
5. Waste	1,727.7	1,703.7	1,698.1	1,734.1	1,815.7	1,838.6
6. Other	NO	NO	NO	NO	NO	NO
Total (with LULUCF)	21,619.8	20,094.6	18,295.3	17,405.4	18,817.8	18,882.0
Total (without LULUCF)	27,609.2	25,808.1	24,563.4	23,697.9	24,188.6	24,304.2

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 2016 excluding LULUCF has the Energy sector with 70.2 percent, followed by Agriculture with 12.1 percent, Industrial Processes and product use with 10.1 percent and Waste with 7.6 percent. This structure is with minor changes consistent through all the observed period from 1990 to 2016. In the year 2016, the total GHG emissions in Croatia was 24,304.2 kt CO_2-eq excluding LULUCF sector while the total emission was 18,882.0 kt CO_2-eq including the LULUCF sector which represents removals by sink from 22.3 percent in that year.

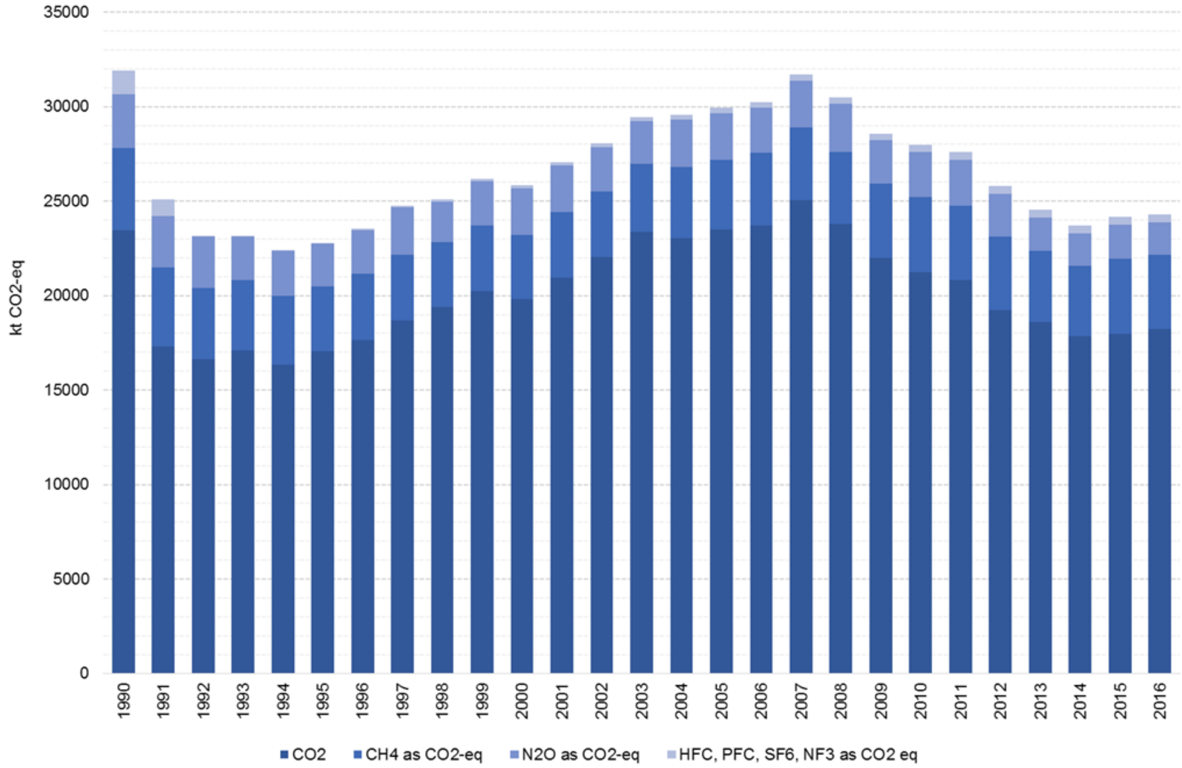
Table ES.2-3: Emissions/removals of GHG by gases for the every five years from 1990 to 2010 (kt CO_2-eq)

Greenhouse gas emissions	1990	2000	2005	2010
CO_2 emissions without net CO_2 from LULUCF	23,442.0	19,815.7	23,489.5	21,245.1
CO_2 emissions with net CO_2 from LULUCF	16,788.3	12,205.8	15,744.5	14,131.1
CH_4 emissions without CH_4 from LULUCF	4,354.5	3,377.0	3,702.2	3,972.8
CH_4 emissions with CH_4 from LULUCF	4,355.7	3,473.9	3,705.0	3,974.5
N_2O emissions without N_2O from LULUCF	2,847.1	2,478.9	2,463.4	2,380.0
N_2O emissions with N_2O from LULUCF	2,885.9	2,587.8	2,554.7	2,481.8
HFCs	NO	147.9	265.8	378.9
PFCs	1,240.2	NO	NO	0.0
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO
SF_6	10.5	11.6	13.0	9.0
NF_3	NO	NO	NO	NO
Total (without LULUCF)	31,894.2	25,831.1	29,934.0	27,985.7
Total (with LULUCF)	25,280.6	18,427.0	22,282.9	20,975.3
Total (without LULUCF, with indirect)	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA

Table ES.2-4: Emissions/removals of GHG by sectors for the every five years from 2011 to 2016 (kt CO_2-eq)

Greenhouse gas emissions	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CO_2 emissions without net CO_2 from LULUCF	20,801.7	19,243.0	18,588.2	17,850.7	17,996.6	18,220.6
CO_2 emissions with net CO_2 from LULUCF	14,679.2	13,363.0	12,215.8	11,456.6	12,500.8	12,681.1
CH_4 emissions without CH_4 from LULUCF	3,961.3	3,864.5	3,788.5	3,738.3	3,949.2	3,950.9
CH_4 emissions with CH_4 from LULUCF	3,979.9	3,903.3	3,790.4	3,738.6	3,963.2	3,959.8
N_2O emissions without N_2O from LULUCF	2,440.7	2,294.2	1,771.7	1,688.2	1,817.7	1,706.6
N_2O emissions with N_2O from LULUCF	2,555.1	2,421.8	1,874.0	1,789.4	1,928.7	1,815.0
HFCs	396.2	397.3	408.9	413.9	419.9	419.7
PFCs	0.0	0.0	0.1	0.1	0.0	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO
SF_6	9.4	9.2	6.1	6.8	5.2	6.4
NF_3	NO	NO	NO	NO	NO	NO
Total (without LULUCF)	27,609.2	25,808.1	24,563.4	23,697.9	24,188.6	24,304.2
Total (with LULUCF)	21,619.8	20,094.6	18,295.3	17,405.4	18,817.8	18,882.0
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA

Figure ES2-2: 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 2016 excluding LULUCF has CO_2 emission with 75.0 percent, followed by CH_4 with 16.3 percent, N_2O with 7.0 percent and HFCs, PFCs and SF_6 with 1.7 percent.

ES.3. Overview of source and sink category emission estimates andtrends

ES.3.1. Greenhouse gas emissions by sectors

ENERGY SECTOR

Energy sector is the largest contributor to GHG emissions. In the year 2016, the GHG emission from Energy sector was 2.1 percent higher in relation to 2015 and 21.8 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) in total CO_2-eq emission is substantially smaller (8 percent) while the contribution of energy in nitrous oxide (N_2O) in total CO_2-eq 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 1990-2016 (kt CO_2-eq)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
1. Energy	21,831.8	18,350.8	21,730.6	19,903.9	19,634.8	18,187.4	17,415.7	16,459.8	16,728.0	17,074.4
A. Fuel comb.	20,722.4	17,319.5	20,601.6	18,957.9	18,705.3	17,399.6	16,666.9	15,743.1	16,198.8	16,582.9
1. Energy industries	7,094.3	5,839.4	6,880.9	5,951.1	6,325.2	5,922.3	5,299.8	4,791.0	4,795.4	4,917.3
2. Manufact. ind.	5,529.0	3,115.6	3,739.0	3,030.1	2,792.1	2,421.9	2,392.8	2,335.0	2,232.0	2,215.3
3. Transport	3,881.1	4,499.4	5,561.6	5,952.3	5,799.5	5,614.2	5,699.5	5,642.5	5,951.8	6,173.4
4. Other sectors	4,217.9	3,865.1	4,420.1	4,024.4	3,788.5	3,441.2	3,274.8	2,974.6	3,219.5	3,276.8
5. Other	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
B. Fugitive em.	1,109.4	1,031.2	1,129.0	946.0	929.5	787.8	748.8	716.7	529.3	491.6
1. Solid fuels	59.6	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NA,NO	NA,NO	NO,NA
2. Oil and nat. gas	1,049.8	1,031.2	1,129.0	946.0	929.5	787.8	748.8	716.7	529.3	491.6
C. CO2 transport and	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

The largest part (36.2 percent in 2016) of the emissions are a consequence of fuel combustion in Transport, then the combustion in Energy industries (28.8 percent in 2016) and the combustion in small stationary energy sources, such as Commercial/ Institutional, Residential and Agriculture/ Forestry/ Fishing (19.2 percent in 2016). Manufacturing Industries and Construction contribute to total emission from Energy sector with 12.9 percent, while Fugitive Emissions from Fuels contribute with about 2.9 percent.

INDUSTRIAL PROCESSES AND PRODUCT USE

In Industrial Processes sector, the key emission sources are Cement Production, Ammonia Production, Nitric Acid Production, Petrochemical and Carbon Black Production, Non-energy Products from Fuels and Solvent Use and Consumption of HFCs in Refrigeration and Air Conditioning Equipment, which all together contribute with 90.6 percent in total sectoral emission in 2016. The iron production in blast furnaces and aluminium production ended in 1992, and ferroalloys production ended in 2003. Generally, GHG 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 due to revitalization of the economy. The effects of the economic crisis influenced the emissions trend from 2008 onwards, followed by a moderate recovery since 2013. The decrease in emissions from chemical industry in 2013 and onwards is due to a strong reduction of N_2O emissions from the nitric acid production after applying abatement technology. In 2016 emissions from industrial processes were decreased by 11.2 percent regarding 2015 and by 47.4 percent regarding 1990. Industrial processes and product use contributed to total GHG emissions with 10.1 percent in 2016. 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 1990-2016 (kt CO_2-eq)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
2. Industrial processes and product use	4,680.6	3,154.1	3,545.3	3,356.6	3,125.9	2,879.7	2,601.3	2,761.9	2,769.7	2,460.2
A. Mineral industry	1,280.9	1,423.1	1,785.4	1,432.3	1,220.1	1,191.1	1,298.3	1,392.2	1,340.5	1,238.1
B. Chemical industry	1,538.5	1,430.8	1,318.6	1,383.5	1,349.3	1,154.7	749.9	826.4	884.0	657.6
C. Metal industry	1,582.7	27.3	11.8	27.6	29.4	2.0	16.9	28.6	13.6	1.1
D. Non-energy products	234.7	80.1	117.4	94.3	89.0	83.1	79.1	74.9	76.2	81.4
E. Electronic Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Product uses as ODS	NO	147.9	265.8	378.9	396.2	397.3	409.0	414.0	419.9	419.7
G. Other prod. manuf.	43.8	45.0	46.4	40.0	42.0	51.5	48.2	25.9	35.5	62.4
H. Other	NA	NA	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 40.1 percent of sectoral CO_2-eq 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 2013 and 2014. Compared to 2015, in 2016 CO_2-eq emission from Enteric fermentation decreased by 0.9 percent. As for Manure management emissions, CO_2-eq emission decreased by 1.0 percent in 2016 compared to 2015. 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. CO_2-eq emission from Agricultural soils increased in 2016 compared to 2015 by 6.5 percent. Overall, in the year 2016 the GHG emission from Agriculture sector increased by 1.9 percent in comparison with 2015. 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 1990-2016 (kt CO_2-eq)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
3. Agriculture	4,398.3	3,131.4	3,320.8	3,029.8	3,120.8	3,037.2	2,848.4	2,742.0	2,875.2	2,930.9
A. Enteric fermentation	2,171.5	1,248.8	1,307.4	1,204.8	1,201.1	1,187.7	1,154.6	1,126.9	1,186.3	1,175.5
B. Manure management	776.2	633.0	661.5	656.4	643.2	620.2	589.9	590.1	611.7	605.6
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	1,400.6	1,188.7	1,266.5	1,080.5	1,171.4	1,128.1	1,029.3	955.5	1,007.9	1,073.6
E. Presc. burning of sav.	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Liming	NO	NO	14.5	21.5	21.3	14.4	14.2	20.0	12.1	11.2
H. Urea application	50.0	60.9	71.0	66.6	83.9	86.9	60.4	49.5	57.2	65.0
I. Other carbon-cont.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
J. Other	NO	NO	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 (2006-2016), 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 m3 while its yearly increment amounts around 10.5 million of m3. The most frequent species are Common Beech (Fagus sylvatica), Pedunculate Oak (Quercus robur), Sessile Oak (Quercus petrea), Common Hornbeam (Carpinus betulus), Silver Fir (Abies alba), Narrow-leafed Ash (Fraxinus angustifolia), Spruce (Picea abies), Black Alder (Alnus glutinosa), Black Locust (Robinia pseudoacacia), Turkey Oak (Quercus cerris) and other. The methodology used for CO_2 removal calculation is taken from the IPCC and it is based on data on increment and fellings. The problem of deforestation in Croatia does not exist. According to present data the total forest area has not been reduced in the last 100 years.

Table ES.3-4 shows the CO_2 removal trend in the forestry sector. Removal arisen in LULUCF sector contribute with 28.7 percent to the total emissions of CO_2 eq in Croatia in year 2016.

Table ES.3-4: Removal trends in LULUCF sector from 1990-2016 (kt CO_2-eq)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
LULUCF removals	-6,613.6	-7,404.1	-7,651.0	-7,010.5	-5,989.4	-5,713.5	-6,268.1	-6,292.5	-5,370.8	-5,422.2

WASTE

Waste Waste sector includes following categories: solid waste disposal, biological treatment of solid waste, incineration and open burning of waste and wastewater treatment and discharge. Solid waste disposal represents dominant CH_4 emission source from that sector. Generally, 69.5 percent of sectoral emissions refer to the emissions from solid waste disposal in 2016, compared to 35.4 percent in 1990. An increase in generated solid waste exists during the entire reporting period, particularly until 2009. Starting with 2009 there is a decrease in registered waste quantities, caused primary by economic crisis but also other factors regarding to effects of measures undertaken to avoid/reduce and recycle waste. 30.2 percent of sectoral emissions refer to the emissions from wastewater treatment and discharge in 2016, compared to 64.5 percent in 1990. Decrease in emissions during the entire reporting period mainly is a result of population decrease (domestic wastewater) as well economic crisis that affected the reduction of economic activity from 2008 onwards (industrial wastewater). Biological treatment of solid waste and incineration and open burning of waste have considerably lower contribution to the sectoral emissions during the reporting period. Waste sector contributes to total GHG emissions with 7.6 percent in 2016. Emission of individual subsectors is presented in the Table ES.3-5.

Table ES.3-5: Waste subsectors total emissions by gases for the period 1990-2016 (kt CO_2-eq)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
5. Waste	983.4	1,194.9	1,337.3	1,695.4	1,727.7	1,703.7	1,698.1	1,734.1	1,815.7	1,838.6
A. Solid waste disposal	348.6	570.4	735.3	1,098.5	1,131.6	1,140.2	1,142.4	1,178.4	1,253.8	1,278.7
B. Biol.treatment of solid waste	NO, NE,IE	NO, NE,IE	NO, NE,IE	1.7	1.7	3.2	4.9	4.9	10.6	4.7
C. Incineration of waste	0.54	6.26	0.16	0.05	0.05	0.08	0.04	0.04	0.05	0.05
D. Waste water treatment	634.3	618.2	601.8	595.2	594.3	560.2	550.8	550.8	551.2	555.1
E. Other	NO	NO	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 1990-2016 (kt CO_2)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Energy	20,758.8	17,485.2	20,811.7	18,987.5	18,764.8	17,363.4	16,610.0	15,725.6	15,924.6	16,276.0
Industrial processes	2,632.6	2,263.5	2,592.2	2,169.5	1,931.7	1,778.2	1,903.6	2,055.5	2,002.6	1,868.4
Agriculture	50.0	60.9	85.5	88.0	105.2	101.2	74.6	69.5	69.3	76.2
LULUCF	-6,653.6	-7,610.0	-7,745.0	-7,114.0	-6,122.5	-5,880.0	-6,372.4	-6,394.1	-5,495.8	-5,539.5
Waste	0.54	6.15	0.16	0.05	0.05	0.08	0.04	0.04	0.05	0.05
Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total CO_2 emission	23,442.0	19,815.7	23,489.5	21,245.1	20,801.7	19,243.0	18,588.2	17,850.7	17,996.6	18,220.6
Net CO_2 emission	16,788.3	12,205.8	15,744.5	14,131.1	14,679.2	13,363.0	12,215.8	11,456.6	12,500.8	12,681.1

ENERGY SECTOR

This sector covers all activities that involve fuel consumption from stationary and mobile sources, and fugitive emission from fuels. Fugitive emission arises from production, transport, processing, storage and distribution of fossil fuels. The Energy sector is the main source of the anthropogenic GHG emission with share of 84.2 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. Emission by sub-sectors is presented in Table ES.3.2-2.

Table ES.3.2-2: CO_2 emission by sub-sectors from 1990-2016 (kt CO_2)

GHG source categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Energy Industries	7,071.4	5,816.8	6,853.4	5,925.0	6,297.1	5,895.7	5,274.7	4,769.8	4,771.7	4,888.8
Manuf.Ind.and Const.	5,501.7	3,103.1	3,723.7	3,015.8	2,779.6	2,409.1	2,380.7	2,324.3	2,222.7	2,207.2
Transport	3,786.9	4,354.2	5,467.5	5,865.0	5,726.0	5,545.0	5,631.1	5,575.6	5,883.5	6,101.4
Other sectors	3,718.9	3,418.4	3,898.1	3,506.2	3,281.8	2,941.6	2,779.6	2,530.5	2,719.8	2,790.0
Fugitive emissions	679.9	792.7	868.9	675.4	680.2	572.1	543.9	525.3	326.9	288.4
Total CO_2 emis	20,078.9	16,692.6	19,942.8	18,312.0	18,084.5	16,791.3	16,066.1	15,200.3	15,597.7	15,987.5

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 2016, the CO_2 emission from Transport sector contributed with 33.5 percent to the national total CO_2 emission. The largest part of the CO_2 emission from Transport sector arises from road transport (96.4 percent of CO_2 emission from transport sector in 2016) 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 1990-2016 (kt CO_2)

GHG source categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Mineral industry	1,280.9	1,423.1	1,785.4	1,432.3	1,220.1	1,191.1	1,298.3	1,392.2	1,340.5	1,238.1
Chemical industry	778.4	733.5	677.7	615.4	593.2	502.0	509.3	559.8	572.3	547.9
Metal industry	338.6	26.8	11.8	27.6	29.4	2.0	16.9	28.6	13.6	1.1
Non-energy products	234.7	80.1	117.4	94.3	89.0	83.1	79.1	74.9	76.2	81.4

Total CO_2 emission	2,632.6	2,263.5	2,592.2	2,169.5	1,931.7	1,778.2	1,903.6	2,055.5	2,002.6	1,868.4

The most significant CO_2 industrial processes emission sources are production of cement, ammonia and lime. In 2016, mineral industry contributes in total sectoral CO_2 emission with 66.3 percent and chemical industry with 29.3 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 2016 CO_2 emissions from industrial processes decreased by 6.7 percent, regarding the year 2015.

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 1990-2016 (kt CH_4)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Energy	33.71	23.65	27.25	27.25	25.94	24.43	23.86	21.46	23.80	23.42
Industrial processes	0.38	0.14	0.16	0.12	0.08	0.01	0.01	0.01	0.01	0.01
Agriculture	103.45	66.54	70.42	67.07	66.71	65.46	63.27	62.27	65.22	64.68
LULUCF	0.05	3.88	0.11	0.07	0.75	1.56	0.08	0.01	0.56	0.36
Waste	36.64	44.75	50.26	64.47	65.73	64.68	64.40	65.80	68.94	69.93
Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total CH_4 emission	174.23	138.96	148.20	158.98	159.20	156.13	151.62	149.55	158.53	158.39

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 1990-2016 (kt N_2O)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Energy	0.77	0.92	0.80	0.79	0.74	0.72	0.70	0.66	0.70	0.71
Industrial processes	2.64	2.44	2.25	2.67	2.64	2.33	0.95	0.96	1.15	0.56
Agriculture	5.91	4.72	4.95	4.24	4.52	4.36	4.00	3.74	3.94	4.15
LULUCF	0.11	0.34	0.26	0.29	0.33	0.37	0.29	0.29	0.32	0.31
Waste	0.22	0.23	0.27	0.28	0.28	0.29	0.30	0.30	0.31	0.30
Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total N_2O emission	9.66	8.66	8.52	8.27	8.52	8.07	6.23	5.95	6.42	6.03

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 N2O 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.

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

ES.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. MEE 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 MEE) 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 1990-2016 (kt CO_2-eq)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Emissions of HFC, PFC	1,240.2	147.9	265.8	378.9	396.2	397.3	409.0	414.0	419.9	419.7
Emissions of SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NF_3 emission	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1,240.2	147.9	265.8	378.9	396.2	397.3	409.0	414.0	419.9	419.7

ES.4. Other information (e.g. indirect GHGs)

The photochemicaly active gases, carbon monoxide (CO), oxides of nitrogen (NO_X) and non-methane volatile organic compounds (NMVOCs) indirectly contribute to the greenhouse gas effect. These are generally called indirect greenhouse gases or ozone precursors, because they are involved in creation and degradation of ozone which is also one of the greenhouse gases. Sulphur dioxide (SO_2), as a precursor of sulphate and aerosols, is believed to contribute negatively to the greenhouse effect. Emissions of indirect GHGs have been taken from the draft of emission inventory report 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2016 Submission to the Convention on Long-range Transboundary Air Pollution'.The calculations of aggregated results for the emissions of indirect gases in the period 1990-2016 are given in table ES.4.1-1.

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

Polutants	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
NO_x Emission	87.26	165.20	86.89	68.61	81.10	94.20	59.02	53.11	64.22	60.50
Energy	81.00	69.12	78.74	62.82	59.22	54.29	53.86	49.71	50.14	48.72
Industrial Processes	2.74	2.61	2.38	1.57	1.18	1.08	1.01	1.07	1.08	0.96
Agriculture	2.79	3.07	3.15	2.59	2.98	2.80	2.30	2.10	2.28	2.43
LULUCF	0.74	90.40	2.62	1.63	17.72	36.02	1.86	0.23	10.71	8.39
Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO Emission	536.39	444.10	418.78	299.94	273.06	255.66	231.93	202.39	216.49	202.29
Energy	495.78	410.34	400.50	298.98	271.63	253.92	231.21	201.62	215.66	201.67
Industrial Processes	40.58	30.88	18.20	0.91	0.81	0.63	0.65	0.77	0.71	0.50
Agriculture	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	0.04	2.89	0.09	0.05	0.62	1.11	0.07	0.01	0.12	0.12
Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOC Emission	164.85	106.52	113.96	88.51	84.14	80.28	73.29	66.86	67.84	68.91
Energy	62.02	53.97	52.42	40.26	36.82	33.58	31.84	27.37	29.30	27.68
Industrial Processes	88.64	33.88	49.98	36.96	35.04	32.86	31.09	29.41	27.89	30.64
Agriculture	13.16	9.23	9.33	8.65	8.32	8.43	7.94	7.95	8.39	8.37
LULUCF	0.10	7.94	0.21	0.15	1.48	3.22	0.15	0.02	0.13	0.16
Waste	0.92	1.49	2.01	2.50	2.47	2.19	2.27	2.11	2.13	2.06
SO_2 Emission	134.62	51.32	58.72	35.21	29.17	25.18	16.90	13.76	15.77	14.68
Energy	133.41	50.55	58.02	35.20	29.16	25.18	16.89	13.74	15.70	14.48
Industrial Processes	1.20	0.76	0.69	0.01	0.01	0.01	0.01	0.02	0.07	0.21
Agriculture	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LULUCF	NA	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	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 for the first commitment period 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. 5/17) 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, 61/17).

In this NIR, the inventory of the emissions and removals of the greenhouse gases (GHG) is reported for the period from 1990 to 2016. 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 twelve reviews so far, in-country review in 2004, 2007, 2008 and 2012 and centralized reviews in 2005, 2006, 2009, 2010, 2011, 2013, 2014 and 2016. 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.

1.1.3. Background information on supplementary information required under Article 7, Paragraph 1 of the Kyoto Protocol

MEE, 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, MEE 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 MEE 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.

1.1.4. Information on Kyoto units

Asigned Amount Units (AAUs)

Pursuant to Article 3(7bis), (8) and (8bis) of the Kyoto Protocol and Paragraph 2 of Annex I to document FCCC/SBSTA//2015/L.13, the assigned amount for the second commitment period is equal to the percentage inscribed in the third column of Annex B of the Annex to the Doha amendment of the aggregate anthropogenic carbon dioxide equivalent emissions of greenhouse gases in the base year multiplied by eight, taking into account Article 3(7bis) of the Kyoto Protocol and paragraph 2 of the Annex to document FCCC/SBSTA/2015/L.13.

The amount of the Assigned amount units (AAUs) for Croatia for the period from 2013 till 2020 is 162,271,086 t CO_2-eq.

Commitment period reserve

Parties are required by decision 11/CMP.1 under the Kyoto Protocol and Paragraph 18 of Decision 1/CMP.8 to establish and maintain a commitment period reserve as part of their responsibility to manage and account for their assigned amount. The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8. Table 1.1-1 provides a calculation using both methods to calculate the commitment period reserve. The last column presents the commitment period reserve applicable for the second commitment period for the Croatia.

Table 1.1-1: Commitment period reserve

	t CO_2-eq
Assigned amount for second commitment period	162,271,086
90 % of assigned amount	146,043,977
Emission from last submitted inventory	24,304,160
100% of most recently reviewed* inventory multiplied by 8	194,443,328
Commitment period reserve	146,043,977

Information from national registry

Changes to the national registry of HR in 2017 are presented in Table1.1-2.

Table 1.1-2: Information on Kyoto Protocol units

Reporting Item	Description
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	The Standard Electronic Format report for 2017 has been submitted to the UNFCCC Secretariat electronically.
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	No discrepant transactions occurred in 2017.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2017.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2017.
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2017.
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.haop.hr/hr/tematska-podrucja/zrak-klima-tlo/klimatske-promjene in Croatian language and at https://ets-registry.webgate.ec.europa.eu/euregistry/HR/index.xhtml in English and Croatian language.
15/CMP.1 annex I.E paragraph 18 CPR Calculation	The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8 (Table ES1.2-2).

There has not been any issuance, acquisition, holding, transfer, cancellation, retirement and/or carry-over of CP2 AAUs, RMUs, ERUs, CERs, tCERs and lCERs in 2017.

Croatia has performed issuance and cancellation of CP1 ERUs in 2015 to account for the LULUCF activities in the first commitment period of the Kyoto protocol. Pursuant to Commission Delegated Regulation (EU) 2015/1844, CP1 AAUs have been exchanged in return for the CER and ERU units exchanged by the operators pursuant to Article 60 of the Regulation (EU) No 389/2013. Retirement transactions have been performed to account for the CP1 emissions.

SEF report which is submitted together with this report contains the information on the transactions in the reporting period, the year 2017. Croatia did not have any holdings or performed any transactions involving CP2 Kyoto units in the reporting period.

Croatia did not conclude any transfers of its annual emission allocation to other Member States pursuant to Decision 406/2009/EC.

1.1.5. Changes in national system

In 2016 Ministry of Environment and Nature Protection changed its name to Ministry of Environment and Energy. There are no other changes regarding national system since NIR 2016.

1.1.6. Changes in national registry

Changes in national registry are given in the table 1.1-3.

Table 1.1-3: Changes in national registry

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	There has been no change of name or contact
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	The version of the EUCR released after 8.0.7 (the production version at the time of the last Chapter 14 submission) introduced minor 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. The database model is provided in Annex A. This document is considered confidential and is available upon request. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. This document is considered confidential and is available upon request. 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). 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 to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The mandatory use of hardware tokens for authentication and signature was introduced for registry administrators.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change in the list of publicly available information with regards to confidentiality of information occurred during the reporting period.
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.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. This document is considered confidential and is available upon request. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission. Annex H technical standard testing is planned later in 2018 when new version of the Union Registry software will be available.
1/CMP.8 paragraph 23 PPSR account	Previous period surplus reserve (PPSR) account will be stablished in the Consolidated System of European Registries (CSEUR).

The Annexes A,and B are considered as confidential and are available upon request.

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 Environment and Energy (MEE), 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. Committee for inter-sectorial coordination for national system for monitoring of GHG emission (National System Committee) is included in the approval process; its members provide their opinion on certain parts of the Inventory within the frame of their speciality. Members of the National System Committee are nominated by the authorized Ministries and others relevant Institutions upon the request of the MEE.

MEE 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;
- collection of activity data;
- 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;
- quantitative estimate of the calculation uncertainty 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 inventory submission until 2018.

1.2.1. Institutional, legal and procedural arrangements

MEE, 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

QA/QC PLAN

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 MEE, CAEN and National System Committee.

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, MEE, 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 2016 in Energy 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 MEE, which, upon receipt, approves the latter. National System Committee is included in the approval process; its members provide their opinion on certain parts of the Inventory within the frame of their speciality. QA/QC coordinator documents all National System Committee 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 2016 Ministry of Environment and Nature Protection changed its name to Ministry of Environment and Energy. There are no other changes regarding national system since NIR 2016.

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

There are no changes regarding staff and capacity since NIR 2017.

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.):

There were no changes regarding the process of inventory planning.

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

There were no changes regarding the process of inventory preparation.

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

There are no changes the process of inventory management.

1.2.5. Information on minimization of activities

According to paragraph 24 of the Annex to Decision 15/CMP.1 Parties included in Annex II, and other Parties included in Annex I that are in a position to do so, shall incorporate information on how they give priority, in implementing their commitments based on relevant methodologies referred to in paragraph 8 of decision 31/CMP.1. Considerations of possible impact of the implementation of response measures form part of the fully transparent process of impact assessments or sustainability impact assessments for EU legislative proposals or trade agreements respectively, such as specific proposals on climate action or cross-border sectoral measures including energy, transport, industry and agriculture.

According to Article 4, paragraphs 8 and 9 of the Convention Croatia strives to implement Kyoto commitments in a way which minimize adverse impact on developing countries. In continuation information on implementation of policies and measures that minimise adverse social, environmental and economic impacts on non-Annex I Parties is provided.

g) Market imperfections, fiscal incentives, tax and duty exemptions and subsidies

The ongoing liberalization of energy market is in line with EU policies and directives. No significant market distortions have been identified. Consumption taxes for electricity and fossil fuels were harmonized recently. The main instrument addressing externalities is the emission trading under the EU ETS.

h) Removing subsidies associated with the use of environmentally unsound and unsafe technologies

In Republic of Croatia no subsidies for environmentally unsound and unsafe technologies have been identified.

i) Technological development of non-energy uses of fossil fuels

The Republic of Croatia has not participated actively in activities of this nature.

j) Carbon capture and storage technology development

The Republic of Croatia does not take part in any such activity.

k) Improvements in fossil fuel efficiencies

In 2014 The Third National Energy Efficiency Action Plan for the 2014- 2016 period has been drawn up in accordance with the template laid down by the European Commission, with which all EU Member States must comply. Measures for the period from 2014 to 2016 regarding energy efficiency are:

- supporting the use of renewable energy sources and energy efficiency by the Environmental Protection and Energy Efficiency Fund (the Fund),

- encouraging the use of renewable energy and energy efficiency through the Croatian Bank for Reconstruction and Development (HBOR),
- energy efficiency projects with repayment through savings (ESCOs),
- increasing energy efficiency in buildings
- energy audits in the industry,
- promoting energy efficiency in households and the services sector through project activities,
- labelling the energy efficiency of household appliances,
- metering and informative billing of energy consumption,
- eco-design of energy using products.

l) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies

As regard of above motioned activity the Republic of Croatia does not take part in any such activity.

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 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 eleven reviews so far, in-country review in 2004, 2007, 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 2016 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 Environment and Energy 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 2016* 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)	- MEE
	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 2016* 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
	Activity data on sewage sludge applied	- CAEN
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	- MEE - CAEN

CRF Sector/Sub-sector	Type of data	Source of data
	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 2016

Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2018)							
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification				Com.
Energy							
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	Yes	L1e,	T1e	L1i	T1i	
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	Yes	L1e	T1e, T2e	L1i	T1i, T2i	
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	Yes	L1e,	T1e, T2e	L1i	T1i, T2i	
1.A.2 Fuel combustion - Manufacturing Industries and	CO_2	Yes	L1e	T1e, T2e	L1i	T1i	
1.A.2 Fuel combustion - Manufacturing Industries and	CO_2	Yes	L1e,	T1e, T2e	L1i	T1i, T2i	
1.A.2 Fuel combustion - Manufacturing Industries and	CO_2	Yes	L1e	T1e, T2e	L1i	T1i, T2i	
1.A.3.b Road Transportation	CO_2	Yes	L1e,	T1e, T2e	L1i, L2i	T1i, T2i	
1.A.3.b Road Transportation	N_2O	Yes	L2e	T2e			
1.A.4 Other Sectors - Biomass	CH_4	Yes	L1e,	T1e, T2e	L1i, L2i	T1i	
1.A.4 Other Sectors - Biomass	N_2O	Yes	L2e	T2e			
1.A.4 Other Sectors - Gaseous Fuels	CO_2	Yes	L1e,	T1e, T2e	L1i	T1i, T2i	
1.A.4 Other Sectors - Liquid Fuels	CO_2	Yes	L1e,	T1e, T2e	L1i	T1i, T2i	
1.A.4 Other Sectors - Liquid Fuels	N_2O	Yes	L2e				
1.A.4 Other Sectors - Solid Fuels	CO_2	Yes		T1e, T2e		T1i	
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	Yes		T2e			
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	Yes		T1e, T2e		T1i, T2i	
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas -	CH_4	Yes	L1e,				
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas -	CO_2	Yes	L1e,	T1e, T2e	L1i	T1i, T2i	
Industrial processes and product use							
2.A.1 Cement Production	CO_2	Yes	L1e	T1e	L1i	T1i	
2.B.1 Ammonia Production	CO_2	Yes	L1e	T1e	L1i	T1i	
2.B.2 Nitric Acid Production	N_2O	Yes		T1e		T1i	
2.B.8 Petrochemical and Carbon Black Production	CO_2	Yes		T1e, T2e		T1i, T2i	
2.C.2 Ferroalloys Production	CO_2	Yes		T1e		T1i	
2.C.3 Aluminium Production	CO_2	Yes				T1i	
2.C.3 Aluminium Production	PFCs	Yes		T1e		T1i	
2.D Non-energy Products from Fuels and Solvent Use	CO_2	Yes		T2e		T1i	
2.F.1 Refrigeration and Air conditioning - Aggregate	F-	Yes	L1e,	T1e, T2e	L1i	T1i, T2i	
Agriculture							
3.A Enteric Fermentation	CH_4	Yes	L1e,	T1e, T2e	L1i, L2i	T1i, T2i	
3.B Manure Management	CH_4	Yes	L1e,	T1e	L1i	T1i	
3.B Manure Management	N_2O	Yes	L1e,	T1e, T2e	L1i	T1i, T2i	

Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2018)

IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification				Com.
3.D.1 Direct N2O Emissions From Managed Soils	N_2O	Yes	L1e,		L1i, L2i		
3.D.2 Indirect N2O Emissions From Managed Soils	N_2O	Yes	L1e,		L1i, L2i		
Land use, land use change and forestry							
4(III).Direct N2O emissions from N mineralization/immobilization	N_2O	Yes			L2i	T2i	
4.A.1 Forest Land Remaining Forest Land	CO_2	Yes			L1i, L2i	T2i	
4.A.2 Land Converted to Forest Land	CO_2	Yes			L1i, L2i	T1i, T2i	
4.B.1 Cropland Remaining Cropland	CO_2	Yes			L1i, L2i	T2i	
4.B.2 Land Converted to Cropland	CO_2	Yes			L2i		
4.C.2 Land Converted to Grassland	CO_2	Yes			L1i, L2i	T1i, T2i	
4.D.2 Land Converted to Wetlands	CO_2	Yes				T2i	
4.E.2 Land Converted to Settlements	CO_2	Yes			L1i, L2i	T1i, T2i	
4.G Harvested Wood Products	CO_2	Yes			L2i	T1i, T2i	
Waste							
5.A Solid Waste Disposal	CH_4	Yes	L1e,	T1e, T2e	L1i, L2i	T1i, T2i	
5.D Wastewater Treatment and Discharge	CH_4	Yes	L1e,		L1i, L2i		
5.D Wastewater Treatment and Discharge	N_2O	Yes	L2e	T2e			

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

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 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.

Uncertainty in the emissions excluding LULUCF

The estimate of CO_2-eq emissions in 2016 was estimated at 24,304.16 Gg CO_2-eq.

The estimate of CO_2-eq emissions in 1990 was estimated at 31,894.24 Gg CO_2-eq.

Monte Carlo analysis shows that with a certainty of 95% total simulated emissions of all categories excluding LULUCF for the year 1990 (32,120.34 Gg CO_2-eq) varies between 30,925.02 Gg CO_2-eq (2.5% percentile) and 33,405.96 Gg CO_2-eq (97.5% percentile).

Uncertainty in the trend excluding LULUCF

The Inventory trend excluding LULUCF is -23.80%, simulated trend is -23.61% and the 95% probability range of the trend is -28.22% (2,5% percentile) to -18.64% (97.5% percentile).

Uncertainty in the emissions including LULUCF

The estimate of CO_2-eq emissions in 2016 was estimated at 18,881.99 Gg CO_2-eq.

The estimate of CO_2-eq emissions in 1990 was estimated at 25,280.64 Gg CO_2-eq.

Monte Carlo analysis shows that with a certainty of 95% total emissions of categories for the year 2016 (23,845.57 Gg CO_2-eq) according to simulation varies between 16,897.68 Gg CO_2-eq (2.5% percentile) and 30,884.18 Gg CO_2-eq (97.5% percentile).

Uncertainty in the trend including LULUCF

The Inventory trend including LULUCF is -25.31%, simulated trend is -16.76% and the 95% probability range of the trend is -44.21% (2,5% percentile) to 16.66% (97.5% percentile), so the uncertainty introduced in trend varies from -18.90% to 41.97% with respect to the base year emissions.

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

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 1990-2016.

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 2016, excluding removals by sinks, amounted 24,304.2 mil. t CO_2-eq (equivalent CO_2 emissions), which represents 23.8 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 2008-2016, emission has been reduced by 15.4 percent in 2012, 19.4 percent in 2013, 22.3 percent in 2014, 20.7 percent in 2015, 20.3 percent in 2016 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 the period from 2008 to 2014 was economic crisis as well as implementation of measures for CO_2 emission reduction according to National Action plan for energy efficiency for the period from 2014 to 2016. 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 2016, overall emissions from industrial processes dropped by 14.6 precent, regarding 2012 and by 35.3 precent, regarding 2008.

The results of the greenhouse gas (GHG) emission calculation are presented for the period from 1990 to 2016. 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.

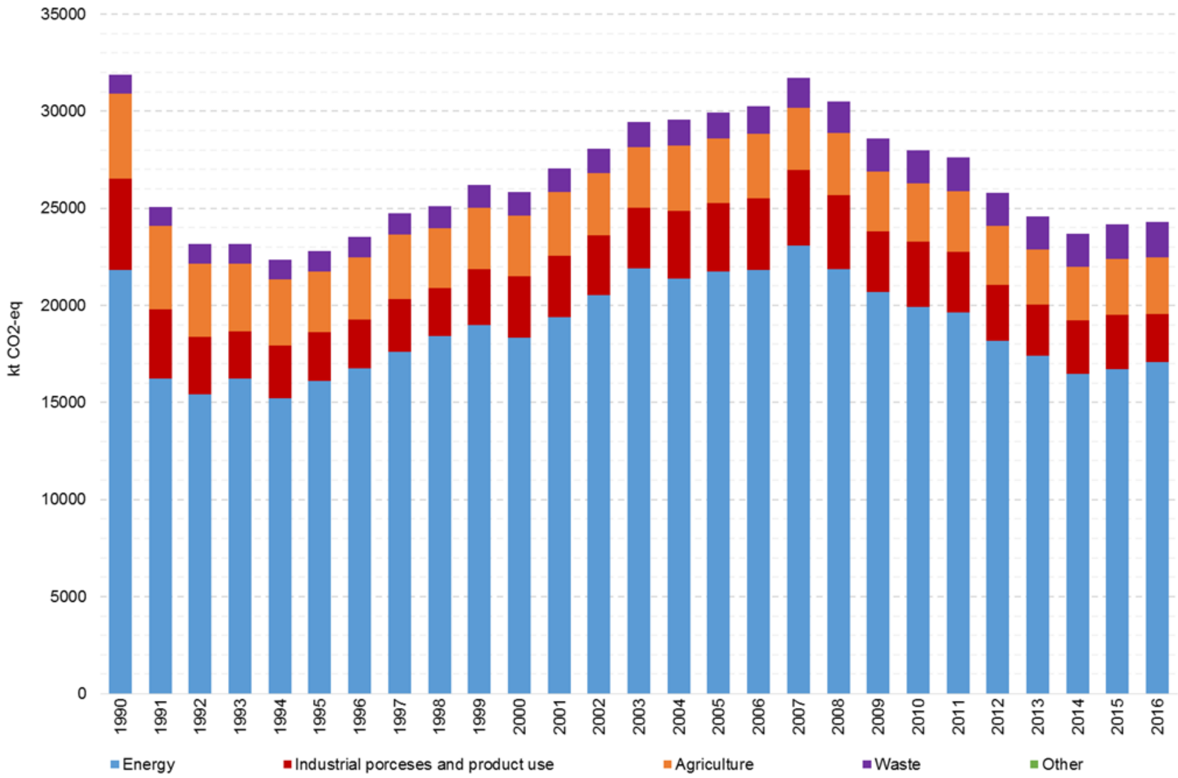
Table 2.1-1: Emissions/removals of GHG by sectors for the every five years from 1990 to 2010 (kt CO_2-eq)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	2000	2005	2010
1. Energy	21,831.8	18,350.8	21,730.6	19,903.9
2. Industrial processes and product use	4,680.6	3,154.1	3,545.3	3,356.6
3. Agriculture	4,398.3	3,131.4	3,320.8	3,029.8
4. Land use, land-use change and forestry	-6,613.6	-7,404.1	-7,651.0	-7,010.5
5. Waste	983.4	1,194.9	1,337.3	1,695.4
6. Other	NO	NO	NO	NO
Total (with LULUCF)	25,280.6	18,427.0	22,282.9	20,975.3
Total (without LULUCF)	31,894.2	25,831.1	29,934.0	27,985.7

Table 2.1-2: Emissions/removals of GHG by sectors for the period from 2010-2016 (kt CO_2-eq)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2011	2012	2013	2014	2015	2016
1. Energy	19,634.8	18,187.4	17,415.7	16,459.8	16,728.0	17,074.4
2. Industrial processes and product use	3,125.9	2,879.7	2,601.3	2,761.9	2,769.7	2,460.2
3. Agriculture	3,120.8	3,037.2	2,848.4	2,742.0	2,875.2	2,930.9
4. Land use, land-use change and forestry	-5,989.4	-5,713.5	-6,268.1	-6,292.5	-5,370.8	-5,422.2
5. Waste	1,727.7	1,703.7	1,698.1	1,734.1	1,815.7	1,838.6
6. Other	NO	NO	NO	NO	NO	NO
Total (with LULUCF)	21,619.8	20,094.6	18,295.3	17,405.4	18,817.8	18,882.0
Total (without LULUCF)	27,609.2	25,808.1	24,563.4	23,697.9	24,188.6	24,304.2

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 2016 excluding LULUCF has the Energy sector with 70.2 percent, followed by Agriculture with 12.1 percent, Industrial Processes and product use with 10.1 percent and Waste with 7.6 percent. This structure is with minor changes consistent through all the observed period from 1990 to 2016. In the year 2016, the total GHG emissions in Croatia was 24,304.2 kt CO_2-eq excluding LULUCF sector while the total emission was 18,882.0 kt CO_2-eq including the LULUCF sector which represents removals by sink from 22.3 percent in that year.

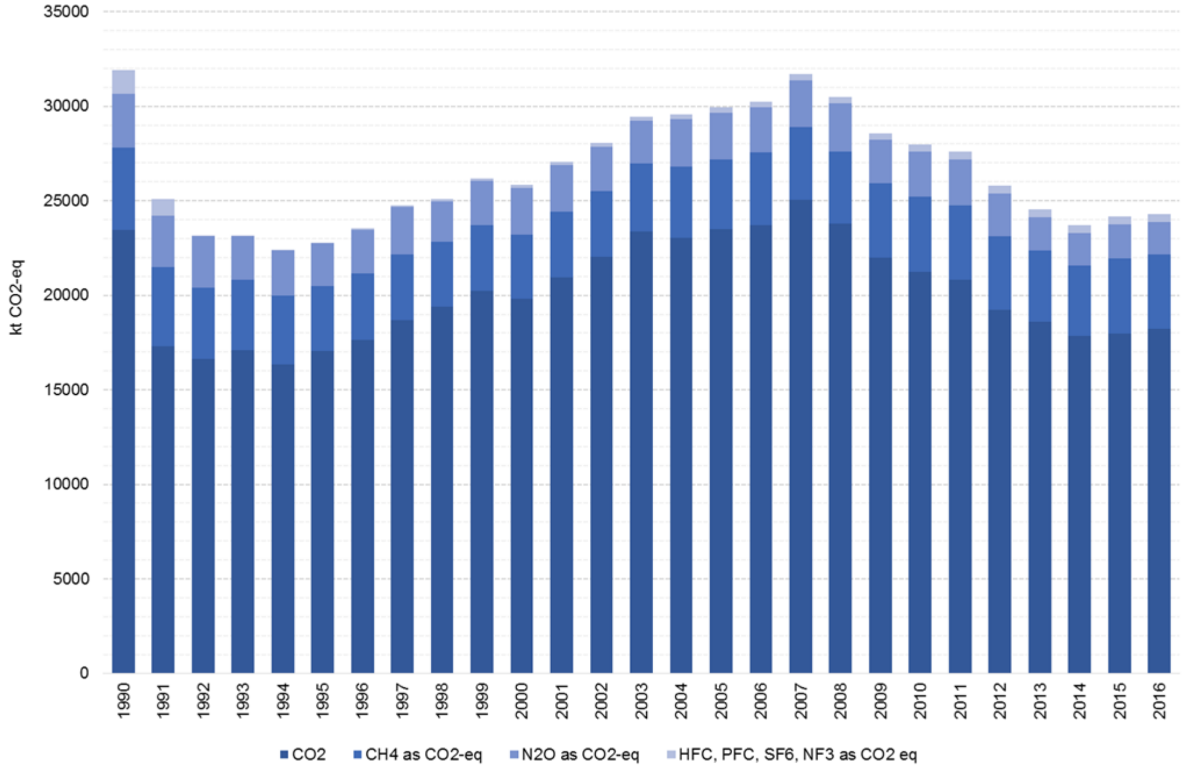
Table 2.1-3: Emissions/removals of GHG by gases for the every five years from 1990 to 2010 (kt CO_2-eq)

GREENHOUSE GAS EMISSIONS	1990	2000	2005	2010
CO_2 emissions without net CO_2 from LULUCF	23,442.0	19,815.7	23,489.5	21,245.1
CO_2 emissions with net CO_2 from LULUCF	16,788.3	12,205.8	15,744.5	14,131.1
CH_4 emissions without CH_4 from LULUCF	4,354.5	3,377.0	3,702.2	3,972.8
CH_4 emissions with CH_4 from LULUCF	4,355.7	3,473.9	3,705.0	3,974.5
N_2O emissions without N_2O from LULUCF	2,847.1	2,478.9	2,463.4	2,380.0
N_2O emissions with N_2O from LULUCF	2,885.9	2,587.8	2,554.7	2,481.8
HFCs	NO	147.9	265.8	378.9
PFCs	1,240.2	NO	NO	0.0
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO
SF_6	10.5	11.6	13.0	9.0
NF_3	NO	NO	NO	NO
Total (without LULUCF)	31,894.2	25,831.1	29,934.0	27,985.7
Total (with LULUCF)	25,280.6	18,427.0	22,282.9	20,975.3
Total (without LULUCF, with indirect)	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA

Table 2.1-4: Emissions/removals of GHG by gases for the for the period from 2011-2016 (kt CO_2-eq)

GREENHOUSE GAS EMISSIONS	2011	2012	2013	2014	2015	2016
CO_2 emissions without net CO_2 from LULUCF	20,801.7	19,243.0	18,588.2	17,850.7	17,996.6	18,220.6
CO_2 emissions with net CO_2 from LULUCF	14,679.2	13,363.0	12,215.8	11,456.6	12,500.8	12,681.1
CH_4 emissions without CH_4 from LULUCF	3,961.3	3,864.5	3,788.5	3,738.3	3,949.2	3,950.9
CH_4 emissions with CH_4 from LULUCF	3,979.9	3,903.3	3,790.4	3,738.6	3,963.2	3,959.8
N_2O emissions without N_2O from LULUCF	2,440.7	2,294.2	1,771.7	1,688.2	1,817.7	1,706.6
N_2O emissions with N_2O from LULUCF	2,555.1	2,421.8	1,874.0	1,789.4	1,928.7	1,815.0
HFCs	396.2	397.3	408.9	413.9	419.9	419.7
PFCs	0.0	0.0	0.1	0.1	0.0	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO
SF_6	9.4	9.2	6.1	6.8	5.2	6.4
NF_3	NO	NO	NO	NO	NO	NO
Total (without LULUCF)	27,609.2	25,808.1	24,563.4	23,697.9	24,188.6	24,304.2
Total (with LULUCF)	21,619.8	20,094.6	18,295.3	17,405.4	18,817.8	18,882.0
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA

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 2016 excluding LULUCF has CO_2 emission with 75.0 percent, followed by CH_4 with 16.3 percent, N_2O with 7.0 percent and HFCs, PFCs and SF_6 with 1.7 percent.

2.2. Description and interpretation of emission trends by sector

ENERGY SECTOR

Energy sector is the largest contributor to GHG emissions. In the year 2016, the GHG emission from Energy sector was 2.1 percent higher in relation to 2015 and 21.8 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) in total CO_2-eq emission is substantially smaller (8 percent) while the contribution of energy in nitrous oxide (N2O) in total CO_2-eq 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 1990-2016 (kt CO_2-eq)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
1. Energy	21,831.8	18,350.8	21,730.6	19,903.9	19,634.8	18,187.4	17,415.7	16,459.8	16,728.0	17,074.4
A. Fuel comb.	20,722.4	17,319.5	20,601.6	18,957.9	18,705.3	17,399.6	16,666.9	15,743.1	16,198.8	16,582.9
1. Energy industries	7,094.3	5,839.4	6,880.9	5,951.1	6,325.2	5,922.3	5,299.8	4,791.0	4,795.4	4,917.3
2. Manufact. ind.	5,529.0	3,115.6	3,739.0	3,030.1	2,792.1	2,421.9	2,392.8	2,335.0	2,232.0	2,215.3
3. Transport	3,881.1	4,499.4	5,561.6	5,952.3	5,799.5	5,614.2	5,699.5	5,642.5	5,951.8	6,173.4
4. Other sectors	4,217.9	3,865.1	4,420.1	4,024.4	3,788.5	3,441.2	3,274.8	2,974.6	3,219.5	3,276.8
5. Other	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
B. Fugitive em.	1,109.4	1,031.2	1,129.0	946.0	929.5	787.8	748.8	716.7	529.3	491.6
1. Solid fuels	59.6	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NA,NO	NA,NO	NO,NA
2. Oil and nat. gas	1,049.8	1,031.2	1,129.0	946.0	929.5	787.8	748.8	716.7	529.3	491.6
C. CO_2 transport and	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

The largest part (36.2 percent in 2016) of the emissions are a consequence of fuel combustion in Transport, then the combustion in Energy industries (28.8 percent in 2016) and the combustion in small stationary energy sources, such as Commercial/ Institutional, Residential and Agriculture/ Forestry/ Fishing (19.2 percent in 2016). Manufacturing Industries and Construction contribute to total emission from Energy sector with 12.9 percent, while Fugitive Emissions from Fuels contribute with about 2.9 percent.

INDUSTRIAL PROCESSES AND PRODUCT USE

In Industrial Processes sector, the key emission sources are Cement Production, Ammonia Production, Nitric Acid Production, Petrochemical and Carbon Black Production, Non-energy Products from Fuels and Solvent Use and Consumption of HFCs in Refrigeration and Air Conditioning Equipment, which all together contribute with 92.9 percent in total sectoral emission in 2016. The iron production in blast furnaces and aluminium production ended in 1992, and ferroalloys production ended in 2003. Generally, GHG 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 due to revitalization of the economy. The effects of the economic crisis influenced the emissions trend from 2008 onwards, followed by a moderate recovery since 2013. The decrease in emissions from chemical industry in 2013 and onwards is due to a strong reduction of N_2O emissions from the nitric acid production after applying abatement technology. In 2016 emissions from industrial processes were decreased by 11.2 percent regarding 2015 and by 47.4 percent regarding 1990. Industrial processes and product use contributed to total GHG emissions with 10.1 percent in 2016. 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 1990-2016 (kt CO_2-eq)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
2. Industrial processes and	4,680.6	3,154.1	3,545.3	3,356.6	3,125.9	2,879.7	2,601.3	2,761.9	2,769.7	2,460.2
A. Mineral industry	1,280.9	1,423.1	1,785.4	1,432.3	1,220.1	1,191.1	1,298.3	1,392.2	1,340.5	1,238.1
B. Chemical industry	1,538.5	1,430.8	1,318.6	1,383.5	1,349.3	1,154.7	749.9	826.4	884.0	657.6
C. Metal industry	1,582.7	27.3	11.8	27.6	29.4	2.0	16.9	28.6	13.6	1.1
D. Non-energy products	234.7	80.1	117.4	94.3	89.0	83.1	79.1	74.9	76.2	81.4
E. Electronic Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Product uses as ODS	NO	147.9	265.8	378.9	396.2	397.3	409.0	414.0	419.9	419.7
G. Other prod. manuf.	43.8	45.0	46.4	40.0	42.0	51.5	48.2	25.9	35.5	62.4
H. Other	NA	NA	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 40.1 percent of sectoral CO_2-eq 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 2013 and 2014. Compared to 2015, in 2016 CO_2-eq emission from Enteric fermentation decreased by 0.9 percent. As for Manure management emissions, CO_2-eq emission decreased by 1.0 percent in 2016 compared to 2015. 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. CO_2-eq emission from Agricultural soils increased in 2016 compared to 2015 by 6.5 percent. Overall, in the year 2016 the GHG emission from Agriculture sector increased by 2.0 percent in comparison with 2015. 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 1990-2016 (kt CO_2-eq)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
3. Agriculture	4,398.3	3,131.4	3,320.8	3,029.8	3,120.8	3,037.2	2,848.4	2,742.0	2,875.2	2,930.9
A. Enteric fermentation	2,171.5	1,248.8	1,307.4	1,204.8	1,201.1	1,187.7	1,154.6	1,126.9	1,186.3	1,175.5
B. Manure management	776.2	633.0	661.5	656.4	643.2	620.2	589.9	590.1	611.7	605.6
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	1,400.6	1,188.7	1,266.5	1,080.5	1,171.4	1,128.1	1,029.3	955.5	1,007.9	1,073.6
E. Presc. burning of sav.	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Liming	NO	NO	14.5	21.5	21.3	14.4	14.2	20.0	12.1	11.2
H. Urea application	50.0	60.9	71.0	66.6	83.9	86.9	60.4	49.5	57.2	65.0
I. Other carbon-cont.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

J. Other	NO	NO	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 (2006-2016), the forests and the forest land cover 47.5 percent of the total surface area. By its origin, approximately 95 percent of the forests in Croatia were formed by natural regeneration (according to the national definitions applied in the sector) and the 5 percent of the forests are grown artificially. The Plan determines, for 2006, growing stock of about 398 millions of m^3 while its yearly increment amounts around 10.5 million of m^3. The most frequent species are Common Beech (Fagus sylvatica), Pedunculate Oak (Quercus robur), Sessile Oak (Quercus petrea), Common Hornbeam (Carpinus betulus), Silver Fir (Abies alba), Narrow-leafed Ash (Fraxinus angustifolia), Spruce (Picea abies), Black Alder (Alnus glutinosa), Black Locust (Robinia pseudoacacia), Turkey Oak (Quercus cerris) and other. The methodology used for CO_2 removal calculation is taken from the IPCC and it is based on data on increment and fellings. The problem of deforestation in Croatia does not exist. According to present data the total forest area has not been reduced in the last 100 years.

Table 2.2-4 shows the CO_2 removal trend in the forestry sector. Removal arisen in LULUCF sector contribute with 28.7 percent to the total emissions of CO_2 eq in Croatia in year 2016.

Table 2.2-4: Emission trends in LULUCF sector from 1990-2016 (kt CO_2-eq)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
LULUCF removals	-6,613.6	-7,404.1	-7,651.0	-7,010.5	-5,989.4	-5,713.5	-6,268.1	-6,292.5	-5,370.8	-5,422.2

WASTE

Waste Waste sector includes following categories: solid waste disposal, biological treatment of solid waste, incineration and open burning of waste and wastewater treatment and discharge. Solid waste disposal represents dominant CH_4 emission source from that sector. Generally, 69.5 percent of sectoral emissions refer to the emissions from solid waste disposal in 2016, compared to 35.4 percent in 1990. An increase in generated solid waste exists during the entire reporting period, particularly until 2009. Starting with 2009 there is a decrease in registered waste quantities, caused primary by economic crisis but also other factors regarding to effects of measures undertaken to avoid/reduce and recycle waste. 30.2 percent of sectoral emissions refer to the emissions from wastewater treatment and discharge in 2016, compared to 64.5 percent in 1990. Decrease in emissions during the entire reporting period mainly is a result of population decrease (domestic wastewater) as well economic crisis that affected the reduction of economic activity from 2008 onwards (industrial wastewater). Biological treatment of solid waste and incineration and open burning of waste have considerably lower contribution to the sectoral emissions during the reporting period. Waste sector contributes to total GHG emissions with 7.6 percent in 2016. Emission of individual subsectors is presented in the Table 2.2.5.

Table 2.2-5: Waste subsectors total emissions by gases for the period 1990-2016 (kt CO_2-eq)

GHG source and sink categories	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
5. Waste	983.4	1,194.9	1,337.3	1,695.4	1,727.7	1,703.7	1,698.1	1,734.1	1,815.7	1,838.6
A. Solid waste disposal	348.6	570.4	735.3	1,098.5	1,131.6	1,140.2	1,142.4	1,178.4	1,253.8	1,278.7
B. Biol.treatment of solid waste	NO, NE,IE	NO, NE,IE	NO, NE,IE	1.7	1.7	3.2	4.9	4.9	10.6	4.7
C. Incineration of waste	0.54	6.26	0.16	0.05	0.05	0.08	0.04	0.04	0.05	0.05
D. Waste water treatment	634.3	618.2	601.8	595.2	594.3	560.2	550.8	550.8	551.2	555.1
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Chapter 3: Energy (CRF sector 1)

3.1. Overview of sector

For the emission calculation for the period from 1990 to 2016 National energy balances were used. In 2014 project 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 project was 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 project was 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 was to determine actual consumption of fuel on domestic and international routes and other to determine real consumption of solid biomass commercial and residential sector. The revised values on fuel consumptions were available for the whole period from 1990 to 2013 and were used to calculate emissions from Transport and Other sectors.

3.1.1. Overview of the energy situation

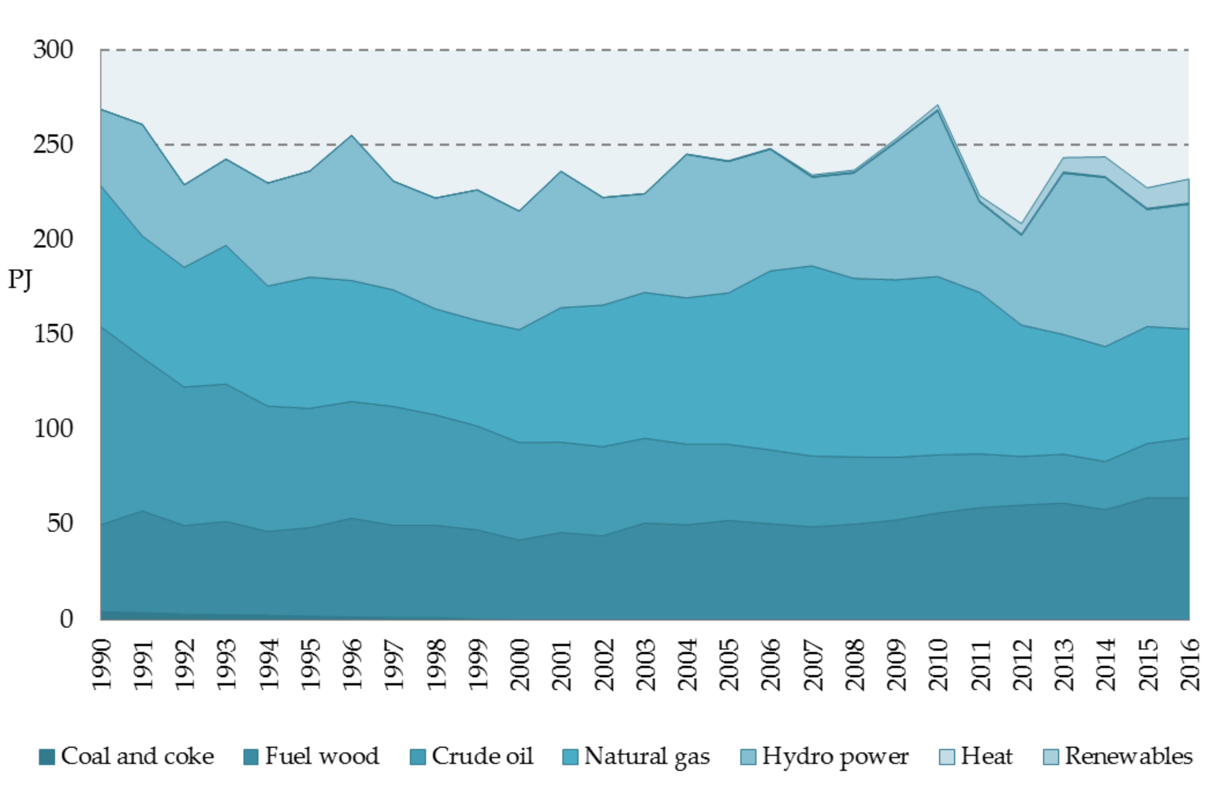
Primary sources of energy that are produced in Croatia are fuel wood, crude oil, natural gas, renewables and hydro power. Coal production stopped in 2000. Primary energy production for the 1990, 2000, 2005 and period from 2010 to 2016 is presented in the Table 3.1-1.

Table 3.1-1: Primary energy production

PJ	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Coal and coke	4.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel wood	45.77	41.97	52.27	56.20	59.01	60.39	61.45	57.97	64.19	64.15
Crude oil	104.54	51.35	40.11	30.69	28.37	25.62	25.71	25.38	28.62	31.47
Natural gas	74.27	59.40	79.76	93.88	85.02	69.19	63.11	60.52	61.61	57.52
Hydro power	40.08	62.53	69.20	87.24	47.58	47.32	84.92	88.99	61.63	65.63
Heat			0.22	0.63	0.60	0.61	0.63	0.52	0.62	0.66
Renewables			0.20	2.63	2.85	5.52	7.55	10.40	10.79	12.68
Total	**268.88**	**215.25**	**241.77**	**271.26**	**223.44**	**208.65**	**243.3**	**243.78**	**227.46**	**232.11**

Figure 3.1-1 presents the trends in the primary energy production from 1990 to 2016.

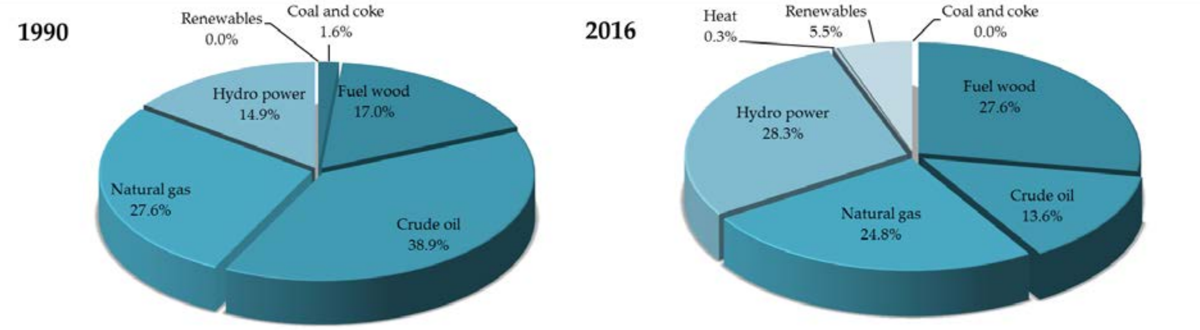
Figure 3.1-1: Trends in primary energy production for the period from 1990 to 2016



In 1990 primary energy production was about 268.9 PJ, which is 13.7% higher comparing to 2016. In 2016, the total primary energy production increased by 2.0% with relation to the 2015. Comparing to 2015, the energy production from renewable sources increased by 17.5% in 2016. The production of natural gas decreased 6.6% as well as production of hydro power (6.5%) and fuel wood (0.1%). Crude oil production increased by 10.0%.

While in 1990 the share of crude oil in primary energy production was the highest one with 38.9%, in 2016 its' share was only 13.6%. In 2016, the share of hydro power (28.3%) was the highest one. It was followed by fuel wood with the share of 27.6%. The comparison of shares in primary energy productions for the 1990 and 2016 are presented in Figure 3.1-2.

Figure 3.1-2: Shares of individual energy forms in the total production for the 1990 and 2016



Primary energy supply

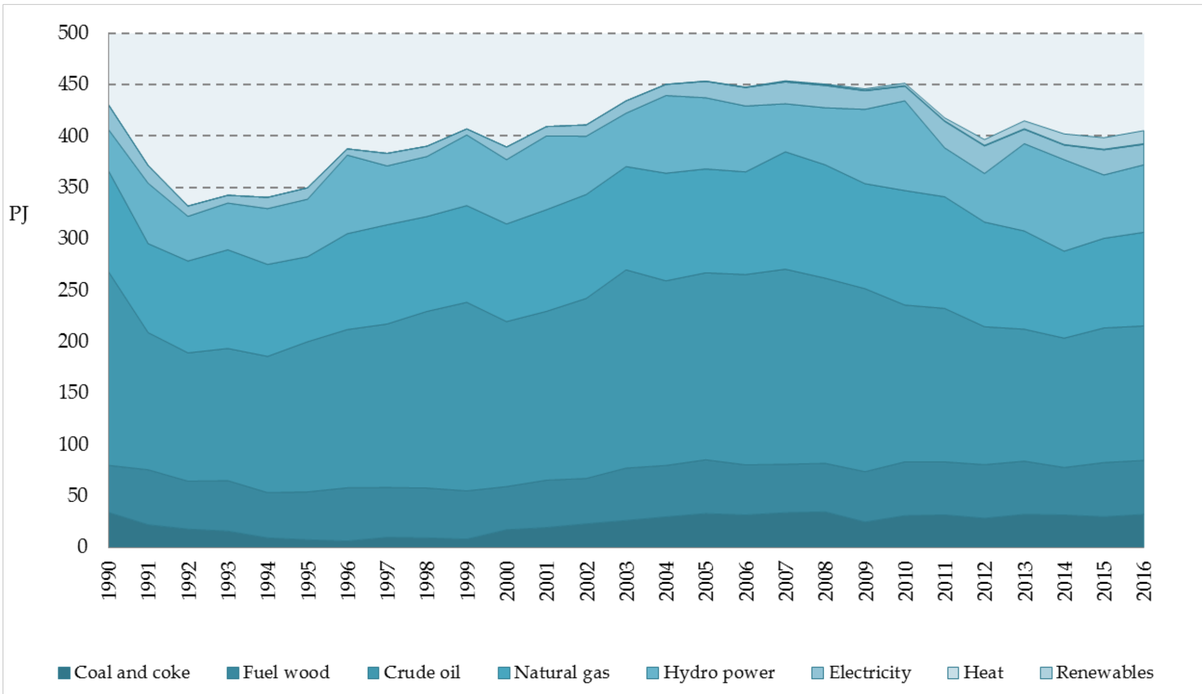
Total primary energy supply is determined by adding the import and subtracting the export of all primary and transformed energy forms to the total primary energy supply. Primary energy supply for the 1990, 2000, 2005 and period from 2010 to 2016 is presented in the Table 3.1-2.

Table 3.1-2: Primary energy supply

PJ	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Coal and coke	34.07	17.15	32.95	30.92	31.66	28.37	32.18	31.59	29.86	32.14
Fuel wood	45.77	41.97	52.27	52.29	51.50	52.10	51.67	46.12	52.69	52.47
Liquid fuels	188.57	160.52	181.88	152.54	149.30	134.17	128.37	125.80	130.92	130.78
Natural gas	98.22	94.98	101.06	111.37	108.60	101.78	95.54	84.62	87.16	91.08
Hydro power	40.08	62.53	69.20	87.24	47.58	47.32	84.92	88.99	61.63	65.63
Electricity	24.09	12.32	15.88	14.28	25.76	26.75	13.93	14.23	24.44	19.91
Heat	0.00	0.00	0.22	0.63	0.61	0.61	0.63	0.52	0.62	0.66
Renewables	0.00	0.00	0.20	2.24	2.83	5.59	7.65	10.35	11.16	12.68
Total	**430.81**	**389.46**	**453.66**	**451.50**	**417.84**	**396.69**	**414.89**	**402.22**	**398.48**	**405.34**

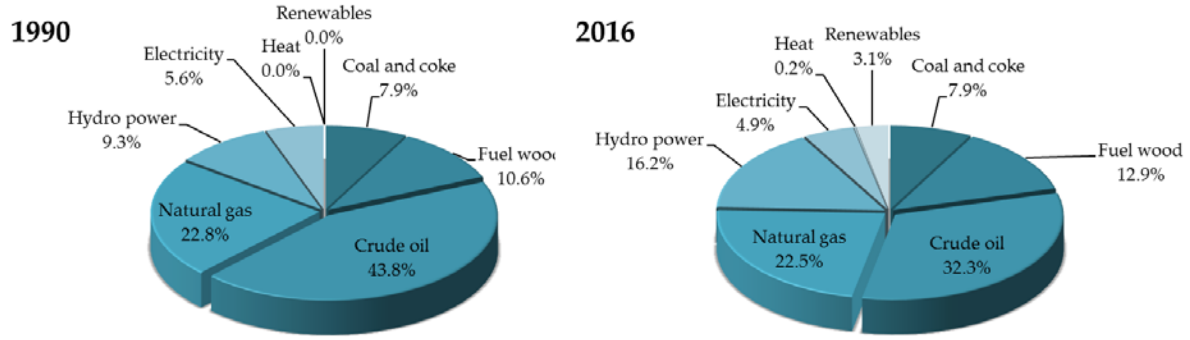
Figure 3.1-3 presents the trends in the primary energy supply from 1990 to 2016.

Figure 3.1-3: Trends in primary energy supply for the period from 1990 to 2016



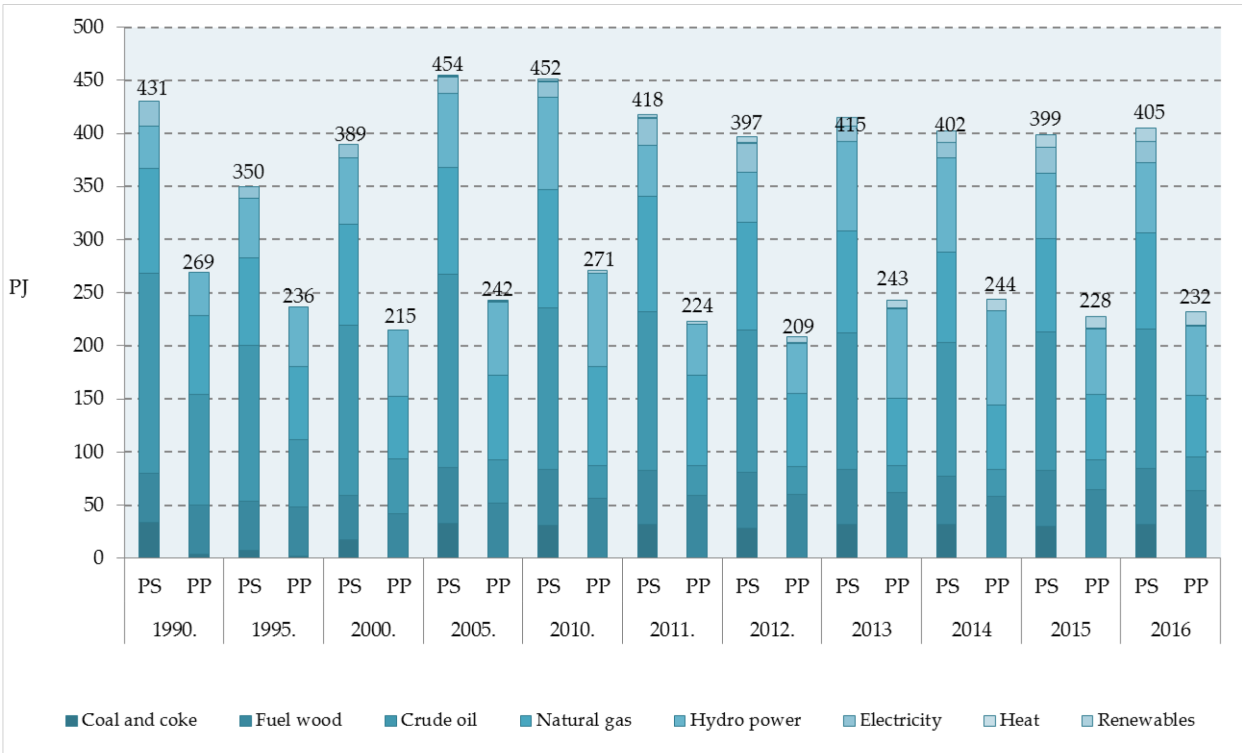
In 1990 primary energy supply was about 430.8 PJ, which is 5.9% higher comparing to 2016. In 2016, the total primary energy supply increased by 1.7% with relation to the previous year. There was an increase in renewable energy sources, coal and coke and hydro power while consumption of natural gas, liquid fuels and fuel wood decreased. Due to good hydrology conditions, hydro power energy supply increased by 6.5% with relation to the 2015. Figure 3.1-4 presents comparison of the shares of individual energy forms in the total primary energy supply for the 1990 and 2016.

Figure 3.1-4: Comparison of the shares of individual energy forms for the 1990 and 2016



Liquid fuels had the largest share in total primary energy supply in 1990 as well as in 2016 (43.8% in 1990 and 32.3% in 2016). It was followed by the natural gas with the share of approximately 22%. 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 2016 amounted 57.3%. 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 import.

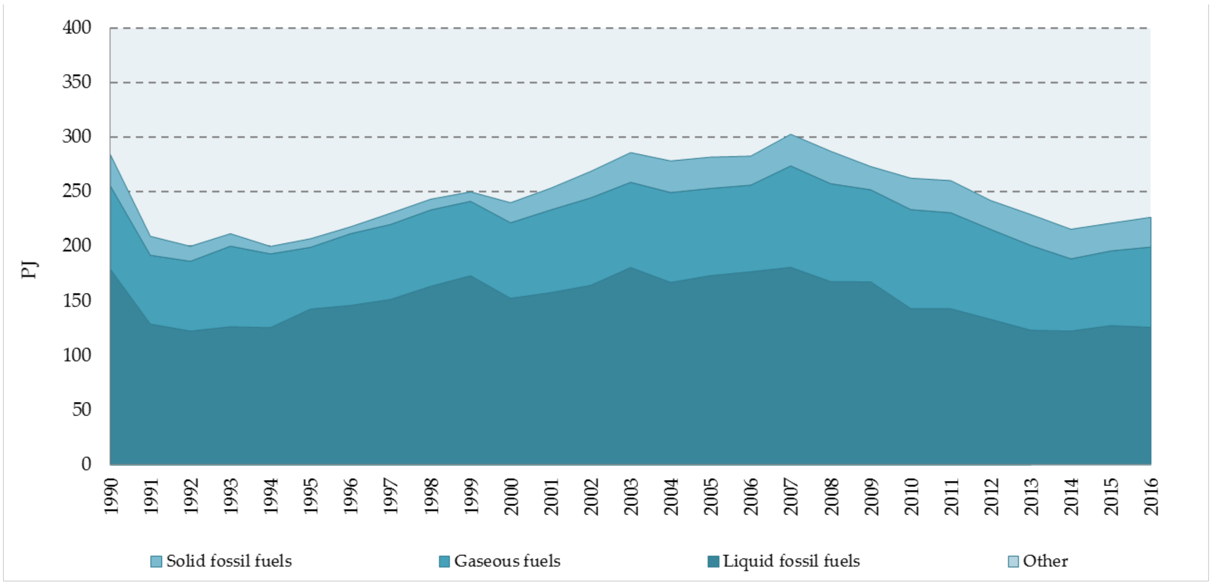
The basis for estimating the GHG emissions from Energy sector is the national energy balance. Data on production, imports, exports, stock change and consumption of fuels are reported both in natural units (kg or m3) and energy units (PJ). National energy balance for 2016 is presented in Annex 4. For 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, CO_2 emission factors and oxidation factors for 2016

Fuel		DOV		CO_2 Emission factor ($t CO_2/TJ$)	Oxidation factor (OF)
		Unit	2016		
Motorni benzin	Motor Gasoline	GJ/t	44.5900	69.30	1
Aviobenzin	Aviation Gasoline	GJ/t	44.5900	70.00	1
Kerozin (Mlazno gorivo)	Jet Kerosene	GJ/t	43.9600	71.50	1
Dizel i ekstra lako loživo ulje (plinsko ulje)	Gas/Diesel Oil	GJ/t	42.7100	74.10	1
Loživo ulje i srednje loživo ulje	Residual Fuel Oil	GJ/t	40.1900	77.40	1
Ukapljeni naftni plin	Liquefield Petroleum Gases	GJ/t	46.8900	63.10	1
Maziva	Lubricants	GJ/t	33.5000	73.30	1
Naftni koks	Petroleum Coke	GJ/t	31.0000	97.50	1
Petrolej	Petroleum	GJ/t	43.9600	73.30	1
Antracit	Anthracite	GJ/t	29.3100	98.30	1
Kameni ugljen-Industrija	*Other bituminouse coal Industry*	GJ/t	27.3900	94.60	1
Kameni ugljen-*Termoelektrane*	Other bituminouse coal *Thermal power plant*	GJ/t	24.9500	94.60	1
Ugljen za proizvodnju koksa (koksni ugljen)	Coking coal	GJ/t	28.2000	94.60	1
Mrki ugljen (smeđi ugljen) *Industrija*	Sub bituminouse coal *Industry*	GJ/t	17.0000	96.10	1
Lignit	Lignite	GJ/t	10.5000	101.00	1
Briketi kamenog ugljena	Brown coal briquettes	GJ/t	20.7000	97.50	1
Koks	Coke oven coke	GJ/t	29.3100	107.00	1
Prirodni plin	Natural Gas	$GJ/10^3m^3$	34.8000	56.10	1
Gradski plin	Gas Works Gas	GJ/t	38.7000	44.40	1
Koksni plin	Coke Oven Gas	GJ/t	38.7000	44.40	1
Rafinerijski plin	Refinery Gas	GJ/t	42.6000	57.60	1

The structure of energy consumption of fossil fuels from 1990 to 2016 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 95 percent in 2016. The contribution of energy in methane (CH_4) emission is substantially smaller (3 percent) while the contribution of energy in nitrous oxide (N_2O) emission is quite small (about 1 percent) in 2016.

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.

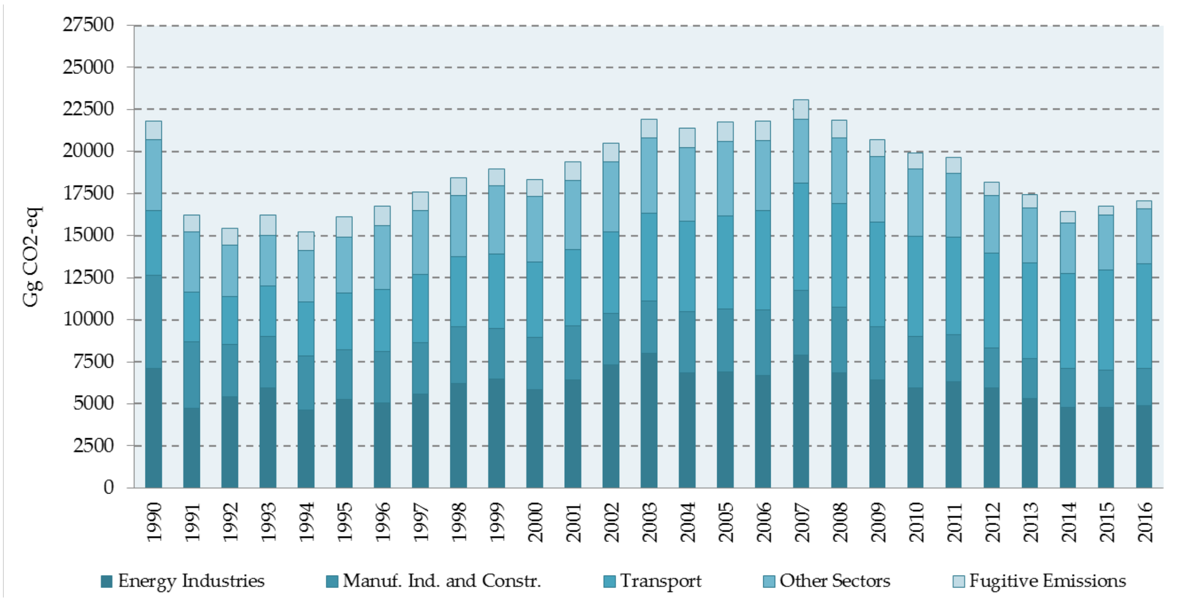
The fuel fugitive emission which is generated during production, transport, processing, storing and distribution of fossil fuels, is also estimated. These activities produce mainly the emission of CH_4, and smaller quantities of CO_2 and N_2O, NMVOC, CO and NOx.

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 (2016), is presented in the Table 3.1-4 while contribution of individual subsectors to GHG emission for the period 1990-2016 is presented in Figure 3.1-7.

Table 3.1-4: Contribution of individual subsectors to emission of greenhouse gases, for 2016

GHG categories	kt			Total	
	CO_2	CH_4	N_2O	CO_2-eq (kt)	%
ENERGY	**16,275.96**	**23.42**	**0.71**	**17,074.45**	**100.00**
A. Fuel combustion activities	15,987.55	15.30	0.71	16,582.85	97.12
1. Energy industries	4,888.84	0.22	0.08	4,917.32	28.80
a) Electricity and heat production	3,389.36	0.18	0.07	3,415.03	20.00
b) Petroleum refining	1,298.59	0.03	0.01	1,301.20	7.62
c) Manufacture of solid fuels	200.89	0.00	0.00	201.09	1.18
2. Manufacturing ind. and constr.	2,207.24	0.11	0.02	2,215.33	12.97
3. Transport	6,101.45	0.47	0.20	6,173.38	36.16
a) Civil aviation	31.11	0.00	0.00	31.37	0.18
b) Road transport	5,880.13	0.46	0.17	5,943.70	34.81
c) Railways	57.92	0.00	0.02	64.64	0.38
d) Navigation (domestic)	132.29	0.01	0.00	133.67	0.78
4. Other sectors	2,790.02	14.50	0.42	3,276.83	19.19
5. Other	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	288.41	8.12	0.00	491.60	2.88
1. Solid fuels	NO	NO	NO	NO	NO
2. Oil and natural gas	288.41	8.12	0.00	491.60	2.88
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 1990-2016



The largest part (36.2 percent) of the emissions are a consequence of fuel combustion in Transport, then the combustion in Energy industries (28.8 percent in 2016) and the combustion in small stationary energy sources, such as Commercial/Institutional, Residential and Agriculture/Forestry/Fishing (19.2 percent in 2016). Manufacturing Industries and Construction contribute to total emission from Energy sector with 13.0 percent, while Fugitive Emissions from Fuels contribute with about 2.8 percent. The majority of energy-related GHG emissions belong to CO_2 (91 to 95 percent), then follows CH_4 (4 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.

3.1.2.1. Energy sector key sources

In Energy sector, fifteen source categories represent key source category regardless of LULUCF (detailed in Table 3.1-5). For European Commission submission new Key sources and Uncertainty analysis were not performed because lack of time. Key sources and Uncertainty analysis were taken from April submission.

Table 3.1-5: Key categories in Energy sector based on the level and trend assessment in 2016

Tier 1 and Tier 2 Analysis - Key Source Analysis Summary (Croatian Inventory, 2018)							
IPCC Source Categories	**GHG**	**Key**	**If Column C is Yes, Criteria for Identification**				**Com**
1. Energy							
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	Yes	L1e, L2e	T1e	L1i	T1i	
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	Yes	L1e	T1e, T2e	L1i	T1i, T2i	
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
1.A.2 Fuel combustion - Manufacturing Industries and	CO_2	Yes	L1e	T1e, T2e	L1i	T1i	
1.A.2 Fuel combustion - Manufacturing Industries and	CO_2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
1.A.2 Fuel combustion - Manufacturing Industries and	CO_2	Yes	L1e	T1e, T2e	L1i	T1i, T2i	
1.A.3.b Road Transportation	CO_2	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i	
1.A.3.b Road Transportation	N_2O	Yes	L2e	T2e			
1.A.4 Other Sectors - Biomass	CH_4	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i	
1.A.4 Other Sectors - Biomass	N_2O	Yes	L2e	T2e			
1.A.4 Other Sectors - Gaseous Fuels	CO_2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
1.A.4 Other Sectors - Liquid Fuels	CO_2	Yes	L1e, L2e	T1e, T2e	L1i	T1i, T2i	
1.A.4 Other Sectors - Liquid Fuels	N_2O	Yes	L2e				
1.A.4 Other Sectors - Solid Fuels	CO_2	Yes		T1e, T2e		T1i	
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas -	CO_2	Yes		T2e			
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	Yes		T1e, T2e		T1i, T2i	
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas -	CH_4	Yes	L1e, L2e				
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas -	CO_2	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

3.1.2.2. Ozone precursors and SO_2 emissions

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 2016 was set up according to the EMEP/CORINAIR methodology. Emissions were obtained from the emission inventory report 'Republic of Croatia Informative Inventory Report for 2016, under Convention on Long-range Transboundary Air Pollution (CLRTAP)' which is Croatia's obligation in the framework of the Long-range Transboundary Air Pollution Convention according to the Act on Air Protection (OG 130/11).

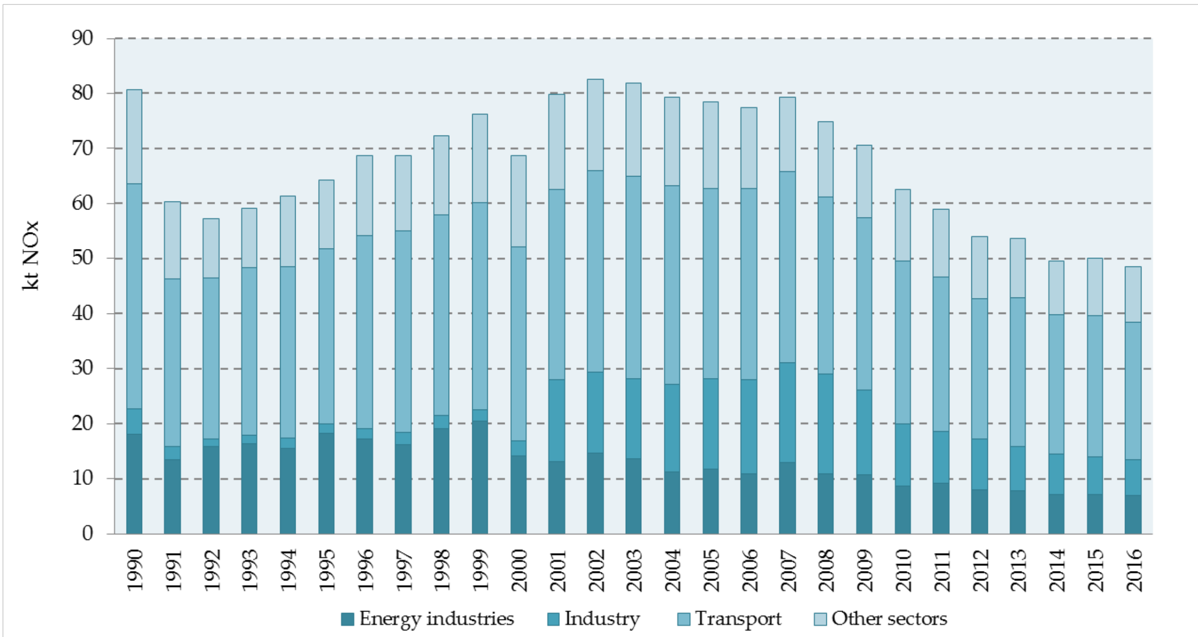
NO_X emissions

The NO_X emission encompasses nitrogen monoxide and nitrogen dioxide emissions. The emissions are expressed as equivalents of 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 2016 was 48.7 kt which is 2.8 percent lower than the year before and 39.8 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 2016 (Figure 3.1-8). The main source of NO_X emission is transport (51.5 percent of total emission in energy sector in 2016). Other sectors accounted for 10.7 percent and emission from industry sector accounted for 13.5 percent to the energy sector in 2016.

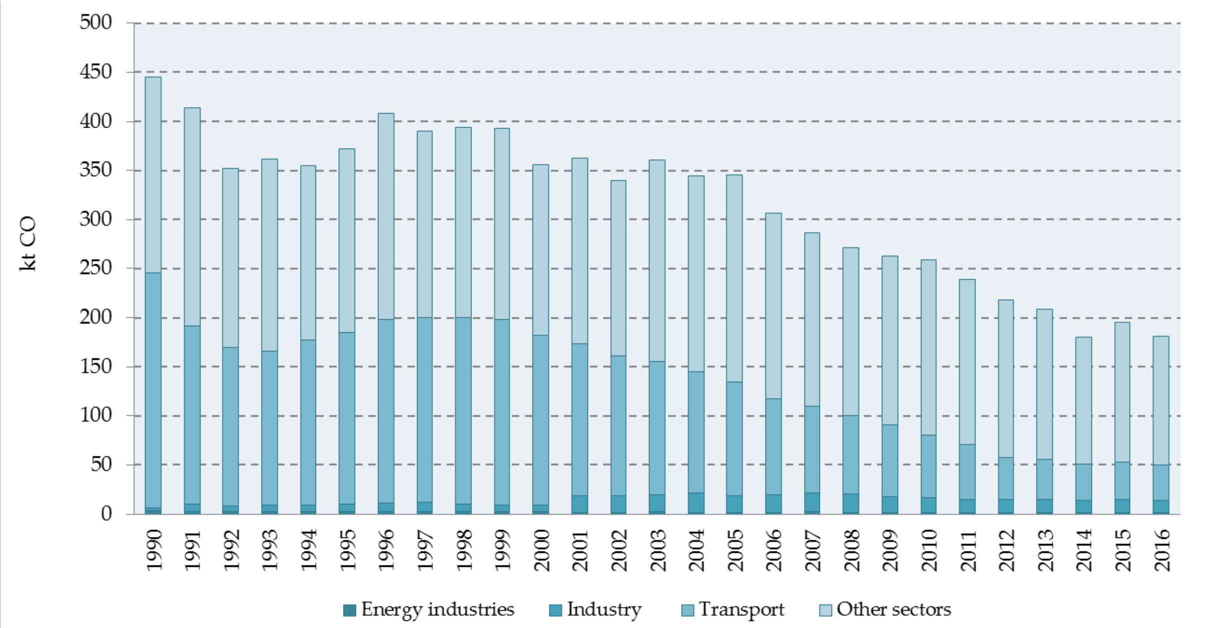
Figure 3.1-8: NO_X emissions from Energy sector in the period 1990-2016



CO emissions

In 2016, the emission of CO from Fuel Combustion Activities was 201.7 kt which is 6.4 percent lower than in the year before and 59.3 percent lower compared to 1990, the year with maximum emission (444.6 kt) of CO in the observed period. The CO emissions from Energy sector in 2016 contribute with approximately 90 percent to national total CO emission. 72.5 percent of CO emission in Energy sector in 2016 was the result of incomplete fossil fuel combustion in Commercial and Residential sector and 20.2 percent in Road transport sector (Figure 3.1-9). Large combustion plants have automatic regulation of air throughput and combustion control, so CO emissions are low (about 0.6% of national total emission).

Figure 3.1-9: CO emissions from Energy sector in the period 1990-2016

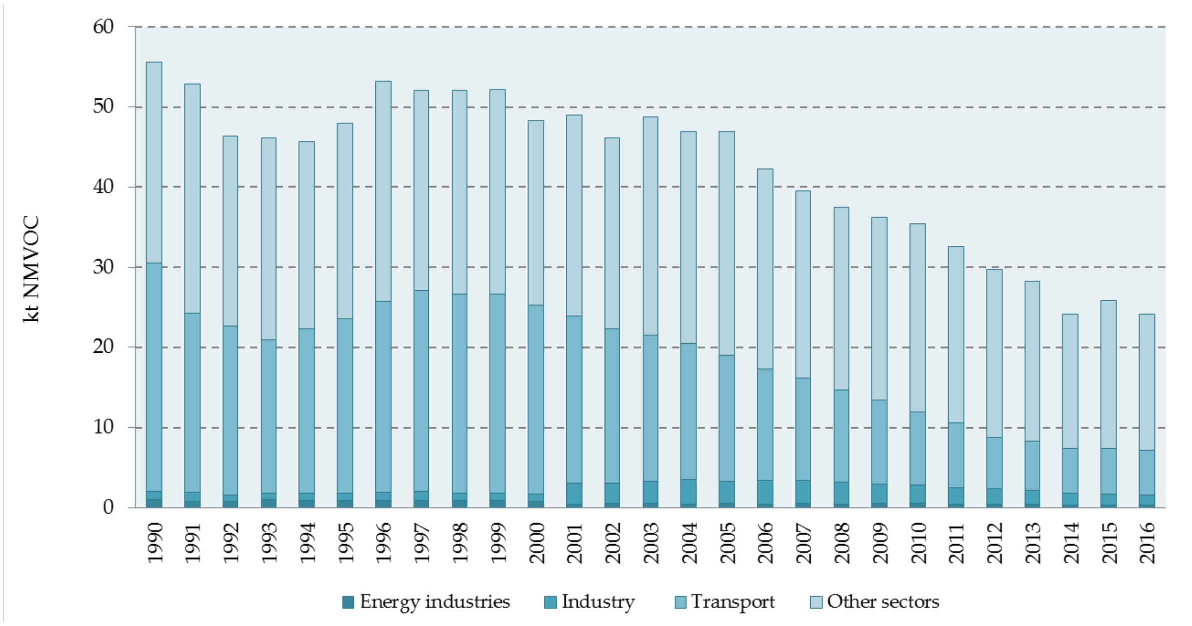


NMVOC emissions

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 27.6 kt in 2016 which was 5.5 percent lower than the year before and 55.3 percent lower than 1990.

The structure of NMVOC emission from Energy sector has not changed significantly in the period from 1990 to 2016 (Figure 3.1-10). The main source of NMVOC emission is stationary combustion sectors accounted with 78.1 percent to the national total, mainly from the Commercial and Residential sector (70.2 percent).

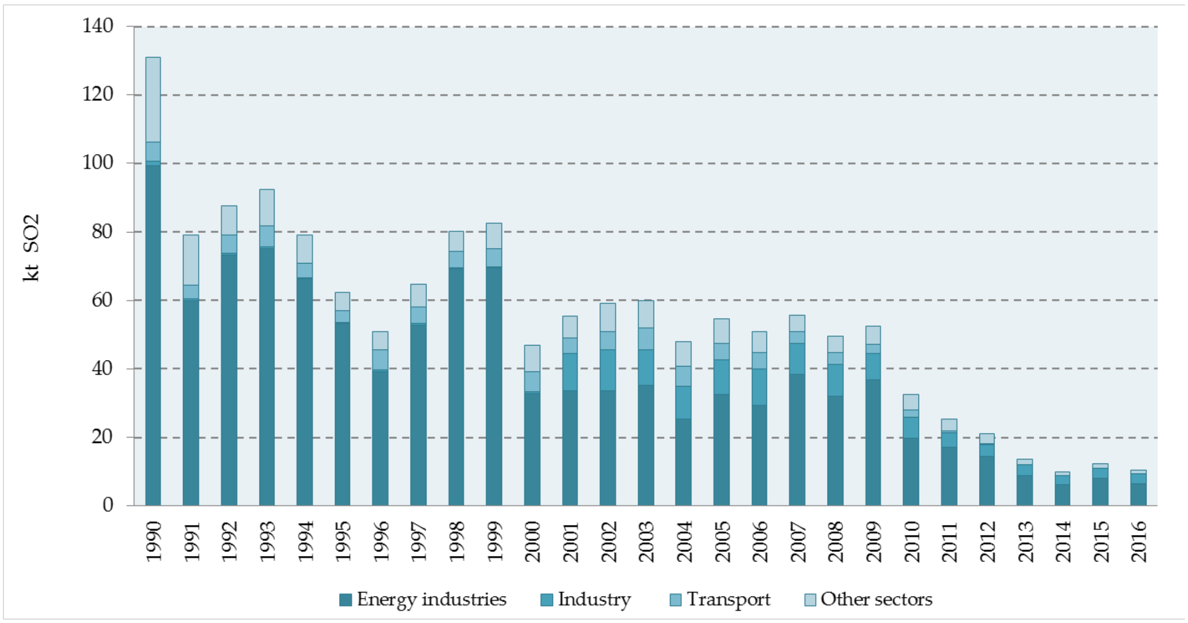
Figure 3.1-10: NMVOC emissions from Energy sector in the period 1990-2016



SO_2 emissions

In accordance with the calculated results, the level of SO_2 emission from Fuel Combustion Activities in 2016 reached 14.5 kt which is approximately 91 percent of total national SO_2 emission. The trend shows that emissions of SO_2 have increased by 7.8 percent compared to the emission in 2016 and decreased by 89.1 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 2016, 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 2016 as well as the share of the particular sectors in total emission of SO_2 in Energy sector 1990 and 2016 is presented in Figure 3.1-11.

Figure 3.1-11: SO_2 emissions from Energy sector in the period 1990-2016



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	2000	2005	2010	2011	2012	2013	2014	2015	2016
Fuel consumption (PJ)										
Ref.appr.	284.14	240.01	281.77	262.82	260.44	242.36	229.52	216.12	221.66	227.07
Sect.appr.	286.87	235.45	280.13	262.61	257.92	243.16	228.35	215.34	220.06	227.96
Rel. Diff.(%)	0.96	-1.90	-0.58	-0.08	-0.97	0.33	-0.51	-0.36	-0.72	0.39
CO_2 emission (kt)										
Ref.appr.	20187.5	16630.3	20020.7	18454.0	18249.6	16718.5	16140.1	15301.1	15704.5	16067.3
Sect.appr.	20078.9	16692.6	19942.8	18312.0	18084.5	16791.3	16066.1	15200.3	15597.7	15987.5
Rel. Diff. (%)	0.54	-0.37	0.39	0.78	0.91	-0.43	0.46	0.66	0.68	0.50

The CO_2 emission calculated by Sectoral approach is lower in comparison to Reference approach. The difference is relatively small (less than 2 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	2000	2005	2010	2011	2012	2013	2014	2015	2016
Liquid fuel consumption (PJ)										
Ref.appr.	179.18	152.46	173.22	142.97	142.89	133.14	123.25	122.53	127.42	125.81
Sect.appr.	181.52	147.92	172.01	142.94	140.49	134.04	122.23	120.54	125.84	126.70
Rel. Diff.(%)	1.31	-2.98	-0.70	-0.02	-1.68	0.67	-0.82	-1.63	-1.25	0.71
CO_2 emission (kt)										
Ref.appr.	13080.7	10984.3	12840.7	10593.6	10501.7	9539.3	9055.6	8956.6	9399.5	9289.6
Sect.appr.	12989.3	11062.3	12743.1	10443.8	10331.0	9607.8	8973.8	8858.3	9290.6	9209.9
Rel. Diff. (%)	0.70	-0.70	0.77	1.43	1.65	-0.71	0.91	1.11	1.17	0.87

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, coal), 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.

In order to adequately compare Reference and Sectora approach some inconsistences with IPPU sector occur. Detailed elaboration of the comparison methodology is given for 2015. Total amount of natural gas used to calculate emissions of Sectoral approach is calculated with top down approach as Energy supplied-non energy use-losses (87.16-17.15-1.1=68.92 PJ). From this amount natural gas consumed in Transformation sector in NGL plant (0.42 PJ) and Gas works (0.01 PJ) should be subtract because this amounts are used as feedstocks. Amount of CO_2 from natural gas in NGL plant is embed in gasoline and amount of CO_2 from natural gas in gas works is embed in gas works gas. So total amount of natural gas used in Sectoral approach is 68.49 PJ which is identical to CRF value mentioned in question.

To conciliate Reference with sectoral approach in "Apparent energy consumption excluding Non-energy uses" amount of natural gas which is lost and amounts of natural gas used in Transformation sector in NGL plant (0.42 PJ) and Gas works (0.01 PJ) are added to non-energy consumption. Total amount of natural gas that is not part of sectoral combustion processes for 2015 is 18.68 PJ (17.15+1.1+0.42+0.001).

In table 1A(b) amount of carbon not emitted is calculated as a multiplication 18.68 PJ and FE for C (15.3 kg/GJ).

In table 1.A(d) only amount of natural gas specified in Croatian energy balance as non-energy use-Petrochemical industry is entered. CO_2 emission is calculated using default carbon content. This CO_2 emission is lower than CO_2 specified in Table2(I)s1 because according to 2006 IPCC guidelines amount of CO_2 recovered is subtracted.

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 2016 consumption of solid fuel and CO_2 emission are the same for both approaches as wll as for gaseous fuels.

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 2016

	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Liquid fuel consumption (TJ)										
Aviation bunkers	6945.7	2813.4	3604.7	4132.2	4352.0	4615.8	5055.4	5077.4	4884.0	5182.9
Marine bunkers	1936.8	757.4	1047.8	255.0	983.9	NO	NO	NO	72.1	175.6
Total bunkers	8882.5	3570.8	4652.5	4387.2	5335.9	4615.8	5055.4	5077.4	4956.1	5358.5
CO_2-eq emission (kt)										
Aviation bunkers	500.8	202.9	259.9	298.0	313.8	332.8	369.6	371.2	357.1	378.9
Marine bunkers	148.7	58.2	80.6	19.8	76.7	NO	NO	NO	5.4	13.3
Total bunkers	649.5	261.1	340.5	317.8	390.5	332.8	369.6	371.2	362.5	392.2

Total CO_2-eq from the international bunker in 2016 amounted to 392.2 kt which is 8.2% higher than in 2015 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 2016, as separate data. Until the year 1994, international marine bunkers are based on expert estimation. From 1994 distribution of fuels in category marine bunkers in Croatia is handled by company INA - Oil Industry dd segment activity SD Retail trade. Questionnaire which is filled by the Croatian oil company INA on fuel consumed in domestic and international navigation is used for fuel statistics data. Concerning international navigation, INA reported that from 2012 did not sell any fuels to international ships because the company does not have adequate infrastructure for filling tanks of international ships.

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 project 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 project was 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 project was 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 was to determine actual consumption of fuel on domestic and international routes. The revised values on fuel consumptions were determined for the whole period from 1990 to 2014 and were used to calculate emissions from Aviation Bunkers.

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.)

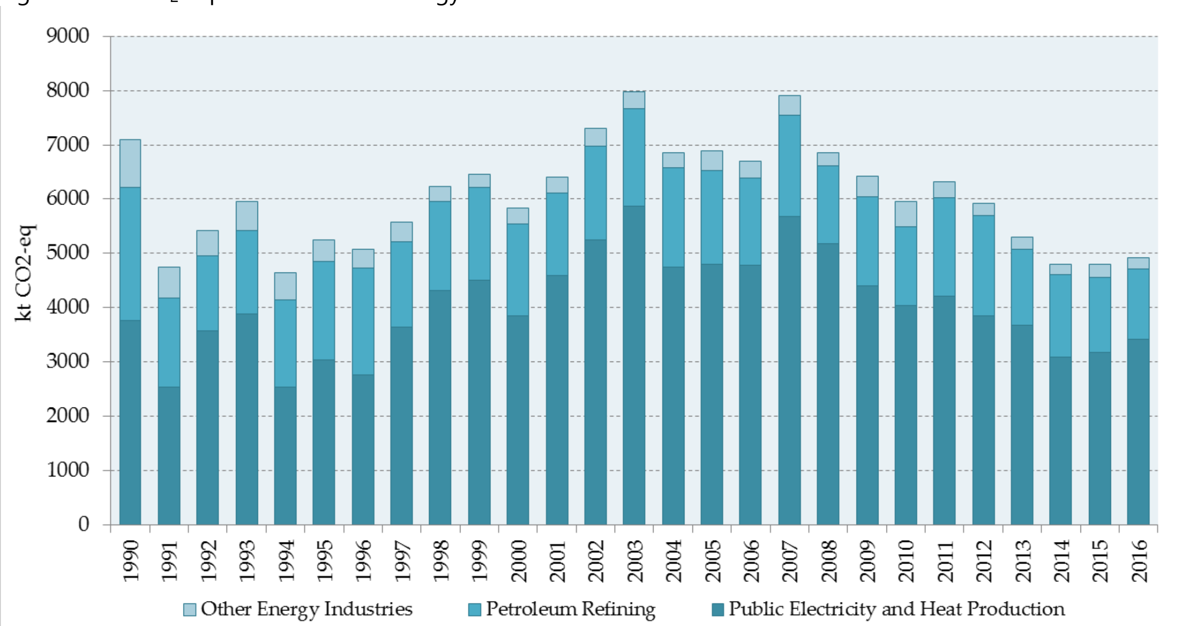
3.2.4.1. Category description

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 3.2-5 and Figure 3.2-1.

Table 3.2-5: The CO_2-eq emissions (kt) from Energy Industries

CO_2-eq emission (kt)	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Public Electricity and Heat Product.	3,768.2	3,840.0	4,794.5	4,037.0	4,217.5	3,851.2	3,673.0	3,094.2	3,169.7	3,415.0
Petroleum Refining	2,451.9	1,704.3	1,733.8	1,452.7	1,809.3	1,852.7	1,397.3	1,518.7	1,390.1	1,301.2
Other Energy Industries	874.2	295.0	352.5	461.5	298.4	218.4	229.5	178.2	235.7	201.1
Total Energy Industries	7,094.3	5,839.4	6,880.9	5,951.1	6,325.2	5,922.3	5,299.8	4,791.0	4,795.4	4,917.3

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 4,105 MW (including TPP Plomin and excluding NPP Krško). Total capacities serving the needs of the Croatian electric power system amount to 4,453 MW (with 50% of Krško capacities). Out of this amount, 1,906 MW is placed in thermal power plant, 2,199 MW in hydro power plant and 348 MW in the nuclear unit Krško (50% of total available capacity). These capacities do not include generating units in other countries from which the Croatian electric power system has the right to withdraw electricity on the basis of capacity lease and share-ownership arrangements. Generating capacities of HPPs, TPPs and NPP Krško are presented in the Table 3.2-6.

Table 3.2-6: Generating capacities of HPPs, TPPs and NPP Krško

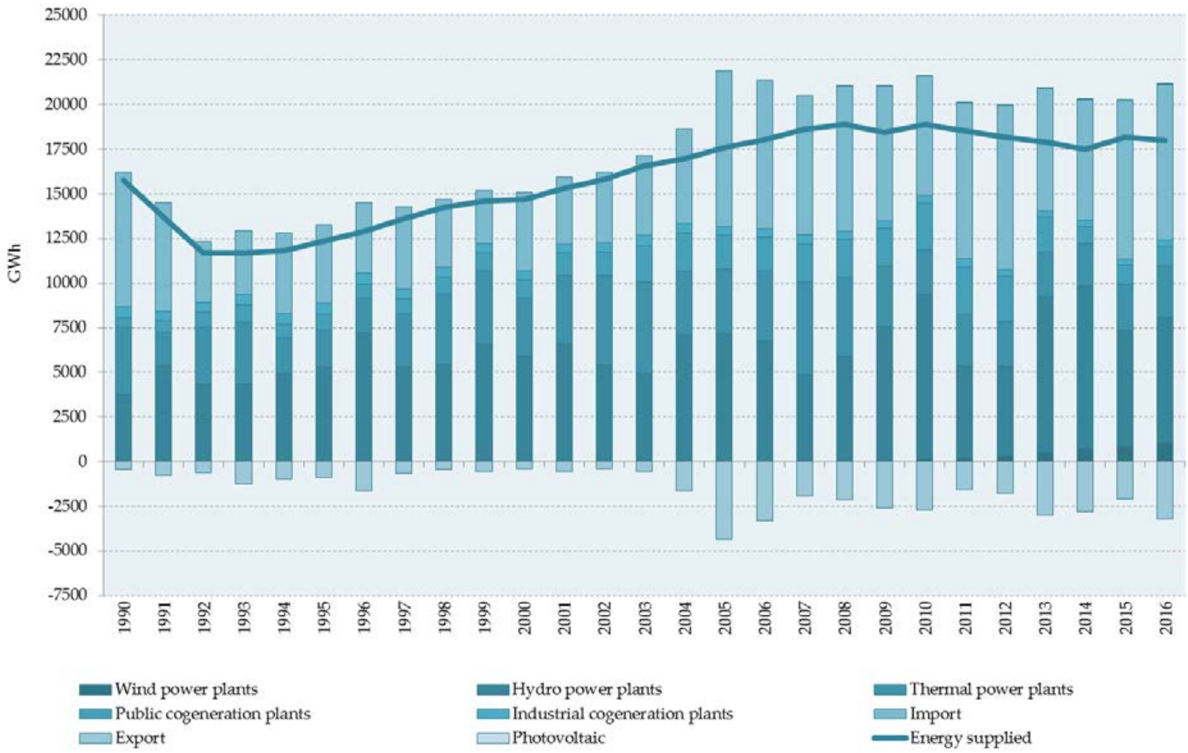
	Available Power (MW) Net Output	Fuel
HPPs	2,198.7	-
NPP Krško*	348.00	uranium oxide (UO_2)
TPP Plomin 1	105.00	coal
TPP Plomin 2**	192.00	coal
TPP Rijeka	303.00	fuel oil
TPP Sisak	631.00	fuel oil / natural gas
CHP Zagreb (east)	422.00	fuel oil / natural gas / extra light oil
CHP Zagreb (west)	89.00	fuel 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)	4,452.70	

* 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 2016 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 2016, the import of electricity was about 50 percent of total electricity consumption in Croatia. Electricity supply for the period from 1990 to 2016 is presented in Figure 3.2-2.

Figure 3.2-2: Electricity supply for the period from 1990 to 2016



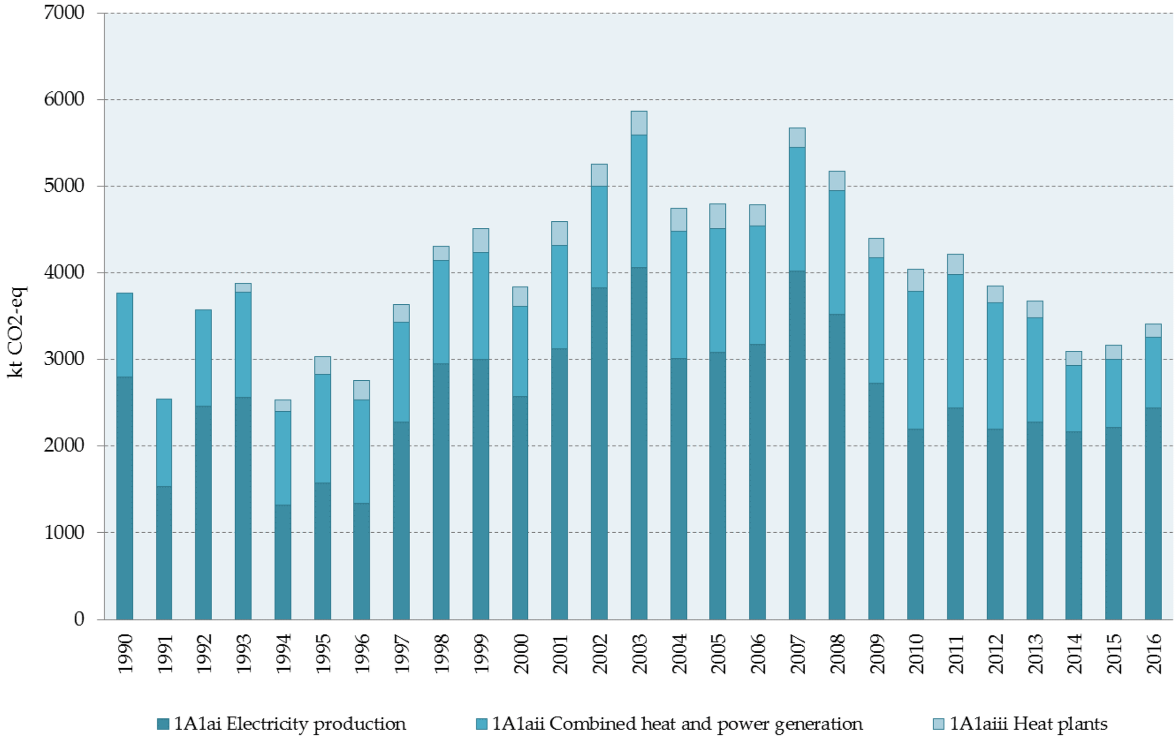
In this subsector there are few types of plants:

- 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 2000, 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 2016.

Figure 3.2-3: CO_2-eq emissions from Public Electricity and Heat Production subsectors

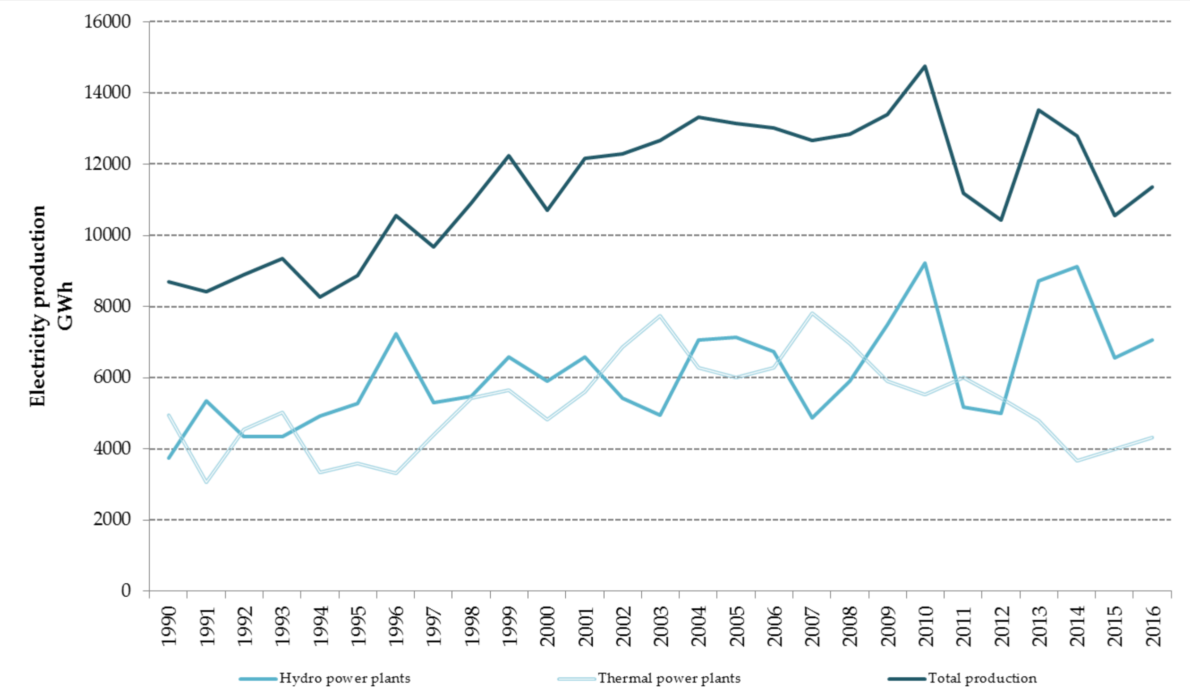


Production of electricity has increasing trend through the years, from 8 TWh (1990) to 13 TWh (2010) but CO_2 emission does not follow this trend. Approximately 53 percent of electricity is generated in hydro power plants (HPP), but this percent depends on hydrological conditions during the year. If 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 2016 is presented in Figure 3.2-4. In 2016, the total electricity production was 7.8 percent higher than in the former year. Increase in energy consumption are mostly due to favorable hydrological conditions which leaded to increase in electricity production from hydro power by 7.7 percent (Table 3.2-7) and from renewables by 41.7%.

Table 3.2-7: Differences between electricity production in 2015 and 2016

ENERGY BALANCE	Electricity, GWh		Difference 2016-2015	Difference %
	2015	2016		
Production	11,402.0	12,449.0	1,047.0	9.2
Hydro power plants	6,555.4	7,057.6	502.2	7.7
Wind power plants	796.3	1,014.2	217.9	27.4
Photovoltaic	57.3	65.5	8.2	14.3
Thermal power plants	2,595.9	2,893.5	297.6	11.5
Public cogeneration plants	1,087.6	1,087.6	0.0	0.0
Industrial cogeneration plants	309.5	330.6	21.1	6.8
Import	8,868.5	8,731.3	-137.2	-1.5
Export	-2,080.1	-3,200.4	-1,120.3	53.9
Total consumption	18,190.4	17,979.9	-210.5	-1.2

Figure 3.2-4: Domestic production of electricity by sources for the period from 1990 to 2016



Fuel consumption, net calorific values and emission factors used for estimating GHG emissions for the years 1990, 2000, 2005, 2010 and for period 2011-2016 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 3.2-8.

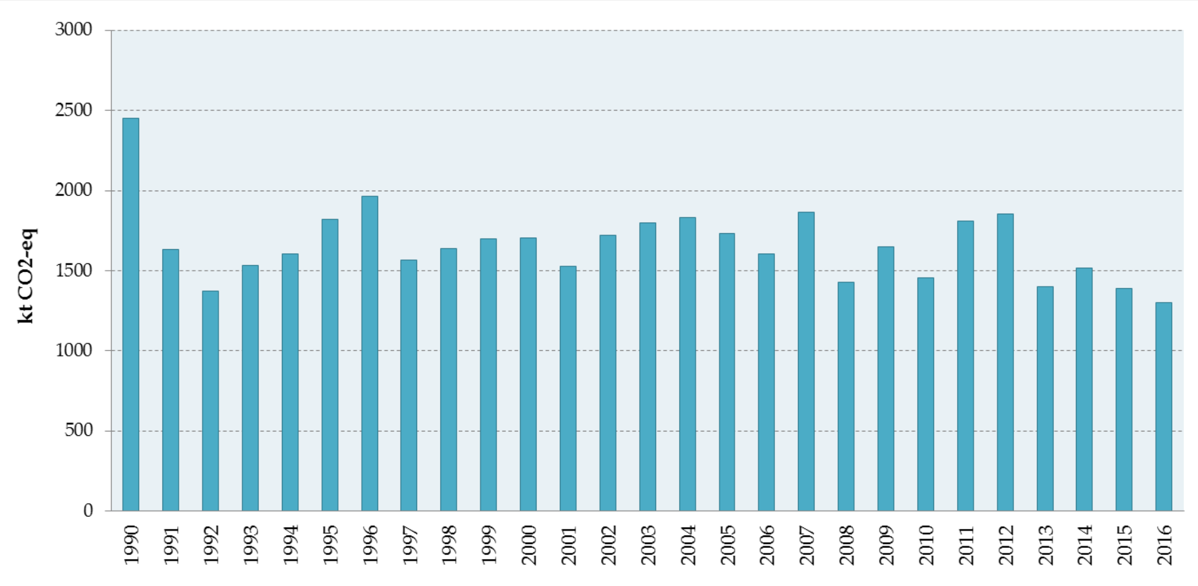
Table 3.2-8: Processing Capacities of Oil and Lube Refineries

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 A3-4 of the Annex 3.

Figure 3.2-5: CO_2-eq emissions from Petroleum Refining subsector for the period from 1990 to 2016



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

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

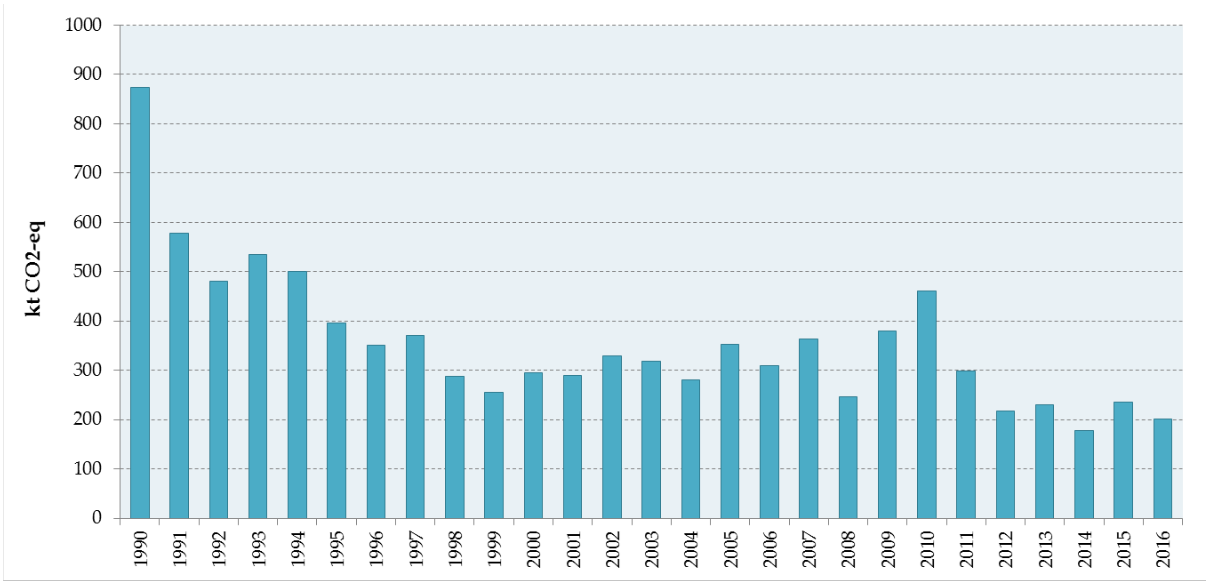
Natural gas is produced from 17 on-shore gas fields and 3 off-shore gas fields, which covers about 63.1 percent of total domestic demand in 2016. The largest share of gas is coming from fields Molve and Kalinovac. They include the units for processing and preparation of gas for transportation to Central Gas Stations (CGS) Molve I, II and III. Their capacities are:

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

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

CO_2-eq emissions from this subsector for the whole period from 1990 to 2016 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 2016



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

Recalculations were not performed in this sector in NIR 2018.

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

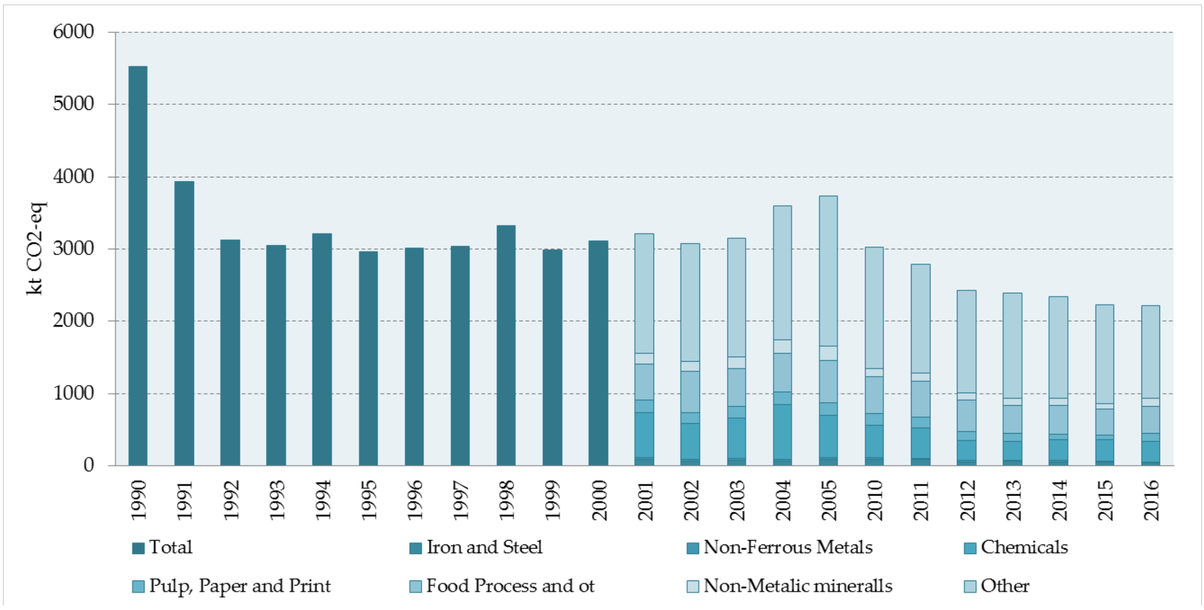
Manufacturing Industries and Construction includes emissions from fuel combustion in different industries, such as iron and steel industries, industries of non-ferrous metals, chemicals, pulp and paper, food processing, beverages and tobacco, construction and building material industries, petrochemical 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 2016 exept for 2013. For 2013 Indusrty analysis balance was estimated using consumption rations from Industry analysis balance for 2012.

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	2000	2005	2010	2011	2012	2013	2014	2015	2016
Iron and Steel Industry	IE	IE	89.2	93.1	84.3	51.2	58.5	55.9	51.7	34.0
Non-Ferrous Metals	IE	IE	21.2	14.0	18.6	19.8	20.0	18.7	10.9	10.7
Chemicals	IE	IE	581.7	450.2	418.2	280.0	253.5	288.4	294.7	296.7
Pulp, Paper and Print	IE	IE	175.0	162.1	148.8	127.1	113.8	71.5	70.2	105.6
Food Proc., Bev. and Tobac.	IE	IE	594.2	515.4	497.1	430.9	389.1	400.7	351.8	377.8
Non-metallic minerals	IE	IE	192.6	115.5	112.3	100.0	96.6	94.8	81.8	110.4
Other	IE	IE	2,085.2	1,679.8	1,512.9	1,412.9	1,461.4	1,404.9	1,370.9	1,280.1
Total Manuf. Ind. and Cons.	5,529.0	3,115.6	3,739.1	3,030.1	2,792.2	2,421.9	2,392.9	2,334.9	2,232.0	2,215.3

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 2001-2016 (Industry analysis balance) exept for 2013. For the 2013 Industry analysis balances were not available so Industrial heating plants were divided on appropriate branches using ratio consumed fuel in each Industry branch/total consumed fuel in industry calculated from 2012 Industry analysis balance.

Data from the national energy balance were recalculated from natural units into energy units by means of its net calorific values for each fuel. Calorific values are also taken from the energy balance. The emission factors used for calculation are taken from IPCC Guidelines (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

Recalculations were not performed in this sector in NIR 2018.

3.2.5.6. Category-specific planned improvements

On short term basis inventory team is planning to divide total consumption of fuel to appropriate branches for the whole period from 1990 to 2000.

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)

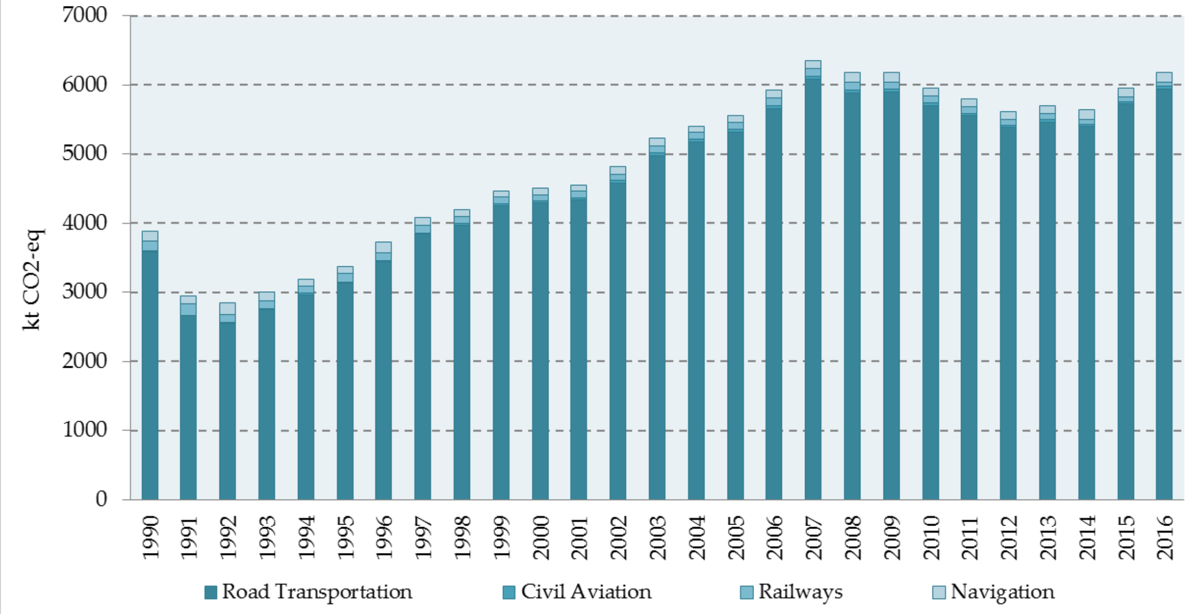
3.2.6.1. Category description of Transport sector

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	2000	2005	2010	2011	2012	2013	2014	2015	2016
Civil Aviation	6.7	25.7	38.0	31.7	34.8	31.7	31.7	30.7	31.1	31.4
Road Transport	3,585.2	4,289.8	5,314.1	5,702.4	5,552.6	5,381.9	5,462.1	5,399.1	5,727.2	5,943.7
Railways	153.5	96.4	107.7	100.7	93.3	87.6	82.7	74.9	61.8	64.6
Navigation	135.8	87.5	101.7	117.6	118.9	113.1	123.1	137.8	131.7	133.7
Total Transport	**3,881.1**	**4,499.4**	**5,561.6**	**5,952.3**	**5,799.5**	**5,614.2**	**5,699.5**	**5,642.5**	**5,951.8**	**6,173.4**

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 2016 was 36.2%. CO_2-eq emissions from the transport sector in 2016 amounted to 6,173.4 kt, which is 3.7% higher than in 2015 as a result of lower 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 2016 and contributed to the CO_2-eq emissions from the transport sector with 96.3%. In 2016, the Navigation sector was contributed to the CO_2-eq emissions with 2.2%, Railways with 1.0% and Civil aviation (domestic) with 0.5% and (Figure 2.3-8). In comparison with 1990, CO_2-eq emissions from the transport sector were increased by 53.4% 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 2016 amounted 31.4 kt, which is 1.0% higher than in 2015, as a result of fuel jet kerosene consumption increase. In comparison with 1990, CO_2-eq emission was 4.7 times higer as a result of increase 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 24.4% in 2016 and 11.4% in 1990. In the period from 1990 to 2016 emissions from road transportation raised by 53.4% 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 as well as implementation of measures for CO_2 emission reduction according to National Action plan for energy efficiency for the period from 2014 to 2016.

Railways (CRF 1.A.3.c)

The CO_2-eq from the sub-sectors Railways in 2016 was amounted to 64.6 kt, which is 4.4% higher than in 2015 as a result of increase of diesel consumption. In comparison with 1990, CO_2-eq was decreased by 57.9% as a result of decrease in railways transportation and consequently decreases in fuel consumption.

Navigation (CRF 1.A.3.d)

The CO_2-eq from the sub-sectors Navigation in 2015 was amounted to 133.7 kt, which is for 1.4% higher than in 2015 as a result of increase in fuel consumption. In comparison with 1990, CO_2-eq decreased by 1.6% as a result of decrease in navigation traffic and consequently decrease 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.

In previous National Inventory Reports Croatia used ERTs' methodology which was prescribed during in country review process in 2008. The ERT strongly recommended that Croatia revise its emission estimates using the number of passengers travelled on domestic and international routes and average kilometres travelled per passenger on domestic and international routes, since these data are available from Croatia's national statistics. Croatia accepted this recommendation and emissions from domestic and international transport were estimate by using drivers such as ratio of domestic/international passengers, taking into account average km travelled for passengers on domestic/international routes.

In 2013 and 2014 ARR ERT recommended that Croatia should improve the accuracy and transparency of its reporting in its next NIR by adopting an approach in accordance with accordance with IPCC good practice guidance, such as using aviation fuel use surveys, 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 was decided that current approach was in that time only way for dividing fuel consumed on domestic and international routes.

In 2014 new project 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 project was 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 project was 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 was to determine actual consumption of fuel on domestic and international routes. Results of this project were published in second quarter of 2016 and they were used as activity data for emission calculation. For the period from 2004 till 2016 data on fuel consumed in domestic transport were obtained from Croatian bureau of statistics from Annual report on air transport. The obligation to submit a report is based on Article 38 of the Law on Official Statistics (OG 103/03, 75/09, and 59/12). This report meets all legal entities and parts that are registered in the activities of air transport and legal persons as well as registered in other activities but dealing with transporting passengers and cargo with aircrafts. Entities are required to submit purchased and consumed fuel as separate date. Consumed fuel has to be submitted in four categories:

- consumed in public domestic transport
- consumed in public international transport
- consumed in schooling and training
- consumed in other activities if exists

For the period from 1990 to 2003, separate data on consumed fuel in domestic and international transport were not available so other statistical data were used to calculate drivers which were used to estimate fuel consumed. Four drivers were developed for domestic transport: fuel by number of passengers travelled, fuel by kilometres travelled, fuel by number of flight and fuel by aviation kilometres. Final driver, which was used for fuel consumed in civil aviation calculation, was determined graphically as average of all drivers.

Quantities of fossil fuel consumed their net calorific values and appropriate GHG emission factor and GHG emissions in the sub-sector Civil aviation for the years 1990, 2000, 2005, 2010 and for period 2011 - 2016 are shown in the Table A3-11 of the Annex 3.

Road Transport

Emissions of CO_2 from liquid and gaseous 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 2016 were extracted from national energy balances. Emissions factors used for calculating CO_2 emissions from liquid and gaseous fuels are from 2006 IPCC guidelines (page 3.16, Table 3.2.1.).

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.

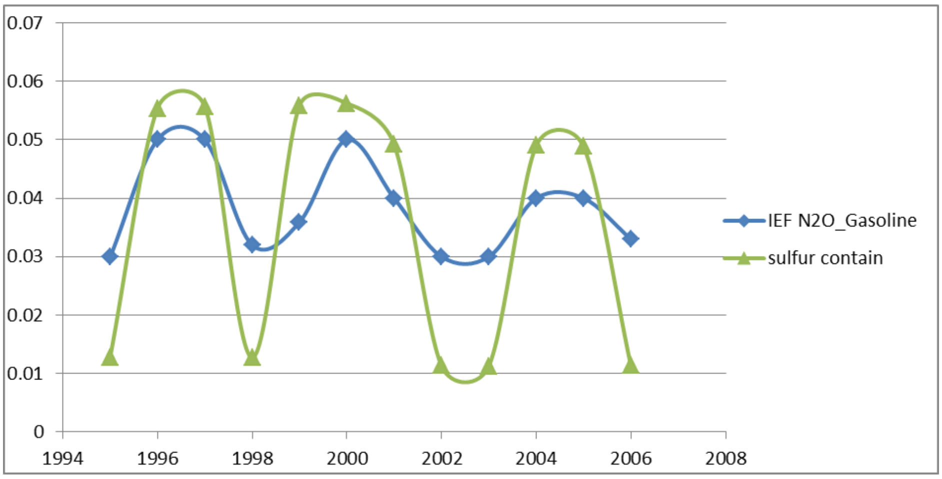
Two assumptions/adjustments are applied in the COPERT model:

- 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 – 2016 are presented in the Table A2-10 of the Annex 3. Comparing the total number of vehicles in 2016 with the number of vehicles in 1990 it can be notice the increase by 52.4 percent. The increase was largely the result of increase in the number of passenger cars by 38.5 percent, constituting 82.3 percent of the total number of road vehicles in 2016. Other classes of vehicles were also increased in this period: the number of Light Duty vehicles increased for 2.3 times, Heavy Duty vehicles included buses increased by 20.5 percent, motorcycles and mopeds for 5.5 times. It is important to emphasize that number of registered vehicles gradually decreased in the period 2008-2014 due to economic crisis, where number of passenger cars which have a highest share in total number of vehicles decreased by 1.3 percent.

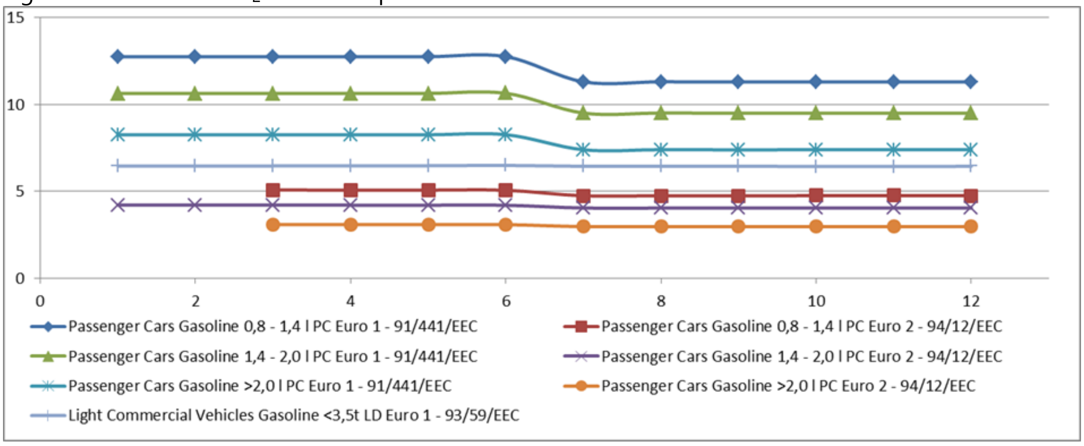
During review of NIR 2014, ERT noticed the fluctuation in the IEF values for the time period 1995-2006 for N_2O emissions. Fluctuations occur only in Sector Passenger cars , subsector Gasoline 0,8-1,4 l, 1,4-2,0 l and >2,0 l, Technology PC Euro 1. These fluctuations are direct in line with fluctuations in sulphur contained of Gasoline fuel (see figure 3.2-9). Data on sulphur contain in fuels are given from Croatian Oil Company.

Figure 3.2-9: Fluctuations in IEF for N_2O and fluctuations on sulphur 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 3.2-10).

Figure 3.2-10: IEF for N_2O when sulphur content is constant

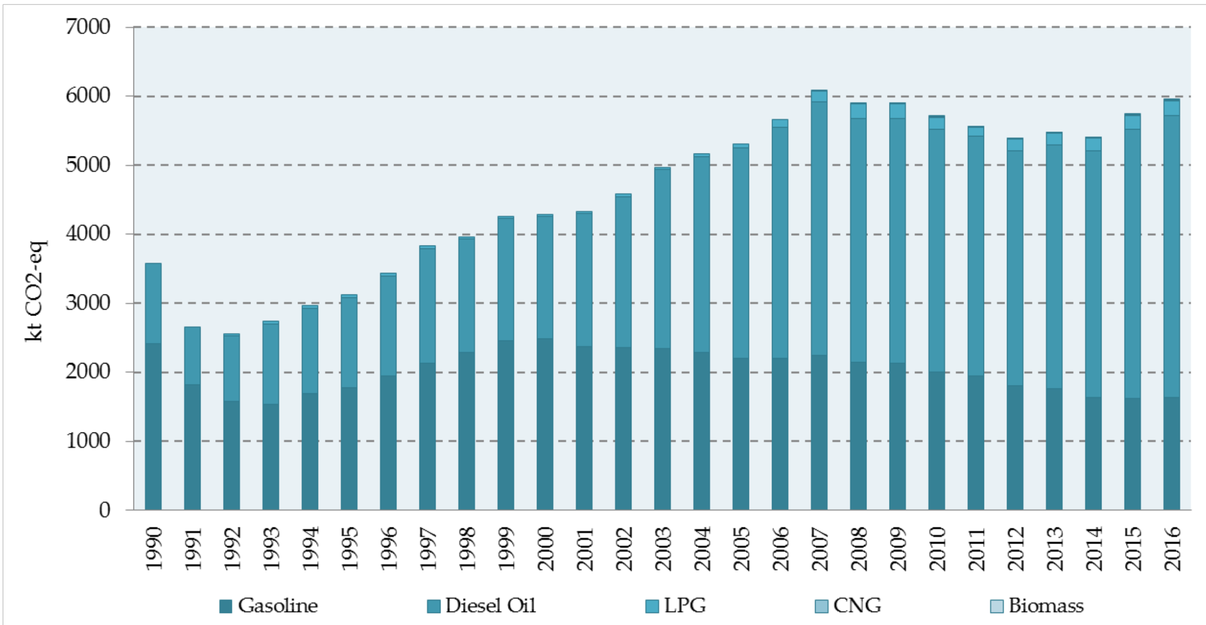


Amounts of fuels consumed, their net calorific values and appropriate GHG emission factors and GHG emissions in the sub-sector Road transport for the years 1990, 2000, 2005, 2010 and for period 2011 - 2016 are shown in Table A3-12 Annex 3.

The CO_2-eq from the sub-sectors Road transport in 2016 amounted to 5,943.7 kt, which is 3.6 percent higher than in 2015 as a result of increase in fuel consumption. In comparison with 1990, CO_2-eq increased by 65.8 percent as a result of grow in diesel fuel consumption (by 3.5 times compared to 1990). At the same time gasoline consumption was decreased by 31.2%.

Trends of CO_2-eq emissions for fossil fuel type consumed in road transport for the period from 1990 to 2015 are shown in Figure 3.2-11.

Figure 3.2-11: The CO_2-eq emission from Road transport sub-sector by fossil fuel type for the period from 1990 to 2016



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 2014 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 - 2016 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 - 2016 are shown in the Table A2-15 of the Annex 3.

Pipeline transport

In Croatia all compressor stations are electric, so no emissions occurred from this source for the whole period from 1990 to 2016. As a confirmation of this claim, in IEA and EUROSTAT energy balance data on consumption of all fuel use for pipeline transport can be found for the whole historical period. In IEA and EUROSTAT energy balance for the whole period, consumption of gas and oil in pipeline transport was 0 TJ. In 2015 for Pipeline transport 3 ktoe electricity is consumed.

In Croatian NGL plant natural gas is consumed in compressor station, but according to IEA methodology only fuel used in compressor stations for oil and natural gas transport through pipelines are part of Pipeline transport sector (excluding compressors on plant location).

Data on input and output fuels from NGL plant Ivanić Grad are collected via annual questionnaire (for the whole historical period). Although according to IEA methodology only input and output of fuels in NGL plant accounts in energy balance (excluding own use), in National energy balance own use of fuels in NGL plant are accounted too. Total amount of fuel used for own use in NGL plant is specified in national energy balance in section Energy sector own use-NGL plant (Tables A4-1 and A4-2 of Annex 2). For 2014 in NGL plant only natural gas was used in own use purposes (3.3*106 m^3). This amount of fuel with all other oil and gas extraction in energy industries are summed in 1A1cii sector.

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 CO_2 emissions from liquid fuels. This is in line with recommendation from the IPCC good practice guidance. The difference between these two approaches is 0.57 percent for combined CO_2 emissions from gasoline and diesel oil in 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

Road Transport

In 2017 Croatia had Comprehensive Technical Review of National Emission Inventories pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (Directive (EU) 2016/2284). TERT noted that there is a lack of transparency regarding the jump in activity data and emissions for 2008 vs 2007 and for 2005 vs 2004. For emission calculation and fuel calculation Croatia uses COPERT model. Except total fuel consumptions by fuel type inputs in COPERT model are population and mileage. Population is obtained from a vehicle database and annual average vehicle mileage is parameter that is estimated so fuel consumption calculated with COPERT should be to a highest possible degree equal to consumption of fuels from the national energy balance. The reason for the jump in the AD and emissions is higher estimated mileage for diesel LDV and Mopeds & Motorcycles. Croatia recognized the need for improvement of expert mileage assessment in 2008 for light duty vehicles and and expert mileage assessment in 2005 for mopeds and motocycles. Data on mileage for light duty vehicles for 2008 were adjusted with mileage for heavy duty vehicle and data on mileage for mopeds and motocycles for 2005 were adjusted with mileage for passenger cars. Total activity data and emissions was not changed significantly after new mileage assessment because total fuel consumption calculated by COPERT was equal to fuel specified in the energy balance. Due to the above mentioned, only the redistribution of the emissions occurred and the differences in emissions is minimal.

During QA/QC checks for other years we noticed discrepancy in 2009 mileage expert judgment for LDV and HDV vehicles. For emission calculation and fuel calculation Croatia uses COPERT model. Except total fuel consumptions by fuel type inputs in COPERT model are population and mileage. Population is obtained from a vehicle database and annual average vehicle mileage is parameter that is estimated so fuel consumption calculated with COPERT should be to a highest possible degree equal to consumption of fuels from the national energy balance. The reason for the jump in the AD and emissions is higher estimated mileage for diesel HDV. Total activity data and emissions was not changed significantly after new mileage assessment because total fuel consumption calculated by COPERT was equal to fuel specified in the energy balance. Due to the above mentioned, only the redistribution of the emissions occurred and the differences in emissions is minimal.

3.2.6.6. Category-specific planned improvements

Civi 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 transport was gathered for the period from 1990 to 2013. It is planned to include those data in calculation of greenhouse gas emissions.

Long term basis 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)

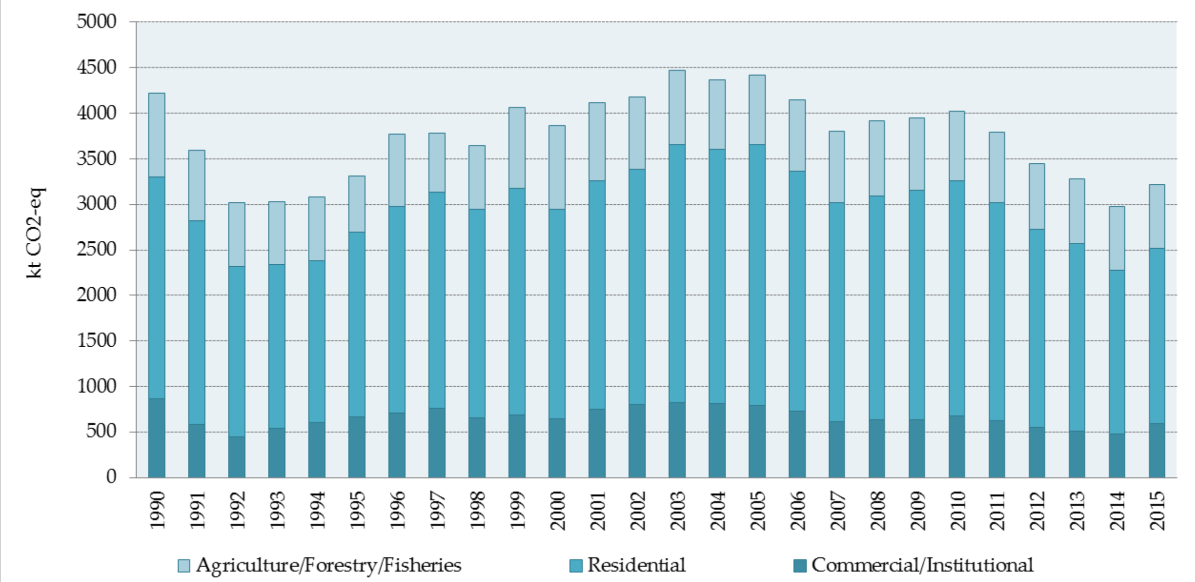
3.2.7.1. Category description

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 3.2-12.

Table 3.2-12: The CO_2-eq emissions (kt) from Small Stationary Energy Sources

	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Commercial/Instit.	858.9	644.0	792.7	674.4	621.1	545.7	512.0	474.5	587.8	611.4
Residential	2,437.5	2,304.3	2,862.8	2,578.7	2,397.1	2,177.4	2,060.4	1,798.8	1,930.9	1,960.7
Agric./Fores/Fishing	921.5	916.9	764.5	771.2	770.3	718.1	702.3	701.2	700.8	704.8
Total	**4,217.9**	**3,865.1**	**4,420.1**	**4,024.4**	**3,788.5**	**3,441.2**	**3,274.8**	**2,974.6**	**3,219.5**	**3,276.8**

Figure 3.2-12: 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 for the period from 1990 to 2016.

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.

In 2014 project 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 project was 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 was 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 was to determine actual consumption of biomass fuel in households. As expected, the amount of consumed biomass in households increased in 2014 by 30 PJ compared to 2013. Amount of consumed biomass increased for the whole period from 1990 to 2013 approximately by 30 PJ. Data for whole historical trend were included in this submission.

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

In Other sector no recalculations were performed in NIR 2018.

3.2.7.6. Category-specific planned improvements

Long term basis improvements

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

3.2.8. Other (CRF 1.A.5)

3.2.8.1. Category description

During 2016 centralised review ERT an TERT noticed that military fuel used has not been included in NIR. It is recommended that this part should be done in a way to improve transparency of reporting without affecting the confidentiality of information.

In national energy balance military aviation and military water borne is included under domestic aviation and navigation sector. Data on fuel sold on each airport/marina are collected via annual questionnaire by Croatian statistical office. This amount of fuel include as well fuel used for military purposes.

Dividing military from domestic aviation/navigation sector is not possible because data for military only are not available and it is not economically justified because fuel used for military purposes is negligibly small for the whole historical period. Domestic aviation sector contributes only with 0.13 % (in 2016) to total emissions of Croatia while navigation contributes with 0.56 % (in 2016). It is most likely that contribution of military aviation and navigation is below the threshold of significance. Emissions from military are all included in 1A3b sector. For transparency purposes in subsector 1A5b, two subsectors were created:

- 1A5b-military aviation component
- 1A5b-military water-borne component.

This two categories were be completed with IE notation key.

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)

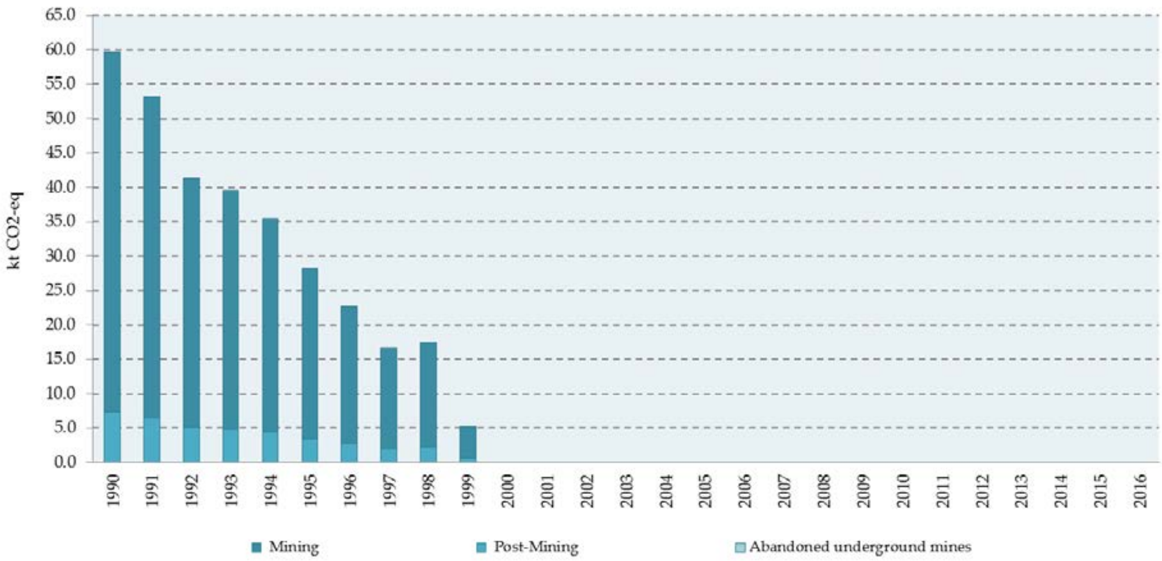
3.3.1.1. Category description

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 2016. 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 1901-2016

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	-	-
2000-2016	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

In sector 1B1 recalculations were not performed.

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. Oil 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.

1.B.2.a. Oil

Exploration production and transport of oil in the Republic of Croatia is carried out by company INA - Oil Industry dd in the segment activity SD Exploration & Production of oil and gas (formerly INA NAFTAPLIN). In Croatia, 34 oil fields are active, and the maximum amount of oil came from 8 most important fields, that contain 83% of the total reserves discovered in Croatia. During the war (1991 - 1995) from 34 oil fields, only 22 of them worked. All oil fields in Croatia are “on shore” filds.

Refining / storage in the Republic of Croatia is carried out in an oil refinery owned by a company INA - Oil Industry dd at two locations in Rijeka (INA - RNR) and Sisak (INA - RNS). Production capacities of the Croatian refineries are shown in Table 3.2-8.

1.B.2.b. Natural gas

In Croatia, the production/processing, and transmission of natural gas takes place in private facilities. Extraction and production of natural gas in Croatia carried out by INA - Oil Industry dd in the segment activity SD Exploration & Production (formerly INA NAFTAPLIN). The main gas fields with 70% of total reserves are located in the three largest gas and gas-condensate fields, namely Molve, Kalinovac and Stari Gradac in the western part of the Drava depression, along the border with Hungary. The work site "Molve" provides between 70% and 75% of gas and condensate per year in Croatia, satisfying about 50% of the needs. One of the old gas fields around the Sava Depression, turned into underground gas storage capacity of 500 mil. m^3.

Molve processing gas facilities includes plant for treatment and preparation of gas for transportation. Natural gas from gas condensate reservoirs "deep Podravine" except hydrocarbons contains a range of harmful substances (CO_2, H_2S, RSH, Hg, sedimentary water). In order to satisfy the quality of output and safety of the processing plants, harmful impurities is necessary to isolate and eventually disposed of without harm to the environment. 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 gas from production wells is transported trough over six gas collection and transmission systems delivered to the processing facilities Molve.

The gas treatment process is divided into several phases:

- separation - the gas phase is separated of liquid (salt water and gas condensate) - salt water is pumped in negative wells and condensate is shipped to the refinery
- removal of mercury from gas with adsorption activated carbon impregnated with sulfur
- separation of CO_2 and H_2S from gas with absorption using 40% solution of methyldiethanolamine. Process solution passes the cleaning process (regeneration) in striper- column. Cleaned and freed of CO_2 gas is returned back into the system. Acid gases are dispatched to the Lo-Cat unit
- gas dehydration with molecular sieves (CPS III), or with triethylene glycol (CPS II and I) removes the remaining moisture
- NGL section – with supercooling gas process heavier hydrocarbons than ethane are liquefied to higher hydrocarbons. C3 + fraction is sent to fractionation facility Ivanic Grad for further processing, and the remaining gas goes into the distribution system or for internal consumption
- Lo-Cat plant processes the current CO_2 and H_2S released from metyldiatomaceous solution. H_2S is oxidized to the elemental sulphur
- EOR compressors -Part of CO_2 with remaining H_2S is sent to the compression where the pressure from 150 mbar is raised to 30 bar, dehydrates and sent to the plant OFIG where the pressure raised to 90 bar and then to 180 bar with compression. Compressed gas is send by pipeline to the oil fields Ivanić and Žutica where gas is used as a propellant to raise oil production
- RTO units -Part of CO_2 with remaining H_2S goes to RTO units. In oxidation process at 800-900oC H2S is converted to SO_2 and released to the atmosphere (drain height 60 m). Regenerative thermal oxidizer (RTO) is a type of thermal oxidizers whose work is on autothermal principle (without the use of burner). RTO used layers of ceramic media to achieve thermal efficiency. Ceramic material absorbs the heat from the exhaust gas and use the captured heat to heat incoming cold gas. In regulated cycle using two or more layers which operate alternately to the heating of input gas or cooling output gas.

CO_2 balance for the period from 2010 till 2015 is given in Table 3.3-2.

Table 3.3-2: CO_2 material balance for the period 2010-2015

Year	Average annual amount of CO_2 in input gas, vol%	Average annual amount of CO_2 in the output gas, ppm	Quantity of gas, input, m^3/year	Quantity of gas, output, m^3/year	water intake gas obtained at stripping MDEA solution m^3 / year	CO_2 from balance, m^3/year	CO_2 from balance, kg/year	CO_2 obtained by measuring, m^3/year	CO_2 obtained by measuring, released to atmosphere, kg/god	CO_2 obtained by calculation, m^3/year	Compressed in EOR unit, m^3/year	Difference of calculated an measured CO_2, %
2010	25.55	9	1,041,050,600	785,655,500	8,543,900	246,851,200	461,611,744	260,567,592	487,261,397	265,988,428	0	5
2011	26.88	8	1,010,863,066	653,903,801	7,621,100	349,338,165	653,262,369	275,200,410	514,624,767	271,719,992	0	-27
2012	24.96	7	932,917,400	576,545,600	6,339,400	350,032,400	654,560,588	229,515,426	429,193,847	232,856,183	0	-53
2013	25.06	7	962,809,200	696,967,200	6,295,400	259,546,600	485,352,142	218,919,822	409,380,067	241,279,986	0	-19
2014	26.78	7	817,973,320	585,844,400	4,894,900	227,234,020	424,927,617	239,663,586	397,082,883	219,053,255	27,319,798	5
2015	28.46	9	786,636,100	561,619,600	4,896,347	220,120,153	411,624,686	223,559,815	192,349,451	223,876,634	120,699,146	2

CO_2 density on 15ºC is 1.87 kg/m^3

The estimated CO_2 emissions, by the material balance method, are presented in Table 3.3-3

Table 3.3-3: The CO_2 emissions (kt) from natural gas scrubbing in CGS Molve

CO_2 emission (kt)	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Central Gas Station Molve	415.9	633.0	691.2	487.3	509.0	429.2	409.4	397.1	192.3	157.1

Transport system, carried out by transport system operator (OTS) company Plinacro Ltd. and by distribution system operators (34 company). The transport system managed by the transmission system operator Plinacro doo, consists of international, main, regional and developable pipeline and facilities to the pipeline, measuring reduction stations (MRS) of various capacities and other facilities and systems that enable reliable and secure transport system. Basic data of the Croatian transport system are shown in Table 3.3-4.

Table 3.3-4: Basic data on the natural gas transport system of the Republic of Croatia

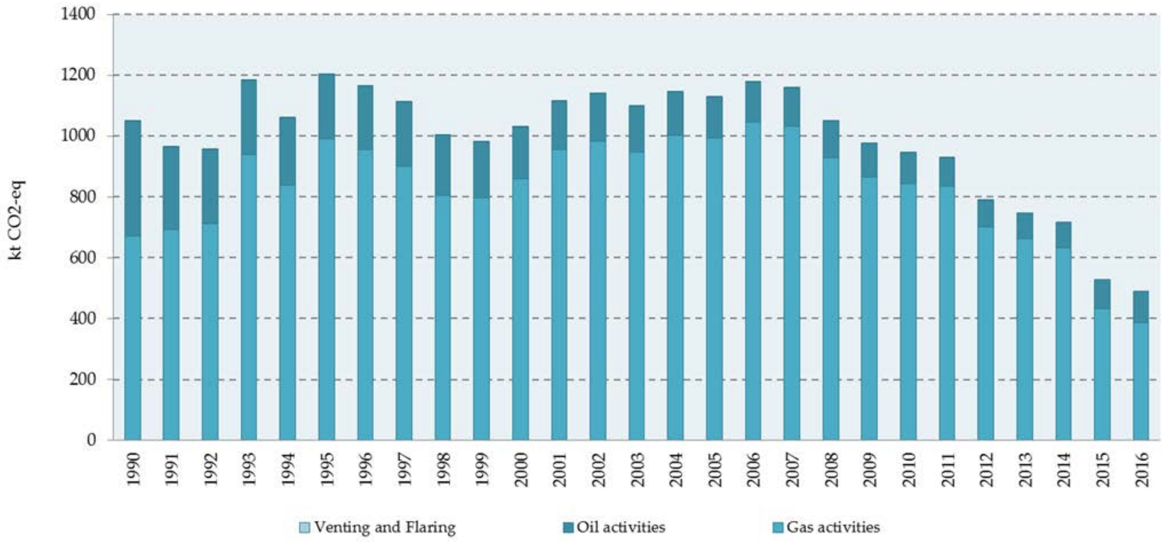
Natural gas transport system of the Republic of Croatia	
Number of transmission system operators	1
The total length of pipeline gas transport system	2 693 km
Interconnection / transmission system operator:	Rogatec / Plinovodi d.o.o. (SLO) Drávaszerdahely / FGSZ Ltd. (HU)
Underground gas storage / gas storage system operator:	Okoli / Podzemno skladište plina d.o.o.
Inputs from domestic production / gas producer	UMS CPS Molve / INA - d.d. UMS Etan, Ivanić Grad / INA - d.d. UMS PS Ferdinandovac / INA - d.d. UMS PS Gola / INA - d.d. UMS PS Hampovica / INA - d.d. UMS Terminal Pula / INAGIP Ltd
Number of connections for end users connection to the transmission system:	34
Number of connections to the distribution systems and the number of distribution system operators:	Number of ports: 153 Number of operators DS: 37
Number of balancing zones:	1

The total GHG fugitive emission from oil and natural gas systems are shown in the Table 3.3-4 and Figure 3.3-2.

Table 3.3-4: The CO_2-eq emissions (kt) from oil and gas systems

	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Oil activities	378.4	171.8	135.0	102.6	94.8	85.6	85.8	84.3	95.4	105.0
Gas activities	670.1	858.9	993.5	843.1	834.5	702.0	662.8	632.2	433.7	386.4
Venting and Flaring	1.2	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Total	**1,049.8**	**1,031.2**	**1,129.0**	**946.0**	**929.5**	**787.8**	**748.8**	**716.7**	**529.3**	**491.6**

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



The CO_2-eq emissions from this sub-sector were 2.9 percent of the total emissions from Energy sector in 2016. From 2006 oil and gas production are continuously decreasing consequently CO_2-eq emission is decreasing too. The amot of the emission in 1990 arised from oil activities (66 percent) while in 2016 the large majority of emissions arised from gas activities (78.6 percent in 2016).

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 SO_2

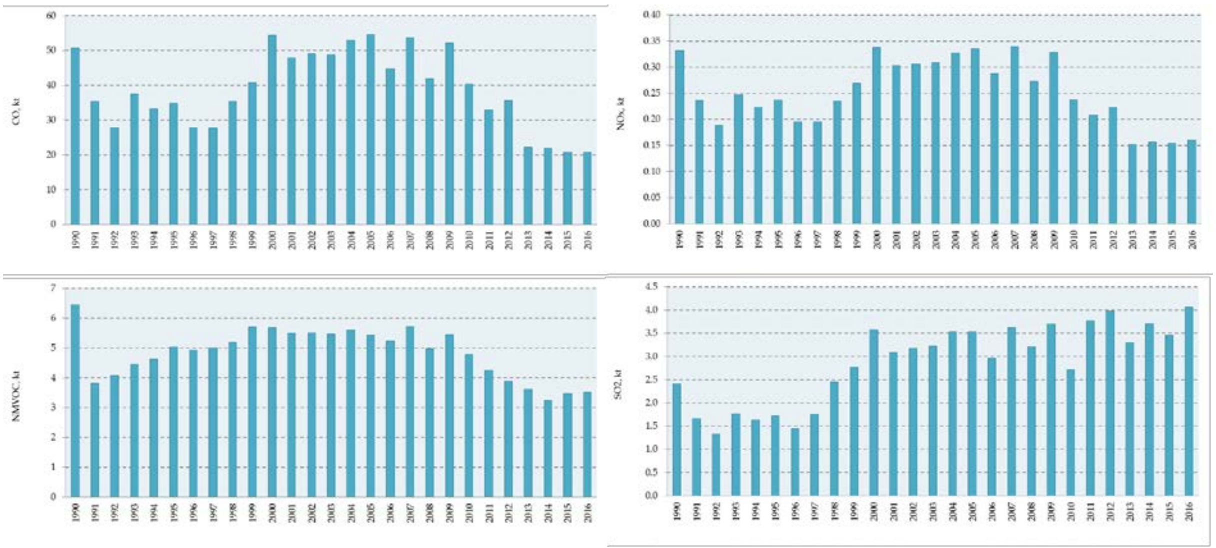
Emissions of indirect GHGs for whole time period (1990-2016) was set up according to the EMEP/CORINAIR methodology. Emissions were obtained from the emission inventory report ‘Republic of Croatia Informative Inventory Report for 2016, under Convention on Long-range Transboundary Air Pollution (CLRTAP)’ 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 3.3-5 and Figure 3.3-3.

Table 3.3-5: The fugitive emissions of ozone precursors and SO2 from fugitive emissions sector

Emissions (kt)	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
CO emission	50.69	54.39	54.71	40.29	32.86	35.59	22.18	21.84	20.74	20.75
NO_x emission	0.33	0.34	0.34	0.24	0.21	0.22	0.15	0.16	0.15	0.16
NMVOC emission	6.45	5.68	5.42	4.80	4.27	3.89	3.62	3.23	3.49	3.52
SO_2 emission	2.42	3.57	3.54	2.72	3.77	3.99	3.29	3.71	3.46	4.06

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



3.3.2.2. Methodological issues

Estimation of Natural gas emissions from Exploration

Natural gas production activity exists in Croatia from 1990. Activity data used from emission calculation was natural gas production taken from National energy balances. In Table 4.2.4 of 2006 IPCC Guidelines (page 4.48) for Well Drilling, Well Testing and Well servicing emission factors are given, but units of measure are Gg per 103 m^3 total oil production. It is concluded that this emission factors relate to oil production only (although the guidelines read that exploration emissions are relevant for both the oil and the natural gas industries). Croatia send this issue to IPCC technical support unit via corresponding query (http://www.ipcc-nggip.iges.or.jp/mail/). Till May 2016 no answer was received so it was decided that emissions from Well Drilling, Well Testing and Well servicing should be estimated with assumption that unit of measure was wrong written, instead of Gg per 103 m3 total oil production should have been written 103m3 total natural gas production.

Fugitive emission of CH_4

For estimating the fugitive emission of methane from oil and gas the simplest procedure has been used (Tier 1), which is based on production, unloading, processing and consumption of oil and gas. According to the IPCC, all countries are divided into regions with relatively homogenous characteristics of oil and gas systems. Croatia used emission factor for developed countries (2006 IPCC Guidelines, pages 4.48-

4.53, table 4.2.4.). For some activities range for emission factor is given in Table 4.2.4., in that case average values were used as emission factors.

Data about quantities of production, unloading, processing, storing and consumption of oil and gas are taken from the national energy balance. Data on oil transported by pipelines were obtained from JANAF d.d. (Jadranski naftovod). Data on oil transported by tankers were obtained from INA d.d. (Industrija nafte).

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. According to the IPCC, all countries are divided into regions with relatively homogenous characteristics of oil and gas systems. Croatia used emission factor for developed countries (2006 IPCC Guidelines, pages 4.48-4.53, table 4.2.4.). For some activities range for emission factor is given in Table 4.2.4., in that case average values were used as emission factors.

Data about quantities of production, unloading, processing, storing and consumption of oil and gas are taken from the national energy balance. Data on oil transported by pipelines were obtained from JANAF d.d. (Jadranski naftovod). Data on oil transported by tankers were obtained from INA d.d. (Industrija nafte).

Fugitive emissions from oil transported by Tanker trucks and Rail cars were estimated for the whole period from 1990 to 2016.

N_2O emission from Oil production was reported under 1B2c2i section because CRF reporter has no possibility of entering N_2O emissions under 1B2a category.

All N_2O emissions from Natural gas production, Processing and Transmission were reported under 1B2c2ii section because CRF reporter has no possibility of entering N_2O emissions under 1B2b category.

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 CO2 content before and after scrubbing units and quantity of scrubbed natural gas.

The fugitive emissions from oil and gas activities are showed in Table A2-19, Annex 3.

'IE' Notation key for CO_2 emissions in 1.B.2.c.2 (Flaring)

In CRF Application in cell comments all necessary comments are entered. Because of bug in CRF application comments are not transferred to CRF tables properly. Data in category 1.B.2.c.2 are allocated in 1.B.2.b category.

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 are 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. The CO2 emission from natural gas scrubbing in CGS 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

In Fugitive emissions from fuels recalculations were not performed in NIR 2018.

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 (GHG) 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 GHGs such as carbon dioxide (CO_2), methane (CH_4) or nitrous oxide (N_2O) are released into the atmosphere.

This chapter includes information on activity data, emission factors and methodologies used for estimating GHG emissions under IPCC Sector 2 Industrial Processes and Product Uses (IPPU) for the period 1990 - 2016. The following sub categories are included: Mineral industry, Chemical industry, Metal industry, Non-energy products from fuels and solvent use, Electronic Industry, Product uses as substitutes for ODS and Other product manufacture and use. Only process related emissions are considered under IPPU sector. Emissions due to fuel combustion in manufacturing industries are allocated to Energy sector (IPCC Category 1.A.2 Fuel Combustion – Manufacturing Industries and Construction).

Industrial processes whose contribution to CO_2 emissions was identified as significant are production of cement and ammonia. Nitric acid production is a source of N_2O emissions. Emissions of CH_4 appear in production of other chemicals.

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 (NOx), 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 prescribes obligation and procedure for emissions monitoring, which comprise estimation and/or reporting of all anthropogenic emissions and removals. According to the requirement, sources of abovementioned greenhouse gases are responsible to report required activity data for more accurate emissions estimation.

Emission factors used for calculation of emissions are, in most cases, default emission factors according to 2006 IPCC Guidelines, mainly due to a lack of plant-specific emission factors. Country-specific emission factors for cement, lime, glass and steel production as well as plant-specific emissions factor for ammonia and nitric acid production were estimated by collecting the actual data from individual plants.

Verified CO_2 emissions reported under EU ETS were available for the years 2012 - 2016 and included in the inventory (process emissions in this chapter). The relavant sources are: 2.A.1 Cement Production; 2.A.2 Lime Production; 2.A.3 Glass Production; 2.A.4 Other Process Uses of Carbonates; 2.B.1 Ammonia Production; 2.B.2 Nitric Acid Production; 2.C.1 Iron and Steel Production. Methodology proposed by the Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2009/29/EC corresponds to the methodology used for the period 1990 - 2011. Data included in emissions estimation are aligned with the data included in the EU ETS reports.

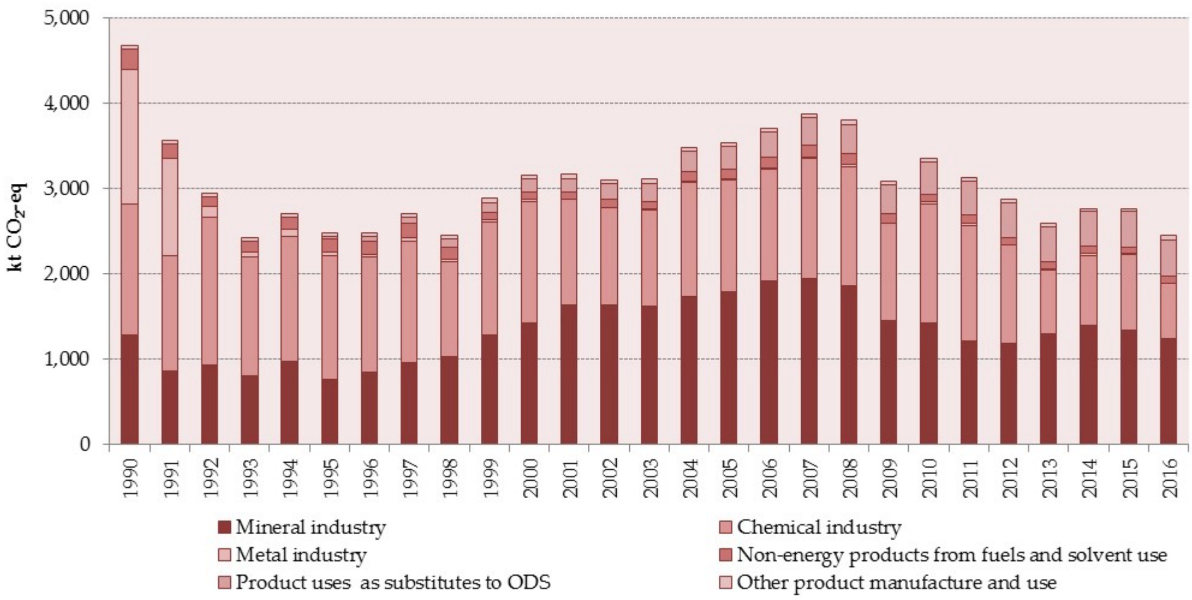
Uncertainty estimates associated with emission factors are based on the recommended uncertainty range estimates reported in 2006 IPCC Guidelines. Uncertainty estimates associated with activity data are based on expert judgements since statistics and manufacturers have not particularly assessed the uncertainties. Based on the obtained information on activity data according the Annual data collection plan, expert responsible for emission calculation for the sector IPPU has estimated uncertainty of the data, used values proposed by the 2006 IPCC Guidelines that are included in the tables in the sections on uncertainty assessment for individual categories. The process undertaken to assess uncertainties using expert judgement follows the guidelines stated in Volume 1, Chapter 3 of the 2006 IPCC Guidelines.

Emission calculation for the categories 2.A.1, 2.A.2, 2.A.3, 2.B.1, 2.B.2 is performed using higher tiers (Tier 2 or Tier 3). In the QA/QC and verification of these categories, activity data was cross-checked with statistical data. It is necessary to include more data and parameters than those are in the statistical reports. Data included in the statistical reports were submitted from the manufacturers that also submit data included into Annual data collection plan. Deviation has been analysed based on the comparison of data.

4.1.1. Emission trends

The total annual emissions of GHGs from Sector 2 IPPU (with related IPCC categories), expressed in kt CO_2-eq, in the period 1990 - 2016 are presented in the Figure 4.1-1.

Figure 4.1-1: Emissions of GHGs from Industrial Processes and Product Use (1990 - 2016)



In 2016, GHG emissions from Sector 2 IPPU amounted 2,460.2 kt CO_2 equivalent, compared to 4,680.6 kt in 1990. These emissions constituted 10.1% of Croatia's total GHG emissions (excluding LULUCF) in 2016 and 14.7% of total emissions in 1990. GHG emissions fluctuate during reporting period:

- 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;
- the iron production in blast furnaces and aluminium production ended in 1992, and ferroalloys production ended in 2003;
- from 1996 to 2008 emissions slightly increased (with some fluctuations), due to revitalization of the economy;
- in the following years emissions decreased (sharply in 2009) due to decreasing of economic activity caused by economic crisis;
- the decrease in emission from chemical industry in the period 2013 - 2016 is due to a strong reduction of N_2O emissions from the nitric acid production after applying abatement technology;
- the trend from 2008 onwards is dominated by the effects of the economic crisis, followed by a moderate recovery since 2013.
- in 2016 emissions decreased primarily due to the reduction of production in some industrial categories (e.g. cement, lime, ammonia, nitric acid, and especially steel).

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

Table 4.1-1: Key categories in Industrial processes and product use sector based on the level and trend assessment in 2016[1]

Table								
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2018)								
IPCC Source Categories	GHG	Key source	If Column C is Yes, Criteria for Identification				Com.
2.A.1 Cement Production	CO_2	Yes	L1e	T1e	L1i	T1i	
2.B.1 Ammonia Production	CO_2	Yes	L1e	T1e	L1i	T1i	
2.B.2 Nitric Acid Production	N_2O	Yes		T1e		T1i	
2.B.8 Petrochemical and Carbon Black Production	CO_2	Yes		T1e, T2e		T1i, T2i	
2.C.2 Ferroalloys Production	CO_2	Yes		T1e		T1i	
2.C.3 Aluminium Production	CO_2	Yes				T1i	
2.C.3 Aluminium Production	PFCs	Yes		T1e		T1i	
2.D Non-energy Products from Fuels and Solvent Use	CO_2	Yes		T2e		T1i	
2.F.1 Refrigeration and Air conditioning - Aggregate	F-gases	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

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

4.2. Mineral industry (CRF 2.A)

4.2.1. Cement production (2.A.1)

4.2.1.1. Category description

In 1990, CO_2 emissions from cement production contributed 3.4 percent to the total GHG emissions in Croatia (without LULUCF). In 2016, CO_2 emissions contributed 4.4 percent to the total GHG emissions.

During cement production, calcium carbonate ($CaCO_3$) is heated in a cement kiln at high temperatures to form lime (i.e. calcium oxide, CaO) and CO_2 in a process known as calcination or calcining. Lime is combined with silica-containing materials (e.g. clay) to form dicalcium and tricalcium silicates which are the main constituents of cement clinker, with the earlier CO_2 being released in the atmosphere as a by-product. The clinker is then removed from the cement kiln, cooled, pulverized and mixed with small amount of gypsum to form final product called Portland cement.

There are three manufacturers (five factories) of Portland cement and one manufacturer of Aluminate cement in Croatia. CO_2 emitted during the cement production process represents the most important source of non-energy industrial process of total CO_2 emissions. Different raw materials are used for Portland cement and Aluminate cement production. The quantity of the CO_2 emitted during Portland cement production is directly proportional to the lime content of the clinker. Emissions of SO_2 (non-combustion emissions) in the cement production originate from sulphur in the raw clay material.

4.2.1.2. Methodological issues

Estimation of CO_2 emissions is accomplished by applying an emission factor, in tonnes of CO_2 released per tonne of clinker produced, to the annual clinker output corrected with the fraction of clinker that is lost from the kiln in the form of Cement Kiln Dust (CKD) (Tier 2 method, *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. Survey of cement manufacturers were performed in the framework of the preparation of the study Croatian Cement Industry and Climate Change (in Croatian, 2007). This study was elaborated at the initiative of the Croatia Cement EIC Association members consisting of three Croatian Portland cement manufacturers: Cemex/Dalmacijacement Inc., Holcim Croatia Ltd, and Našicecement Inc. Study analysis and results are related to the plants pertaining to the above-mentioned companies. All information used for the preparation of the study was obtained from manufacturers. Most of the information was obtained through comprehensive questionnaires. Input data for the preparation of the study are confidential and are not shown in the study. Except for the GHG emissions review, all manufacturing indicators, GHG emission projections and emission reduction costs, are jointly presented for the entire cement industry. The analysis encompasses the period from 1990 to 2006. For the years after 2006, all manufacturers were submitted completed questionnaires adjusted for the emissions calculation within the sector IPPU, which are an integral part of the Annual data collection plan. Confidential data are specifically marked in these questionnaires. The data were cross-checked with cement production data from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Activity data and emissions for the period 2012 - 2016 were defined in line with requirements of the EU ETS. Verified CO_2 emissions for the whole cement industry in Croatia were reported directly by the cement manufacturers who sent reports to the Croatian Agency for the Environment and Nature in the forms ''Annual report on greenhouse gas emissions for industrial installations". Verification of activity data and emissions for the period 2012 - 2016 is defined in line with requirements of the EU ETS. Verified process emissions are included in Cement Production for the period 2012 - 2016.

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 - 2016)

Year	Clinker production Portland cement (t)1	Clinker production Aluminate cement (t)1	Actual clinker production (t)2	Emission factor Portland cement (t CO2/t clinker)	Emission factor Aluminate cement (t CO2/t clinker)
1990	2,017,840	44,585	2,103,674	0.521	0.313
1991	1,296,146	40,974	1,363,862	0.521	0.321
1992	1,538,923	27,378	1,597,627	0.521	0.301
1993	1,264,565	40,511	1,331,178	0.523	0.306
1994	1,548,980	34,702	1,615,356	0.526	0.311
1995	1,148,756	48,854	1,221,562	0.523	0.311
1996	1,245,692	60,570	1,332,387	0.524	0.306
1997	1,470,234	63,541	1,564,451	0.515	0.308
1998	1,571,767	77,344	1,682,093	0.517	0.304
1999	2,063,838	87,175	2,194,033	0.517	0.305
2000	2,308,148	73,999	2,429,790	0.518	0.306
2001	2,645,180	94,065	2,794,030	0.517	0.300
2002	2,627,934	70,667	2,752,573	0.511	0.309
2003	2,609,349	82,741	2,745,932	0.510	0.301
2004	2,764,331	87,911	2,909,287	0.512	0.301
2005	2,827,258	99,320	2,985,110	0.510	0.293
2006	3,007,818	96,549	3,166,454	0.508	0.308
2007	3,046,209	114,311	3,223,730	0.507	0.304
2008	2,883,266	111,787	3,054,954	0.507	0.305
2009	2,355,148	83,911	2,487,840	0.499	0.305
2010	2,229,152	91,332	2,366,894	0.515	0.304
2011	1,965,307	106,353	2,113,093	0.508	0.301
2012	1,880,328	99,587	2,019,513	0.515	0.294
2013	2,093,282	105,014	2,242,262	0.520	0.292
2014	2,165,514	112,966	2,324,050	0.540	0.278
2015	2,036,196	122,468	2,201.837	0.546	0.277
2016	1,936,322	122,364	2,099.860	0.528	0.262

[1] Clinker production reported by the cement manufacturers

[2] Actual clinker productions calculated as a product of clinker production and CF_{ckd}.

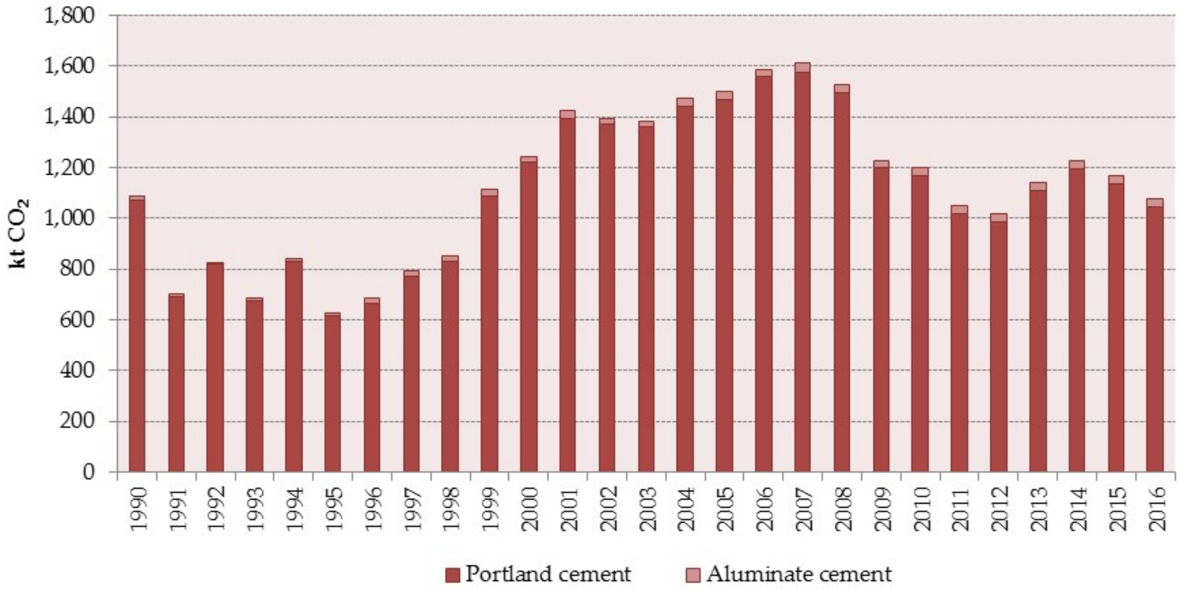
Import/export quantities of clinker are presented in Table 4.2-2.

Table 4.2-2: Import/export quantities of clinker (1990 - 2016)

Year	Clinker import (t)		Clinker export (t)		Change in clinker stocks (t)	
	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
2014	0	0	398,072	397	27,175	242
2015	0	398	316,299	620	-61,566	2,787
2016	0	497	214,289	469	43,433	3,518

The resulting emissions of CO_2 from Cement Production in the period 1990 - 2016 are presented in the Figure 4.2-1.

Figure 4.2-1: Emissions of CO_2 from Cement Production (1990 - 2016)



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, 40.3 percent in 2012, 35.6 percent in 2013, 34.2 percent in 2014, 34.6 percent in 2015 and 36.4 percent in 2016, regarding the year 2008). In 2013 and 2014, the cement production started increase slightly compared to 2012 while in 2015 and 2016 decreased (significantly in 2016). Accordingly, CO_2 emissions was higher 12.2 percent in 2013, 20.4 percent in 2014, 15.0 percent in 2015 and 5.8 percent in 2016, regarding the year 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 - 2016)

Year	Cement production (t)	
	Portland	Aluminate
1990	2,598,066	44,698
1991	1,702,589	33,184
1992	1,810,780	30,532
1993	1,596,244	36,895
1994	2,049,140	31,499
1995	1,571,415	39,731
1996	1,643,049	51,654
1997	1,906,133	59,365
1998	2,161,827	68,503
1999	2,549,726	79,743
2000	2,909,466	83,388

Year	Cement production (t)	
	Portland	Aluminate
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	103,036
2014	2,375,333	112,166
2015	2,355,903	118,355
2016	2,285,374	118,881

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 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

4.2.1.3. Uncertainties and time-series consistency

Activity data and emission factor uncertainty was calculated in detail. Uncertainty estimate associated with activity data amounts to 2 percent, based on expert judgement - it is assumed the data are accurate because were reported directly by the manufacturers, as well included in the EU ETS verification reports (general explanation on expert judgement is provided in Chapter 4.1.). 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 the period 1990 - 2011. Verified CO_2 emissions reported in line with requirements of the EU ETS were used for the period 2012 - 2016. Methodology proposed by the Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2009/29/EC corresponds to the methodology used for the period 1990 - 2011.

4.2.1.4. 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 cement production were estimated using Tier 2 method which is a *good practice*. Basic activity data from Annual PRODCOM results were compared with data provided by individual plants. Results of this comparison showed that there is no significant difference between these two sets of data. Country-specific emission factors for Portland cement were compared with IPCC default emission factor. Difference between these two data sets is caused by difference in CaO/MgO content in raw materials and clinker.

4.2.1.5. Category-specific recalculations

There are no source-specific recalculations in this report.

4.2.1.6. Category-specific planned improvements

More information for uncertainty estimation associated with activity data is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates associated with activity data are based on expert judgements since statistics and manufacturers have not particularly assessed the uncertainties. It should be necessary to include more experts from the relevant institutions as well as manufacturers (source of data) in the assessment of activity data uncertainties. Experts who are directly associated with the activity data can more accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

4.2.2. Lime production (2.A.2)

4.2.2.1. Category description

In 1990, CO_2 emissions from lime production contributed 0.5 percent to the total GHG emissions in Croatia (without LULUCF). In 2016, CO_2 emissions contributed 0.4 percent to the total GHG emissions.

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.

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 and since 2012 yet another.

Certain amounts of quicklime were produced in the blast furnace processes during 1990 and 1991. During the reporting period in operation are three sugar rafineries in Croatia, where a certain amount of quicklime is produced.

4.2.2.2. Methodological issues

Calculation of CO_2 emissions from lime production is accomplished by applying an emission factor in tonnes of CO_2 released per tonne of quicklime or dolomitic lime produced, to the annual lime output (Tier 2 method, *2006 IPCC Guidelines*). 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.

Activity data and emissions for the period 2012 - 2016 were defined in line with requirements of the EU ETS. Verified CO_2 emissions for the whole lime industry in Croatia were reported directly by the lime manufacturers who sent reports to the Croatian Agency for the Environment and Nature in the forms ''Annual report on greenhouse gas emissions for industrial installations". Verified process emissions from the production of lime in lime factories and sugar rafineries are included in 2.A.2 Lime Production in the CRF for the period 2012 - 2016.. Verification of activity data and emissions for the period 2012 - 2016 is defined in line with requirements of the EU ETS.

The data on lime production are presented in the aggregated form for quicklime (1990 - 2011) and dolomitic lime (1990 - 2012). After those periods, data are presented separately for lime factories and sugar refineries (Table 4.2-4).

Table 4.2-4: Lime production (1990 - 2016)

Year	Quicklime production (t)		Dolomitic lime production (t)	
	Lime factories	Sugar refineries	Lime factories	Sugar refineries
1990	224,830		7,474	
1991	165,397		0	
1992	124,493		0	
1993	134,482		0	
1994	140,116		0	
1995	139,701		0	
1996	137,667		38,070	
1997	131,741		55,171	
1998	142,018		53,367	
1999	136,408		52,704	
2000	124,437		68,572	
2001	154,526		84,838	
2002	174,893		94,378	
2003	153,146		96,191	

Year	Quicklime production (t)		Dolomitic lime production (t)	
	Lime factories	Sugar refineries	Lime factories	Sugar refineries
2004	227,322		56,689	
2005	233,235		76,351	
2006	260,584		105,653	
2007	261,276		115,315	
2008	246,700		120,680	
2009	163,210		87,789	
2010	129,900		92,574	
2011	110,380		71,761	
2012	44,752	35,525	59,334	
2013	44,921	29,077	52,857	136
2014	40,042	42,872	53,400	302
2015	52,033	35,828	46,201	173
2016	44,205	38,517	42,150	209

There was no production of dolomitic lime in the period 1991 - 1995.

According to the TERT recommendation during 2017 ESD review, technical corrections have been made including resolved of transparency issue regarding activity data and reported emissions.

There are new separated data for quicklime and dolomitic lime production in sugar refineries for the period 2013 - 2016 that included after technical correction made by the TERT during 2017 ESD review. Consequently, there are some differences in emission estimation in this report comparing with the emissions estimation calculated in the framework of technical correction. Total activity data remained the same, only the emissions were changed due to the different EF for quicklime and dolomitic lime. In technical corrections, it was calculated as if only quicklime lime was produced. New separated data are included in order to improve the accuracy of the estimation.

The background information on the content of CaO and CaO*MgO used to derive the EFs for quicklime and dolomite lime production in lime factories are presented in Table 4.2-5 and Table 4.2-6.

Table 4.2-5: Content of CaO and EF for quicklime production in lime factories (1990 - 2016)

Year	t CaO/t lime				AVERAGE	t CO_2/t CaO[1]	EF
	Factory 1	Factory 2	Factory 3	Factory 4	(t CaO/t lime)		(t CO_2/t lime)
1990	0.990	0.902	0.937	0.880	0.927	0.785	0.728
1991	0.990	0.921	0.933	0.884	0.932	0.785	0.732
1992	0.000	0.928	0.930	0.893	0.688	0.785	0.540
1993	0.000	0.938	0.931	0.893	0.691	0.785	0.542
1994	0.000	0.919	0.951	0.900	0.692	0.785	0.544
1995	0.000	0.937	0.936	0.938	0.703	0.785	0.551
1996	0.000	0.927	0.932	0.900	0.690	0.785	0.541
1997	0.000	0.918	0.933	0.900	0.688	0.785	0.540
1998	0.990	0.929	0.912	0.904	0.934	0.785	0.733
1999	0.990	0.937	0.933	0.900	0.940	0.785	0.738

Year	t CaO/t lime				AVERAGE (t CaO/t lime)	t CO_2/t CaO[1]	EF (t CO_2/t lime)
	Factory 1	Factory 2	Factory 3	Factory 4			
2000	0.990	0.900	0.921	0.913	0.931	0.785	0.731
2001	0.990	0.938	0.945	0.904	0.944	0.785	0.741
2002	0.990	0.944	0.955	0.913	0.951	0.785	0.746
2003	0.990	0.968	0.956	0.900	0.954	0.785	0.749
2004	0.990	0.964	0.940	0.910	0.951	0.785	0.747
2005	0.990	0.975	0.975	0.919	0.965	0.785	0.757
2006	0.990	0.947	0.959	0.928	0.956	0.785	0.750
2007	0.990	0.975	0.979	0.922	0.966	0.785	0.759
2008	0.956	0.975	0.984	0.920	0.959	0.785	0.752
2009	0.880	0.929	0.926	0.930	0.916	0.785	0.719
2010	0.897	0.981		0.930	0.936	0.785	0.735
2011	0.866	0.546		0.938	0.783	0.785	0.615
2012	*	*	*	*	*	*	0.654
2013	*	*	*	*	*	*	0.654
2014	*	*	*	*	*	*	0.641
2015	*	*	*	*	*	*	0.644
2016	*	*	*	*	*	*	0.625

[1] 2006 IPCC Guidelines, Volume 3, Table 2.4

* see explanation on EFs calculation below

Table 4.2-6: Content of CaO*MgO and EF for doliomitic lime production in lime factories (1990 - 2016)

Year	t CaO*MgO/t lime	t CO_2/t CaO*MgO[2]	EF (t CO_2/t lime)
	Factory 2		
1990	0.952	0.913	0.869
1991	-	-	-
1992	-	-	-
1993	-	-	-
1994	-	-	-
1995	-	-	-
1996	0.945	0.913	0.862
1997	0.931	0.913	0.850
1998	0.957	0.913	0.874
1999	0.952	0.913	0.870
2000	0.972	0.913	0.887
2001	0.971	0.913	0.887
2002	0.977	0.913	0.892
2003	0.963	0.913	0.879

Year	t CaO*MgO/t lime	t CO_2/t CaO*MgO[2]	EF
	Factory 2		(t CO_2/t lime)
2004	0.980	0.913	0.895
2005	0.959	0.913	0.875
2006	0.980	0.913	0.895
2007	0.985	0.913	0.899
2008	0.986	0.913	0.900
2009	0.943	0.913	0.861
2010	0.989	0.913	0.903
2011	0.391	0.913	0.357
2012	*	*	0.843
2013	*	*	0.849
2014	*	*	0.858
2015	*	*	0.863
2016	*	*	0.858

[2] *2006 IPCC Guidelines*, Volume 3, Table 2.4

* see explanation on EFs calculation below

In 2011, Factory 2 for dolomitic lime production was not in operation continuously. Data on the content of CaO and CaO*MgO are different from the previous trend. The accuracy of the data is verified with the factory.

For the period 2012 - 2016 data from verified ETS reports for lime factories are used, so the EFs for lime production in lime factories were calculated from the data for CO_2 emissions and the data for lime production.

Stoihichiometric ratio (tonne CO_2 per tonne CaO or CaO*MgO) proposed by *2006 IPCC Guidelines*, Chapter 2.3.1.2, Table 2.4, were used for the calculation of emission factors for quicklime and dolomite lime (0.785 tonne CO_2 per tonne CaO; 0.913 tonne CO_2 per tonne CaO*MgO).

The background information on the content of CaO and CaO*MgO used to derive the EFs for quicklime and dolomite lime production in sugar refineries are presented in Table 4.2-7 and Table 4.2.8.

Table 4.2-7: Content of CaO and EF for quicklime production in sugar refineries (1990 - 2016)

Year	t CaO/t lime			AVERAGE	t CO_2/t CaO[1]	EF
	Factory 1	Factory 2	Factory 3	(t CaO/t lime)		(t CO_2/t lime)
1990	0.455	-	-	0.455	0.785	0.357
1991	-	-	0.960	0.480	0.785	0.377
1992	0.455	-	0.960	0.707	0.785	0.555
1993	0.470	-	0.960	0.715	0.785	0.561
1994	0.503	-	0.960	0.731	0.785	0.574
1995	0.482	-	0.960	0.721	0.785	0.566

Year	t CaO/t lime			AVERAGE (t CaO/t lime)	t CO_2/t CaO[1]	EF (t CO_2/t lime)
	Factory 1	Factory 2	Factory 3			
1996	0.481	-	0.960	0.720	0.785	0.565
1997	0.480	-	0.960	0.720	0.785	0.565
1998	0.474	-	0.960	0.717	0.785	0.563
1999	0.446	0.984	0.960	0.797	0.785	0.625
2000	0.470	0.964	0.960	0.798	0.785	0.626
2001	0.496	0.962	0.960	0.806	0.785	0.633
2002	0.462	0.984	0.960	0.802	0.785	0.630
2003	0.452	0.986	0.960	0.799	0.785	0.627
2004	0.540	0.980	0.960	0.827	0.785	0.649
2005	0.422	0.982	0.960	0.788	0.785	0.619
2006	0.435	0.982	0.960	0.793	0.785	0.622
2007	0.458	0.982	0.960	0.800	0.785	0.628
2008	0.358	0.982	0.960	0.767	0.785	0.602
2009	0.353	0.983	0.960	0.765	0.785	0.601
2010	0.418	0.983	0.960	0.787	0.785	0.618
2011	0.992	0.983	0.960	0.978	0.785	0.768
2012	0.994	0.992	0.960	0.982	0.785	0.771
2013	0.994	0.986	0.960	0.980	0.785	0.769
2014	0.986	0.976	0.960	0.974	0.785	0.765
2015	0.986	0.973	0.960	0.973	0.785	0.764
2016	0.989	0.981	0.960	0.977	0.785	0.767

[1] *2006 IPCC Guidelines*, Volume 3, Table 2.4

There were no production of quicklime in Factory 1 in 1991, in Factory 2 in the period 1990 - 1998 and in Factory 3 in 1990.

In 2011, the data on the content of CaO for Factory 1 is different from the previous trend. The data for the Factory 1 for the period 1990 - 2010 are different from the data for the Factory 2 and Factory 3. The accuracy of the data is verified with the factory.

Table 4.2-8: Content of CaO*MgO and EF for doliomitic lime production in sugar refineries (2013 - 2016)

Year	t CaO*MgO/t lime	t CO_2/t CaO*MgO[2]	EF (t CO_2/t lime)
	Factory 2		
2013	0.014	0.913	0.013
2014	0.024	0.913	0.022
2015	0.027	0.913	0.025
2016	0.019	0.913	0.017

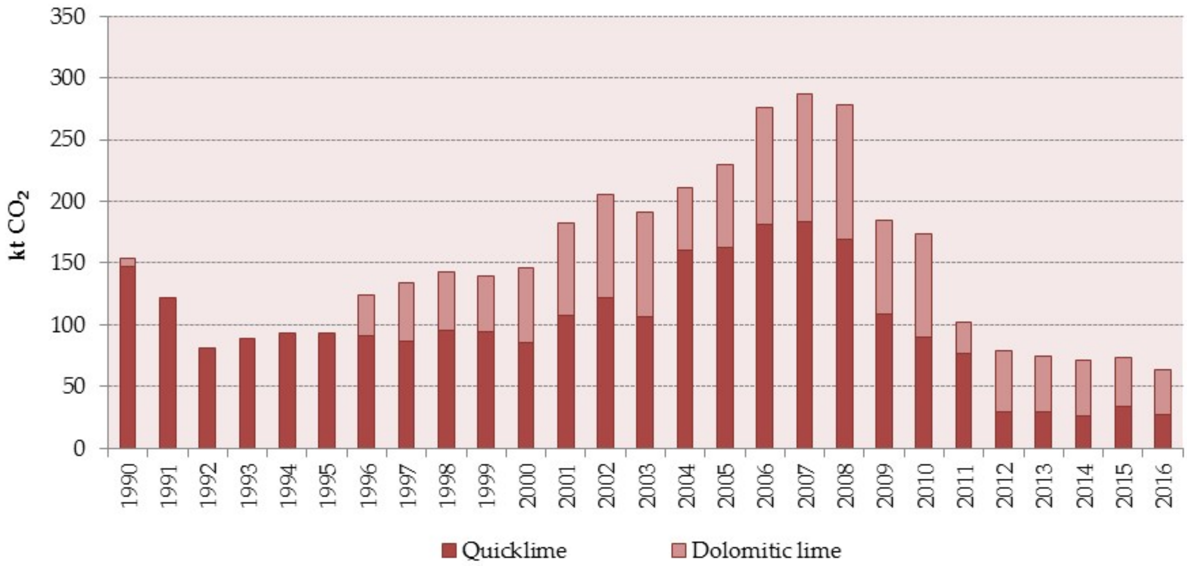
[2] *2006 IPCC Guidelines*, Volume 3, Table 2.4

There was production of dolomitic lime in sugar efineries only for the period 2013 - 2016.

Variation in IEFs reflects changes in lime production volume and ratio of quicklime and dolomitic lime.

The resulting emissions of CO_2 from Lime Production in the period 1990 - 2016 are presented in the Figure 4.2-2.

Figure 4.2-2: Emissions of CO_2 from Lime Production (1990 - 2016)



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 31.7 percent in 2009, 39.4 percent in 2010 and 50.4 percent in 2011, regarding the year 2008. Emissions decreased by 33.7 percent in 2009, 37.8 percent in 2010 and 63.4 percent in 2011, regarding the year 2008. In 2012, three factories of lime were not in operation and one factory canceled the production of quicklime and started the production of dolomitic lime. The total production of lime decreased by 23.4 precent in 2012, 30.3 percent in 2013, 25.5 percent in 2014, 26.3 percent in 2015 and 31.3% in 2016, regarding the year 2011. CO_2 emissions was lower 8.4 percent in 2016, regarding the year 2011.

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 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

4.2.2.3. Uncertainties and time-series consistency

Activity data and emission factor uncertainty was calculated in detail. Uncertainty estimate associated with activity data amounts to 2 percent, based on expert judgement - it is assumed the data are accurate because were reported directly by the manufacturers, as well included in the EU ETS verification reports (general explanation on expert judgement is provided in Chapter 4.1.). 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 the period 1990 - 2011. Verified CO_2 emissions reported in line with requirements of the EU ETS were used for the period 2012 - 2016. Methodology proposed by the Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2009/29/EC corresponds to the methodology used for the period 1990 - 2011.

4.2.2.4. 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.

CO_2 emissions from lime production were estimated using Tier 2 method which is a *good practice*. Basic activity data from Annual PRODCOM results were compared with data provided by individual plants. Results of this comparison showed that there is no significant difference between these two sets of data. Country-specific emission factors for quicklime and dolomitic were compared with IPCC default emission factor. Difference between these two data sets is caused by difference in CaO/CAO*MgO content in lime.

4.2.2.5. Category-specific recalculations

In the previous report, total quicklime production (from lime factories and sugar refineries) was included in the 2.A.2 CRF tables, while emissions only from lime factories were included in the CRF. Emissions from sugar refineries were not included in 2.A.2 for the period 2012 - 2015. Verified process emissions from the production of lime in lime factories were included in category 2.A.2. The misinterpretation was that emissions from sugar refineries were included in the Energy sector, in the verified reports for the combustion. EU ETS reports for sugar refineries contain only data on combustion. According to the Directive 2003/87/EC, the threshold values for combustion installation is 20 MW, and for production of lime is 50 tonnes per day. Because sugar refineries do not have production capacity of 50 tonnes of lime per day, those do not report on emissions from production process in the verified ETS reports.

According to the TERT recommendation during 2017 ESD review, technical corrections have been made including resolved of transparency issue regarding activity data and reported emissions. Since process emissions for sugar refineries were not included in the previous report, it is necessary to make recalculations for the period 2012 – 2015. Recalculated process emissions for the period 2012 - 2015 are added to the process emissions for lime production in lime factories.

In addition, there are new separated data for quicklime and dolomitic lime production in sugar refineries that included after technical correction made by the TERT during 2017 ESD review. Consequently, there are some differences in emission estimation in this report comparing with the emissions estimation calculated in the framework of technical correction.

Total activity data remained the same, only the emissions were changed due to the different EF for quicklime and dolomitic lime. In technical corrections, it was calculated as if only quicklime was produced. New separated data are included in order to improve the accuracy of the estimation.

According to the explanation, recalculation have been made for the period 2012 – 2015.

4.2.2.6. Category-specific planned improvements

More information for uncertainty estimation associated with activity data is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates associated with activity data are based on expert judgements since statistics and manufacturers have not particularly assessed the uncertainties. It should be necessary to include more experts from the relevant institutions as well as manufacturers (source of data) in the assessment of activity data uncertainties. Experts who are directly associated with the activity data can more accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

4.2.3. Glass production (2.A.3)

4.2.3.1. Category description

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

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. Since 2011 there is only one manufacturer of container glass.

4.2.3.2. 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 (Tier 3 method, *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 4.2-9) were cross-checked with glass production data from Annual PRODCOM results published by Central Bureau of Statistics, Department of Manufacturing and Mining.

Activity data and emissions for the period 2012 - 2016 were defined in line with requirements of the EU ETS. Verified CO_2 emissions were reported directly by the glass manufacturer who sent reports to the Croatian Agency for the Environment and Nature in the forms ''Annual report on greenhouse gas emissions for industrial installations". Verification of activity data and emissions for the period 2012 - 2016 is defined in line with requirements of the EU ETS. Verified process emissions are included in Glass Production for the period 2012 - 2016.

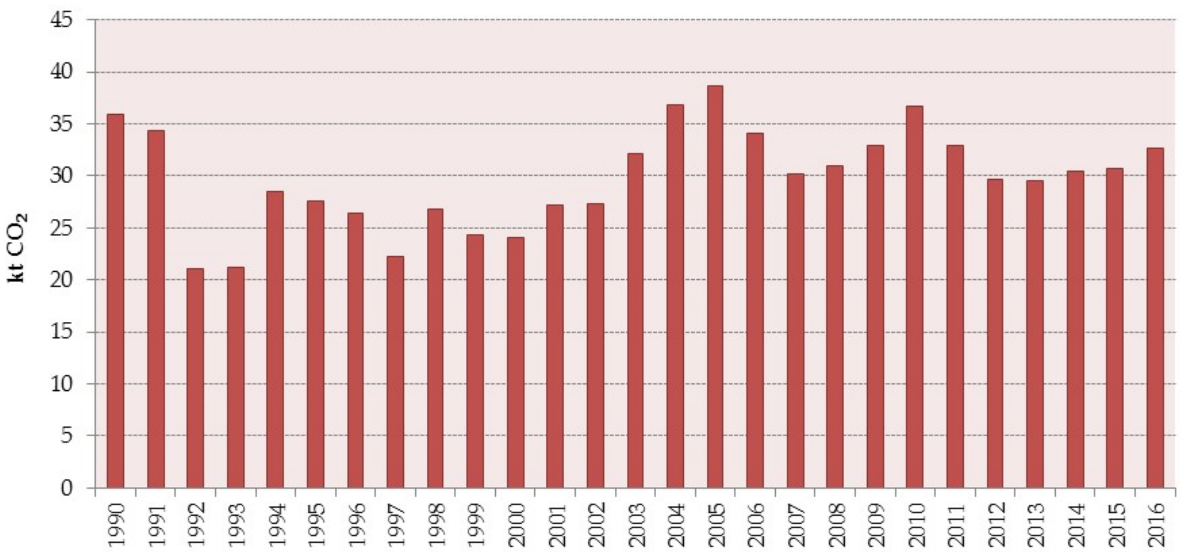
Table 4.2-9: Glass production (1990 - 2016)

Year	Glass production (t)
1990	275,490
1991	252,936
1992	143,904
1993	134,413
1994	162,218
1995	166,810
1996	153,761
1997	127,323

Year	Glass production (t)
1998	148,328
1999	136,263
2000	139,056
2001	150,341
2002	158,539
2003	186,973
2004	210,654
2005	227,810
2006	228,673
2007	231,481
2008	241,749
2009	236,811
2010	231,570
2011	245,959
2012	227,270
2013	251,582
2014	276,562
2015	237,801
2016	259,460

The resulting emissions of CO_2 from Glass Production in the period 1990 - 2016 are presented in the Figure 4.2-3.

Figure 4.2-3: Emissions of CO_2 from Glass Production (1990 - 2016)



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 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

4.2.3.3. Uncertainties and time-series consistency

Activity data and emission factor uncertainty was calculated in detail. Uncertainty estimate associated with activity data amounts to 2 percent, based on expert judgement - it is assumed the data are accurate because were reported directly by the manufacturer, as well included in the EU ETS verification reports (general explanation on expert judgement is provided in Chapter 4.1.). 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 for the period 1990 - 2011. Verified CO_2 emissions reported in line with requirements of the EU ETS were used for the period 2012 - 2016. Methodology proposed by the Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2009/29/EC corresponds to the methodology used for the period 1990 - 2011.

4.2.3.4. 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 glass 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 data. Country-specific emission factor were compared with IPCC default emission factor. Difference between these two data sets is caused by difference in carbonates content in the minerals.

4.2.3.5. Category-specific recalculations

There are no source-specific recalculations in this report.

4.2.3.6. Category-specific planned improvements

More information for uncertainty estimation associated with activity data is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates associated with activity data are based on expert judgements since statistics and manufacturers have not particularly assessed the uncertainties. It should be necessary to include more experts from the relevant institutions as well as manufacturers (source of data) in the assessment of activity data uncertainties. Experts who are directly associated with the activity data can more accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

4.2.4. Other process uses of carbonates (2.A.4)

4.2.4.1. Category description

It is good practice to report emissions from the consumption of carbonates in the source category where the carbonates are consumed and the CO_2 emitted (*2006 IPCC Guidelines*, Volume 3, Chapter 2). According to this explanation, emissions from consumption of limestone, dolomite and soda ash for glass production, as well emissions from consumption of limestone and dolomite in iron and cast production, during the entire production processes, are reported in the respective source categories –

2.A.3 and 2.C.1. Therefore, all emissions fom uses of carbonates except emissions included into 2.A.3 and 2.C.1 are included into 2.A.4. Subcategories Ceramics (2.A.4.a), Other uses of soda ash (2.A.4.b) and Other (2.A.4.d) are included into 2.A.4, according to the *2006 IPCC Guidelines*.

For category 2.A.4., the major consumption of limestone ($CaCO_3$) and dolomite ($CaCO_3$*$MgCO_3$) occurs in brick, ceramics and refractory materials manufacture. Soda ash is mainly used as a raw material in industrial processes including the manufacture of soap and detergents. Data for the period from 2000 - 2016 also include significant limestone use in desulphurization process in Thermal Power Plant (TPP) and dolomite use in production of insulation materials (rock and mineral wool, etc.).

4.2.4.2. 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 (Tier 2 method, *2006 IPCC Guidelines*).

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. A 100 percent purity of raw material was assumed for the purpose of calculations.

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*).

The activity data for limestone consumption in ceramic production were collected by a survey of manufacturers. The activity data for dolomite consumption in 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.

The activity data for soda as consumption 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). It was concluded that all consumed soda ash for 1990 and 1991 falls under the category 2.A.3 and therefore consumption of soda ash for category 2.A.4 in 1990 and 1991 amounted to zero. Data from 2013 - 2015 were delivered directly by the manufacturers. Data for 2016 was not provided, so extrapolation was performed, taking into account the trend 2013 - 2015.

The activity data for limestone and dolomite consumption in other use (desulphurization process in TPP and production of insulation materials) were colected by a survey of manufacturers.

For the operators under EU ETS, activity data and emissions for the period 2012 - 2016 were defined in line with requirements of the EU ETS. Verified CO_2 emissions were reported directly by the manufacturers who sent reports to the Croatian Agency for the Environment and Nature in the forms ''Annual report on greenhouse gas emissions for industrial installations". Verification of activity data and emissions for the period 2012 - 2016 is defined in line with requirements of the EU ETS. Verified process emissions are included in Other Process uses of Carbonates for the period 2012 - 2016.

Data on limstone and dolomite consumption in production of ceramics, data on soda ash consumption in other use and data on limstone and dolomite consumption in other use (desulphurization process in TPP and production of insulation materials) that are included in CRF 2.A.4 are presented in the Table 4.2.10.

Table 4.2-10: Data on carbonates consumption in production of ceramics, other use of soda ash and other (desulphurization in TPP and insulation materials) (1990 - 2016)

Year	Ceramics (CRF 2.A.4.a)		Other use of soda ash (CRF 2.A.4.b)	Other (CRF 2.A.4.d)	
	Limestone (t)	Dolomite (t)	Soda ash (t)	Limestone (t)	Dolomite (t)
1990	0	12,098	0	0	0
1991	0	10,018	0	0	0
1992	0	9,173	13,753	0	0
1993	677	7,632	10,020	0	0
1994	676	15,722	12,960	0	0
1995	575	6,541	17,053	0	0
1996	731	8,323	13,367	0	0
1997	784	0	13,776	0	0
1998	826	0	10,956	0	0
1999	529	0	12,862	0	0
2000	834	585	14,037	6,135	0
2001	990	623	14,747	8,136	0
2002	882	850	16,355	11,563	0
2003	467	1,180	14,696	13,937	0
2004	667	1,360	15,705	12,657	0
2005	658	12,567	14,315	11,441	0
2006	455	15,564	16,185	11,587	0
2007	781	15,776	16,861	10,614	0
2008	720	12,828	15,172	15,235	2,950
2009	4,914	9,982	13,985	7,234	6,189
2010	13,137	3,880	18,959	9,200	9,699
2011	24,564	2,820	21,386	19,446	11,001
2012	19,003	1,662	21,233	15,189	54,090
2013	4,477	4,086	13,574	14,709	56,168
2014	6,586	4,086	14,675	7,354	66,162
2015	11,035	7,514	16,270	7,297	77,123
2016	7,944	5,970	17,571	7,323	78,236

The resulting emissions of CO_2 from limestone and dolomite use for Ceramics and Other use (desulphurization in TPP and production of insulation materials) in the period 1990 - 2016 are presented in the Figure 4.2-4. The resulting emissions of CO_2 from Other use of soda ash in the period 1990 - 2016 are presented in the Figure 4.2-5.

Figure 4.2-4: Emissions of CO_2 from Limestone and Dolomite Use (1990 - 2016)

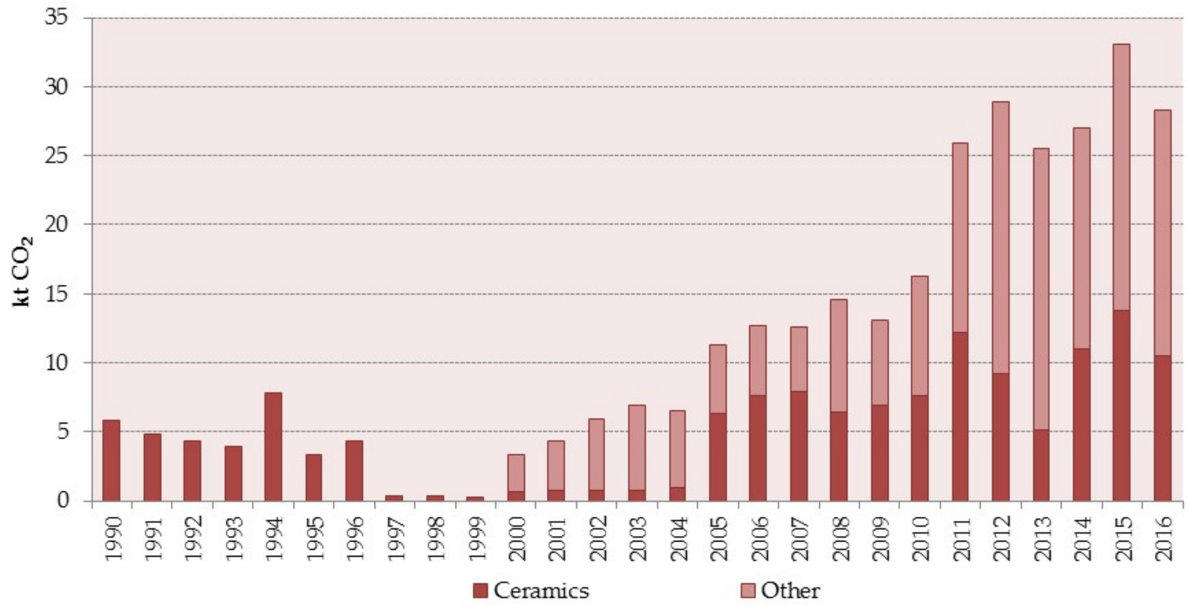
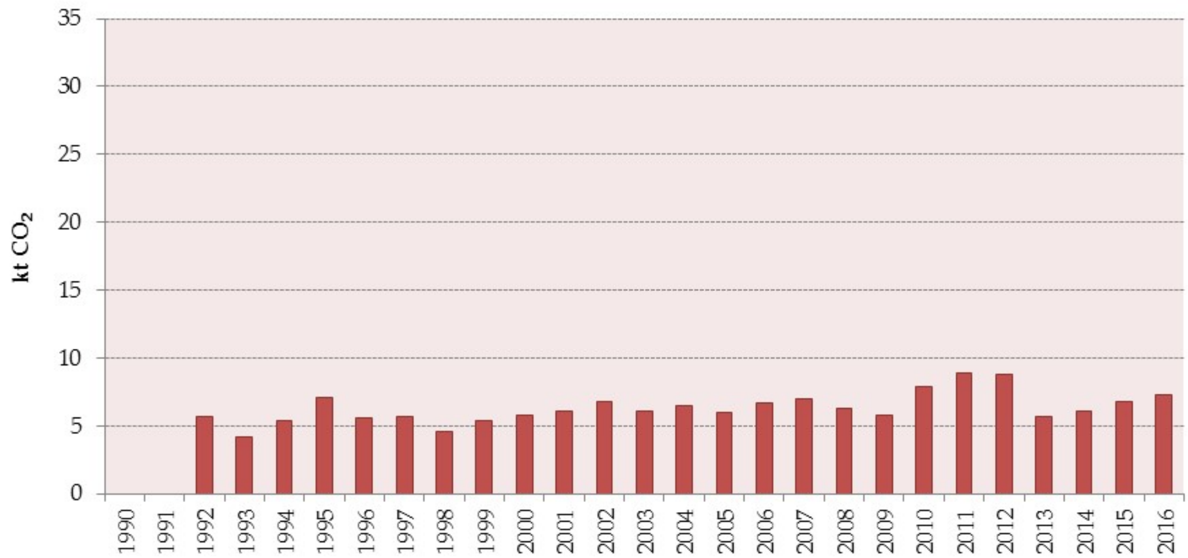


Figure 4.2-5: Emissions of CO_2 from Soda Ash Use (1990 – 2016)



4.2.4.3. Uncertainties and time-series consistency

Uncertainty estimate associated with activity data amounts to 7.5 percent, based on expert judgement (general explanation on expert judgement is provided in Chapter 4.1.). 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 the period 1990 - 2011. Verified CO_2 emissions reported in line with requirements of the EU ETS were used for the period 2012 - 2016. Methodology proposed by the Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2009/29/EC corresponds to the methodology used for the period 1990 - 2011.

4.2.4.4. 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.

4.2.4.5. Category-specific recalculations

There are no source-specific recalculations in this report.

4.2.4.6. 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 (from operators under ETS and operators not included in ETS) should be further investigated in order to ensure accurate CO_2 emission calculation for the whole time series. Additional data investigation should be performed and competent authorities need to cooperate in the process of determining the quality of available data for the entire reporting period.

More information for uncertainty estimation associated with activity data is required, regarding more accurate and transparent uncertainty analysis For now, uncertainty estimates associated with activity data are based on expert judgements since statistics and manufacturers have not particularly assessed the uncertainties. It should be necessary to include more experts from the relevant institutions as well as manufacturers (source of data) in the assessment of activity data uncertainties. Experts who are directly associated with the activity data can more accurately determine the uncertainties of the data, thereby increasing transparency in the reportings.

4.3. Chemical industry (CRF 2.B)

4.3.1. Ammonia production (2.B.1)

4.3.1.1. Category description

In 1990, GHG emissions from ammonia production contributed 1.8 percent to the total GHG emissions in Croatia (without LULUCF). In 2016, GHG emissions contributed 2.3 percent to the total GHG emissions.

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

4.3.1.2. Methodological issues

For purposes of ammonia production in Croatia, natural gas is used as both feedstock and fuel. 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 4.3-1) 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.

Data included in emissions estimation are aligned with the data included in the EU ETS reports (2012 – 2016). Methodology used for the CO_2 emission calculation corresponds to the methodology proposed by the Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2009/29/EC. Verification of activity data and emissions for the period 2012 - 2016 is defined in line with requirements of the EU ETS.

Table 4.3-1: Consumption and composition of natural gas in Ammonia Production (1990 - 2016)

Year	Natural gas consumption (m^3)	Natural gas consumption (m^3)	Natural gas consumption (GJ)	Carbon content factor of 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
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

Year	Natural gas consumption (m^3)	Natural gas consumption (m^3)	Natural gas consumption (GJ)	Carbon content factor of the fuel (kg C/GJ)
	Feedstock	Fuel	Total	
2014	280,859,370	193,526,581	16,461,192	15.121
2015	279,506,970	193,110,018	16,417,296	15.121
2016	264,399,390	176,125,592	15,321,459	15.143

Natural gas is the main feedstock for ammonia production and because of this the composition of natural gas has the influence on CO_2 IEF. Carbon oxidation factor of the fuel amount of 1 is used for the entire period.

CO_2 recovered (see Table 4.3-2) for downstream use (urea, NPK) is subtracted from the CO_2 emission. According to the submitted data, the whole amount of urea and fertilizer which are produce in this process actually applied in agriculture. CO_2 emission are estimated in 3. IPCC Sector. According to the explanation given to the TERT during 2017 ESD review, the specific amount of urea and fertilizers used in agriculture are presented in Chapter 5.5.1 and Chapter 5.9 in the Agriculture sector. All necessary data are included in the Annual data collection plan. The data on amount of urea and fertilizers used in agriculture are estimated according to the import-export and production data (estimated application data). CAEN is responsible for the data collection.

In addition, only information on amount of dry ice is available. There is no additional information on the dry ice production processes. For now, Croatia has no accurate information on where dry ice is applied. It is necessary to do a research (long-term). According to the result of research, a more detailed explanation could be given. The share of recovered dry ice in the total CO_2 emission from ammonia production is about 1.0 - 6.6 percent, depending on the year. Pursuant to the TERT recommendation, since Croatia has no information on the dry ice process and as according to the *2006 IPCC Guidelines* (box3.1), the amount of CO_2 recovered from ammonia production used in freezing applications is not accounted for separately and because it should be assumed that all the CO_2 will be released in the producing country.

Table 4.3-2: CO_2 recovered for downstream use (1990 - 2016)

Year	R_{CO2} - urea (t)	R_{CO2} - NPK (t)	R_{CO2} - total (t)
1990	208,896.5	5,049.0	213,945.5
1991	248,296.1	5,323.0	253,619.1
1992	273,809.1	3,182.0	276,991.1
1993	211,675.7	2,740.0	214,415.7
1994	213,692.4	2,089.0	215,781.4
1995	241,286.6	1,146.0	242,432.6
1996	270,528.1	1,411.0	271,939.1
1997	283,199.6	1,476.0	284,675.6
1998	219,196.8	558.0	219,754.8
1999	284,156.1	1,071.0	285,227.1
2000	274,579.2	983.0	275,562.2
2001	211,607.7	825.0	212,432.7
2002	179,355.8	817.0	180,172.8

2003	254,133.6	0.0	254,133.6
2004	305,753.6	0.0	305,753.6
2005	291,590.8	0.0	291,590.8
2006	291,445.2	0.0	291,445.2
2007	312,432.4	0.0	312,432.4
2008	323,920.0	0.0	323,920.0
2009	306,615.5	0.0	306,615.5
2010	332,935.0	0.0	332,935.0
2011	338,136.4	0.0	338,136.4
2012	325,986.3	0.0	325,986.3
2013	332,779.0	0.0	332,779.0
2014	352,839.0	0.0	352,839.0
2015	337,981.0	0.0	337,981.0
2016	302,845.0	0.0	302,845.0

The resulting emissions of CO_2 from Ammonia Production in the period 1990 - 2016 are presented in the Figure 4.3-1.

Figure 4.3-1: Emissions of CO_2 from Ammonia Production (1990 – 2016)

Tier 1 method are used for CH_4 and N_2O emission calculation from combustion of natural gas as fuel (see Table 4.3-3). Default emission factors of 1.0 kg CH_4/TJ and 0.1 kg N_2O/TJ are used (*2006 IPCC Guidelines*).

Table 4.3-3: CH_4 and N_2O emissions from Ammonia Production (1990 - 2016)

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

Year	CH_4 from fuel (kt)	N_2O from fuel (kt)
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
2014	0.006715	0.000672
2015	0.006708	0.000671
2016	0.006126	0.000613

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 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

4.3.1.3. 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.

Activity data and emission factor uncertainty was calculated in detail. Uncertainty of CO_2 emission estimate associated with activity data amounts to 2 percent, based on information provided by manufacturer. Along with questions on activity data, data sources, competent authorities, methodology for data collection and other important information, Annual data collection plan includes questions on the uncertainties of submitted data. For each measured data that is included into emissions calculation, ammonia manufacturer has submitted uncertainty of measurement devices according to which then uncertainty of activity data has been estimated.

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.

4.3.1.4. 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.

Emissions of CO_2 from consumption of natural gas were estimated using Tier 3 method which could be considered as a *good practice*. Basic activity data from Annual PRODCOM results were compared with data provided by plant. Results of this comparison showed that there is no significant difference between these two sets of data.

4.3.1.5. Category-specific recalculations

In the previous report, CO_2 recovered for downstream use (urea, NPK and dry ice) was subtracted from the CO_2 emission.

According to the submitted data, the whole amount of urea and fertilizer which are produce in this process actually applied in agriculture. CO_2 emission are estimated in 3. IPCC Sector. According to the explanation given to the TERT during 2017 ESD review, the specific amount of urea and fertilizers used in agriculture are presented in Chapter 5.5.1 and Chapter 5.9 in the Agriculture sector. The data on amount of urea and fertilizers used in agriculture are estimated according to the import-export and production data (estimated application data).

In addition, only information on amount of dry ice is available. There is no additional information on the dry ice production processes. The share of recovered dry ice in the total CO_2 emission from ammonia production is about 1.0 - 6.6 percent, depending on the year. Pursuant to the TERT recommendation, since Croatia has no information on the dry ice process and as according to the *2006 IPCC Guidelines* (box3.1), the amount of CO_2 recovered from ammonia production used in freezing applications is not accounted for separately and because it is assumed that all the CO_2 is released in the producing country.

According to the explanation, recalculation have been made for the period 1990 - 2015.

4.3.1.6. Category-specific planned improvements

Use of urea and NPK in agriculture should be investigated for future reports (long-term goal). In addition, Croatia has no accurate information on where dry ice is applied. Accordingly, it is necessary to do a research (long-term goal). According to the result of research, a more detailed explanation on application of dry ice could be given.

4.3.2. Nitric acid production (2.B.2)

4.3.2.1. Category description

In 1990, N_2O emissions from nitric acid production contributed 2.4 percent to the total GHG emissions in Croatia (without LULUCF). In 2016, N_2O emissions contributed 0.4 percent to the total GHG emissions. Reduction of N_2O emissions from the nitric acid production is a result of applying the abatement technology.

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.

4.3.2.2. Methodological issues

Emissions of N_2O from nitric acid production have been calculated by multiplying annual nitric acid production by plant-specific EFs using Tier 2 methodology (*2006 IPCC Guidelines*). 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[2] (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). Abatement technology 'catalytic decomposition' is used for N_2O emission reduction in nitric acid production. N_2O emission reduction up to 88% can be achieved by installing the catalyst. The operator use measurement-based methodologies on continuous emission measurement systems for N_2O emissions of Nitric acid Plants. All measurements are carried out applying methods based on EN 14181 Stationary source emissions - Quality assurance of automated measuring systems, and EN 15259 Air quality - Measurement of stationary source emissions - Requirements for measurement sections and sites and for the measurement objective, plan and report, and other corresponding EN standards. The Automated Measuring Systems for the determination of the pollutants' concentrations (N_2O) include Analyzer: ABB, model EL 3020 Uras 26. Principle of measurement for the N_2O is NDIR (don dispersive infrared).

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.

Activity data and emissions for the period 2012 - 2016 were defined in line with requirements of the EU ETS. Verified N_2O emissions were reported directly by the nitric manufacturers who sent reports to the Croatian Agency for the Environment and Nature in the forms ''Annual report on greenhouse gas emissions for industrial installations". Verified process emissions are included in Nitric Acid Production for the period 2012 - 2016.

Accordingly QA/QC procedures performed by Croatian Agency for the Environment and Nature, after the data have been obtained from nitric acid manufacturer, verification of production of nitric acid per

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

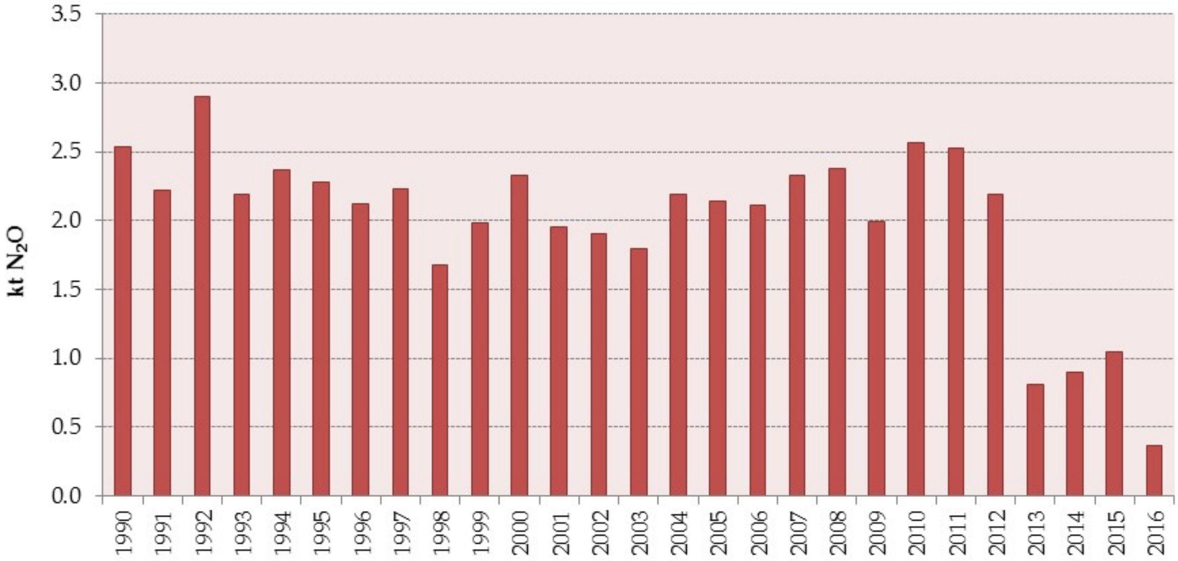
production unit were performed. Verification of activity data and emissions for the period 2012 - 2016 is defined in line with requirements of the EU ETS.

Table 4.3-4: Nitric acid production (1990 - 2016)

Year	Nitric acid production UNIT 1 (t)	Nitric acid production UNIT 2 (t)	Nitric acid production TOTAL (t)
1990	206,962	125,497	332,459
1991	178,267	113,730	291,997
1992	248,601	133,196	381,797
1993	187,465	100,339	287,805
1994	192,133	119,103	311,236
1995	199,251	100,046	299,297
1996	179,387	99,296	278,683
1997	175,990	116,902	292,892
1998	132,760	87,749	220,509
1999	163,204	96,994	260,198
2000	199,027	107,174	306,201
2001	181,263	76,271	257,534
2002	160,789	89,203	249,992
2003	132,470	103,176	235,646
2004	189,608	97,959	287,567
2005	176,988	103,758	280,746
2006	177,916	99,673	277,590
2007	204,984	101,635	306,619
2008	196,676	116,252	312,928
2009	163,042	98,436	261,478
2010	199,650	137,145	336,794
2011	217,288	115,425	332,713
2012	196,200	92,007	288,207
2013	186,777	110,768	297,545
2014	196,873	110,424	307,296
2015	236,151	108,487	344,638
2016	211,735	81,525	293,260

The resulting emissions of N_2O from Nitric Acid Production in the period 1990 - 2016 are presented in the Figure 4.3-2.

Figure 4.3-2: Emissions of N_2O from Nitric Acid Production (1990 - 2016)



Reduction of N_2O emissions from the nitric acid production in the period 2013 - 2016 is a result of applying the abatement technology. A strong reduction is in 2016.

Emissions of NO_x and NH_3 have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

4.3.2.3. Uncertainties and time-series consistency

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

Activity data and emission factor uncertainty was calculated in detail. 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 2016, 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 the period 1990 - 2011. Verified CO_2 emissions reported in line with requirements of the EU ETS were used for the period 2012 - 2016. Methodology proposed by the Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2009/29/EC corresponds to the methodology used for the period 1990 - 2011.

4.3.2.4. 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.

Emissions of N_2O from nitric acid production were based on plant-specific emission factor and annual amount of nitric acid production. It is a *good practice* to use direct emission measurement for national emission factor calculation. Basic activity data from Annual PRODCOM results were compared with data provided by individual plant. Results of this comparison showed that there is no significant difference between these two sets of data.

4.3.2.5. Category-specific recalculations

There are no source-specific recalculations in this report.

4.3.2.6. Category-specific planned improvements

More detailed information about using of direct emission measurement for calculation of national emission factor are planned collect. 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.

4.3.3. Adipic acid production (2.B.3)

This category does not exist in Croatia.

4.3.4. Caprolactam, glyoxal and glyoxylic acid production (2.B.4)

This category does not exist in Croatia.

4.3.4.1. Carbide production (2.B.5)

This category does not exist in Croatia.

4.3.5. Titanium dioxide production (2.B.6)

This category does not exist in Croatia.

4.3.6. Soda ash production (2.B.7)

This category does not exist in Croatia.

4.3.7. Petrochemical and carbon black production (2.B.8)

4.3.7.1. Category description

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.

4.3.7.2. 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*. For now, data for using higher tier methodology are not available except incomplete data for carbon black. Majority of production of petrochemicals and carbon black was halted several years ago, which has consequently decreased the possibility to collect data for using higher tier methodology.

The annual production of chemicals (see Table 4.3-5) 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 - 2016 are reported in the Table 4.3-6.

Table 4.3-5: Annual production of chemicals (1990 - 2016)

Year	Carbon black (t)	Ethylene (t)	Ethylene dichloride (t)	Methanol (t)
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	0.00	0.00
2003	21,295	41,252	0.00	3.72
2004	20,272	49,886	0.00	3.80
2005	18,498	50,263	0.00	2.93
2006	26,264	48,824	0.00	2.95
2007	23,724	45,438	0.00	2.03
2008	16,904	43,045	0.00	2.00
2009	3,976	38,797	0.00	1.00
2010	0.00	36,271	0.00	0.87
2011	0.00	23,323	0.00	1.92
2012	0.00	0.00	0.00	3.17
2013	0.00	0.00	0.00	1.01
2014	0.00	0.00	0.00	0.94
2015	0.00	0.00	0.00	0.95
2016	0.00	0.00	0.00	1.95

Table 4.3-6: Emissions of CO_2 and CH_4 from Petrochemical and Carbon Black Production (1990 - 2016)

Year	Carbon black (t)		Ethylene (t)		Ethylene dichloride (t)		Methanol (t)	
	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	0.0000	0.000000

Year	Carbon black (t)		Ethylene (t)		Ethylene dichloride (t)		Methanol (t)	
	CO_2 (kt)	CH_4 (kt)	CO_2 (kt)	CH_4 (kt)	CO_2 (kt)	CH_4 (kt)	CO_2 (kt)	CH_4 (kt)
1991	49.211	0.001	115.687	0.201	13.050	NA	0.0000	0.000000
1992	35.315	0.001	118.190	0.205	17.589	NA	0.0000	0.000000
1993	44.862	0.001	118.737	0.206	15.205	NA	0.0000	0.000000
1994	56.246	0.001	112.943	0.196	18.628	NA	0.0000	0.000000
1995	71.225	0.002	116.856	0.203	16.115	NA	0.0000	0.000000
1996	70.046	0.002	112.073	0.194	9.289	NA	0.0000	0.000000
1997	63.441	0.001	109.948	0.191	5.016	NA	0.0000	0.000000
1998	63.108	0.001	104.056	0.180	5.980	NA	0.0000	0.000000
1999	54.043	0.001	104.310	0.181	9.108	NA	0.0000	0.000000
2000	52.476	0.001	67.328	0.117	13.631	NA	0.0000	0.000000
2001	55.492	0.001	80.673	0.140	12.308	NA	0.0000	0.000000
2002	50.870	0.001	75.348	0.131	0.000	NA	0.0000	0.000000
2003	55.793	0.001	71.366	0.124	0.000	NA	0.0025	0.000009
2004	53.113	0.001	86.303	0.150	0.000	NA	0.0025	0.000009
2005	48.465	0.001	86.955	0.151	0.000	NA	0.0020	0.000007
2006	68.812	0.002	84.466	0.146	0.000	NA	0.0020	0.000007
2007	62.157	0.001	78.608	0.136	0.000	NA	0.0014	0.000005
2008	44.288	0.001	74.468	0.129	0.000	NA	0.0013	0.000005
2009	10.417	0.000	67.119	0.116	0.000	NA	0.0007	0.000002
2010	0.000	0.000	62.749	0.109	0.000	NA	0.0006	0.000002
2011	0.000	0.000	40.349	0.070	0.000	NA	0.0013	0.000004
2012	0.000	0.000	0.000	0.000	0.000	NA	0.0021	0.000007
2013	0.000	0.000	0.000	0.000	0.000	NA	0.0007	0.000002
2014	0.000	0.000	0.000	0.000	0.000	NA	0.0006	0.000002
2015	0.000	0.000	0.000	0.000	0.000	NA	0.0006	0.000002
2016	0.000	0.000	0.000	0.000	0.000	NA	0.0013	0.000004

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 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

4.3.7.3. 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 (general explanation on expert judgement is provided in Chapter 4.1.).

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.

4.3.7.4. 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.

4.3.7.5. Category-specific recalculations

There are no source-specific recalculations in this report.

4.3.7.6. Category-specific planned improvements

As explained, data for using higher tier methodology are not available except incomplete data for carbon black (which production was stopped in 2009). Majority of production of petrochemicals and carbon black was halted several years ago, which has consequently decreased the possibility to collect the data for using higher tier methodology. It was included in the Annual data collection plan and would be collected in the future if it will be possible.

More information for uncertainty estimation associated with activity data and emission factors is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates associated with activity data and emission factors are based on expert judgements since statistics and manufacturers have not particularly assessed the uncertainties. It should be necessary to include more experts from the relevant institutions as well as manufacturers (source of data) in the assessment of activity data uncertainties. Experts who are directly associated with the activity data can more accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

4.3.8. Fluorochemical production (2.B.9)

This category does not exist in Croatia.

4.4. Metal industry

4.4.1. Iron and steel production (2.C.1)

4.4.1.1. 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.

4.4.1.2. Methodological issues

Pig Iron Production

Emissions of CO_2 have been calculated by multiplying annual production of pig iron by the emission factor proposed by *2006 IPCC Guidelines* (1.6 t CO_2/t 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[3].

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. Notation key IE is used in the CRF 2.C.1.b for 1990 and 1991. Allocation in the Energy sector (1.A.2.a) and nk explanation are included in the cell comments, but this information are not visible in the Reporting Table 2(I).A-H Sectoral Background Data for Industrial Processes and Product Use.

Steel Production

There are five steel manufacturers in Croatia. Steel production by one manufacturer was halted in 2009. In 2012, steel production was considerably reduced, while in 2013 began to increase. In 2014 steel production was considerably increased in relation to the previous period and again decreased in 2015. In 2016 emissions strong decreased primarily due to stopping of production in largest steel factory.

A method based on annual consumption of carbon donors in EAFs has been used for CO_2 emission calculation for each manufacturer. Calculation of CO_2 emissions is accomplished by applying an emission factor in tonnes of CO_2 released per tonne of carbon donors (input material) to the consumed quantity of the input material. The carbon emission factor is based on carbon loss from carbon donors. Total CO_2 emission has been calculated as follows:

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

Methodology used for CO_2 emission calculation corresponds to the methodology proposed by the Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2009/29/EC. Activity data and emissions for the period 2012 - 2016 were defined in line with requirements of the EU ETS. Verified CO_2 emissions were reported directly by the steel manufacturers who sent reports to the Croatian Agency for the Environment and Nature in the forms ''Annual report on greenhouse gas emissions for industrial installations". Verification of activity data and emissions for the period 2012 - 2016 is defined in line with requirements of the EU ETS. Verified process emissions are included in Steel Production for the period 2012 - 2016.

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, are presented in Table 4.4-1.

[3] 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.

The other carbon donors were used in minor quantity. Within installations natural gas, diesel oil and liquefied petroleum gases were used as reducing agents (see Table 4.4-2).

Table 4.4-1: Consumption of main carbon donors (input materials) in EAFs (1990 - 2016)

Year	Scrap iron (t)	Steel scrap (t)	EAF carbon electrodes (t)	EAF charge carbon (t)	Petroleum coke (t)
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	59,448	4,785	221	558	0
2014	186,197	14,238	580	1,774	2,247
2015	152,405	12,707	479	1,894	240
2016	14,643	5,860	0	198	0

Table 4.4-2: Consumption of other carbon donors (input materials) and reducing fuels in EAFs (1990 - 2016)

Year	Lime (t)	Other carbon donors* (t)	Natural gas (m3)	Diesel oil (t)	Liquefied petroleum gases (t)
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

Year	Lime (t)	Other carbon donors* (t)	Natural gas (m3)	Diesel oil (t)	Liquefied petroleum gases (t)
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	2,449	1,985	2,061,350	0	0
2014	7,993	5,518	-	0	0
2015	6,263	5,020	2,967,484	0.4	0
2016	0	920	1,159,439	0.4	0

* other carbon donors include alloys Fe-Cr, Fe-Mn,, Fe-Si, Fe-S, Fe-P, Fe-Si-Mn, Fe-Mn-MC, Fe-Cr-CH, Fe-Mo, Si carbide, Ca carbide and antracite

Default emission factors for main carbon donors[4] (Table 4.4-3) and reducing fuels[5] (Table 4.4-4) have been used for CO_2 emission calculation.

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

Carbon donors	EF (t CO_2/t)
Scrap iron	0.15
Steel scrap	0.008
EAF carbon electrodes	3.00
EAF charge carbon	3.04
Petroleum coke	3.19

Table 4.4-4: EF and net calorific values for reducing fuel in EAFs

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

[4] 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

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

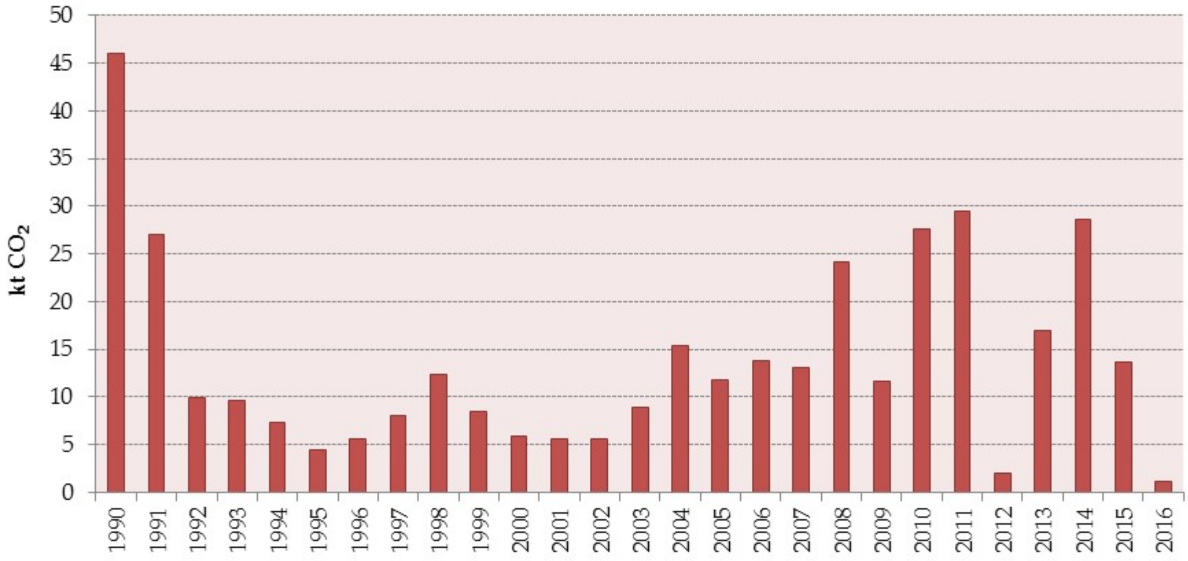
The activity data for steel production (see Table 4.4-5) were collected by bottom up analysis from steel manufacturers.

Table 4.4-5: Steel production (1990 - 2016)

Year	Steel production (t)
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	65,258
2014	174,620
2015	148,583
2016	23,620

The resulting emissions of CO_2 from Steel Production in the period 1990 - 2016 are presented in the Figure 4.4-1. CO_2 emissions from limestone and dolomite use in steel production are included in total CO_2 emissions for this category.

Figure 4.4-1: Emissions of CO_2 from Steel Production (1990 - 2016)



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

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 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

4.4.1.3. Uncertainties and time-series consistency

Uncertainty estimate associated with activity data amounts to 10 percent for 1990 and 5 percent for 2016, based on expert judgement (general explanation on expert judgement is provided in Chapter 4.1.). Uncertainty estimate associated with emission factors amounts to 10 percent for 1990 and 5 percent for 2016, accordingly to values reported in *2006 IPCC Guidelines* and based on expert judgement (detailed in Annex 1).

Emissions from from Steel Production have been calculated using the same method and data sets for the period 1990 - 2011. Verified CO_2 emissions reported in line with requirements of the EU ETS were used for the period 2012 - 2016. Methodology proposed by the Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2009/29/EC corresponds to the methodology used for the period 1990 - 2011.

4.4.1.4. 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.

4.4.1.5. Category-specific recalculations

There are no source-specific recalculations in this report.

4.4.1.6. Category-specific planned improvements

More information for uncertainty estimation associated with activity data is required, regarding more accurate and transparent uncertainty analysis.

4.4.2. Ferroalloys production (2.C.2)

4.4.2.1. 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.

4.4.2.2. 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 4.4-6) 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 4.4-6: Ferroalloys production (1990 - 2003)

Year	Ferroalloys production (t)		
	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

Year	Ferroalloys production (t)		
	Ferromanganese	Silicon manganese	Ferrochromium
2003	62	660	2

In previous reports CO_2 emission was calculated using a higher tier approach. The data needed to calculate emissions using Tier 2 methodology are incomplete. Tier 1 methodology has been use because complete data is available for this approach. ERT recommended to use a combined approach using both Tier 1 and Tier 2 methodology – the Tier 2 for the most recent year and Tier 1 to ensure the consistency in time-series. In the previous reports explanation was provided on insufficient data for reducing agent coke from coal for the period 1994 - 1996 and 1999 - 2001. The data for 2002 and 2003 considerably differ from the previous trend. The second used reducing agent, coal electrodes, has significantly lower proportion in relation to coke from coal. Therefore, Tier 1 methodology was used for entire period. It should be noticed that ferroalloys production was halted in 2003, which has consequently decreased the possibility to recheck activity data.

Emissions of CO_2 and CH_4 from Ferroalloys Production (Tier 1 approach) in the period 1990 - 2003 are reported in the Table 4.4-7.

Table 4.4-7: Emissions of CO_2 and CH_4 from Ferroalloys Production (1990 - 2003)

Year	CO_2 emissions (kt)			CH_4 emissions (kt)
	Ferromanganese	Silicon manganese	Ferrochromium	Ferroalloys (total)
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

Annual data on reducing agents and emissions of CO_2 from Ferroalloys Production (Tier 2 approach) in the period 1990 - 2003 are reported in the Table 4.4-8.

Table 4.4-8: Annual data on reducing agents and emissions of CO_2 from Ferroalloys Production (1990 - 2003) – Tier 2

Year	Coke from coal (t)	Coal electrodes (t)	CO_2 emissions (kt) Ferroalloys total
1990	36,216.00	1,824.00	126.03
1991	41,981.00	2,533.00	147.50
1992	25,619.00	1,645.00	90.37
1993	8,519.00	799.00	30.94
1994	8,566.00	988.00	31.77
1995	9,529.00	650.00	33.75
1996	3,860.00	266.00	13.68
1997	11,867.00	817.78	42.06
1998	5,166.00	356.00	18.31
1999	6,054.10	417.20	21.46
2000	3,624.40	249.76	12.84
2001	1,194.69	82.33	4.23
2002	4.00	0.28	0.01
2003	13.00	0.90	0.05

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 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

4.4.2.3. Uncertainties and time-series consistency

Uncertainty estimate associated with activity data amounts to 10 percent, based on expert judgement (general explanation on expert judgement is provided in Chapter 4.1.). 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.

4.4.2.4. 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.

4.4.2.5. Category-specific recalculations

There are no source-specific recalculations in this report.

4.4.2.6. 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. Comparison for Tier 1 and Tier 2 approach has been made. Data for Tier 2 approach seem unreliable, particularly for the last two years. Due to this fact, Tier 1 methodology has been used for emissions calculation. There is no possibility for improvements for this category.

4.4.3. Aluminium production (2.C.3)

4.4.3.1. 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.

There is a company that manufactures castings in aluminum by the pressure injection process. It does not deal with primary or secondary aluminum production, or production of aluminum from bauxite or recycled aluminum so emissions of F-gases (PFC and HFC) and sulfur hexhexafluoride (SF6) do not exists.

4.4.3.2. Methodological issues

The quantity of CO_2 released was estimated from the production of primary aluminium and the specific consumption of carbon which is oxidized to CO_2 in the process. During alumina reduction using prebaked anodes approximately 1.5 tonnes of CO_2 is emitted for each tonne of primary aluminium produced (*2006 IPCC Guidelines*).

Data on primary aluminium production were collected by survey of aluminium manufacturer[6]. Primary aluminium production were closed at the end of 1991, which has consequently decreased the possibility to collect data for using higher tier methodology.

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/t Al for CF_4 and 0.17 kg/t 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.

[6] Primary aluminium production (electrolysis) were closed at the end of 1991 mainly due to war activities near the location of aluminium plant.

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

4.4.3.3. Uncertainties and time-series consistency

Uncertainties related to calculation of CO_2 emissions are primarily due to applied emission factor. A less uncertain method to calculate CO_2 emissions would be based upon the amount of reducing agent, i.e. amount of prebaked anodes used in the process but this information was not available. Nevertheless, it is very likely that use of the technology-specific emission factor, provided by *2006 IPCC Guidelines*, along with the correct production data produce accurate estimates.

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.

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.

4.4.3.4. 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.

4.4.3.5. Category-specific recalculations

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

4.4.3.6. Category-specific planned improvements

As explained, data for using higher tier methodology are not available. Primary aluminium production were closed at the end of 1991, which has consequently decreased the possibility to collect the data for using higher tier methodology. Need for information on historical AD on anode consumption and anode effect performance was included in the Annual data collection plan and would be collected in the future if it will be possible.

4.4.4. Magnesium production (2.C.4)

This category does not exist in Croatia.

4.4.5. Lead production (2.C.5)

This category does not exist in Croatia.

4.4.6. Zinc production (2.C.6)

This category does not exist in Croatia.

4.5. Non-energy products from fules and solvent use (CRF 2.D)

4.5.1. Lubricant use (2.D.1)

4.5.1.1. Category description

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

4.5.1.2. Methodological issues

Emissions of CO_2 from lubricant use have been calculated using Tier 1 methodology, by multiplying an total annual consumption of lubricants with related default emission factor and ODU factor provided by *2006 IPCC Guidelines*. Default carbon content (CC) factor of lubricants (20.0 t C/TJ on a Lower Heating Value basis), default Oxidised During Use (ODU) factor (0.2) and the mass ratio of CO_2/C (44/12) have been used for CO_2 emission calculation for entire period 1990 - 2016.

The annual consumption of lubricants (see Table 4.5-1) was extracted from Energy Balance.

Table 4.5-1: Consumption of lubricants (1990 - 2016)

Year	Consumption of lubricants (kt)
1990	147.46
1991	126.14
1992	89.71
1993	109.95
1994	122.26
1995	119.08
1996	128.74
1997	140.92
1998	105.53
1999	33.50
2000	30.00
2001	31.10
2002	33.60
2003	29.00
2004	39.40
2005	35.40
2006	38.10

Year	Consumption of lubricants (kt)
2007	45.10
2008	38.90
2009	37.30
2010	33.20
2011	33.40
2012	29.70
2013	28.70
2014	29.80
2015	32.20
2016	34.50

Emissions of CO_2 from Lubricants in the period 1990 - 2016 are presented in the Table 4.5-2.

Table 4.5-2: Emissions of CO_2 from Lubricant (1990 - 2016)

Year	CO_2 emissions from lubricants use (kt CO_2)
1990	72.60
1991	61.98
1992	44.08
1993	54.02
1994	60.07
1995	53.04
1996	63.26
1997	69.95
1998	52.57
1999	16.46
2000	14.74
2001	15.28
2002	16.51
2003	14.25
2004	19.36
2005	17.39
2006	18.72
2007	22.16
2008	19.11
2009	18.33
2010	16.31
2011	16.41
2012	14.59
2013	14.10
2014	14.64
2015	15.82
2016	16.95

4.5.1.3. Uncertainties and time-series consistency

General explanation on expert judgement is provided in Chapter 4.1.

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

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

4.5.1.4. 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.

4.5.1.5. Category-specific recalculations

There are no source-specific recalculations in this report.

4.5.1.6. Category-specific planned improvements

Separate data for lubricant and paraffin wax use are reported in the Energy Balance for the period 1999 – 2015. For the period 1990 – 1998, separation of aggregated data have been performed according to estimation on share in total quantity that should be further investigated. Trend analysis should be carried out so that all necessary data and information will be collected at time and to the extent for an accurate and transparent emission calculation.

4.5.2. Parafin wax use (2.D.2)

4.5.2.1. Category description

Paraffin wax are used in different industrial applications. More detailed information about use of paraffin wax should be investigated for future reports.

4.5.2.2. Methodological issues

Emissions of CO_2 from paraffin wax use have been calculated using Tier 1 methodology, by multiplying an total annual consumption of paraffin wax with related default emission factor and ODU factor provided by *2006 IPCC Guidelines*. Default carbon content (CC) factor of paraffin wax (20.0 t C/TJ on a Lower Heating Value basis), default Oxidised During Use (ODU) factor (0.2) and the mass ratio of CO_2/C (44/12) have been used for CO_2 emission calculation for entire period 1990 - 2016.

The annual consumption of paraffin wax (see Table 4.5-3) was extracted from Energy Balance.

Table 4.5-3: Consumption of paraffin wax(1990 - 2016)

Year	Consumption of paraffin wax (kt)
1990	46.34
1991	39.64

Year	Consumption of paraffin wax (kt)
1992	28.19
1993	34.55
1994	38.42
1995	37.42
1996	40.46
1997	44.28
1998	33.17
1999	9.80
2000	10.50
2001	10.00
2002	9.80
2003	11.30
2004	10.80
2005	11.00
2006	11.10
2007	10.90
2008	9.50
2009	9.10
2010	7.90
2011	7.70
2012	6.20
2013	5.80
2014	7.00
2015	7.70
2016	7.90

Emissions of CO_2 from Paraffin Wax Use in the period 1990 - 2016 are presented in the Table 4.5-4.

Table 4.5-4: Emissions of CO_2 from Paraffin Wax Use (1990 - 2016)

Year	CO_2 emissions from paraffin wax use (kt CO_2)
1990	22.82
1991	19.48
1992	13.85
1993	16.98
1994	18.88
1995	16.67
1996	19.88
1997	21.98
1998	16.52
1999	4.82
2000	5.16
2001	4.91
2002	4.82
2003	5.55
2004	5.31
2005	5.40
2006	5.45

Year	CO_2 emissions from paraffin wax use (kt CO_2)
2007	5.36
2008	4.67
2009	4.47
2010	3.88
2011	3.78
2012	3.05
2013	2.85
2014	3.44
2015	3.78
2016	3.88

4.5.2.3. Uncertainties and time-series consistency

General explanation on expert judgement is provided in Chapter 4.1.

Uncertainty estimate associated with activity data for CO_2 emissions calculation resulting by consumption of paraffin wax amounts to 5percent, based on expert judgement.

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

4.5.2.4. 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.

4.5.2.5. Category-specific recalculations

There are no source-specific recalculations in this report.

4.5.2.6. Category-specific planned improvements

Separate data for lubricant and paraffin wax use are reported in the Energy Balance for the period 1999 – 2015. For the period 1990 – 1998, separation of aggregated data have been performed according to estimation on share in total quantity that should be further investigated. Trend analysis should be carried out so that all necessary data and information will be collected at time and to the extent for an accurate and transparent emission calculation. In addition, more detailed information about use of paraffin wax should be investigated for future reports (long-term goal).

4.5.3. Other (2.D.3)

4.5.3.1. Category description

This category includes following sub-categories:

- Solvent use
- Road paving with asphalt

- Asphalt roofing
- Urea based catalytic converters

4.5.3.2. 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 2016 Submission to the Convention on Long-range Transboundary Air Pollution*'. The NMVOC emissions have been calculated by using Tier 2 methodology. Default emission factor (EMEP-CORINAIR Emission Inventory Guidebook) with the effect of implementation the abatement technology during application of adhesives, has been applied for source categories. 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 = 0.6 (*2006 IPCC Guidelines*, Volume 3, p. 5.17, default fossil carbon content fraction of NMVOC is 60 percent by mass) and the mass ratio of CO_2/C (44/12). The overall conversion factor has value of 2.2 and uses for entire period 1990 - 2016.

The resulting emissions of CO_2 from Solvent Use in the period 1990 - 2016 are presented in the Table 4.5-5.

Table 4.5-5: Emissions of CO_2 from Solvent Use (1990 - 2016)

Year	CO_2 emission (kt CO_2)
1990	139.315
1991	92.310
1992	59.893

Year	CO_2 emission (kt CO_2)
1993	57.382
1994	58.164
1995	83.923
1996	80.142
1997	65.608
1998	63.397
1999	56.795
2000	57.522
2001	58.158
2002	70.881
2003	72.893
2004	85.481
2005	89.960
2006	100.495
2007	101.245
2008	103.620
2009	73.954
2010	68.870
2011	63.557
2012	60.373
2013	56.831
2014	51.462
2015	50.765
2016	54.462

Drop in NMVOC emissions (from which CO_2 emissions are calculated) is related to the trend of AD, especially in the IIR NFR code 2.D.3.i Other solvent and product use, as well as application of abatement measures for the SNAP code 06405 Use of adhesives. As well, decreasing of economic activity after 2008 influenced a decrease in emissions.

Emissions of SO_2, CO, NO_x and NH_3 have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

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 2016 Submission to the Convention on Long-range Transboundary Air Pollution'.

Default fossil carbon content fraction of NMVOC from asphalt production and use for road paving which varies between 40 to 50 percent by mass (average value of 45 percent is used) and about 80 percent for NMVOC from asphalt roofing (80 percent is used), proposed by *2006 IPCC Guidelines*, Volume 3, p. 5.16, as well mass ratio of CO_2/C (44/12), have been used for CO_2 emission calculation.

Emissions of CO_2 from Road paving with asphalt and Asphalt roofing in the period 1990 - 2016 are presented in the Table 4.5-6.

Table 4.5-6: Emissions of CO_2 from Road paving with asphalt and Asphalt roofing (1990 - 2016)

Year	CO_2 emission (kt)	
	Road paving with asphalt	Asphalt roofing
1990	0.005	0.009
1991	0.004	0.006
1992	0.001	0.005
1993	0.001	0.005
1994	0.007	0.005
1995	0.007	0.006
1996	0.009	0.007
1997	0.013	0.002
1998	0.013	0.004
1999	0.014	0.005
2000	0.013	0.009
2001	0.010	0.004
2002	0.020	0.004
2003	0.030	0.009
2004	0.036	0.009
2005	0.032	0.017
2006	0.030	0.028
2007	0.029	0.018
2008	0.035	0.010
2009	0.029	0.009
2010	0.024	0.007
2011	0.026	0.006
2012	0.023	0.004
2013	0.018	0.006
2014	0.021	0.005
2015	0.020	0.015
2016	0.020	0.007

Urea based catalytic converters

This source category encompasses CO2 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 (*2006 IPCC Guidelines*), by multiplying amount of urea-based additive consumed for use in catalytic converters and the mass fraction of urea in the urea-based additive. Default value for purity (32.5 percent) as well mass ratio of CO_2/C (44/12) have been included in CO_2 emission calculation. Emissions from 1990 to 1999 do not occur because urea-based catalytic converters were introduced after 2000 only. For emission estimation from the period 2000 till 2016 data on total diesel fuel consumed was used.

Emissions of CO_2 from Urea Based Catalytic Converters in the period 1990 - 2016 are presented in the Table 4.5-7.

Table 4.5-7: Emissions of CO_2 from Urea Based Catalytic Converters (1990 – 2016)

Year	CO_2 emission (kt CO_2)
1990	NO
1991	NO
1992	NO
1993	NO
1994	NO
1995	NO
1996	NO
1997	NO
1998	NO
1999	NO
2000	2.659
2001	2.865
2002	3.258
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
2014	5.340
2015	5.805
2016	6.099

4.5.3.3. Uncertainties and time-series consistency

General explanation on expert judgement is provided in Chapter 4.1.

Solvent use

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

Road paving with asphalt and Asphalt roofing

Uncertainty estimate associated with activity data (statistical data) for NMVOC emissions calculation amounts to 10 percent, based on expert judgement.

Uncertainty estimate associated with default emission factors for CO_2 emissions calculation amounts to 50 percent, based on expert judgement.

Urea based catalytic converters

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

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

4.5.3.4. 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.

4.5.3.5. Category-specific recalculations

Solvent use

New data for source categories are included for entire reporting period that caused the change in NMVOC emissions. Consequently, CO_2 emissions was changed. Therefore, recalculations of CO_2 emissions were performed for the period 1990 - 2015.

Road paving with asphalt and Asphalt roofing

There are no source-specific recalculations in this report.

Urea based catalytic converters

There are no source-specific recalculations in this report.

4.5.3.6. Category-specific planned improvements

More information for uncertainty estimation associated with activity data and emission factors is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates associated with activity data and emission factors are based on expert judgements since statistics and manufacturers have not particularly assessed the uncertainties. It should be necessary to include more experts from the relevant institutions as well as manufacturers (source of data) in the assessment of activity data uncertainties. Experts who are directly associated with the activity data can more accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

4.6. Electronics industry (CRF 2.e)

This category does not exist in Croatia.

4.7. Product uses as substitutes for ods (2.F)

4.7.1. Refrigeration and air conditioning (2.F.1)

4.7.1.1. Category description

Category Refrigeration and air conditioning accounts for the majority of emissions in IPCC 2.F Sector (96.1 percent). In 2016, HFCs and PFCs emissions contributed 17.1 percent to the sectoral GHG emission, as well 1.7 percent to the total GHG emissions.

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.

MEE 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, MEE 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.

MEE 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.

HFC-s started to be used in larger extent in the middle of the last decade and taken into consideration that lifespan of the equipment is 20 years and more, if it is regularly maintained, such equipment where not disposed yet.

In contacts with some of service providers MEE get information that they did not have any case of HFC-s equipment disposal. However MEE will contact disposal of refrigeration and air conditioning equipment facilities and recovery, recycling and reclaim centers (RRR centers) regarding collection of data about disposal of waste HFC refrigerants and equipment. For now, data are not collected.

4.7.1.2. Methodological issues

Emissions of HFCs used in Refrigeration and Air Conditioning Equipment have been calculated for the period 1995-2016, since there was no use of these substances prior to 1995.

MEE collects data on installed quantities of HFCs as well as added and recovered quantities and data on consumption of F-gases (import and export data). Operators of equipment are obliged to fill up the form prescribed in the Croatian ODS and F-gas Regulation (OG 92/2014) and send to MEE (in future to the CAEN). Service technicians are obliged to send data on added and recovered quantities of HFCs (Form prescribed in the Croatian Regulation) to MEE. According to received data MEE forwarded data to the CAEN.

Tier 2 methodology is used for HFCs emission calculation. For some gases, as HFC-23 (used in 2010, 2011, 2013 - 2015), PFC-14 (used in 2010), PFC-218 (used in the period 2009 - 2012) and PFC-116 (used in the period 2013 - 2015) 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. Emission factor represents annual emission rate during operation (% of initial charge/year), accounting for annual leakage and average annual emissions during servicing. The *2006 IPCC Guidelines* propose a range of values (Volume 3, Chapter 7, Table 7.9), where lower value is proposed for developed countries and higher value for developing countries. An average value of emission factors are calculated for each sub-applications to adjust it to national circumstances.

Data on import and export of HFCs and PFCs, which were used for emission calculation by means of Tier 1a methodology, have been also compiled by the MEE. These emissions data were generated by means of a mass balance approach.

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 and PFCs used in Refrigeration and Air Conditioning Equipment in the period 1995 - 2016 are reported in the Table 4.7-1.

Table 4.7-1: Emissions of HFCs and PFCs used in Refrigeration and Air Conditioning Equipment (t) (1995-2016)

Source/Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
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	9.21	9.90
HFC-134a	0.14	0.24	0.30	0.44	0.47	0.54	0.57	0.68	0.73	0.84	0.90

Source/Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
HFC-143a	1.87	3.16	3.86	5.73	6.08	7.02	7.37	8.78	9.48	10.88	11.70
Domestic Refrigeration											
HFC-134a	0.03	0.06	0.14	0.18	0.20	0.23	0.27	0.29	0.33	0.42	0.45
Industrial Refrigeration											
HFC-23	NO	NO	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	2.99	3.58
HFC-125	0.56	0.68	0.92	1.24	1.52	2.00	2.32	2.48	2.60	3.08	3.69
HFC-134a	0.33	0.42	0.58	0.92	1.00	1.16	1.66	1.83	1.91	2.25	2.66
HFC-143a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.01
PFC-14	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
PFC-116	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
PFC-218	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Transport Refrigeration											
HFC-134a	4.89	5.30	5.98	6.50	7.80	8.97	11.10	13.39	16.18	18.80	21.03
Mobile Air-Conditioning											
HFC-134a	2.47	8.38	16.80	25.03	33.57	42.60	45.33	51.14	54.93	61.49	68.37
Stationary Air-Conditioning											
HFC-32	0.30	0.50	0.96	1.24	1.67	2.02	2.33	2.49	2.72	3.13	3.50
HFC-125	0.31	0.51	0.99	1.28	1.71	2.08	2.40	2.56	2.80	3.23	3.60
HFC-134a	0.29	0.44	0.81	0.99	1.22	1.51	1.82	1.90	2.18	2.39	2.55

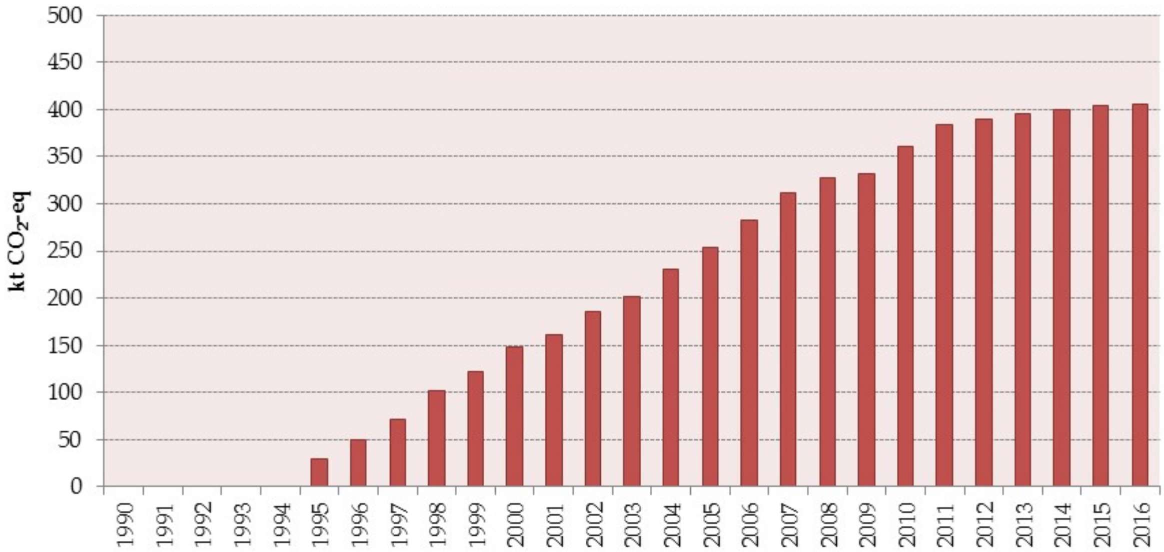
Table 4.7-1: Emissions of HFCs and PFCs used in Refrigeration and Air Conditioning Equipment (t) (1995-2016), cont.

Source/Gas	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2.F.1. Refrigeration and Air Conditioning Equipment											
Commercial Refrigeration											
HFC-125	10.49	11.68	11.88	11.98	13.07	15.44	15.84	16.04	16.34	16.53	16.73
HFC-134a	0.95	1.06	1.08	1.09	1.19	1.40	1.44	1.46	1.49	1.50	1.52
HFC-143a	12.40	13.81	14.04	14.16	15.44	18.25	18.72	18.95	19.31	19.54	19.77
Domestic Refrigeration											
HFC-134a	0.41	0.32	0.30	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.27
Industrial Refrigeration											
HFC-23	NO	NO	NO	NO	0.066	0.036	NO	0.067	0.022	0.011	NO
HFC-32	3.81	3.97	4.09	4.36	4.71	4.94	5.06	5.33	5.41	5.64	5.69
HFC-125	3.96	4.14	4.27	4.56	4.92	5.16	5.28	5.58	5.72	5.98	6.00
HFC-134a	2.83	2.83	2.91	3.00	3.41	3.58	3.66	3.91	3.91	4.08	3.99
HFC-143a	0.04	0.06	0.07	0.08	0.08	0.08	0.08	0.10	0.16	0.18	0.16
PFC-14	NO	NO	NO	NO	0.004	NO	NO	NO	NO	NO	NO
PFC-116	NO	NO	NO	NO	NO	NO	NO	0.005	0.005	0.003	NO
PFC-218	NO	NO	NO	0.029	0.001	0.002	0.004	NO	NO	NO	NO
Transport Refrigeration											
HFC-134a	22.75	24.96	26.62	26.98	28.86	29.19	29.32	29.51	29.58	29.58	29.58
Mobile Air-Conditioning											
HFC-134a	80.91	89.28	97.14	97.50	107.40	107.70	108.00	108.75	109.35	109.65	109.95
Stationary Air-Conditioning											
HFC-32	3.83	4.09	4.20	4.22	4.33	4.40	4.48	4.59	4.63	4.75	4.92
HFC-125	3.94	4.20	4.31	4.34	4.45	4.53	4.60	4.71	4.76	4.89	5.05
HFC-134a	2.73	2.86	2.99	2.99	3.12	3.17	3.22	3.30	3.35	3.46	3.48

In Croatia there are large 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.

Emissions of HFCs and PFCs used in Refrigeration and Air Conditioning Equipment in the period 1990 - 2016 are presented in the Figure 4.7-1.

Figure 4.7-1: Emissions of HFCs and PFCs used in Refrigeration and Air Conditioning Equipment (1990 - 2016), (kt CO_2-eq)



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.

4.7.1.3. Uncertainties and time-series consistency

Activity data and emission factor uncertainties were calculated in detail. 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 judgement (detailed in Annex 1). General explanation on expert judgement is provided in Chapter 4.1.

4.7.1.4. 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.

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 4.7.1.6).

4.7.1.5. Category-specific recalculations

There are no source-specific recalculations in this report.

4.7.1.6. 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.

According to TERT recommendation during 2016 ESD review, for category 2F1 Refrigeration and air conditioning equipment containing <3 kg of refrigerants, such as for example residential air conditioners, should be included in the estimated emissions. It was included in the Annual data collection plan (short-term goal). During 2017 ESD review, TERT asked for the information regarding reporting requirements according EU F-gases Regulation and related reporting obligations that have been reviewed in 2014. The TERT assumes that reporting requirements have also been updated in Croatia and asked for more information that is being reported by operators (e.g. equipment containing F-gas quantities >5 tonnes of CO2 equivalents as mentioned in Regulation 517/2014, Article 4(1)). In addition, the TERT asked for more detail on the approach used and data source for each subcategory of 2.F.1. MEE, as responsible institution, provided an explanation that Republic Croatia is developing a reporting system which will enable to collect data in accordance with Regulation 517/2014, Article 4(1) and that is planned to collect data which will include equipment containing <3 kg of refrigerants and equipment containing F-gas quantities >5 tonnes of CO2 equivalents. However, for now, these data are not included in the inventory. This is the short-term goal.

Regarding the technical correction for category 2F1d Transport refrigeration during ESD 2016, further analysis should be carried out to investigate the actual share of trucks with refrigeration equipment, so that all necessary data and information will be collected at time and to the extent for an accurate and transparent emission calculation. It was included in the Annual data collection plan (short-term goal). However, for now, these data are not collected and included in the inventory. In addition, data for 2016 was not provided, so it is estimated according to data for 2015 that is the same as data for 2014. Therefore, it is necessary to provide accurate data for 2015 and 2016 in order to accurate emission calculation. This is the short-term goal.

Currently, the category 2F1e Mobile air-conditioning includes only mobile air conditioning in passenger cars. According to TERT recommendation during 2016 ESD review, additional analysis for including emissions from all types of mobile applications in the mobile air conditioning subcategory (trucks, buses, trains and ships) should be carried out, so that all necessary data and information will be collected at time and to the extent for an accurate and transparent emission calculation. It was included in the Annual data collection plan (short-term goal). During 2017 ESD review, TERT noted again that additional information and emission estimates for mobile air conditioning in other types of vehicles than passenger cars should be included in the inventory. MEE, as responsible institution, provided an explanation that the collection of such data have been started. However, for now, these data are not included in the inventory. This is the short-term goal.

More information for uncertainty estimation associated with activity data and emission factors is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates are based on expert judgement. It should be necessary to include more experts from the relevant institutions in the assessment of uncertainties. Experts who are directly associated with the activity data can more accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

4.7.2. Foam blowing agents (2.F.2); Fire protection (2.F.3); Aerosols (2.F.4); Solvents (2.F.5)

4.7.2.1. 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 MEE.

4.7.2.2. Methodological issues

Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 have been calculated for the period 1995 - 2016, since there was no use of these substances prior to 1995.

MEE collects data on installed quantities of HFCs in Fire protection equipment. Operators of equipment are obliged to fill up the form prescribed in the Croatian ODS and F-gas Regulation (OG 92/2014) and send to MEE (in future to the CAEN). According to received data MEE forwarded data to the CAEN. MEE also collects data for import/export on Fire Protection HFC gases.

Tier 2 methodology is used for HFCs emission calculation in 2.F.3 and 2.F.4. Calculation of 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). Default emission factors proposed by *2006 IPCC Guidelines* have been used for emission calculation.

Tier 1a methodology is used for emission calculation in 2.F.2 due to the missing data on average annual stocks. Data on import and export of HFCs are used for emission calculation by means of Tier 1a methodology for Foam Blowing Agents (HFC-152a). During 2017 ESD review, TERT noted that no emissions from foams have been reported since 2010 and asked clarification for that issue. MEE, as responsible institution, explained that according to data received from importers in Croatia, there is no import of HFC-152a since 2010, which is the last year for which data have been received. Companies which used this foam blowing agent do not exist anymore. There is a few producers of foam products, which use alternatives foam blowing agents (non-HFC).

Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 in the period 1995-2015 are reported in the Table 4.7-2.

Table 4.7-2: Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 (t) (1995 - 2016)

Source/Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
2.F.2 Foam Blowing Agents											
HFC-152a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F.3 Fire Protection											

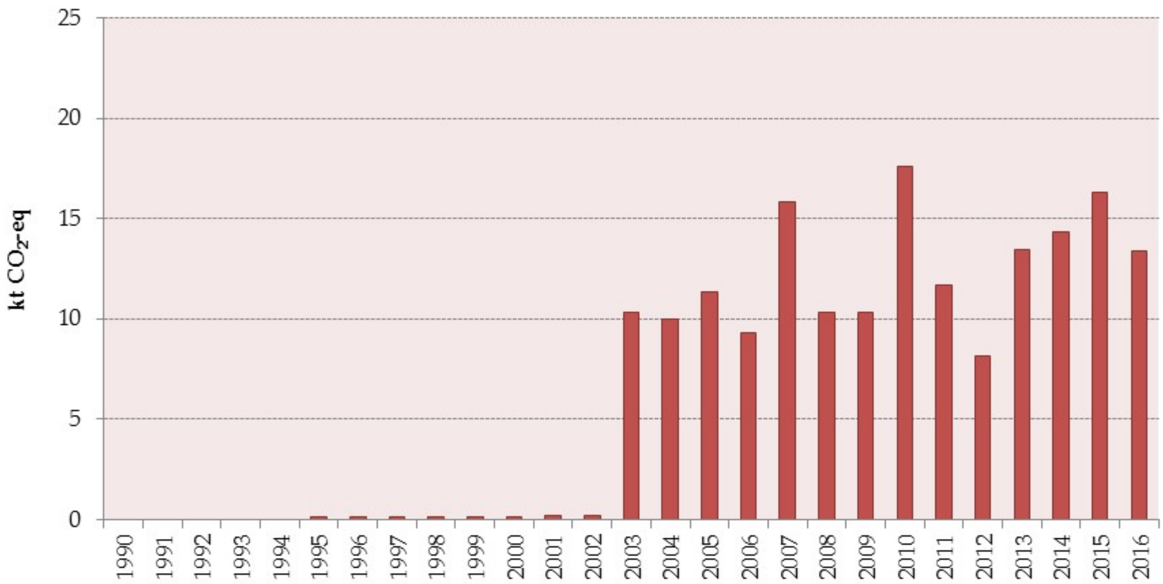
Source/Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
HFC-125	NO	NO	NO	NO	NO	NO	NO	NO	0.01	0.01	0.01
HFC-227ea	0.04	0.04	0.04	0.04	0.04	0.04	0.06	0.06	0.06	0.06	0.07
HFC-236fa	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F.4 Aerosols											
HFC-134a	NO	NO	NO	NO	NO	NO	NO	NO	7.05	6.84	7.74

Table 4.7-2: Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 (t) (1995 - 2016), cont.

Source/Gas	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2.F.2 Foam Blowing Agents											
HFC-152a	0.40	0.40	NO	0.24	36.09	NO	NO	NO	NO	NO	NO
2.F.3 Fire Protection											
HFC-125	0.01	0.01	0.01	0.02	0.04	0.06	0.06	0.13	0.14	0.14	0.14
HFC-227ea	0.15	0.32	0.39	0.48	0.56	0.68	0.91	1.00	1.04	1.08	1.09
HFC-236fa	0.04	0.08	0.12	NO	NO	0.05	0.05	0.06	0.06	0.07	0.07
2.F.4 Aerosols											
HFC-134a	5.85	9.73	5.51	6.07	7.80	6.13	3.13	6.40	6.92	8.11	6.08

Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 in the period 1990 - 2016 are presented in the Figure 4.7-2.

Figure 4.7-2: Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 (kt CO_2-eq), (1990 - 2016)



4.7.2.3. 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). General explanation on expert judgement is provided in Chapter 4.1).

4.7.2.4. 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.

4.7.2.5. Category-specific recalculations

Data on the amount of HFC-134a for category 2.F.4 Aerosols/Metered Dose Inhalers for 2014 and 2015 were corrected. Therefore, recalculations of emissions of HFC-134a were performed for 2014 and 2015.

4.7.2.6. 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.

According to ERT recommendation during 2016 centralized review, for category 2F2 Foam blowing agents, analysis of the type of foam application used (open cells or closed cells) should be verified. In NIR 2017 it is assumed to be open cells, according to the ERT recommendation in the Report on the individual review of the annual submission of Croatia submitted in 2016 (FCCC/ARR/2016/HRV, 28 March 2017). However, for now, these data are not analysed and additional explanation are not included in the inventory. It was included in the Annual data collection plan (short-term goal).

More information for uncertainty estimation associated with activity data and emission factors is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates are based on expert judgement. It should be necessary to include more experts from the relevant institutions in the assessment of uncertainties. Experts who are directly associated with the activity data can more accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

4.8. Other product manufacture and use (CRF 2.G)

4.8.1. Electrical equipment (2.G.1)

4.8.1.1. Category description

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

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.

4.8.1.2. 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 (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 1990-2016 are presented in the Table 4.8-1.

Table 4.8-1: Emissions of SF_6 (kt CO_2-eq), (1990 - 2016)

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	9.18
2013	6.05
2014	6.77
2015	5.22
2016	6.39

4.8.1.3. 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). General explanation on expert judgement is provided in Chapter 4.1.

4.8.1.4. 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.

4.8.1.5. Category-specific recalculations

New data on total charge of SF_6 and leakage and maintenance loses for the period 2013 - 2015 were provided. Accordingly, recalculation were performed for the period 2013 - 2015.

4.8.1.6. 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 analysed and reviewed for the entire reporting period. Any potential changes in data should be included in the inventory. It was included in the Annual data collection plan (short-term goal).

More information for uncertainty estimation associated with activity data and emission factors is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates are based on expert judgement. It should be necessary to include more experts from the relevant institutions in the assessment of uncertainties. Experts who are directly associated with the activity data can more accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

4.8.2. SF_6 and PFCs from other product use (2.G.2)

This category does not exist in Croatia.

4.8.3. N_2O from product uses (2.G.3)

4.8.3.1. 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 on use of N_2O have been compiled by the CAEN. Data are obtained by distributors of N_2O in Croatia who delivered a confirmation on use of N_2O to the CAEN.

4.8.3.2. Methodological issues

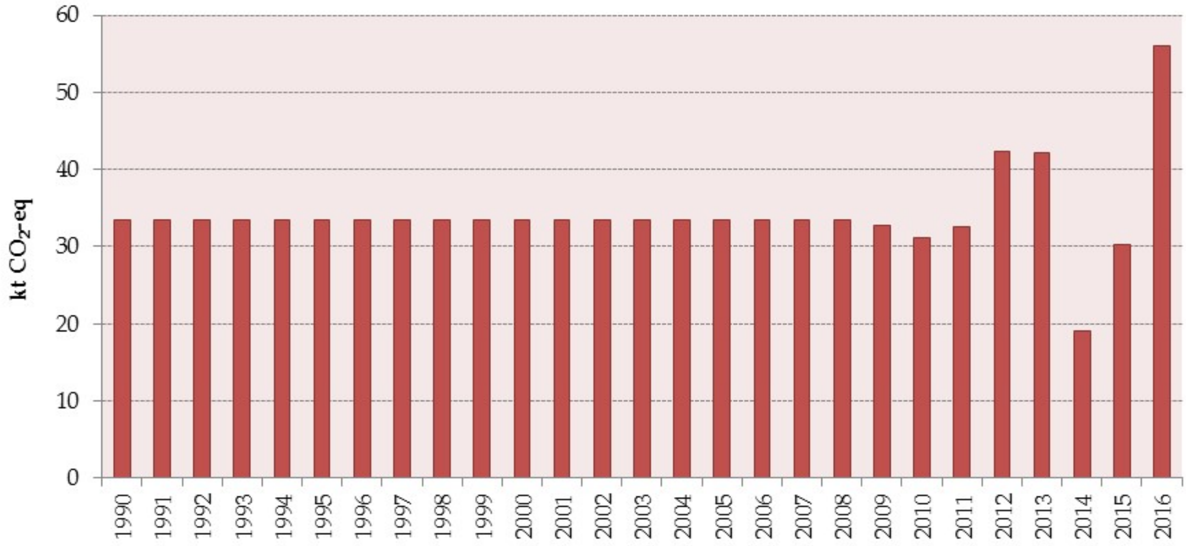
N_2O emissions have been calculated by multiplying annual quantity of N_2O used for anaesthesia and aerosol cans with default emission factor proposed by *2006 IPCC Guidelines*.

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.

According to the TERT recommendation during 2017 ESD review, data for use of N_2O for aerosol cans that are not available for 2014 and 2015 are estimated by extrapolation method, using the trend for the period 2010 - 2012.

Emissions of N_2O from Product Use in the period 1990 - 2016 are presented in the Figure 4.8-1.

Figure 4.8-1: Emissions of N_2O from Product Use (kt CO_2-eq), (1990 - 2016)



4.8.3.3. 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). General explanation on expert judgement is provided in Chapter 4.1.

4.8.3.4. 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.

4.8.3.5. Category-specific recalculations

New data for quantity of N_2O used for anaesthesia for 2015 were provided. In addition, according to the TERT recommendation during 2017 ESD review, data for use of N_2O for aerosol cans that are not available for 2014 and 2015 are estimated by extrapolation method, using the trend for the period 2010

- 2012. Data for 2013 was also corrected. Accordingly, recalculation were performed for the period 2013 - 2015.

4.8.3.6. Category-specific planned improvements

Data for N_2O use in anaesthesia and aerosol cans should be analysed and reviewed for the entire reporting period. Any potential changes in data should be included in the inventory. It was included in the Annual data collection plan (short-term goal).

More information for uncertainty estimation associated with activity data and emission factors is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates are based on expert judgement. It should be necessary to include more experts who are directly associated with the activity data to accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

4.9. Other (2.H)

This category includes following sub-categories:

- Pulp and paper
- Food and baverage industry
- Wood processing

4.9.1. Pulp and paper (2.H.1)

Emissions of SO_2, CO, NO_x, NMVOC and NH3 have been taken from the emission inventory report 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2016 Submission to the Convention on Long-range Transboundary Air Pollution.

4.9.2. Food and baverages industry (2.H.2)

Emissions of NMVOC have been taken from the emission inventory report 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2016 Submission to the Convention on Long-range Transboundary Air Pollution'.

4.9.3. Wood processing (2.H.3)

Information on not applicable emissions (NA) has been taken from the emission inventory report 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2016 Submission to the Convention on Long-range Transboundary Air Pollution'.

Chapter 5: Agriculture (CRF sector 3)

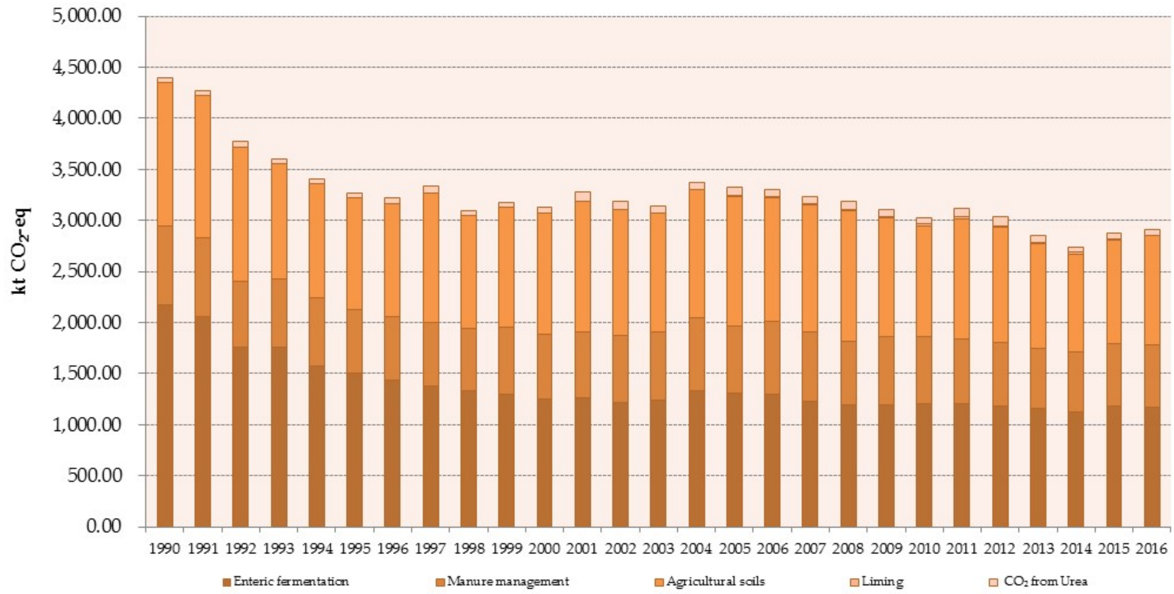
5.1. Overview of sector

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 2016 caused by agricultural activities was 2,931.81 kt CO_2-eq, which represents 12.1 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 are relatively high in 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. In the post-war period the sector began to revitalize and emission trend stabilized 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 1990-2016.

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	86.86	16.58	103.45	1.21	4.7	5.91	0	50.02	50.02
1991	82.12	17.06	99.18	1.17	4.67	5.84	0	50.95	50.95
1992	70.39	14.53	84.92	0.95	4.39	5.34	0	65.51	65.51
1993	70.15	15.48	85.64	0.96	3.77	4.67	0	52.14	52.14
1994	63.02	15.74	78.76	0.90	3.77	4.67	0	47.57	47.57
1995	60.03	15.16	75.19	0.78	3.65	4.42	0	46.29	46.29
1996	57.41	15.44	72.85	0.81	3.69	4.5	0	52.44	52.44
1997	55.16	15.58	70.74	0.78	4.25	5.03	0	68.39	68.39
1998	53.14	15.74	68.88	0.76	3.69	4.45	0	44.25	44.25
1999	51.85	17.12	68.97	0.78	3.93	4.71	0	50.49	50.49
2000	49.95	16.59	66.54	0.73	3.99	4.72	0	60.87	60.87
2001	50.47	17.12	67.59	0.73	4.28	5.01	0	92.09	92.09
2002	48.89	17.39	66.28	0.71	4.16	4.87	0	80.76	80.76
2003	49.56	18.21	67.77	0.72	3.88	4.6	0	71.79	71.79
2004	53.17	19.7	72.86	0.76	4.19	4.95	0	75.94	75.94
2005	52.3	18.12	70.42	0.7	4.25	4.95	14.49	70.97	85.46
2006	51.8	19.98	71.78	0.72	4.06	4.78	17.48	63.19	80.67
2007	49.24	19.08	68.32	0.67	4.16	4.83	16.6	72.72	89.32
2008	47.77	17.6	65.37	0.62	4.27	4.89	20.78	75.83	96.6
2009	47.92	18.96	66.88	0.63	3.92	4.55	11.92	65.04	76.96
2010	48.19	18.88	67.07	0.62	3.63	4.24	21.46	66.58	88.04
2011	48.04	18.67	66.71	0.59	3.93	4.52	21.32	83.86	105.18
2012	47.51	17.96	65.46	0.57	3.79	4.36	14.38	86.85	101.23
2013	46.18	17.09	63.27	0.55	3.45	4	14.23	60.39	74.61
2014	45.08	17.19	62.27	0.54	3.21	3.74	19.99	49.47	69.47
2015	47.45	17.77	65.22	0.56	3.38	3.94	12.09	57.25	69.34
2016	47.02	17.66	64.68	0.55	3.6	4.15	11.22	64.96	76.18

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	2,171.55	414.61	2,586.16	361.58	1,400.57	1,762.15	0.00	50.02	50.02	4,398.33
1991	2,052.95	426.61	2,479.56	348.58	1,390.75	1,739.33	0.00	50.95	50.95	4,269.83

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
1992	1,759.69	363.28	2,122.97	282.34	1,308.74	1,591.08	0.00	65.51	65.51	3,779.56
1993	1,753.83	387.04	2,140.87	267.29	1,123.26	1,390.55	0.00	52.14	52.14	3,450.99
1994	1,575.44	393.53	1,968.97	268.33	1,123.77	1,392.11	0.00	47.57	47.57	3,408.65
1995	1,500.78	387.96	1,879.73	232.13	1,087.36	1,319.49	0.00	46.29	46.29	3,116.36
1996	1,435.18	386.09	1,821.27	241.45	1,100.93	1,342.38	0.00	52.44	52.44	3,216.09
1997	1,378.94	389.60	1,768.54	233.87	1,265.20	1,499.06	0.00	68.39	68.39	3,335.99
1998	1,328.58	393.38	1,721.96	225.96	1,100.66	1,326.62	0.00	44.25	44.25	3,092.84
1999	1,296.21	428.04	1,724.25	231.61	1,171.08	1,402.69	0.00	50.49	50.49	3,177.43
2000	1,248.80	414.74	1,663.54	218.26	1,188.72	1,406.99	0.00	60.87	60.87	3,131.40
2001	1,261.76	427.89	1,689.65	218.79	1,274.46	1,493.24	0.00	92.09	92.09	3,274.99
2002	1,222.20	434.74	1,656.94	212.53	1,239.15	1,451.68	0.00	80.76	80.76	3,189.38
2003	1,239.01	455.35	1,694.36	214.77	1,156.88	1,371.65	0.00	71.79	71.79	3,137.80
2004	1,329.13	492.40	1,821.53	227.83	1,247.54	1,475.37	0.00	75.94	75.94	3,372.84
2005	1,307.40	453.08	1,760.48	208.39	1,266.46	1,474.85	14.49	70.97	85.46	3,320.79
2006	1,294.90	499.57	1,794.47	214.99	1,208.95	1,423.95	17.48	63.19	80.67	3,299.09
2007	1,231.08	477.02	1,708.10	199.90	1,238.52	1,438.41	16.60	72.72	89.32	3,235.84
2008	1,194.35	439.94	1,634.29	184.55	1,271.86	1,456.42	20.78	75.83	96.60	3,187.31
2009	1,197.95	474.00	1,671.94	188.24	1,167.05	1,355.30	11.92	65.04	76.96	3,104.20
2010	1,204.84	471.93	1,676.77	184.46	1,080.49	1,264.96	21.46	66.58	88.04	3,029.76
2011	1,201.06	466.73	1,667.80	176.47	1,171.37	1,347.85	21.32	83.86	105.18	3,120.82
2012	1,187.66	448.95	1,636.61	171.26	1,128.08	1,299.34	14.38	86.85	101.23	3,037.18
2013	1,154.55	427.29	1,581.85	162.58	1,029.35	1,191.93	14.23	60.39	74.61	2,848.39
2014	1,126.94	429.82	1,556.77	160.23	955.53	1,115.76	19.99	49.47	69.47	2,742.00
2015	1,186.26	444.13	1,630.39	167.60	1,007.87	1,175.47	12.09	57.25	69.34	2,875.20
2016	1,175.51	441.42	1,616.92	164.19	1,073.64	1,237.84	11.22	64.96	76.18	2,930.94

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 2016[7]

IPCC Source Categories	Direct GHG	Criteria for Identification			
		If Column C is Yes, Criteria for Identificatio			
AGRICULTURE SECTOR		Excluding LULUCF		Including LULUCF	
3.A Enteric Fermentation	CH_4	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i
3.B Manure Management	CH_4	L1e	T1e	L1i	T1i
3.B Manure Management	N_2O	L1e, L2e	T1e, T2e	L1i	T1i, T2i
3.D.1 Direct N2O Emissions From Managed Soils	N_2O	L1e, L2e		L1i, L2i	

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

IPCC Source Categories	Direct GHG	Criteria for Identification			
		If Column C is Yes, Criteria for Identificatio			
3.D.2 Indirect N2O Emissions From Managed Soils	N_2O	L1e, L2e	T2e	L1i, L2i	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

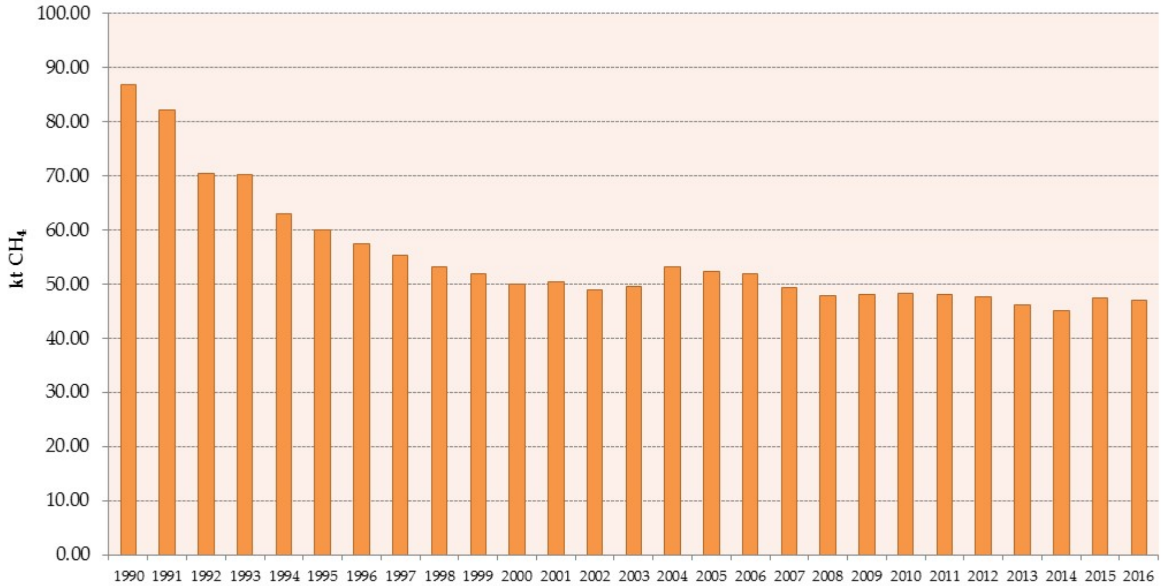
5.2. CH_4 emissions from enteric fermentation in domestic livestock (CRF 3.A.)

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 47% of total CH_4 emission from Enteric fermentation in 2013, followed by young representing about 28%. Cattle livestosck in total is responsible for around 84% of total CH_4 emission from Enteric fermentation.

Figure 5.2-1 shows emission of methane from Enteric fermentation for the period from 1990-2016. The emission trend follows the trend of animal population which significantly decreased during the war period in the early 1990s (up to 1996). The decrease is recorded for each animal category (see Table 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 cattle, swine and sheep, while other livestock categories (goats, horses and mules&asses) defaulted to Tier 1 methodology.

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[8]. Development of national emission factors marks a significant change and ongoing improvement of the inventory.

Additional detailed information on methodology used for cattle, swine and sheep emission estimate is included within this chapter.

The main two sources regarding the number of animals produced annualy (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 provided by Croatian Agricultural Agency (CAA) for the years 2008-2016. Animal number for the rest of the dataset (years 1990 to 2007) was extrapolated based on the 2008-2016 numbers, based on the expert opinion of Croatian Agency for the Environment and Nature. National data (provided by CBS and CAA) is considered to be the most accurate source. For animal categories where national data was not available, FAO data was considered an adequate replacement source.

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

Animal category	CBS	FAO	Croatian Agricultural Agency	Extrapolation
Dairy cattle			2008-2016	1990-2007
Other cattle	1990-2016			
Sheep	1990-2016			
Goats	1990-1991; 1999-2016	1992-1998		
Horses	1990-1994		1995-2016	
Mules/assess	1990-1991	1992-1994	1995-2016	
Swine	1990-2016			
Poultry	1990-2016			

Table 5.2-2: Number of animals produced annualy in the period from 1990 – 2016

[8] Poultry is not a source of CH_4 emissions from Enteric Fermentation, however it is a shared activity data with other source categories (Manure Management)

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	10640
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
2014	179	264	605	61	21	2	1156	10317
2015	175	303	608	62	22	2	1195	10190
2016	168	316	619	76	23	3	1193	9856

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 1990-2016, 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. Croatian Agricultural Agency (CAA) provided detailed national data for the population numbers of horses (1995-2016) and mules/asses (1995-2016). 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. Thus, further 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.

Cattle

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 from 1996 IPCC guidelines with national values (see Table 5.2-4). 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 2010-2014. Average value of national live animal weights dataset for the years 2010-2014 was used for cattle categories. Since the methodology for the subcategorization (more specifically, category names) of cattle in the statistical data has changed slightly over the years, Table 5.2-3 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.

Cattle classification used for Tier 2 is as follows:

- Mature dairy – mature dairy cows
- Mature non dairy – mature females and males (other cows, heifers, bullocks, oxen)
- Young cattle – calves

Table 5.2-3: Non-dairy cattle classification into main IPPC subcategories

IPPC categories	CBS categories		
	1990-1999	2000-2006	2007-2016
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 male and female) ▪ Bovine animals aged between 1 and 2 years (male and female animals for slaughter and breeding)

Average daily gains

Average daily gain in intensive fattening of beef cattle is between 1.2 and 1.35 kg. Intensive fattening in Croatia is performed on Simmental cattle and their hybrids with other meat breeds. The above mentioned growth is achieved under intense corn silage diet and ground corn grain with the addition of oilseeds. Use of hay / straw or other poorly digestible forage is minimal (1-1.5 kg / day). This provides daily gains often greater than the above. Thanks to the use of large amounts of corn (silage / grain) digestibility is satisfactory.

There is no tradition of fattening dairy breed calves (Holstein) in Croatia. Average daily gains in raising heifers intended for her renewal (150-550 kg body weight) is around 0.6 kg. These gains are achieved by intake of dry matter kg / day (DMI), depending on age, with an equal proportion of corn silage, hay and haylage in the meal.

Meal digestibility - DE (%) Feed digestibility

Dairy cows - Major structural changes were carried out in the dairy industry during the 1990-2016 period. These encompass a reduction in the number of animals (dairy cows, but also other categories of cattle), changes in the breed structure (increase of dairy breeds), an increase of genetic potential in terms of milk production within the Simmental breed as the largest cattle breed in Croatia, improving the conditions for accommodation and nutrition. Increase in the number of animals on farms and their predisposition in the production of milk and/or meat.

Decrease in the number of cattle (cows) was highest in the grazing cattle and low productivity cattle population, where the diet was based mostly on the low digestibility forage (<55%; uncultivated pasture, low quality hay, straw, corn, etc.).

On the other hand, the number of high dairy cows increased (Holstein breed, increase of milk production of Simmental breed) which are held enclosed and require forage of higher digestibility (>65%). In order to meet the nutritional requirements of such cows, feed is based on a combination of high-quality forage (corn silage and alfalfa/grass) and concentrated forage (cereals and oilseeds). At least 40% (60% in cows with milk production >8000kg) daily food intake (expressed in dry matter) comes in the form of a concentrated high digestibility forage (~82-85% digestibility). The remaining 60% (40%) are good digestibility forages, of which 50% is composed of corn silage (~70-72% digestibility) and 50% grass silage, clover/grass mixture and alfalfa (~60-65% digestibility). This results in the digestibility value for the dairy cows meal of an average 70-75% .

Furthermore, for 2016 it is estimated that the mentioned diet was used for slightly above 40% of dairy cows (cows under milk production control with average production of 5,800kg of milk, CAA), while in 1990 was applied in only 10% of cows. It is estimated that by 2050 increase in milk production per cow will continue to rise, with the feed digestibility reaching 75% for more than 70% of cow population. On the other hand, the share of cows whose meal is based on a high proportion of high volume forage was gradually reduced from 1990 to 2016. Voluminous part of a meal in such cows is based on the meadow hay, corn silage and smaller quantities of haylage grass/clover grass mixtures (digestibility ranging from 55% to 65%). The share of concentrate does not exceed 10% or 25% (relative to the total dry matter of portion) of the meal, which results in the total digestibility of 60%-65%. It is estimated that in 2015, the number of cows on this diet will be about 20 - 35%, while in 1990 it was about 40%. In conclusion - considering of all above mentioned, the amount of meal production and type and the corresponding share of cows, the average meal digestibility for dairy cows in 2016 amounted to ~69%. This value is expected to further increase until 2050 to an average of 72.5%.

Non-dairy cattle (mature) - cattle whose milk is used exclusively for the calf (cows in the cow-calf system), bulls and female bovine animals older than 24 months (mostly pregnant heifers). Cows intended exclusively for the production of calves are kept mostly on pastures. In addition to grazing, forages of poor to medium quality are used as a food source (uncultivated pasture, meadow hay, straw, corn stalks; digestibility <60%) with the addition of concentrated fodder or maize silage in small quantities mainly during the winter when animals are kept in enclosed or confined areas. Therefore the digestibility of the meal for these cows varies greatly and depends on the quality of pasture or hay and residues from crop production (straw, etc.). According to the conventional technology of keeping and feeding in the conditions of continental and upland Croatia, cows are kept on natural pastures (with pasture as the only food source for 8 months). The rest of the year (winter, without vegetation) meadow hay, corn silage, haylage, straw and corn are also added in the diet. Since this is the most sensitive period in the production (late gravidity, parturition, lactation start), forage of higher quality is often used (better digestibility - silage grass, clover/grass mixture, corn).

The share of the female breeding offspring older than 2 years and of bulls in total number of non-dairy cows (matures) is around 40%. This includes heifers of dairy breeds, heifers of fattening cow breeds, and also breeding bulls older than 24 months. The least amount, about 10% (<1000) are heifers of meet breeds intended for herd renewal in the cow-calf system. The same maintenance and feeding method for cows that are used for calf production is also used for the aforementioned category of animals. About 90% of heifers older than 24 months are heifers of dairy breeds, used for herd renewal of dairy cows. With the anual rate of 25%, it is estimated that in 2015 there were around 10,000 such heifers. They are being kept in enclosed areas or areas with an outlet and are fed with high volume fodder of medium quality (average digestibility <60%; hay, reed, silage grass/clover-grass mixture with a minimal addition of corn silage and concentrate).

Taking this into account mentioned national issues for category of non-dairy cattle, it is estimated that the average meal digestibility in recent years (2014/2015) was around 57%. Compared to year 1990 when there was more than 400,000 cows in Croatia, average digestibility of the meal was <50% due to the use of large amounts of lower quality forage (meadow hay, uncultivated pasture, straw, corn stalks). Digestibility was ona a gradual rise and it is estimated that by 2050 will reach around 60%. Gradual increase in the number of (shares) in cows producing calves that are kept on cultivated pastures, changes in diet in which grazing will be used in an earlier stage of development, as well as higher quality forages in complementary feeding is also expected.

Cattle younger than 2 years - This category consists of calves, beef cattle, and male and female breeding animals in growth. Beef cattle accounts for the largest share in this category (about 65%). Feeding beef cattle is based on of corn silage and concentrated forage (milled grain corn meal with the addition of oilseeds and mineral-vitamin supplement) using the minimum amount of hay or straw (1-1.5 kg/head/day). Gains that are obtained during fattening are around 1.2-1.35 kg/day. The high share of grain corn (40% dry matter intake) and corn silage (30% dry matter intake) accounts for the high digestibility (75%) of beef cattle feed. Traditionally, fattening beef cattle in Croatia does not occur in grazing systems. Minor share of heifers are fattened enclosed, with a greater amount of forage with medium digestibility (grass hay, alfalfa, straw) and the addition of ground corn grain. It is estimated that in recent years there was about 17% of such animals and that the average digestibility of their meals was 67%.

Female reproductive offspring accounts for about 15% of all animals in this category and is intended to replace culled cows. Their feeding is based on the voluminous, medium quality feed (grass silage, alfalfa and corn silage and hay) with the addition of concentrated forage in order to achieve the average daily weight gain of 700 grams. It is estimated that the digestibility of the meal in this animal category is around 65%. Taking into account these meal characteristics, as well as the share of the individual categories in the total number of cattle younger than 2 years, the average digestibility for recent years was 74%. Since the beef cattle in intensive fattening (baby beef fattening technology) accounts for the largest share of the population, which has a long tradition in Croatia, there was not significant increase in digestibility compared to 1990 (72%) as it was present in the other categories of cattle. A slight increase in meals digestibility is expected in the category of cattle younger then 24 months, up to 76% in 2050 and it is based on the use of silage with higher digestibility (harvested at an earlier stage, and with larger yield in corn silage).

Calculation of digestibility in meals for each category of cattle is based on the proportion of the different ingredients and their digestibility, which depends on the chemical composition of feed. In this purpose, the average composition of the 4 types of meals for dairy cows (high-diary cows, cows with the average milk production, cows with low milk production and cows kept on pasture) overall digestibility of the meal is determined based on their composition and chemical analysis of individual forage.

In the category of non-dairy cattle older then 24 months, meal digestibility was analyzed for non-dairy cows and heifers. Breeding bull category, due to the small number of animals was not analyzed separately, but is taken in to the account for calculating the digestibility value for non-dairy cows.

In the young cattle category meal portions were analyzed for fattening cattle, inlcluding: intensive fattening cattle to produce so caled "Baby Beef"; Semi-intensive fattening in closed systems based on a greater proportion of forage with addition of concentrate. Furthermore, the meals for growing heifers intended for herd renewal of dairy cows and other cows were analyzed. Based on the composition of meals and share of mentioned categories, average digestibility for this group of cattle is calculated. Digestibility of certain types of forage was determined using the data from scientific and professional literature, 2006 IPCC Guidelines and FAO (2010).

Methane conversion factor (Ym)

Analysis of diet composition and its digestibility is the base for the calculation of methane conversion factor (Ym) which, in turn, together with the data for daily food intake, is the base for the calculation factors of methane emmision. While Ym dependes primarily on the type and digestibility of forage, daily food intake is dependent on the quality (digestibility) of the forage and the amount of production of milk and meat. Ym value for each type of meal within certain categories of cattle was calculated according to the following equation: Ym=9.75 -0.05*DE% with possible deviations up to 5%. Average values of Ym by groups of cattle were determined on the basis of the contribution (share) of each category within the group.

Emission factor (EF)

Table 5.2-4: National data used in emission factor calculation for cattle for 2016

Animal	weight (kg)	Cfi	Ca	WG (kg/day)	fat (%)	$C_{pregnancy}$	DE (%)	Ym
mature dairy	562.82	0.429	0.008	0.00	4.00	0.10	69.20	0.062
mature non-dairy	529.06	0.365	0.097	0.00	-	-	57.20	0.068
young	301.64	0.365	0.000	1.25	-	-	75.60	0.058

Milk yield per cow per day for the period from 1990-2016 is presented in Table 5.2-5. AD set on milk yield per cow was provided by CAA for the years 2008-2016, 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 and Faculty of Agriculture.

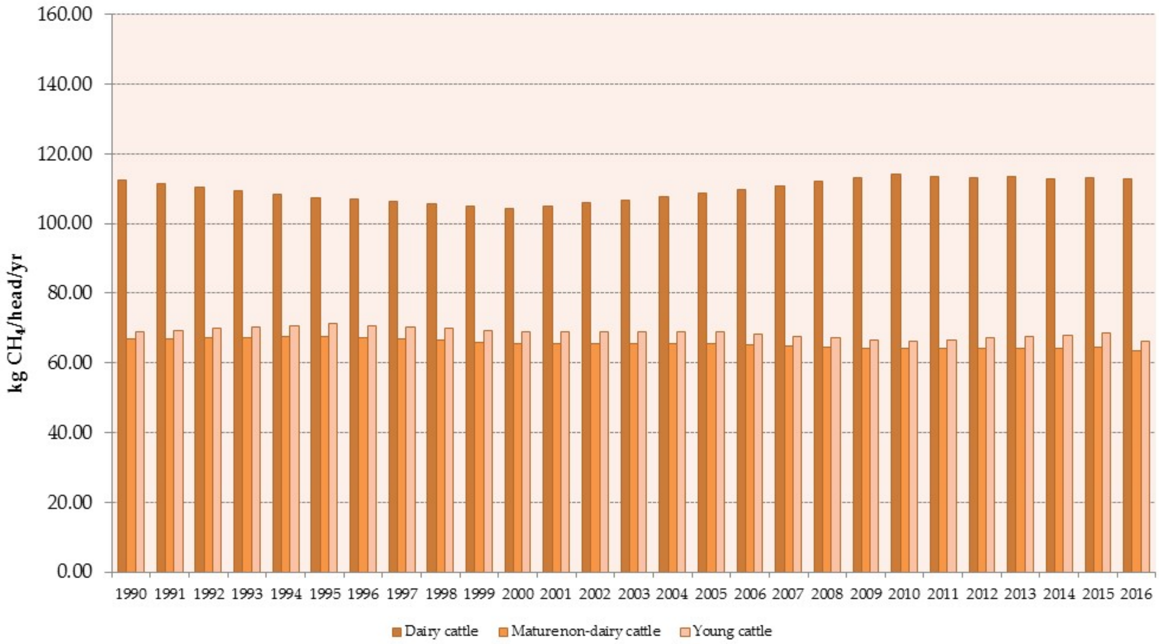
Table 5.2-5: Milk yield per cow

Milk yield	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
(kg/day)	7.83	8.09	8.35	8.60	8.86	9.12	9.51	9.91	10.30	10.70	11.09	11.47	11.84

Milk yield	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
(kg/day)	12.22	12.59	12.97	13.50	14.04	14.57	15.11	15.64	15.57	15.83	16.15	16.15	16.32	16.60

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



Swine

Methane emissions factor from enteric fermentation is determined by dry matter intake, energy content and methane conversion factor which depends on the type and category of animals and the type and digestibility of forage in the meal. Although pigs do not contribute significantly to the emission of methane from enteric fermentation, there are certain differences between different production systems. In addition to decrease in the number of animals, there was a significant change in the keeping and feeding technology caused by changes in genetic basis. Today, animals of high genetic potential for fertility, daily gain and share of meat in the hull are kept on farms, which allowed the production of significantly larger number of fattening pigs per sow/per year with consumption of less feed. At the same time, the number of swine breeders decreased, but the number of animals on each farm increased.

Meal digestibility - DE (%) Feed digestibility

Two systems of swine farming can be distinguished in the period from 1990 to 2016, based on keeping and feeding methods. One is characteristic for small farms with few animals, mostly for personal use and the other for the intensive farming system, characteristic for commercial producers. Within the commercial producers there are those who keep swine in large industrial type farms with large number of animals (a thousand or more), and family type farms with a smaller number of animals (tens or hundreds of animals).

For small producers, it is characteristic that they keep less productive animals including indigenous breeds and their hybrids with white breeds (Landrace). They are kept mostly in modest facilities with discharge or in the open (pastures). Their feed usually consists of corn germ with the addition of wheat bran, other crop residues from household and green forage (pasture, alfalfa, etc.). The average digestibility of such meal, depending on the proportion of forage, ranges from 60-80%. Since the corn germ (ground maize grain) is the regular meal ingredient for these animals and makes between 50 and 60% of dry matter intake, it is estimated that the average digestibility of such a meal is about 77% and that adult breeding animals enter around 49.2 MJ GE/day.

Commercial producers whose pigs are kept exclusively in closed (controlled) conditions, apply finished feed as the only feed which is adapted to the animal needs depending on age, production stage and genetic potential. This feed consist mainly of ground grains (corn, barley, wheat), oilseeds and vitamin/mineral supplements. Digestibility of such meals for breeding swine is estimated at about 82%, while for the fattening pigs amounts 85%. It is estimated that in such systems, breeding animals enter an average of 45 MJ GE/day, while those in fattening systems enter about 33.0 MJ GE/day.

The average annual energy intake, expressed as MJ GE/day as well as digestibility of meals for breeding and fattening animals, is calculated on the basis of estimated percentage of animals in each of these systems. It is estimated that in 1990 over 70% of animals were raised on small farms and some form of extensive keeping, while 30% of the pigs were in intensive systems on larger farms. Gradual decrease of total number of swine resulted in a decrease of the share of pigs on small farms and an increase of the share of animals on large farms. It is estimated that currently about 25% of the pigs are held extensively on small non-commercial farms, while 75% are raised on farms using intensive systems.

Methane conversion factor (Ym)

Swine are species with simple digestive system as well as type of feed, and therefore do not contribute significantly to total emission of methane from enteric fermentation. The methane emission factor, which is used to calculate methane emissions for pigs, was 0.6% (GGELS, 2010[9]).

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[9] GGELS (2010): Evaluation of the livestock sector's contribution to the EU's greenhouse gas emissions, European Commission, Joint Research Centre (Leip A. et al).

Table 5.2-6: Food intake and digestibility of meal in different swine breeding systems

Category	Weight (kg)	Food intake (kg/day)	DE (%)	Ym
Mated sows - intensive	200	3.4	82	0.6
Mated sows - extensive	200	3.45	76	0.6
Fattening pigs	50	2.25	85	0.6

Sheep

Sheep are ruminants and release significant amount of methane as a result of enteric fermentation. Similar methodology to the one for cattle is used for calculating the methane emissions factors, since the digestion process and the type of feed consumed is very similar. Therefore, the average daily food intake (measured in dry matter) is estimated as well as its average energy value. Furthermore, methane conversion factor (Ym) is estimated considering the type of feed material, ie. digestibility of feed material. Methane conversion factor is calculated according to the equation: Ym = 9.75 to 0.05% * DE.

Meal digestibility - DE (%) Feed digestibility and Methane conversion factor (Ym)

When calculating the average digestibility, it is taken into account that the DE% is largely influenced by the production system. In Croatia most of the sheep are kept in the coastal (sub-Mediterranean) region and in highland area. Indigenous breed ("*Pramenka*") is the most common breed and has modest requirements regarding keeping and feeding. Feeding is based on grazing on natural pasture (uncultivated) of lower quality, most of the year. In the winter the animals are kept in stalls or confined areas with shelters where they are fed with hay and very small amounts of grain cereal. Given the structure of pastures and the time of mowing such meadows in these areas, it is estimated that DE% of the meal is about 55%.

A smaller amount of sheep in the coastal area that are kept for milk production and particularly those in the northwestern part of the Republic of Croatia are fed with the certain amounts of concentrated feed material and silage during lactation. Therefore the digestibility in feed of such sheep can range from 60 to 70%. Furthermore, similar digestibility of the meal can be expected in meat sheep breeds from continental Croatia (lowland). They have higher requirements on the type and quantity of feed. Feed for said sheep requires the use of higher quality forage but also a certain amount of grains and and it is therefore of higher digestibility (65%).

Considering the proportion of animals from each of the production system in the total number of sheep, average digestibility is calculated to be within 55 to 57% range. The reason for the relatively low digestibility is the fact that the largest percentage of total sheep number is in the in coastal karst area, with rudimentary vegetation of poor digestibility (about 50%). Therefore, the calculated methane conversion factor is in range between 6.5 and 7.0, as presented in Table 5.2-7.

Data from scientific literature and guidelines given in the IPCC (2006) and FAO (2010) was used in determining the digestibility of certain types of feed.

Table 5.2-7: Ym and digestibility of meal in different sheep breeding systems

Category	DE (%)	Ym
Indigenous breeds on rudimentary pastures	55	0.07
Meat sheep breeds from lowland pastures	60	0.0675
Sheep for milk production	65	0.065

For other animals (goats, horses, mules and asses) default emission factors for developed countries were used for the entire data series. See Table 5.2-8.

Table 5.2-8: National enteric fermentation emission factors for other animal categories

Animal Category	Methodology used	EF / kg per head per year
		2015
Goats	Tier1	5.00 (default)
Horses	Tier1	18 (default)
Mules/asses	Tier1	10.00 (default)

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 1990-2015 period for the young cattle category due to a correction of error which lead to an underestimation of Ym in the calculation of the EF.

Emissions were recalculated for the entire 1990-2014 period for market swine animal category, due to a removal of NAPA to AAP correction of CBS data for swine and poultry (as recommended by TERT during ESD revision).

5.2.6. Category specific planned improvement

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

- During the NIR 2017 QA/QC process on the activity data, CBS identified changes in the AD for non-dairy cows and swine, for several years. The differences in the animal population numbers is within the ± 1-5% range. The AD was not ready in time for the resubmission of NIR 2018, but will be corrected in the next submission.
- 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) with the purpose of gathering more detailed activity data, including sheep annual population subcategorization
- Revisiting CBS data on NAPA activity data on swine and poultry categories using a more detailed model for accurate cross-analysis of available data, with the goal of getting a more accurate AAP value. Until such analysis is performed and a model developed, Croatia will use the CBS NAPA data for swine and poultry subcategories without conversion to AAP.
- Continued improvements and verifications of parameters for Tier 2 emission calculation for historical years.

5.3. Manure management (CRF 3.B.)

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 CH_4 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.

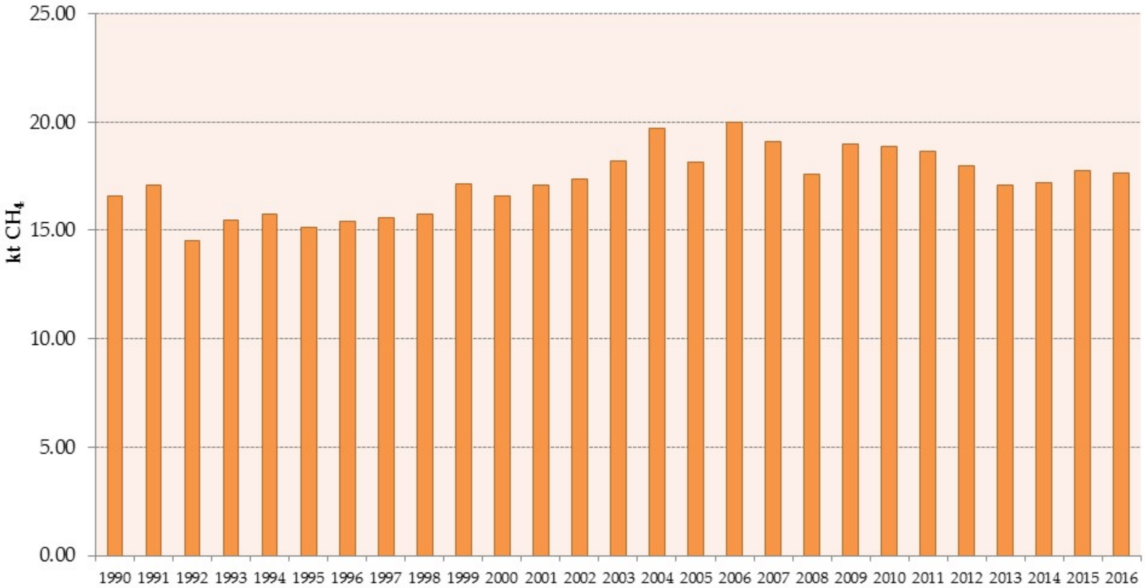
N_2O is produced during the storage and treatment of manure before it is applied to land or otherwise used for feed, fuel, or construction purposes. The emission of N_2O from manure during storage and treatment depends on the nitrogen and carbon content of manure, and on the duration of the storage and 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.

5.3.1. Manure management – CH_4 emissions (CRF 3.B.1.)

5.3.1.1. Category description

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 2016 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



5.3.1.2. 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. Estimates have been calculated using default values and average VS excretion rates from the 2006 IPCC Guidelines, combined with the national data and manure management systems (MMS) ratios (see Chapter 5.3.2.2 for detailed information on MMS).

Table 5.3-1: Manure management emission factors for each animal category for the year 2016

	VS	B0	CH4 emission, per head (FE)		MMS Distribution						
					Anaerobic lagoon	Liquid system	Daily spread	Solid storage and dry lot	Pasture range and paddock	Digesters	Other
				MCF	22	22	0	2	1	2	1,5
Mature dairy cattle	4.50	0.24	**34.00**		5.0%	49.5%	0.0%	37.5%	2.0%	5.0%	1.0%
Other mature cattle	2.70	0.17	**9.93**		0.0%	34.5%	0.0%	54.5%	5.0%	5.0%	1.0%
Growing cattle	2.70	0.17	**9.93**		0.0%	34.5%	0.0%	54.5%	5.0%	5.0%	1.0%
Sheep	0.34	0.14	**0.14**		0.0%	0.0%	0.0%	18.0%	82.0%	0.0%	0.0%
Market swine	0.30	0.45	**6.30**		2.0%	83.4%	0.0%	9.6%	0.0%	5.0%	0.0%
Breeding swine	0.50	0.45	**9.43**		2.0%	73.7%	0.0%	18.3%	1.0%	5.0%	0.0%
Goats	0.30	0.14	**0.11**		0.0%	0.0%	0.0%	5.0%	95.0%	0.0%	0.0%
Horses	2.09	0.27	**1.79**		0.0%	0.0%	0.0%	30.0%	70.0%	0.0%	0.0%
Mules and Asses	2.09	0.27	**1.52**		0.0%	0.0%	0.0%	10.0%	90.0%	0.0%	0.0%
Poultry	0.02	0.37	**0.07**		0.0%	8.6%	0.0%	88.5%	1.8%	0.0%	1.1%

5.3.1.3. Uncertainties and time-series consistency

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

5.3.1.4. 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.

5.3.1.5. Category specific recalculations

Emissions were recalculated for the entire 1990-2015 period for market swine and poultry animal categories due to a removal of NAPA to AAP correction of CBS data for swine and poultry (as recommended by TERT during ESD revision).

5.3.1.6. Category specific planned improvement

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

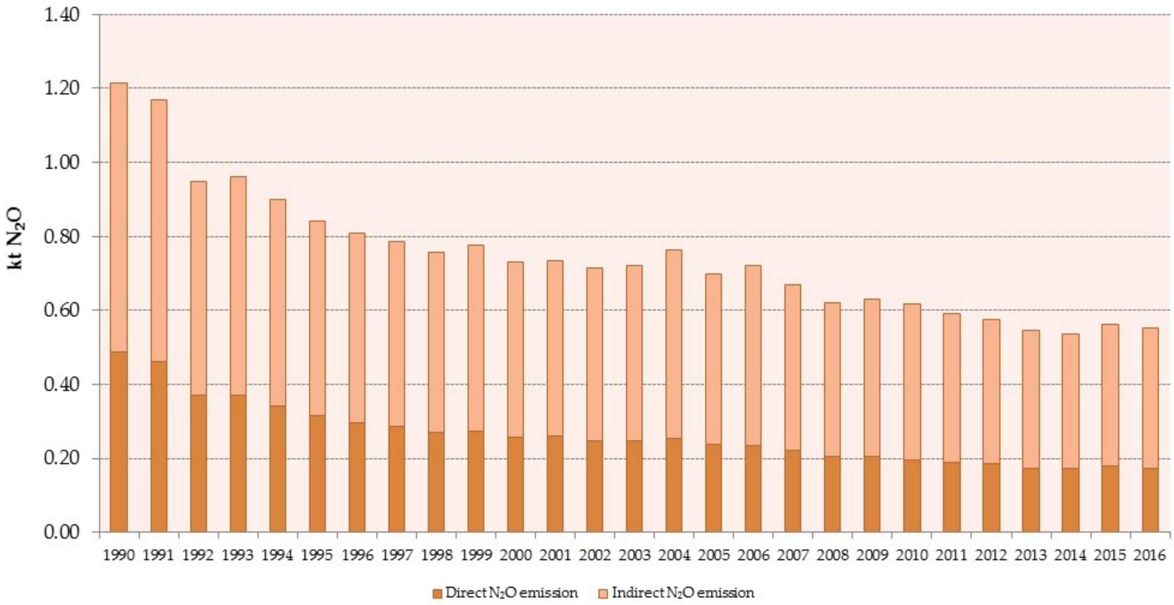
- Revision of the methodology and development of updated national emission factors.
- Planned improvements for the Enteric Fermentation source (regarding AD) will also improve emissions calculation from Manure management sector. Please refer to chapter 5.2.6 for the planned improvements for Enteric Fermentation.

5.3.2. Manure management – N_2O emissions (CRF 3.B.2.)

5.3.2.1. Category description

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 2016 are presented in Figure 5.3-2.

Figure 5.3-2: N_2O Emissions from Manure management



5.3.2.2. 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 5.3-2 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 5.3-2: Manure management emission factors for each animal category and AWMS for the year 2016

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	89.37	5.00	49.60	38.40	2.00	4.00	1.00
Other Cattle	49.93	0.00	34.60	55.40	5.00	4.00	1.00
Sheep	8.03	0.00	0.00	17.60	82.40	0.00	0.00
Goats	16.53	0.00	0.00	5.00	95.00	0.00	0.00
Horses	41.61	0.00	0.00	30.00	70.00	0.00	0.00
Mules	41.61	0.00	0.00	10.00	90.00	0.00	0.00
Market swine	9.76	2.00	83.35	10.65	0.00	4.00	0.00
Breeding swine	30.76	1.80	73.99	19.21	1.00	4.00	0.00
Layers	0.55	0.00	11.00	88.00	1.00	0.00	0.00
Broilers	0.55	0.00	1.00	98.00	1.00	0.00	0.00
Turkeys	0.40	0.00	0.00	98.00	1.20	0.00	0.80
Ducks	1.62	0.00	1.00	93.00	5.00	0.00	1.00
Other poultry	0.76	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 NOx 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).

5.3.2.3. 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%.

5.3.2.4. 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.

5.3.2.5. Category specific recalculations

Emissions were recalculated for the entire 1990-2015 period for market swine and poultry animal categories due to a removal of NAPA to AAP correction of CBS data for swine and poultry (as recommended by TERT during ESD revision).

Additionaly, emissions were recalculated for all other animal categories for the year 2015 due to a correction of error in the calculation that used national emission parameters for 2014. This resulted in a minor change in emissions.

5.3.2.6. Category specific planned improvement

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

- Revision of the methodology and development of updated national emission factors.
- During the NIR 2017 QA/QC process on the activity data, CBS identified changes in the AD for non-dairy cows and swine, for several years. The differences in the animal population numbers is within the ± 1-5% range. The AD was not ready in time for the resubmission of NIR 2018, but will be corrected in the next submission.

5.4. Rice cultivation (CRF 3.C.)

5.4.1. Category description

Anaerobic decomposition of organic material in flooded rice fields produces methane (CH_4) which escapes into the atmosphere by diffusive transport through the plants during the growing season. Rice cultivation does not occur in Croatia, so there is no possible emissions from this source.

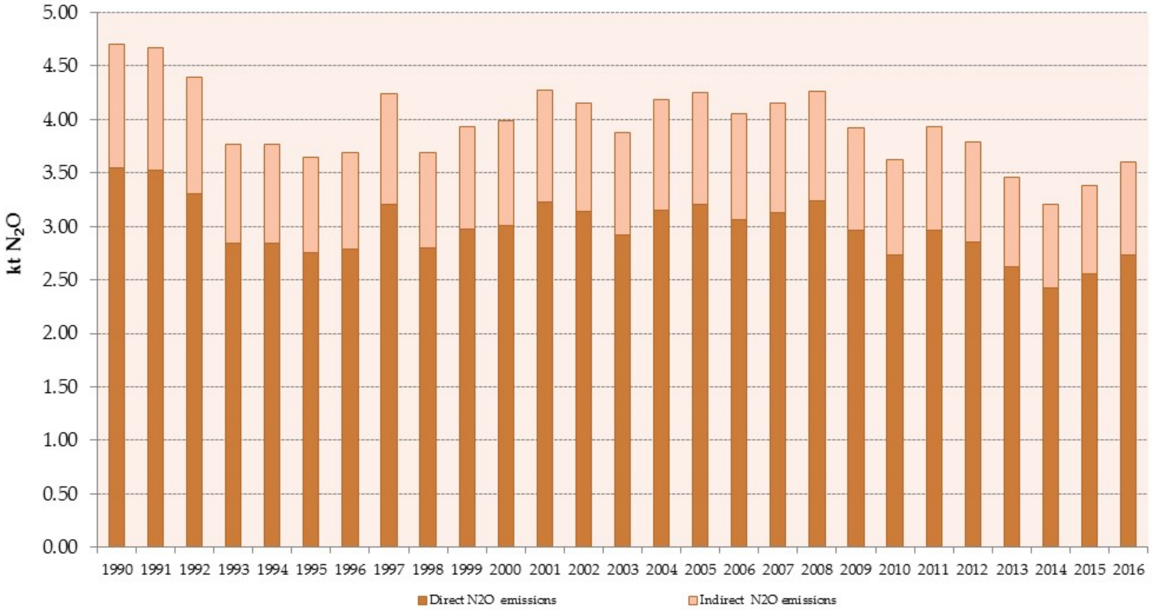
5.5. Agricultural soils (CRF 3.D.)

A number of agricultural activities add nitrogen to soils, thereby increasing the amount of nitrogen available for nitrification and denitrification, and ultimately the amount of N_2O emitted. Usage of synthetic and organic fertilisers, deposited manure, crop residues, sewage sludge, mineralisation of N in soil organic matter due to management of organic soils, etc. Two sources of nitrous oxide emissions are distinguished:

- Direct N_2O Emissions from Managed Soils (CRF 3.D.1.)
- Indirect N_2O Emissions from Managed Soils (CRF 3.D.2.)

Direct N_2O emissions are estimated separately from indirect emission, thought both use the same set of activity data. Emissions of nitrous oxide (N_2O) from Agricultural soils for the period from 1990 to 2015 are presented in Figure 5.6-1. Emissions decreased after 1990 and during the war due to specific national circumstances and limited agricultural practice at that time. Afterwards the emission trend is mostly influenced by the changes in the direct soil emissions. In 1997, 2001 and 2002 direct soil emissions increased due to the increase in mineral fertilizer consumption (1997, 2001) and also due to the increase in crop production. In the period from 2004-2008, emission increased in comparison to 2003 due to increases in mineral fertilizer consumption, number of animals and crop production. Emissions for the years 2009 and 2010 continue on a declining trend, mostly related to economic recession, while the year 2011 shows a slight increase again, due to increase in mineral fertilizer consumption. Data for the years 2012 - 2015 again show decline in consumption, after which it grows in 2015 and 2016.

Figure 5.5-1: Total N_2O emissions from Agricultural soils



5.5.1. Direct N_2O Emission from Managed Soils (CRF 3.D.1.)

5.5.1.1. Category description

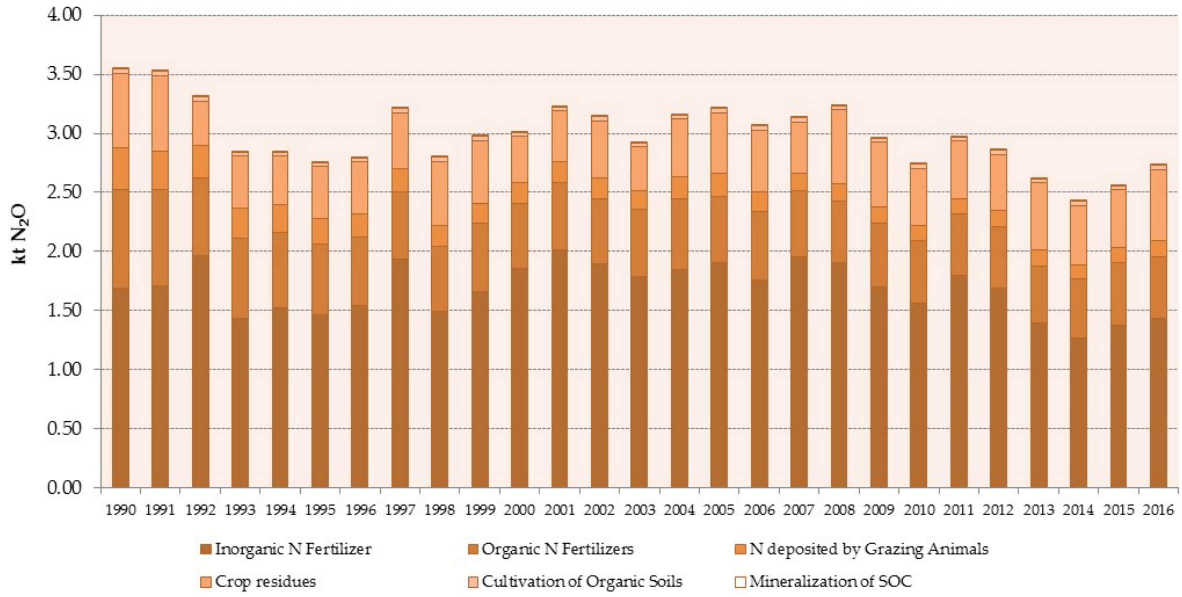
Direct N_2O emissions from agricultural soils include total amount of nitrogen applied to soils through human induced N aditions and/or change od practices. Specific N sources estimated are as follows:

- 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 2016 are shown in Figure 5.5-2.

Figure 5.5-2: Direct N_2O emissions from Agricultural soils



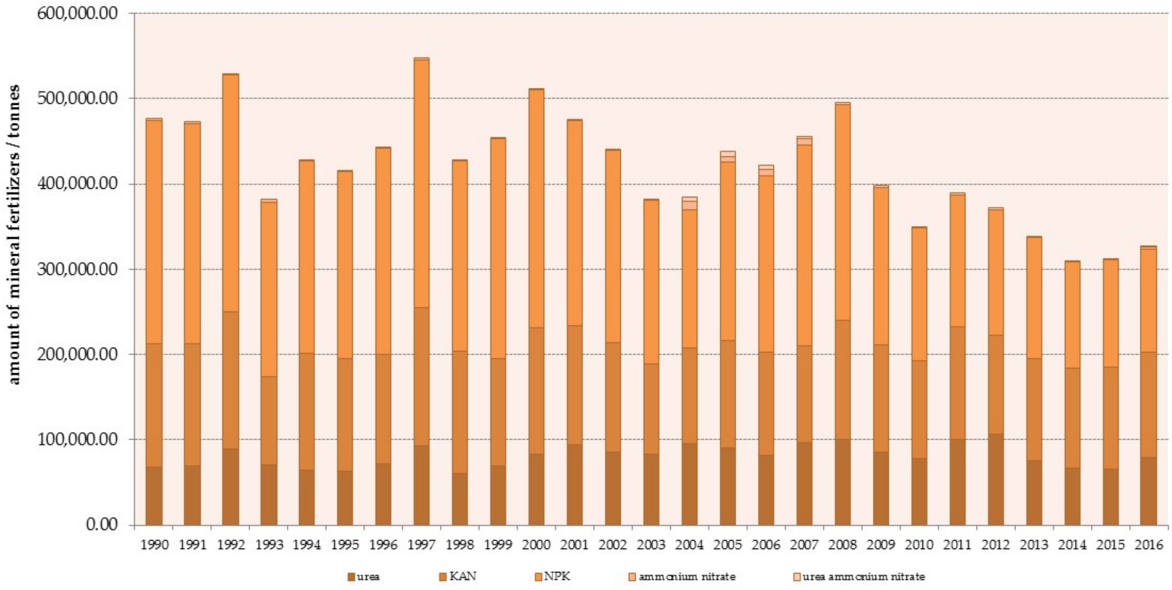
5.5.1.2. Methodological issues

In order to calculate emission from Agricultural Soils, the IPCC methodology (Tier 1) has been used. Emission factors were taken from the 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 1992-2016. 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 1990-2016 is presented in Figure 5.5-3 while the nitrogen applied in the same period is shown in Table 5.5-1.

Figure 5.5-3: Mineral fertilizers applied to soil in the period from 1990-2016



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 5.5-1: Nitrogen from applied inorganic fertilizers in the period 1990-2016

Year	Nitrogen applied / tonnes					
	Urea	Calcium ammonium nitrate	NPK	Ammonium nitrate	Urea ammonium nitrate	TOTAL
1990	31,376.02	39,030.12	36,285.99	721.27	0.00	107,413.40
1991	31,957.26	38,643.46	37,441.72	672.22	0.00	108,714.66
1992	41,093.64	43,521.03	39,921.42	282.41	0.00	124,818.50
1993	32,705.54	27,743.58	29,856.30	1,053.58	0.00	91,358.99
1994	29,839.28	36,707.85	29,814.55	549.07	0.00	96,910.74
1995	29,038.88	35,701.02	28,395.91	279.73	0.00	93,415.53

Year	Nitrogen applied / tonnes					
	Urea	Calcium ammonium nitrate	NPK	Ammonium nitrate	Urea ammonium nitrate	TOTAL
1996	32,894.14	34,644.78	30,768.66	81.74	0.00	98,389.32
1997	42,897.76	43,609.05	35,924.21	920.92	0.00	123,351.94
1998	27,755.94	38,790.63	28,358.87	341.03	0.00	95,246.47
1999	31,669.16	34,221.42	39,495.69	235.17	0.00	105,621.44
2000	38,179.54	39,921.66	39,861.79	41.88	0.00	118,004.86
2001	57,768.64	37,933.11	32,340.63	300.50	0.00	128,342.88
2002	50,655.66	38,065.68	31,650.89	96.82	0.00	120,469.05
2003	42,176.48	31,017.33	33,360.69	5,203.22	1,863.30	113,621.02
2004	45,109.44	32,069.52	33,626.10	5,126.17	1,647.30	117,578.53
2005	41,939.58	36,264.78	36,438.61	4,983.13	1,682.70	121,308.80
2006	37,505.18	36,121.41	34,055.42	2,729.58	1,390.20	111,801.79
2007	44,424.04	37,700.91	38,342.62	3,415.66	777.30	124,660.53
2008	46,659.18	39,456.18	34,110.03	332.99	589.50	121,147.88
2009	39,667.18	36,485.91	31,102.13	18.76	737.40	108,011.38
2010	40,999.13	34,811.64	23,196.56	21.11	498.00	99,526.43
2011	51,674.69	35,651.19	26,631.44	17.76	603.53	114,578.60
2012	53,465.65	31,327.41	22,413.62	0.00	661.99	107,868.67
2013	37,397.93	32,440.15	18,356.24	0.00	314.58	88,508.90
2014	30,539.66	31,633.10	18,212.75	0.00	321.60	80,707.11
2015	35,377.73	32,176.82	19,825.93	8.38	347.04	87,735.90
2016	40,110.16	33,633.47	16,499.23	689.82	417.55	91,350.22

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 2005-2016, 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. Data source is the yearly publication "Waste water purification sludge management for the sludge used in agriculture", Croatian Agency for Environment and Nature which contains AD (tonns applied) and average composition of the sludge and that the report on the sludge used is required for all producers/users of the aforemention sludge according to the „Ordinance for waste water purification sludge management for the sludge used in agriculture" set in the Official Gazette of the Republic of Croatia. 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 of 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.

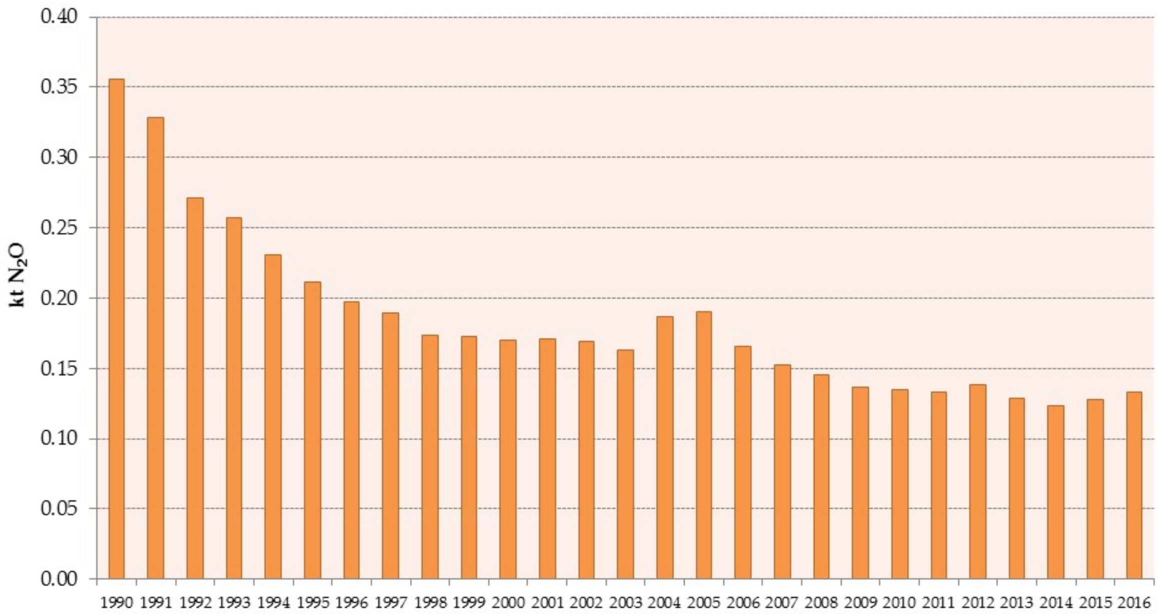
Table 5.5-2: Amount of sludge and nitrogen percentage applied

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%
2014	920	3.89%
2015	1321	3.89%
2016	1555	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 N_2O 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 5.5-4.

Figure 5.5-4: N_2O emissions due to urine and dung deposited by grazing animals 1990-2016



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 5.5-3). 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 used. 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 5.5-4.

Table 5.5-3: Data sources regarding crop production

	Crop yield			Crop area		
Crop	CBS	FAO	Extrapolation*	CBS	FAO	Extrapolation*
Soyabeans	1990-2016			1990-2016		
Beans, dry	1990-2016			1990-2016		
Cow peas, dry	2008-2016	1992-2007	1990-1991	1998-1999 2008-2016	1992-1997 2000-2007	1990-1991
Lentils	1990-1991	1992-2016		1990-1998	1999-2016	
Peas, dry	1990-2016			1990-2016		

	Crop yield			Crop area		
Crop	CBS	FAO	Extrapolation*	CBS	FAO	Extrapolation*
Vetches	1990-1997	1998-2016		1990-1997	1998-2016	
Clover	1990-2016			1990-2016		
Alfaalfa	1990-2016			1990-2016		
Wheat	1990-2016			1990-2016		
Maize	1990-2016			1990-2016		
Potatoes	1990-2016			1990-2016		
Sugar beets	1990-2016			1990-2016		
Tobacco	1990-2016			1990-2016		
Sunflowers	1990-2016			1990-2016		
Rape seed	1990-2016			1990-2016		
Tomatoes	1990-2016			1990-2016		
Barley	1990-2016			1990-2016		
Oats	1990-2016			1990-2016		
Cabbages and other brassicas	1990-2016			1990-2016		
Garlic**	1990-2016			1990-2016		
Onions**	1990-2016			1990-2016		
Rye	2014-2016	1992-2013	1990-1991	2014-2016	1992-2013	1990-1991
Sorghum***	1990-1997	1998-2016		1990-1997	1998-2016	
Watermelons	1990-2016			1990-2016		

**Extrapolation was based on data for the period of 5 consecutive years.*

***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 5.5-4: Production and harvest data for crops in the period from 1990 – 2016

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	318,955	1,951,066	503,342	610,236	77,016	1,205,928	29,872	12,394	10,105	52,995	20,971	33,200	12,647	54,742	5,801
1991	1,495,625	324,460	2,388,555	488,178	658,687	78,510	1,244,439	28,568	10,460	9,300	46,455	18,773	22,816	9,004	48,601	5,703
1992	658,019	168,865	1,358,084	370,205	480,079	60,758	525,105	16,537	11,651	8,377	40,414	18,153	24,183	11,743	35,262	4,318
1993	886,921	211,845	1,672,593	373,166	507,898	64,754	537,196	14,717	9,585	7,635	42,724	17,564	28,665	13,010	39,771	4,784
1994	750,330	198,381	1,686,992	370,517	563,285	66,356	591,819	16,043	8,613	6,659	26,547	17,871	28,341	13,889	46,276	4,959
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	360,824	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	370,986	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	377,536	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	383,925	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	182,333	1,190,238	292,431	198,243	17,237	482,211	20,985	9,714	5,678	53,956	25,715	29,436	12,886	15,530	477
2001	811,674	184,274	1,733,003	305,867	242,709	17,435	964,880	23,757	10,502	5,500	42,985	25,336	22,456	10,319	16,721	499
2002	822,650	179,153	1,956,418	306,805	266,055	17,222	1,183,445	25,149	10,905	5,489	62,965	26,835	25,585	13,041	15,437	472
2003	506,212	157,175	1,279,617	304,722	164,051	16,919	677,569	27,327	9,680	5,748	69,253	28,211	28,596	15,524	12,320	481
2004	801,424	162,634	1,931,627	306,347	247,057	16,043	1,260,444	26,503	10,293	5,394	68,973	28,328	31,392	14,282	15,191	461
2005	601,748	146,253	2,206,729	318,973	273,409	18,903	1,337,750	29,370	9,579	5,131	78,006	49,769	41,275	20,149	18,731	659
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	16,507	461
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	30,779	920
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	17,327	689
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	22,082	690
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	22,279	499
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	17,536	23,585	595
2012	999,681	186,949	1,297,590	299,161	151,278	10,232	919,230	23,502	11,787	5,958	90,019	33,534	26,406	9,893	18,438	448
2013	998,940	204,506	1,874,372	288,365	162,501	10,234	1,050,715	20,245	9,834	5,172	130,576	40,805	47,827	17,972	26,026	583
2014	648,917	156,139	2,046,966	252,567	160,847	10,310	1,392,000	21,900	9,164	5,196	99,489	34,869	71,228	23,122	19,374	319
2015	758,638	140,986	1,709,152	263,970	171,179	10,047	756,509	13,883	10,132	4,752	94,075	34,494	56,783	21,977	36,273	423
2016	960,081	168,029	2,154,470	252,072	193,962	9,866	1,169,622	15,493	8,977	4,413	110,566	40,254	112,990	36,778	24,571	370

Table 5.5-4: Production and harvest data for crops in the period from 1990 – 2016 (cont.)

Year	Production of crops / tonnes/ ha															
	Barley		Oats		Cabbages and		Garlic		Onions		Rye		Sorghum		Watermelons	
	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha
1990	196,554	51,565	62,287	25,495	122,045	10,174	12,214	3,647	39,925	7,000	15,840	3,053	17	176	20,938	1,898
1991	185,695	51,643	53,851	23,425	116,540	10,445	11,095	3,546	37,864	7,100	14,069	2,974	1,401	146	17,941	2,119
1992	106,811	32,873	45,262	17,582	68,422	7,745	6,744	2,304	28,717	5,082	6,069	2,252	17	140	8,062	682
1993	125,671	36,605	41,074	17,204	79,828	8,559	7,345	2,439	31,081	5,417	6,273	2,453	31	147	8,014	767
1994	107,810	36,225	42,425	18,493	95,791	8,788	9,346	2,543	40,896	5,955	7,146	2,963	23	136	16,045	1,141
1995	103,281	32,518	38,237	15,763	116,879	8,858	9,384	2,419	43,010	5,842	5,051	1,930	18	133	21,384	1,382
1996	88,091	31,034	39,529	16,290	122,635	8,767	8,820	2,474	39,421	5,852	5,517	2,043	18	12	26,901	1,867
1997	108,496	33,759	46,796	18,142	134,323	9,011	9,002	2,460	43,776	6,033	5,009	1,959	12	128	25,450	1,847
1998	143,510	42,737	56,110	21,669	129,674	9,247	10,624	2,651	51,662	6,565	5,530	2,146	547	130	60,243	2,599
1999	124,890	44,517	56,823	24,124	144,018	9,701	10,277	2,670	55,633	6,797	6,246	2,446	643	156	53,437	2,890
2000	179,652	55,511	61,604	26,042	27,351	1,390	1,468	187	8,145	656	7,236	2,931	655	163	24,044	929
2001	192,067	61,267	71,632	26,103	25,777	1,230	2,034	210	11,929	764	10,796	3,186	674	179	24,044	971
2002	206,478	61,165	74,187	24,484	29,770	1,397	1,889	193	11,298	699	9,207	3,470	560	150	26,417	1,038
2003	160,203	65,001	53,025	25,300	27,368	1,281	1,572	193	9,276	690	5,967	3,192	627	180	15,183	933
2004	237,603	67,538	73,462	23,457	26,310	1,225	1,864	360	11,309	448	8,994	2,900	756	227	22,411	865
2005	162,530	50,341	49,470	21,185	40,525	1,826	2,379	596	14,033	484	4,737	1,848	600	200	27,191	923
2006	215,262	59,159	66,630	24,914	42,193	1,628	2,770	619	16,392	432	5,487	2,008	800	300	25,593	966
2007	225,265	59,000	56,150	27,967	32,477	1,856	3,390	786	20,084	391	4,364	1,731	1,200	400	26,017	1,171
2008	279,106	65,536	65,328	19,873	43,492	3,084	3,725	958	22,349	477	4,079	1,367	760	217	33,643	1,393
2009	243,609	59,584	62,297	20,901	59,208	3,123	3,680	708	21,879	352	2,860	998	1,130	455	42,280	1,556
2010	172,359	52,524	48,190	19,280	33,839	1,571	3,198	600	19,594	239	2,507	1,035	1,000	390	21,679	849
2011	193,961	48,318	77,223	25,344	34,963	1,806	2,728	687	19,569	562	2,949	871	1,280	400	19,902	727
2012	235,778	56,905	94,542	28,514	21,106	1,187	3,287	543	19,646	301	2,426	846	1,372	384	20,226	685
2013	201,339	53,796	60,178	21,656	35,033	1,723	3,621	768	20,478	612	2,955	1,019	1,388	365	30,327	818
2014	175,592	46,160	56,555	21,146	24,703	850	4,272	548	24,160	436	2,800	1,373	1,205	500	25,598	791
2015	193,451	43,700	71,743	23,462	38,413	1,484	4,634	234	26,204	940	3,356	1,093	1,205	500	15,771	608
2016	263,165	56,483	80,414	26,572	37,315	1,492	1,297	245	25,093	906	3,356	1,093	1,205	500	19,908	682

Table 5.5-4: Production and harvest data for crops in the period from 1990 – 2016 (cont.)

Year	Production of crops / tonnes/ ha															
	Soyabeans		Beans, dry		Cow peas, dry		Lentils		Peas, dry		Vetches		Clover		Alfalfa	
	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha	tonnes	ha
1990	55,461	27,260	18,437	8,132	1,790	153	202	115	1,000	3,402	3,457	1,148	225,466	54,785	252,563	56,801
1991	56,365	22,840	21,949	8,921	1,521	149	164	114	987	3,174	3,190	1,052	226,546	52,902	251,486	57,323
1992	46,129	26,220	15,961	5,980	895	186	155	92	812	2,597	2,125	871	129,747	35,665	142,613	36,769
1993	49,456	21,424	17,588	6,514	1,651	270	180	78	339	2,738	2,160	706	136,012	36,733	137,225	36,554
1994	44,127	20,435	20,596	6,958	441	120	167	86	400	2,899	2,509	741	155,087	36,595	162,457	37,519
1995	34,319	15,018	21,844	6,733	400	100	92	78	853	2,915	2,210	674	143,910	35,047	158,557	37,350
1996	35,896	16,423	20,221	6,975	662	164	123	89	611	2,787	2,386	690	165,973	36,632	188,462	40,464
1997	39,469	16,030	20,527	7,521	633	158	135	89	577	3,041	1,921	637	157,559	35,640	179,669	39,428
1998	77,458	34,015	21,003	5,946	600	234	142	90	746	562	2,397	752	158,516	36,396	201,778	41,759
1999	115,853	46,336	22,291	6,581	949	501	130	82	824	660	2,400	720	167,266	36,424	223,387	42,939
2000	65,299	47,484	2,657	7,470	510	129	125	79	913	555	2,400	720	100,179	21,198	85,575	17,238
2001	91,841	41,621	4,421	7,149	400	100	130	84	1,930	778	2,300	700	115,709	20,621	98,305	18,162
2002	129,470	47,897	5,163	7,104	400	100	118	76	2,082	872	2,272	716	131,103	20,470	107,815	17,279
2003	82,591	49,860	4,967	6,826	400	100	114	72	1,155	889	2,309	730	51,890	20,604	72,056	17,186
2004	97,923	36,979	4,459	6,137	400	100	111	71	1,859	813	2,314	734	124,813	19,921	103,555	16,712
2005	119,602	48,211	6,041	6,477	409	102	114	73	893	447	2,366	753	125,460	19,779	147,272	25,411
2006	174,214	62,810	4,058	6,367	400	100	140	100	715	326	2,400	750	121,411	19,134	162,694	26,282
2007	90,637	46,506	2,503	4,451	400	100	100	64	670	374	2,300	700	111,675	20,948	137,291	23,959
2008	107,558	35,789	3,263	2,147	1,149	371	41	41	870	351	2,083	678	176,089	24,683	196,244	25,265
2009	115,159	44,292	2,460	1,947	1,468	656	74	41	955	372	2,000	664	147,763	23,347	174,274	26,544
2010	153,580	56,456	1,641	1,276	1,197	577	29	16	340	221	2,061	700	119,969	20,472	177,652	27,207
2011	147,271	58,896	1,059	1,232	1,939	614	82	56	696	252	1,700	700	105,075	21,176	153,240	25,126
2012	96,718	54,109	472	788	1,863	798	22	11	404	139	1,830	650	83,817	20,270	124,055	24,803
2013	111,316	47,156	1,480	1,097	1,378	721	80	44	189	154	1,700	660	82,844	16,783	177,857	25,694
2014	131,424	47,104	1,329	1,483	1,413	678	83	29	579	219	1,500	500	70,873	10,497	128,702	22,116
2015	196,431	88,867	1,156	1,475	1,346	600	83	29	194	94	1,500	500	82,992	9,549	112,876	18,386
2016	244,075	78,614	1,461	1,574	3,985	1,543	83	29	246	71	1,500	500	67,853	9,920	191,540	23,559

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 te emission calculation, except for dry matter fraction where a combination of sources were used, as presented in the Table 5.5-5. Slovenian, Portuguese and Hungarian NIRs were selected as a source for the dry matter fraction values due to the similarities and comparability of growing conditions for the selected crops for which national dry matter fraction data are not available. Dry matter fraction needed to be incorporated so that adjustments for moisture contents could be made.

Table 5.5-5: 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	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)

For the estimation of N_2O direct emissions from managed soils concerning loss of soil organic matter resulting from change of land use or management of mineral soils, equation 11.8 from 2006 Guideines was applied:

$$F_{SOM} = \sum_{LU} \left[\left(\Delta C_{Mineral,LU} * \frac{1}{R} \right) * 1000 \right]$$

Where:

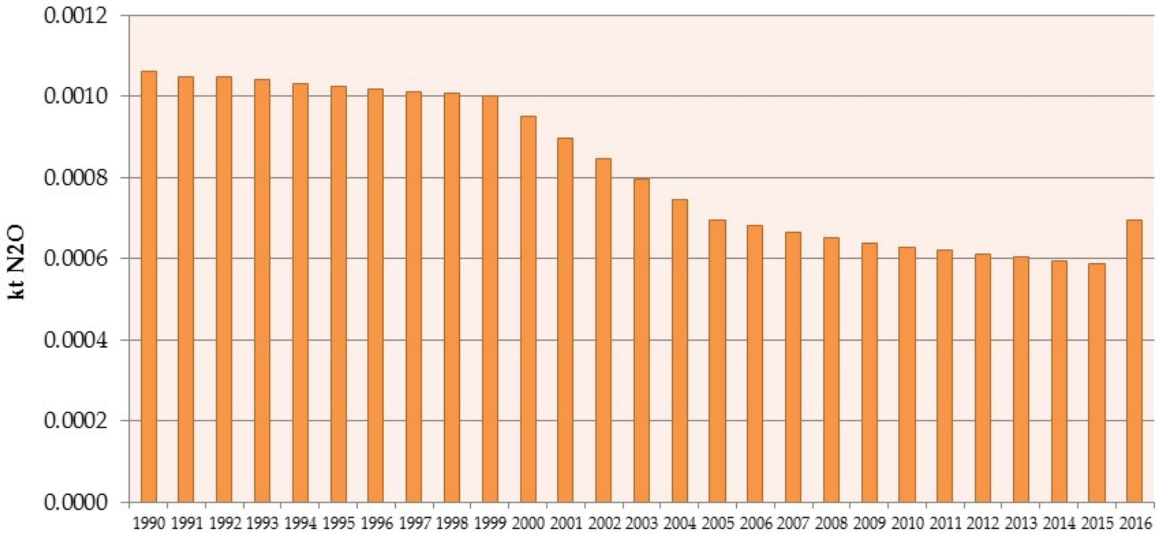
FSOM = the net annual amount of N mineralized in mineral soils as a result of loss of soil carbon through change in land use or management, [kg, N]

ΔCMineral, LU = average annual loss of soil carbon for each land-use type (LU), [tonnes C]

R = C:N ratio of the soil organic matter

This equation was applied in case of management changes in cropland remaining cropland, for conversion from perennial cropland to annual cropland. All others Direct N_2O emissions due to land use changes and loss/gain of soil organic matter are reported under LULUCF chapter i.e. CRF Table 4(III).

Figure 5.5-5: N_2O Emissions due to Loss/Gain of Soil Organic Content 1990-2016



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 Enviroment 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 CEA expert judgment this value is accurate on a national level and can be used for each year in the entire period from 1990-2016.

5.5.1.3. 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 N2O 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.

5.5.1.4. Category-specific QA/QC and verification

During the preparation of inventory submission, activity data for the entire time series were checked and revised if found necessary, including the FAO data. National Inventory Reports of countries with similar climate and soil conditions were consulted and checked for values on dry matter fraction, residue/crop ratio and N fraction for non N-fixing crops. Therefore, activities related to quality control were focused on completeness and consistency of emission estimates. After a final draft of this chapter was prepared, an audit was carried out to check selected activities from Tier 1 General inventory level QC procedures which revealed that most of the activities were correctly carried out, during inventory preparation, despite the fact that formal QC procedures were not prepared.

5.5.1.5. Category specific recalculations

Due to changes in FAO activity data on crop production, emissions for 3.D.1.4 source category were recalculated as follows: Cow peas, dry (1996-1998, 2000, 2005).

Croatian Agency for Environment and Nature provided new activity for Sewage Sludge applied to Soils for the period 2013-2015 ("Report for waste water purification sludge management data for the sludge used in agriculture"), resulting in a recalculation of the 3.D.1.2.b. source category for those years.

Emissions were recalculated for the entire 1990-2015 period for 3.D.1.2.a Animal Manure applied to Soils and 3.D.1.3 Urine and Dung deposited by Grazing Animals source categories due to a change of animal number (following removal of NAPA to AAP correction of CBS data as recommended by TERT during ESD revision) for swine and poultry.

5.5.1.6. Category specific planned improvement

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

- During the NIR 2017 QA/QC process on the activity data, CBS identified changes in their AD for some crops, for several years. New data were not ready in time for the resubmission of NIR 2018, but will be corrected in the next submission.
- 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.
- Investigation of the difference in statistical data of mineral fertilizer usage that is leading to the possible overestimation of direct N2O emissions from the Agricultural Soils .
- Continued improvements and investigation of activity data (mineral fertilizer, crop production, sewage sludge, compost) with the purpose of more detailed explanation of the activity data trends and further verification of source data.

5.5.2. Indirect N_2O Emissions from Managed Soils (CRF 3.D.2.)

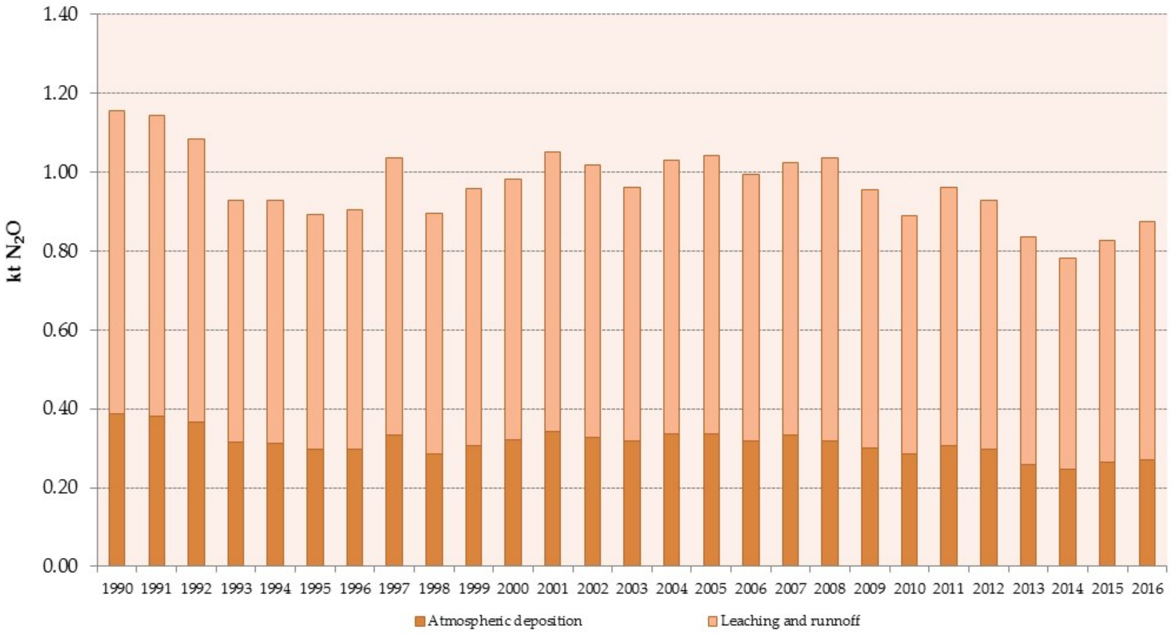
5.5.2.1. Category description

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 2015 are shown in Figure 5.6-6.

Figure 5.5-6: Indirect N_2O emissions from Managed Soils



5.5.2.2. Methodological issues

Atmospheric deposition due to volatilization

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.

Nitrogen leaching and run-off

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.

5.5.2.3. Uncertainty and time-series consistency

The uncertainty of the calculation is conditioned by the use of emission factors recommended by the methodology and the input data unreliability. According to the bibliography, uncertainty of the recommended emission factors is high.

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 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.

5.5.2.4. 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 N2O Emissions from Agricultural Soils, respectively).

5.5.2.5. Category specific recalculations

Emissions from all sources from managed soils were recalculated for the entire 1990-2014 period due to AD changes and improvements made in sources: Manure Management – N_2O Emissions (CRF 3.B.2.) and Direct N_2O Emissions from Managed Soils (CRF 3.D.1.) See Chapter 5.3.1 and 5.5.1 for detailed recalculation explanations.

5.5.2.6. Category specific planned improvement

Planned improvements in this category are shared with the planned improvements for the N_2O Emissions from Manure Management (Chapter 5.3.1) and Direct emission from agricultural soils (Chapter 5.5.1).

5.6. Prescribed burning of savannas (CRF 3.E.)

5.6.1. 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.

5.7. Field burning of agricultural residues (CRF 3.F.)

5.7.1. 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.

5.8. Liming (CRF 3.G.)

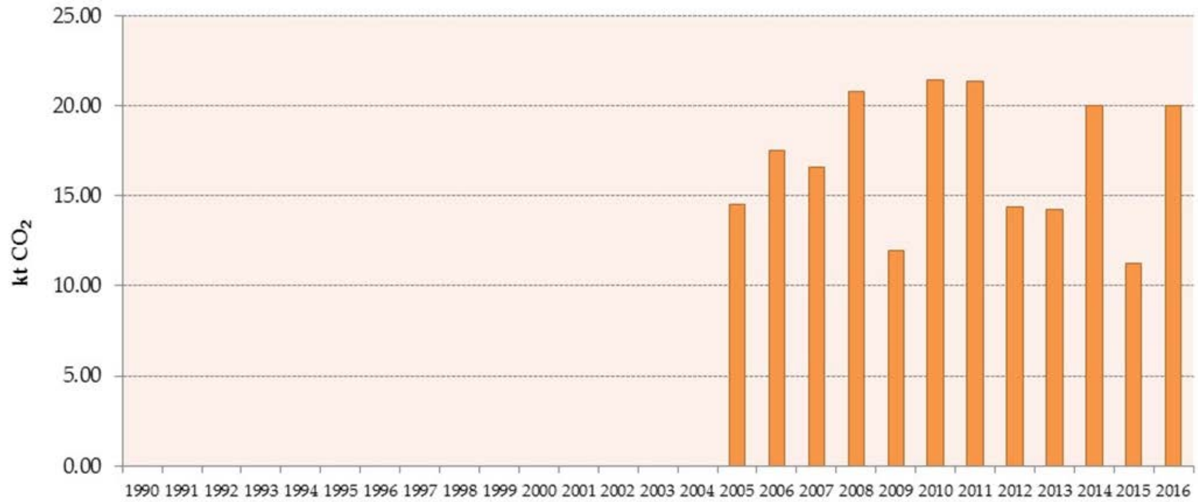
5.8.1. Category description

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 in case of one sugar factory, and in case of another sugar factory since 2010 (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 which is still practice in one of factories.

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.

CO_2 emisisons from liming for the period from 1990 to 2016 are presented in Figure 5.8-1. Further investigation on this issue is foreseen in due time, See Chapter 6.5.6.

Figure 5.8-1: Direct CO_2 emissions from Liming



5.8.2. Methodological issues

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

5.8.3. 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.

5.8.4. 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.

5.8.5. Category specific recalculations

No recalculcations were performed.

5.8.6. Category specific planned improvement

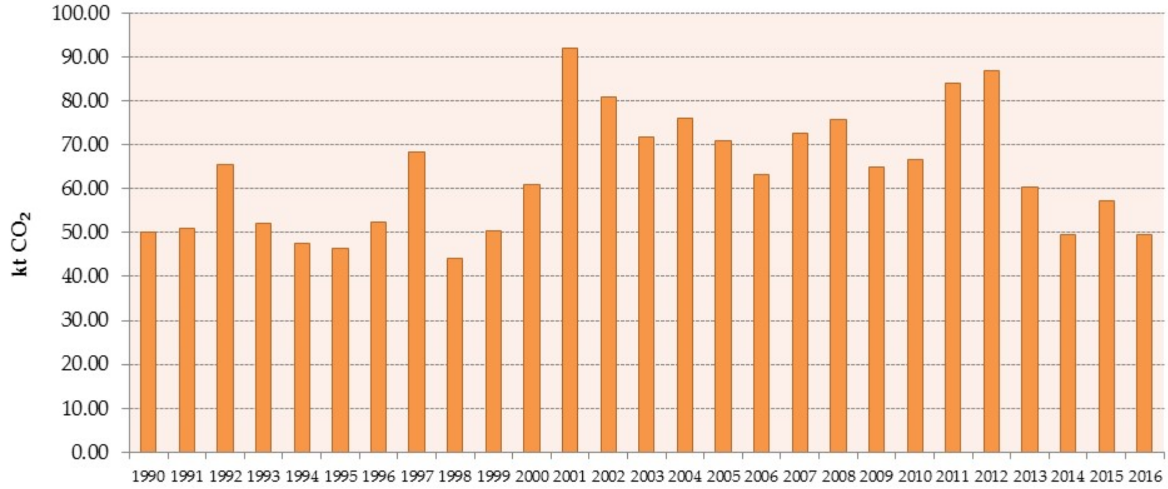
There is no improvement plan for this category.

5.9. Urea application (CRF 3.H.)

5.9.1. 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 2015 is shown in Figure 5.9-1.

Figure 5.9-1: Direct CO_2 emissions from Urea Application



5.9.2. 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 Agricutural 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.

5.9.3. 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 N_2O 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.

5.9.4. 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).

5.9.5. Category specific recalculations

No recalculcations were performed.

5.9.6. Category specific planned improvement

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 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 2006 Guidelines, the land use categories relevant for the greenhouse gas (GHG) reporting are:

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

According to the IPCC 2006 Guidelines, 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 and reported in the respective categories aferwards. Also in compliance with the 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 analysis for LULUCF sector based on the level and trend assessment for 2016

Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2018)					
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification		Com.
4(III).Direct N2O emissions from N mineralization/ immobilization	N_2O	Yes	L2i	T2i	
4.A.1 Forest Land Remaining Forest Land	CO_2	Yes	L1i, L2i	T1i, T2i	
4.A.2 Land Converted to Forest Land	CO_2	Yes	L1i, L2i	T1i, T2i	
4.B.1 Cropland Remaining Cropland	CO_2	Yes	L2i	T1i, T2i	
4.B.2 Land Converted to Cropland	CO_2	Yes	L2i	T2i	
4.C.2 Land Converted to Grassland	CO_2	Yes	L2i	T2i	
4.D.2 Land Converted to Wetlands	CO_2	Yes		T2i	
4.E.2 Land Converted to Settlements	CO_2	Yes	L1i, L2i	T1i, T2i	
4.G Harvested Wood Products	CO_2	Yes	L2i	T1i, T2i	

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.

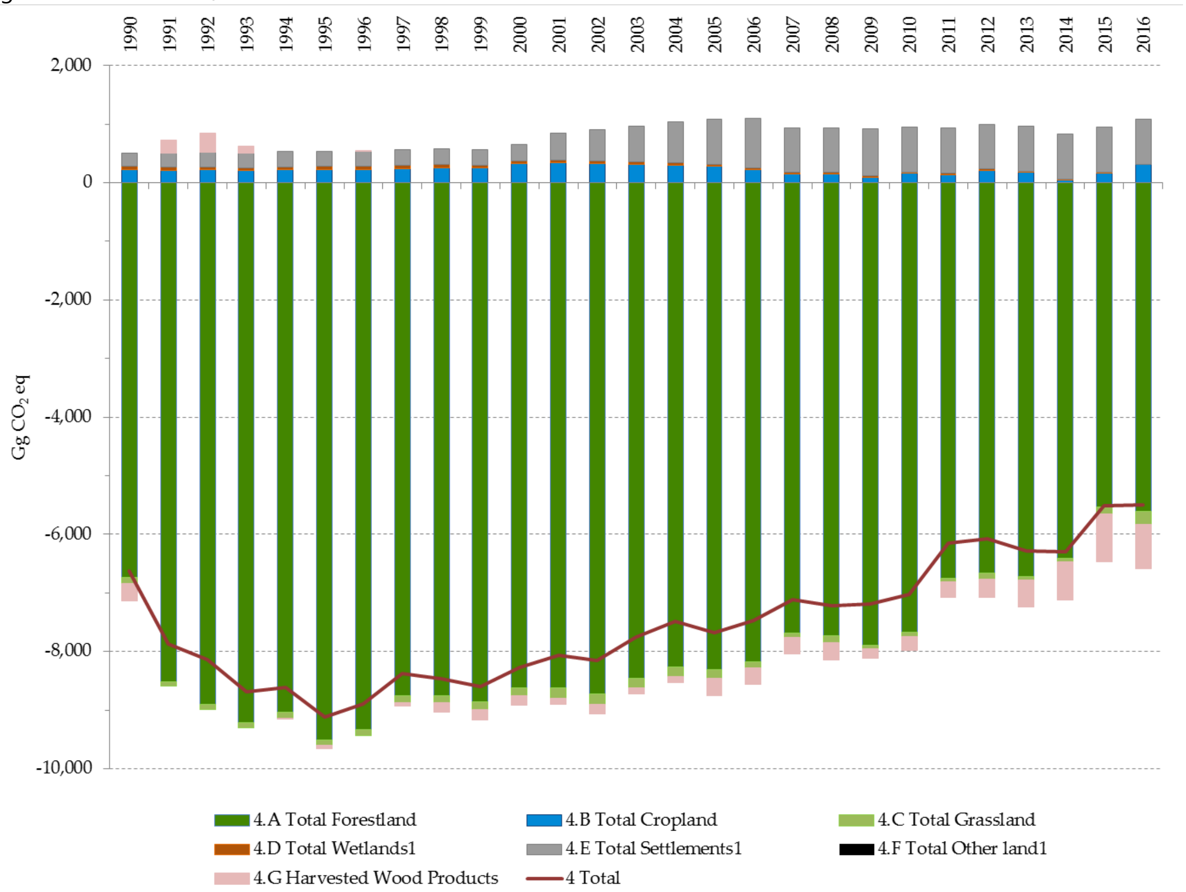
Table 6.1-2: Reported LULUCF categories - status of emission estimates

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	x	x
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	x
D. Wetlands	x	NO	NO
1. Wetlands remaining Wetlands	NE	NO	NO
2. Land converted to Wetlands	x	NO	x
E. Settlements	x	NO	NO
1. Settlements remaining Settlements	NE	NO	NO
2. Land converted to Settlements	x	NO	x
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

On the report of the previous figures and Figure 6.1-1, the conclusion is that LULUCF sector in Croatia presents a sink of greenhouse gases. Two land use categories, namely 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 Saturday paper in 2012 regarding the traceability and identification of lands that are subject of forest activities, Croatia developed and implemented project "Improving Croatian reporting in Land use, Land

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

use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol" (abbreviated LULUCF 1). Special surveys were executed during the project 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 (MENP) through joint cooperation with relevant institutions.

Information on areas of the wetlands, grassland and settlements for the single years (1980, 1990, 2000, 2006 and 2012) were obtained from the Corine Land Cover (CLC) database. When presenting areas of Settlement, correction factor has to be defined and applied since these areas were observed smaller than areas in other countries.

Information on areas of the cropland was extracted from the national Statistical Yearbooks and from the CLC 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 year 2000 were corrected using the data from 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
- 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. Conducted survey under the LULUCF 1 project concluded that there is no conversion from Other land to forest land, as Croatia reported in previous reports before this survey.

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 was 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. Organized survey had determined the former land use types on the identified new forest areas and classified according to the ownership.

IPCC 2006 Guidelines Approach 1 was applied for representing the areas of LUC in other categories of land by using information from available statistics and assumptions based on recognized pattern on land use changes. Then, the remaining area was calculated as the difference between the total area of a land use category and the land use changes to each category. Detailed descriptions of the methodology of area information are given in corresponding chapters of the report.

The table 6.1-3 presents presents the total area of the respective land uses and land-use changes between categories for the base and the inventoried year as well as the net changes for the period.

Table 6.1-3: Land use and LUC for Croatia for the years 1990-2016

Area in kha	1990	2016	2016-1990
4.A Forest land - Total	2,315.73	2,370.34	54.61
4.A1. Forest land remaining forest land	2,315.73	2,368.91	53.18

Area in kha	1990	2016	2016-1990
4.A1a Forest land remaining forest land -coniferous	200.32	216.75	16.43
4.A1b Forest land remaining forest land -deciduous	1,675.55	1,632.37	-43.18
4.A1c Forest land remaining forest land -out of yield	439.85	519.79	79.94
4.A2 LUC in Forest land	0	1.43	1.43
4.A2.1a Annual cropland in forest land	0	0	0
4.A2.1b Perennial cropland in forest land	0	0	0
4.A2.2 Grassland in forest land	0	1.43	1.43
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	1,625.17	1,530.52	-94.66
Cropland annual	1,480.51	1,414.24	-66.27
Cropland perennial	144.66	116.13	-28.38
4.B1. Cropland remaining cropland	1,624.83	1,530.18	-94.64
4.B1a Annual cropland remaining annual cropland	1,480.51	1,530.30	50.13
4.B1b Perennial cropland remaining perennial cropland	144.66	116.13	-28.47
4.B1c LUC perennial cropland in annual cropland	0.02	0.02	-0.00
4.B1d LUC annual cropland in perennial cropland	0.04	0.02	-0.02
4.B2 LUC in cropland	0.35	0.33	-0.02
4.B2.1a Forest land in annual cropland	0	0	0
4.B2.1b Forest land in perennial cropland	0	0.01	0.01
4.B2.2a Grassland in annual cropland	0.33	0.2	-0.12
4.B2.2b Grassland in perennial cropland	0.02	0.12	0.09
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	1,210.35	1,187.70	-22.65
4.C1. Grassland remaining grassland	1,209.37	1,185.82	-23.56
4.C2. LUC in grassland	0.97	1.89	0.91
4.C2.1 Forest land in grassland	0	0	0
4.C2.2a Annual cropland in grassland	0.89	1.72	0.83
4.C2.2b Perennial cropland in grassland	0.08	0.17	0.09
4.C2.3 Wetlands in grassland	0	0	0

Area in kha	1990	2016	2016-1990
4.C2.4 Settlements in grassland	0	0	0
4.C2.5 Other land in grassland	0	0	0
4.D Wetlands	72.32	74.54	2.22
4.D1. Wetlands remaining wetlands	72.13	74.53	2.4
4.D2. LUC in wetlands	0.2	0.01	-0.18
4.D2.1 Forest land in wetlands	0	0	0
4.D2.2a Annual cropland in wetlands	0.18	0.01	-0.17
4.D2.2b Perennial cropland in wetlands	0.02	0	-0.02
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	204.32	264.83	60.51
4.E1 Settlements remaining Settlements	203.53	263.59	60.06
4.E2 LUC in Settlements	0.8	1.25	0.45
4.E2.1 Forest land in Settlements	0	0.02	0.02
4.E2.2a Annual cropland in Settlements	0.22	0.33	0.11
4.E2.2b Perennial cropland in Settlements	0.02	0.03	0.01
4.E2.3 Grassland in Settlements	0.56	0.86	0.30
4.E2.4 Wetlands in Settlements	0	0	0
4.E2.5 Other land in Settlements	0	0	0
4.F Other land	78.87	60.86	-18.01
4.F1 Other land remaining other land	78.87	60.86	-18.01
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

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 (4.A)

Definitions applied within this inventory regarding the Forest land are consistent with the 2006 Guidelines and KP reporting requirements 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. Reforestation activity does not occur in Croatia. All definitions applied for KP are the same as applied for the UNFCCC reporting (as presented in Croatian NIR 2018, 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 shrub. Therefore, the Forest land remaining forest land is forest land covered with high forests, plantations, cultures, coppice, maquies and shrub.

According to the Ordinance[11] total forest land in Croatia is divided in two main categories and several subcategories, 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, within the national frames, there exists forest 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. Following the IPCC definitions of land use categories, land under the forest management plans on which afforestation is performed in Croatia, falls under the Grassland category. Hence, this afforestation land (though always "forest land" in the Croatian administrative understanding) represents a LUC land from grassland to forest land according to IPCC and is reported as such. The Croatian reporting of lands and LUCs follows the IPCC definitions. Other land category had been used previously to present land under the forest management (without tree cover). Since 2012 report and before LULUCF 1 project was executed this has been changed and this land was reported under the Grassland category.

[11] Ordinance on forest management (OG 79/15)

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 revised and data were adjusted according to 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)

6.2.3. Grassland (4.C)

Following the IPCC definition of the grassland category, the next 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 and classes presented below 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 forwarded from 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[12] 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.

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

The Ministry of Agriculture supervises the decision making processs of management plans as well as their renewal and revision.

The FMAP, among others, 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, four 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),
- FMAP encompassing the period from 2016-2025 (FMAP 2016-2025).

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 on Forest Management forest stands are managed either as even-aged or uneven-aged forests. In case of uneven-aged forests two types of selection systems can be performed. In these forests two types of uneven-aged forest management are applied:

- a group-tree-selection system (Type 1 of the uneven-aged forest management), or
- a single-tree selection system (Type 2 of the uneven-aged forest management).

In case of Type 1 a group of trees of the same age and development stages within (sub)compartment, needs to be larger than 0.2 ha and up to maximum of the 2.0 ha.

Even-aged forest stands make regular forests with a share of about 52% of total growing stock (excluding maquis, shrub, garigue and scrub). Uneven-aged forests take share of 30 % of total growing stock (excluding maquis, shrub, garigue and scrub). Type 1 uneven-aged forests take share of about 18 % of total growing stock.

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 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 6.3-1). This division was established in 1996.

Regional forests administrations consist of regional forest offices. 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 on forest management plans for individual management unit approved by the Ministry of Agriculture. An example of one forest administration divided into 12 forest offices is presented in Figure 6.3-6.

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

Figure 6.3-1: Spatial division of the Republic of Croatia on forest districts

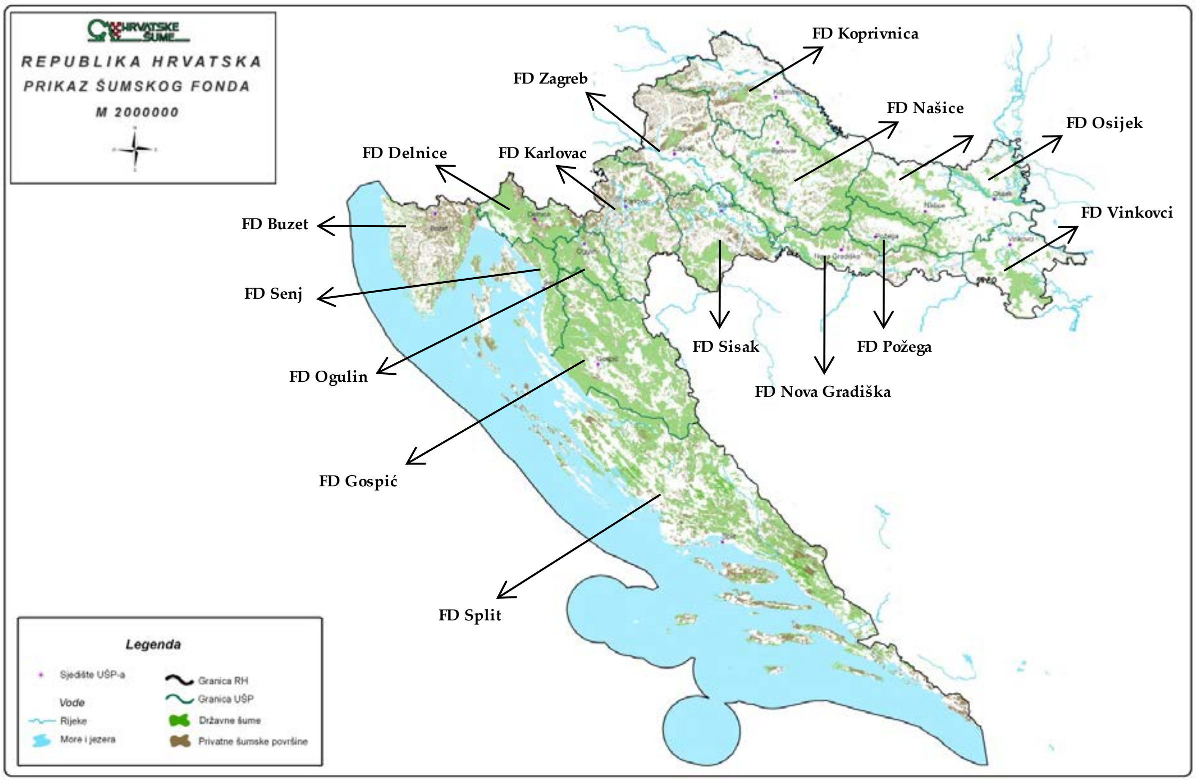


Figure 6.3-2: Division of forest district "Vinkovci" on related forest units (example, UŠP refers to FD)

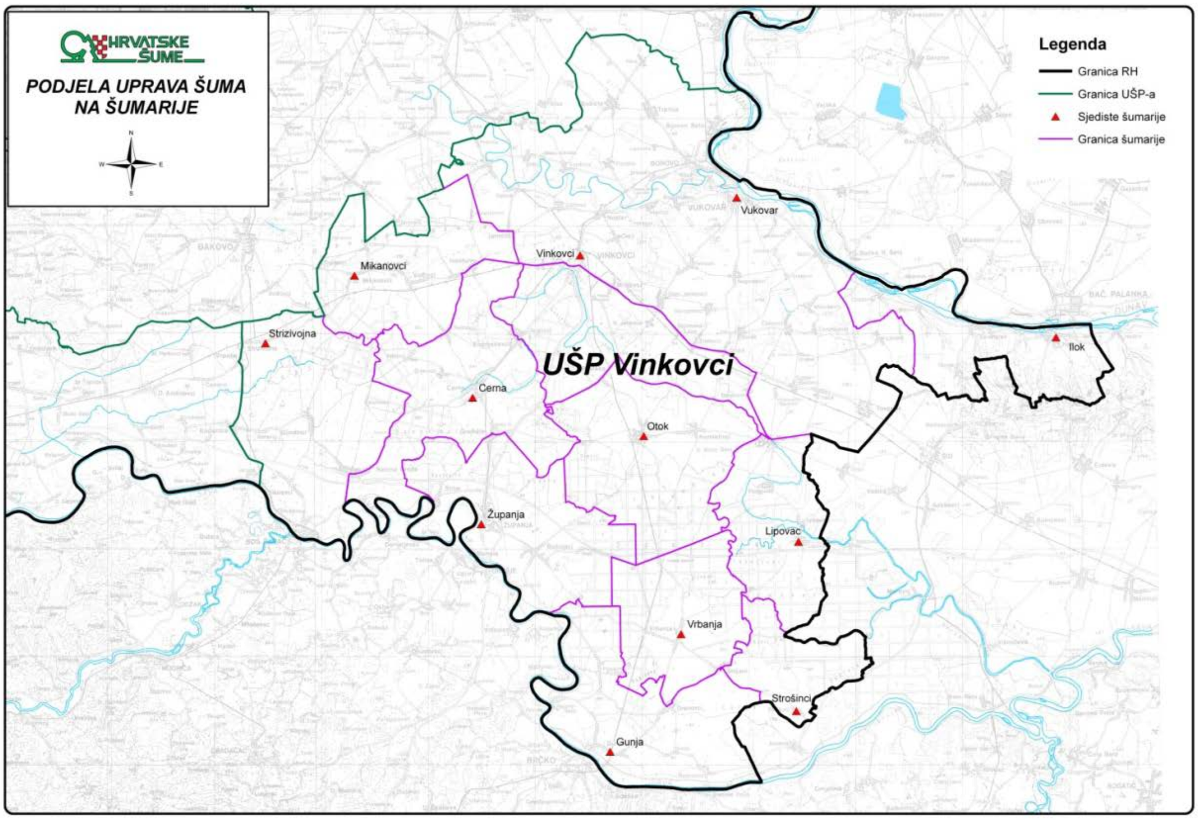


Figure 6.3-3: Area of a forest unit "Cerna" with the spatial division on related management units (example)

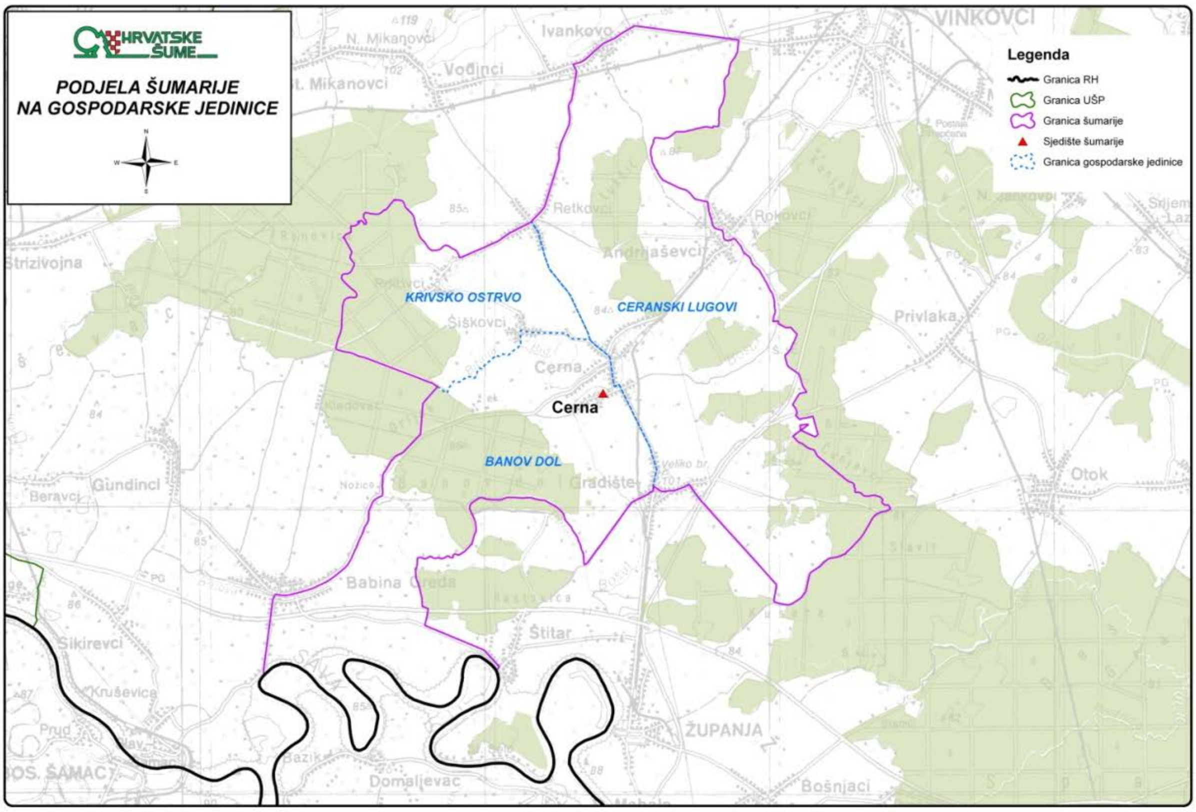


Figure 6.3-4: Area of a management unit "Krivsko ostrvo" divided into compartments (example)

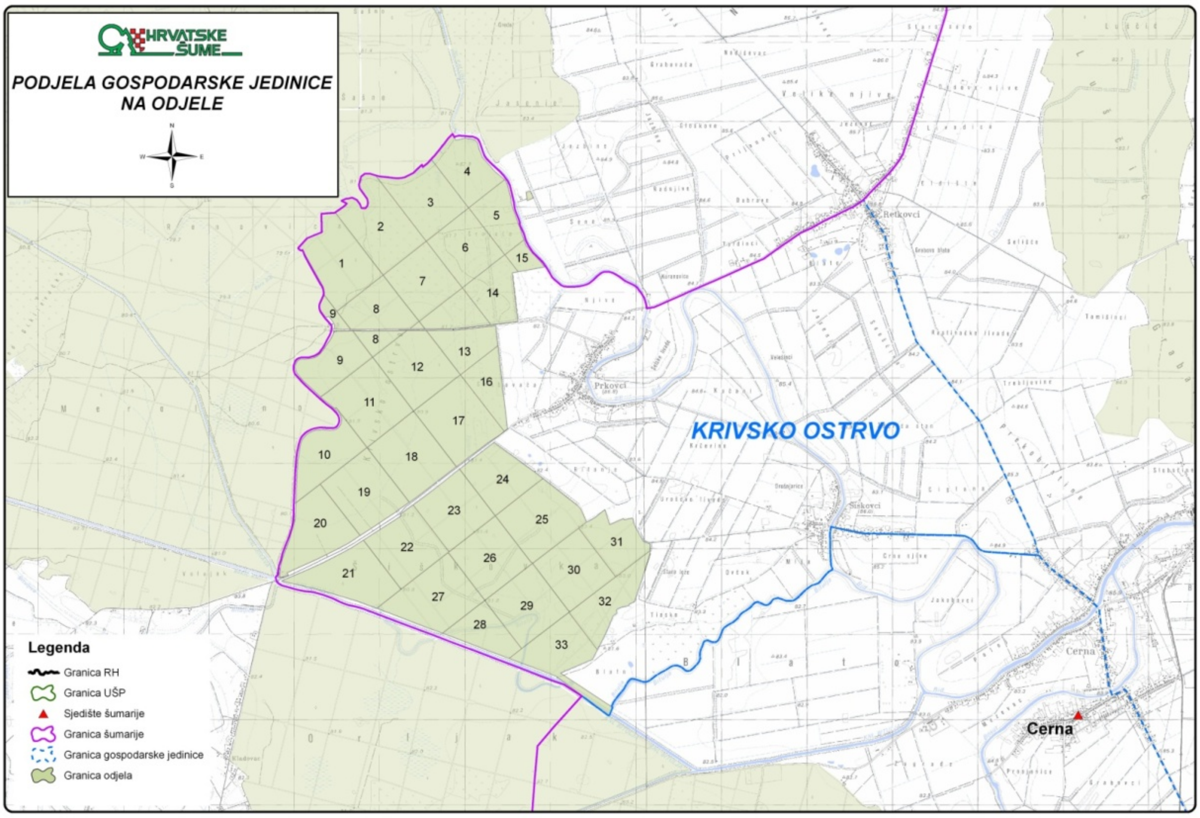
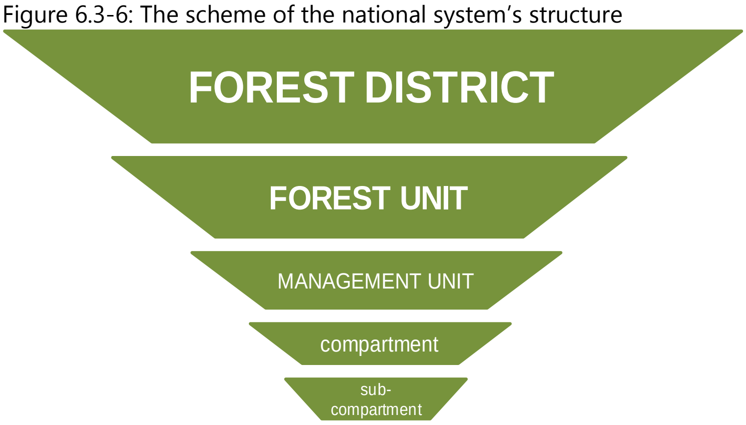


Figure 6.3-5: Compartment area divided into sub-compartments (example)

Short scheme of the system's structure is presented in Figure 6.3-6.

Figure 6.3-6: 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.

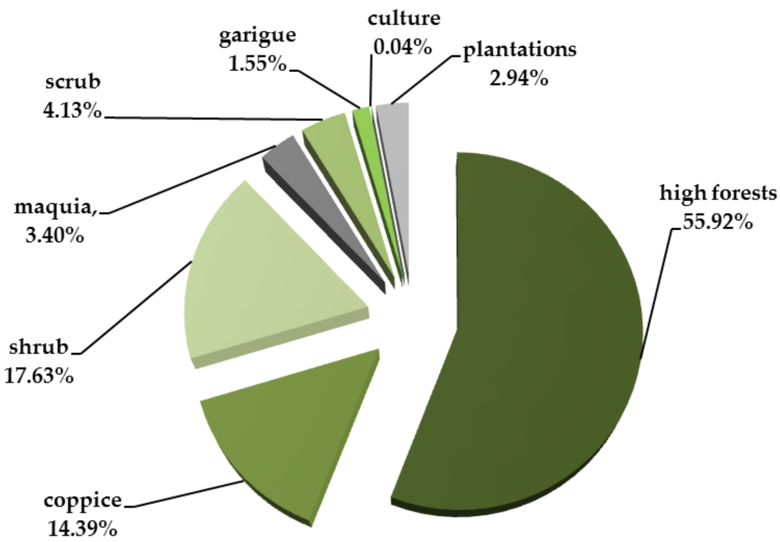
The following figures are based on data for 2016 provided in the Forest Management Area Plan for the period 2016-2025 (FMAP 2016-2025) and present forest area in Croatia as defined by Forest Act and Ordinance on Forest management.

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

- High forests
- Plantations
- Forest cultures
- Coppice
- Maquia
- Shrub
- Garigue
- Scrub.

The share of forest land with tree cover in the forest land with tree cover is shown in Figure 6.3-7.

Figure 6.3-7: The share of each forest stand in forest land with tree cover, year 2016



According to the Forest Act forests are classified in three categories:

- management forests (which made about 52 % of total forest area in 2016)

- protection forests (which made about 30 % of total forest area in 2016)
- forests with special purpose (which made about 18 % of total forest area in 2016).

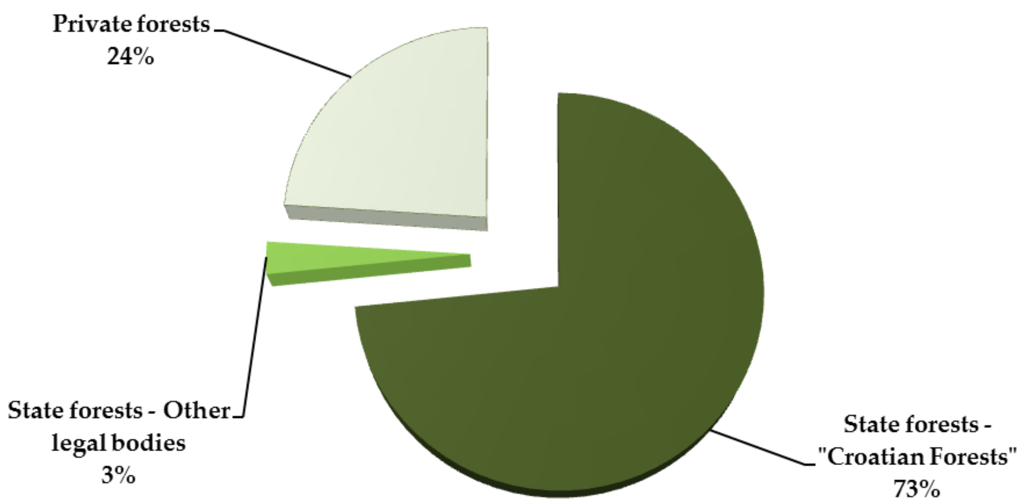
Based on the ownership, there are two types of forests in Croatia:

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 76% of total forest area, while the remaining 24% are privately owned (Figure 6.3-8).

Figure 6.3-8: The ownership structure of forest area in Croatia, year 2016



The area of forests is determined based on all available cadastral maps in various scales. However, while preparing the FMAP 2016-2025, 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 FMAP 2016-2025 determines total growing stock of about 418 mil. m^3 in 2016 (shares shown in Figure 6.3-9 and 6.3-10) 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 forest 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 performed using the expert judgement on increment in these forests.

Figure 6.3-9: The share of growing stock in state and private forests, year 2016

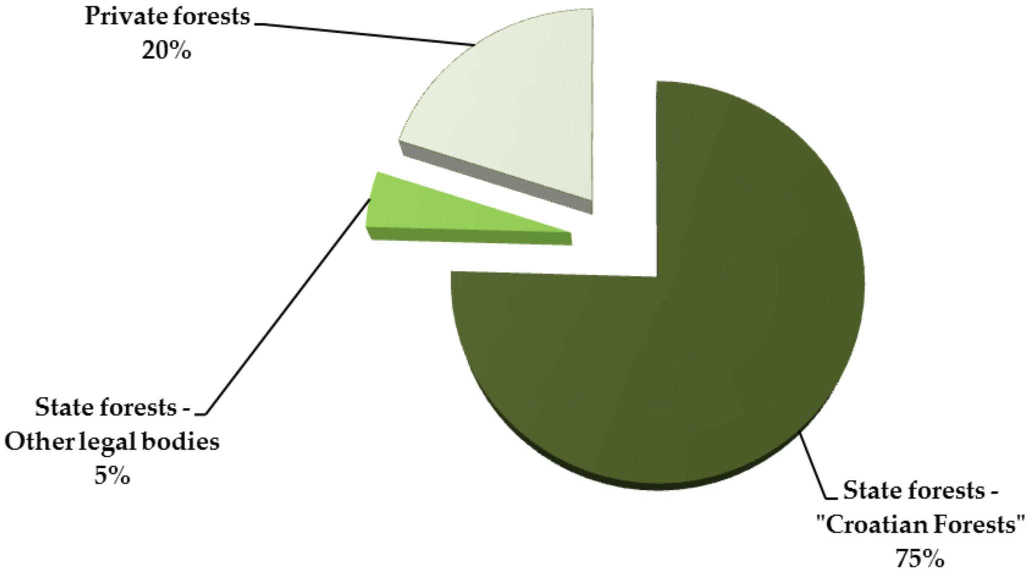
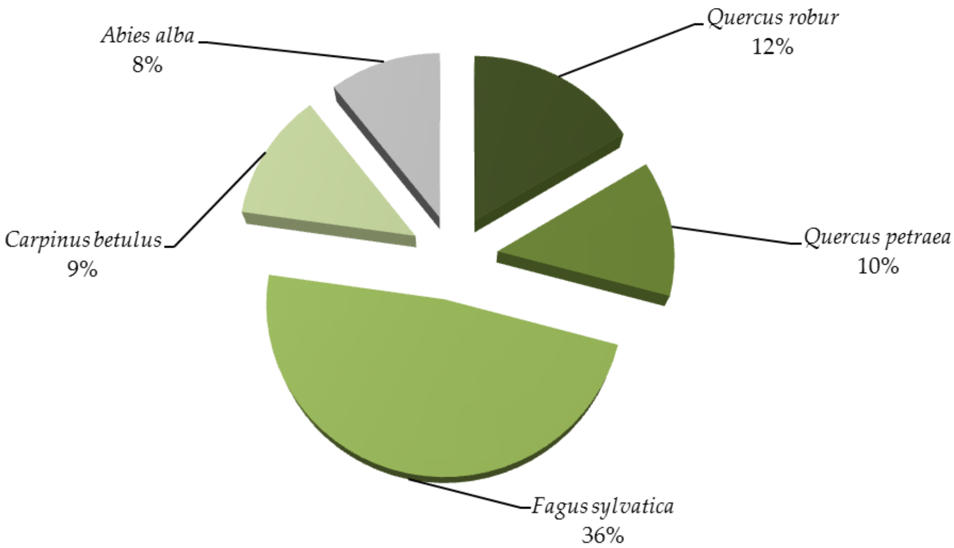


Figure 6.3-10: Share of main species in total growing stock, year 2016



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:

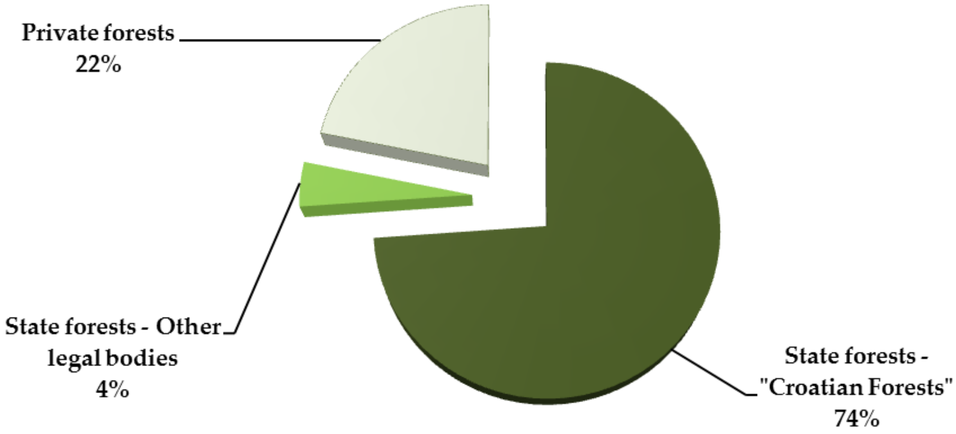
- Extracting the sub-compartment at 143,000 ha
- Measurements of breast diameters at 69,000 sample plots of the 5% sample trees
- Measurements of breast diameters at 25,000 sample plots of the 2% sample trees
- Measurements of breast diameters of all trees at 6,000 ha
- Measurements of 123,000 tree heights
- Taking 43,000 bores.

Based on the legislation[13], 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 6.3-11.

[13] Ordinance on Forest Management

Figure 6.3-11: The share of increment in state and private forests, year 2016



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).

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, 2006 and 2012) 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, 2006 and 2012. 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, CLC change 2000-2006 and CLC change 2006-2012[14]. For the purposes of this reporting Croatian Agency for Environment and Nature develped special CLC

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

change database that refers to the period 1990-2006. This database has been used for the first time for determing the conversions between land use categoris and this year reporting.

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 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 before 1990 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.

These CBS data are used to define the total Cropland area in Croatia in period 1990-2016. From the total area, areas that belong to perennial and annual cropland are defined. For this purpose CBS data on shares between annual and Perennial Croplands are used. Final tuning in the total cropland area was performed subtracting the difference of areas that are converted to and from cropanld area in corresponding years.

When analysing CBS data for the puproses of this reporting the significant changes in cropland and grassland area in the period after 2000 was notice. It was 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.

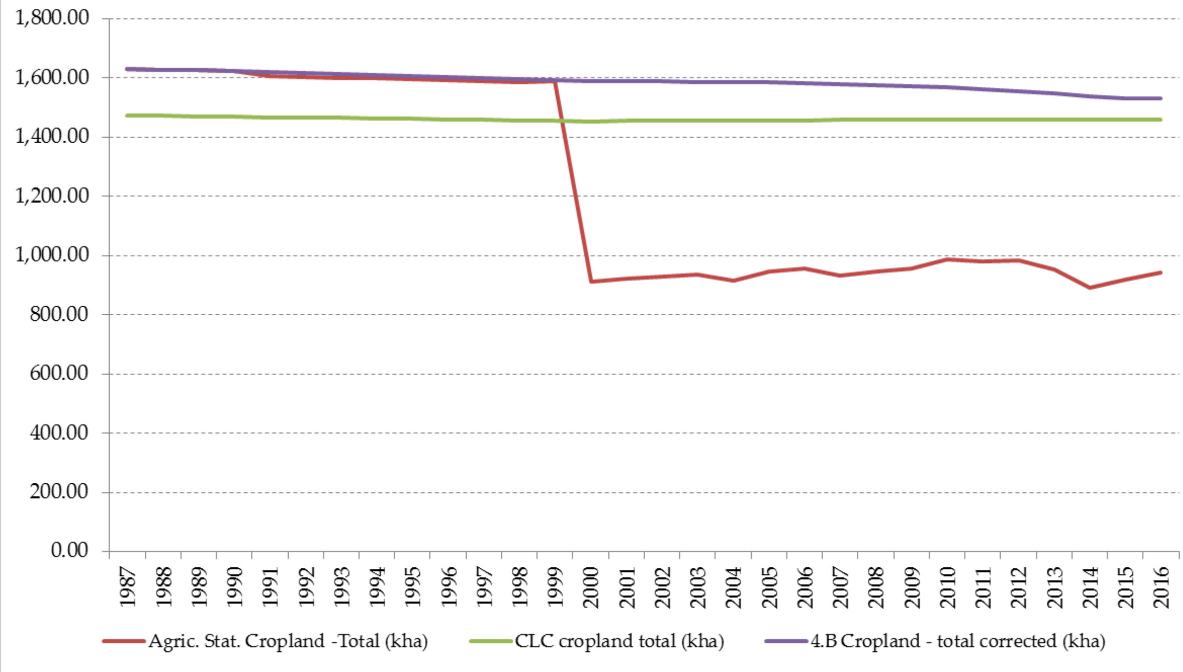
The main purpose of this revision was the methodological harmonisation of data and methods of estimating data for the mentioned period. The methodology is fully harmonised with the EUROSTAT recommendations''[15].

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 adjustment of area data after year 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 below.

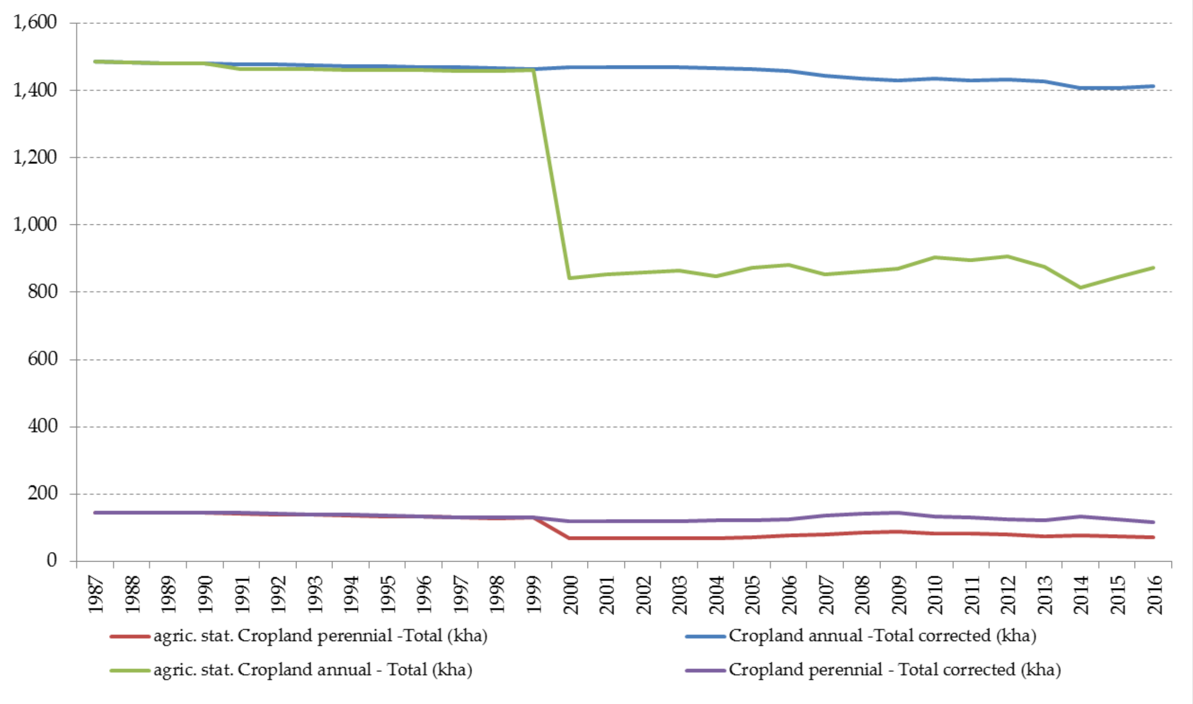
[15] Statistical Yearbook of the Republic of Croatia 2012. See list of References

Figure 6.3-13: 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 6.3-14: 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, 1990-2006 and 2006-2012). For the years after 2012 extrapolation of the CLC trend 2006-2012 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, 2006 and 2012) were reviewed. Significant changes were observed requiring data adjustments for the whole time series.

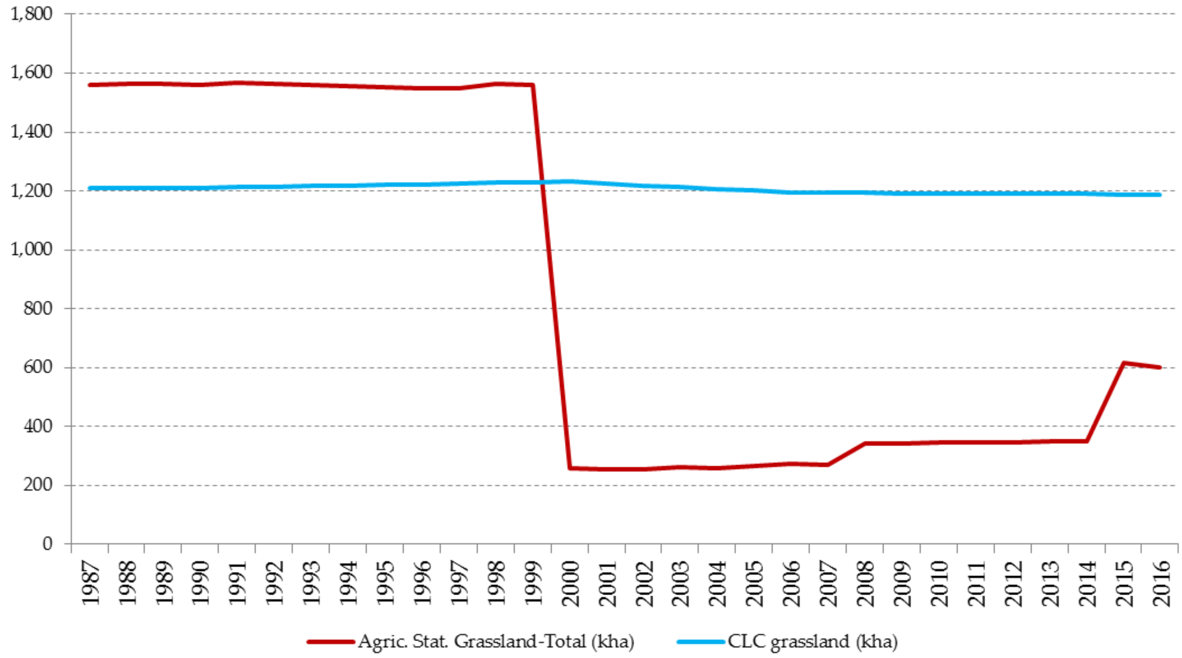
The complete examination of CBS data demonstrated its inadequateness related to the total area of Croatia. The adjustment of CBS data with CLC data for the time series since 2000 had the same results, leading to the exceedance of the total area of Croatia. At the same time, self-standing CLC data fitted 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 6.3-15).

Figure 6.3-15: 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, 2006 and 2012. Linear interpolation of the CLC trend between these CLC assessment years was carried out. Extrapolation of the CLC trend 2006-2012 was applied for the years after 2012.

According to the CLC trends, the total grassland areas increased in the period 1990-2000 by 2.11 kha annually and had been continuously decreasing since the year 2001: in the period 2001-2006 by 6.11 kha annualy and in 2006-2016 by 0.72 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, 2006 and 2012) 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 was carried out using the data from CLC database changes 1980-1990, 1990-2006 and 2006-2012. For the years after 2012 extrapolation of the CLC trend 2006-2012 was applied.

According to CLC trends the wetland area increased 0.2k ha per year in the period 1980-2000, 0.02 kha per year in the period 2001-2006 and 0.01 kha per year in the period 2007-2016. 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, 2006 and 2012) 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 3.1 % 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 2.3%. 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 and it 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, 2006 and 2012 was done using the correction factor which is estimated to be:

$$((1/(1-0.45+0.023))-(0.031 \times 0.45 \times \text{total area of Croatia})$$

This correction factor is multiplied with the CLC settlement area to estimate the adjusted settlement area. The term 1/(1-0.45+0.023)) expands the settlement area for traffic lines (45 % of the settlement area are assumed to be traffic lines, of which only 2.3 % are covered by the CLC results and need to be added to avoid an overestimate). In a next step of this correction factor estimate -(0.031 x 0.45 x total area of Croatia) those 45% area share of traffic lines that fall within the detected CLC settlement areas (3.1 % 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 was carried out using the data from CLC database changes 1980-1990, 1990-2006 and 2006-2012. For the years after 2012. For the years after 2006 extrapolation of the CLC trend 2006-2012 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 specially designed CLC 1990-2006 database change and CLC 2006-2012 half of the settlements area increase on the basis of agricultural land comes from cropland and 70% 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, 2006 and 2012) 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 78.63 and 53.77 kha in the period 1990-2016, 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. 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 104.93 and 168.19 kha.

Table 6.9.-1 presents activity data for Other Land. As can be seen, there are annual decreases of the area of other land.

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. Inclusion of this category of land into the uncertainty estimate is planned as one of long-term improvements in Croatian LULUCF reporting.

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[16] 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.

Regarding the areas affected by forest fires, Croatia informs that cut volume on these areas has to be separately recorded as s called random yield and it referes to the partially burnt and harvested wood. After the conducted consultation with the forest experts, it was concluded that 60% of the biomass is fully burnt during the forest fires, while the remaining 40% is only partially burnt. It was assumed that 60% of areas correspond to 60% of wood (fully) burnt.

According to the Ordinance on forest management (OG 79/15) provisions, all areas subject of natural disturbances need to be remediated and prescribed forest activities have to be performed securing that forest area remain forest area. Consequently, this means that the partially burnt wood is a subject of regular forest works and salvage logging operations. This 40% of wood affected by fires are removed from the forest and reported as included in biomass loss sue t fellings (notation key: IE)[17].

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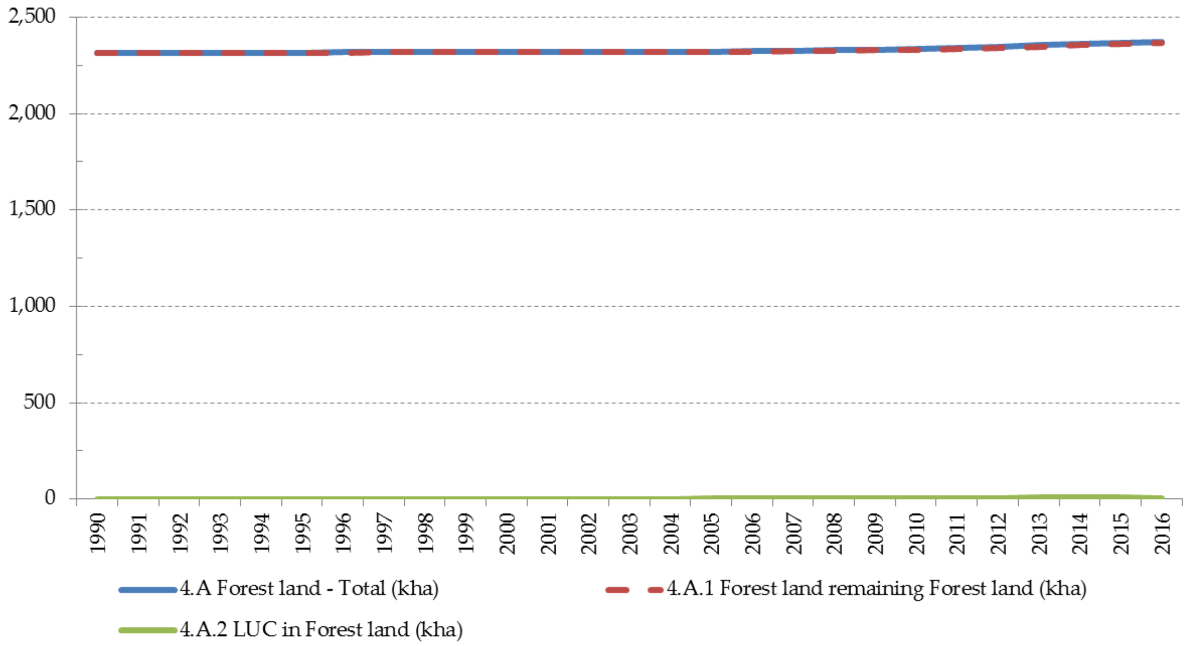
[16] Below ground biomass is combined with the above ground and thus the notation key IE is used for below ground biomass.

17 This is a reason for reporting emissions from only 60% of forest areas affected by forest fires for the necessity of determining the background and margin level in FM areas (more details in KP chapter 1.3.1.3).

Figure 6.4.-1: Trend of forest land and LUC to forest land in conversion period of 20 years (1990-2015) in kha*



* forest land area including forests out of yield

CO_2 removals from forest land remaining forest land in 2016 are -5,384 kt CO_2 and from Land converted to Forest land -231kt CO_2. Therefore, the share of removals from land conversion in total Forest land removals makes only 4.1%. 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	-6,733	-6,704	-28.74	0.00	-28.74	NO	NO	NO
1991	-8,522	-8,496	-25.64	0.00	-25.64	NO	NO	NO
1992	-8,905	-8,879	-26.21	0.00	-26.21	NO	NO	NO
1993	-9,218	-9,193	-25.00	0.00	-25.00	NO	NO	NO
1994	-9,040	-9,014	-26.18	0.00	-26.18	NO	NO	NO
1995	-9,507	-9,480	-26.97	0.00	-26.97	NO	NO	NO

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
1996	-9,331	-9,304	-26.91	0.00	-26.91	NO	NO	NO
1997	-8,757	-8,729	-28.48	0.00	-28.48	NO	NO	NO
1998	-8,753	-8,725	-28.09	0.00	-28.09	NO	NO	NO
1999	-8,863	-8,835	-28.06	0.00	-28.06	NO	NO	NO
2000	-8,618	-8,588	-29.99	0.00	-29.99	NO	NO	NO
2001	-8,617	-8,586	-30.39	0.00	-30.39	NO	NO	NO
2002	-8,724	-8,693	-30.68	0.00	-30.68	NO	NO	NO
2003	-8,458	-8,427	-31.72	0.00	-31.72	NO	NO	NO
2004	-8,259	-8,229	-30.05	0.83	-30.88	NO	NO	NO
2005	-8,316	-8,318	1.91	1.55	0.37	NO	NO	NO
2006	-8,173	-8,166	-6.75	1.21	-7.96	NO	NO	NO
2007	-7,691	-7,694	2.65	1.42	1.23	NO	NO	NO
2008	-7,733	-7,691	-41.86	0.41	-42.27	NO	NO	NO
2009	-7,887	-7,871	-15.83	0.78	-16.60	NO	NO	NO
2010	-7,666	-7,632	-33.96	0.56	-34.52	NO	NO	NO
2011	-6,757	-6,727	-30.78	-1.51	-29.28	NO	NO	NO
2012	-6,663	-6,584	-79.22	0.04	-79.27	NO	NO	NO
2013	-6,723	-6,644	-79.13	-1.16	-77.98	NO	NO	NO
2014	-6,413	-6,327	-85.61	0.74	-86.35	NO	NO	NO
2015	-5,539	-5,412	-127.10	5.11	-132.21	NO	NO	NO
2016	-5,615	-5,384	-231.01	-19.19	-211.82	NO	NO	NO

Table 6.4.-2: CO_2 emissions from wildfires

Year	Area burnt (ha)	CO_2 emission (kt)	CH_4 emission ($CO_{2\ eq}$ (kt))	N_2O emission ($CO_{2\ eq}$ (kt))
1990	482	8.99	0.04	0.00
1991	1,291	24.07	0.12	0.01
1992	5,864	109.30	0.55	0.03
1993	14,102	262.86	1.31	0.07
1994	4,591	85.58	0.43	0.02
1995	3,011	56.12	0.28	0.02
1996	6,494	121.04	0.60	0.03
1997	6,885	128.33	0.64	0.04
1998	17,093	318.61	1.59	0.09
1999	1,830	34.11	0.17	0.01
2000	37,364	696.45	3.48	0.19
2001	6,880	128.24	0.64	0.04
2002	2,414	44.99	0.22	0.01
2003	15,395	286.97	1.43	0.08
2004	839	15.64	0.08	0.00
2005	913	17.01	0.08	0.00
2006	2,322	43.28	0.22	0.01
2007	12,575	234.39	1.17	0.06
2008	3,643	67.90	0.34	0.02
2009	2,044	38.09	0.19	0.01
2010	688	12.82	0.06	0.00
2011	6,478	120.75	0.60	0.03
2012	15,270	284.63	1.42	0.08
2013	615	11.46	0.06	0.00
2014	79	1.47	0.01	0.00
2015	4,068	75.83	0.38	0.02
2016	2,829	52,73	0,26	0,01

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 1990-2015 and the main data source is the Forest Management Area Plan (FMAP 2016-2025). Data are divided based on the forest type upon which the related emission/removal calculation was performed using primarily Tier 1. Thus, estimation is performed for coniferous, deciduous and out of yield forests (maquies and shrub) and data are presented in CRF the same way. 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:

$\Delta C_{FFLB} = \Delta CFFG_j - \Delta CFFL_j$

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}

$\Delta CFFG_j$ = annual increase in carbon stocks due to biomass growth

$\Delta CFFL_j$ = annual decrease in carbon stocks due to biomass loss,

Where j =

1 - broadlevaed

2 - coniferous

3 –maquies and shrub

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

Following recommendation given by ERT during the in county review 2012 Croatia decided to apply same approach to calculate carbon gains in increments for all forests regardless the ownership structure. For this reporting purposes, 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 forest areas in Croatia regardless the ownership type.

Since the War period, in Croatia there is an active process of returning previously confiscated forests to private owners[18] which makes difficult to follow difference in area based on ownership structure which

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

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.

Croatia uses national values for wood densities for coniferous, deciduous and maquies and shrub 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 (see chapter 6.4.1).

Data used in the CO_2 emission/removal calculation are presented in Table 6.4-3.

Table 6.4-3: Data used in the CO_2 emission/removal calculation

	tonnes d.m.m^{-3}	dimensionless	dimensionless	dimensionless	(tonnes d.m.)$^{-1}$
	D	BEF1	R/S	BEF2	CF
Deciduous	0.56	1.20	0.23	1.197	0.48
Coniferous	0.39	1.15	0.29	1.0387	0.51
Out of Yield (maquies and shrub)	0.68	1.1	0.46	1.15	0.47

According to the harvest practices applied in Croatia, in period of last five reporting years 14.5% of harvested volume is left on the site in case of deciduous forests and 20.1% in case of coniferous forests. Amount of total volumes harvested in these of type of forests were corrected with corresponding percentages.

Based on the wood density values available through the nationally conducted scientific investigations[19] and share of species in total growing stock in Croatia[20], it is estimated that wood density in deciduous species is 0.558 t d.m/ha and 0.395 t d.m/ha in case of coniferous species. For these estimations, wood densities of absolute dry wood per fresh volume (m_o/VWET) were used except in case of common hornbeam wood density where value for wood density in absolute dry were used and corrected by the shrinkage factor of 17.1% [21].

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[22]. 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.

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

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

[21] Scientific paper of Sinković, Govorčin and Sedlar. See list of References

[22] Scientific paper of Horvat. See list of References

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[23] 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[24].

The detailed overview of the approach is shown below:

$$\Delta C_B = \Delta C_G - \Delta C_L$$

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

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, $m^3 ha^{-1} yr^{-1}$
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	=	$L_{wood-removals} + L_{fuelwood} + L_{disturbance}$

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

$L_{wood-removals}$ = Σ H x BEF_2 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
A	=	area of land remaining in the same land-use category, ha
H	=	annual wood removal, roundwood, m^3/ha
BEF_2	=	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 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 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 1st January 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 2006

IPCC Guidelines: 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[25] as one of outcomes of the project. Detailed description of conducted work is presented in KP Chapter.

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

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

In case of afforestation in private forests generated through planting and seeding measures, analyses conducted through LULUCF 1 project proved that in period 1990-2012 in private forests no afforestation has occurred through planting and seeding measures. This was expected outcome, since according to the Ordinance[26] 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*[27], 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

[25] Janes *et al.* (2014), Separation of areas under the Article 3.3 and 3.4 of the Kyoto protocol. See list of References

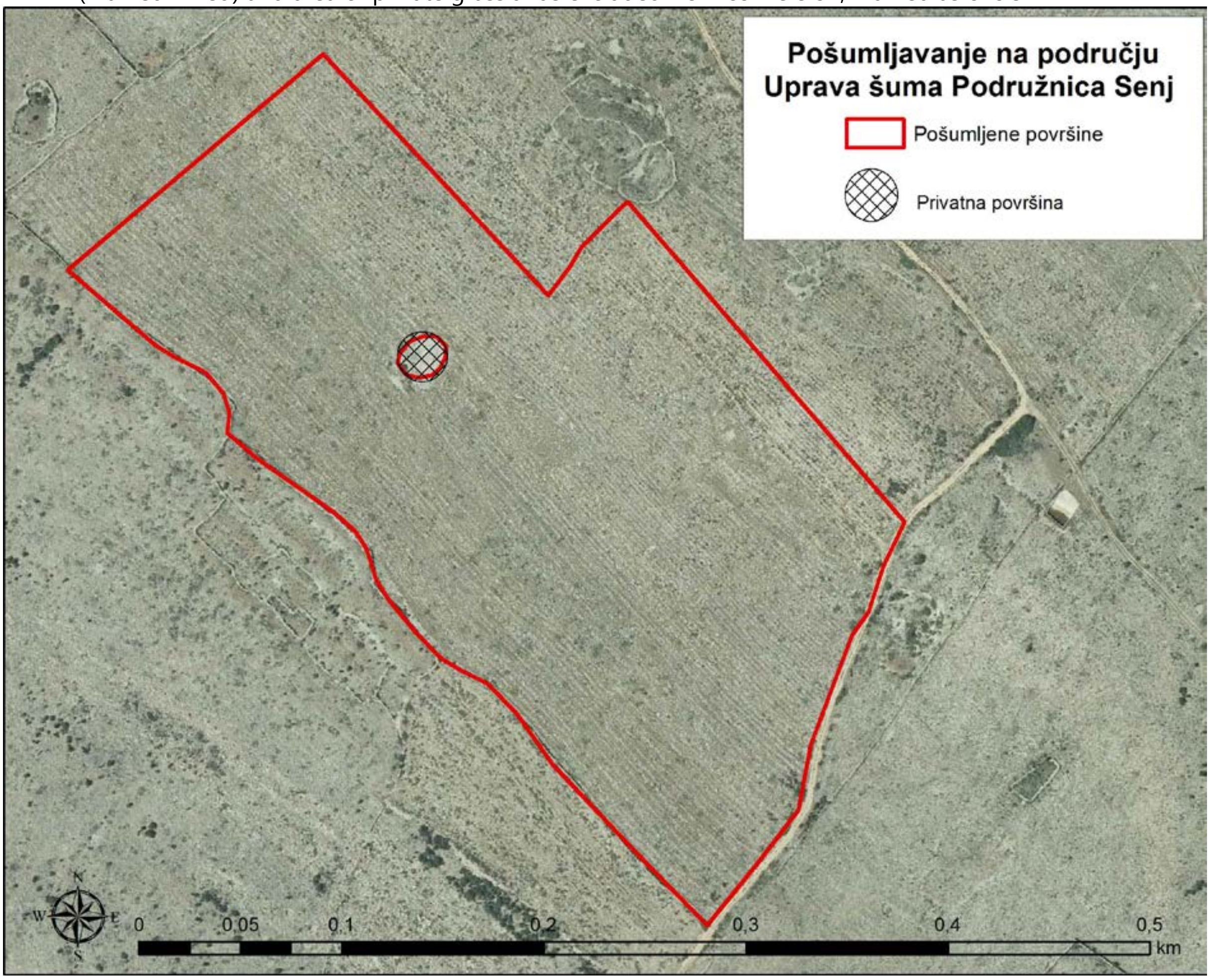
[26] Regulations on the procedure for granting funds from fees for the use of beneficial functions of forests for work performed in private forests (OG 66/06, 25/11). See list of References.

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

economically less valid, it is understandable that afforestation in private forests in karst region on land that has not been forested for a period of at least 50 years did not occur.

Through the conducted survey detailed data and information about conversion to forest land category through seeding and planting measures were collected and areas of conversion are well know (Figure 6.4-2)

Figure 6.4.-2: State owned area of land under the forests management (grassland) converted to Forest land (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, especially for the identification and traceability of lands that are converted to/from forest land.

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	-	-	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
2014	388.76	38.16	7,920.78
2015	559.21	54.89	5,765.62
2016	-	-	1,427.48

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 2018, 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.

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 (referring to period 1990-2012) 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. The same is valid for years 2013–2016.
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. These shares are applied for period 2013–2016.
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. This is valid also for period 2013–2016.

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 IPCC 2006 Guidelines were used (0.4 (for coniferous in age class ≤ 20 years), 0.29 (for coniferous in age class ≥ 20 years), 0.46 (for deciduous) in both age classes). Regarding the maquies and shrub forests the expert judgement was applied when deciding to use the value of 0.46 from IPCC 2006 Guidelines.

5) Applied Carbon fraction values were the same used in the estimation of carbon stock change: 0.51 tC/ t dm for coniferous, 0.48 tC/ t dm for deciduous and 0.47 tC/ t dm for maquie and shrubs.

Based on the above mentioned factors, average biomass growth was calculated to be 2.14 tC/ha annually in case of coniferous forests in age class ≤ 20 years and 1.97 tC/ha in age class ≥ 20 years. Value of 2.8 tC/ha was used s average biomass growth for deciduous. Average biomass growth was calculated to be 0.34 tC/ha for maquies and shrub forests.

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 and Litter pool

The soil data collected through the scientific investigation performed in 2017 (Chapter 6.5.2.1) were analyzed and the mean values determined for each land use category are taken into calculation.

The estimation was performed using the national value of 9 for C/N ratio in case of Grassland mineral soils that are converted to Forestland.

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 0-30 cm determined through the national scientific soil survey conducted in 2017were used in order to present the carbon stock changes in soil (see chapter 6.5.2.1). The results of national survey and determined mean values of carbon stock changes in soil are:

- Cropland (annual): 52.71 t C/ha
- Cropland (perennial): 71.01 t C/ha
- Forest land: 69.86 t C/ha
- Grassland: 75.75 t C/ha
- Settlements: 86.91 t C/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.

For this year submission data used from the scientific investigation on determining carbon stock in soil and litter pool are used (Chapter 6.5.2.1).

Annual carbon stock changes in litter at lands converted to and from forests are calculated as follows:

Δ C LT = A* (CLTo – CLTo-t)/T

Δ C LT = average annual carbon stock change in litter (t C/a)

A = annual D area, respectively the AR area following a transition period of 20 years.

CLTo = carbon stock in litter after conversion, (4,57 t C/ha in case of land converted to FL and 0,00 in case of land converted from FL)

CLTo-t = carbon stock in litter before conversion, (0,0 t C/ha in case of land converted to FL and 4,57 tC/ha in case of land converted from FL)

T = transition period for the litter carbon stock changes (1 year for D areas, 20 years for AR areas)

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

Gg C					
Year	Biomass carbon stocks gains	Biomass carbon stocks losses	Biomass net carbon stock change	Net soil carbon stock change	Total
1990	8.073	0.000	8.073	-1.044	7.029
1991	8.145	-0.916	7.229	-1.052	6.177
1992	8.082	-0.698	7.383	-1.045	6.338
1993	8.340	-1.280	7.060	-1.077	5.983
1994	8.498	-1.111	7.387	-1.099	6.288
1995	8.599	-0.995	7.605	-1.112	6.493
1996	8.831	-1.235	7.596	-1.142	6.454
1997	8.867	-0.843	8.024	-1.144	6.88
1998	9.040	-1.118	7.922	-1.166	6.756
1999	9.349	-1.425	7.925	-1.209	6.716
2000	9.502	-1.047	8.455	-1.226	7.229
2001	9.657	-1.090	8.567	-1.246	7.321
2002	9.939	-1.286	8.653	-1.279	7.374
2003	10.164	-1.221	8.944	-1.308	7.636
2004	11.492	-3.007	8.484	-1.410	7.074
2005	13.366	-13.474	-0.109	-2.187	-2.296
2006	15.113	-12.750	2.363	-2.910	-0.547
2007	17.516	-17.554	-0.039	-3.934	-3.973

Gg C					
Year	Biomass carbon stocks gains	Biomass carbon stocks losses	Biomass net carbon stock change	Net soil carbon stock change	Total
2008	20.538	-8.420	12.118	-4.329	7.789
2009	25.078	-19.909	5.169	-5.454	-0.285
2010	31.971	-21.715	10.256	-6.694	3.562
2011	36.498	-26.874	9.624	-8.261	1.363
2012	46.196	-23.326	22.870	-9.408	13.462
2013	55.737	-32.788	22.949	-11.075	11.874
2014	63.418	-38.626	24.792	-13.000	11.792
2015	67.247	-31.391	35.856	-14.153	21.703
2016	70.402	-6.131	64.272	-14.489	49.783

6.4.3. Uncertainties and time-series consistency

For the purpose of defining uncertainties in LULUCF sector in Croatia, special questionnaire was developed in 2013 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

Inputs	Uncertainty	Source of information
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
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

Inputs	Uncertainty	Source of information
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 10,000. 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.

According to the uncertainty estimate performed in LULUCF sector in 2016, the relative combined uncertainty of CO_2 equivalent emission/removal ranges between -53.40% and 194.63% in Forest land remaining forest land 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 -225.23% and 182.21%.

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

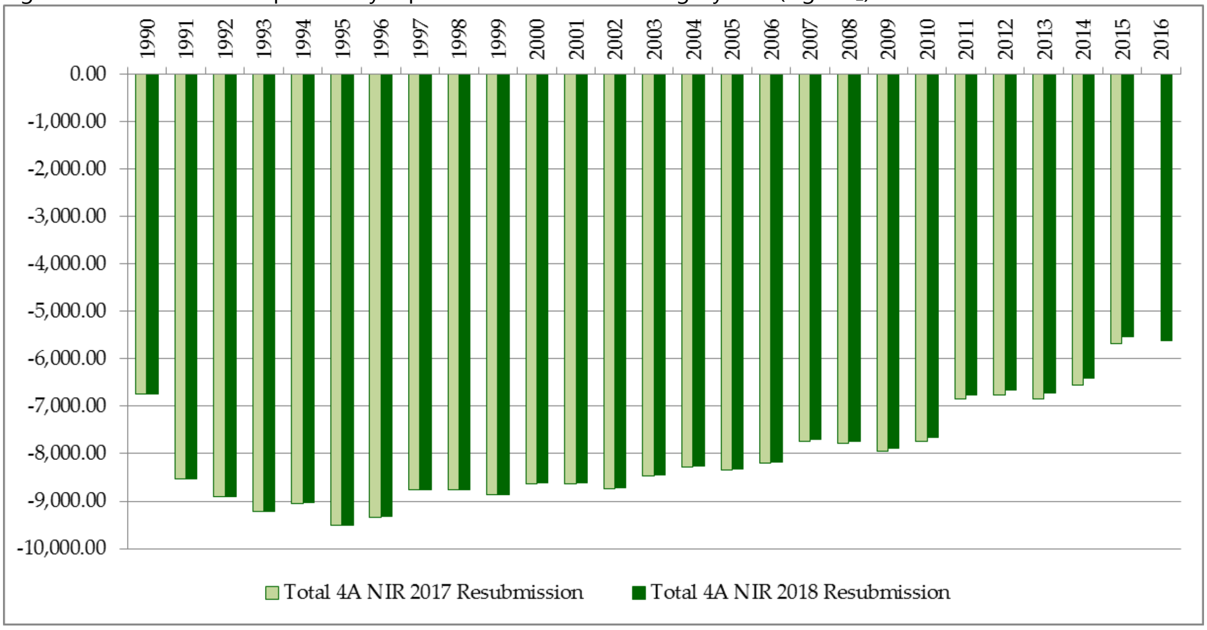
During the preparation of inventory, experts from all relevant fields were included. All input data were checked by the experts. The definitions, factors and methods applied in the report were agreed with the experts in relevant fields, ensuring in that way consistency and completeness of input data. 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

Since the last submission, the emission estimates were recalculated for the entire category and reporting period. The main reson for this was use of data for soil carbon content that are result of newly conducted scientific investigation. In addition, the recalculations are performed for year 2015 because of mistake done when connecting two cells in Excel sheet for total forest area.

The result of the performed recalculation can be seen in Figure 6.4-3. On average, removals decreased by 0.49 % compared to the previously reported estimates

Figure 6.4-3: Current and previously reported emissions for category 4.A (Gg CO_2)



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) still does not have the 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 data coming from the forest management plans. 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.

It has been envisiged that two consecutive CRONFIs should be conducted before the all data collected through this process are used for the UNFCCC reporting purposes. Before that, only specific data collected through the first CRONFI could be used for the improvements in Croatian LULUCF reporting (i.e. data relevant for the estimation in dead wood pool).

6.5. Cropland (CRF category 4.b)

6.5.1. Description

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

Cropland area ranged from 1,530.52 kha to 1,625.17 kha in the period 1990-2016. Total emissions from cropland category ranged from 48.06 Gg CO_{2eq} to 342.28 Gg CO_{2eq} to for same period.

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 1990-2016.

Table 6.5-1: Activity Data of Cropland from 1990 to 2016 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 perenial 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.a Grassland converted to annual cropland	4.B.2.b Grassland converted to perennial cropland
1990	1,625.17	1,624.83	1,480.17	144.59	0.02	0.04	0.35	0.33	0.02
1991	1,621.60	1,621.50	1,477.85	143.62	0.02	0.02	0.10	0.10	0.00
1992	1,618.09	1,617.98	1,476.27	141.68	0.02	0.02	0.10	0.10	0.00
1993	1,614.43	1,614.33	1,474.56	139.73	0.02	0.02	0.10	0.10	0.00
1994	1,610.88	1,610.77	1,472.94	137.79	0.02	0.02	0.10	0.10	0.00
1995	1,607.29	1,607.19	1,471.30	135.85	0.02	0.02	0.10	0.10	0.00
1996	1,603.65	1,603.54	1,469.60	133.91	0.02	0.02	0.10	0.10	0.00
1997	1,600.17	1,600.07	1,468.05	131.98	0.02	0.02	0.10	0.10	0.00
1998	1,596.66	1,596.56	1,466.47	130.05	0.02	0.02	0.10	0.10	0.00
1999	1,593.01	1,592.90	1,463.24	129.62	0.02	0.02	0.10	0.10	0.00
2000	1,589.57	1,589.47	1,589.45	120.18	0.02	0.02	0.10	0.10	0.00
2001	1,588.96	1,587.78	1,587.87	118.46	0.00	0.00	1.18	1.09	0.09
2002	1,588.31	1,587.13	1,587.21	119.24	0.00	0.00	1.18	1.09	0.09
2003	1,587.62	1,586.44	1,586.52	119.10	0.00	0.00	1.18	1.09	0.09

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 perenial 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
2004	1,587.00	1,585.78	1,585.91	121.34	0.00	0.00	1.22	1.09	0.09
2005	1,585.55	1,584.34	1,584.46	121.57	0.00	0.00	1.21	1.09	0.09
2006	1,582.84	1,581.63	1,581.75	125.77	0.00	0.00	1.21	1.09	0.09
2007	1,578.57	1,578.10	1,578.35	134.87	0.02	0.02	0.46	0.20	0.12
2008	1,576.60	1,576.15	1,576.38	140.71	0.02	0.02	0.45	0.20	0.12
2009	1,572.21	1,571.41	1,571.99	143.00	0.02	0.02	0.80	0.20	0.12
2010	1,567.21	1,566.73	1,566.99	132.12	0.02	0.02	0.49	0.20	0.12
2011	1,560.82	1,560.33	1,560.60	131.67	0.02	0.02	0.48	0.20	0.12
2012	1,555.49	1,555.07	1,555.27	124.03	0.02	0.02	0.42	0.20	0.12
2013	1,547.98	1,547.59	1,547.76	122.14	0.02	0.02	0.39	0.20	0.12
2014	1,539.13	1,538.79	1,538.91	132.88	0.02	0.02	0.34	0.20	0.12
2015	1,532.45	1,531.96	1,532.23	124.95	0.02	0.02	0.49	0.20	0.12
2016	1,530.52	1,530.18	1,530.30	116.13	0.02	0.02	0.33	0.20	0.12

Table 6.5-2: Emissions (+) / removals (-) of CO_2 in Cropland from 1990 to 2016 (Gg 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	N_2O in CO_2 eq
1990	223.99	196.90	27.09	0.00	23.13	NO	NO	NO	3.95
1991	210.98	184.02	26.96	0.00	23.15	NO	NO	NO	3.82
1992	218.25	192.24	26.01	0.00	22.33	NO	NO	NO	3.68
1993	206.34	181.29	25.05	0.00	21.51	NO	NO	NO	3.54
1994	222.30	198.20	24.10	0.00	20.69	NO	NO	NO	3.40
1995	227.91	204.77	23.14	0.00	19.87	NO	NO	NO	3.27
1996	225.24	203.06	22.19	0.00	19.06	NO	NO	NO	3.13
1997	242.59	221.36	21.23	0.00	18.24	NO	NO	NO	2.99
1998	255.65	235.37	20.27	0.00	17.42	NO	NO	NO	2.86
1999	247.22	227.90	19.32	0.00	16.60	NO	NO	NO	2.72
2000	322.25	303.89	18.36	0.00	15.78	NO	NO	NO	2.58
2001	342.28	324.31	17.97	0.00	14.92	NO	NO	NO	3.05

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	N_2O in CO_2 eq
2002	326.28	305.05	21.23	0.00	17.71	NO	NO	NO	3.52
2003	314.83	290.34	24.49	0.00	20.50	NO	NO	NO	3.99
2004	303.58	274.32	29.26	1.51	23.29	NO	NO	NO	4.46
2005	279.10	247.35	31.75	0.74	26.08	NO	NO	NO	4.92
2006	224.53	189.84	34.69	0.43	28.87	NO	NO	NO	5.39
2007	150.56	105.00	45.56	7.61	32.63	NO	NO	NO	5.33
2008	149.81	110.32	39.48	2.76	31.47	NO	NO	NO	5.27
2009	94.64	44.70	49.94	14.45	30.31	NO	NO	NO	5.20
2010	160.19	126.65	33.54	-0.72	29.15	NO	NO	NO	5.14
2011	136.96	102.84	34.12	0.13	28.80	NO	NO	NO	5.21
2012	210.33	181.81	28.52	-5.19	28.46	NO	NO	NO	5.29
2013	176.69	148.08	28.61	-4.83	28.11	NO	NO	NO	5.36
2014	48.06	25.04	23.02	-10.15	27.77	NO	NO	NO	5.44
2015	160.83	120.51	40.31	7.42	27.42	NO	NO	NO	5.51
2016	312.26	288.88	23.37	-9.25	27.08	NO	NO	NO	5.59

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:

1. annual remaining annual and perennial remaining perennial cropland
2. annual cropland converted to perennial cropland
3. perennial cropland converted to annual cropland.

The soil and biomass gains/or losses of annual cropland due to land use changes to/from annual cropland were presented in this report according to the Guidelines' foreseen method for land use changes within the cropland category. This approach was applied following the fact that annual cropland has a completely different carbon stock and accumulation rate comparing to perennial cropland and following the examples of some other countries (Austria, Bulgaria, Luxemburg[28]) in presenting carbon stock changes in this land use category.

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

A) Biomass

Since the biomass of annual cropland is harvested annually, there is no long term carbon storage, thus changes in carbon stocks in biomass are not considered in 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. Following this method, the perennial cropland accumulates biomass over the first 30 years of growing, and 3.33% of perennial crops are removed annualy resulting in the emissions.

The following IPCC Tier 1 equation was used for calculating carbon stock change of living biomass on perennial cropland remaining perennial cropland:

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

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

The IPCC default value of 63 tC/ha annually was used for the aboveground biomass carbon stock at harvest.

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 including partly country specific emission factors (EFs) and equation below were used:

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

where:

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

ΔC_{Growth} = Carbon accumulation rate of perennial cropland = 2.1 tC/ 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 tC/ha (IPCC default value)

The county specific average biomass stock in annual cropland was used for annual cropland biomass losses in the year of LUC from annual to perennial cropland. The source of information for the annual cropland aboveground biomass was CBS Statistical Yearbooks ie. 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 weight of dry matter 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[29]), as well as expansion factors from the Austrian Expert

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

Panel for Soil Fertility[30]. The related biomass of strew, leaves or other aboveground plants parts have been determined using the expansion factor from Austria also.

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

The weighted mean value of the total biomass per ha was calculated for each year in period 2000-2010 on the basis of yields of individual crops and the corresponding areas in Croatia. These results were a basos for determining the average annual carbon stock in annual cropland biomass for Croatia (5.67 tC/ha).

The IPCC Guidelines Tier 1 method for LUCs with partly country specific EFs and below presented equation were used to calculate the annual change in carbon stock of living biomass of perennial cropland converted to annual cropland:

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

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 according to the Guidelines.

The area of Cropland Remaining Cropland in 2015 was 1,595.32kha.

B) Soil

In order to perform carbon stock chaneg estimation in soil pool for all categories of land in LULUCF sector, Croatia firstly used results of the scientific research program named “Geological Maps of Croatia”. In this investigation wet combustion method was used. Soils samples were taken on depth of 20 cm in such a way that the whole humus layer was included. The contribution of rock fragments to the soil’s total carbon content was not considered. Results of this investigation was used for NIR 2012. Since the method used for carbon stock determination was not in line with the IPCC Guidelines, in 2013 new investigation was performed. In the new investigation, the dry combustion method was applied[31]. The representative number of samples were defined and the soil samples were taken on the points from the above mention research program. The samples were taken on the depth of 30 cm, but includeing the whole humus layer (litter). Results of this work were used for the Croatian reporting in 2013-2017. For this year reporting, in 2017 CAEN initated a new scientific investigation on soil carbon content in LULUCF

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

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

categories of land[32]. Representative number of plots from the program "Geological Maps of Croatia" were revisited and samples were taken on 30 cm depth, separating the humus layer from the rest of soil sample. In addition as part of this work C:N ratio was defined for different categories of land. By this way, Croatia collected and determined carbon stock in soil pool for each LULUCF land category and for litter pool in Forest land. Following the IPCC Guidelines (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

$\Delta SOC = (SOC_0 – SOC_{0-T})/20$ =0.95 tC/ha annually

where:

ΔSOC = annual change in carbon stock soil

SOC_0 = Croatian soil organic carbon stock in the inventory year = 71.01 tC/ha for perennial cropland

SOC_{0-T} = Croatian soil organic carbon stock *T* years prior to the inventory = 52.71 tC/ha for annual cropland

T = Assessment period (20 years)

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.

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

National value for C/N ratio (9) was used for the estimation in case of Grassland mineral soils that are converted to Cropland.

Organic Soils

Since NIR 2016 submission, based on the recommendation given by ERT, Croatia has been separately reporting on 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 year 2016 in case of annual cropland was 2.23 kha and 0.23 kha in case of perennial cropland and with emissions of 22.32 and 2.27 $GgCO_2$ 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:

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[32] Work performed by Croatian Geological Institute, Croatian forest Institut Jastrebarsko and Agency for Agricultural land . See list of References ("SOC stock changes, total nitrogen and total organic carbon trends, C:N ratio")

$\Delta C_{CC\ Organic}$ = 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 1990-2016. 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:

- 2.10 tC/ha – for biomass growth in perennial cropland (default, IPCC)
- 5.67 tC/ha – for biomass growh in annual cropland (default, IPCC).

Next nationally determined values were used for the purposes of calculating losses due to conversion from forest land:

- 56.1 tC/ha when calculating losses due to conversion of deciduous forests to perennial Cropland (including below-ground biomass),
- 7.6 tC/ha when calculating losses due to conversion of maquies and shrub forests to perennial Cropland (including below-ground biomass).

The source for the maquies and shrub forests conversion factor is the main data provider in forest sector (Croatian forests Ltd) which records data on harvest on deforested areas as a part of its obligation defined by the national legislation.

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: 71.01 tC/ha
- forest land: 69.86 tC/ha

Soil removal factor determined in this case is 0.058 tC/ha annually.

In case of Forest land that is converted to Cropland, Croatia currently cannot perform estimation of carbon stock changes in dead wood pool since the lack of the data on national level. However, new project regarding the determination on carbon stock in dead wood pool in deforested areas in Croatia was intiated, and these results will be used for next report.

Estimation of crbon stock changes in litter pool was conducted for the fitrst time in this year reporting, using the equation and carbon stock in litter pool (Chapter 6.4.2.2.) determined on national level in above mention scientific investigation.

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, 0.20 kha of grassland area were converted to cropland in 2016. The changes of carbon stocks during the conversion from one category to another vary from year to year. In 1990 LUC in this category resulted in emissions of 23.13 kt CO_2 and in 2016 in emissions of 27.08 kt CO_2.

In case of Grassland category that is converted to Cropland, Croatia uses Tier 1 assumption that DOM pools in non-forest land categories after the conversion is zero.

A) Changes in Carbon Stocks in Biomass

National data were used for the calculation of carbon stock in living biomass of grassland. The source of information for the grasslands' aboveground biomass was the CBS Statistical Yearbooks ie. data for hay yield. The mean value of hay biomass was calculated (2.5 t dm/ha annually) based on data available for the period 2000-2010. 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 tonnes of carbon.

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.

The IPCC GPG Tier 1 method was applied to calculate the annual change in carbon stock of grassland living biomass converted to annual and perennial cropland:

Annual change in carbon stock in biomass = annual area of converted land x ($L_{Conversion}$ + ΔC_{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 tC/ 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 2006 Guidelines, 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) 52.71 tC/ha for annual cropland

2) 71.01 tC/ha for perennial cropland

SOC_T = soil organic carbon stock *T* years prior to the inventory, equals 75.75 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 calculated emission factor for grassland converted to annual cropland was -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 -0.06 to 0.40 Gg C for grassland converted to perennial cropland for the period 1990-2016. In case of grassland converted to annual cropland, removals were from -4.90 to -10.33 Gg C.

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 equation 11.8 as follows:

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

where:

$EF_{\mathbf{1}}$ **=** the emission factor for calculating emissions of N_2O from N in the soil = 0.01 kg N_2O- N/kg N (IPCC default value)

$\Delta C_{\mathbf{LCmineral}}$ **=** 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 -1736.20% and 1742.65% using uncertainties for emission factors and area as presented in Table 6.4-6. In case of category Cropland remaining Cropland, uncertainty for total CO_2 eq ranges between -338.06% and 350.94%.

Comparison between the uncertainties in calculations Tier 1 and Tier 2 methods by categories and carbon pools is presented in Annex 1.

6.5.4. Category-specific QA/QC and verification

The data calculation for this category was included in the overall QA/QC system of the Croatian GHG inventory.

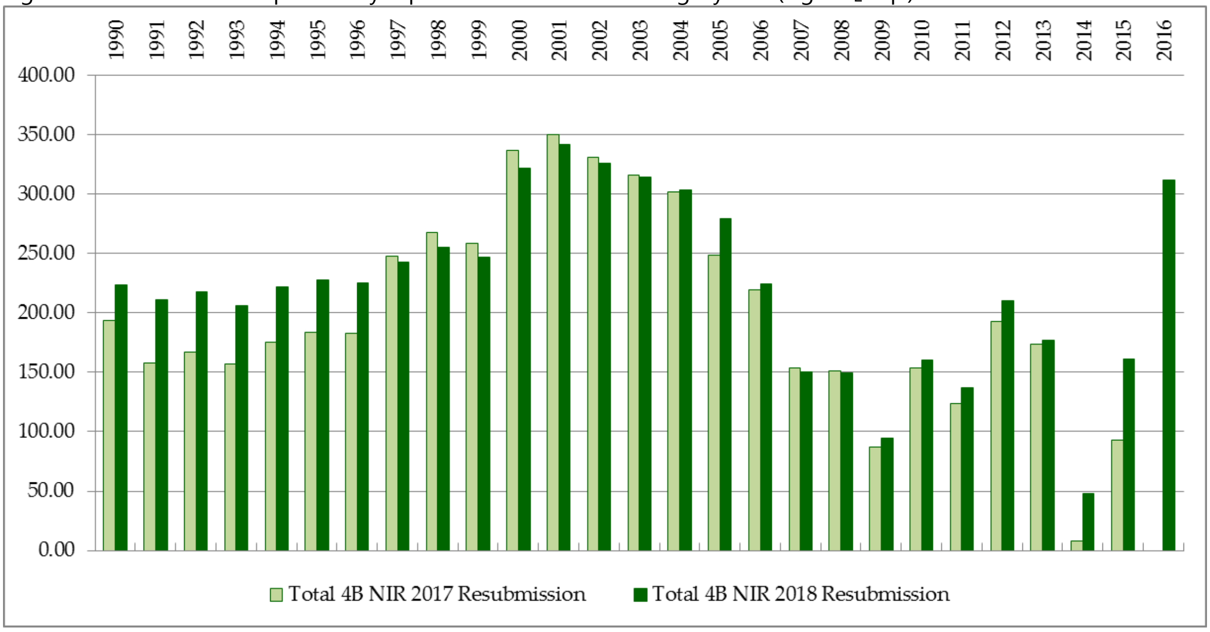
6.5.5. Category-specific recalculations

Since the last submission the emission estimate was recalculated for the entire category and reporting period. Recalculations in this category of land refers to the revision of activity data on land areas based on newly delivered CLC data for year 1990, as well as the new data on land use changes from specially designed CLC 1990-2006 change databases, accordingly and changes in method used for determing the total area of Cropland.

Data on soil carbon contnt collected through a new scientific investigation in 2017 were used for this year reporting.

The result of the performed recalculation can be seen in Figure 6.5-1. On average, emissions increased by 8.58 % compared to the previously reported estimates.

Figure 6.5-1: Current and previously reported emissions for category 4.B (Gg CO_2 eqv)



6.5.6. Category-specific planned improvements

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. This is one of long-term planned improvements in Croatian reporting

6.6. Grassland (CRF category 4.c)

6.6.1. Description

Only emissions/removals from the grassland management (Grassland Remaining Grassland and Land Converted to Grassland) were considered in this category. A combination of the IPCC Tier 1 and Tier 2 approach was used to calculate the carbon stock changes for the purpose of this report.

The grassland area ranged from 1,187.7 kha to 1,231.49 kha in the period 1990-2016. Removals from the change in carbon stock in biomass and soil ranges from -54.17 ktCO_2 to -215.63 ktCO_2 in period 1990-2016.

Annual LUCs to grassland occurred in only the cropland category (annual and perennial).

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 2016.

Table 6.6-1: Activity Data of Grassland in the period 1990-2016 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.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	1,210.35	1,209.37	0.97	NO	0.89	0.08	NO	NO	NO
1991	1,212.46	1,209.30	3.16	NO	2.97	0.2	NO	NO	NO
1992	1,214.58	1,211.46	3.11	NO	2.92	0.19	NO	NO	NO
1993	1,216.69	1,213.44	3.25	NO	3.04	0.2	NO	NO	NO
1994	1,218.80	1,215.64	3.17	NO	2.97	0.2	NO	NO	NO
1995	1,220.92	1,217.74	3.18	NO	2.98	0.2	NO	NO	NO
1996	1,223.03	1,219.80	3.24	NO	3.03	0.2	NO	NO	NO
1997	1,225.15	1,222.06	3.09	NO	2.9	0.19	NO	NO	NO
1998	1,227.26	1,224.13	3.14	NO	2.94	0.19	NO	NO	NO
1999	1,229.38	1,226.12	3.26	NO	3.05	0.2	NO	NO	NO
2000	1,231.49	1,228.42	3.07	NO	2.89	0.19	NO	NO	NO
2001	1,225.38	1,225.38	0.00	NO	0.00	0.00	NO	NO	NO
2002	1,219.28	1,219.28	0.00	NO	0.00	0.00	NO	NO	NO
2003	1,213.17	1,213.17	0.00	NO	0.00	0.00	NO	NO	NO
2004	1,207.07	1,207.07	0.00	NO	0.00	0.00	NO	NO	NO
2005	1,200.96	1,200.16	0.8	NO	0.72	0.08	NO	NO	NO
2006	1,194.86	1,192.81	2.05	NO	1.86	0.19	NO	NO	NO
2007	1,194.14	1,189.84	4.3	NO	3.91	0.38	NO	NO	NO
2008	1,193.43	1,191.40	2.03	NO	1.85	0.18	NO	NO	NO
2009	1,192.71	1,187.99	4.72	NO	4.29	0.42	NO	NO	NO
2010	1,192.00	1,187.00	4.99	NO	4.54	0.45	NO	NO	NO
2011	1,191.28	1,184.92	6.36	NO	5.79	0.57	NO	NO	NO
2012	1,190.57	1,185.43	5.13	NO	4.67	0.46	NO	NO	NO
2013	1,189.85	1,182.63	7.22	NO	6.58	0.65	NO	NO	NO
2014	1,189.13	1,180.76	8.38	NO	7.63	0.75	NO	NO	NO
2015	1,188.42	1,182.23	6.19	NO	5.63	0.56	NO	NO	NO
2016	1,187.70	1,185.82	1.89	NO	1.72	0.17	NO	NO	NO

Table 6.6-2: Emissions (+) / removals (-) of CO_2 in Grassland 1990-2016 (kt CO_2 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	-101.85	2.07	-103.92	NO	-103.92	NO	NO	NO
1991	-73.17	2.07	-75.24	NO	-75.24	NO	NO	NO
1992	-80.46	2.07	-82.53	NO	-82.53	NO	NO	NO
1993	-83.81	2.07	-85.88	NO	-85.88	NO	NO	NO
1994	-92.04	2.07	-94.10	NO	-94.10	NO	NO	NO
1995	-98.07	2.07	-100.14	NO	-100.14	NO	NO	NO
1996	-103.24	2.07	-105.31	NO	-105.31	NO	NO	NO
1997	-112.73	2.07	-114.80	NO	-114.80	NO	NO	NO
1998	-117.81	2.07	-119.87	NO	-119.87	NO	NO	NO
1999	-121.52	2.07	-123.59	NO	-123.59	NO	NO	NO
2000	-131.83	2.07	-133.90	NO	-133.90	NO	NO	NO
2001	-180.37	2.07	-182.44	NO	-182.44	NO	NO	NO
2002	-173.94	2.07	-176.01	NO	-176.01	NO	NO	NO
2003	-167.51	2.07	-169.57	NO	-169.57	NO	NO	NO
2004	-161.07	2.07	-163.14	NO	-163.14	NO	NO	NO
2005	-137.40	2.07	-139.47	NO	-139.47	NO	NO	NO
2006	-109.11	2.07	-111.18	NO	-111.18	NO	NO	NO
2007	-67.22	2.07	-69.29	NO	-69.29	NO	NO	NO
2008	-123.13	2.07	-125.20	NO	-125.20	NO	NO	NO
2009	-70.78	2.07	-72.85	NO	-72.85	NO	NO	NO
2010	-79.96	2.07	-82.03	NO	-82.03	NO	NO	NO
2011	-59.41	2.07	-61.48	NO	-61.48	NO	NO	NO
2012	-96.43	2.07	-98.50	NO	-98.50	NO	NO	NO
2013	-61.65	2.07	-63.72	NO	-63.72	NO	NO	NO
2014	-54.17	2.07	-56.24	NO	-56.24	NO	NO	NO
2015	-118.11	2.07	-120.18	NO	-120.18	NO	NO	NO
2016	-215.63	2.07	-217.70	NO	-217.70	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 2006).

The area of grassland remaining grassland in 2016 amounts to 1,185.82 kha.

According to the IPCC 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 0.56 GgC annually for the period 1990-2016.

According to expert judgment liming does not occur in the grassland category.

6.6.2.2. Land use change to Grassland (4.C.2)

6.5.2.2.4 Forest land converted to Grassland (4.C.2.1)

There has not been conversion from the Forestland to Grassland in the last decades

6.5.2.2.5 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, 66.61 kha of Cropland area were converted into Grassland in year 2016. 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 removals of -103.92 Gg CO_2 and -217.7 GgCO_2 in year 2016.

A) Changes in carbon stocks in biomass

National data were used for the calculation of carbon stock in living biomass of Grassland. 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 ($L_{Conversion}$ + ΔC_{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 default value)

C_{After} = Carbon stock immediately after conversion = 0 t C/ha (IPCC default 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 2006, 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)** 52.71 tC/ha for annual Cropland **2)** 71.01 tC/ha for perennial Cropland

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory, which is 75.75 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 change in soils when annual cropland converted to grassland in 2016 was 74.25 GgC and for perennial cropland converted to grassland was 1.33 GgC.

6.6.3. Uncertainties and time-series consistency

The uncertainty values for total CO_2 eq in category Land converted to Grassland ranges from -128.39% to 232.40% 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 ranges from -95.89% to 95.67%.

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

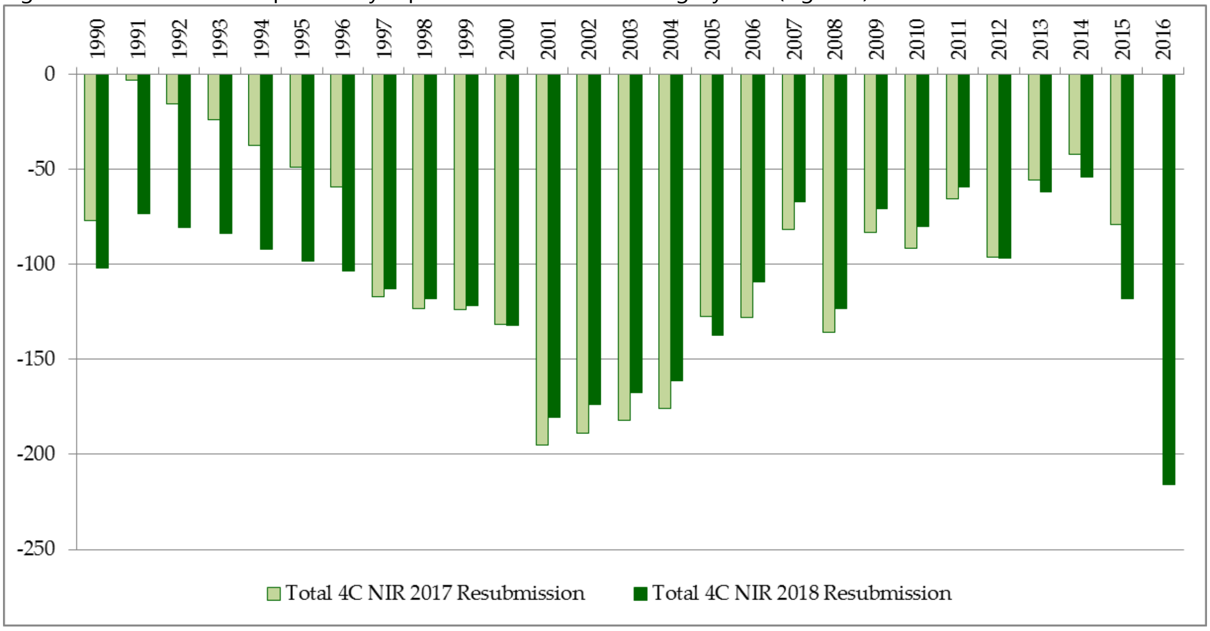
The calculation of the data for category 4.C was included in overall QA/QC system of the Croatian GHG inventory.

6.6.5. Category-specific recalculations

Since the last submission the emission estimate was recalculated for the entire category and reporting period. Recalculations in this category of land refers to the correction of activity data on land areas based on delivered CLC data for year 1990, as well as the data on land use changes from specially designed CLC 1990-2006 change databases, accordingly. Data on soil carbon contnt collected through a new scientific investigation in 2017 were used for this year reporting.

The result of the performed recalculation can be seen in Figure 6.6-1. On average, removals decreased by 11.7 % compared to the previously reported estimates.

Figure 6.6-1: Current and previously reported emissions for category 4.C (Gg CO_2)



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. This is predicted as one of long-term improvments needed in Croatian reporting.

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 74.54 ha in 2016.

The land use change and removals/emissions from the IPCC land use categories to wetland in the period 1990-2016 are presented in Tables 6.7-1 and 6.7-2.

Table 6.7-1: Activity data of wetland in the period 1990-2016 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.2.2a Annual Cropland to Wetlands	4.D.2.2b Peremmial Cropland 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	72.13	0.20	NO	0.18	0.02	0.00	NO	NO
1991	72.52	72.32	0.20	NO	0.00	0.00	0.00	NO	NO
1992	72.72	72.52	0.20	NO	0.18	0.02	0.00	NO	NO
1993	72.92	72.72	0.20	NO	0.18	0.02	0.00	NO	NO
1994	73.11	72.92	0.20	NO	0.18	0.02	0.00	NO	NO
1995	73.31	73.11	0.20	NO	0.18	0.02	0.00	NO	NO
1996	73.51	73.31	0.20	NO	0.18	0.02	0.00	NO	NO
1997	73.71	73.51	0.20	NO	0.18	0.02	0.00	NO	NO
1998	73.90	73.71	0.20	NO	0.18	0.02	0.00	NO	NO
1999	74.10	73.90	0.20	NO	0.18	0.02	0.00	NO	NO
2000	74.30	74.10	0.20	NO	0.18	0.02	0.00	NO	NO
2001	74.32	74.30	0.02	NO	0.02	0.00	0.00	NO	NO
2002	74.34	74.32	0.02	NO	0.02	0.00	0.00	NO	NO
2003	74.36	74.34	0.02	NO	0.02	0.00	0.00	NO	NO
2004	74.38	74.36	0.02	NO	0.02	0.00	0.00	NO	NO
2005	74.40	74.38	0.02	NO	0.02	0.00	0.00	NO	NO
2006	74.42	74.40	0.02	NO	0.02	0.00	0.00	NO	NO
2007	74.44	74.42	0.01	NO	0.01	0.00	0.00	NO	NO
2008	74.45	74.44	0.01	NO	0.01	0.00	0.00	NO	NO
2009	74.46	74.45	0.01	NO	0.01	0.00	0.00	NO	NO
2010	74.47	74.46	0.01	NO	0.01	0.00	0.00	NO	NO
2011	74.48	74.47	0.01	NO	0.01	0.00	0.00	NO	NO
2012	74.50	74.48	0.01	NO	0.01	0.00	0.00	NO	NO
2013	74.51	74.50	0.01	NO	0.01	0.00	0.00	NO	NO
2014	74.52	74.51	0.01	NO	0.01	0.00	0.00	NO	NO
2015	74.53	74.52	0.01	NO	0.01	0.00	0.00	NO	NO
2016	74.54	74.53	0.01	NO	0.01	0.00	0.00	NO	NO

Table 6.7-2: Emissions of wetland in the period 1990-2016 in $ktCO_2$

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	53.01	NE	53.01	0.00	46.78	0.00	0.00	0.00
1991	53.09	NE	53.09	0.00	46.86	0.00	0.00	0.00
1992	53.11	NE	53.11	0.00	46.88	0.00	0.00	0.00
1993	53.13	NE	53.13	0.00	46.89	0.00	0.00	0.00
1994	53.15	NE	53.15	0.00	46.91	0.00	0.00	0.00
1995	53.16	NE	53.16	0.00	46.92	0.00	0.00	0.00
1996	53.18	NE	53.18	0.00	46.94	0.00	0.00	0.00
1997	53.20	NE	53.20	0.00	46.96	0.00	0.00	0.00
1998	53.22	NE	53.22	0.00	46.97	0.00	0.00	0.00
1999	53.24	NE	53.24	0.00	46.99	0.00	0.00	0.00
2000	53.26	NE	53.26	0.00	47.00	0.00	0.00	0.00
2001	44.24	NE	44.24	0.00	38.26	0.00	0.00	0.00
2002	42.22	NE	42.22	0.00	36.52	0.00	0.00	0.00
2003	40.20	NE	40.20	0.00	34.78	0.00	0.00	0.00
2004	38.18	NE	38.18	0.00	33.04	0.00	0.00	0.00
2005	36.16	NE	36.16	0.00	31.30	0.00	0.00	0.00
2006	34.14	NE	34.14	0.00	29.56	0.00	0.00	0.00
2007	31.66	NE	31.66	0.00	27.37	0.00	0.00	0.00
2008	29.54	NE	29.54	0.00	25.54	0.00	0.00	0.00
2009	27.41	NE	27.41	0.00	23.71	0.00	0.00	0.00
2010	25.29	NE	25.29	0.00	21.87	0.00	0.00	0.00
2011	23.15	NE	23.15	0.00	20.03	0.00	0.00	0.00
2012	21.01	NE	21.01	0.00	18.18	0.00	0.00	0.00
2013	18.86	NE	18.86	0.00	16.33	0.00	0.00	0.00
2014	16.72	NE	16.72	0.00	14.49	0.00	0.00	0.00
2015	14.58	NE	14.58	0.00	12.64	0.00	0.00	0.00
2016	12.44	NE	12.44	0.00	10.79	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 was no conversion 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 and Grassland Converted to Wetland

For the calculation of the annual change in carbon stocks of living biomass in cropland converted to wetland the IPCC 2006 Gideliness 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); **3)** for grassland converted to cropland 4.3 t C/ha

$B_{After=}$ living biomass in land immediately before conversion to wetland (default = 0 t C/ha a)

Changes in carbon stocks in soil of cropland and grassland 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 52.71 t C /ha; **2)** for perennial cropland 71.01 t C/ha a (See Chapter 6.4.1.); **3)** for grassland converted to wetland 75.75 tC/ha

B_{After} = carbon stock in soil immediately after conversion to wetland (default = 0 t C/ha)

N_2O Emissions in Soils of Land Converted to Wetland

The annual release of N2O due to the conversion of Cropland and Grassland to Wetland were calculated using the IPCC default value (Tier 1) and equation 11.8 as follows:

$N_2O_{net-min} - N = EF1 \times \Delta CLC_{mineral} \times 1/(C/N\ ratio)$

where:

EF1 = the emission factor for calculating emissions of N_2O from N in the soil = 0.01 kg N2O- N/kg N (IPCC GPG default value)

ΔCLCmineral = 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)

6.7.3. Uncertainties and time-series consistency

The uncertainty for the total CO_2 eq in category Land converted Wetland ranges between -206.92% and 503.32% according to the Tier 2 method used for the estimations. Uncertainties for emission factors and areas used in this estimation are presented in table 6.4-6. The comparison between the uncertainties calculated using Tier 1 and Tier 2 methods by categories and carbon pools is presented in Annex 5.

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

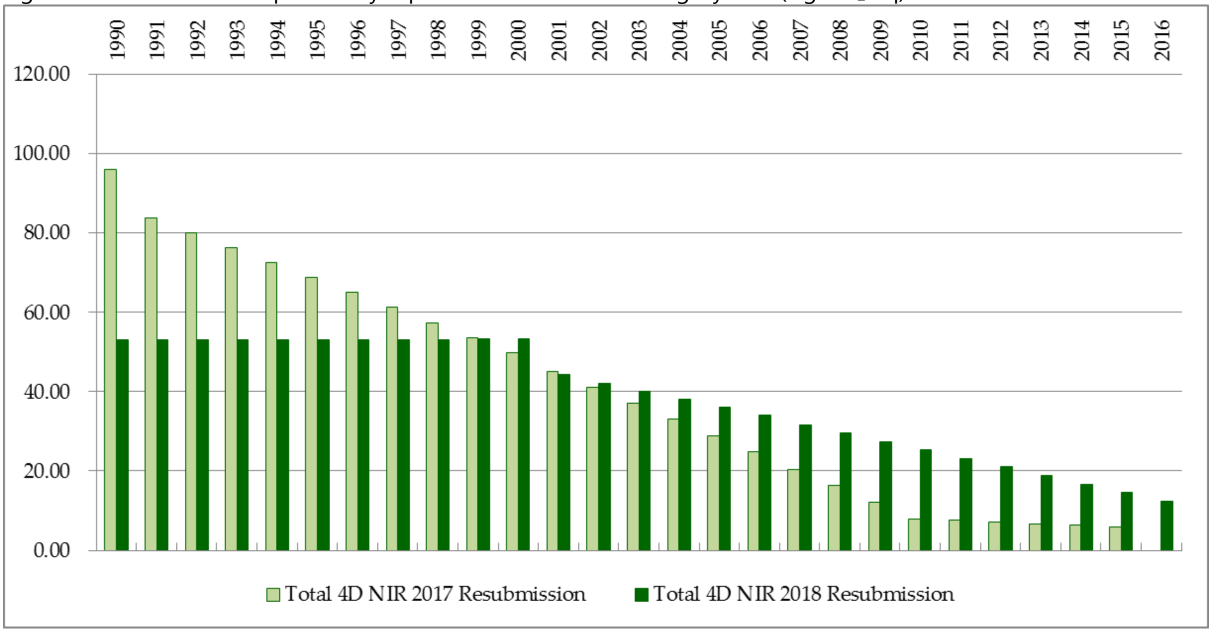
The calculation of the data for category 4.D was included in overall QA/QC system of the Croatian GHG inventory.

6.7.5. Category-specific recalculations

Since the last submission the emission estimate was recalculated for the entire category and reporting period. Recalculations in this category of land refers to the correction of activity data on land areas based on delivered CLC data for year 1990, as well as the data on land use changes from specially designed CLC 1990-2006 change databases, accordingly. Data on soil carbon contnt collected through a new scientific investigation in 2017 were used for this year reporting.

The result of the performed recalculation can be seen in Figure 6.7-1. On average, emissions increased by 3.7 % compared to the previously reported estimates.

Figure 6.7-1: Current and previously reported emissions for category 4.D (Gg CO_2 eq)



6.7.6. Category-specific planned improvements

NA

6.8. Settlements (CRF category 4.E)

6.8.1. Description

This category considers only emissions/removals from sub-categories "Land converted to Settlements".

It was assumed that dead wood and litter do not occur in the settlements area.

The settlements area ranges from 204.32 kha in 1990 to 264.83 kha in 2016. Emissions from the change in the carbon stock in biomass and soil ranges from 234.66 kt CO_2 to 836.12 kt 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 2016.

Table 6.8-1: Activity data of Settlements for 1990-2016 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.2.2A Annual Cropland to settlement	4.E.2.2b Perennial Cropland 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	204.32	203.53	0.80	0.00	0.22	0.02	0.56	NO	NO
1991	205.37	204.32	1.04	0.00	0.29	0.03	0.73	NO	NO
1992	206.41	205.37	1.04	0.00	0.29	0.03	0.73	NO	NO
1993	207.45	206.41	1.04	0.00	0.29	0.03	0.73	NO	NO
1994	208.50	207.45	1.04	0.06	0.27	0.03	0.69	NO	NO
1995	209.54	208.50	1.04	0.00	0.28	0.03	0.73	NO	NO
1996	210.59	209.54	1.04	0.00	0.29	0.03	0.73	NO	NO
1997	211.63	210.59	1.04	0.08	0.26	0.03	0.68	NO	NO
1998	212.68	211.63	1.04	0.10	0.26	0.03	0.66	NO	NO
1999	213.72	212.68	1.04	0.03	0.28	0.03	0.71	NO	NO
2000	214.77	213.72	1.04	0.17	0.24	0.02	0.61	NO	NO
2001	221.04	214.77	6.27	0.35	1.61	0.16	4.14	NO	NO
2002	227.31	221.04	6.27	0.23	1.65	0.16	4.23	NO	NO
2003	233.57	227.31	6.27	0.10	1.69	0.17	4.32	NO	NO
2004	239.84	233.57	6.27	0.31	1.63	0.16	4.17	NO	NO
2005	246.11	239.84	6.27	0.33	1.62	0.16	4.15	NO	NO
2006	252.38	246.11	6.27	0.32	1.62	0.16	4.16	NO	NO
2007	253.63	252.38	1.25	0.08	0.32	0.03	0.82	NO	NO
2008	254.87	253.63	1.25	0.28	0.26	0.03	0.68	NO	NO
2009	256.12	254.87	1.25	0.12	0.31	0.03	0.79	NO	NO
2010	257.36	256.12	1.25	0.18	0.29	0.03	0.75	NO	NO
2011	258.61	257.36	1.25	0.02	0.33	0.03	0.85	NO	NO
2012	259.85	258.61	1.25	0.14	0.30	0.03	0.77	NO	NO
2013	261.10	259.85	1.25	0.09	0.32	0.03	0.81	NO	NO
2014	262.34	261.10	1.25	0.02	0.33	0.03	0.86	NO	NO
2015	263.59	262.34	1.25	0.07	0.32	0.03	0.82	NO	NO
2016	264.83	263.59	1.25	0.02	0.33	0.03	0.86	NO	NO

Table 6.8-2: Emissions of Settlements 1990-2016 in kt CO_2

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	234.66	NE	234.66	2.70	52.34	151.86	NO	NO
1991	243.61	NE	243.61	2.56	55.97	156.87	NO	NO
1992	247.01	NE	247.01	2.42	56.69	159.26	NO	NO
1993	250.42	NE	250.42	2.27	57.41	161.65	NO	NO
1994	253.52	NE	253.52	3.87	57.27	162.88	NO	NO
1995	257.15	NE	257.15	2.74	58.63	165.83	NO	NO
1996	260.62	NE	260.62	2.59	59.39	168.25	NO	NO
1997	262.42	NE	262.42	3.55	58.97	169.10	NO	NO
1998	267.46	NE	267.46	6.91	59.09	170.25	NO	NO
1999	271.25	NE	271.25	5.94	60.57	173.11	NO	NO
2000	276.42	NE	276.42	12.81	59.20	172.42	NO	NO
2001	459.04	NE	459.04	12.91	132.24	272.43	NO	NO
2002	537.95	NE	537.95	16.99	148.15	321.86	NO	NO
2003	613.84	NE	613.84	16.32	164.48	372.55	NO	NO
2004	692.87	NE	692.87	28.96	176.23	417.71	NO	NO
2005	763.96	NE	763.96	30.00	190.01	464.51	NO	NO
2006	836.12	NE	836.12	31.10	204.29	511.82	NO	NO
2007	748.05	NE	748.05	43.96	149.43	464.99	NO	NO
2008	753.49	NE	753.49	50.97	147.59	464.57	NO	NO
2009	805.79	NE	805.79	94.91	150.39	469.38	NO	NO
2010	770.48	NE	770.48	56.96	150.44	471.24	NO	NO
2011	771.84	NE	771.84	52.47	152.73	474.47	NO	NO
2012	767.15	NE	767.15	49.34	151.53	473.79	NO	NO
2013	766.60	NE	766.60	46.08	152.41	475.31	NO	NO
2014	764.19	NE	764.19	38.95	153.86	478.21	NO	NO
2015	777.90	NE	777.90	51.77	153.69	478.94	NO	NO
2016	766.56	NE	766.56	36.83	154.77	481.13	NO	NO

6.8.2. Methodological issues

6.8.2.1. Land Use Change to Settlements (5.E.2)

A) Biomass

The IPCC Tier 2 approach was used for the calculation of annual change in carbon stocks of living biomass of the land use categories converted to settlements. 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. Following 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 46.4 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 70.6 tC/ha in Grassland before LUC was used in estimation.

For the calculation of the annual change in carbon stocks of living biomass in forest land converted to settlements, specific harvest data for these deforestation areas delivered by the Croatian Forests Ltd were used.

B) Soil

The approach follows exactly the method in the other LUC categories. The calculation of emissions from soil carbon stock changes due to land use changes from other subcategories refer to a soil depth of 0-30 cm. Research on carbon stock in Croatian soils was done so that the humus layer (litter) was removed from the soil sample. 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 86.91 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.

For this year reporting Croatia used value for the litter carbon stock that comes from the scientific investigation performed in 2017. The IPCC method as described in Chapter 6.4.2.2 was used for the estimation of carbon stock chanes in litter pool in forest land that is converted to settlements.

6.5.1.1.1 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 3.05 kha in 1900-2016.

Changes in Carbon Stocks in Biomass of Forest Land Converted to Settlements

Annual net carbon change rates due to loss of forest biomass and increase of biomass in the settlements area was in the range from 0.03 to -14.79 Gg C in the period 1990-2016.

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 (69.86 t C/ha) and carbon stocks in soils of settlements (86.91 t C/ha for the unsealed settlement area or 3.98 t C/ha for the total settlement area).

Annual net change rates due to carbon stock changes in soil ranged from -0.63 to -10.04 Gg C in the period 1990 to 2016.

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.

6.5.2.2.6 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 4.71 kha to 15.36 kha in the years 1990-2016.

Changes in Carbon Stocks in Biomass of Cropland Converted to Settlements

Annual net change due to loss of cropland biomass and increase of biomass in settlements area ranged from -1.08 to -9.0 Gg C in annual cropland and -1.34 to -10.45 Gg C in perennial cropland converted to settlements in the years 1990-2016.

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 (52.71 t C/ha) and perennial cropland (71.01 t C/ha), as well as carbon stocks in soils of settlements (86.91 t C/ha for the unsealed settlement area or 3.98 t C/ha for the total settlement area).

Annual net rates due to carbon stock changes in soil ranged from -10.44 to -34.06 Gg C in annual cropland converted to settlements and from -1.42 to -4.63 Gg C in perennial cropland converted to settlements in the years 1990-2016.

6.5.2.2.7 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 10.98 kha to 35.84 kha.

Changes in Carbon Stocks in Biomass of Grassland Converted to Settlements

Annual net rates due to loss of grassland biomass and increase of biomass in settlements area ranged from -1.89 to -17.14 Gg C during the period 1990-2016.

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 (75.75 t C/ha) and carbon stocks in soils of settlements (86.91 t C/ha for the unsealed settlement area or 3.98 t C/ha for the total settlement area).

Annual net rates due to carbon stock changes in soil ranged from -39.41 to -128.61 Gg C in the period 1990-2016.

N_2O Emissions in Soils of Land Converted to Settlements

The annual release of N_2O due to the conversion of forestland, grassland and cropland to Settlement were calculated using the IPCC default value (Tier 1) and equation 11.8 as follows:

$N_2O_{net-min} - N = EF1 \times \Delta CLC_{mineral} \times 1/(C/N \text{ ratio})$

where:

EF1 = the emission factor for calculating emissions of N_2O from N in the soil = 0.01 kg N_2O- N/kg N (IPCC GPG default value)

ΔCLCmineral = 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 (8 for Grassland and 9 for Cropland converted to Settlements and 11 for Forest land converted to Settlements)

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 -93.23% and 139.70%. 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

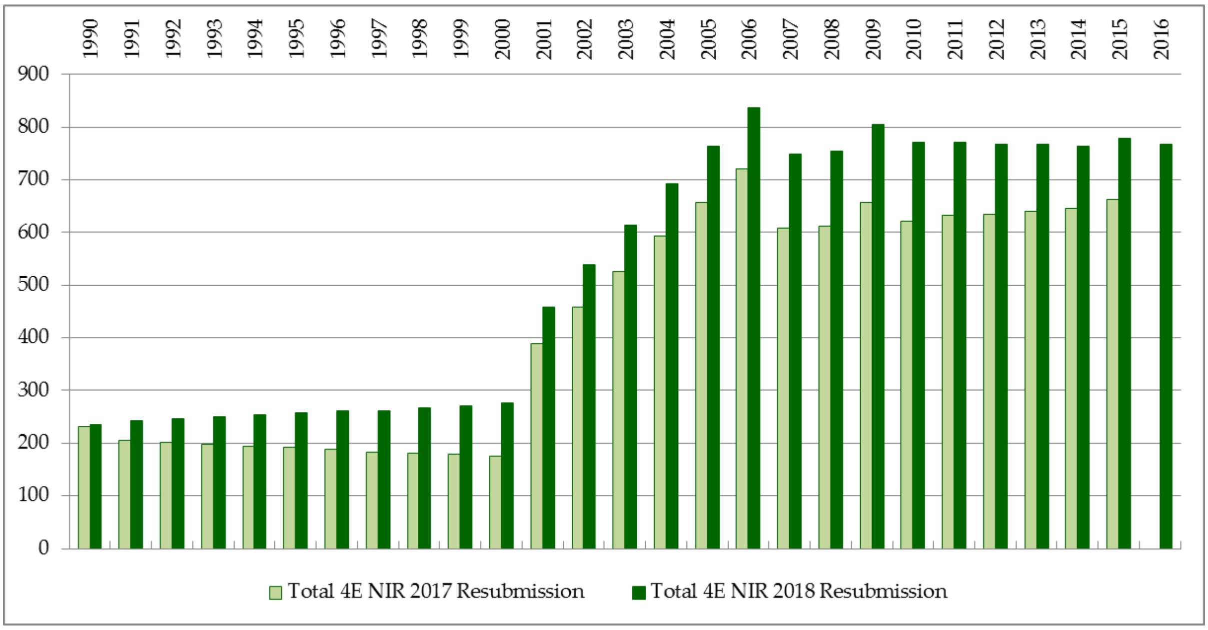
The calculation of the data for category 4.E was included in overall QA/QC system of the Croatian GHG inventory.

6.8.5. Category-specific recalculations

Since the last submission the emission estimate was recalculated for the entire category and reporting period. Recalculations in this category of land refers to the correction of activity data on land areas based on delivered CLC data for year 1990, as well as the data on land use changes from specially designed CLC 1990-2006 change databases, accordingly. Data on soil carbon contnt collected through a new scientific investigation in 2017 were used for this year reporting.

The result of the performed recalculation can be seen in Figure 6.8-1. On average, emissions decreased by 22.1 % compared to the previously reported estimates.

Figure 6.8-1: Current and previously reported emissions for category 4.E (Gg CO_2 eqv)



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.F Total Other land	4.F.1 Other land remaining other land	4.F.2 Land converted to Other land	4.F.2.1 Forest and converted to Other land	4.F.2.2.A Annual Cropland converted to Other land	4.F.2.2.B Perrenial Cropland converted to Other land	4.F.2.3 Grassland converted to Other land	4.F.2.4 Wetland converted to Other land	4.F.2.5 Settlement converted to Other land
1990	78.87	78.87	NO	NO	NO	NO	NO	NO	NO
1991	78.63	78.63	NO	NO	NO	NO	NO	NO	NO
1992	78.39	78.39	NO	NO	NO	NO	NO	NO	NO
1993	78.14	78.14	NO	NO	NO	NO	NO	NO	NO
1994	77.90	77.90	NO	NO	NO	NO	NO	NO	NO
1995	77.65	77.65	NO	NO	NO	NO	NO	NO	NO
1996	77.41	77.41	NO	NO	NO	NO	NO	NO	NO

Year	4.F Total Other land	4.F.1 Other land remaining other land	4.F.2 Land converted to Other land	4.F.2.1 Forest and converted to Other land	4.F.2.2.A Annual Cropland converted to Other land	4.F.2.2.B Perrenial Cropland converted to Other land	4.F.2.3 Grassland converted to Other land	4.F.2.4 Wetland converted to Other land	4.F.2.5 Settlement converted to Other land
1997	77.17	77.17	NO	NO	NO	NO	NO	NO	NO
1998	76.92	76.92	NO	NO	NO	NO	NO	NO	NO
1999	76.68	76.68	NO	NO	NO	NO	NO	NO	NO
2000	76.43	76.43	NO	NO	NO	NO	NO	NO	NO
2001	72.66	72.66	NO	NO	NO	NO	NO	NO	NO
2002	68.88	68.88	NO	NO	NO	NO	NO	NO	NO
2003	65.10	65.10	NO	NO	NO	NO	NO	NO	NO
2004	61.32	61.32	NO	NO	NO	NO	NO	NO	NO
2005	57.55	57.55	NO	NO	NO	NO	NO	NO	NO
2006	53.77	53.77	NO	NO	NO	NO	NO	NO	NO
2007	54.48	54.48	NO	NO	NO	NO	NO	NO	NO
2008	55.19	55.19	NO	NO	NO	NO	NO	NO	NO
2009	55.90	55.90	NO	NO	NO	NO	NO	NO	NO
2010	56.60	56.60	NO	NO	NO	NO	NO	NO	NO
2011	57.31	57.31	NO	NO	NO	NO	NO	NO	NO
2012	58.02	58.02	NO	NO	NO	NO	NO	NO	NO
2013	58.73	58.73	NO	NO	NO	NO	NO	NO	NO
2014	59.44	59.44	NO	NO	NO	NO	NO	NO	NO
2015	60.15	60.15	NO	NO	NO	NO	NO	NO	NO
2016	60.86	60.86	NO	NO	NO	NO	NO	NO	NO

6.9.2. Methodological issues

As informed in Chapter 6.3.6, area of Other land category has been always reported by Croatia as a difference between the total area of Croatia and sum of all other categories of land which is in line with the IPCC 2006 GL.

Corine Land Cover (CLC) was one of the data sources that was examined during the process of land use change matrix development. Regarding the identification of forest land category (which includes forest land that are subject of forest fires), it was conclude that CLC database is not appropriate for this category of land due its resolution and the fact that the minimum area for mapping the land cover is 25 ha and the minimum area for mapping of changes is 5 ha, while the 0,1 ha is set as the threshold for defining forest areas in Croatia. All forest areas are identified using the maps (with more precise scales than CLC) that are produced and make integral part of the Forest management plan for the Republic of Croatia and other relevant programs and plans in forest sector. Following the fact that all forest areas are identified, there is no Open spaces with less or no vegetation (Level 2 of CLC) that reaches thresholds defined for forest and emissions of which should be reported under the Other category of land due to the forest fires.

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. Harvested wood products (CRF category 4.G)

6.10.1. Category description

Since NIR 2015 submission, Parties to the UNFCCC and the KP are obliged to submit their national estimation of emissions/removals in harvested wood products (HWP), following the stipulations of Decision 2/CMP.7. Carbon stock changes in this new pool are included within the LULUCF sector as a separate category (CRF 4.G).

Estimation performed for Croatia is presented in below Table 6.10-1 and graph shows fluctuation of emissions/removals during the reporting period 1990-2016. The estimation has been based on of HWP production data for Croatia presented in Table 6.10-2.

Table 6.10-1: Emissions/removals from HWPs in the period between 1990-2016 [GgCO_2]

Year	**HWP**(produced and consumed domestically)	Sawn wood	Wood panels	Paper and paper board
1990	-301.54	-338.61	-62.53	99.59
1991	222.39	-52.70	-6.75	281.86
1992	324.54	-114.62	1.19	437.98
1993	111.24	-163.41	-16.95	291.61
1994	-16.42	-70.05	6.57	47.04
1995	-55.59	-30.18	18.78	-44.18
1996	5.35	-23.36	22.74	5.98
1997	-62.82	-19.61	19.09	-62.30

1998	-165.16	-88.51	9.98	-86.64
1999	-185.7	-103.91	3.10	-84.88
2000	-170.05	-107.05	9.86	-72.86
2001	-106.47	-19.15	4.80	-92.11
2002	-161.32	-84.35	8.10	-85.07
2003	-90.96	-30.93	-5.83	-54.19
2004	-104.64	-41.72	-14.09	-48.84
2005	-299.45	-79.71	-37.39	-182.34
2006	-285.91	-121.90	-67.81	-96.18
2007	-285.59	-155.23	-80.37	-50.01
2008	-295.95	-179.91	-85.71	-30.32
2009	-165.01	-107.68	-47.16	-10.16
2010	-237.43	-131.49	-55.62	-50.31
2011	-259.63	-203.59	-44.35	-11.70
2012	-310.18	-297.69	-51.85	39.34
2013	-461.02	-618.90	-109.16	267.04
2014	-658.07	-778.66	-103.19	223.78
2015	-806.10	-859.10	-88.27	141.28
2016	-763.42	-786.77	-21.76	45.14

Table 6.10-2: Production of HWP in Croatia in the period between 1990-2016 according to the FAO Statistics

Year	Sawn wood [m^3]	Wood panels [m^3]	Paper and paper board [t]
1990	861,180	152,239	473,626
1991	586,923	98,603	306,427
1992	651,000	90,000	100,000
1993	699,000	108,000	114,000
1994	601,000	83,400	247,000
1995	578,000	73,000	324,000
1996	598,000	71,000	304,000
1997	644,000	80,000	393,000
1998	676,000	84,000	403,000
1999	685,000	90,000	417,000
2000	642,000	78,000	406,000
2001	574,000	85,000	451,000
2002	640,000	81,000	467,000
2003	585,000	96,000	463,000
2004	582,000	103,000	464,000

Year	Sawn wood [m^3]	Wood panels [m^3]	Paper and paper board [t]
2005	624,000	128,000	592,000
2006	669,000	161,000	564,000
2007	702,000	175,000	545,000
2008	721,000	181,000	535,000
2009	653,000	143,000	524,000
2010	677,000	153,000	560,000
2011	754,000	143,000	540,000
2012	851,000	151,900	499,700
2013	1,191,804	212,350	299,285
2014	1,362,804	209,520	270,398
2015	1,488,353	199,882	288,740
2016	1,433,500	134,039	337,710

6.10.2. Methodological issues

For the estimation of emissions/removals from harvested wood products (HWP) Croatia used Tier 2 applying the production approach (approach B).

Input data on types of HWP production on national level were collected within the scope of the project "Upgrading the Croatian National System for the reporting of greenhouse gas emissions for the implementation of the Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities" (abbreviated: LULUCF 2 project; implemented in period 2014-2015). A separate document was produced for the purposes of the estimation and this reporting.[33]

Data that had been delivered by the Republic of Croatia to the UNECE/FAO were analysed and compared with the data available in different data sources on national level. It had been decided that data delivered by Croatia to the UNECE/FAO database for the period 1992-2014 would be used for the estimation. Since the data on total harvested volume in Croatai refers to the wood harvested on areas under the forest amnagement and aread that were subject to deforestation, in order to comply with the requirements of Decision 2/CMP.7 (Annex, Part E, point 31), the special ratio was determened. As it has been already reported, there is no harvest in category Out of yield (maquies and Shrub) forests and the exact data on harvested volume of conifeous as well as decidous forests on deforested areas are well know. These volumes were subtraced from the total volume cut in Croatia and carbon stock changes in case of these woods were estimated using the instantanious oxidation method. The determened ratio showes that 99% of total volume harvested in Croatia belongs to the volume cut on areas that falls under the forest management activity. Carbon stock changes in harvetsed wood products volume cut on this area was calculated using the first ordey decay method.

[33] Elaborat The development of the national methodology for calculating carbon stock in wood products, 2014 (originally in Croatian: Razvoj nacionalnih metodologija za izračun zalihe ugljika u drvnim proizvodima)

For the period from 1961 to 1991, data on harvested wood products in the Republic of Croatia were taken from a number of statistical yearbooks, statistical reports, statistical bulletins[34] , that are and stored / available to the Central Bureau of Statistics (CBS).

For the period before 1961, equation 12.6 from 2006 Guidelines (Vol 4, chapter 12) was used in order to determine harvested wood products data on production in the period between 900-1960. For the year 1900, value of zero was used as input data on domestic production for all types of HWPs.

$$\boldsymbol{V_t = V^{1961} * e^{[(U*(t-1961)]}}$$

Where:

Vt = annual production, imports/exports for a solid wood/paper product for year t [Gg C/a]

t = year

V_{1961} = annual production, imports/exports for a solid wood/paper product for year 1961 [Gg C/a]

U=value of 0.0151=estimated continuous rate of increase for industrial roundwood consumption (harvest) in Europe between 1900-1961 (2006 Guidelines, Vol 4 , Tbl. 12.3);

When data were collected for all HWPs types for the period between 1961 to 2016 and after 'forecast back' data were defined for the period between 1900 to 1960 the share of domestic products in total production were determined by applying the equation 2.8.1 (Chapter 2 of the IPCC (2014) KP supplement):

$$\boldsymbol{f_{IRW}(i)} = \frac{\mathbf{IRWp(i) - IRWex(i)}}{\mathbf{IRWp(i) + IRWim(i) - IRWex(i)}}$$

Where:

fIRW (i) = share of wood from domestic harvest for year i

IRWp (i)= production of industrial roundwood in year i, [m^3]

IRWim (i) = import of industrial roundwood in year i, [m^3]

IRWex (i) = export of industrial roundwood in year i, [m^3]

Since for the year 1961 data were not found for the production in case of fibreboard (HDF; MDF; Insulating boards) in the available/existing statistical reports, it was concluded that this kind of production was not presented in Croatia. Since in the FAO database for this type of HWP was reported zero for all years, consequently for the period between 1900-2015 value of zero was used in estimation.

Based on the part of existing data for paper and paperboard, the equation of a linear trend was defined for the period from 1962 to 1981:

$$y = 21582 \cdot t - 42231736$$

[34] Department of Statistics and records. Statistical Yearbook for the period 1953-1959; Industry, Report of the Executive Council of NR Croatia and Report to the Executive Council of the Parliament of NR Croatia for period 1957-1970; Industry. Statistical Bulletins for period 1971-1989; Important products in the export and import of SR Croatia for period 1976 -1990. See References

where:

t = year

y = value of the variable 10 tons (paper and paperboard)

The correlation coefficient r = 0.99202183 and the coefficient of determination R2 = 0.98410732 are extremely high suggesting that the trend equation perfectly describes the movement of the value of variable 10 in the analysed period.

Using the equation of trend the value of variable 10 for the year 1961 was calculated:

$$y = 21582 \cdot 1961 - 42231736 = 90566$$

Determined value of 90,566 tons for y(1961) was used for calculation purposes and determination of paper production in period 1900-1960.

Finally, the changes in the carbon stock of HWP products in use are estimated by using equation 12.1 (IPCC 2006 Guidelines, Chapter 12):

$$\boldsymbol{C(i+1) = \mathrm{e}^{-k} * C(i) + \left[\frac{(1-e^{-k})}{k}\right] * Infow(i+1)}$$

Where:

i = year

C(i) = the carbon stock of the HWP pool in the beginning of year i [Gg C]

k = decay constant of first-order decay for each HWP category given in units, yr^{-1}

(k = ln(2)/HL where HL is half-life of the HWP pool in years)

Inflow (i) = the inflow to the HWP pool during year i [Gg C/yr]

Following KP supplement recommendations when applying Tier 2 in estimation (Table 2.8.2) next values were used:

- Sawn wood – 35 years
- Wood panels – 25 years
- Paper – 2 years

Then the carbon stock change is calculated as the difference of C(i+1) and C(i).

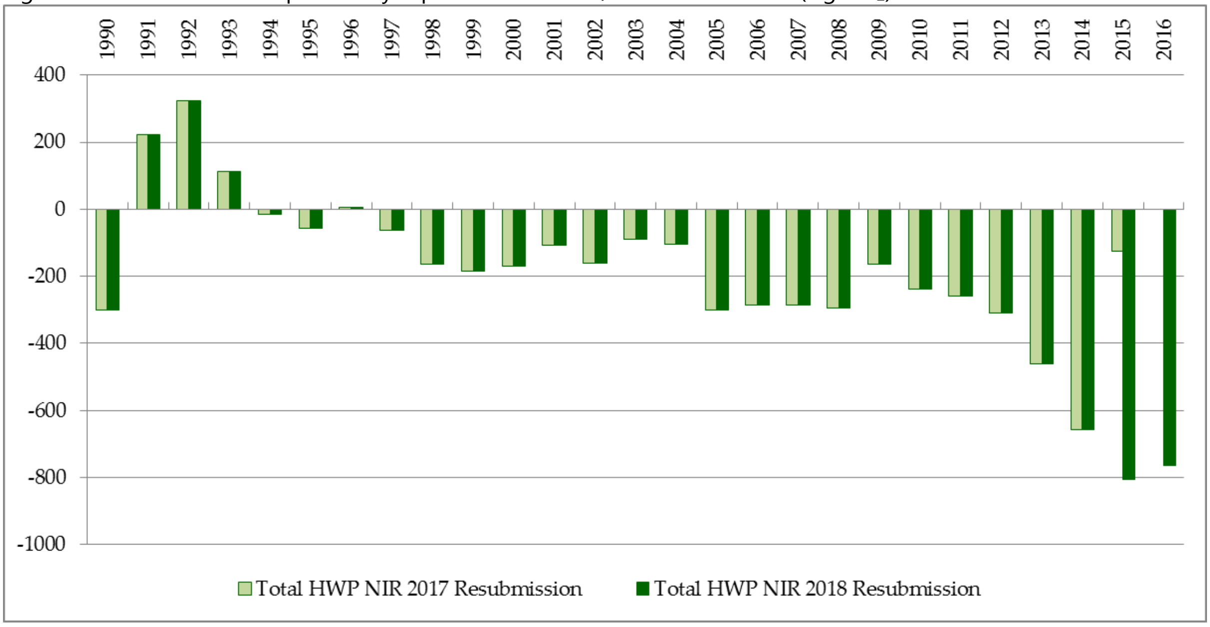
6.10.3. Uncertainty assessment

First uncertainty estimation for harvested wood products was conducted for NIR 2015, and the overall uncertainty for this category ranges from -87.78% to 130.36%.

6.10.4. Recalculations

There has not been recalculation in this pool since NIR 2016. On average, removals increased by 16.4 % compared to the previously reported estimates.

Figure 6.10-1: Current and previously reported emissions/removals in HWP (Gg CO_2)



6.10.5. Planned Improvements

New uncertainty estimation for harvested wood products will be performed for NIR 2018 Resubmission.

6.11. 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.

6.12. 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 1990-2015 and no data are reported.

6.13. Direct N_2O 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)

6.13.1. Description

N_2O emissions from Cropland remaining Cropland (perennial Cropland converted to annual Cropland) are reported in the agriculture sector. Under this category according to the IPCC 2006 Gudelines, N_2O emissions associated with disturbance of land use changes that occurs in Croatia are reported as follows:

1. Forestland converted to Cropland; Forestland converted to Settlements,
2. Cropland converted to Wetlands; Cropland converted to Settlements,

3. Grassland converted to Cropland; Grassland converted to Wetlands; Grassland converted to Settlements.

6.13.2. Methodological issues

The annual release of N_2O due to the above mentioned conversions was calculated using the IPCC default value (Tier 1) and equation 11.8:

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

where:

$EF_{\mathbf{1}}$ **=** the emission factor for calculating emissions of N_2O from N in the soil = 0.01 kg N_2O- N/kg N (IPCC GPG default value)

$\Delta C_{\mathbf{LCmineral}}$ **=** 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 for forestland) and 10 (national value for Grassland and Cropland category)

6.13.3. Category-specific recalculations

Since NIR 2015 where N_2O emissions coming from forestland and grassland converted to Cropland were reported, for this year submission N_2O emissions that come from land use changes from other categories of land (Chapter 6.13.1) are also reported.

6.14. Indirect N_2O emissions from managed soils (CRF category 4 IV)

Under land use change, N_2O emissions from leaching and run-offs are considered not occuring in Croatia according to the expert judgement, thus reported as such in CRF tables.

6.15. Biomass burning (CRF category 4 V)

6.15.1. Description

Detailed analyses conducted within the LULUCF 1 project for the purposes of determining the areas affected by fires in the period 1990-2014 years included categories of forest land, grassland and cropland. Analyses comprehended data and information primarily available in the Register on forest fires. This register was established in 2009 pursuant to the *Forest Act*[35] and at that time relevant Ordinance[36]. It contains all data and information on fires that occurred in forests or land under the forest management after year 1990. 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

[35] Forest Act (OG 140/05), Article 40

[36] *Ordinance on the method of data collection, conducting the Register and requirements for using data on forest fires* (OG 126/06)

agricultural lands in Croatia. This Register is currently running based on new legislative act[37] 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[38].

Based on the conducted analyses it was determined that Cropland areas were not affected by fires in the period 1990-2014. Cropland areas were affected by fires in 2015 and the estimation of emissions for this category were performed for the first time in NIR 2017.

The analyses of 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 1990-2014 were covered. According to the available data and information during the period 1990-2014 fires did not occur in state forests that are managed by other legal bodies. Data and information presented in this report concerning fire emissions refer to state owned forests managed by Croatian forests Ltd and private forests.

Emissions are reported in CRF tables under corresponding categories of land.

For future work on Croatian LULUCF and KP reporting update of the Register has been recognized as relevant within the LULUCF 1 project. It has been recommended this to be performed through a separate project[39]. 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.

6.15.2. Methodological issues

Data available in the Registry on forest fires can be described concearning two time periods and depending on the methods used for data collection. The first period covers time frame from 1990 to November 2006. The second period describes time from November 2006 to 2012, when the Registry was officially established based on the *Forest Act* [40]and *Ordinance*[41] provisions. In the first period, the methods of collecting data on forest fires were not legally prescribed, and Croatian forests Ltd. had been recording data and information on fires in analog 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-

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[37] *Ordinance on the method of data collection, conducting the Register and requirements for using data on forest fires* (OG 175/13)

[38] 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

[39] Ibid

[40] Ibid

[41] Ibid

compartments at 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 6.15-1, and Figure 4.15-2).

Although it has not been officially prescribed yet, 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 6.15-3). This work enabled development of the map with detailed spatiall informattion on forest fires (Figure 6.15-4).

Figure 6.15-1: 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))

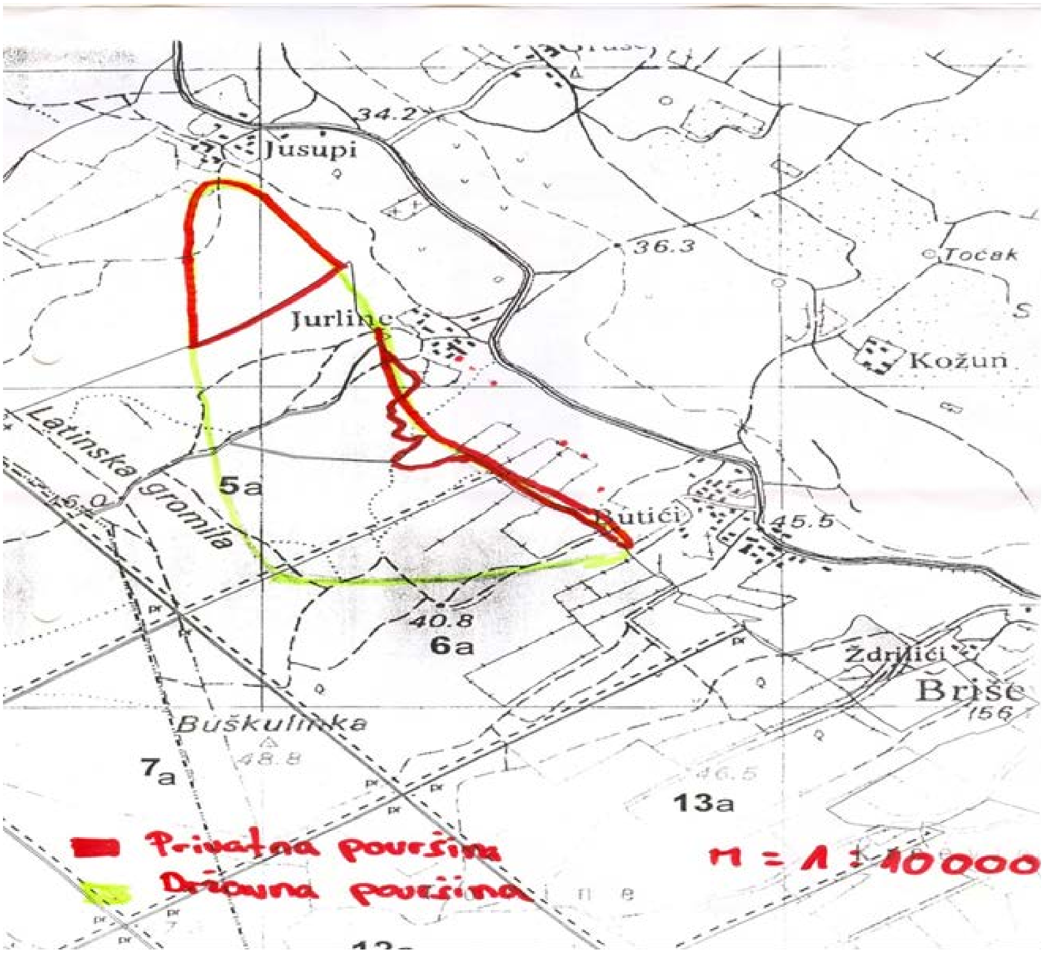


Figure 6.15-2: Map of state owned forests affected by fires in 2007 defined using GPS (Forest district Split, Forest unit Metković, Management unit Šibovnica; total affected area 77.10 ha)

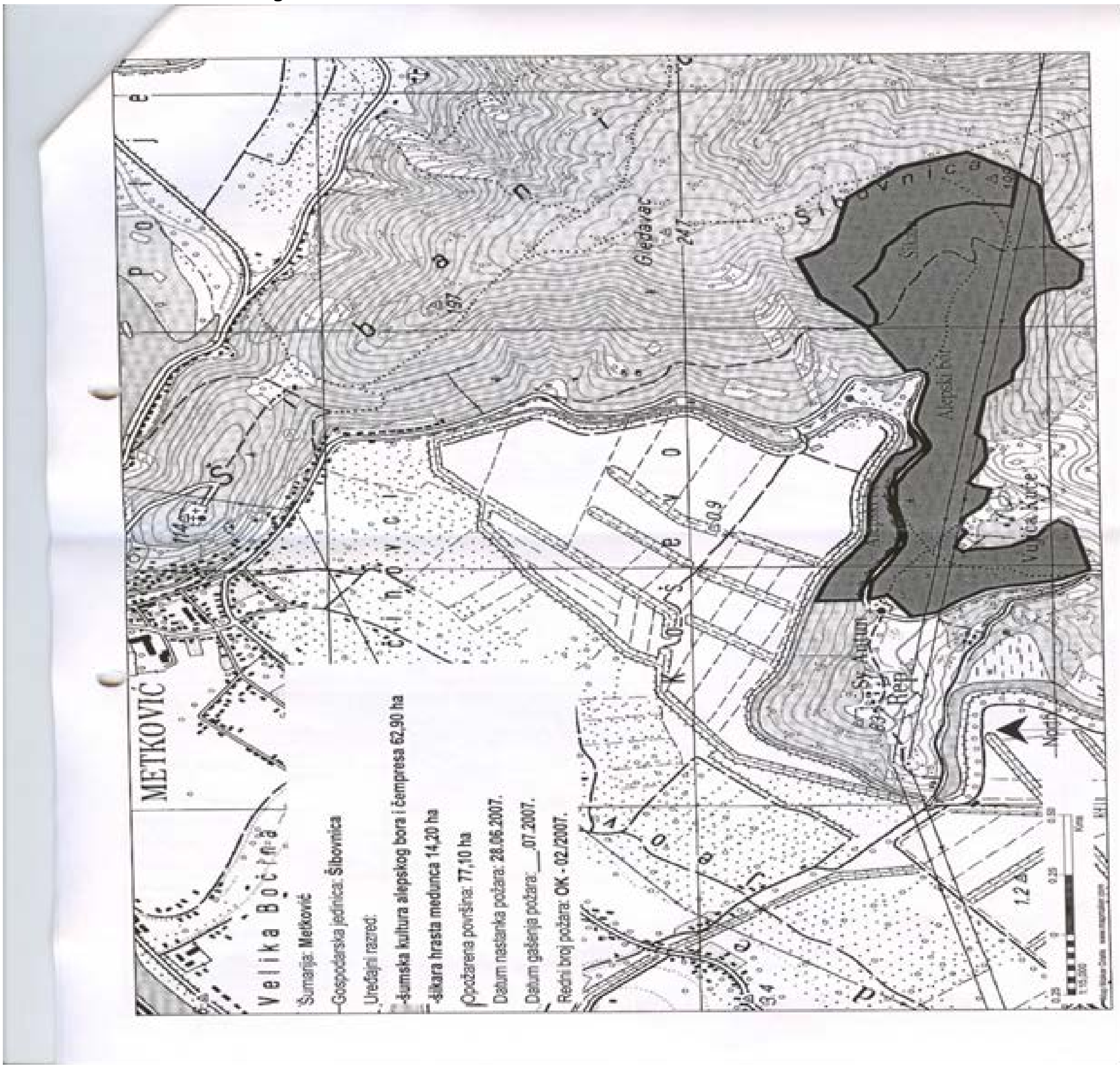


Figure 6.15-3: Map from unified GIS database on forest fires, Forest district Split, Forest unit Split, Management unit Mosor-Perun (state owned forests affected by fires (marked in pink) in 2006 and 2007; total affected area 18.43 ha)

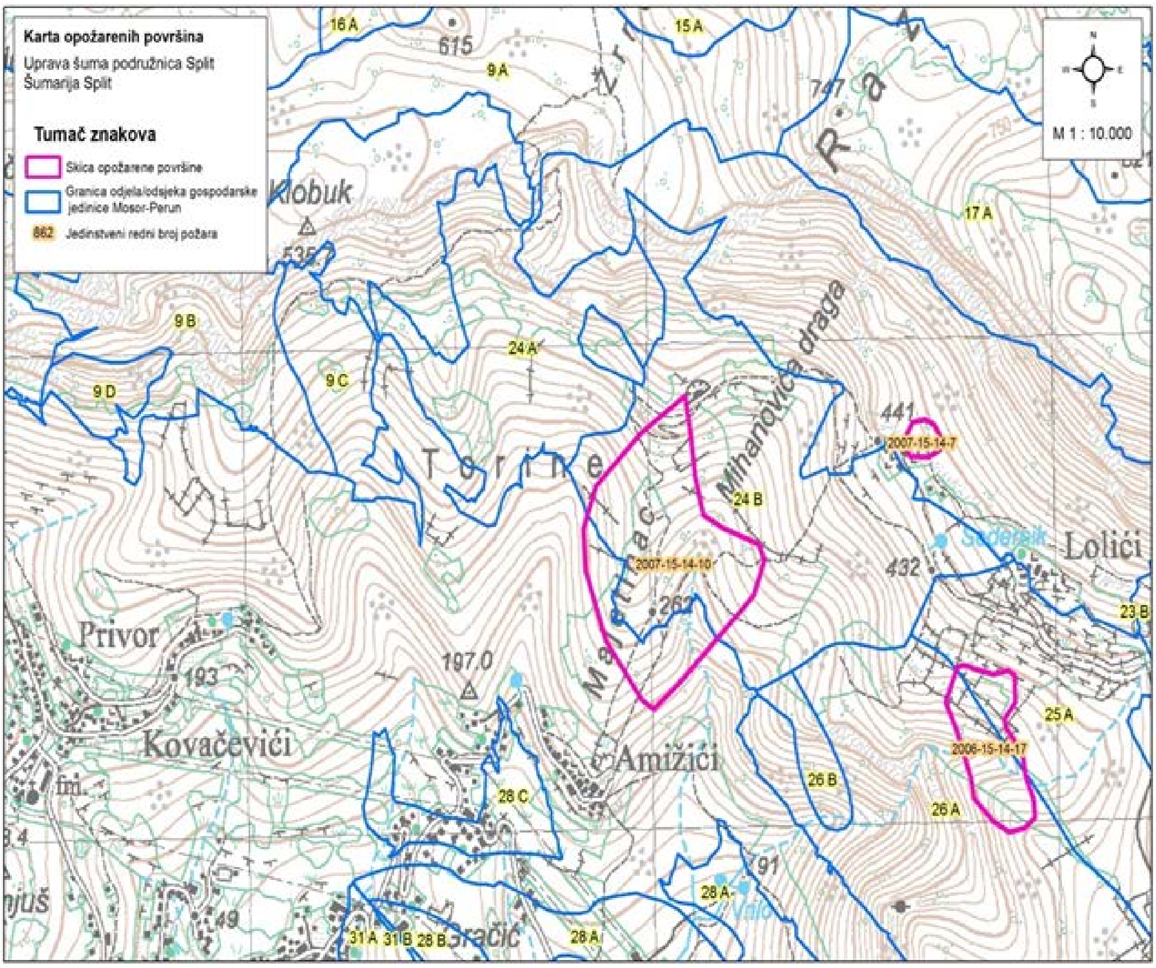
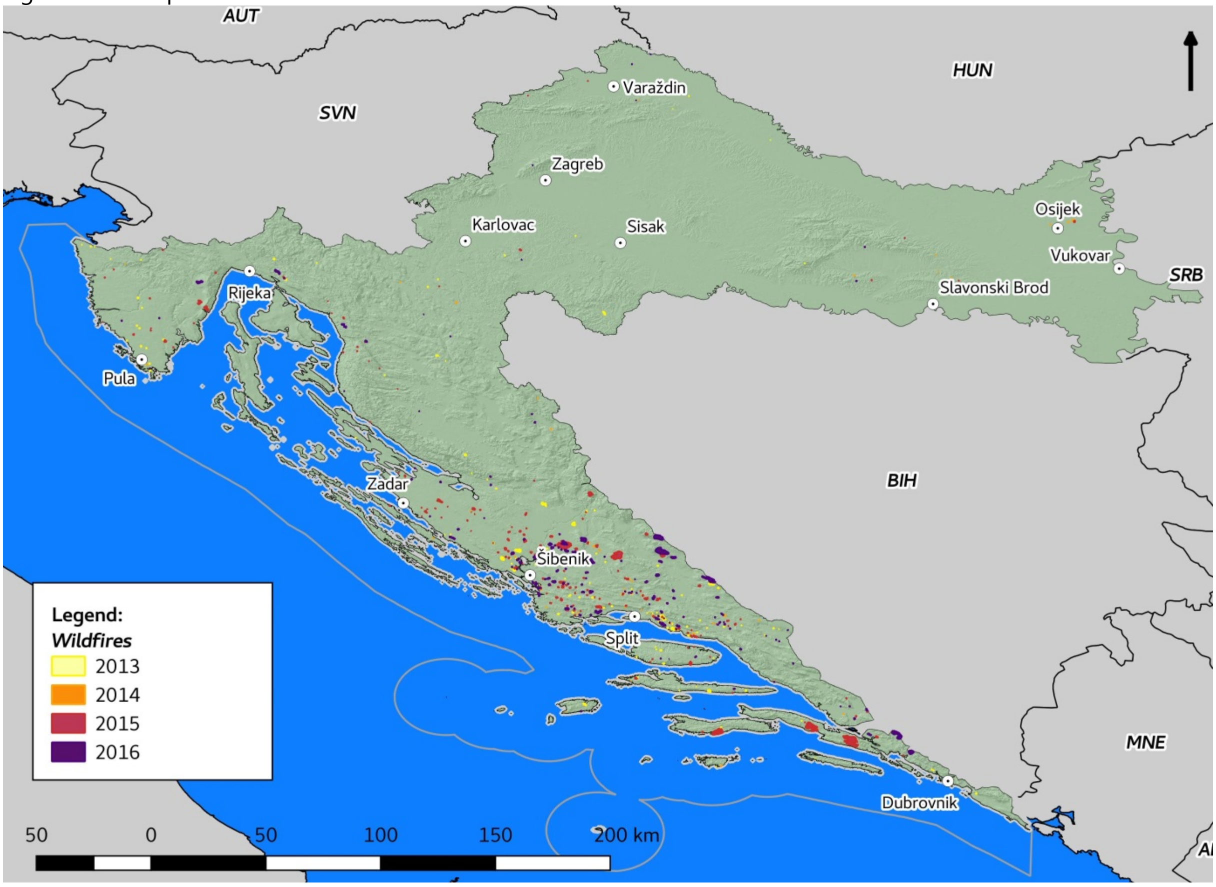


Figure 6.15-4: Spatial distribution of forest fires in Croatia 2013-2017



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 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, Cropland areas were affected by fires only in year 2015 during the whole reporting period. Additionally, since conversion from Forest land to Settlement in Croatia happens in general for infrastructure purposes, 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 category *Extra tropical forests* as this category includes all other forest types as follows: CO_2

(1569), CH_4 (4.7) and N_2O (0.26). Data on areas of forest fires are the only nationally setermined values for this estimation.

When estimating emissions in category annual Cropland remaining annual Cropland, assumption was used that the values applicable to Grassland category are valid since the Guidelines do not provide factors for aCL (exept for residues). In this case CH_4 and N_2O emissions are reported in CRF tables while CO2 emissions are supstitued by the biomass regrowth. When estimating emissions due to the fires in perennial Cropland remaining perennial Cropland category of land, the same factors as for Forest land category are used because no separate factors are prescribed for pCL by Guidelines.

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.

$$L_{fire}\ (tGHG) = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

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 CO_2 emissions ranged between 1.47 and 696.45 $ktCO_2$ equivalents, CH_4 emissions ranged between 0.01 and 3.48 while N_2O emissions ranged from 0 to 0.19 $ktCO_2$ equivalent in the reporting period 1990-2016. Emissions of these gases are significantly lower in category Land converted to Forest land.

As informed by Croatia, volume cut on areas affected by forest fires has to be separately recorded as so called random yield and it refers also to the partially burnt and harvested wood. It makes a part of total yield in a specific year that is registered in Croatia. So, the total harvest felling and the biomass losses also include volume of the partially burnt biomass. The estimation of emissions due to the biomass burning has been performed using the Tier 1 methodology and the default values for mass available for combustion and combustion factor (MB*Cf) from the 2006 GL (Table 2.4). The area of forest fires is the only nationally determined value used for this estimation.

It has been estimated (expert judgement) that in case of forest fires 60% of volume cut is fully burnt. The estimation of emissions were performed taking into account this fact. For the remaining 40% of biomass (partially) burnt, Croatia reports included elsewhere (IE) because this part of the volume cut has been included in biomass loss due to fellings.

6.15.3. Uncertainties and time-series consistency

When performing uncertainty analyses in LULUCF sector, values presented in Table 6.15-1 were used in case of forest fires. Regarding forest fire emissions, the calculations of N_2O emission uncertainty vary between -31.82% and 37.19, between -27.01 and 36.01% for CH_4 emission and between -23.12% and 36.62% for CO_2.

Table 6.15-1 Uncertainties of the emission 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

6.15.4. Category-specific QA/QC and verification

Emission estimation due to fires are included in overall QA/QC system in LULUCF sector.

6.15.5. Category-specific recalculations

There has not been recalculation in emission estimation due to the fires since NIR 2016.

6.15.6. Category-specific planned improvements

During the 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" various data and information about forest fires were collected. Detailed analyses of recently available data (that are not at the moment used for NIR 2018 reporting) are foreseen in next period in order to check their 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 and N_2O emissions from treatment of domestic and industrial wastewater 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 [42] and Waste Management Plan[43]. 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[44] is transposed in the area of waste management into the Croatian legislation by the Sustainable Waste Management Act which is adopted in 2013.

Article 53 of the Sustainable Waste Management Act defines specific waste types as well procedures and objectives for the management of these waste. One of these is the construction and demolition waste. Ordinance on construction waste and asbestos-containing waste (OG 69/2016) (suceeding Ordinance on construction waste management from 2008) stipulates the objectives of construction waste management and the manner of handling with this waste. Special attention in new Ordinance is given to measures related to waste prevention, separation at construction site and re-use. A certain part of construction and demolition waste that is disposed at landfills in the framework of industrial waste, pursuant to the Act and Ordinance, is disposed according to procedures and practices as well as municipal waste. General conditions for landfilling are prescribed in Ordinance on the methods and conditions for the landfill of waste, categories and operational requirements for waste landfills (OG 114/2015) and Council Decision 2003/33/EC of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC.

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

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[42] Sustainable Waste Management Act (OG 94/13, 73/17)

[43] Waste Management Plan of the Republic of Croatia for the period 2017 - 2022 (OG 3/17)

[44] Waste Framework Directive 2008/98/EC

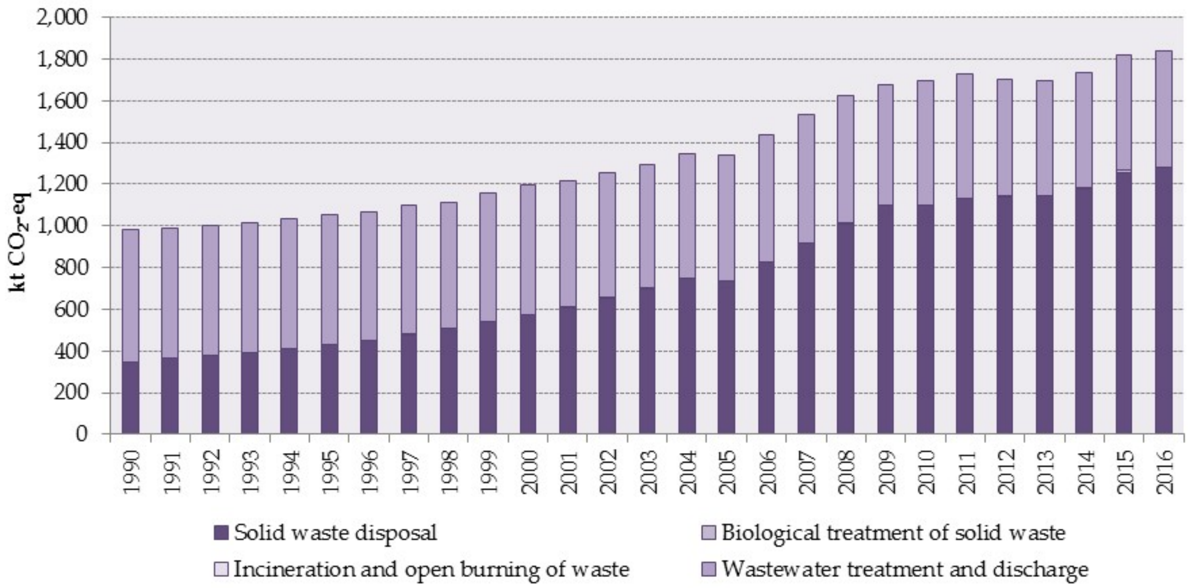
the managed controlled landfills has the lowest rank in the waste management hierarchy. According to the Waste Management Plan the backbone of the system will be recycling centres with sorting of waste. Waste management system in Croatia will be organized as integral unit of all subjects at the national, regional and local level.

Regulation on the Greenhouse Gases Emissions Monitoring, Policy and Measures for Climate Change Mitigation in the Republic of Croatia[45] 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.

7.1.1. Emission trends

The total annual emissions of GHGs from Sector 5 Waste (with related IPCC categories), expressed in kt CO_2-eq, in the period 1990 - 2016 are presented in the Figure 7.1-1.

Figure 7.1-1: Emissions of GHGs from Waste sector (1990 - 2016)



In 2016, GHG emissions from Sector 5 Waste amounted to 1,838.58 kt CO_2 equivalent, compared to 983.41 kt in 1990. These emissions constituted 7.6% of Croatia's total GHG emissions (without LULUCF) in 2016 and 3.1% of total emissions in 1990. GHG emissions from this sector increases during the reporting period:

- 69.5% of sectoral emission refer to the emission from solid waste disposal in 2016, compared to 35.4% in 1990. An increase in generated solid waste exists during the entire reporting period, particularly until 2009. Starting with 2009 there is a decrease in registered waste quantities,

[45] Regulation on the Greenhouse Gases Emissions Monitoring, Policy and Measures for Climate Change Mitigation in the Republic of Croatia (OG 5/17)

caused primary by economic crisis but also other factors regarding to effects of measures undertaken to avoid/reduce and recycle waste;

- 30.2% of sectoral emission refer to the emission from wastewater treatment and discharge in 2016, compared to 64.5% in 1990. Decrease in emissions during the entire reporting period mainly is a result of population decrease (domestic wastewater) as well economic crisis that affected the reduction of economic activity from 2008 onwards (industrial wastewater);
- biological treatment of solid waste and incineration and open burning of waste have considerably lower contribution to the sectoral emission during the reporting period.

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 2016[46]

Table								
Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2018)								
IPCC Source Categories	GHG	Key	If Column C is Yes, Criteria for Identification					Com.
5.A Solid Waste Disposal	CH_4	Yes	L1e, L2e	T1e, T2e	L1i, L2i	T1i, T2i		
5.D Wastewater Treatment and Discharge	CH_4	Yes	L1e, L2e		L1i, L2i			
5.D Wastewater Treatment and Discharge	N_2O	Yes	L2e	T2e				

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 (MSW) per capita has registered significant increasing trend until 2009. Starting with 2009 there is a decrease in quantities registered, caused primary by economic crisis but also other factors regarding to effects of measures undertaken to avoid/reduce and recycle waste. Priority is given according avoiding and reducing waste generation and reducing its hazardous properties. If waste generation can neither be avoided nor reduced, waste must be re-used-recycled and/or recovered; reasonably unusable waste must be permanently deposited in an environmentally friendly way.

Data on municipal waste quantities and, separately, on industrial waste quantities landfilled were provided by the CAEN, for period 2010 - 2016. In 2016, there was 73% municipal waste and 27% industrial waste in total waste landfilled at official landfills. From total municipal waste landfilled in 2016,

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

65% were biodegradable. From total industrial waste landfilled in 2016, 4% were biodegradable waste (sludge from wastewater treatment excluded) and 3% were sludge from wastewater treatment.

Before 2010, data reported for landfilling were based on reports from municipal waste collectors/landfill operators. There were no data of sufficient quality on the share of industrial waste in total waste landfilled, but most of the quantities sent to landfills were mixed municipal waste. Thus, the share of industrial biodegradable waste in total biodegradable waste landfilled was very small.

The total amount of municipal waste generated in Croatia in 2016 was 1,679,765 tonnes, which is in average 392 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 Commission Decision 2000/532/EC, the 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.

Of the total amount of MSW generated in 2016, 26 percent (428,466 tonnes) was separately collected fractions. The largest separately collected fraction was paper and cardboard waste (36 percent) followed by bulky waste (15 percent) and biowaste (14 percent). The recovery rate of MSW in 2016 was 21 percent. Of the total amount of municipal waste landfilled in 2016 (1,598,607 tonnes) 1,280,377 tonnes was MSW and 318,230 was other waste. The largest share in the total amount of landfilled MSW was mixed municipal waste (about 94 percent). Landfill operators report data on each waste type landfilled. Additional information on separate collection and landfilling (by waste code) is available in a 2016 Report on municipal waste in Croatia.

There has been no systematic monitoring of the composition of municipal and industrial waste. The report "The methodology for determining the composition and quantity of mixed municipal waste with the Instructions for ordering and implementation of determining the average composition of mixed municipal waste" 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 2015). This report contains data on estimated composition of mixed municipal waste for 2015.

Apart from certain amount of waste being separately collected, still a plenty of waste are disposed to landfills and there is a need to improve pre-treatment of waste prior to disposal of the residual part, in accordance with the waste management hierarchy. 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[47] and Ordinance on the waste management[48], 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 305 official landfills registered in the Republic of Croatia since 2005, remediation processes for all the locations are either in planning phase, ongoing or completed. By the end of the 2016 municipal waste was actively landfilled at 119 official sites (thereof 79 are managed, 32 are unmanaged deep and 8 are unmanaged shallow SWDSs); 103 SWDSs have been closed (waste remains on the location) (thereof 50 are managed, 6 are unmanaged deep and 47 are unmanaged shallow SWDSs) and 83 SWDS were closed with waste completely removed from those locations.

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. This activities combined with planned increase of primary separation, will further lead to the considerable reduction of biodegradable municipal and industrial waste on landfills. The Environmental Protection and Energy Efficiency Fund (EPEEF) has since 2005 co-financed many projects the purpose of which was to improve technical standards at landfills, in order to comply with requests of the EU Landfill Directive. For that purpose remediation or improvement activities have been implemented at many landfills. Some of those landfills are still active, some are closed.

From the year 2005 till the year 2016, a total number of 315 locations of landfills have been registered on which the data is collected. Out of this number, on 305 locations municipal waste has been landfilled (as explained previously). At the end of the year 2016, there have been a total of 130 active landfills, while there were a total of 185 closed landfills (at 103 locations waste is still present, others have been remediated ex-situ).

Out of the 130 landfills on which municipal waste was landfilled in 2016, 11 landfills were closed by the end of the year. Out of the 119 remaining active landfills, until the end of the year 2016 remediation has been completed on 55 locations of active municipal landfills, while on 21 locations of active municipal landfills were undergoing process of remediation and 43 locations of active municipal landfills were in the preparation state. Out of the 185 closed landfills until the end of the year 2016, remediation has been completed on 131 locations, remediation processes have been undergoing on 7 locations and 46 locations were in the preparation state. Remaining landfills do not have contracts with EPEEF for co-financing of remediation or improvement.

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 - 2016.

[47] Ordinance on the methods and conditions for the landfill of waste, categories and operational requirements for waste landfills (OG 114/15)

[48] 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 Waste Management Information System. By the Ordinance on the Environmental Pollution Register[49] 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. For example, in 2016 28% of disposed waste has not been weighed while in 2015 38% of disposed waste has not been weighed.

Main source for activity data on municipal and industrial waste is Environmental Pollution Register database and Waste Management Information System 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.

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,*

[49] Ordinance on the Environmental Pollution Register (OG 87/15)

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 Environment and Energy. Data for the quantity of disposed municipal solid waste in 2005 were obtained from *Waste Management Plan in the Republic of Croatia for 2007 - 2015 (OG 85/07, 126/10, 31/11, 46/15).* 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 generated and disposed municipal and industrial solid waste for the period 2010 - 2016 was obtained from the Environmental Pollution Register - reports delivered by the operators of active landfills. Data on the quantity of disposed biodegradable municipal and industrial solid waste as well sludge from wastewater treatment for the period 2010 - 2016 was obtained from the Waste Management Information System - reports on landfills and waste disposal.

A fluctuating trend for solid waste disposal by type at SWDS during the period 1990 - 2016 was due to multiple factors, such as the fact that AD for MSW were acquired from several sources (which has been approved by the ERT during in-country and centralized reviews) as well the influence of the economic crisis and measures undertaken to avoid or reduce solid waste disposal. Further, a number of new legislation acts have been adopted with the purpose to increase separate collection, recycling and recovery of different waste types. National schemes based on „extended producer responsibility" have been introduced for collection and recovery of different waste categories.

Waste Management Information System 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). Active landfills for municipal waste are obligated by legislation to deliver this data to CEAN in prescribed form (Form on landfills and landfilling of waste), as for the rest (closed landfills and landfills for the industrial waste) 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; Funduruljа, 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 Environment and Energy. 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 for 2007 - 2015*. 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 Waste Management Information System 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 the period 2013 - 2016 (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 (for 2013), second half of 2014 (for 2014), second half of 2015 (for 2015) and second half of 2016 (for 2016) 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 - 2016 (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 (for 2013), second half of 2014 (for 2014), second half of 2015 (for 2015) and second half of 2016 (for 2016) 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 solid waste, industrial biodegradable solid waste and sludge from wastewater treatment which is generated and disposed on different types of SWDSs in the period 1990 - 2016 are reported in the Table 7.2-2.

Table 7.2-2: The total annual quantity of municipal solid waste, industrial biodegradable solid waste and sludge from wastewater treatment which is generated and disposed on different types of SWDSs (1990 - 2016)

Year	Generated municipal 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
2014	1,637	0.82	972	305	72
2015	1,654	0.82	1,093	244	23
2016	1,678	0.78	1,146	158	12

* quantity of waste removed from remediated landfills is added

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 = 0.09) for Climate zone Boreal and Temperate/Wet, 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 - 2016. 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 - 2016, are reported in the Table 7.2-3.

Table 7.2-3: The total weighted average MCF (1990 - 2016)

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
2014	0.923
2015	0.954
2016	0.970

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 MSW and DOC for the period 1955 - 2014

Waste stream	Percent in the MSW (1955-1997)	Percent in the MSW (1998-2004)	2005-2014
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[50] and Waste Management Plan[51], include the assumed time-lags with respect to relevant EU legislation

Reference value for paper and textiles are used according to proposed default values, as well expert judgement - using drivers from above mentioned Report. Composition of waste was given for municipal waste only, not for industrial.

In 2015 the project was implemented for determination of average composition of municipal waste. Results are available for mixed municipal waste (european list of waste, waste code: 20 03 01), as well as for total municipal waste (mixed municipal waste+separately collected fractions from municipal waste). The biodegradable fraction of mixed municipal waste was determined (as 65%). This project contains data on estimated composition of mixed municipal waste for 2015 which is presented in the Table 7.2-5. This data are more detailed than the data for the previous period and therefore are shown separately. Data are in line with the *2006 IPCC Guidelines*. Default values for DOC content (in % of wet waste) for MSW component is taken from Table 2.4, Volume 5. It is used for 2015 and 2016.

Table 7.2-5: Composition of MSW and DOC for 2015 and 2016

Waste stream	Percent in the MSW (2015 and 2016)
Paper/cardboard	23.19
Textiles	3.71
Food waste	30.93
Wood	0.98
Garden and Park waste	5.68
Nappies	3.97
Rubber and Leather	0.67
Plastics	22.87
Metal	2.07
Glass	3.65
Other, inert waste	2.28
DOC	17.58

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

[50] Waste Management Strategy of the Republic of Croatia (OG 130/05)
[51] Waste Management Plan of the Republic of Croatia for 2007 - 2015 (OG 85/07, 126/10, 31/11, 46/15)

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 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 Waste Management Information System. CH_4 that is burned in a flare (without energy recovery) in the period 2004 - 2016 have been included in emission estimation. The net CH_4 emissions from waste disposal were calculated by subtracting the flared CH_4. Data on flared CH_4 for the period 2004 – 2016 are presented in the Table 7.2-6 as well in the CRF 5.A.1.a (Amount of CH_4 flared). Emissions from the use of CH_4 for electricity generation are included in the Energy sector, which is in line with the *2006 IPCC Guidelines*. Notation key IE is used in the CRF 5.A.1.a for the Amount of CH_4 for energy, for the periods 2004 - 2010 and 2013 – 2016. Allocation in the Energy sector (1.A.1.a) and nk explanation are included in the cell comments, and this information should be visible in the Reporting Table 5.A Sectoral Background Data for Waste.

A fluctuating trend for flared CH_4 during the period 2004 - 2016 was due to remediation of the landfills, which is explained in Chapter 7.2.1. It should be noted that all landfills are not equiped with the system for the collection and treatment of landfill gas. Significant reduction of flared CH_4 in 2015 and 2016 is due to the use of CH_4 for electricity generation at two largest landfill (emissions are included in the Energy sector) - more methane was energy recovered and less flared.

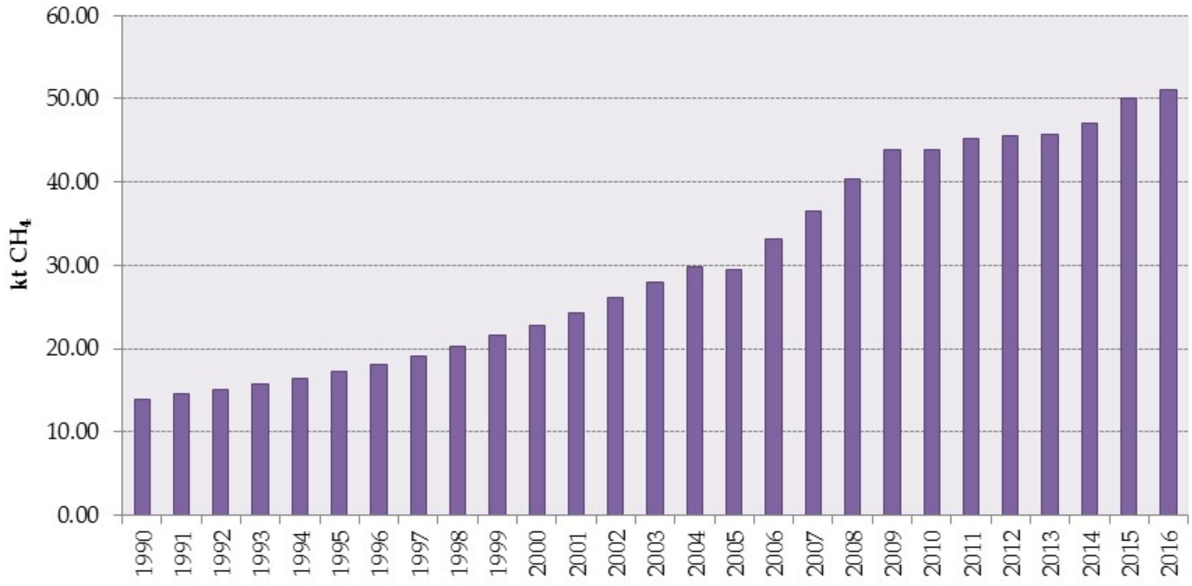
Table 7.2-6: Flared CH_4 (2004 - 2016)

Year	Recovered CH_4 (kt)
2004	0.242
2005	2.723
2006	1.615
2007	1.370
2008	1.144
2009	1.239
2010	3.818
2011	4.851
2012	5.817
2013	6.920
2014	4.057
2015	1.650
2016	1.871

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 - 2016 are presented in the Figure 7.2-1.

Figure 7.2-1: Emissions of CH_4 from Solid Waste Disposal (1990 - 2016)



Emissions of NMVOC have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

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=0.09).

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, Waste Management Information System 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) for the period 1955 – 2014. 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 2015 from the report "The methodology for determining the composition and quantity of mixed municipal waste with the Instructions for ordering and implementation of determining the average composition of mixed municipal waste", 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 2015). Data for 2015 and 2016 are more accurate.

Activity data and emission factor uncertainty was calculated in detail.

Uncertainty estimate associated with activity data amounts 50 percent, based on expert judgements. Based on the obtained information on activity data according the Annual data collection plan, expert responsible for emission calculation for the Waste sector has estimated uncertainty of the data, used values proposed by the *2006 IPCC Guidelines* that are included in the tables in the sections on uncertainty assessment for individual categories. The process undertaken to assess uncertainties using expert judgement follows the guidelines stated in Volume 1, Chapter 3 of the *2006 IPCC Guidelines*.

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.

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

There are no source-specific recalculations in this report.

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 and weighing or more accurate estimation;
- harmonization of data for DOC for the period 1995 – 2014 with the data for 2015 and 2016;
- to estimate 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.

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 associated with activity data and emission factors is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates are based on expert judgement. It should be necessary to include more experts who are directly associated with the activity data to accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

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 are included in this category. Emissions from anaerobic digestion of organic waste at biogas facilities are included in the Energy sector, because CH_4 is used for electricity generation.

CH_4 and N_2O emissions from composting of municipal and industrial solid waste, sludge and other organic waste are included in emissions estimates for the period 2007 – 2016. Data for previous years are not available. Data on the total amount of CH_4 recovered are not available for entire period 1990 - 2016.

7.3.2. Methodological issues

7.3.2.1. Composting

CH_4 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).

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 (0.24 kg N_2O/t waste treated).

Data on different types of waste (dry weight) that treated by Composting are presented in the Table 7.3-1.

Table 7.3-1: Data on different types of waste (dry weight) that treated by Composting (1990 – 2016)

Year	Municipal solid waste (t)	Industrial waste (t)	Sludge (t)	Other organic waste (t)	TOTAL WASTE (t)
1990	NE	NE	NE	NE	NE
1991	NE	NE	NE	NE	NE
1992	NE	NE	NE	NE	NE
1993	NE	NE	NE	NE	NE
1994	NE	NE	NE	NE	NE
1995	NE	NE	NE	NE	NE
1996	NE	NE	NE	NE	NE
1997	NE	NE	NE	NE	NE
1998	NE	NE	NE	NE	NE
1999	NE	NE	NE	NE	NE
2000	NE	NE	NE	NE	NE
2001	NE	NE	NE	NE	NE
2002	NE	NE	NE	NE	NE
2003	NE	NE	NE	NE	NE
2004	NE	NE	NE	NE	NE

Year	Municipal solid waste (t)	Industrial waste (t)	Sludge (t)	Other organic waste (t)	TOTAL WASTE (t)
2005	NE	NE	NE	NE	NE
2006	NE	NE	NE	NE	NE
2007	10,965.6	NE	NE	NE	10,965.6
2008	10,699.2	NE	NE	NE	10,699.2
2009	8,992.8	NE	NE	NE	8,992.8
2010	9,705.6	NE	NE	NE	9,705.6
2011	10,094.4	NE	NE	NE	10,094.4
2012	18,691.2	NE	NE	NE	18,691.2
2013	21,160.8	6,151.5	907.2	297.0	28,516.5
2014	24,099.4	3,954.9	323.6	215.6	28,593.5
2015	19,751.0	41,465.7	241.4	148.5	61,606.6
2016	21,591.4	4,928.4	258.8	657.0	27,435.6

The resulting emission of CH_4 and N_2O from Composting are presented in the Table 7.3-2.

Table 7.3-2: Emissions of CH_4 and N_2O from Composting (1990 - 2015)

Year	CH_4 emission (kt)	N_2O emission(kt)
1990	NE	NE
1991	NE	NE
1992	NE	NE
1993	NE	NE
1994	NE	NE
1995	NE	NE
1996	NE	NE
1997	NE	NE
1998	NE	NE
1999	NE	NE
2000	NE	NE
2001	NE	NE
2002	NE	NE
2003	NE	NE
2004	NE	NE
2005	NE	NE
2006	NE	NE
2007	0.044	0.003
2008	0.043	0.003
2009	0.036	0.002
2010	0.039	0.002
2011	0.040	0.002
2012	0.075	0.004
2013	0.114	0.007
2014	0.114	0.007
2015	0.246	0.015
2016	0.110	0.007

Notation key NE is used in the CRF 5.B.1.a for the period 1990 - 2006. Nk explanation that emissions are not estimated because activity data are not available are included in the cell comments, and this information should be visible in the Reporting Table 5.B Sectoral Background Data for Waste.

Notation key IE is used in the CRF 5.B.1.b for entire period 1990 - 2016. Allocation in the CRF 5.B.1.a and nk explanation are included in the cell comments, and this information should be visible in the Reporting Table 5.B Sectoral Background Data for Waste.

Emissions of CO and NH_3 have been taken from the emission inventory report 'Republic of Croatia *Informative Inventory Report for LRTAP Convention for the Year 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

7.3.2.2. Anaerobic Digestion at Biogas Facilities

CH_4 emissions from anaerobic digestion of organic waste at biogas facilities are included in the Energy sector, because CH_4 is used for electricity generation.

Notation key IE is used in the CRF 5.B.2.a and CRF 5.B.2.b for entire period in which electricity was generated (2009 – 2016). Allocation in the Energy sector (1.A.1, 1.A.4) and nk explanation are included in the cell comments, and this information should be visible in the Reporting Table 5.B Sectoral Background Data for Waste.

Activity data on amount of waste treated (kt dry matter) for the last four years (2013 – 2016) are included in the CRF 5.B.2.a, as follows: 7.1 kt for 2013; 43.5 kt for 2014, 59.9 kt for 2015 and 239.0 kt for 2016. Activity data for the period 2009 – 2012 are not available and notation key NE, with explanation provided in the cell comments, are included in the CRF 5.B.2.a. Activity data for other types of waste (industrial, sludge and other organic waste) are presented together with the data for municipal solid waste in CRF 5.B.2.a. Notation key IE, with explanation provided in the cell comments, are included in the CRF 5.B.2.b.

7.3.3. Uncertainties and time-series consistency

The uncertainties contained in CH_4 and N_2O emissions estimates from composting are related primarily to assess activity data for entire period and applied default emission factors.

Uncertainty estimate associated with activity data for composting amounts 50 percent, based on expert judgement. Based on the obtained information on activity data according the Annual data collection plan, expert responsible for emission calculation for the Waste sector has estimated uncertainty of the data, used values proposed by the *2006 IPCC Guidelines* that are included in the tables in the sections on uncertainty assessment for individual categories. The process undertaken to assess uncertainties using expert judgement follows the guidelines stated in Volume 1, Chapter 3 of the *2006 IPCC Guidelines*.

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).

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.

7.3.5. Category -specific recalculations

There are no source-specific recalculations in this report.

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 - 2016.

More information for uncertainty estimation associated with activity data and emission factors is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates are based on expert judgement. It should be necessary to include more experts who are directly associated with the activity data to accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

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 21 of Ordinance on the Environmental Pollution Register [52] the completed forms should be submitted for the previous calendar year not later than March 31 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) 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 - 2016 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 are included in emission estimates for the period 1990 - 2008. After 2008, incineration of industrial waste was performed with energy recovery and emissions are included in the Energy sector. CO_2 emission from incineration of clinical waste are included in emission estimates for the period 1990 - 2016.

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[52] Ordinance on the Environmental Pollution Register (OG 87/15)

There is no open burning of waste - it is prohibited by law. This operation is not allowed in Croatia, therefore no data collection procedures in this segment are prescribed in legislation. CEAN has no information on such occurrences, nor the information on possible or estimated quantities of open-burned waste.

7.4.2. Methodological issues

Generally, default emission factors are used for emissions calculation from category 5C because of insufficient data to use higher tier. Incineration of waste is not a key source.

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.

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.

2006 IPCC Guidelines, Volume 5, not define default emission factor for CH_4 emission from incineration of clinical waste. In *2006 IPCC Guidelines*, under Section 5.4.2 is explained that for continuous incineration of MSW and industrial waste it is good practice to apply the CH_4 emission factors provided in Volume 2, Chapter 2, Stationary combustion. For the other type of incineration (semi-continuous and batch, which is the case in Croatia) only default CH_4 emission factors for incineration of MSW is presented (Table 5.3, Page 5.20). Because MSW and clinical waste have different contents, it is assumed that CH_4 emission factors for MSW and clinical waste are different. In addition, under Section 5.4.1, page 5.11 in *2006 IPCC Guidelines* is explained that methane can also be generated in the waste bunker of incinerators if there are low oxygen levels and subsequent anaerobic processes in the waste bunker. This is only the case where wastes are wet, stored for long periods and not well agitated (which is the case of Croatia). Where the storage area gases are fed into the air supply of the incineration chamber, they will be incinerated and emissions will be reduced to insignificant levels. Regarding to this, CH_4 emission for incineration of clinical waste for entire period 1990 - 2016 is defined as NA.

2006 IPCC Guidelines, Volume 5, not define default emission factor for N_2O emission from incineration of clinical waste. In *2006 IPCC Guidelines*, under Section 5.4.3 is explained that nitrous oxide emissions from waste incineration are determined by a function of the type of technology and combustion conditions, the technology applied for emission reduction as well as the contents of the waste stream. Only default N_2O emission factors for incineration of MSW, industrial waste, sludge and sewage sludge is presented (Table 5.6, Page 5.22). Regarding to this, N_2O emission for incineration of clinical waste for entire period 1990 - 2016 is defined as NA.

Data on incineration of industrial waste for the period 1990 - 2008 have been provided by CAEN. Submitted data include hazardous waste and plastics. Data have been submitted in the aggregate form. 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 - 2016.

Data for quantity of incinerated clinical waste for the period 1990 - 2016 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 - 2016.

Data for CO_2 and N_2O emission calculation from Incineration of Waste (without energy recovery) for the period 1990 - 2016 are presented in the Table 7.4-1.

Table 7.4-1: Incinerated waste (without energy recovery) (1990 - 2016)

Year	Incinerated waste (t)	
	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
2012	0.00	93.10
2013	0.00	48.00
2014	0.00	51.08
2015	0.00	51.79
2016	0.00	55.68

The resulting annual emissions of CO_2 from Incineration of Waste in the period 1990 - 2016 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 - 2016)

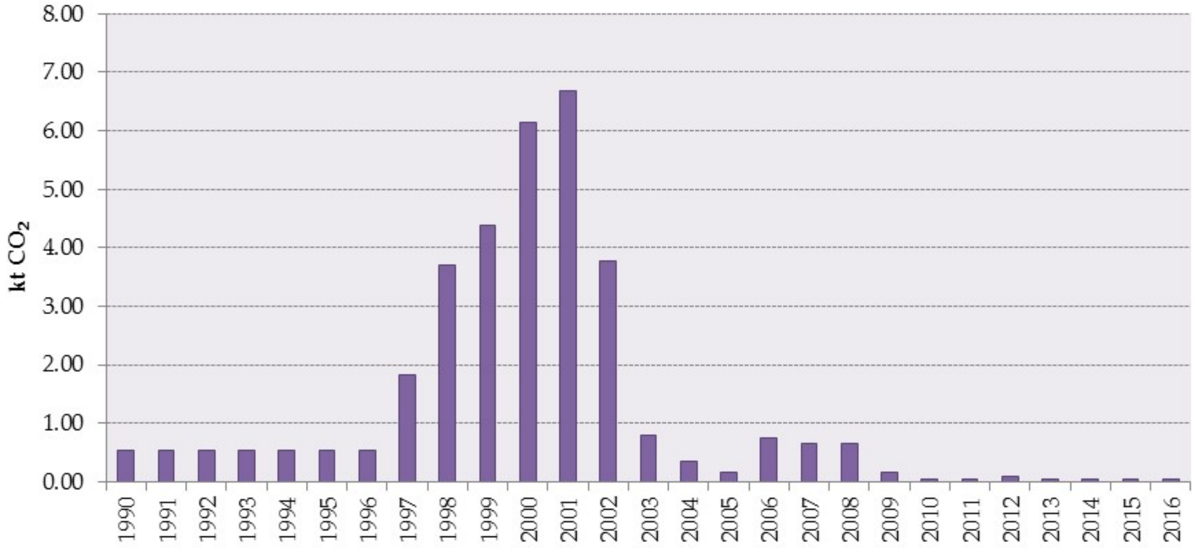
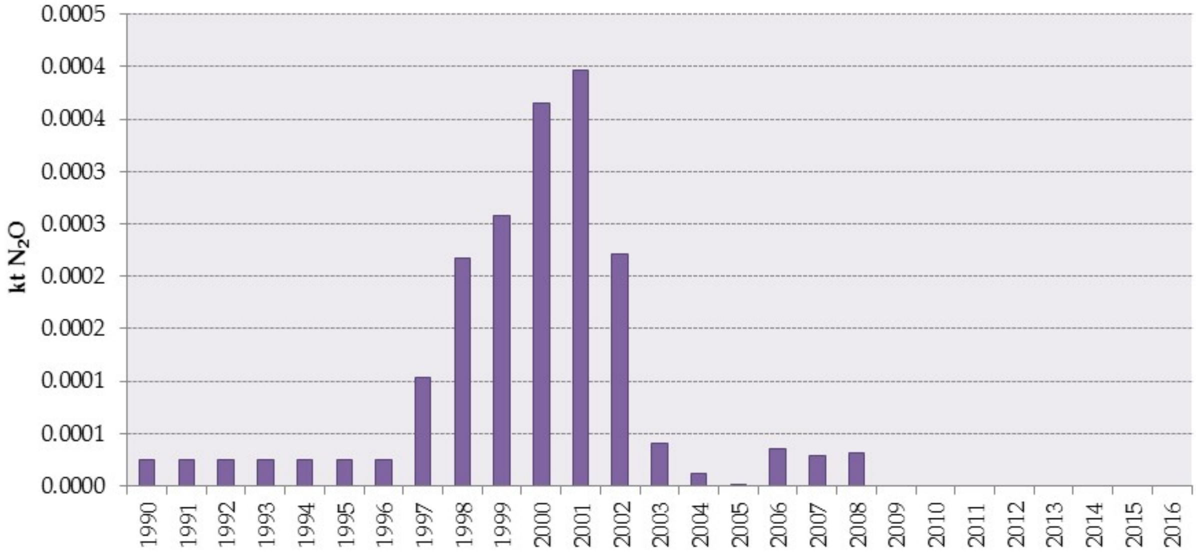


Figure 7.4-2: Emissions of N_2O from Incineration of Waste (1990 - 2016)



Notation key IE is used in the CRF 5.C.1.1.b for entire period 1990 - 2015. Allocation in the CRF 5.C.1.2.b and nk explanation are included in the cell comments, and this information should be visible in the Reporting Table 5.C Sectoral Background Data for Waste.

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 2016* Submission to the Convention on Long-range Transboundary Air Pollution'.

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 judgement. Based on the obtained information on activity data according the Annual data collection plan, expert responsible for emission calculation for the Waste sector has estimated uncertainty of the data, used values proposed by the *2006 IPCC Guidelines* that are included in the tables in the sections on uncertainty assessment for individual categories. The process undertaken to assess uncertainties using expert judgement follows the guidelines stated in Volume 1, Chapter 3 of the *2006 IPCC Guidelines*.

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.

7.4.5. Category specific recalculations

There are no source-specific recalculations in this report.

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.

The value of % of dry content of waste is not available for Croatia. Definition NA is used, as well in the *2006 IPCC Guidelines.* This should be investigated (long-term goal).

More information for uncertainty estimation associated with activity data and emission factors is required, regarding more accurate and transparent uncertainty analysis. For now, uncertainty estimates are based on expert judgement. It should be necessary to include more experts who are directly associated with the activity data to accurately determine the uncertainties of the data, thereby increasing transparency in the reporting.

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 means that there is no methane emission.

According to the Article 21 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.

State company *Croatian Waters* receive and interpret data on the systems for collection and treatment of domestic wastewater in accordance with the obligations from the Water Act (OG 153/09, 130/11, 56/13, 14/14) and relevant by-laws. The data sources are always providers of water services, and the quality of the original data depends on their internal data tracking systems and information providing, but systematic flow of information is not yet established.

Croatian Waters are working to improve the Water Information System that will include all relevant information collected directly from the water service supplier. Until the full functionality of the system and standardization of the output data and information on wastewater treatment is established, the calculations are based on potentially available data and on estimates.

In Croatia, as well as in the other EU member states, agglomerations have been identified, 767 of them (reference year is 2012), in whose territory construction of the public sewerage system for domestic wastewater and/or individual systems is planned. From the total number of identified agglomerations, 281 have an input exceeding 2000 equivalent inhabitants and whose status is required to be reported to the European Commission.

Out of the total population of Croatia (official data from the census of 2011 - 4,284,889 inhabitants), 89% resides in the settlements of mentioned 281 agglomerations for whom the construction of the public sewerage system is planned (mathematically, it would be 3,813,551 inhabitants). It is estimated that 51% of these 3,813,551 residents are connected to public drainage systems. When computing these 51%, there would be a total of 1,944,911 inhabitants. In the total population of the Republic of Croatia, these 1,944,911 inhabitants account for 45.38%. Concluding, at the Croatian level it is estimated that about 45% of the total population is connected to public drainage systems. It is considered that others have an individual solution for collecting wastewater from households.

7.5.2. Methodological issues

7.5.2.1. Domestic wastewater

Methane (CH_4) and nitrous oxide (N_2O) emissions from treatment of domestic wastewater are included in emission estimates for the period 1990 - 2016.

Methane (CH_4) emissions from 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 Croatian Water (Hrvatske vode) for 1990, 1995, 2000 and for the period 2003 - 2016. Insufficient data for years between those years have been assessed by interpolation method. Submitted data on sludge treatment show that aerobic processes are used. Fraction of DOC removed as sludge is reported to be zero for entire period 1990 - 2016. Data for CH_4 emission calculation for the period 1990 - 2016 are presented in the Table 7.5-1.

Table 7.5-1: Data for CH_4 emission calculation from Domestic Wastewater (1990 - 2016)

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
2011	21,865.31	2,450,000	53.57
2012	21,878.26	2,300,000	50.32
2013	21,900.95	2,275,700	49.84
2014	21,894.41	2,254,000	49.35
2015	21,897.40	2,232,000	48.88
2016	21,898.90	2,210,000	48.39

* data for population with individual system of drainage

No country-specific data are available for methane conversion factor. Default value for anaerobic systems (MCF = 0.5), proposed by *2006 IPCC Guidelines*, has been used for emission calculation for entire period 1990 - 2016.

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 – 2016.

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 - 2016.

According to the TERT recommendation during 2017 ESD review, technical correction were performed using recommended fraction of treated wastewater in septic tank that amounts 100 percent. Wastewater emission from septic tank depend on organic pollution (BOD_5) only and not on amount or use of water. This approach is complying with *2006 IPCC Guidelines* for estimating emissions from wastewater. Proposed values of 100% have been used for methane emission calculation for entire period 1990 - 2016.

Septic tank combines two processes. Sedimentation takes place in the upper portion of the tank, and the accumulated solids are digested by anaerobic decomposition in the lower portion. As sewage from a building enters a septic tank, its rate of flow is reduced so that the heavier solids sink to the bottom and the lighter solids including fats and grease rise to the surface. These solids are retained in the septic tank, and the clear effluent is discharged.

The following are some information on fraction of wastewater type treated by a particular type of system. All systems and parts of the public wastewater system built so far, still do not end with a functional device for treatment of domestic wastewater. It is estimated that wastewaters of 76% of the population connected to public wastewater systems are purified through public devices. At the national level – looking at the overall population of the Republic of Croatia, the share of residents whose water is purified with some of the purification processes is 35%, and the share of residents whose water is collected but not treated is about 11%.

In Croatia, the largest number of people is connected to the most common devices for the treatment of domestic wastewater - secondary wastewater treatment. The following are preliminary purification devices that are built mainly in the coastal area. Preliminary purification procedures include lower levels of processing than the first stage of treatment (removal of solids dispersed and floating matter and the release of the long sea outfalls), which allows the receiver to meet its objectives of water quality. The smallest number of devices built are for the third level of wastewater treatment, and the lowest number of inhabitants are connected to such devices.

It is estimated that, at the national level, 13% of the total population is connected to devices with preliminary purification and the primary level of treated wastewater, and approximately 21% of the total population is connected to devices with secondary and third level of wastewater treatment.

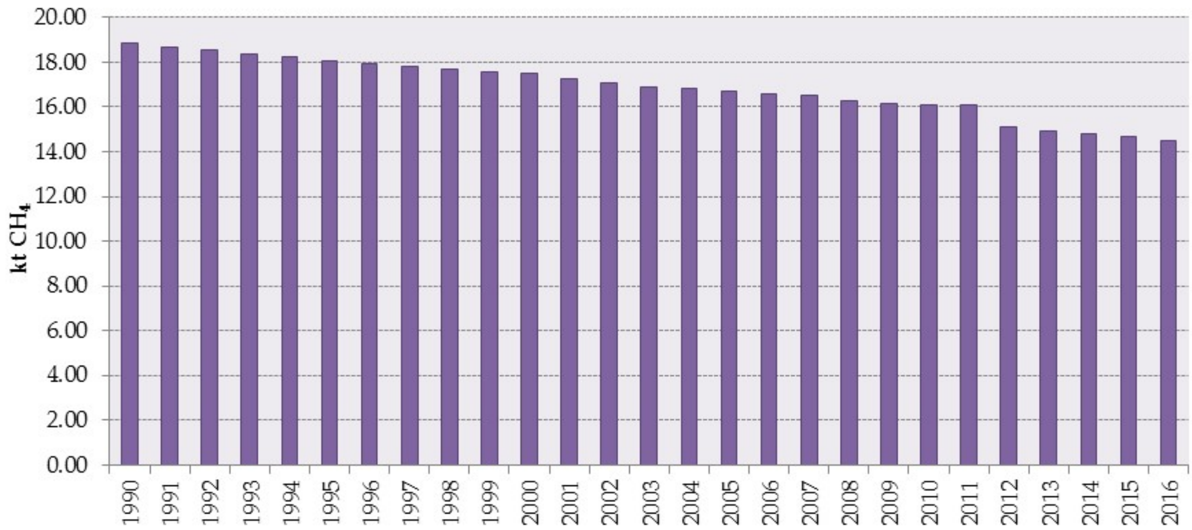
More detailed information on the procedures and technologies that are applied to devices for domestic wastewater treatment are still not collected in *Croatian Waters* in the full extent. Monitoring of such information is planned with the development of Water Information System.

Receivers of treated wastewater, as well as collected and untreated wastewater, are mainly the waterways and the sea, but release to the underground (through the soil) is rare.

Domestic water in areas where public sewerage system is not yet built, whose functioning is under competent utility company, are treated by individual treatment and discharge of wastewater. The source of information on individual solutions could be the suppliers of water services in the area of its jurisdiction. *Croatian Waters* have no sufficient information on such individual systems and estimates on the number of residents who have individual drainage are only indicative. Croatian Waters have no accurate information on individual solutions for purification and drainage (septic tanks, small individual devices etc.) and that is why the estimates included in calculation. A precondition for better information and data on individual ways of wastewater treatment is to establish a system for monitoring the source data, on the level of water suppliers.

The resulting annual emissions of CH_4 from Domestic Wastewater in the period 1990 - 2016 are presented in the Figure 7.5-1.

Figure 7.5-1: Emissions of CH_4 from Domestic Wastewater (1990 - 2016)



Nitrous oxide (N_2O) emissions from wastewater

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 - 2016 were taken from Statistical Yearbook. Croatian data on the annual per capita Protein intake value (PIV), for the period 1992 -2013, 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 from 1992 to 1994 has been used for calculation of data in 1990 and 1991. The pattern from 2010 to 2013 has been used for calculation of insufficient data for the period 2014 - 2016. Data on Population and PIV for the period 1990 - 2016 are presented in the Table 7.5-2.

Table 7.5-2: Data on population and PIV (1990 - 2016)

Year	Population	Protein intake (kg/person/yr)
1990	4,778,000	21.35
1991	4,513,000	21.38
1992	4,470,000	21.72
1993	4,641,000	20.99
1994	4,649,000	21.78

Year	Population	Protein intake (kg/person/yr)
1995	4,669,000	23.54
1996	4,494,000	23.33
1997	4,572,500	23.12
1998	4,501,000	22.83
1999	4,554,000	24.30
2000	4,381,000	24.34
2001	4,305,494	26.40
2002	4,305,384	27.81
2003	4,305,725	27.61
2004	4,310,861	27.46
2005	4,312,487	28.52
2006	4,313,530	29.38
2007	4,311,967	29.76
2008	4,309,796	30.16
2009	4,302,847	30.72
2010	4,289,857	29.44
2011	4,280,622	29.82
2012	4,267,558	30.49
2013	4,255,689	30.79
2014	4,238,389	31.33
2015	4,203,604	31.80
2016	4,174,349	32.27

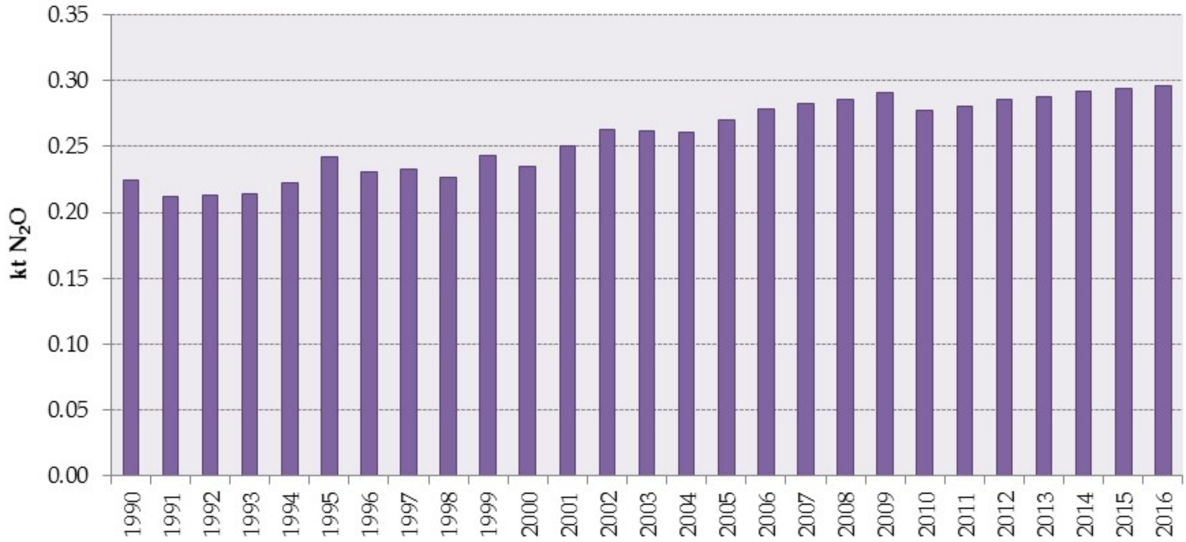
Default values of factors and parameters proposed by *2006 IPCC Guidelines* (Table 6.11) has been used for emission calculation for entire period 1990 - 2016:

- emission factor ($EF_{EFFLUENT}$) = 0.005 kg N_2O-N/kg - N;
- fraction of nitrogen in protein (F_{NPR}) = 0.16 kg N/kg protein;
- factor for non-consumed protein added to the wastewater ($F_{NON-CON}$) = 1.4;
- factor for industrial and commercial co-discharged protein into the sewer system ($F_{IND-COM}$) = 1.25;
- nitrogen removed with sludge (N_{SLUDGE}) = 0 kg N/yr.

Regarding TERT recommendation during 2017 ESD review about estimation on N_2O from municipal wastewater, there is no information on the use of garbage disposal units in households in Croatia. During review Croatia proposed to keep the Factor for non-consumed protein F (non-con) = 1.4 for developed countries instead of F (non-con) = 1.1 for developing countries, because it is necessary to do a research which can not be done in the short term. Croatia provided calculations with both of factors, F (non-con) = 1.4 and F (non-con) = 1.1 and asked TERT for confirmation on proposal to keep factor for developed countries. Competent institution should confirm assumption that less than 1% of household uses garbage disposal units. For now, information are not available. Because of that, F (non-con) = 1.4 is included in the N_2O emission calculation. Revision with F (non-con) = 1.1 will be prepared for resubmission, after confirmation of competent institution.

The resulting annual N_2O emissions from wastewater in the period 1990 - 2016 are presented in the Figure 7.5-2.

Figure 7.5-2: N_2O Emissions from Wastewater (1990 - 2016)



7.5.2.2. Industrial wastewater

Methane (CH_4) emissions from treatment of industrial wastewater are included in emission estimates for the period 1990 - 2016.

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. Central Bureau of Statistics is responsible for the data on industrial output (tonne/yr). Croatian Chamber of Economy processes the data.

Data on industrial output for the period 1990 - 2016 are presented in the Table 7.5-3.

Table 7.5-3: Data on industrial output (1990 - 2016)

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	3,522,245	656,501	2,719,302
2011	3,622,671	639,814	2,716,974
2012	3,539,366	559,322	2,430,380
2013	3,423,691	505,283	2,350,500
2014	3,604,340	506,894	2,474,924
2015	3,491,784	522,121	2,677,701
2016	3,591,059	597,989	2,636,864

* 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 2016 are available in different (aggregated) form and therefore is assessed according to data for 2015. Data on wastewater output for the period 1990 - 2016 are presented in the Table 7.5-4.

Table 7.5-4: Data on wastewater output (1990 - 2016)

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

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
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
2014	2,473,000	1,719,000	482,000
2015	3,136,000	1,484,000	500,000
2016	3,136,000	1,484,000	500,000

According to recommendation provided by the ERT during in-country review in 2012, for calculation of total organically degradable material in wastewater from industry (in kg COD/yr) it is necessary to multiply total industrial output (in tonne) with wastewater produced (in m^3/tonne product) and degradable organic component, DOC (in kg COD/m^3 wastewater).

$$t\ x\ \frac{m^3}{\mathrm{t}} x \frac{kg\ COD}{\mathrm{m}^3} = kg\ COD$$

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 6.9), has been used for emission calculation for entire period 1990 - 2016 (Table 7.5-5).

Table 7.5-5: Data on degradable organic component and wastewater produced (1990 - 2015)

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 - 2016.

Organic wastewater from industrial sources (kg COD/yr) for the period 1990 - 2016 are presented in the Table 7.5-6.

Table 7.5-6: Organic wastewater from industrial sources (1990 - 2016)

Year	Organic wastewater from industrial sources (kg COD/yr)			Total organic wastewater (kg COD/yr)
	Manufacture of food products and beverages	Manufacture of pulp, paper and paper products	Manufacture of chemicals and chemical products	
1990	384,830,928	494,480,700	666,974,280	1,546,285,908
1991	387,412,545	515,599,830	654,285,552	1,557,297,927
1992	389,994,161	536,718,960	641,596,824	1,568,309,945
1993	392,575,778	557,838,090	628,908,096	1,579,321,964
1994	395,157,395	661,536,882	616,219,368	1,672,913,645
1995	397,739,012	600,991,974	632,598,255	1,631,329,241
1996	400,320,628	542,081,484	585,923,442	1,528,325,554
1997	394,311,342	619,875,990	594,391,773	1,608,579,105
1998	421,645,826	607,538,394	476,547,684	1,505,731,904
1999	401,378,361	673,123,608	557,552,694	1,632,054,663
2000	409,672,529	788,738,634	584,368,506	1,782,779,669
2001	226,665,918	790,919,802	485,329,977	1,502,915,697
2002	241,489,797	828,474,966	467,510,925	1,537,475,688
2003	256,612,012	794,510,856	470,850,540	1,521,973,408
2004	272,033,068	826,314,210	559,757,061	1,658,104,339
2005	359,747,391	683,497,278	616,414,941	1,659,659,610
2006	394,959,469	785,560,194	590,784,426	1,771,304,089
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	254,988,991	957,178,754	546,579,716	1,758,747,461
2011	262,259,276	932,848,676	546,111,704	1,741,219,657
2012	256,228,465	815,490,789	488,506,379	1,560,225,633
2013	247,854,293	736,702,182	472,450,505	1,457,006,980
2014	260,932,204	739,050,968	497,459,727	1,497,442,899
2015	252,783,831	761,252,581	538,217,882	1,552,254,294
2016	259,970,733	871,868,585	530,009,668	1,661,848,985

There is no sufficient information on fraction of wastewater type treated by a particular type of system.

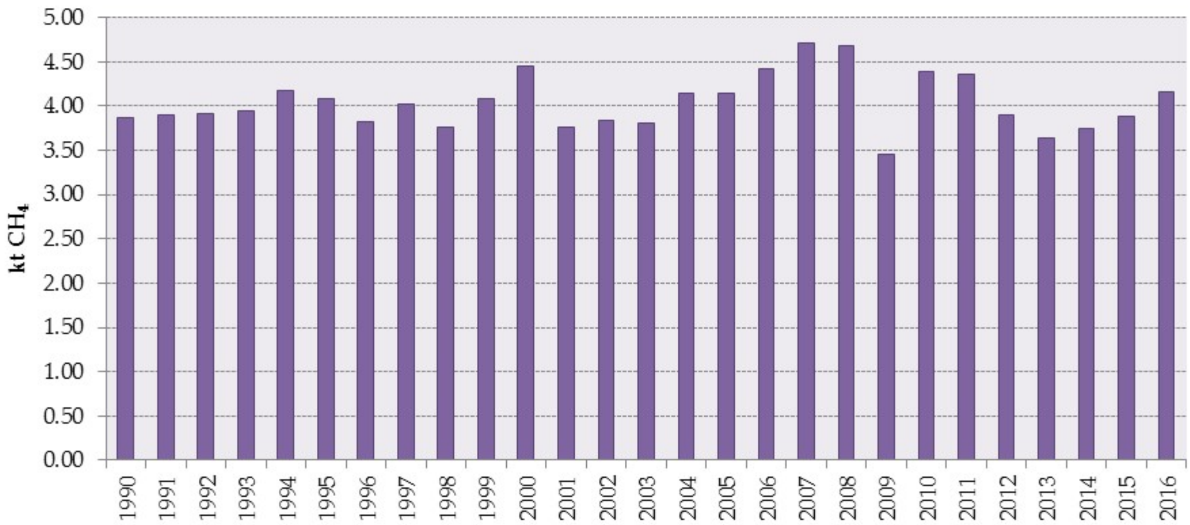
No country-specific data are available for methane conversion factor (MCF). Due to the fact that wastewaters are mostly handled aerobically, MCF is assessed to be 0.01 according to expert judgement (comparison with the other countries). This value has been used for emission calculation for entire period 1990 - 2016.

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 - 2016.

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 - 2016.

The resulting annual emissions of CH_4 from Industrial Wastewater in the period 1990 – 2016 are presented in the Figure 7.5-3.

Figure 7.5-3: Emissions of CH_4 from Industrial Wastewater (1990 - 2016)



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 method, 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.

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 to 30 percent, according to provided uncertainty assessment in *2006 IPCC Guidelines* (detailed in Annex 1).

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, according 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.

CH_4 and N_2O 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

Methane (CH_4) emissions from domestic wastewater

In the previous report, water consumption in rural areas was estimated to be 120 litres/person/day and 70% of this amount is returned to the drainage system (overflow in septic tanks). Therefore, according to expert judgement provided by Croatian Water, fraction of treated wastewater in septic tank has been estimated to be 0.3. Proposed values of 30% have been used for methane emission calculation for entire reporting period.

In this report, according to the TERT recommendation during 2017 ESD review technical correction were performed using recommended fraction of treated wastewater in septic tank that amounts 100 percent. Wastewater emission from septic tank depend on organic pollution (BOD_5) only and not on amount or use of water. This approach is complying with *2006 IPCC Guidelines* for estimating emissions from wastewater. Proposed values of 100% have been used for methane emission calculation for entire reporting period. Therefore, recalculations of CH_4 emissions were made for the period 1990 - 2015.

Nitrous oxide (N_2O) emissions from wastewater

New data on the annual per capita Protein intake value (PIV) by the FAOSTAT Statistical Database are available for the period 1994 – 2013 (Last Updates: February 13, 2017), Therefore, recalculations of N_2O emissions were made for the extrapolated years 1990 and 1991, and for all years in the period 1994 - 2015.

Industrial wastewater

New 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 for the period 2010 – 2015. Therefore, recalculations of CH_4 emissions were made for the period 2010 - 2015.

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, in order to use higher tier method for emission calculation:
  - 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 detailed information and further clarifications on discharge pathways for wastewater, particularly domestic wastewater treated in the individual system (septic tank) - a precondition for better information and data on individual ways of wastewater treatment is to establish a system for monitoring the source data, on the level of water suppliers.

Regarding TERT recommendation during 2017 ESD review about estimation on N_2O from municipal wastewater, there is no information on the use of garbage disposal units in households in Croatia. During review Croatia proposed to keep the Factor for non-consumed protein F (non-con) = 1.4 for developed countries instead of F (non-con) = 1.1 for developing countries, because it is necessary to do a research which can not be done in the short term. Croatia provided calculations with both of factors, F (non-con) = 1.4 and F (non-con) = 1.1 and asked TERT for confirmation on proposal to keep factor for developed countries. Competent institution should confirm assumption that less than 1% of household uses garbage disposal units. For now, information are not available. Because of that, F (non-con) = 1.4 is included in the N_2O emission calculation. Revision with F (non-con) = 1.1 will be prepared for resubmission, after confirmation of competent institution.

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 (SO_2), as a precursor of sulphate and aerosols, is believed to contribute negatively to the greenhouse effect. Emissions of indirect GHGs have been taken from the draft of emission inventory report 'Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2016 Submission to the Convention on Long-range Transboundary Air Pollution'.The calculations of aggregated results for the emissions of indirect gases in the period 1990-2016 are given in table 9.2-1.

Table 9.2-1: Emissions of ozone precursors and SO_2 by sectors (kt)

Polutants	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
NO_x Emission	87.26	165.20	86.89	68.61	81.10	94.20	59.02	53.11	64.22	60.50
Energy	81.00	69.12	78.74	62.82	59.22	54.29	53.86	49.71	50.14	48.72
Industrial Processes	2.74	2.61	2.38	1.57	1.18	1.08	1.01	1.07	1.08	0.96
Agriculture	2.79	3.07	3.15	2.59	2.98	2.80	2.30	2.10	2.28	2.43
LULUCF	0.74	90.40	2.62	1.63	17.72	36.02	1.86	0.23	10.71	8.39
Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO Emission	536.39	444.10	418.78	299.94	273.06	255.66	231.93	202.39	216.49	202.29
Energy	495.78	410.34	400.50	298.98	271.63	253.92	231.21	201.62	215.66	201.67
Industrial Processes	40.58	30.88	18.20	0.91	0.81	0.63	0.65	0.77	0.71	0.50
Agriculture	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
LULUCF	0.04	2.89	0.09	0.05	0.62	1.11	0.07	0.01	0.12	0.12
Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOC Emission	164.85	106.52	113.96	88.51	84.14	80.28	73.29	66.86	67.84	68.91
Energy	62.02	53.97	52.42	40.26	36.82	33.58	31.84	27.37	29.30	27.68
Industrial Processes	88.64	33.88	49.98	36.96	35.04	32.86	31.09	29.41	27.89	30.64
Agriculture	13.16	9.23	9.33	8.65	8.32	8.43	7.94	7.95	8.39	8.37
LULUCF	0.10	7.94	0.21	0.15	1.48	3.22	0.15	0.02	0.13	0.16
Waste	0.92	1.49	2.01	2.50	2.47	2.19	2.27	2.11	2.13	2.06
SO_2 Emission	134.62	51.32	58.72	35.21	29.17	25.18	16.90	13.76	15.77	14.68
Energy	133.41	50.55	58.02	35.20	29.16	25.18	16.89	13.74	15.70	14.48
Industrial Processes	1.20	0.76	0.69	0.01	0.01	0.01	0.01	0.02	0.07	0.21
Agriculture	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LULUCF	NA	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	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 2016 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 2016 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 2016 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 2016 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 1990-2015 are described in each chapter of Inventory. Difference between emissions NIR 2018 and NIR 2017 for 1990 are shown in the Table 10.1-1 while for 2015 are shown in Table 10.1-2.

Table 10.1-1: Difference between emissions estimated in NIR 2018 and NIR 2017 for 1990

Difference between NIR 2018 and NIR 2017 submission for 1990	CO_2(1)	CH_4	N_2O	HFCs, PFCs, SF_6, NF_3	Total
	CO_2 equivalent (kt)				
Total (net emissions)(1)	25.6	610.3	80.4	NO	716.4
1. Energy	0.0	0.0	0.0	NO	0.0
A. Fuel combustion (sectoral approach)	0.0	0.0	0.0	NO	0.0
B. Fugitive emissions from fuels	0.0	0.0	0.0	NO	0.0
2. Industrial processes and product use	51.9	0.0	0.0	NO	51.9
A. Mineral industry	0.0	NO	NO	NO	0.0
B. Chemical industry	6.6	0.0	0.0	NO	6.6
C. Metal industry	0.0	0.0	NO	NO	0.0
D. Non-energy products from fuels and solvent use	45.3	NO	NO	NO	45.3
E. Electronic industry	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes	NO	NO	NO	NO	NO
G. Other product manufacture and use	NO	NO	0.0	NO	0.0
3. Agriculture	0.0	280.8	78.5	NO	359.2
A. Enteric fermentation	NO	194.0	NO	NO	194.0
B. Manure management	NO	86.8	37.7	NO	124.6
C. Rice cultivation	NO	NO	NO	NO	NO
D. Agricultural soils	NO	NO	40.7	NO	40.7
E. Prescribed burning of savannas	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	NO	NO	NO	NO	NO
G. Liming	NO	NO	NO	NO	NO
H. Urea application	0.0	NO	NO	NO	0.0
4. Land use, land-use change and forestry(1)	-26.2	0.0	2.1	NO	-24.2
A. Forest land	9.9	0.0	0.0	NO	9.9
B. Cropland	30.5	NO	0.1	NO	30.5
C. Grassland	-25.2	0.0	0.0	NO	-25.2
D. Wetlands	-39.6	NO	-3.6	NO	-43.2
E. Settlements	-1.8	NO	5.6	NO	3.8
F. Other land	NO	NO	NO	NO	NO
G. Harvested wood products	0.0	NO	NO	NO	0.0
5. Waste	0.0	329.5	-0.1	NO	329.4
A. Solid waste disposal	NO	0.0	NO	NO	0.0
B. Biological treatment of solid waste	NO	NO	NO	NO	NO
C. Incineration and open burning of waste	0.0	NO	0.0	NO	0.0
D. Waste water treatment and discharge	NO	329.5	-0.1	NO	329.4
Total CO_2 equivalent emissions without land use, land-use change and forestry					740.54
Total CO_2 equivalent emissions with land use, land-use change and forestry					716.37

Table 10.1-2: Difference between emissions estimated in NIR 2018 and NIR 2017 for 2015

Difference between NIR 2018 and NIR 2017 submission for 2015	CO_2(1)	CH_4	N_2O	HFCs, PFCs, SF6, NF3	Total
	CO_2 equivalent (kt)				
Total (net emissions)(1)	-325.9	518.6	114.8	-0.04	307.4
1. Energy	0.0	0.0	0.0	NO	0.0
A. Fuel combustion (sectoral approach)	0.0	0.0	0.0	NO	0.0
B. Fugitive emissions from fuels	0.0	0.0	0.0	NO	0.0
2. Industrial processes and product use	77.8	0.0	26.4	-0.04	104.2
A. Mineral industry	27.4	NO	NO	NO	27.4
B. Chemical industry	35.2	0.0	0.0	NO	35.2
C. Metal industry	0.0	NO	NO	NO	0.0
D. Non-energy products from fuels and solvent use	15.2	NO	NO	NO	15.2
E. Electronic industry	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes	NO	NO	NO	0.01	0.0
G. Other product manufacture and use	NO	NO	26.4	-0.05	26.4
3. Agriculture	0.0	261.6	58.3	NO	319.9
A. Enteric fermentation	NO	161.9	NO	NO	161.9
B. Manure management	NO	99.7	20.9	NO	120.5
C. Rice cultivation	NO	NO	NO	NO	NO
D. Agricultural soils	NO	NO	37.4	NO	37.4
E. Prescribed burning of savannas	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	NO	NO	NO	NO	NO
G. Liming	0.0	NO	NO	NO	0.0
H. Urea application	0.0	NO	NO	NO	0.0
4. Land use, land-use change and forestry(1)	-403.8	0.0	24.7	NO	-379.1
A. Forest land	148.7	0.0	0.0	NO	148.7
B. Cropland	68.1	0.0	-0.4	NO	67.8
C. Grassland	-39.3	0.0	0.0	NO	-39.3
D. Wetlands	7.3	NO	1.3	NO	8.6
E. Settlements	91.3	NO	23.7	NO	115.0
F. Other land	NO	NO	NO	NO	NO
G. Harvested wood products	-679.9	NO	NO	NO	-679.9
5. Waste	0.0	257.0	5.4	NO	262.4
A. Solid waste disposal	NO	0.0	NO	NO	0.0
B. Biological treatment of solid waste	NO	0.0	0.0	NO	0.0
C. Incineration and open burning of waste	0.0	NO	NO	NO	0.0
D. Waste water treatment and discharge	NO	257.0	5.4	NO	262.4
Total CO_2 equivalent emissions without land use, land-use change and forestry					686.47
Total CO_2 equivalent emissions with land use, land-use change and forestry					307.39

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 2017)

In 2018 Inventory recalculations are mainly made according to ESD and UNFCCC experts review teams. Detailed information on reasons for recalculations of the 1990 and 2016 referred to in Article 7(1)(e) of Regulation (EU) No 525/2013 are given in table 10.4-1.

10.3. Implications for emission trends, including time-series consistency

In 2018 Inventory recalculations are mainly made according to ESD and UNFCCC experts review teams and because of correction of errors and usage of higher tier metod for emission calculation.

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 10.4-3 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 Improvement Plan and approved by competent authorities. This recalculations were performed in NIR 2018.

Table 10.4-1: Recommendations from the last draft of ARR with the status of implementation

CRF category / issue	Review recommendation		MS response / status of implementation	Chap. NIR
Energy sector				
1.A. Fuel Combustion-Sectoral Approach – Liquid fuels – CO_2, Accuracy	In 2012, the difference between the reference approach and the sectoral approach was more than 2% for liquid fuels and the Party didn't provide any explanation for such difference in the NIR	E.14	Implemented	3.2.1
1.A.2 Manufacturing Industries and Construction – CO_2, CH_4, N_2O (22, 2014) Consistency	Improve on the consistency of the NIR, time-series consistency is necessary from the base year	E.8	embedded in Annual Improvement Plan	3.2.5.6.
Fuel combustion-reference approach – [natural gas] – CO_2	ERT recommends the party to provide a more detailed and transparent explanation for the observed CO_2 emission differences between the reference approach and the sectoral approach	E.2	Implemented	3.2.1.
International bunkers and multilateral operations – Liquid fuels – [CO_2] (26, 2014) ([27, 2013]) Transparency	ERT recommends the party to provide a detailed explanation of the factors contributing to decreases in bunker fuel consumption and associated CO_2 emissions.	E.6	Implemented	3.2.2.

CRF category / issue	Review recommendation		MS response / status of implementation	Chap. NIR
1.A.1.a Public electricity and heat production – [Coal, Fuel oil, natural gas] – CO_2, CH_4, N_2O (28, 2014) Accuracy	ERT recommends the party to take steps to obtain and use plant-specific CO_2 EFs to improve the accuracy of emission estimates	E.15	embedded in Annual Improvement Plan	3.2.4.6.
1.A.3.a. Domestic aviation-liquid fuels CO_2	The ERT recommends that Croatia provide a description of the methodology used to determine the fuel consumption on domestic and international aviation in the NIR	E.17.	Implemented	3.2.6.2.
1.B.2 Natural gas – CO_2, CH_4, N_2O Transparency	The ERT recommend the Party to Provide a description of the country specific methodology used for the estimation of emission from natural gas scrubbing in the next submission	-	Implemented	3.3.2.
1.B.1.a Coal mining and handling – Solid fuels – CH_4 (33, 2014) (31, 2013) (57, 2012) Accuracy	ERT recommends the party to use actual coal production figures for estimating emissions from coal mining and handling.	E.10	embedded in Annual Improvement Plan	3.3.1.5.
Other (mobile) – [Liquid fuels – CO_2, CH_4, N_2O] (35, 2014) Transparency	ERT recommends the party to indicate in the NIR the category under which military fuel use has been included. It should be done in a way to improve transparency of reporting without affecting the confidentiality of information.	E.11	Implemented	3.2.8.
Industrial processes and product use				
Issues and/or problems raised in the previous review report of Croatia: issues not solved				

CRF category / issue	Review recommendation		MS response / status of implementation	Chap. NIR
IPPU, 2.C.2 Ferroalloys production – CO_2 Transparency, Accuracy	Provide more details on the plans to increase the transparency and accuracy of its estimates by obtaining AD for ferroalloys production to replace the interpolated data.	40, 2014 40, 2013	Information is provided in the NIR 2018. Comparison the estimates of Tier 1 and Tier 2 is presented.	4.4.2.2.
IPPU, 2.F. Product uses as substitutes for ozone depleting substances – PFCs, HFCs Accuracy	Continue conducting surveys on the status of disposal of refrigeration and air-conditioning equipment and include the results in the NIR.	41, 2013 41, 2014	Information is provided in the NIR 2018. Ministry of Environment and Energy (MEE) is responsible for data collection. For now, data are not collected.	4.7.1.1.
Waste, 5.C.1 Waste incineration – CO_2, CH_4, N_2O Transparency	Identify the technologies applied in the incineration of hazardous waste and estimate N_2O emissions from waste incineration.	83, 2014 79, 2013 120, 2012	Information is provided in the NIR 2018. Partly solved. Croatian Agency for the Environment and Nature (CAEN) is responsible for data collection. Explanation on incineration of clinical waste is provided.	7.4.2.
Provisional main findings made during the 2016 technical review				
IPPU, 2.B.8 Petrochemical and carbon black production – CO_2, Accuracy	A tier 1 approach is used to estimate CO_2 emissions for the petrochemical and carbon black category. This category has been identified as a key category. It is recommended to use a higher tier to calculate emissions for this category.	I.9	Not implemented. For now, data for using higher tier methodology are not available. Majority of production of petrochemicals and carbon black was halted several years ago, which has consequently decreased the possibility to collect data for using higher tier methodology. It was included in the Annual data collection plan and would be collected in the future if it will be possible.	4.3.8.6.

CRF category / issue	Review recommendation		MS response / status of implementation	Chap. NIR
IPPU, 2.C.2 Ferroalloys production – CO_2, Accuracy	Explore the use of a combined approach using both tier 1 and tier 2. The tier 2 would be used for the most recent year and tier 1 to ensure the consistency in time-series. Estimates of tier 1 and 2 should be compared to support this approach.	I.10	Comparison for Tier 1 and Tier 2 approach has been made. Data for Tier 2 approach seem unreliable, particularly for the last two years. Due to this fact, Tier 1 methodology has been used for emissions calculation. There is no possibility for improvements for this category.	4.4.2.6.
IPPU, 2.D Non-energy products from fuels and solvents use – CO_2, Accuracy	Collect the necessary activity data in order to separate paraffin wax from lubricants and to use a higher tier to calculate emissions for each significant subcategory, 2D1, 2D2 and 2D3.	I.12	Separate data for lubricant and paraffin wax use are reported in the Energy Balance for the period 1999 – 2016. For the period 1990 – 2008, separation of aggregated data have been performed according to estimation on share in total quantity that should be further investigated. Trend analysis should be carried out so that all necessary data and information will be collected at time and to the extent for an accurate and transparent emission calculation. In addition, more detailed information about use of paraffin wax should be investigated for future reports (long-term goal). It was included in the Annual data collection plan. Higher tier is used for 2D3 – Solvent use.	4.5.1.6. 4.5.2.6. 4.5.3.2.
IPPU, 2.C.3 Aluminium production – CO_2, PFC, Accuracy	Further research the activity data for anode and paste consumption for the aluminium produced in 1990 and 1991 in order to use higher tier methodology.	I.11	Data for using higher tier methodology are not available. Primary aluminium production were closed at the end of 1991, which has consequently decreased the possibility to collect the data for using higher tier methodology. It was included in the Annual data collection plan and would be collected in the future if it will be possible.	4.4.3.6.
IPPU, 2.F.2 Foam blowing agents – HFC 152-a, Accuracy	Research the type of foam application used to verify if the foam cell application is of open cell or closed cell application and recalculate the emissions using the methodology described in Section 7.4.2 in Volume 3 of the 2006 IPCC Guidelines if necessary.	I.13	Analysis of the type of foam application used (open cells or closed cells) should be verified. For now is assumed to be closed cells. It was included in the Annual data collection plan.	4.7.2.6.

CRF category / issue	Review recommendation		MS response / status of implementation	Chap. NIR
IPPU, 2.A.4 Other process uses of carbonates – CO_2, Transparency	Provide an explanation clarifying the source activities of the emissions reported in 2.A.4. Report for category 2.A.4 according to the subcategories suggested by the 2006 IPCC Guidelines.	I.7	Emissions from consumption of limestone, dolomite and soda ash for glass production, as well emissions from consumption of limestone and dolomite in iron and cast production, during the entire production processes, are reported in the respective source categories – 2.A.3 and 2.C.1. Therefore, all emissions from uses of carbonates except emissions included into 2.A.3 and 2.C.1 are included into 2.A.4. Subcategories Ceramics, Other uses of carbonates and Other uses of soda ash are included into 2.A.4, according to the 2006 IPCC Guidelines.	4.2.4.1. 4.2.4.2.
Agriculture				
General (agriculture) – CH_4, Accuracy	In the assessment report, significant inter-annual changes in the IEF between 2013 and 2014, for Mature dairy cattle and Other mature cattle have been found. Iinter-annual changes are not explained in the inventory, recommends that Croatia correct the errors in the next inventory submission		Implemented	5.2.5
3.B Manure management – CH_4 Adherence to UNFCCC Annex I inventory reporting guidelines	Fill the additional information CRF table 3.B(a) for the livestock species whose CH_4 manure management emissions were estimated based on a Tier 2 methodology, in order to improve the completeness of the inventory and/or recommends the Party to include such information in the NIR.	A.10	Under implementation	5.2.2
3.D.a.2 Organic N fertilizers – N_2O, Transparency	In table 5.5-2 in the NIR, Croatia included values for the average nitrogen content in the sewage sludge applied to	A.11	Implemented	5.5.1.2

CRF category / issue	Review recommendation		MS response / status of implementation	Chap. NIR
	soils, but did not include detailed information on the source of the presented data. In order to improve the transparency of data and information in the inventory, ERT recommends that Croatia include in the NIR the explanation provided during the review.			
3.D.a.3 Crop residues – N_2O, Transparency	In Table 5.5-5 in the NIR, Croatia included the values for the parameter dry matter fraction of different harvested crops from inventories of Slovenia, Portugal and Hungary; no rationale for using these values is included in the NIR In order to improve the transparency of data and information in the inventory, ERT recommends Croatia to include in the NIR the explanation provided during the review.	A.12	Implemented	5.5.1.2
LULUCF				
LULUCF – general	The ERT recommends that Croatia continue enhancing the transparency of its reporting, including in the category-specific recalculations chapter of the inventory report detailed information on all recalculations performed in comparison to the previous inventory submission.		Implemented in NIR 2018 and will be continued in further submissions	LULUCF – general
LULUCF - general	The ERT recommends that Croatia make efforts to report separately carbon stock changes in the litter and soil organic pools in land-use change categories. In addition, the ERT recommends that Croatia reports on the progress made with regard to the new soil project in the next annual submission.	L.12	Performed	LULUCF - general
4.A.1	The ERT recommends that Croatia make significant efforts to use the results of National Forest Resources Inventory to improve the accuracy of estimations. Further, the ERT		Planned for NIR 2019	4.A.1

CRF category / issue	Review recommendation		MS response / status of implementation	Chap. NIR
	recommends that Croatia provide detailed information on the progress made in the official approval procedures of the NFI results in the next annual submission.			
4.A.2	The ERT recommends that Croatia estimate and report emissions and removals associated with carbon stock changes in the dead wood pool in the next submission. Further the ERT recommends that Croatia provide detailed information on the analysis performed and progress made with regard to data collected through the CRONFI process, and whether those data cover both dead wood and litter pools.	L.16	Planned for NIR 2019	4.A.2
LULUCF-general	The ERT recommends that Croatia perform significance analysis based on principles and following guidance provided in 2006 IPCC Guidelines, and to provide detailed information on the results of such analysis in its next annual inventory submission. Further the ERT recommends that Croatia collect the necessary data to allow use for higher than tier 1 methods for the key categories and significant pools in future submissions.	L.13	Planned for NIR 2019	LULUCF-general
4.B.2	The ERT recommends that Croatia estimate and report carbon stock changes in dead wood pool in forest land converted to cropland in the next submission. For that purpose Croatia can either use national data as a first choice, or further examine the use of data from neigboring countries with similar ecological, climatic, and management practices regime. Further the ERT recommends that Croatia provide detailed information on the progress made in the official approval procedures of the NFI results with regard to DOM pool in the next annual submission.	L.17	Planned for NIR 2019	4.B.2

CRF category / issue	Review recommendation		MS response / status of implementation	Chap. NIR
LULUCF - General	The ERT recommends that Croatia correct all the inconsistencies identified within the NIR and between the NIR and the CRF Tables, in the next submission. In addition, the ERT recommends that Croatia further improve the QA/QC activities in order to identify, and correct such inconsistencies during the inventory preparation process.		Performed	LULUCF - General
LULUCF - General	The ERT recommends that Croatia improve its QA/QC system and correct the land use matrices for the different land use, land-use change categories in the next submission. The ERT recommends that Croatia pay special attention to the consistency of the land area reporting across the time-series, ensuring that the total country area reported is constant in the whole inventory period both in CRF Table 4.1 and the background Tables 4.A-4.F. Further, in order to improve transparency of the inventory report, the ERT recommends that Croatia provide transparent information on the 20 years land use, land-use changes area in its next submission by including a set of 20 years land-use matrices in its NIR from 1990 to the latest inventory year.	L.14	Performed	LULUCF - General
4 (V) Biomass burning	The ERT recommends that Croatia estimate and report CO_2 emissions from biomass burnt and combusted in forest land, following the guidance provided in 2006 IPCC guidelines in order to avoid underestimation of emissions from biomass burning in the next submission.	L.19	Implemented	4 (V) Biomass burning
4 (IV) Indirect N_2O emissions from managed soils	The ERT recommends that Croatia estimate indirect N_2O emissions associated with loss of soil organic matter resulting from change of land use or management on mineral soils and report those emissions in CRF Table 4(IV), following the guidance of footnotes (2), (4), and guidance provided in 2006 IPCC guidelines	L.18	Implemented	4 (IV) Indirect N_2O emissions from managed soils

CRF category / issue	Review recommendation		MS response / status of implementation	Chap. NIR
4.A.1	The ERT recommends that Croatia further investigate and collect additional data in order to estimate and report carbon stock losses from the living biomass pool in "Out of yield" forest land remaining forest land in the next submission.	L.15	Additional analyse and further information will be presented in NIR 2019	4.A.1
Waste				
Waste, 5.A Solid waste disposal on land, Transparency	Clarification on the practices adopted for the disposal of construction and demolition solid waste material.	W.8	Implemented	7.1.
Waste, 5.A Solid waste disposal on land – CH_4, Transparency	Clarification on the procedures associated to solid waste separation process regarding the Croatian policy for waste prevention and management.	W.9	Implemented	7.1.
Waste, 5.A Solid waste disposal on land – CH_4, Transparency	Clarification on the types of measures to reduce the impact of waste disposal to the environment and the impacts of such activities the emission of GHGs on the solid waste disposal sector.		Implemented	7.1. 7.2.1 7.2.2.
Waste, 5.A Solid waste disposal on land – CH_4, Transparency	Clarification of the particular instable trend of solid waste disposal on site by types of SWDS s from 1990-2014.		Implemented	7.2.1. 7.2.2.
KP-LULUCF				

CRF category / issue	Review recommendation		MS response / status of implementation	Chap. NIR
	In addition, the ERT recommends that Croatia further improve the QA/QC activities in order to identify, and correct such inconsistencies during the inventory preparation process.	General	Performed	
	The ERT recommends that Croatia further investigate and collect additional data in order to estimate and report carbon stock losses from the living biomass pool in "Out of yield" forests under forest management activity in the next submission.	KL.6	Additional analyse and further information will be presented in NIR 2019	
	The ERT recommends that Croatia estimate and report CO2 emissions from biomass burnt and combusted in land under forest management, following the guidance provided in IPCC guidelines in order to avoid underestimation of emissions from biomass burning in the next submission.		Implemented	6.15.1
	The ERT recommends that Croatia exclude from the estimation and reporting of the HWP contribution those HWP originating from deforestation events (to zero the net contribution to the national total net CO2 emissions), and exclude also all HWP from forests already accounted for in the 1st commitment period on the basis of instantaneous oxidation, in accordance with paragraphs 16, and 31, annex to Decision 2/CMP.7, in the next submission.	KL.8	HWP originating from the deforestation are exempted from the estimation.	
	Since 2006 Guidelines do not provide information about exemption of HWP already accounted for in the 1st CP, Croatia intends to do this in one of following submissions.			11.3.1.4

CRF category / issue	Review recommendation		MS response / status of implementation	Chap. NIR
	The ERT recommends that Croatia make use of the already existing national data for all the types of ND for which intends to apply the ND provision. The ERT recommends that Croatia collect the updated data expected as a result of the on-going project for that purpose, as soon as possible. The ERT recommends that Croatia use the appropriate methodologies described in decision 2/CMP.7, annex, paragraph 33, and footnotes (7)–(9) to the annex of decision 2/CMP.7, following the guidance provided in the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (chapters 2.3.9, 2.5 and 2.7) and to provide all the necessary information with the 2017 annual inventory submission, in accordance with decisions 2/CMP.7, annex, paragraph 33, and 2/CMP.8, annex II.		Implemented	11.3.1.3

European Commission and Convention performed reviews on Croatian inventory and give recommendations for recalculations. Implemented recommendations from European Commission and Convention are given in Table 10.4-2.

Table 10.4-2: Recalculations performed in NIR 2018

CRF category / issue	Review recommendation			Chapter/section in the NIR
	UNFCCC	ESD	Error detected by Expert	
Energy sector				
Road transport	-	-	Improvement of expert mileage assessment in 2008 for light duty vehicles and expert mileage assessment in 2005 for mopeds and motocycles	3.2.6.5.

CRF category / issue	Review recommendation			Chapter/section in the NIR
	UNFCCC	ESD	Error detected by Expert	
Industrial processes and product use				
2.A.2 Lime production		In the previous report, total quicklime production (from lime factories and sugar refineries) was included in the 2.A.2 CRF tables, while emissions only from lime factories were included in the CRF. Emissions from sugar refineries were not included in 2.A.2 for the period 2012 - 2015. Verified process emissions from the production of lime in lime factories were included in category 2.A.2. The misinterpretation was that emissions from sugar refineries were included in the Energy sector, in the verified reports for the combustion. EU ETS reports for sugar refineries contain only data on combustion. According to the Directive 2003/87/EC, the threshold values for combustion installation is 20 MW, and for production of lime is 50 tonnes per day. Because sugar refineries do not have production capacity of 50 tonnes of lime per day, those do not report on emissions from production process in the verified ETS reports. According to the TERT recommendation during ESD 2017 technical corrections have been made, including resolved of transparency issue regarding activity data and reported emissions. Since process emissions for	In addition, there are new separated data for quicklime and dolomitic lime production in sugar refineries that included after technical correction made by the TERT during ESD 2017. Consequently, there are some differences in emission estimation in this report comparing with the emissions estimation calculated in the framework of technical correction. Total activity data remained the same, only the emissions were changed due to the different EF for quicklime and dolomitic lime. In technical corrections, it was calculated as if only quicklime was produced. New separated data are included in order to improve the accuracy of the estimation. According to the explanation, recalculation have been made for the period 2012 – 2015.	4.2.2.5.

CRF category / issue	Review recommendation			Chapter/section in the NIR
	UNFCCC	ESD	Error detected by Expert	
		sugar refineries were not included in the previous report, it is necessary to make recalculations for the period 2012 – 2015. Recalculated process emissions for the period 2012 - 2015 are added to the process emissions for lime production in lime factories.		
2.B.1 Ammonia production		In the previous report, CO_2 recovered for downstream use (urea, NPK and dry ice) was subtracted from the CO_2 emission. According to the submitted data, the whole amount of urea and fertilizer, which are produce in this process actually applied in agriculture. CO_2 emission are estimated in 3. IPCC Sector. According to the explanation given to the TERT during ESD 2017, the specific amount of urea and fertilizers used in agriculture are presented in Chapter 5.5.1 and Chapter 5.9 in the Agriculture sector. The data on amount of urea and fertilizers used in agriculture are estimated according to the import-export and production data (estimated application data). In addition, only information on amount of dry ice is available. There is no additional information on the dry ice production processes. The share of recovered dry ice in the total CO_2 emission from ammonia production is about 1.0 - 6.6 percent, depending on the year. Pursuant to the TERT recommendation, since Croatia has no information on the dry ice process and as according to the 2006 IPCC Guidelines (box3.1), the amount of CO_2 recovered from ammonia production		4.3.1.5.

CRF category / issue	Review recommendation		Error detected by Expert	Chapter/section in the NIR
	UNFCCC	ESD		
		used in freezing applications is not accounted for separately and because it is assumed that all the CO_2 is released in the producing country. According to the explanation, recalculation have been made for the period 1990 - 2015.		
2.D.3 Other			New data for source categories are included for entire reporting period that caused the change in NMVOC emissions. Consequently, CO_2 emissions was changed. Therefore, recalculations of CO_2 emissions were performed for the period 1990 - 2015.	4.5.3.5.
2.F.4 Aerosols/Metered Dose Inhalers			Data on the amount of HFC-134a for category 2.F.4 Aerosols/Metered Dose Inhalers for 2014 and 2015 were corrected. Therefore, recalculations of emissions of HFC-134a were performed for 2014 and 2015.	4.7.2.5.
2.G.1 Electrical equipment			New data on total charge of SF_6 and leakage and maintenance loses for the period 2013 - 2015 were provided. Accordingly, recalculation were performed for the period 2013 - 2015.	4.8.1.5.
2.G.3 N_2O from product uses		According to the TERT recommendation during 2017 ESD review, data for use of N_2O for aerosol cans that are not available for 2014 and 2015 are estimated by extrapolation method, using the trend for the period 2010 - 2012. Data for 2013 was also corrected. Accordingly, recalculation were performed for the period 2013 – 2015.	New data for quantity of N_2O used for anaesthesia for 2015 were provided. Recalculation was made.	4.8.3.5.
2.A.2 Lime production		In the previous report, total quicklime production (from lime factories and sugar refineries) was included in the 2.A.2 CRF tables, while emissions only from lime	In addition, there are new separated data for quicklime and dolomitic lime production in sugar refineries that included after technical correction made by the TERT	4.2.2.5.

CRF category / issue	Review recommendation			Chapter/section in the NIR
	UNFCCC	ESD	Error detected by Expert	
		factories were included in the CRF. Emissions from sugar refineries were not included in 2.A.2 for the period 2012 - 2015. Verified process emissions from the production of lime in lime factories were included in category 2.A.2. The misinterpretation was that emissions from sugar refineries were included in the Energy sector, in the verified reports for the combustion. EU ETS reports for sugar refineries contain only data on combustion. According to the Directive 2003/87/EC, the threshold values for combustion installation is 20 MW, and for production of lime is 50 tonnes per day. Because sugar refineries do not have production capacity of 50 tonnes of lime per day, those do not report on emissions from production process in the verified ETS reports. According to the TERT recommendation during ESD 2017 technical corrections have been made, including resolved of transparency issue regarding activity data and reported emissions. Since process emissions for sugar refineries were not included in the previous report, it is necessary to make recalculations for the period 2012 – 2015. Recalculated process emissions for the period 2012 - 2015 are added to the process emissions for lime production in lime factories.	during ESD 2017. Consequently, there are some differences in emission estimation in this report comparing with the emissions estimation calculated in the framework of technical correction. Total activity data remained the same, only the emissions were changed due to the different EF for quicklime and dolomitic lime. In technical corrections, it was calculated as if only quicklime was produced. New separated data are included in order to improve the accuracy of the estimation. According to the explanation, recalculation have been made for the period 2012 – 2015.	
Agriculture				

CRF category / issue	Review recommendation			Chapter/section in the NIR
	UNFCCC	ESD	Error detected by Expert	
3.A Enteric fermentation, CH4		For category 3.A and gas CH4 for year 2015 the TERT noted a low IEF for growing cattle for enteric fermentation. In response to a question raised during the review, Croatia provided an explanation of the methodology and sources of information used for estimating methane emissions from this source. The TERT commends Croatia for its efforts to improve the Tier 2 for enteric fermentation and recommends providing detailed information in its next submission.		5.2.5.
3.B Manure management, CH4, N2O		For category 3.A and gasses CH4 and N2O the TERT noted that the number of animals for swine and poultry has been corrected leading to an underestimation of emissions for the agriculture sector. In response to a question raised during the review, Croatia agreed to provide revised estimates for year 2015. The TERT agreed with the revised estimate provided by Croatia as presented above. The TERT recommends that Croatia include the revised estimate in its next submission.		5.3.1.5.
3.B Manure management, N2O			Emissions were recalculated for correction of error in the calculationof all animal categories for the year 2015 due to a that used national emission parameters for 2014. This resulted in a minor change in emissions	5.3.2.5.
LULUCF				
4.A			use of new figures for soil carbon content; estimation of CSC in litter pool;	6.4.5

CRF category / issue	Review recommendation			Chapter/section in the NIR
	UNFCCC	ESD	Error detected by Expert	
4.B			Changes in LUC matrix and use of new figures for soil carbon content; estimation of CSC in litter pool;	6.5.5
4.C			Changes in LUC matrix and use of new figures for soil carbon content;	6.6.5
4.D			Changes in LUC matrix and use of new figures for soil carbon content;	6.7.5
Waste				
5.D.1 Domestic wastewater		In the previous report, water consumption in rural areas was estimated to be 120 litres/person/day and 70% of this amount is returned to the drainage system (overflow in septic tanks). Therefore, according to expert judgement provided by Croatian Water, fraction of treated wastewater in septic tank has been estimated to be 0.3. Proposed values of 30% have been used for methane emission calculation for entire reporting period. In this report, according to the TERT recommendation during 2017 ESD review technical correction were performed using recommended fraction of treated wastewater in septic tank that amounts 100 percent. Wastewater emission from septic tank depend on organic pollution (BOD_5) only and not on amount or use of water. This approach is complying with 2006 IPCC Guidelines for estimating emissions from wastewater. Proposed values of 100% have been used for methane emission calculation for entire reporting		7.5.5.

CRF category / issue	Review recommendation			Chapter/section in the NIR
	UNFCCC	ESD	Error detected by Expert	
		period. Therefore, recalculations of CH_4 emissions were made for the period 1990 - 2015.		
5.D.1 Domestic wastewater			New data on the annual per capita Protein intake value (PIV) by the FAOSTAT Statistical Database are available for the period 1994 – 2013 (Last Updates: February 13, 2017), Therefore, recalculations of N_2O emissions were made for the extrapolated years 1990 and 1991, and for all years in the period 1994 - 2015.	7.5.5.
5.D.2 Industrial wastewater			New 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 for the period 2010 – 2015. Therefore, recalculations of CH_4 emissions were made for the period 2010 - 2015.	7.5.5.

Table 10.4-3: Indication on timeline of implementation

Sector-specific planned improvements

Energy

Category	Recommendation	NIR 2018	NIR 2019	Long-term
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	•		
Stationary combustion	Harmonization of data on fuel consumption from the National Energy Balance, and data from the emissions trading scheme		•	
	Take steps to obtain and use plant-specific CO_2 EFs to improve accuracy of the emission estimates		•	
	Development of Industry analysis balance for the period from 1990 to 2000		•	
Road transportation: liquid and gaseous fuels – CO_2	emissions from 1A3b Road Transportation for gasoline and diesel are key categories and that fuel producers and suppliers regularly need to measure carbon contents, the TERT recommends that Croatia engage with fuel producers/suppliers and with experts from other EU countries to derive future country specific EFs for future submissions.			•
Coal mining and handling: solid fuels –CH_4	Use the actual coal production figures for estimating emissions		•	

Industrial Processes and Product Use

Category	Recommendation	NIR 2018	NIR 2019	Long-term
2.A.2 Lime production	Technical corrections have been made, including resolved of transparency issue regarding activity data and reported emissions.	•		
2.B.1 Ammonia production	The amount of CO_2 recovered from ammonia production used in freezing applications is not accounted for separately and because it is assumed that all the CO_2 is released in the producing country.	•		
2.B.1 Ammonia production	Use of urea and NPK in agriculture should be investigated for future reports (long-term goal). In addition, Croatia has no accurate information on where dry ice is applied. Accordingly, it is necessary to do a research (long-term goal). According to the result of research, a more detailed explanation on application of dry ice could be given.			•
2.B.8 Petrochemical and carbon black production – CO2	Use a higher tier to calculate emissions for this category.			•
2.C.3 Aluminium production	Further research the activity data for anode and paste consumption for the aluminium produced in 1990 and 1991 in order to use higher tier methodology.			•
2.D.1 Lubricant use 2.D.2 Paraffin wax use	Trend analysis of separated data for lubricants and paraffin wax.		•	
2.D.1 Lubricant use 2.D.2 Paraffin wax use	Investigation and collection more detailed information about use of paraffin wax.			•
2.D.3 Other	Including new data for source categories for entire reporting period.	•		

Category	Recommendation	NIR 2018	NIR 2019	Long-term
2.F. Product uses as substitutes for ozone depleting substances – PFCs, HFCs	Continue conducting surveys on the status of disposal of refrigeration and air-conditioning equipment.		•	
2F1 Refrigeration and air conditioning	According to TERT recommendation during 2016 ESD review, for category 2F1 Refrigeration and air conditioning equipment containing <3 kg of refrigerants, such as for example residential air conditioners, should be included in the estimated emissions. It was included in the Annual data collection plan (short-term goal). During 2017 ESD review, TERT asked for the information regarding reporting requirements according EU F-gases Regulation and related reporting obligations that have been reviewed in 2014. The TERT assumes that reporting requirements have also been updated in Croatia and asked for more information that is being reported by operators (e.g. equipment containing F-gas quantities >5 tonnes of CO_2 equivalents as mentioned in Regulation 517/2014, Article 4(1)). In addition, the TERT asked for more detail on the approach used and data source for each subcategory of 2.F.1. MEE, as responsible institution, provided an explanation that Republic Croatia is developing a reporting system which will enable to collect data in accordance with Regulation 517/2014, Article 4(1) and that is planned to collect data which will include equipment containing <3 kg of refrigerants and equipment containing F-gas quantities >5 tonnes of CO_2 equivalents. However, for now, these data are not included in the inventory. This is the short-term goal.2F1d Regarding the technical correction for category 2F1d Transport refrigeration during ESD 2016, further analysis should be carried out to investigate the actual share of trucks with refrigeration equipment, so that all necessary data and information will be collected at time and to the extent for an accurate and transparent emission calculation. It was included in the Annual data collection plan (short-term goal). However, for now, these data are not collected and included in the inventory. In addition, data for 2016 was not provided, so it is estimated according to data for 2015 that is the same as data for 2014. Therefore, it is necessary to provide accurate data for 2015 and 2016 in order to accurate emission calculation. This is the short-term goal. Currently, the category 2F1e Mobile air-conditioning includes only mobile air conditioning in passenger cars. According to TERT recommendation during 2016 ESD review, additional analysis for including emissions from all types of mobile applications in the mobile air conditioning subcategory (trucks, buses, trains and ships) should be carried out, so that all necessary data and information will be collected at time and to the extent		•	

Category	Recommendation	NIR 2018	NIR 2019	Long-term
	for an accurate and transparent emission calculation. It was included in the Annual data collection plan (short-term goal). During 2017 ESD review, TERT noted again that additional information and emission estimates for mobile air conditioning in other types of vehicles than passenger cars should be included in the inventory. MEE, as responsible institution, provided an explanation that the collection of such data have been started. However, for now, these data are not included in the inventory. This is the short-term goal.			
2F2 Foam blowing	According to ERT recommendation during 2016 centralized review, for category 2F2 Foam blowing agents, analysis of the type of foam application used (open cells or closed cells) should be verified. In NIR 2017 it is assumed to be open cells, according to the ERT recommendation in the Report on the individual review of the annual submission of Croatia submitted in 2016 (FCCC/ARR/2016/HRV, 28 March 2017). However, for now, these data are not analysed and additional explanation are not included in the inventory. It was included in the Annual data collection plan (short-term goal).		•	
2.F.4 Aerosols/Metered Dose Inhalers	Correction of data on HFC-134a for 2014 and 2015.	•		
2.G.1 Electrical equipment	Including new data for the period 2013 – 2015.	•		
2.G.1 Electrical equipment	Activity data regarding SF_6 emissions should be analysed and reviewed for the entire reporting period. Any potential changes in data should be included in the inventory. It was included in the Annual data collection plan (short-term goal).		•	
2.G.3 N_2O from product uses	Estimation of data for use of N_2O for aerosol cans for 2014 and 2015.	•		

Agriculture

Category	Recommendation	NIR 2018	NIR 2019	Long-term
Sectoral	Continued investigation of activity data (livestock population) with the purpose of gathering more detailed activity data.			●
Sectoral	During the NIR 2017 QA/QC process on the activity data, CBS identified changes in the AD for non-dairy cows and swine, for several years. The differences in the animal population numbers is within the ± 1-5% range. The AD was not ready in time for the resubmission of NIR 2018, but will be corrected in the next submission.		●	
3.A. Enteric Ferementation	Continue efforts to improve country-specific EFs to estimate CH_4 emissions from enteric fermentation			●
3.B Manure management	Revision of the methodology and development of updated national emission factors for the CH_4 and N_2O emission estimate.		●	
3.D.1 Direct N2O emissions from managed soils	Investigation into application of compost to soils in Croatia as part of agricultural practices.		●	
3.D.1 Direct N2O emissions from managed soils	Improving emission calculation from agricultural soils due to mineral fertilizers.			●
3.D.1.4 Crop Residues	During the NIR 2017 QA/QC process on the activity data, CBS identified changes in their AD for some crops, for several years. New data were not ready in time for the resubmission of NIR 2018, but will be corrected in the next submission.		●	
3.H Urea application	Development of proportion estimates of urea in applied urea solutions AD.			●

Waste

Category	Recommendation	NIR 2018	NIR 2019	Long-term
5.A Solid waste disposal on land	Harmonization of data for DOC for the period 1995 – 2014 with the data for 2015 and 2016.		●	
5.A Solid waste disposal on land	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.			●
5.D.1 Domestic wastewater	Technical correction were performed using recommended fraction of treated wastewater in septic tank that amounts 100 percent. Wastewater emission from septic tank depend on organic pollution (BOD5) only and not on amount or use of water. This approach is complying with 2006 IPCC Guidelines for estimating emissions from wastewater.	●		
5.D.1 Domestic wastewater	New data on the annual per capita Protein intake value (PIV) by the FAOSTAT Statistical Database (Last Updates: February 13, 2017) are included for the period 1994 – 2013.	●		
5.D.1 Domestic wastewater	Regarding TERT recommendation during 2017 ESD review about estimation on N_2O from municipal wastewater, there is no information on the use of garbage disposal units in households in Croatia. During review Croatia proposed to keep the Factor for non-consumed protein F (non-con) = 1.4 for developed countries instead of F (non-con) = 1.1 for developing countries, because it is necessary to do a research which can not be done in the short term. Croatia provided calculations with both of factors, F (non-con) = 1.4 and F (non-con) = 1.1 and asked TERT for confirmation on proposal to keep factor for developed countries. Competent institution should confirm assumption that less than 1% of household uses garbage disposal units. For now, information are not available. Because of that, F (non-con) = 1.4 is included in the N2O emission calculation. Revision with F (non-con) = 1.1 will be prepared for resubmission, after confirmation of competent institution.		●	
5.D.2 Industrial wastewater	New data on industrial output (tonne/yr) are included for the period 2010 – 2015.	●		
5.C.1 Waste incineration	Identify the technologies applied in the incineration of hazardous waste and more detailed information on and N_2O emission calculation.		●	

LULUCF

Category	Recommendation	NIR 2018	NIR 2019	Long-term
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 – CO_2	Make significant efforts to use the results of CRONFI to improve the LULUCF sector inventory			●
Land converted to forest land – CO_2	Make significant efforts to use the results of CRONFI to improve the LULUCF sector inventory			●
Cropland remaining cropland – CO_2	Implement the tier 2 approach to perennial cropland remaining perennial cropland			●
Land converted to cropland – CO_2	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 – CO_2	Work towards using a higher tier method for reporting estimates for DOM in this category			●
Land converted to grassland – CO_2	Improve cropland biomass estimates to enable the implementation of a tier 2 method for estimating cropland biomass in this category			●
Settlements – CO_2	Improve cropland biomass estimates to enable the implementation of a tier 2 method for estimating cropland biomass in this category			●

Chapter 11: KP-LULUCF

11.1. General information

Following the establishment of the National system in 2007 required under the Decision 19/CMP.1, the Ministry of Environmental and Energy undertakes different activities in order to streamline and strengthen flow of data and information relevant for accounting of LULUCF activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol.

This resubmission follow the previously agreed procedure between the Ministry of Agriculture and the Ministry of Environmental and Nature Protection that preparation of the annual GHG Inventory, in respect of LULUCF sector, should be based on forest management plans. The results of conducted national forest inventory (CRONFI) still have no official status and consequently cannot be used for purposes of this reporting.

Under the Article 3, paragraph 3 of the Kyoto Protocol (KP) Croatia reports emissions and removals from afforestation (A) and deforestation (D) activities, while Reforestation (R) does not occur in Croatia. Under the Article 3.4 of the KP Croatia elected activity Forest management (FM) for the estimation of emissions and removals by sink.

The UNFCCC and the KP reporting are harmonized as presented in Table 11.1-1; thus, the same data division was used for emission/removal calculation. Therefore, all stated for the UNFCCC is valid also for the KP (definitions, methodology, etc.).

Table 11.1-1: The relationship between KP activities and reported UNFCCC land categories

UNFCCC			**KP**	
Land Use Category	Subcategories		Activities	Article
Forest land	Land converted to Forest land		Afforestation	
	Cropland converted to Forest Land	*Grassland converted to Forest land*		
Cropland	*Land converted to Cropland*		Deforestation	3.3
	Forest land converted to perennial Cropland			
Settlements	*Land converted to Settlements*			
	Forest land converted to Settlements			

11.1.1. Definition of forest and any other criteria

Definition of forest

Forest is a land spanning more than 0.1 hectares with trees higher than 2 meters and canopy cover more than 10 percent, or trees able to reach these thresholds in situ (Table 11.1-2)

Table 11.1-2: Thresholds in defining forest

Parameter	Range	Selected value
Minimum land area	0.05 - 1 ha	0.1 ha
Minimum crown cover	10 - 30 %	10 %
Minimum tree height	2 - 5 m	2 m

In pursuit of the selected values for KP reporting, forest includes the following forest stands: high forests, plantations, forest cultures, coppice, maquia and shrub forests.

Based on ERT's request from 2012, since NIR 2014 Croatia performs estimation for all types of forests (including maquies and shrub forests) that meets thresholds for defining forests under the Kyoto protocol (see also subchapter 6.2).

Based on the Forest Act (Article 4), forests also allude forest nurseries and seed orchards in cases when they are an integral part of the forest; forest infrastructure; fire breaks and other less open areas within forests; forests in protected areas under a special regulation; forests of special ecological, scientific, historical or cultural interest; windshields and buffer zones in area larger than 10 acres and a width greater than 20 m. Thus, these areas are also included under the LULUCF and KP reporting.

A separate group of forest trees in the area up to 10 acres, forest nurseries and seed orchards, which are not part of the forest, windbreaks and buffer zones - protective tree belt area of less than 10 acres and a width of less than 20 m, tree rows and parks in urban areas do not present forest and these areas are not subject of this reporting.

According to the same legislative act, areas covered by garigues and scrub forests (degraded stages of maquies and shrub forests) also belongs to forest category. However, since these types of forests are not able to reach thresholds defined by Croatia under the KP, these areas are excluded from the estimation and are not subject of reporting under the KP.

11.1.2. Elected activities under Article 3, Paragraph 4, of the Kyoto Protocol

Croatia has elected Forest Management (FM) as an activity under Article 3.4 for inclusion in the accounting for the first commitment period in accordance with Paragraph 6 of the Annex to Decision 16/CMP.1. Credits from Forest Management are capped in the first commitment period. Following the Decision 22/CP.9, the cap was equal to 0.265 Mt C (0.972 Mt CO_2) per year, or to 1.325 Mt C (4.858 Mt CO_2) for the whole commitment period.

No additional activites were elected by Croatia for the second commitment period. According to the Appendix to the Decision 2/CMP.7 Forest management reference level defined for Croatia equals -6.289 $MtCO_2eq$/year for the second commitment period.

11.1.3. Description of how the definitions of each activity under Article 3.3 and each elected activity Under article 3.4 have been implemented and applied consistently over time

The time consistency is achieved due to the fact data were collected for the entire period from 1990 to 2016 based on definitions presented further in this subchapter. Applied definitions are as follows.

11.1.3.1. Definition and identification of Afforestation/Reforestation areas since 1990.

Pursuant to Article 27 of the Ordinance on forest management , afforestation in national circumstances is the activity within the forest regeneration and it refers to establishment of forests (afforestation) on non-forest land and also to establishment of plantations of fast growing species. Forest regeneration is a part of the Forest Management plans/programs (FMAPs) and thus afforestation done by seeding and planting is clearly human induced.

Following request given by the ERT in ARR 2012 to trace and identify all lands under the Article 3.3 and Article 3.4 of the KP, Croatia conducted special survey under the framework of project "Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol" (abbreviated LULUCF 1).

In the part of survey that concerns identification and traceability of areas that were subject of afforestation, by the survey both types of afforestation as defined by IPCC were covered: afforestation by seeding and planting and afforestation due to human induced promotion of natural seed sources. The survey was performed in all areas under the forest management as defined by KP regardless the ownership and forest types.

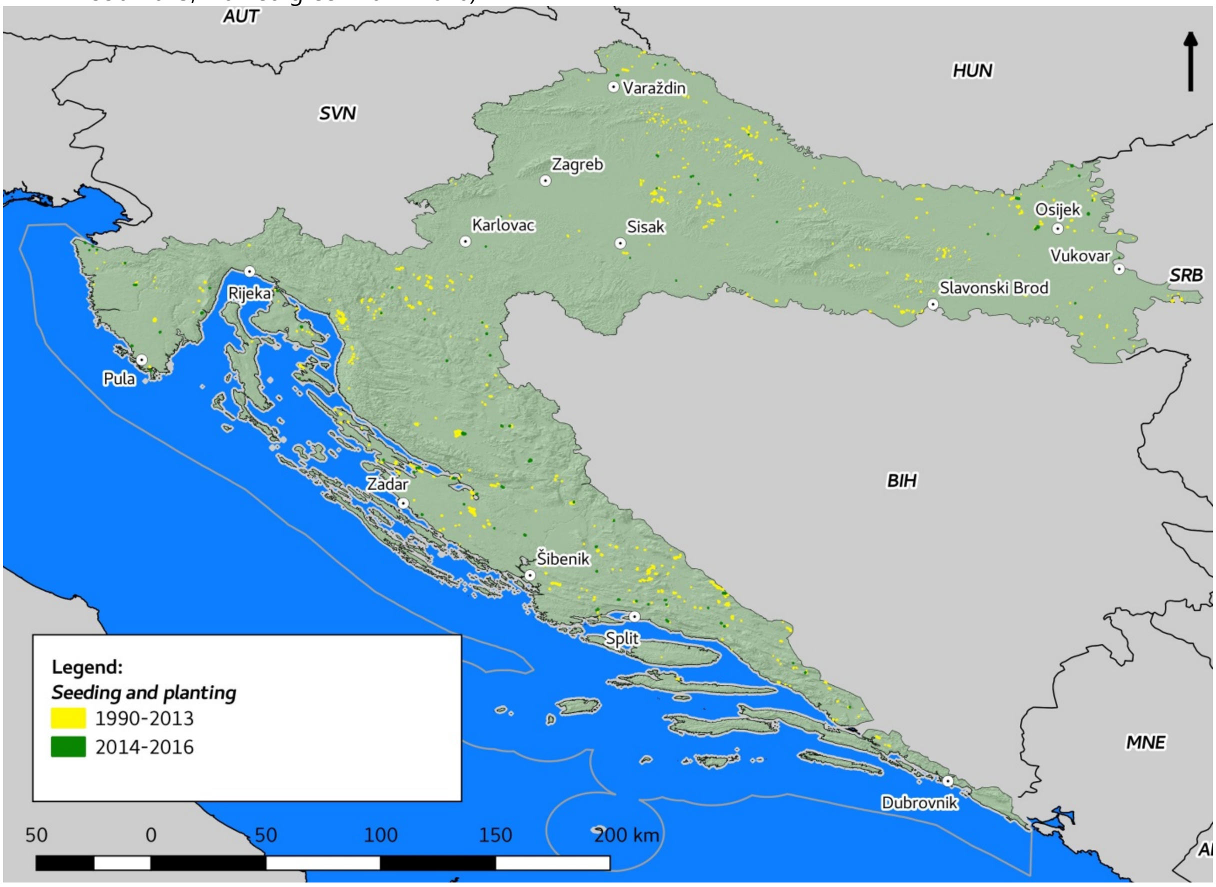
The Approach 3 and wall to wall mapping was applied during the survey for collecting data and information on areas afforested through seeding and planting regardless the ownership and forest types. A special Questionnaire was designed for this purpose. Data and information requested by questionnaire were collected at two levels of forestry administrations:

1) The level of Forest Administration such as: a) the name of Forest Administration; b) the name of regional Forest office; c) the name of management unit (FMU); d) FMU code
2) The level of regional forest office providing the data and information at the time of afforestation e) Period of validity of forest management program; f) year of afforestation; g) compartment code; h) cub-compartment code; i) sub-compartment size area; j) size of sub-compartment area afforested
3) The level of regional forest office providing the data and information at present time such as: k) period of validity of forest management plan/program; l) compartment code; m) sub-compartment code; n) size of sub-compartment area afforested; o) GIS afforested area.

The questionnaire was designed in order to review all previously data reported by Croatia under the KP, and to develop a unique map of areas afforested in Croatia through seeding and planting in period 1990-2012. After the LULUCF 1 project was finalized in 2015, new recording system was introduced in database system of Croatian forests Ltd. in order to support Croatian KP reporting in part of identification and traceability of lands that are subject of afforestation and deforestation activities and securing application of Approach 3 in the reporting during the 2nd Commitment period. Areas afforested in Croatia through seeding and planting in period 1990-2016 are presented in Figure 11.1-1.

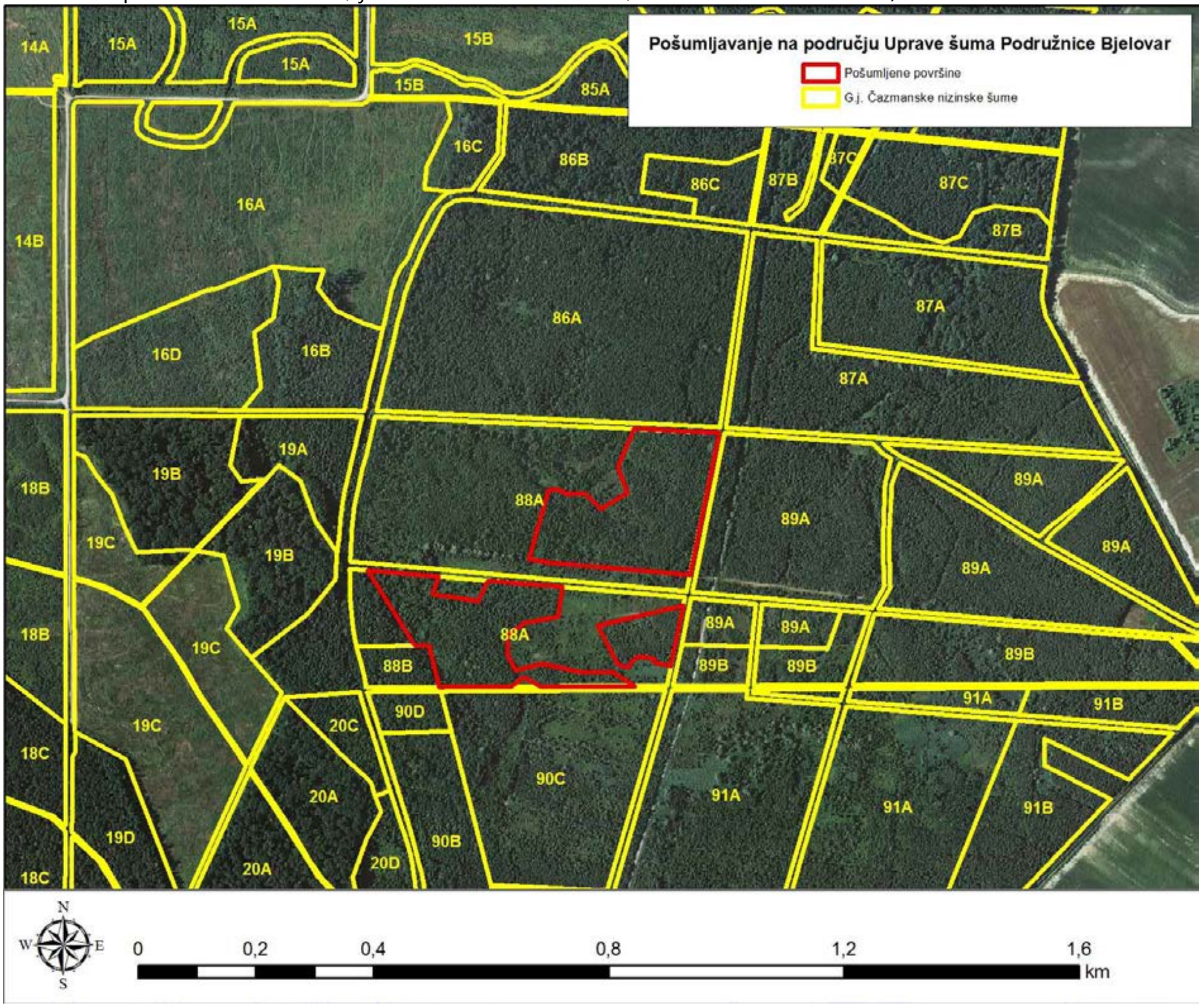
Data and information collected at the level of Forest administration and level of regional forests offices were merged within GIS layer of forest management types in order to perform final checks using the topographical map (1:25,000) from 1970s, new topographical maps, Croatian base map 1: 5,000 and old management maps. An example of performed checks is presented in Figure 11.1-2.

Figure 11.1-1: Areas afforested in Croatia through seeding and planting in 1990-2016 (marked yellow-period 1990-2013, marked green 2014-2016)



When performing this work, all areas that were previously reported as afforestation areas and for which was found mismatch with IPCC definition of term afforestation in fully, exclusion from the areas eligible for KP reporting was done.

Figure 11.1-2 An example of afforested area registered on forest managemenet map with orto-photo background layer showing present state of areas (Forest Administration Bjelovar, FMU Cazmanske nizinske sume, sub-compartments 88 a and b, year of afforestation 1993, afforested area 10.01 ha)



Croatia believes that collecting the data on the level of a part of area of sub-compartment on which afforestation was actually successful, complete and detailed analyses of afforestation through seeding and planting was performed.

Afforestestation due to human induced promotion of natural seed sources were performed for all type of forests and forests ownership. Performed analyses differed depending on forest ownership. In case of state owned forest managed by Croatian forests Ltd. Approach 3 and wall to wall mapping was performed as presented below.

For the extraction of surface vector layer in ESRI, .shp format of forests expanded by spreading of seeds on new areas software packages ESRI's ArcEditor 10, QGIS Desktop 2.4 and AutoCAD Map 3D with raster design module were used.

Spatial vector and raster data associated with official "HS fond" (contains all data on parameters relevant for forest sector) database of "Croatian forests Ltd" were used as an input data. Areas and boundaries (polygons) of the compartments/sub-compartments of every single FMU were analysed. Additionally, in the analyses was used a vector layer of forest boundaries obtained by using GIS methods from old topographic maps in scale 1: 25,000. Raster data used during the analyses were primarily topographic maps 1: 25,000 whose content corresponds to situation in period 1971 – 1980, digital ortho-photo raster data from period 1998-2006, and recent data from digital ortho-photo in 2012.

Performed GIS analysis is presented in nine steps on the example of one Forest Administration (Našice). Small methodological difference could be noted when taking into consideration whether analyses is performed in even aged forests (all nine steps necessary to identify area increase) or uneven aged forests (steps four and seven not needed).

Step 1: Forest management maps presenting areas on sub-compartment level and maps showing boundaries of Forest Administration were used (Figure 11.1-3)

Step 2: All areas that do not comply with KP definition of forests (i.e. garigues and scrubs) as well as forest area that are not grown naturally (cultures, plantations) were identified in order to be removed from the analyses (Figure 11.1-4)

Step 3: All areas that are not cover by forests are detected in order to be removed from the maps and future analyses (Figure 11.1-5)

Step 4: All area covered with forests older than 24 years are identified and removed from the analyses (in case of even aged forest, Figure 11.1-6) because they were forests already in 1990

Step 5: Forest areas that remain after conducting steps 1-4 were then overlapped with topographical maps (1:25000) from 1980 on which vector layer of forests were created using the GIS methods for this purpose. The result of the overlap was a vector layer presenting forest area that were not forest before 1990 (Figure 11.1-7)

Step 6: In this step correction in areas was made due to difference in scale of maps used (i.e. basis for present forest management maps is cadastre and its maps in scale 1:2,000 or 1:2,880 or digital orto-photo in scale of 1:5,000 while forest areas in 1980 are presented in topographical maps in scale of 1:25,000). Correction was made after overlapping with topographical maps - all areas that were not forests were removed (Figure 11.1-8)

Step 7: In this step all areas that were younger than 24 years and which grows on areas that were registered as forest area even before 1990 were identified in order to be removed from the analyses. This step was needed because some of areas went through natural regeneration before 1990 without adequate result and were subject of replanting and were not detected on topographical maps. (Figure 11.1-9)

Step 8: Areas that were remaining after steps 1-7 were conducted were subject of final control which was done using the state orto-photo from 2012. Due to use of different maps with different scales it was not possible to get full compliance among cadastral and forest management maps and there were cases in which remained identified areas were actually arable land or unfertile land and not forests. For this reason in this step of analyses, all these areas were checked on the level of regional forest offices on the site (Figure 11.1-10)

Step 9: Areas identified as a subject of human induced promotion of natural seed sources on level of each of 16 Forests Administrations were merged in order to present these areas on a single map (Figure (11.1-11))

Figure 11.1-3: Forest Administration Našice (boundary of Administration marked in green dots, forests area according to national definitions in 2014 marked in green)

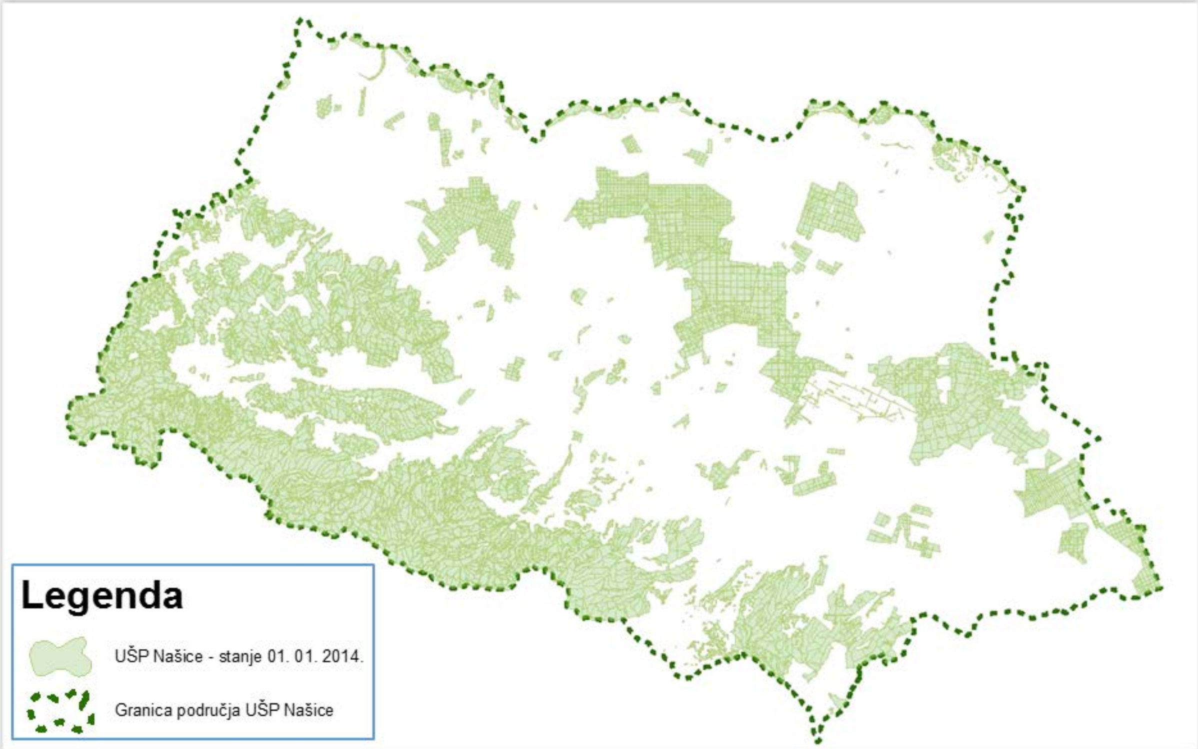


Figure 11.1-4: Forest Administration Našice (boundary of Administration marked in green dots, forests area according to KP definition of forests marked in pink, area not complying with KP definition of forests marked in green)

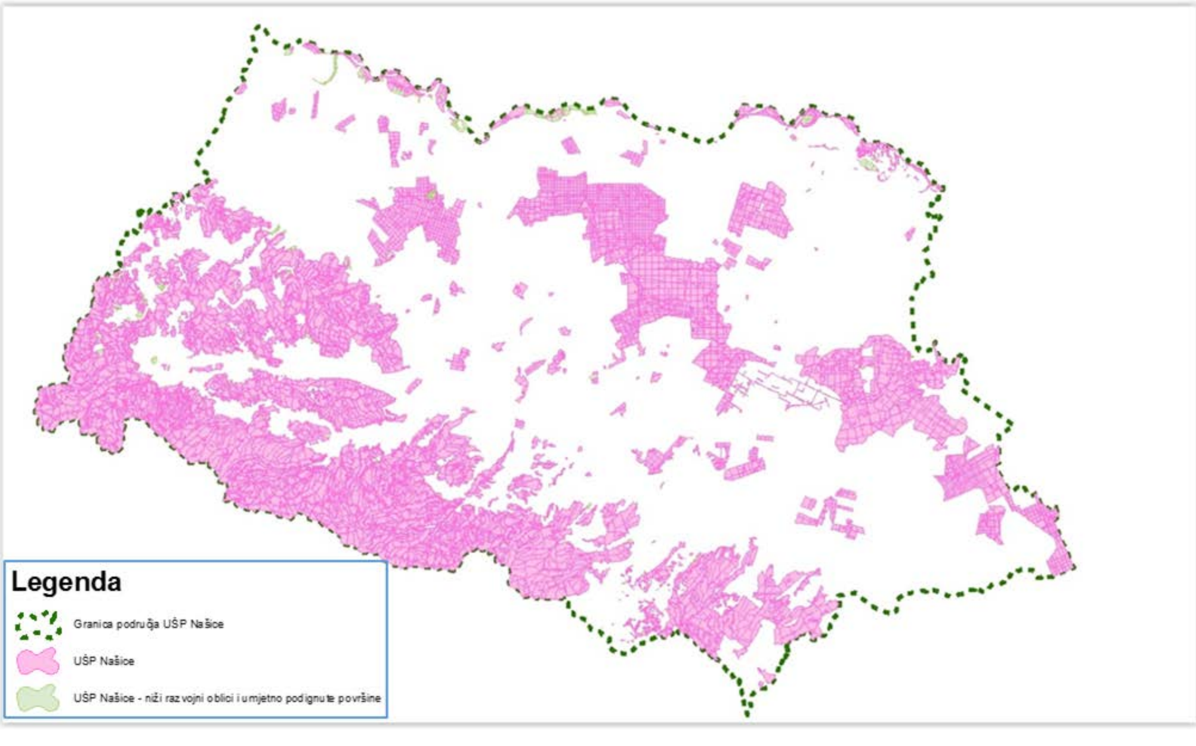


Figure 11.1-5: Forest Administration Našice (boundary of Administration marked in green dots, forests area marked in yellow, non-stocked forest area (i.e. clearings) marked in green)

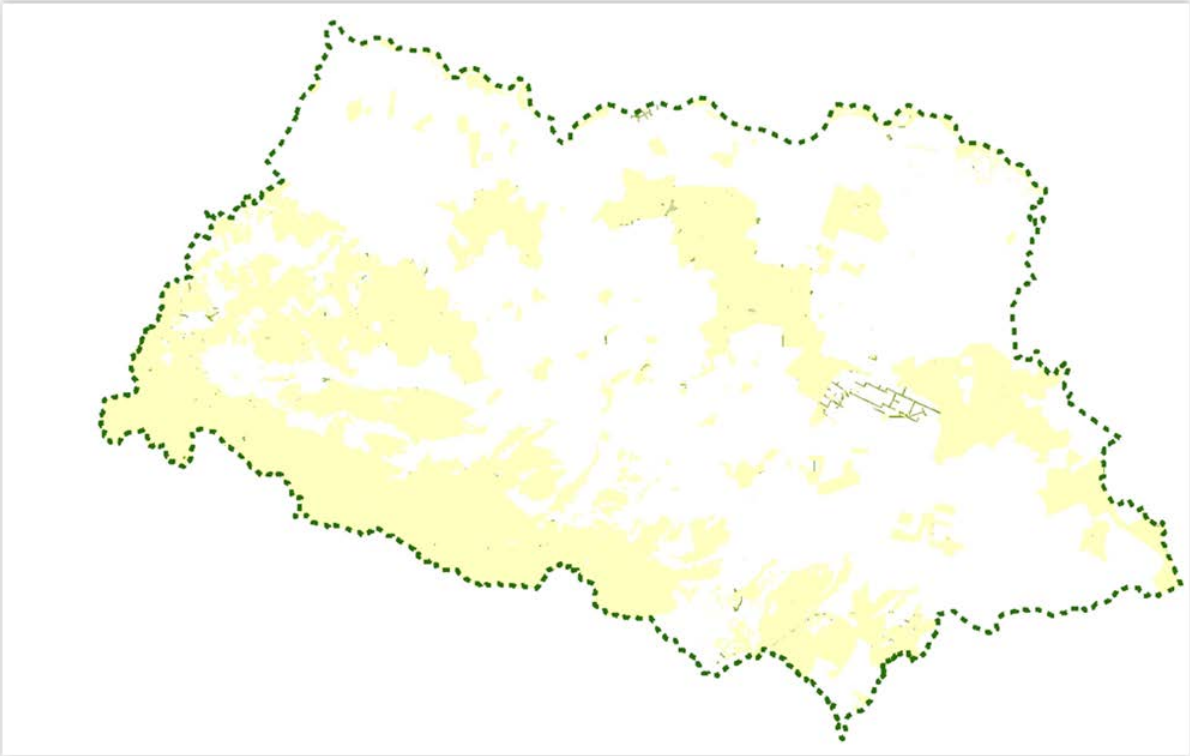


Figure 11.1-6: Forest Administration Našice (boundary of Administration marked in green dots, forests older that 24 years marked in green, remaining forest area marked in pink)

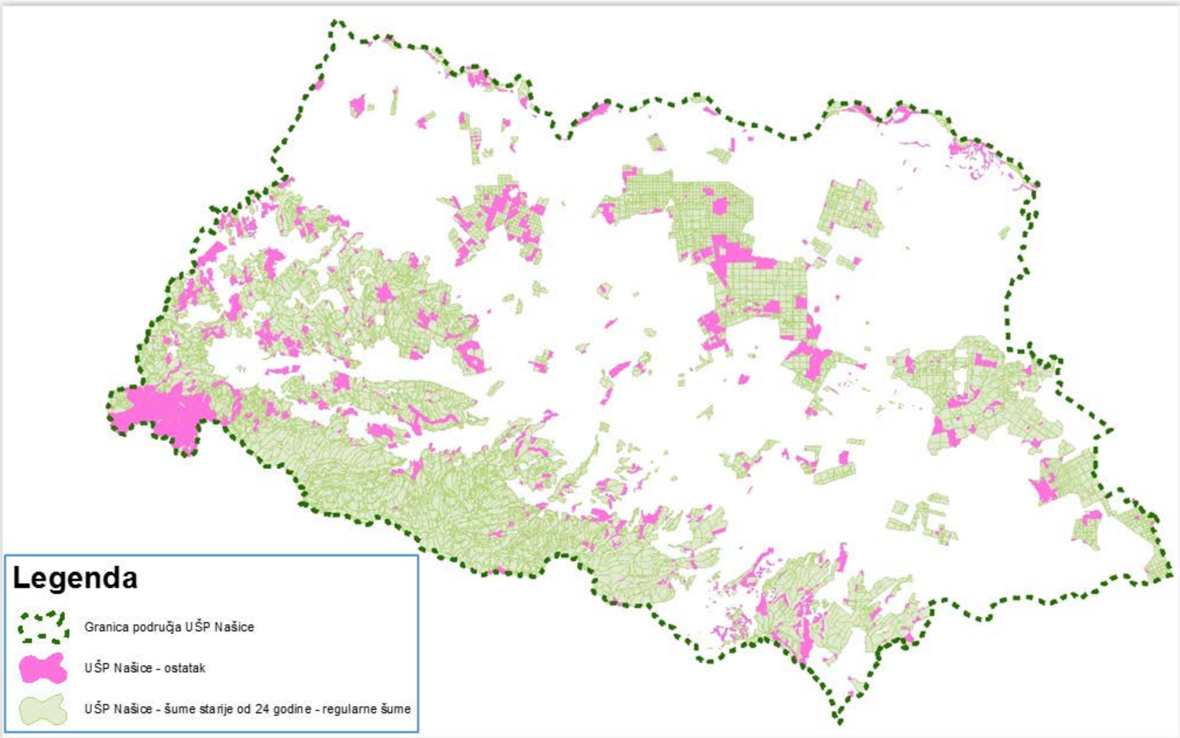


Figure 11.1-7: Forest Administration Našice (boundary of Administration marked in green dots, forests according to polygons of forests from topographical map marked in green, remaining forest area marked in pink)

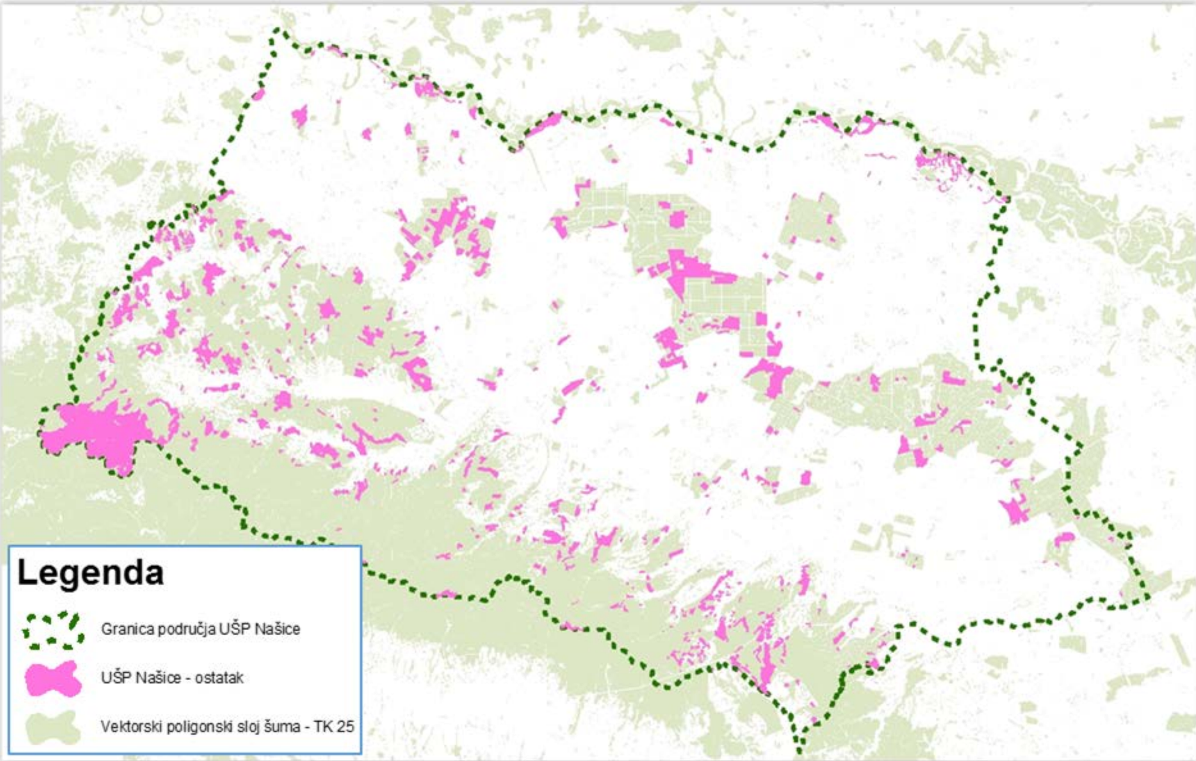


Figure 11.1-8: Forest Administration Našice (boundary of Administration marked in green dots, forests according to topographical map marked in green, remaining forest area after overlapping with topographical map marked in pink)

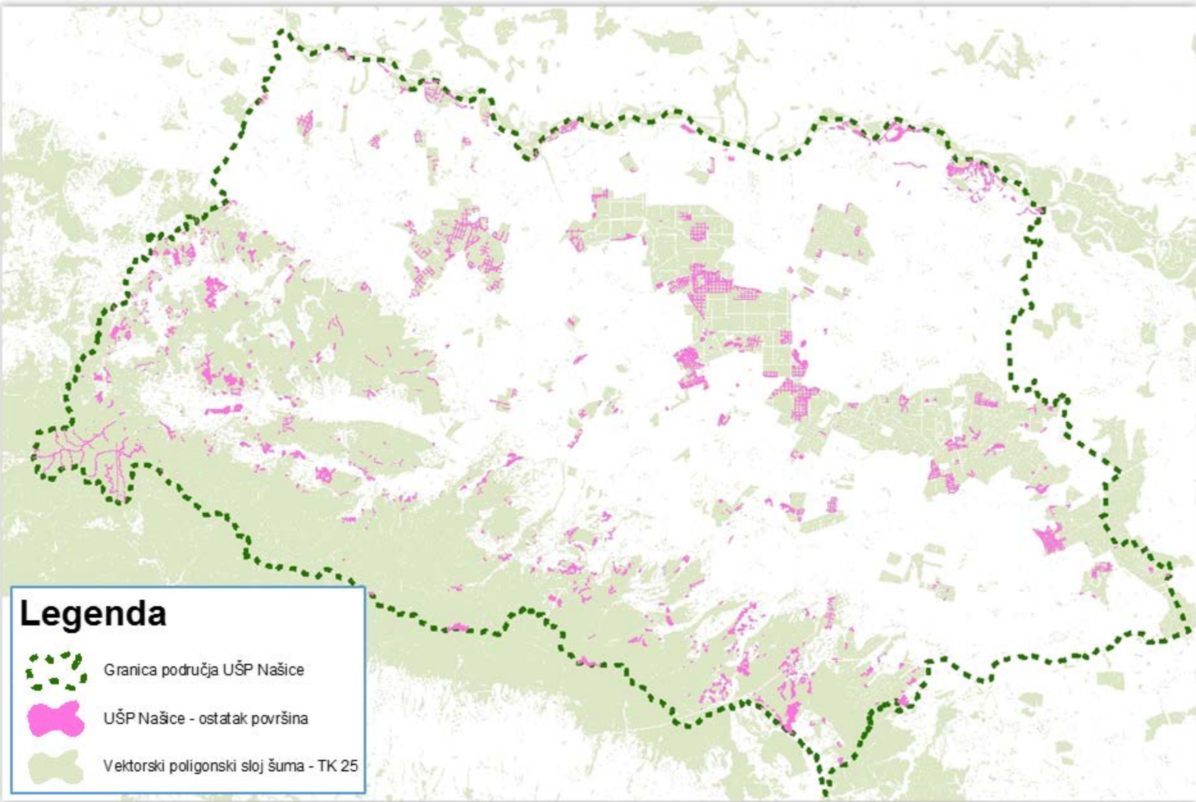


Figure 11.1-9: Forest Administration Našice (boundary of Administration marked in green dots, forests according to topographical map marked in green, remaining forest area after conducting step No. 6 marked in blue)

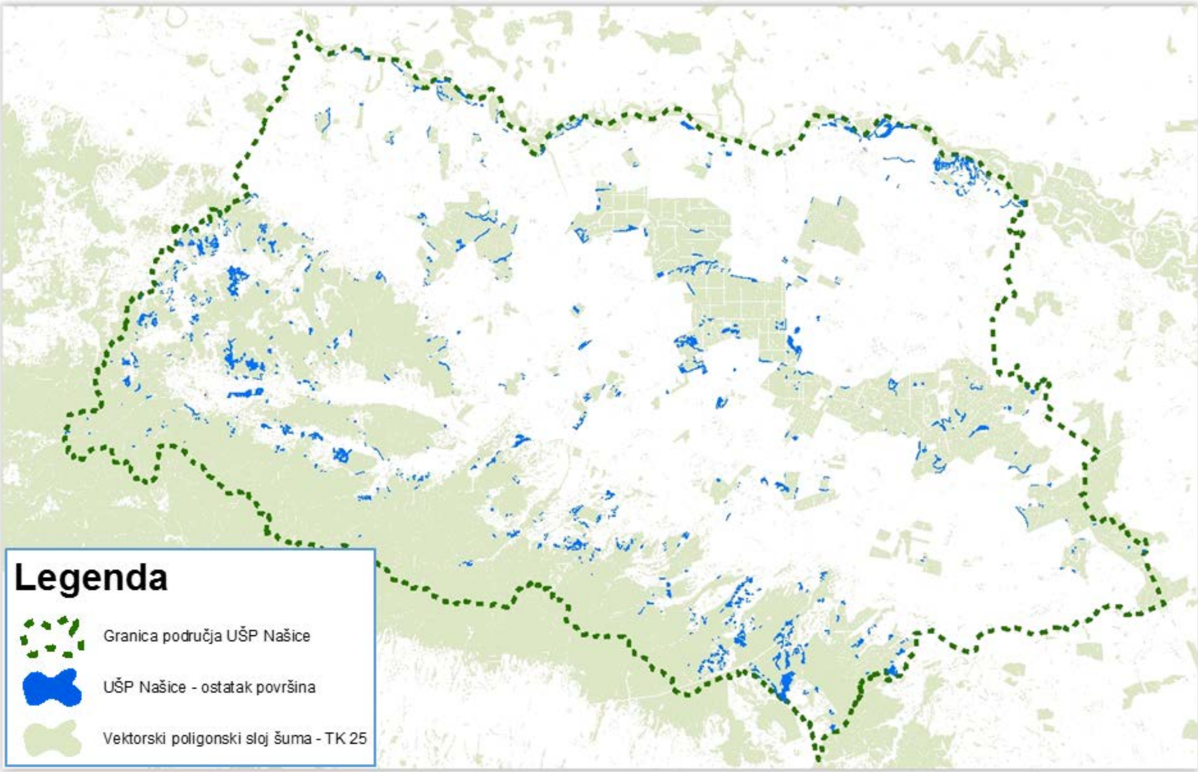


Figure 11.1-10: Forest Administration Našice (boundary of Administration marked in green dots, forest areas younger than 24 years marked in blue, remaining forest area marked in purple)

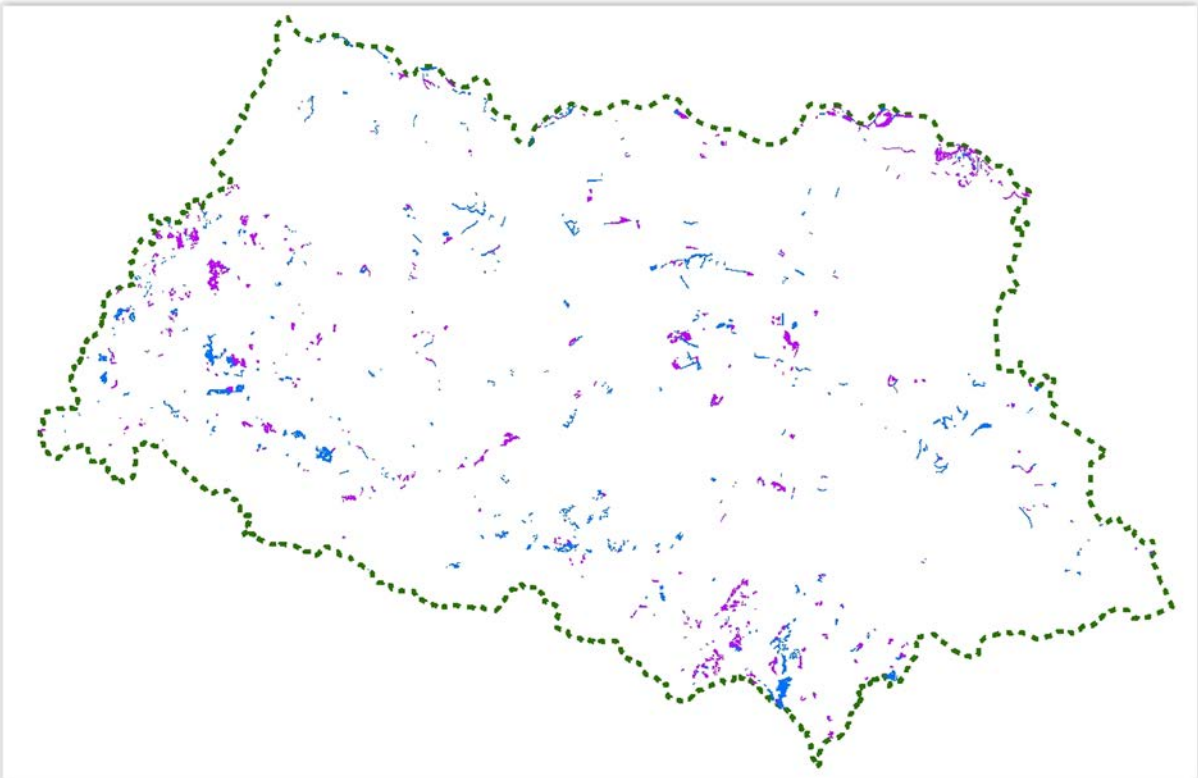
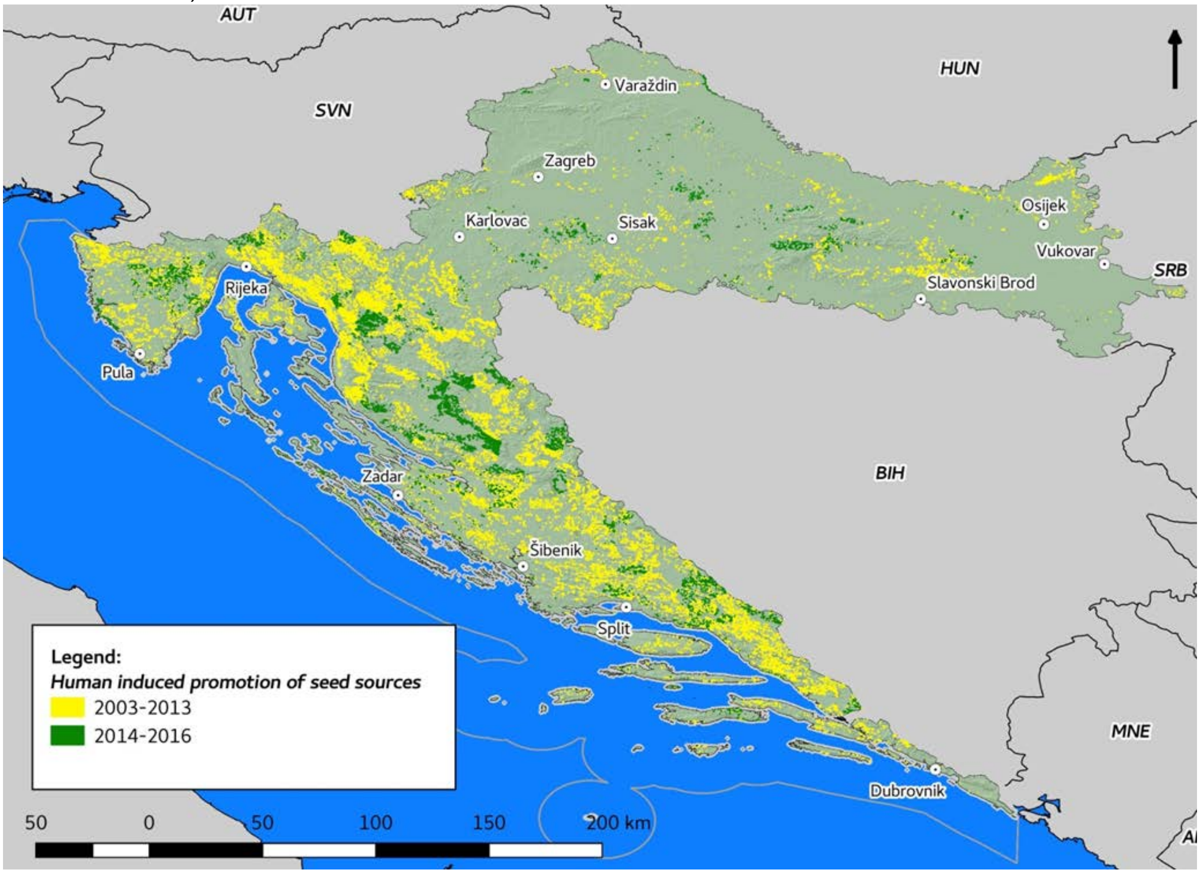


Figure 11.1-11: Forest Administration Našice (boundary of Administration marked in green dots, areas identified as not forests after step No 8. marked in red, areas identified as afforested after steps No1-No8 were performed marked in green)

After analyses were done, forests area that are identified as a result of afforestation due to human induced natural promotion of seed sources in state owned forests were presented in below map (Figure 11.1-12)

Figure 11.1-12: Identified afforested areas as a result of human induced promotion of seed sources in period 1990-2014 in state owned forests (areas marked in yellow for the period 1990-2013, marked in green 2014-2016)



According to the national legislation and forest practices applied in Croatia, afforested areas on which seeding/planting are conducted have to be separately registered. This means that these areas were well known before the LULUCF 1 project was conducted in Croatia. Regarding the identification of afforested lands due to human induced promotion of seed sources in private forests it was not possible to conduct survey on the same way as for state owned forests managed by Croatian forests Ltd. These forests are mostly managed as uneven aged forests, their area is not fully covered with official forest management programs (only 50% of area) at this time and there is no sufficient number of quality data and information on their previous state. Using the results of conducted survey in state owned forests proxy estimate was done. In order to determine category from which conversion to private forests happened, data and information from 10% of private forests covered by forest management programs were taken and expanded to whole area of private forests. This 10% represents 63.217,44 ha of private owned forests. At the time of LULUCF 1 project implementation 50% of private owned forests were covered by the forest management programs.

Reforestation, as defined by Kyoto, does not exist in Croatia due to strict legal provisions.

11.1.3.2. Definition and identification of Deforested areas since 1990

According to the Croatian *Forest Act*[53], deforestation implies clear cutting of forest in order to use area for other non-forestry purposes. It has to be performed in accordance with the spatial planning documents or provisions of the Decree on procedures and criteria for easement establishment on a forest or forest land owned by the Republic Croatia to cultivation of perennial crops[54]. Therefore, for an activity to be referred as deforestation, certain forest area must be excluded from the national forest management area which is strictly regulated by the Forest Act (Articles 32, 35, 51, 51a and 52). Based on the latter, land use changes from forest to other land use categories are allowed in very limited circumstances (e.g. for important infrastructure projects etc.). The national definition is in line with the KP definition.

Based on the recommendations given by the ERT in ARR 2012, Croatia carried out a special survey in order to trace and identify all deforested areas regardless ownerships and types of forests. The work was performed in the framework of the LULUCF 1 project.

All data and information concerning deforested areas are presented in a separate document[55] as one of outcomes of the LULUCF 1 project. The same procedure was applied for identification of these areas in years 2013, 2014, 2015 and 2016.

During the period 1990-2012 deforestation did not occur in state forests that are managed by other legal bodies in Croatia than Croatian Forests according to the data and information gained through the conducted survey. This was expected outcome since forests belonging to this type of ownership have rigorous or some degree of protection under the provisions of Law on nature protection. Consequently, data and information presented in this report and concerning deforested areas and corresponding emissions refer to state owned forests managed by Croatian forests Ltd and private forests.

When performing the survey under the LULUCF 1 project Approach 3 and wall to wall mapping was applied in identification and traceability of areas that were subject of deforestation activity in period 1990-2012.

For a start, in case of state owned forests, all permits officially issued by the Ministry of Agriculture for the purposes of extraction of forests from forest management area in Croatia and its conversion to other land use were collected and then checked in order to secure that areas which were deforested were forest according to the thresholds set by Croatia for KP reporting purposes. Issuing of permits for exclusion of forests from forest management plans and its use for purposes other than for forest management has been regulated by provisions of Forest Act. Then, data and information recorded in each single permit that referred to forest area according to the KP definition had to be checked on a level of forest sub-compartment in each single management unit verifying that deforestation allowed by permit was actually executed on the field. In this work were used:

- old scanned and recently digitized map of forest management units
- Croatian base map 1:5,000
- topographic maps 1:25,000

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[53] Ibid

[54] OG 12/2008, Article 1.

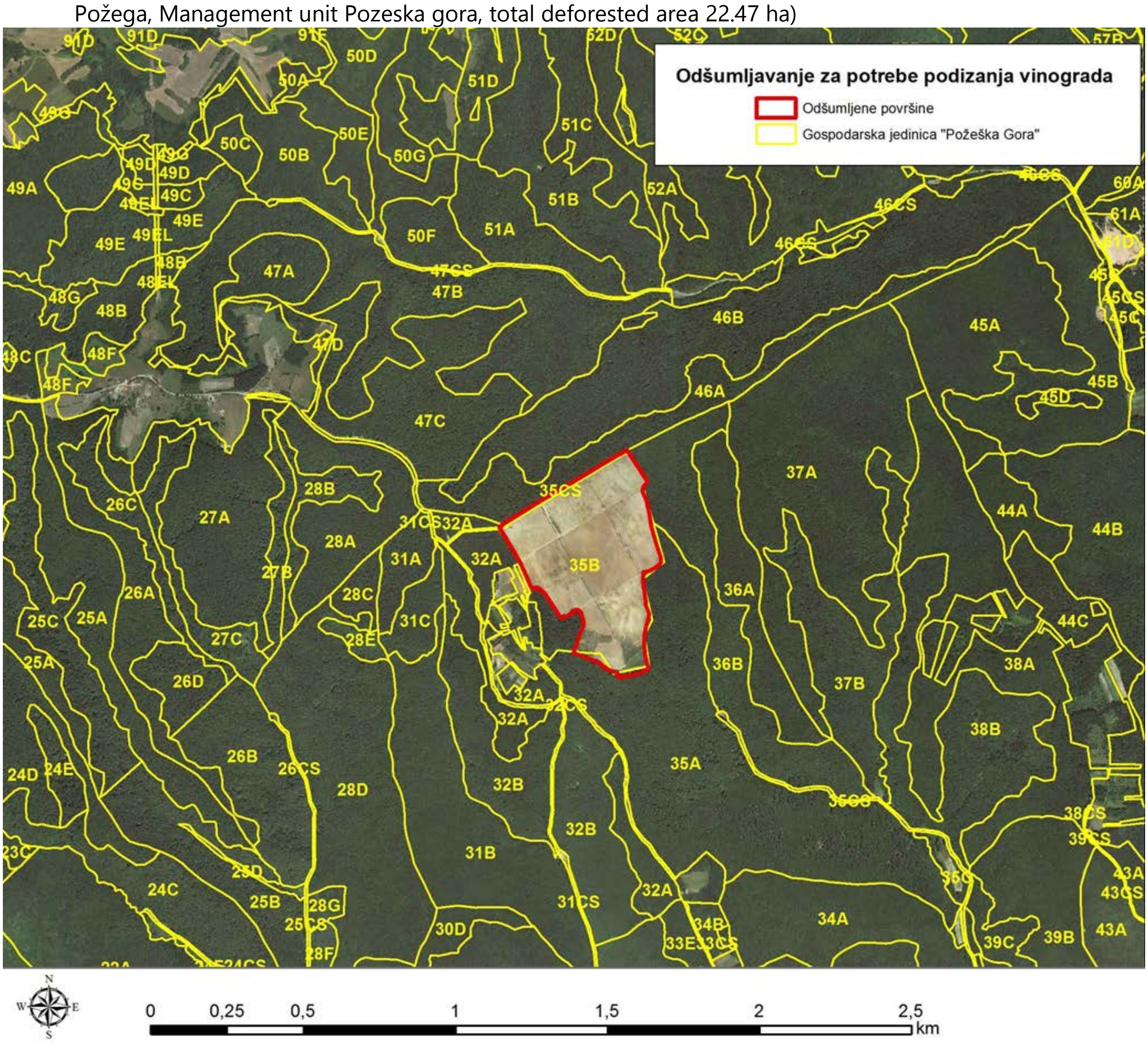
[55] D. Janeš, G. Kovač, A. Durbešić (2014), Identification of deforested areas in Croatia according to the requirements of Article 3.3 of the Kyoto Protocol

- digital ortho-photo
- digital cadastral maps

In order to avoid situation that some of deforested areas are not identified because they were not subject of permitting (i.e. due to War disturbance), additional checking was performed on fields on a level of single management unit. Identified deforested areas not covered by permitting had to be officially mapped and registered for the purposes of this reporting.

An example on identified deforested area is shown in Figures 11.1.-13

Figure 11.1-13: Map of forest management unit with deforested area marked in red (Forest Administration Požega, Management unit Pozeska gora, total deforested area 22.47 ha)



Deforested areas in the period 1990-2012 in private forests were identified on the level of forest sub-compartment in each single forest office by using maps of forest management units or by cadastral maps in cases where forest management program for private forests has not been developed yet. Areas had to be officially registered and in cases that they were not mapped before, this had to be performed for the purposes of this reporting.

When collecting data and information on deforested areas (regardless the ownership type) regional forest offices had to provide all information and data requested by specially designed Questionnaire for the purposes of KP reporting besides the mapping of deforested areas. Data and information requested by questionnaire were: **a)** the name of Forest Administration; **b)** the name of Forest office; **c)** the name of management unit (FMU); **d)** FMU code; **e)** information about the ownership; **f)** year of deforestation; **g)** compartment code; **h)** sub-compartment code; **i)** sub-compartment size area; **j)** size of sub-compartment area deforested; **k)** management type; **l)** growing stock deforested; **m)** reason for deforestation. In part of questionnaire that refers to management type additional data were collected providing information about species of coniferous and deciduous types of forests and information about maquies and shrub. Also, part of questionnaire that refers to growing stock deforested was further subdivided into coniferous and deciduous part.

The whole process was performed in several steps on different levels of Croatian forests Ltd. administration. In order to support Croatian reporting in KP, new recording system for identification and traceability of deforested lands after 2012 was introduced.

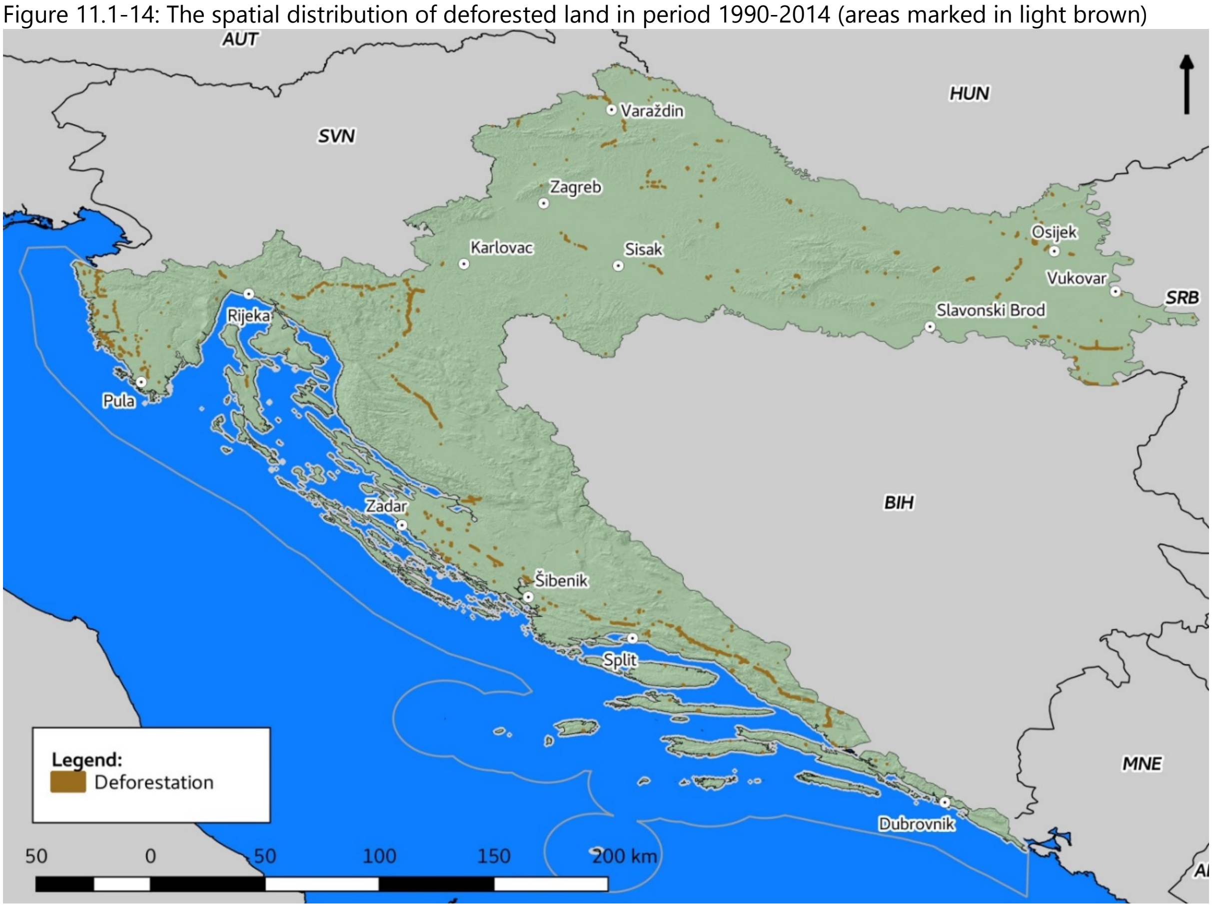
Table 11.1-3: Area deforested in Croatia in period 1990-2016 (ha/year)

Year	Deciduous	Coniferous	Maquies and shrub	Total
1990	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00
1994	23.79	34.56	0.96	59.31
1995	0.00	3.01	0.00	3.01
1996	0.00	0.00	0.00	0.00
1997	3.68	8.02	66.80	78.50
1998	55.84	48.92	0.00	104.76
1999	27.56	0.48	4.39	32.43
2000	143.60	23.22	1.43	168.25
2001	50.65	28.44	275.24	354.33
2002	85.42	109.16	32.90	227.48
2003	46.50	19.08	29.89	95.47
2004	136.89	52.02	158.63	347.54
2005	106.17	37.50	221.13	364.80
2006	51.24	17.59	283.43	352.26
2007	56.38	39.21	129.56	225.15
2008	122.57	69.80	217.18	409.55
2009	92.52	18.77	494.68	605.97
2010	69.00	57.12	223.25	349.37
2011	18.37	19.03	154.14	191.54
2012	49.54	94.32	101.01	244.87
2013	79.12	3.39	84.08	166.59

2014	17.14	0.81	26.57	44.52
2015	128.80	8.02	104.23	241.05
2016	21.74	12.01	0.42	34.17
Total	1,364.78	692.47	2,609.50	4,666.75

Results of work performed on complete forest management area are presented in Table 11.1-3 and Figure 11.1-14.

Figure 11.1-14: The spatial distribution of deforested land in period 1990-2014 (areas marked in light brown)



11.1.3.3. Definition and identification of Forest Management areas since 1990

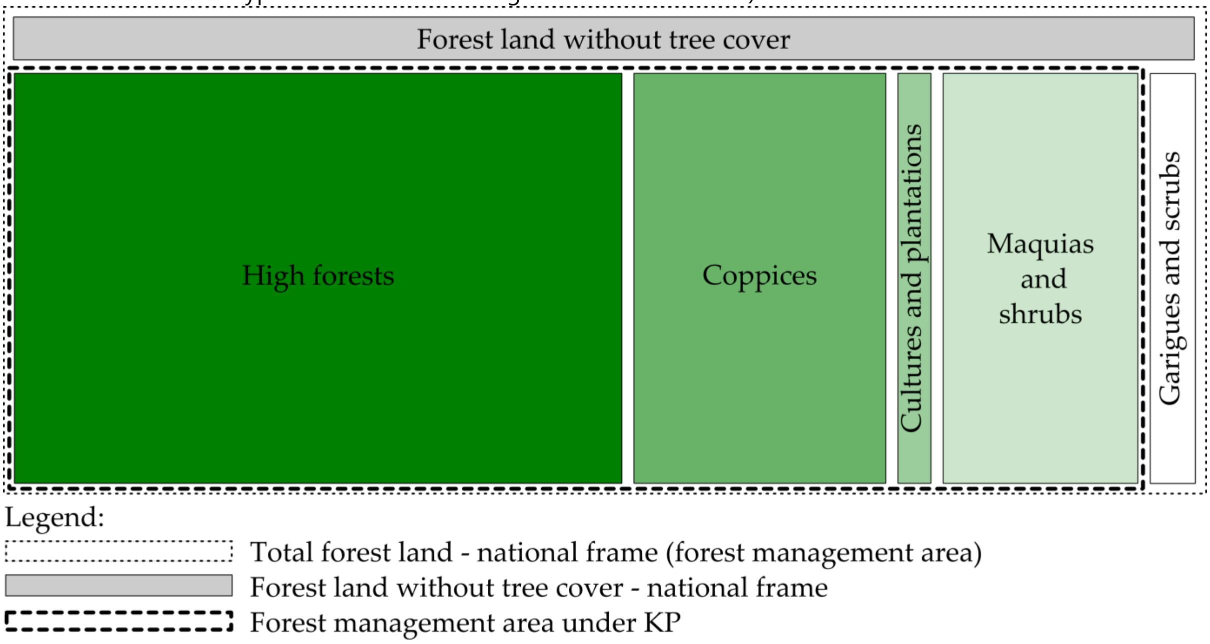
According to the national legislation, forest management has been interpreted in a same way as described in the IPCC 2006 Guideliness. However, definition of forest area in the national context has a broader framework than defined by Croatia within selected values for the purposes of reporting under the Kyoto Protocol. By the national framework forest land with tree cover (forests) and without tree cover (land under the forest management) constitutes one forest management area which is sustainable managed based on the FMAPs regardless the ownership type, purposes, forest stands etc. (see Chapter 6.3. for detail explanation).

Therefore, the area under the forest management according to the criteria set for KP reporting is not identical to forest management area in the national framework (Figure 11.1-15).

Croatian forest land area reported under forest management for the purposes of KP reporting refers to the area of high forests, cultures, plantations, coppice, maquies and shrub forests.

All forests fulfilling the definition of forests as defined in Table 11.1-2 are managed. Area of these forests is eligible area under forest management activity, since the entire Croatian forest area is defined as managed forest lands.

Figure 11.1-15: Forest management area under the KP and within the national framework (based on the relative share of forest types in total forest management area in Croatia)



Based on the results of conducted survey under the LULUCF 1 project and followed upgrade of databases in Croatian Forests Ltd., all areas detected as afforested and deforested in period 1990-2016 were subtracted from the forest land area to estimate the FM area.

To complete the analyses, the increase in forest area on basis of afforestations that happened before 1st January 1990 needed to be determined since some of these areas were already included in FM areas and emissions/removals were accounted under single years from period 1990-2012. One of reason for this was that in 1993 a regulation[56] by the Croatian law gave the obligation to Croatian forests to take over all existing forest meeting the forest definition that were not registered as forests before 1993 into the forest land (including the forests managed by holdings or enterprises). The background for this law was that all forest area in Croatia should be under forest management plans. As a result of this regulation also mature forests were for the first time counted as forest land under the new forest management plans.

All these areas previously reported under FM that were detected by the described current survey as afforested due to human induced promotion of natural seed sources that happened before 1990, were shifted from the years were they were previously reported for the first time to the FM area in 1990.

[56] The Regulation on amendments to the Law on Forests (OG 14/93, Article 18) and Law on amendments to the Law on Forests (OG 76/93, Article 22)

11.1.4. Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified

As Croatia has elected only the forest management under Article 3.4 activities, there is no need to develop a hierarchy between forest management and other Article 3.4 activities.

11.2. Land-related information

11.2.1. Spatial assessment unit used for determining the area of the units of land under Article 3.3

The spatial assessment unit used for determining the area of the units of land under Article 3.3 is 0.1 ha, which corresponds to the minimum area of forest defined by FAO. There is no need for further stratification of forests on more specific forest type (Coniferous, Deciduous and Out of yield forests (maquies and shrub)) due to the facts that Croatian territory is relatively small, Croatian forests create one unique area and all data related to the forestry sector are available form one source (Croatian Forests Ltd.).

11.2.2. Methodology used to develop the land transition matrix

Activity matrices are presented for 2016, 2015, 2014, 2013, 2012, 2011, 2010, 2009 and 2008 (Tables 11.2-1, 11.2-2, 11.2-3, 11.2-4, 11.2-5, 11.2-6, 11.2-7, 11.2-8, 11.2-9) based on the results of survey conducted under the LULUCF 1 project and as it was presented in subchapters 11.1.3.1 -11.1.3.3 of this Chapter.

Corrections have been made in comparison to matrix presented in previous NIRs of Croatia. The matrix was developed by adding and subtracting the conversion areas to and from land use category areas using the data from different databases available in Croatia (i.e. Croatian Forests Ltd., Croatian Bureau of Statistics, Corine Land Cover). Detailed information on approaches used to define the land use change area of each IPCC Land use category are given in parts 6.2-6.9 of the report.

Based on the Forest Act and Forest Ordinance[57] afforestation activities have to be prescribed by the Forest Management Plan for management units (FMAP). According to the Articles 31, 32 and 51, 51a and 52 of Forest Act, deforestation is strictly regulated and allowed in very limited circumstances for all forest under forest management regardless the type of forests and ownership.

The data for total forest area for the single year as well as the relative share of coniferous and deciduous forests are presented. Out of yield forests (maquies and shrub) are fully assessed in high resolution (0.05 ha grid) and amply described in the forest management plans for the management subunits. Maps of silvicultural activities are integral part of the programs according to the legislative act[58]. This is also applicable to the activities on ARD areas in Croatia since afforestations of new areas are the part of silvicultural activities.

The forest management system is organized so complete Croatian territory is divided into 16 forest districts – Forest Administrations (organizational and territorial units). This division was established in

[57] OG 111/06, OG 141/08,

[58] Ordinance on Forest Management (OG 111/06 (Article 63), OG 141/08)

1996. Forest Administrations consist of Forest offices, currently of 169 all together. The single Forest office is the basic organizational unit for performing all forest management activities (see Chapter 6.3).

An increase of forest area was assessed within the reporting period. Total area of forest land in Croatia is known as well as total areas of forest land converted to settlement and cropland categories thanks to FMAP system and strict national legislation. Also, the grassland area converted to forest land is well known due to the fact that afforesttation in Croatia has been done strictly on land under the forest management plans (without tree cover) which belongs to the grassland category according to the IPCC 2006 Guidelines. At the same time, the decrease in area of grassland was detected during the reporting period.

In order to identify and trace forest areas in accordance with provisions of decision 15/CMP.1 and requirements set in ARR 2012, Croatian Ministry of Environmental and Nature Protection initiated the project "Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol". The survey conducted during the project addressed the issue of increasing forest area in a way that:

1. Forest area increase on basis of afforestations that happened before 1st January 1990 was determined (e.g. in 1993 a regulation[59] by the Croatian law gave the obligation to Croatian Forests to take over all existing forest land covered under previous forest management plan and also from other enterprises). The background for this law was that all forest area in Croatia should be under forest management plans. As a result of this law also mature forests were for the first time counted as forest land under the new forest management plans). Croatia counted these lands under Art. 3.4 FM.
2. Afforestation and the former land use after 1st January 1990 and direct human induced LUC were identified. These areas are counted under Art. 3.3 AR.
3. Afforestation not direct human induced were examined. There is no afforestation in Croatia that can be considered as not direct human induced.

All forests regardless the type and ownership were included in the survey. Results of this study have significantly changed previously reported information under the Article 3.3 and 3.4 of the KP (NIR 2013). The same procedure was applied for years 2013, 2014, 2015 and 2016.

Table 11.2-1: Land transition matrix for year 2008, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2008
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	13.86							13.85
	D		2.41						2.41
Article 3.4 activities	FM		0.41	2,312.90					2,313.31
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA

[59] The Regulation on amendments to the Law on Forests (OG 14/93, Article 18) and Law on amendments to the Law on Forests (OG 76/93, Article 22)

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2008
		A/R	D	FM	CM	GM	RV		
	RV	NA			NA	NA	NA		NA
Other		1.83	0.00	0.00	0.00	0.00	0.00	3,327.99	3,329.82
TOTAL (end of 2008)		15.69	2.82	2,312.90	0.00	0.00	0.00	3,327.99	5,659.40

Table 11.2-2: Land transition matrix for year 2009, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2009
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	15.69							15.69
	D		2.82						2.82
Article 3.4 activities	FM		0.61	2,312.30					2,312.90
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		4.45	0.00	0.00	0.00	0.00	0.00	3,323.54	3,327.99
TOTAL (end of 2009)		20.14	3.43	2,312.30	0.00	0.00	0.00	3,323.54	5,659.40

Table 11.2-3: Land transition matrix for year 2010, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2010
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	20.14							20.14
	D		3.43						3.43
Article 3.4 activities	FM		0.35	2,311.95					2,312.30
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		4.81	0.00	0.00	0.00	0.00	0.00	3,318.73	3,323.54
TOTAL (end of 2010)		24.94	3.78	2,311.95	0.00	0.00	0.00	3,318.73	5,659.40

Table 11.2-4: Land transition matrix for year 2011, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2011
		A/R	D	FM	CM	GM	RV		
	A/R	24.94							24.94

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2011
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	D		3.78						3.78
Article 3.4 activities	FM		0.19	2,311.76					2,311.76
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		6,04	0.00	0.00	0.00	0.00	0.00	3,312.68	3,318.73
TOTAL (end of 2011)		30.99	3.97	2,311.76	0.00	0.00	0.00	3,312.68	5,659.40

Table 11.2-5: Land transition matrix for year 2012, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2012
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	30.99							30.99
	D		3.97						3.97
Article 3.4 activities	FM		0.24	2,311.51					2,311.76
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		5.03	0.00	0.00	0.00	0.00	0.00	3,307.66	3,312.68
TOTAL (end of 2012)		36.02	4.21	2,311.51	0.00	0.00	0.00	3,307.66	5,659.40

Table 11.2-6: Land transition matrix for year 2013, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2013
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	36.02							36.02
	D		4.21						4.21
Article 3.4 activities	FM		0.17	2,311.35					2,311.51
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		7.14	0.00	0.00	0.00	0.00	0.00	3,300.51	3,307.66
TOTAL (end of 2013)		43.16	4.38	2,311.35	0.00	0.00	0.00	3,300.51	5,659.40

Table 11.2-7: Land transition matrix for year 2014, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2014
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	43.16							43.16
	D		4.38						4.38
Article 3.4 activities	FM		0.04	2,311.30					2,311.35
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		8.35	0.00	0.00	0.00	0.00	0.00	3,292.17	3,300.51
TOTAL (end of 2014)		51.51	4.43	2,311.30	0.00	0.00	0.00	3,292.17	5,659.40

Table 11.2-8: Land transition matrix for year 2015, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2015
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	51.51							51.51
	D		4.43						4.43
Article 3.4 activities	FM		0.24	2,311.06					2,311.30
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		6.38	0	0	0	0	0	3,285.79	3,292.17
TOTAL (end of 2015)		57.89	4.67	2,311.06	0	0	0	3,285.79	5,659.40

Table 11.2-9: Land transition matrix for year 2016, kha

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2016
		A/R	D	FM	CM	GM	RV		
Article 3.3 activities	A/R	57.89							57.89
	D		4.67						4.67
Article 3.4 activities	FM		0.03	2,311.03					2,311.06
	CM	NA	NA		NA	NA	NA		NA
	GM	NA	NA		NA	NA	NA		NA
	RV	NA			NA	NA	NA		NA
Other		1.43	0	0	0	0	0	3,284.36	3,285.79

		Article 3.3 activities		Article 3.4 activities				Other	TOTAL 2016
		A/R	D	FM	CM	GM	RV		
TOTAL (end of 2016)		59.31	4.70	2,311.03	0	0	0	3,284.36	5,659.40

11.2.3. Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

All forest lands are assessed by by Croatian Forests' forest land assessment system. Croatian Forests have a legal duty to assess the total area of forest land of Croatia every ten years. Thus, estimations provided in this report are based on reliable data referring to the total territory of Croatia and irrespective to the type of forest or ownership.

Geographical units used for reporting are based on the forest ownership (state and private forests). The annexes of FMAP 2006-2015 contain thematic maps including map on the forest ownership. This map is prepared by merging digital spatial data with HS-Fond's database, scale 1:100.000 Therefore, the ownership is also spatially located (See Chapter 6.3).

Forests maps that are prescribed by article 51 of the Ordinance[60] as part of the FMAP 2006-2015 are:

- Geological map
- Phytocoenological map
- Soil Map detecting erosion and floodplains, rivers and water bodies
- Forest ownership overview map
- General maps of the spatial distribution of forests at the forest management unit especially for state-owned forests (showing boundaries of management units, forest offices, the forest administration, counties, specifically designated karst) and private forests (showing boundaries of cadastral municipalities or economic units, municipalities, counties, with specially designated karst).
- Forest map according to their purpose (commercial, protective, special purpose)
- Forest map by origin and the method of management (even-aged, uneven-aged forests)
- Forest map of main tree species
- Map of forest infrastructure (existing and planned forest infrastructure)
- Forest fire risk map
- Map of forest ecosystem services including larger settlements, industrial plants, agricultural areas, transport corridors

The maps are in scale 1:300,000 and repeatedly produced every 10 years at FMAP regular revision or renewed during the FMAP's additional or intermediate audits if required, except geological, soil and phytocoenological map which had been produced just once (during the development of first FMAP).

In order to comply with the ERT findings presented in ARR 2012 regarding the traceability and identification of lands as defined in paragraphs 6(a), 6(b), 6(e), 8(c), 9(a), 9(c) and 9(d) of the annex to decision 15/CMP.1, separate project was designed. Through surveys conducted within the framework of

[60] Ordinance on Forest Management (OG 111/06 and 141/08)

LULUCF 1 project Croatia managed to identify and trace lands that should be reported under paragraphs 3.3 and 3.4 of the Kyoto Protocol (see points 11.1.3.1-11.1.3.3 of the report). The survey was conducted on all Croatian forest areas that met thresholds for forests defined under the KP regardless the ownership and forest types (this includes maquies and shrubs). All data and information from conducted survey are presented in a separate document[61] as one of outcomes of LULUCF 1 project.

To conduct this work detailed analyses of spatial data and all relevant data available in official forest database HS Fond were performed consulting the forest management plans and programs valid in previous periods during the analysis and making field checks in forms of site visits on a level of forest sub-compartment when it was needed.

All identified areas that belong to ARD areas were incorporated into a GIS database of Croatian forests Ltd. as geospatial ESRI Shapefile (.shp) files. These are polygon layers with accompanying descriptive (attribute) data projected in HTRS96/TM coordinate system. Descriptive data use as a link between layer polygons and existing databases of Croatian forests Ltd.

Therefore, all reported ARD areas are geographically explicitly determined (Figure 11.2-1, Figure 11.2-2 and Figure 11.2-3) and traced as described.

Regarding geographical identification of afforested areas and their traceability in private and state forests that area managed by other legal bodies, it should be emphasized that performed work had proved increase in forest area due to promotion of natural seed resources while afforestation through planting and seeding activities do not occur in these forests (explanation provided under the Chapter 6.4.2.2).

Examples of areas registered as areas subject of ARD activities are presented in Figure 11.2-1 and Figure 11.2-2.

[61] Janeš *et al.* Separation of areas under the Article 3.3 and 3.4 of the Kyoto Protocol

Figure 11.2-1: A map of one forest district in Croatia presenting areas that are afforestated in period 1990-2010 (marked green) and areas that are foreseen for the afforestation in period 2011-2020 (marked yellow)

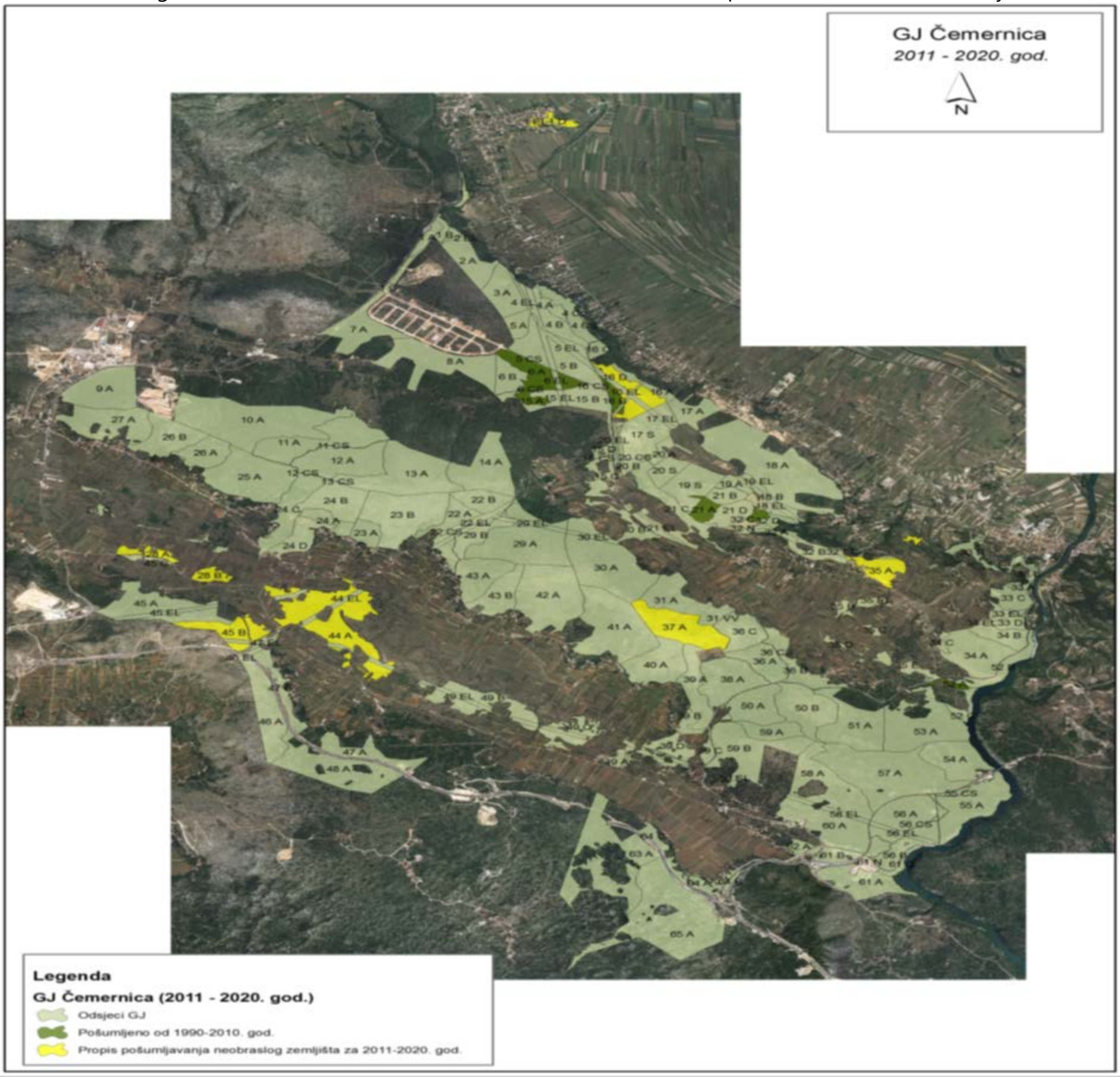
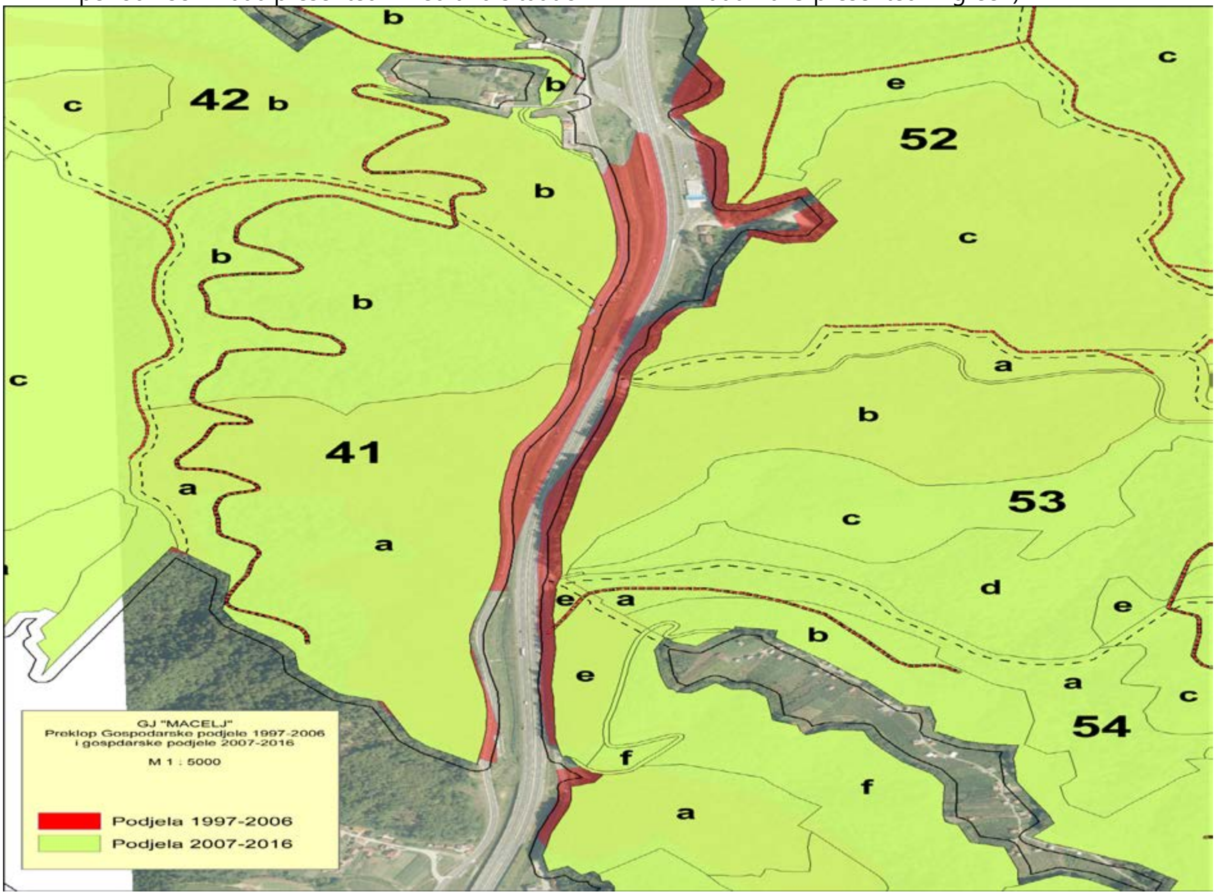


Figure 11.2-2. A map of the area with traced changes in the territory (area which was excluded from forest land in period 1997-2006 presented in red and situation in FMAP 2006-2015 presented in green)



11.3. Activity-specific information

Data used in the calculations are attained from FMAPs. The data were categorised according to forest type and reported as Deciduous, Coniferous and Out of yield forests (maquies and shrub). This disaggregation of data was used for presenting the carbon stock in living biomass. Data on carbon stocks in soil are presented as aggregated and without division by type of forests.

11.3.1. Methods for carbon stock change and GHG emission and removal estimates

11.3.1.1. Description of the methodologies and the underlying assumptions used

Methods and assumptions for estimating carbon stock changes in forests on areas under the Article 3.3 (afforestation/reforestation and deforestation) and Article 3.4 (forest management) of the Kyoto Protocol follow those applied for the UNFCCC reporting (see chapter 6.3).

In order to comply recommendations given by the ERT, emissions from forest fires are reported separately for FM and ARD areas since NIR 2014 reporting. This has been performed using officially submitted data from Croatian Forests Ltd gained through the activities of LULUCF 1 project and using the data from newly established data recording system introduced by Croatian forests Ltd to support Croatian KP reporting during the 2nd CP.

GHG Emissions on FM areas are estimated using the IPCC 2006 Guidelines default values for Other temperate forests. When estimating emissions form fires in afforested areas, values for biomass consumption and emission factors that also refer to Other temperate forests (IPCC 2006 Guidelines, Table 2.4 and 2.5) are used. Estimate of emissions from wildfires cover also Out of yield forests (maquies and shrub) but high forest biomass losses are used in estimation which represents overestimation of emissions under this type of forests. Additionally, due to the officially prescribed data collection methodology, it was not possible to distinguish areas affected by fires in case of maquies and shrub forests from scrub areas (degraded forms of shrub forests). Therefore, areas of scrub forests affected by fires make part of areas of maquies and shrub forests and estimation was done using the same values as for high forests. Maquies and shrub forest have significantly lower C stock, thus this approach is source of overestimation of emissions form fires in Croatian reporting.

After the conducted consultation with the forest experts, it was concluded that 60% of the biomass is fully burnt during the forest fires, while the remaining 40% is only partially burnt. Thus, CO_2 emissions reported in CRF tables from the biomass burning refers to the 60% of biomass lost due to the fires. For the remaining 40% of the emissions, notation key IE should be used since corresponding wood affected by fires (partially burnt) has been removed from forests and is included in total biomass harvested. N_2O and CH_4 emissions are reported in fully in CRF tables.

Detailed description of method used for estimation has been described in Chapter 6.15.2.

CO_2 emissions from biomass burning in areas subject to Article 3.3 and Article 3.4 are included in CRF tables 5(KP-I)A.1.1 Losses and 5(KP-I)B.1 Losses, accordingly.

1) ARD activities

Emissions and removals from ARD activities have been calculated using Tier 1 method for biomass gains and Tier 2 method for biomass losses and for soil. The activity data obtained refer to living biomass and soil as follows:

- For afforestation – afforested area
- For deforestation – deforested area and related volume felled

As regarding the afforestation, all land units have not been harvested since the beginning of the First commitment period.

Biomass

In order to determine the changes in biomass carbon stocks in ARD areas in Croatia, results and outcomes of the conducted survey under the LULUCF 1 project were used as presented below:

1. During the reporting period, afforestation by seeding and planting as well as supporting natural spreading of forests through human decision, did not happen in state owned forest areas that are managed by other legal bodies.
2. Only afforestation due to human decision to support natural spreading of forests on new areas occurred in private forests during the reporting period (see also Chapter 6.4.2.2)
3. In case of state owned forests managed by Croatian forests Ltd. afforestation through seeding and planting activities occurred. Also, natural spreading of forests on new areas were recorded as result of human decision to support increase of forest areas

4. Afforestation that occurred in state owned and private forests refers to conversions from grassland and cropland (annual and perennial) to forest land.

Values presented below were used for estimations according to the type of conversion (from Grassland or Cropland) and type of forests:

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 t d.m./ha annually (for coniferous), 4 t d.m./ha (for deciduous), and 0.5 t d.m./ha (for maquies and shrub)
4. Mean values of the average Root to Shoot ratio from IPCC 2006 Guidelines were used (0.4 (for coniferous in age class ≤ 20 years), 0.29 (for coniferous in age class ≥ 20 years), 0.46 (for deciduous)). Regarding the maquies and shrub forests the expert judgement was applied using the value 0.46.
5. Applied Carbon fraction values were the same one used in the estimation of carbon stock change: 0.51 tC/ t dm for coniferous, 0.48 tC/ t dm for deciduous and 0.47 tC/ t dm for maquie and shrubs.

Based on the above mentioned factors, average biomass growth was calculated to be 2.14 tC/ha annually in case of coniferous forests in age class ≤ 20 years and 1.97 tC/ha in age class ≥ 20 years. This constant value was used for all afforested coniferous areas of the first age class and multiplied by the total AR area of the first age class. The estimates for the second age class (AR areas that have been changed into the second age class since 1990) were calculated by multiplying the average biomass stock of the second age class by the area of the second age class. The same procedure was used when calculating gains for deciduous and maquies and shrub forests. Values of 2.8 tC/ha and 0.34 tC/ha as average biomass growth for deciduous and maquies and shrub forests were used accordingly.

Moreover, average annual increment in biomass calculation was separately done for above-ground biomass (AGB) and below-ground (BGB) biomass as presented in Table 11.3-1.

Table 11.3-1: Annual increment in biomass (tC/ha)

Forest type	Age class	Annual increment in biomass (TOTAL)	Annual increment in biomass (AGB)	Annual increment in biomass (BGB)
Coniferous	<20	2.14	1.53	0.61
	>20	1.97	1.53	0.44
Other Broadleaves	<20	2.80	1.92	0.88
	>20	2.80	1.92	0.88
Out of yield (maqies and shrub)	NS	0.34	1.15	0.11

The value of 107 m^3/ha were used for deciduous and coniferous forests for determining biomass growth per each forest type and lowest value from the range defined in IPCC 2006 Guidelines was used for maquies and shrub forests. In order to determine which R factor from the IPCC 2006 GL Table 4.4 to use, information on growing stock was needed. According to the recent national data the growing stock in the forests of second class age is 107 m^3/ha. This value was used as an input data for the estimation of above-ground biomass and the corresponding R factor.

To determine above-ground biomass growth in maquies and shrub forests, the lowest value defined in 2006 GL (Table 4.9) for Temperate continental forests (0.5 tonnes d.m./ha*y) was used.

In order to calculate the biomass carbon stock losses as a result of grassland and cropland conversions to the forestland, the nationally determined value of 4.29 tC/ ha annually for grassland category and 5.67 tC/ha annually for annual Cropland category were used. Default value of 63.0 tC/ha (IPCC 2006 Guidelines) annually was used for estimating carbon stock losses due to conversion of perennial Cropland to forestland.

As regarding D areas, the losses in living tree biomass per ha are calculated in the year of D using national information such as average harvested volume in period 1990-2016 by forest type and wood densities and also IPCC values (IPCC 2006 Guidelines) as presented in Table 11.3-2.

Table 11.3-2: Parameters used for the carbon losses estimation on deforested areas

Forest type	Average harvested volume (m^3/ha)	Wood density (t.d.m./m^3)	BEF 2	R/S	CF (tC/t d.m)$^{-1}$
Deciduous	144.57	0.56	1.4	0.23	0.48
Coniferous	108.85	0.39	1.3	0.29	0.51
Out of yield (maqies and shrub)	13.67	0.68	1.15	0.46	0.47

Regarding the maquies and shrub forests, conservative approach was applied when using value of 1.15 as a lowest value from a range defined for Temperate coniferous species in IPCC. Also, in case of R/S factor Croatia used value of 0.46 from the range defined in 2006 Guidelines for Other broadleaf forests with aboveground biomass less than 75 tonnes/ha (0.12-0.93) because it is considered that R/S factor in maquies and shrub forests is much higher since these forests come in Mediterranean parts of Croatia with dry climate and in order to survive they have to struggle for water and because of it is known by studies that they have very large roots. Based on the national data on stocks in deciduous and coniferous forests and ranges defined in 2006 Guidelines (Table 4.4), R factor of 0.23 and 0.29 were used accordingly.

IPCC 2006 Guideliness' default values for BEF2 and R/S factor for deciduous and coniferous forests are used for estimation of aboveground biomass (t/ha) which is calculated using national level derived values for average growing stocks and wood densities of each forest type. Considering that 2006 Guidelines does not provided figures for BEF 2, Croatia used BEF 2 as it was prescribed in GPG 2003. According to the harvest practices applied in Croatia, in period of last five reporting years, 14.5% of harvested volume is left on the site in case of deciduous forests and 20.1% in case of coniferous forests. Amount of total volumes harvested in these forest types were corrected with corresponding percentages. BEF 2 values from GPG 2003, Table 3A 1.10 was corrected with % of wood that remains in forests after harvesting operations. For the estimation purposes R/S factors were obtained from IPCC 2006 GL Table 4.4.

In period 2008-2016 harvesting rates were as presented in below Table 11.3-3.

Table 11.3-3: Volume harvested on deforested areas according to the forest types (m^3/ha)

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Deciduous	114.45	42.38	180.28	182.80	180.74	181.37	242.24	143.62	144.57
Coniferous	123.04	48.43	20.22	14.08	12.12	356.34	211.11	103.89	108.85
Out of yield (maquies and shrub)	16.34	13.05	14.68	14.53	4.10	6.93	14.30	13.67	13.67

Values of carbon stock in total biomass (AGB+BGB) are determined based on nationally determined average values for deforested volume in period 1990-2016 by each forest type as follows:

1. 57.04 tC/ha for deciduous forests
2. 29.36 tC/ha for coniferous forests
3. 7.36 tC/ha for Out of yield forests (maquies and shrub)

Approach 3 was applied when identifying all deforested forest areas in Croatia in period 1990-2014. Results form the analyses conducted through the project LULUCF 1 suggest that deforestation happens in Mediterranean (on 50.3% of all deforested areas with the 26.6 m^3/ha average volume deforested) and continental part of Croatia (on 49.7% of all deforested areas with the 180.1 m^3/ha average volume deforested). Most of harvested coniferous species are in the class of younger coniferous forests (more than 55% of volume deforested refers to young Aleppo pine forests) leading to the conclusion that carbon stock in coniferous forest is relatively small.

This is in line with stipulation of Forest Law (Article 57) which determines conversion of forest land to cropland category of land can be performed primarily on: 1) land under the forests management (land without tree cover) 2) forest land with woody (shrub) vegetation and 3) young forests.

When calculating gains due to biomass growth on deforested area, below presented values were used:

1. 0.19 tC/ha - for annual plants in area of Settlement (nationally determined)
2. 0.0256 tC/ha – for perennial plants in area of Settlement (nationally determined)
3. 2.10t C/ha – for perennial Cropland (IPCC 2006 Guidelines)

Description of the underlying methods and assumptions can be found in related part of the report (Chapters 6.8.2.1.1 and 6.5.2.2.1).

A) Dead wood

Dead wood occurs only in the category of forest land. Therefore, this pool would represent a sink at AR lands if estimated or data were available. For D lands, the data of extracted stem volume at these lands according to Croatian Forests Ltd. also account as dead wood. Therefore, the emissions from the dead wood pool at the D lands are included in the emissions from the biomass pool in the D lands and IE is reported for the dead wood pool.

B) Litter

For this year submission data used from the scientific investigation on determining carbon stock in litter pool are used (Chapter 6.8.2.1).

Annual carbon stock changes in litter at ARD areas are calculated as follows:

$\Delta C_{LT} = A * (C_{LTo} - C_{LTo-t})/T$

ΔC_{LT} = average annual carbon stock change in litter (t C/a)

A = annual D area, respectively the AR area following a transition period of 20 years.

CL_{To} = carbon stock in litter after conversion, (4.57 t C/ha in case of A areas and 0.00 in case of D areas))

CL_{To-t} = carbon stock in litter before conversion, (0.0 t C/ha in case of A areas and 4.57 tC/ha in case of D areas)

T = transition period for the litter carbon stock changes (1 year for D areas, 20 years for AR areas)

C) Soil

The estimates of the soil carbon stock changes at ARD areas follow the equation below:

ΔCLFMineral =[(SOCref – SOCbefore ARD) x AARD]/TARD

where:

$\Delta C_{LFMineral}$ = annual change in carbon stock in mineral soils for inventory year

SOC_{ref} = reference carbon stock

$SOC_{before\ ARD}$ = stable soil organic carbon on previous land use

T_{ARD} = duration of the transition from SOC before ARD to SOCref (20 years)

A_{ARD} = total AR or D area after conversion still in SOC transition of 20 years

The values of soil carbon stock determined through the national scientific investigation performed in 2017 were used in order to estimate the carbon stock changes in soil due to afforestation activity. The investigation was done taking the samples on 30 cm depth and excluding the litter pool from the sample.

Conversion that happens in the Croatian case refers to grassland and perennial cropland converted to forestland with following soil C stocks:

- Grassland: 75.7 tC/ha
- Forestland: 69.9 tC/ha
- Annual Cropland: 52.7 tC/ha
- perennial Cropland: 71.0 tC/ha

Soil removal factors determined in this cases were 0.85 tC/ha, -0.057 tC/ha and -0.29 tC/ha annually.

The values of soil carbon stock determined through the above mentioned national scientific investigation were used in order to estimate the carbon stock changes in soil due to conversion Forest land to perennial Cropland. Soil C stocks are:

- Forestland: 69.9 tC/ha
- Perennial Cropland: 71.0 tC/ha

Soil emission factor determined in this case is 0.006 tC/ha annually.

For determination of soil carbon stock changes due to deforestation activity to settlement, the used values for soil carbon stocks are presented below, and emission factor was calculated to be 3.3 tC/ha annually:

- Settlements: 4.0 tC/ha
- Forestland: 69.9 tC/ha

Detailed description of the methodologies and the underlying assumptions used are presented in Chapters 6.5.2.2.1 and 6.8.2.1.1 and Chapter 6.4.2. Methodological issues.

2) FM activities

Emissions and removals from FM were calculated based on related equations from the IPCC 2006 Guidelines.

The entire description of the methodological approach is presented in Chapter 6.4.2.

The estimates under forest management for the KP reporting refer to high forests, cultures, plantations, coppice, maquies and shrub forests.

Based on the ERT recommendations given in 2012 during the In country review, CO_2 emissions/removals in period 2008 – 2016 were estimated using the per ha values for increment and harvest for all types of forest ownerships.

11.3.1.2. Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

Omitting GHG emissions/removals

Table 5(KP-I)A.1.2 Article 3.3 activities: Afforestation and Reforestation. Units of land harvested since the beginning of the commitment period

With respect to ensure determination of harvesting or future deforestation on afforested land, country wide forest management plans secure that all forest management activities are transparent and prescribed. Each of these plans define all measures and activities for the period of its validity (10 years), and they also give a description of the measures that are required in the following 10 years period. Based on the legislation[62] execution of each activity prescribed under forest management plans must be recorded on yearly basis (which refers also to afforested areas) and at the end of forest management plan officially registered by the Ministry of Agriculture. Following national forest legislation[63], only pre-commercial thinning is defined as possible harvesting operation in forests of the first age class. In case of the second age class forests no harvesting operation occurred during the First commitment period. These legislative acts and forest management practices related to first and second age classes forests on afforested areas, allows Croatia to report units of land harvested since the beginning of the commitment period, if this occurred. Croatia uses notation key NO in CRF tables since harvesting has not been performed on afforested area so far.

Table 5(KP-I)A.2.1 Article 3.3 activities: Deforestation. Units of land otherwise subject to elected activities under Article 3.4 (information item)

Only forest management has been elected under Article 3.4. As Deforestation is a permanent loss of forest cover, any unit of land that has been deforested under Article 3.3 cannot also be subject to the forest management under Article 3.4.

Table 5(KP-II)1. Direct N_2O emissions from N fertilization

N fertilization of forests is not performed in Croatia, so emissions are reported as not occurring.

Table 5(KP-II)2. N_2O emissions from drainage of soils

[62] Ordinance on Forest management

[63] Forest Act

Drainage of soils does not occur in Croatia.

Table 5(KP-II)3. N_2O emissions from disturbance associated with land use conversion to cropland.

The annual release of N_2O due to the conversion of forestland to cropland was calculated using the default value (Tier 1) and equations 11.1 and 11.2 from IPCC 2006 Guidelines:

$N_2O_{net-min}$ - N = EF_1 x $\Delta C_{LCmineral}$ x 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)

Table 5(KP-II)4. Carbon emissions from lime application

No lime is applied to forests and perennial cropland from D activities, so emissions are reported as NO.

Controlled biomass burning

Controlled biomass burning does not occur in Croatia. All fires can be addressed as wildfires.

Omitting carbon pools

Croatia performs estimation in the aboveground and belowground biomass and soil pools for Article 3.3 and estimation in the aboveground and belowground biomass for Article 3.4. As for other carbon pools, based on the forest management practices and the legal framework within which the latter is performed, it is concluded that these pools are not emission sources. The background information on this issues as follows:

ARD areas

As for afforestation areas and dead wood carbon pool, it is considered that conversion of Grassland and Cropland to Forestland can not generate carbon stock changes in terms of losses of dead wood, especially in the long-term. Generally, afforestation by seeding and planting has been performed only in state owned forests on the land under forest management that is without tree cover. Based on the IPCC GPG definitions of categories of land, this type of land is categorised under the Grassland. Since there is no dead wood stock in Grassland area, conversion of this type of land to the Forest land contributes to the increase in the dead wood pool and is not a source of emissions. The same apply to areas converted from Grassland and annual Cropland category due to human decision to support natural spreading of forests. Furthermore, by the age of 20 years old of stands, the dead trees occur due to natural mortality and cause by tree competition. This leads to a continually increasing number of dead trees. Therefore it is expected that inputs are larger than decomposition. With such argumentation, Croatia conservatively assumes that deadwood is not a net source of emissions on AR lands and NO notation key has been used in CRF tables.

Emissions on deforested areas are estimated based on harvest volumes of living and already dead trees (dead wood, being part of the amount of harvested biomass). All that biomass/dead wood is assumed to be oxidized in the year of D – so the worst case (complete instant oxidation of the harvested biomass in the year of D) was assumed and there is no reason to calculate any further decay at site. Due to the assessment systems and data used DW and fine woody debris component of litter are part of the biomass and soil pool, so they cannot be assessed a second time in order to avoid double accounting. Dead wood removed is part of the stock which is assessed as being removed due to deforestation.

Due to forest management practices in Croatia, there are two types of dead wood – dead wood that refers to wood thicker than 7 cm which is removed from the forests and wood thinner than 7 cm (wood residues) which is left in the forest to decay after harvest operations. Dead wood reported as IE in CRF tables refers to dead wood thicker than 7 cm and removed from the forests.

Leaving wood residues thinner than 7 cm into the forests presents one of operations regularly performed durig the harvest practices in Croatia. However, deforestation is not regular operation under the forest management practices and as such it has been strictly and separately regulated by the law. Deforestation in Croatia happens due to conversion of Forest land to Cropland and Settlement category of land. Conversion to Settlement category has been performed mainly due to important infrastructural works (i.e. high ways constructions) and in case of Cropland category due to cultivation of vineyards, orchards or olive gardens. Both types of conversion require removal of all wood components including the wood residues in order to have successful conversion of forest land to cropland or settlement category (i.e. land requires tillage in case of orchards and wood residues would present obstacle to that work). Hence, normal practice of leaving wood residues thinner than 7 cm into the forests is not and can not be applied when deforestation activity has been performed. As it was reported in Chapter 11.1.3 Approach 3 has been applied when identifying land subject to deforestation activity and only land where deforestation was actually happened was reported according to the corresponding year of conversion. Consequently, there is no situation when wood have been cut and deforestation performed without real conversion to other types of land. This means that there are no situations wood residues are left on site due to failure to conduct planned conversion.

FM areas

a) Omitted pools of dead wood, litter and soil in subcategory Out of yield forests (maquies and shrub forests)

According to the national definition[64,] maquies and shrub forests are forests where besides the trees, bushes are presented in the same crown layer.

This type of forest in Croatia include typical Sub-Mediterranean and Eu-mediterranean species such as Holly oak and Pubescent oak (and naturally associated species) as well as pines (i.e. Aleppo pine) that appear in the smaller areas or as a number of trees created through afforestation or natural means (fires) that due to its dispersion cannot be classified as coniferous culture.

According to the forest law and prescribed management plans, these forests are primarily left to the natural development supported through the specific management measures such as: fire protection measures, afforestation (using primarily pioneer tree species) and sporadic activities with the purpose of converting these forests to the form of high forests (i.e. according to the FMAP 2016-2025 conversion to high form of forests and reconstruction of maquies and shrub forests is prescribed to be executed on more than 20 000 ha in 10 year period). The main role of these forests is protection, so this is the reason that, accordinig to the national legislation, there is no biomass harvest in maquis and shrub forests, but sporadic measures of planting to convert such forests into higher form of forests.

[64] Ordinance on Forest management (OG 111/06), Article 13

As one of the measures for preservation of maquies and shrub forests, ban of goat keeping in these forests was introduced by Croatian law on forest during 1950. This measure supported spreading of pioneer tree species, their role in maquies and shrub forests and helped return of native vegetation.

Additionally, given species of small dbh prevail in these forests, their exploitation for firewood consumption would require more time and resources than the exploitation of wood in the high forests, that make them unattractive for firewood extraction. At the same time, vicinity of Lika region with high quality forest species of firewood, contributes to the preservation of maquies and shrub forests.

According to the measures in energy sector adopted by the Croatian Government and Parliament[65] (i.e. completion of gas pipelines for Dalmatia (Mediterranean region) and supporting measures to the production of electricity that originates form wind farms and solar panels both of which are most suitable for this region), and increase of prices of wood for heating, lower consumption of wood for heating is expected in Mediterranean part of Croatia and in the future there will be no demand for consumption of wood that originates from maquies and shrub forests. Additionally, it is not expected that legal framework by which maquies and shrub forests are defined and managed as protective forests with no harvest, will be changed in the future.

Harvest have not been carried out in these forest. Sporadic planting measure and the pressure from animals decreased due to the depopulation of rural areas. Therefore, as there no harvest in out of yield forests Croatia assumes that carbon losses does not occur in biomas pools ad notation key NO was used in CRF tables.

Croatia believes that presented arguments prove that these changes in maquies and shrub forests consequently are connected to the increase in the input of dead wood from natural mortality due to the increase in biomass. Additionally, Croatia believes that dead wood stock can only increase with time as a result of forest fires and the fact that these forests grow mainly in Mediterranean part of Croatia which is due to climate conditions frequently disturbed by forest fires. Although these forests have very good ability to regenerate themselves after the fires, in cases of long lasting fires when biomass is lost, all biomass burnt has to be cut when preparing forest area for restoration. In these cases all biomass is left on the side to decay.

According to the Article 32 of Forest Act[66] removal of peat, litter and humus is strictly prohibited and their use, in exceptional situations, is regulated by Article 33. For the same arguments as provided for dead wood (steady increase in biomass in these forests due to the lack of harvest and planting measures and less pressure from agricultural animals), litterfall and consequently the litter pool and the soil pool under the maquies and shrub forests are not a source of emissions, but a C sink.

b) Omitted pools in subcategories Decidous and Coniferous forest

b.1) Dead wood

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[65]Energy Development Strategy of the Republic of Croatia (OG 130/2009); Law on Energy (OG 120/12); Tariff system for the production of electricity from renewable energy sources and cogeneration (OG 33/07); Amendments to the plan of development, construction and modernization of gas transportation system in the Republic of Croatia from 2002 to 2011 - The second investment cycle 2007 – 2011

[66] Ibid

According to the Croatian report for FAO Forest Resources Assessment 2005 (FRA 2005)[67] carbon stock in this pool for forest land has increased in Croatia within the period 1990-2005:

Table 11.3-4. Thresholds in defining forest

FRA 2005	1990	2000	2005
dead wood / Mt C	20.8	26	27

The latter clearly indicates that this pool is not an emission source.

Data on wood removal from FRA reports (for 1990 FRA 2005 and for 2000 and 2005 FRA 2010) were compared to NIR data on fellings. The comparison indicated that not all wood was removed from the forest and that certain percentage (about 10-15%) was left in the forest; thus contributing to a C input in other carbon pools. Reporting on wood removals under the FRA fits adequately to the wood removals practices conducted in Croatia that is performed in a way that harvest residues and wood less than 7 cm in diameter are left in the forest. Within the KP Forest management reporting, total gross fellings (i.e. including branches and bark) are reported. Considering latter, there are no underestimations in regard to dead wood.

Furthermore, based on the available data on growing stocks and harvest which prove steadily increase in the standing stocks in Croatia (Table 11.3-5) while the forest management methods remain the same. Under such circumstances and due to the fact that mortality is correlated with stand density, also an increase in dead wood stocks is very likely, as indicated by the FRA results.

Table 11.3-5: Growing stock, harvest, increment and forest areas in Croatia

	2008	2009	2010	2011	2012	2013	2014	2015	2016
	Growing stock (m^3/ha)								
Deciduous	211.5	212.6	213.7	214.7	215.8	216.9	219.2	228.1	229.5
Coniferous	247.4	249.4	251.5	253.5	255.6	257.6	260.8	250.9	251.0
Out of yield forests	50.0*	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
	Harvest (m^3/ha)								
Deciduous	2.707	2.620	2.709	3.014	3.050	3.000	3.100	3.400	3.500
Coniferous	3.759	3.625	3.445	4.001	3.988	4.400	4.900	4.600	4.700
Out of yield forests	NO**	NO	NO	NO	NO	NO	NO	NO	NO
	Increment (m^3/ha)								
Deciduous	5.604	5.576	5.549	5.522	5.495	5.500	5.500	5.600	5.700
Coniferous	5.527	5.564	5.601	5.637	5.674	5.700	5.800	5.400	5.400
Out of yield forests	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	FM area (kha)								

[67] FAO, Forest Resources Assessment Croatia 2005 (FRA 2005), (http://www.fao.org/forestry/8405-0ae983caa45ca038755a439ceae4f532e.pdf)carbon

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Deciduous	1,674.64	1,674.55	1,674.48	1,674.46	1,674.41	1,674.34	1,674.32	1,618.73	1,618.01
Coniferous	199.83	199.81	199.75	199.73	199.64	199.63	199.63	207.71	208,29
Out of yield forests	438.43	437.94	437.71	437.56	437.46	437.38	437.35	484.62	484.73

*According to the expert judgement growing stock ranges between 20 to 50 m^3/ha in these forests

**Not occurring (NO)

Also, it should be mentioned that the forest management practice is governed by the strict legal framework which prohibits, for example, to cut the branches or their parts (unless it is provided by the forest management plans), to collect and remove leaf litter, moss etc. (Forest Act, Article 32).

As a consequence of War, areas polluted with mines are still present in Croatia. Although continued work has been conducted for de-mining purposes, according to the data available at Croatian Mine Action Centre (CMAC) there are still more than 61 kha[68] of areas polluted with mines.

According to the data delivered by Croatian Forests Ltd., forest areas polluted with mines were more than 243 kha in year 1997 and more than 54 kha in 2011 and 49 kha in 2012. Figures presented here refer to forest according to the Croatian thresholds chosen in defining forests for reporting under the Kyoto protocol. Due to safety reasons, regular forest management activities have not been conducted on forest areas 2.5 times bigger than area officially proclaimed as mine polluted. In these forest areas no forest work has been performed as long as they are polluted by mines. De-mined forest areas are subject to official procedure prescribed by Forest Act[69] and special audit has to be performed and new Forest management plan for the corresponding forest unit has to be developed. By this plan all activities that need to be conducted in ten year period are prescribed. However, due to safety reasons activities defined by the plan on de-mined areas are usually executed slower than activities in forest areas that are not mine polluted.

Comparing to the total forest management area in Croatia it means that 12% of forest area was not accessible for managing in year 1997 and around 5.5% in 2011 and 2012.

Forest areas polluted with mines are determined by official maps available at the CMAC, overlapping them with official forest maps present at Croatian forest Ltd.

Due to above presented facts, Croatia believes dead wood stock increases and consequently carbon stock in this pool is increasing. The reason is the prevention of dead wood removal from forests and the implementation of required thinning operations on the areas polluted with mines or that are de-mined.

Before it was approved, Forest management plan for the Republic of Croatia in period 2016-2025 (FMAP 2015-2025) was subject of official approval of other relevant institutions in Croatia. Requirements of the Ministry of Environment (Nature Protection Directorate) to ensure that a constant number (3-5 trees/ha) of old and dry, standing and fallen trees, especially trees with hollows are left on logging sites, are incorporated into the FMAP.

Additionally, according to the Article 26 of Forest Act, all forest management plans that need to be developed for forest incorporated in one of areas protected under the Law of Nature Protection (i.e

[68] Croatian Mine Action Centre, http://www.hcr.hr/hr/minSituac.asp
[69] OG (140/05,82/06,129/08,80/10,124/10, 25/12, 68/12, 148/13), Article 21

national park), have to be approved by the Ministry of Environment and in order to be in line with the requirements of nature protection. Securing biological diversity through leaving certain number of dead trees on logging sites is one of constant requirement requested by the Ministry of Environment and Energy.

Since Forest Act was published in 2005 according to the Article 8, Croatian Forests Ltd. and private forest owners are obliged to manage forests by maintaining and enhancing biological and landscape diversity and promote the protection of forest ecosystems in a way that due attention must be given to other species in the ecosystem that are associated with dry and dead trees through leaving the required number of old dead wood, hollow and decayed trees, in spatial distribution and number which preserves biological biodiversity.

Since 2002 Croatian Forests Ltd disposes with FSC (Forest Stewardship Council) certificate for forest management which proves that forests are managed according to strict environmental, social and economic standards. Since the first certificate was gained, certificate has been renewed on regular basis every 5 years. According to the available information, FSC certificate refers to more than 2.0 million ha of Croatian forests and land under the forest management[70].

In order to secure compliance with FSC requirements and national legislation, 3-5 dead wood/ha have to be left on the logging sites since year 2002.

The area and number of protected areas in Croatia increased during the years. According to the Protected Areas Register of the Ministry of Environmental and Nature Protection, 1.7% of Croatian terrestrial area is protected in categories of strict reserve and national park[71]. In these protected categories forests make significant part.

Due to the fact any economic activity and commercial use of natural resources are prohibited in these protected areas[72], it can be assumed that dead wood stock increases in forests within these protected categories. Consequently carbon stock in dead wood pool also increases.

Croatia believes that arguments provided on requirements of national legislation and international standard regarding the dead wood pool prove that dead wood stock in Croatia increases year by year and that carbon stock in dead wood consequently also increases.

An additional support to Croatian claim that dead wood pool is not source of emissions is the fact that reporting performed by neighbouring countries (Slovenia, Hungary) and country with partially similar ecological conditions (Greece)[73] claimed that dead wood pool is not source of emissions in their countries and presented exact data proving this.

b.2) Litter

According to the recent scientific paper[74] carbon stock in litter pool in penduculate oak forests increases with the forest age and reaches its maximum (10.34 tC/ha) in age of 137 years.

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70 Croatian Forests Ltd, http://split.hrsume.hr/index.php/hr/component/content/article/1-latest-news/472-10-godina-fsc-certifikata-u-hrvatskim-umama

71 State Institute for Nature Protection, http://www.dzzp.hr/eng/protected-areas/protected-areas-in-croatia/protected-areas-in-croatia-–-national-categories-1137.html

72 Law on Nature Protection (OG 80/13), Articles 112 and 113

73 UNFCCC, National Inventory Submissions 2013, http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/7383.php

74 Ostrogović, M. Z. (2013) *Carbon stocks and carbon balance in even-aged forest of penduculate oak (Quercus robur L.) forest in river Kupa basin*, table 38, page 58

According to the FMAP 2016-2025[75], penduculate oak forests are spred on the largest area when in the fifth (100 years) and sixth age class (120 years). Since Ordinance on Forest management[76] prescribes cutting of penduculate oak forests in age of 140 years, this means that continuous accumulation of carbon stock in litter pool will occur in these forests.

Since oak is one of main species in Croatian forests (12% of total growing stock in Croatia comes from this species[77]) and there is no changes in management practices in any type of forests in Croatia, Croatia assumes that carbon stock in litter pool increases in all forests.

In addition, the assessments show that biomass stocks in the Croatian Forests increased steadily in the last decades. It is evident that litterfall is higher in forests with higher biomass. In parallel, increased harvest in the last decades in the Croatian forest was associated with a higher flux of dead biomass from harvest residues (e.g. branches, stemwood parts, stumps, roots) to the soil. Also, this trend is connected with an increase in litterfall to soil.

Additionally, following the above mentioned legal framework that prohibits the removal of peat, litter and humus from the forest and herein reported data that clearly indicate increase of biomass stock and increment and harvest, it can be concluded that a decrease in the carbon stocks of the litter pool is very unlikely. In addition to this, based on the Forest act, exceptionally and under strict conditions, the use of humus can be allowed but only if it is in accordance with the forest management plans and special legal regulations. Taking the latter into account and evidence for a rise in the C input into litter/soil due to the increase in biomass standing stock and in harvest causing an increase in the input of harvest residues, it can be concluded that the litter pool of the Croatian forests is not an emission source.

b.3) Soil

Within the reporting period, there was no change in the forest management.

At this moment in Croatia there is no expert and scientific literature or investigation the hypothesis soil pool under the Forest management is not a source of emissions.

However, based on the data and information provided above that prove carbon stock increases in biomass, dead wood and litter pool, an increase in these pools is correlated with an increase of the C input to the mineral soil and consequently with an increase of carbon stock in soil. Consequently, it can be also assumed this pool is not a source of emission.

11.3.1.3. Information relating to exclusion/inclusion of emissions from natural disturbances

Regarding the explicit indication for which of the activities of afforestation and reforestation (AR) under Article 3, paragraph 3, of the Kyoto Protocol and/or forest management (FM) under Article 3, paragraph 4, of the Kyoto Protocol intends to apply the ND provision Croatia reports that intends to apply ND provisions as follows:

1. For the activity of afforestation under the Article 3, paragraph 3 of the Kyoto protocol
2. For the forest management activity under the Article 3, paragraph 4 of the Kyoto protocol.

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[75] FMAP 2006-2015, table 93, page 293
[76] OG (OG 111/06, 141/08), Article 24
[77] FMAP 2006-2015, table 72, page 276

Regarding the Country-specific information on the background level of emissions associated with annual natural disturbances that have been included in its forest management reference level, Croatia reports that the FMRL of Croatia is based on a projection without consideration of biomass losses due to ND events. Therefore, there is no Technical Correction of the FMRL needed due to Croatia's use of the ND provision, net credits due to the use of the ND provision will not occur

In nest lines, Croatia reports how the background level(s) for afforestation and reforestation under Article 3, paragraph 3, of the Kyoto Protocol and/or forest management under Article 3, paragraph 4, of the Kyoto Protocol have been estimated, and information on how it avoids the expectation of net credits or net debits during the commitment period, including information on how a margin is established, if a margin is needed:

A) ND provisions for Afforestation area under Article 3, paragraph 3 of the KP

The background level of emissions associated with annual natural disturbances has been estimated following an iterative process described in detail below, in accordance with footnotes 7 and 9 of annex Decision 2/CMP.7 and the guidance provided by the KP Supplement. For the necessity of determining the background and margin level of emissions in afforestation areas due to natural disturbances, forest fires were selected as the only type of ND that Croatia intends to exclude and consequently to report about. This type of ND was selected based on the first analyses conducted in Croatia regarding the ND types in period 1990-2009 and its occurrence. There has been not found other types of ND that significantly occurred in these areas during the calibration period. This is why it was assumed that other types of ND will be unlikely significant at these areas in future. Since forests on these areas mostly belong to the first age class at the moment (the oldest forest is 24 years old), first analyses showed that in case of forest fires all biomass is fully burnt. Because of that the estimation of emissions for ND provision purposes is performed by using the complete afforestation area and biomass affected with forest fires during the calibration period.

The background level was determined in line with the provisions given in Annex E to decision 2/CMP.7 for the emissions due to ND on AR areas. The background level and the margin have been determined by applying the IPCC default method, as follows:

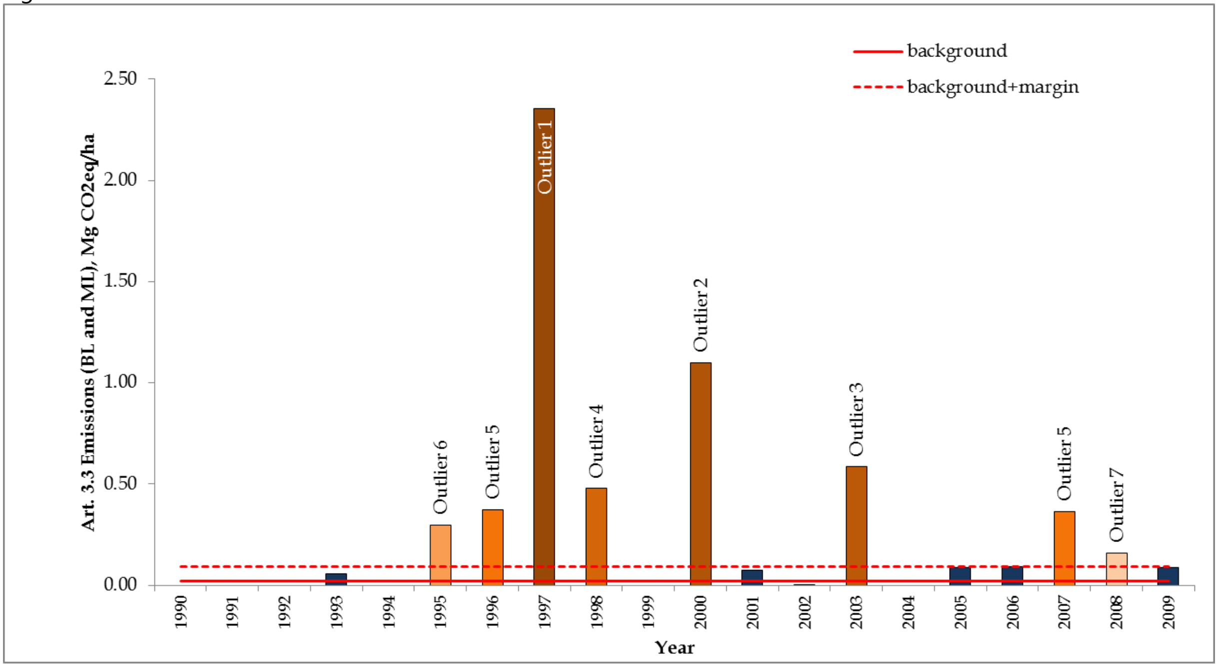
i. A consistent and complete time series containing area specific annual emissions from wildfires for the calibration period 1990 - 2009 was set.
ii. The arithmetical mean and standard deviation of the emissions from wildfires were calculated.
iii. Any emissions that were larger than the arithmetic mean plus twice the standard deviation (outlier) were removed from the time series.
iv. The process mentioned in points 2. and 3. above was iterated until no further outliers were identified.
v. The arithmetic mean and twice the standard deviation estimated in the last step of this process (no outliers remain) define the background level and the margin, respectively.
vi. Both the area-specific background level and the margin were multiplied by the average afforested annual area estimated for the commitment period. For the projection of the area under afforestation for the commitment period, constant increase of afforested areas of 1.8 kha per year was assumed for years 2015-2020. For the remaining two years of the commitment period (2013 and 2014), exact data were available and used in estimation.

The total and the area-specific emissions associated with disturbances for the calibration period for AR lands are presented in Table 11.3-6. and Figure 11.3.1.

Table 11.3-6. Emissions from natural disturbances for AR

Total and area specific emissions from disturbances for the calibration period for AR																				
Distrubance type*	Inventory year during the calibration period																			
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	Total annual emission [Gg CO_2 eq.]																			
Wildfires				0.04		0.35	0.54	3.88	0.91		2.73	0.21	0.01	1.94		0.61	0.91	5.04	2.49	1.80
Insect attacks, disease infestations																				
extreme weather events																				
geological disturbances																				
other																				
SUM				0.04		0.35	0.54	3.88	0.91		2.73	0.21	0.01	1.94		0.61	0.91	5.04	2.49	1.80
For all land under AR	Total area [kha]																			
		0.21	0.38	0.67	0,93	1.16	1.45	1.65	1.91	2.24	2.48	2.74	3.04	3.32	3.97	7.02	9.89	13.85	15.69	20.14
	Area-specific emissions (Emissions per unit of land area under AR, Mg CO_2 eq. ha^{-1})**																			
				0.057		0.298	0.373	2.353	0.477		1.099	0.076	0.005	0.584		0.087	0.092	0.364	0.159	0.089
* Sub-division of types can be added as needed																				
** In any year, emissions per unit of land area are calculated as the Sum divided by the total area under AR																				

Figure 11.3-1. Emissions from natural disturbances for AR



The results of the whole process as described above are:

1. Background level: 1.12 Gg CO_2eq
2. Margin: 3.98 Gg CO_2eq
3. Background level plus margin: 5.10 Gg CO_2eq
4. Total number of years with fires: 14
5. Number of excluded years: 8
6. Years excluded: 1997, 2000, 2003, 1998, 1996, 2007, 1995, 2008.

By applying the KP Supplement in the way just described for the development of the background level and the associated margin, Croatia believes that the expectation of net credits or net debits has been avoided.

Croatia intends to apply the ND provisions for Afforestation area under Article 3, paragraph 3 of the KP in respect to forest fires.

B) ND provisions for Forest management area under Article 3, paragraph 4 of KP

The background level of emissions associated with annual natural disturbances has been estimated following an iterative process described in detail below, in accordance with footnotes 7 and 9 of annex Decision 2/CMP.7 and the guidance provided by the KP Supplement. For the necessity of determining the background and margin level of emissions in FM areas due to natural disturbances, forest fires were selected as the first type of ND that Croatia decided to report about. This type of ND was selected based on the first analyses conducted in Croatia regarding the ND types in period 1990-2009 and its occurrence. After the conducted consultation with the forest experts, it was concluded that 60% of the biomass is fully burnt during the forest fires, while the remaining 40% is only partially burnt. It was assumed that 60% of areas correspond to 60% of wood (fully) burnt.

According to the Ordinance on forest management (OG 79/15) provisions, all areas subject of natural disturbances need to be remediated and prescribed forest activities have to be performed securing that forest area remain forest area. Consequently, this means that the partially burnt wood is a subject of regular forest works and salvage logging operations. This 40% of wood affected by fires are removed from the forest. This is a reason for reporting emissions from only 60% of forest areas affected by forest fires for the necessity of determining the background and margin level in FM areas. The estimation of forest fires emissions are performed using the equation 2.27 from the 2006 IPCC Guidelines and Tier 1 method. For this estimation Croatia uses only data about areas affected by forest fires that are determined on national level.

In order to use natural disturbances provision as defined in Annex I to decision 2/CMP.8 natural disturbances areas on which wood have been left on site needed to be determined. Taking into consideration provisions of national legislation regarding the natural disturbances in forests (remediation prescribed and requested), it was concluded that damaged wood has been left on site after the natural disturbances only in special circumstances, and that this can happen only in case of:

a) Forest areas that are strictly protected on which any kind of forest practices are forbidden (i.e. strict forest reserves)
b) Areas with forest which diameter breast height (dbh) is under the measurement limit (i.e. first age class forests)
c) High mountains forest areas without access by forest roads
d) Areas still under the mines as a consequence of War in Croatia in 1990's

The additional analyses performed in Croatia showed that other types of ND (except the forest fires) also occurred on above listed areas during the calibration period, and it is reasonable to expect these ND types will repeat in the future also. This is a reason that Croatia decided to report emissions from extreme weather events as part of its ND provisions under the Decision 2/CMP.8. This ND type (extreme weather events) has been additionally presented as: (i) Windbreaks; (ii) Snow-breaks and ice-breaks (presented together).

In order to perform the emission estimation due to extreme weather events and presenting the data in the Initial repor, a proxy was used. The emission estimation arising from the above listed ND (sub)types are calculated for FM areas using the Gain-Loss method from the IPCC 2006 Guidelines and Tier 2.

However, since then Croatia initiated a separate project in order to determine emissions due to natural disturbances selected in the Initial report and defining BL and ML in FM areas. Within the project a specially designed Questionnaire was sent out to all forest units in Croatia (169) with the request to check areas affected by natural disturbances in period 1990 -2015. and deliver data on forest types (decidous, coniferus maquies and shrub), volume and areas affected. The questionnaire refered to all forests in Croatia, regardless the forest ownerships. Detailed results of the project and conducted survey are presented in a separate, official document[78].

The basis for determing wood volume left on the site after the disturbance made data on the so called salvage logging (refers to volume cut due to natural disturbance and which is removed from the site) on FM areas and shares between FM and the ND areas without salvage logging. Through this project

[78] Janeš, D., Kovač, G. i Grubišić, I. (2017): Assessment of the effects of natural disturbances - windbreaks, snowbreaks and icebreaks - for the needs of the project: Calculation of greenhouse gas emissions due to natural disturbaces under the provisions of Decision 2/CMP.7

Croatia collected detailed data on natural disturbances by type, year of its occurrence and species (deciduous, coniferous, maquies and shrub) affected by it. The data collected refers to areas listed in point B of this paper (forest areas that are strictly protected on which any kind of forest practices are forbidden, areas with forest which dbh is under the measurement limit, high mountains forest areas that are not adequately accessible by forest roads, areas still under the mines) and to the following types of natural disturbances:

- Windbreaks
- Snow-breaks and ice-breaks (presented together)

Since Croatia already disposes with the data about forest fire emissions that are recently revised (through the LULUCF 1 project implemented in period 2014-2015) there was no need for additional check about data on this type of natural disturbance.

After the relevant new data were collected through the project, and using the already existing data on forest fire emissions, Croatia performed a new estimation of emissions from listed (sub)types of NDs (windbreaks, snow-breaks and ice-breaks) on defined areas (forest areas that are strictly protected, areas with forest which dbh is under the measurement limit, high mountains forest areas without access by forest roads, areas still under the mines as a consequence of War in Croatia in 1990s). After that, the corresponding background and margin level were defined in accordance with footnotes 7 and 9 of annex Decision 2/CMP.7 and the guidance provided by the KP Supplement, as follows:

i. A consistent and complete time series containing annual emissions from selected ND types (Table 2) for the calibration period 1990 - 2009 was set.

ii. The arithmetical mean and standard deviation of the emissions were calculated.

iii. Any emissions that were larger than the arithmetic mean plus twice the standard deviation (outlier) were removed from the time series.

iv. The process mentioned in points 2. and 3. above was iterated until no further outliers were identified.

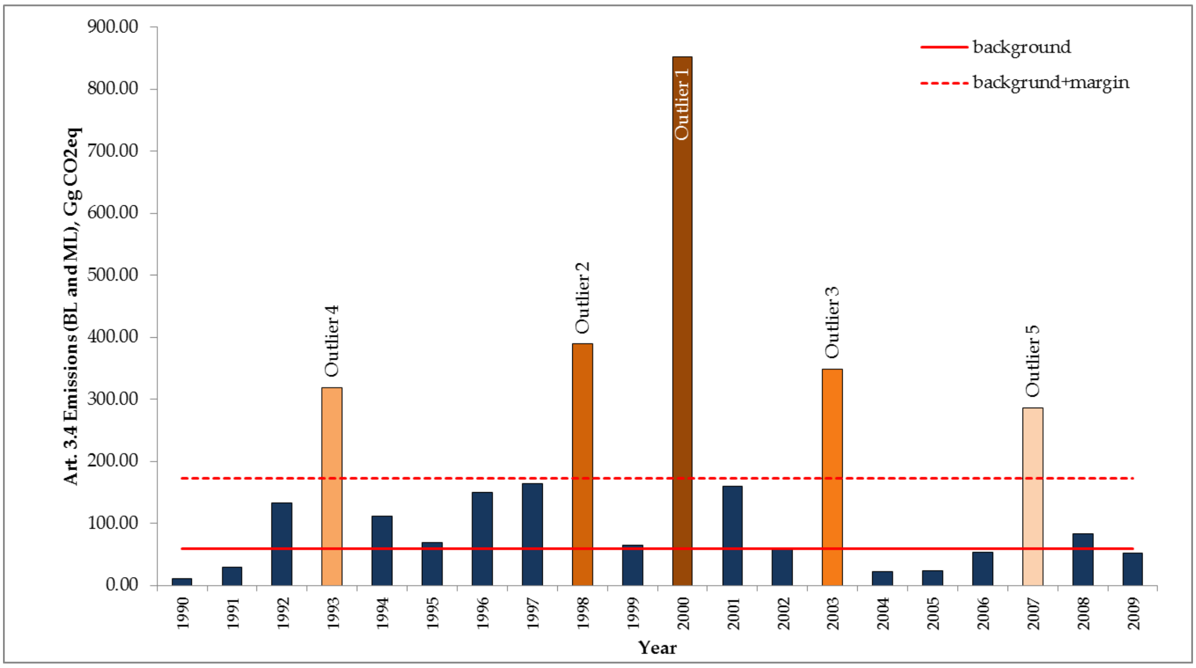
v. The arithmetic mean and twice the standard deviation estimated in the last step of this process (no outliers remain) define the background level and the margin, respectively.

The total emissions associated with the disturbances for the calibration period for FM lands are presented in Table 11.3-7 while defined BL and ML on these areas are presented in Figure 11.3-2.

Table 11.3.7. Emissions from natural disturbances for FM

Total and area specific emissions from disturbances for the calibration period for FM																				
Distrubance type*	Inventory year during the calibration period																			
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	Total annual emission [Gg CO_2 eq.]																			
Wildfires	10.84	29.05	131.93	317.29	103.307	67.74	146.11	154.90	384.59	41.16	840.69	154.79	54.30	346.40	18.87	20.53	52.24	282.93	81.95	45.98
Insect attacks, disease infestations																				
extreme weather events (total)	0.94	0.14	1.14	2.02	8.04	1.23	3.82	9.77	4.84	23.74	11.61	5.63	3.45	2.90	4.24	3.70	1.34	3.69	2.18	6.36
1. windbreaks	0.76	0.07	0.09	1.48	0.45	0.34	0.42	3.50	2.72	22.12	11.16	5.01	3.37	2.82	3.90	3.70	1.27	3.68	2.18	6.15
2.snowbreaks and icebreaks	0.17	0.06	1.04	0.53	7.59	0.88	3.40	6.27	2.12	1.62	0.44	0.61	0.07	0.07	0.33	0	0.07	0.01	0	0.21
geological disturbances																				
other																				
SUM	11.78	29.20	133.08	319.32	111.35	68.97	149.94	164.67	389.44	64.91	852.30	160.43	57.76	349.30	23.12	24.23	53.59	286.63	84.14	52.34
For all land under FM	Total area [kha]																			
	2,314.03	2,314.03	2,314.0	2,314.03	2,313.97	2,313.97	2,313.97	2,313.89	2,313.79	2,313.75	2,313.59	2,313.23	2,313.00	2,312.91	2,312.56	2,312.20	2,311.84	2,311.62	2,311.21	2,310.60
	Area-specific emissions (Emissions per unit of land area under FM, Mg CO_2 eq. ha^{-1})** (= t CO2eq/ha)																			
	0.005	0.013	0.058	0.138	0.048	0.030	0.065	0.071	0.168	0.028	0.368	0.069	0.025	0.151	0.010	0.010	0.023	0.124	0.036	0.023
* Sub-division of types can be added as needed																				
** In any year, emissions per unit of land area are calculated as the Sum divided by the total area under FM																				

Figure 11.3.2. Emissions from natural disturbances for FM



The results of the whole process as described above are:

1. Background level: 59.48 Gg CO_2eq.
2. Margin: 114.07 Gg CO_2eq.
3. Background level plus margin: 173.55 Gg CO_2eq.
4. Total number of years: 20
5. Number of excluded years: 5
6. Years excluded: 2000, 1998, 2003, 1993, 2007.

By applying the KP Supplement in the way just described for the development of the background level and the associated margin, Croatia believes that the expectation of net credits or net debits has been avoided.

As it can be seen from the information reported above, in case of FM areas, Croatia intends to apply the ND provisions in respect to: (i) forest fires; (ii) extreme weather events (additionally presented as: 1) windbreaks; 2) snow-breaks and ice-breaks (presented together)).

Since the emissions from natural disturbances in 2013, 2014, 2015 and in 2016 did not exceed the background level plus the margin for neither Afforestation under article 3.3 nor for Forest management under article 3.4. in respsct to spreific provisions of decision 2/CMP.8, Croatia reports as follows:

- Identification of lands subject to the exclusion due to natural disturbances
- Referring to decision 2/CMP.8, Annex II, paragraph 2 (f) (i), no lands was subject to exclusion in years 2013, 2014, 2015 or 2016.
- Annual emissions and subsequent removals areas excluded from the accounting
- Referring to decision 2/CMP.8, Annex II, paragraph 2 (f) (ii), no lands was subject to exclusion in years 2013, 2014, 2015 or 2016.
- Land-use change occurring on lands for which the Natural disturbances provision apply
- Referring to decision 2/CMP.8, Annex II, paragraph 2 (f) (iii), no lands was subject to exclusion in years 2013, 2014, 2015 or 2016.

- Demonstration that the events or circumstances related to excluded emissions from Natural disturbances were beyond the control of the Party
- Referring to decision 2/CMP.8, Annex II, paragraph 2 (f) (iv), no lands was subject to exclusion in years 2013, 2014, 2015 or 2016.
- Efforts taken to rehabilitate, where practicable, the land for which the natural disturbances provisions are applied
- Referring to decision 2/CMP.8, Annex II, paragraph 2 (f) (v), no lands was subject to exclusion in years 2013, 2014, 2015 or 2016.
- Salvage logging

Referring to decision 2/CMP.8, Annex II, paragraph 2 (f) (vi), emissions associated with salvage logging no lands was subject to exclusion in years 2013, 2014, 2015 or 2016.

11.3.1.4. Information relating emissions and removals from the harvest wood products

For the estimation of emissions/removals from Harvested wood products (HWPs) in areas that are subject of Forest management activity, Croatia applied Tier 2 and production approach (approach B) as it is described in NIR 2016, Chapter 6.10. According to the official data the harvest operations have not been performed on afforested areas in Croatia so far. Areas that are subject of reforestation activity do not occur in Croatia.

Harvested wood products resulting from the deforestation are accounted on the basis of instantaneous oxidation as it is defined in Annex to the Decision 2/CMP.7. Estimation performed for this purpose is in line with the Croatian estimation applied for Forest land converted to Cropland and Forest land converted to Settlement categories of land (NIR 2016, Chapters 6.5.2.2.1 and 6.8.2.1.1) by using the same parameters in the estimation for HWP originating from the deforested areas as in mentioned NIR 2016 Chapters. Emissions are calculated for each type of forest land (deciduous, coniferous and maquies and shrub forests) that are converted to perennial Cropland (conversion from FL-aCL does not exists) or settlement category of land.

Croatian forest's exact data on FM and D areas and corresponding harvested volumes were used for defining the ratio of volume of each HWP category on deforested areas in the total volume cut in Croatia. Since in cases of deforested areas there is harvested volume that belongs to maquies and shrub forests also (which is not a case in FM areas), this volume was added to the deciduous category of forests when defining the mention ratio. Average volume of deciduous forests cut on deforested areas in the period 1990-2015 is only 0.002% while in case of coniferous forests this share is 0.005% in the same period, comparing to the total deciduous and coniferous volume cut in Croatia. After the ratio was defined, carbon stock changes in each category of the HWP pool on FM lands were estimated by decreasing total volume cut in Croatia with the volume cut on deforested areas for each year and by using the first order decay function. At the same time, carbon stock changes in HWP pool in deforested lands were estimated based on the instantaneous oxidation.

Information on Harvested Wood Products under article 3.4 (Decision 2/CMP.8, paragraph g)

(i) Information on activity data for the HWP categories

The HWP estimates for the KP activities follow the same approach as those for the HWP estimates under the UNFCCC. Detailed information on the activity data is provided in 6.10.

(ii) Information on half-lives, information on methodologies used

The HWP estimates for the KP activities follow the same approach as those for the HWP estimates under the UNFCCC (production approach from domestic harvest). Detailed information on the half-lives and methodology is provided in chapter 6.10.

(iii) If FMRL is based on a projection, information on whether emissions from HWP originating

from forests prior to the start of the second CP have been included in the accounting

The estimates of the HWP share in the FMRL and those of the HWP emissions and removals under FM are fully consistent. The projections of the HWP emissions and removals include also those from the forests prior to the start of the 2nd CP.

(iv) Information on how emissions from HWP pool that have been accounted for during the first CP on the basis of instantaneous oxidation have been excluded from the accounting of the 2nd CP

Emissions from harvested wood products already accounted for during the first commitment period on the basis of instantaneous oxidation were not excluded so far. Although, the guidance in the IPCC 2013 KP supplement is not clear on this issue, Croatia recognizes these provisions in paragraph 16, Annex of Decision 2/CMP.7. and intendes to performed needed correction in the following NIR 2019 submission.

(v) Demonstrate that HWP from D have been accounted as instantaneous oxidation

The HWP removals and emissions are estimated and reported separately for three activities (A, D, FM), which ensures that those for D are not accounted. Details for the separate estimation for all activities are provided in chapters 6.10.

(vi) Showing that CO_2 emissions from SWDS are separately accounted, and wood for energy

purposes accounted on the basis of instantaneous oxidation

Croatia uses Tier 2 (first order decay function) and the production approach for the estimation of carbon stock changes in HWP pool. Emissions from HWP in SWDS are not separately accounted and they make a part of emissions in SWDS that are reported under the Waste sector.

(vii) Information showing that emissions/removals from HWPs which are accounted do not

include imported HWP

In NIR Chapter 6.10 the methodological details and the used IPCC approach are presented. The description proves that the applied approach has been implemented to separate the HWP production originating from domestic harvest in Croatia from the total HWP production.

11.3.1.5. Information on whether or not indirect and natural GHG emissions and removals have been factored out

Croatia has not factored out removals from elevated carbon dioxide concentrations, indirect nitrogen deposition or the dynamic effects of age structure resulting from activities prior to 1 January 1990, considering also that GPG gives no methods for factoring out. For the first commitment period, the effect of indirect and natural removals will be considered through the cap under Article 3.4 credits from the Forest management. For Croatia the cap was 0.265 Mt C per year.

11.3.1.6. Changes in data and methods since the previous submission (recalculations)

When comparing the forest management areas for the period 1990-2015 between NIR 2017 and NIR 2018 two mistakes were detected in estimation sheets for NIR 2017. The both mistakes were result of mismatching rows in Excel estimation spreadsheets:

1) When detecting areas that were afforested before 1990, the mistake occurred connecting the estimation table with the total value of the forest area which contains both types of afforested areas (human induced promotion of natural forest spreading and planting and seedling). Instead of that, in this estimation step, the estimation table should have been connected with the Excel row that refers only to the areas afforested before 1990 and that are result of human induced promotion of natural forest spreading.
2) When subtracting afforested areas from the total forest areas, the value of afforested area in 1990 was fixed in excel sheet causing the subtraction of this value from the total forest area for all years in the period 1990-2015. Instead of that, afforested areas of each year from the period 1990-2015 had to be subtracted from the corresponding years and the total forest areas.

The both mistakes led to the average difference of 0.55% between NIR 2017 and NIR 2018 total forest management areas in period 1990-2015.

3) The change in forest area that comes from the forest areas defined under the two consecutive plans/programs (reported by Croatia in previous NIRs) leading to the difference between areas reported under the FL-FL category and FL-FL category in two consecutive NIRs was not a case for this year reporting. For NIR 2018 there has not been detected any deference between in FL-FL category of land due to a renewal of forest management plans. However, identification of forest areas in new forest plans/programs that are result of human induced afforestation before 1990 is continuous process and will last for the next couple of years. It is expected that there will be less and less difference between areas reported in two consecutive NIRs for FL-FL category of land in the next couple of years.

11.3.1.7. Uncertainty estimates

For the purpose of defining uncertainties in LULUCF sector in Croatia, special questionnaire was developed and several different experts from several Croatian institutions were consulted. This work was supported with the expert help secured through the EU project "Assistance to Member States for effective implementation of the reporting requirements under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC)".

The input uncertainties, associated with the different emission factors and the activity data as well as the sources of information (default values, empirical data or expert judgment) are presented in Table 6.4-6.

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 10,000.

In case of Article 3.3 using the Tier 2 method uncertainty of total CO_2 eq emissions for ARD activities are determined in range of ± 247 to ± 681% in period 2008-2012. In the same period uncertainty of total CO_2 eq emissions for AR activities are determined in range of ± 151 to ± 158% and in case of D activities range is between ± 190 and ± 197%. In regards to FM, uncertainty was determined to ranges between ± 65 and ± 66%.

The same approach and methodology were applied for both the UNFCCC and the KP reporting frame as already presented in Chapter 6.4.3.

11.3.1.8. Information on other methodological issues

Additional information regarding the Forest Reference Management Level (FMRL)

Since its FMRL submission in 2011 during the first commitment period, Croatia performed several changes in its estimation in LULUCF sector and activities connected with forestry sector. Due to these changes and improvements Croatia decided to submit its first technical correction of Forest Reference Management Level within the 2016 report (NIR 2016 Resubmission) since for NIR 2015 countries are not submitting their data for KP in the CRF database.

The reasons for the FMRL technical correction arises from: **a)** the application of IPCC 2006 Guidelines, specifically equation 2.12 that addresses annual carbon loss in biomass due to wood removal in a way that includes R/S factor which differs comparing to the equation 3.2.7 from the previously used GPG 2003; **b)** including category Out of yield forests (maquies an shrub) in Croatian reporting which was not performed for FMRL submission in 2011; **c)** inclusion of HWP in the estimation **d)** changes in other parameters used in estimation since FMRL submission in 2011.

Information on Technical corrections of FMRL

Croatia submitted in October 2011 its projections until 2020 of the GHG emissions/removals due to the 2010 business-as-usual of the Kyoto Protocol Activity "Forest Management" (FM) and the resulting Forest Management Reference Level for the 2nd Commitment period (CP) 2013 to 2020.

According to the COP decisions for the 2nd CP and according to the IPCC (2014) KP supplement guidelines for reporting the LULUCF activities in this period, technical corrections to the FMRL should be carried out and reported in the National Inventory Report (NIR) if methodological changes in the estimates of the historic GHG emissions/removals of FM were carried out. Methodological consistency between the historic emissions/removals and the FMRL are needed.

Since the submission of FMRL Croatia implemented several methodological improvement steps in estimating its emissions/removals of FM. Due to these methodological improvements (details are provided below) the following changes in the FM input data, FM estimates and FM figures of historic years occur:

Table 11.3-8: Methodological Improvements in FM input data, FM estimates and FM figures of historic years

Factor subject to the change	Old (period 2005 – 2009 at the time of FMRL submission)	New (period 2005 – 2009 at the time of submission 2016)	Difference (%)
Average annual FM increment, high forests (mil. m3)	10.04	10.97	+8.5 %
Average annual FM harvest, high forests (mil. m3)	5.19	5.12	-1.4 %
Maquies and shrub forests	Not considered	Estimated	
Wood density deciduous	0.588	0.558	-5.4 %
Wood density coniferous	0.400	0.395	-1.3 %
Wood density Maquies and shrub forests	Not considered	0.683	
Root/shoot ratio for increment - deciduous	0.24	0.23	-4.3 %
Root/shoot ratio for increment - coniferous	0.23	0.29	+20.7 %

Factor subject to the change	Old (period 2005 – 2009 at the time of FMRL submission)	New (period 2005 – 2009 at the time of submission 2016)	Difference (%)
Root/shoot ratio for increment - Maquies and shrub forests	Not considered	0.46	
Root/shoot ratio for harvest	Root biomass losses not considered (in line with IPCC 2003 GPG)	Root biomass losses considered (in line with IPCC 2006 GL)	
Biomass expansion factor for increment - Maquies and shrub forests	Not considered	1.10	
Biomass expansion factor for harvest - deciduous	1.4	1.197	-16.9%
Biomass expansion factor for harvest - coniferous	1.3	1.0387	-25.2%
Biomass expansion factor for harvest - Maquies and shrub forests	Not considered	0	
Carbon fraction - deciduous	0.5	0.48	-4.2%
Carbon fraction - coniferous	0.5	0.51	+2.0%
Carbon fraction - Maquies and shrub forests	0.5	0.47	-6.4%
Harvested Wood Products	Instantaneous oxidation (HWP carbon stock change not estimated)	Estimated	

As a consequence of the methodological improvements (except the estimates of root biomass losses due to harvest which is an improvement in the IPCC 2006 GL and HWP which are new for the 2nd CP, respectively), the average annual net removals for the 1st CP changed from 8,158.15 Gg CO_2 at the time of FMRL submission (2011) to 7,287.79 Gg CO_2 accounted in NIR 2016.

These methodological improvements in the table above request the following average changes in the FMRL input data for the 2nd CP to secure methodological consistency between the FMRL and the historic FM emissions/removals:

Table 11.3-9: Average changes in the FMRL input data for the 2nd CP

	Old	New	Difference (%)
Increment, high forests 2020 (1000 m3)	10676	10068	-6.0 %
Harvest, high forests 2020 (1000 m3)	8000	7903	-1.2 %
Stock change Maquies and Shrub 2020 (1000 m3)	0	+89	
Wood density deciduous	0.588	0.558	-5.4 %
Wood density coniferous	0.400	0.395	-1.3 %

	Old	New	Difference (%)
Wood density Maquies and shrub forests	Not considered	0.683	
Root/shoot ratio for increment deciduous	0.24	0.23	-4.3%
Root/shoot ratio for increment coniferous	0.23	0.29	+20.7 %
Root/shoot ratio for increment - Maquies and shrub forests	Not considered	0.46	
Root/shoot ratio for harvest (deciduous)	0	0.23	+23 %
Root/shoot ratio for harvest (coniferous)	0	0.29	+29 %
HWP stock change (Gg CO2)	0	+477.96755	

The introduction of the root biomass losses due to harvest into the estimation for the 2nd CP has significantly increased the lost harvest biomass in the 2nd CP and consequently also in the FMRL correction estimates by approximately 20%.

As a consequence of all these methodological changes the FMRL changes from -6,289 Gg CO_2 net removals to FMRLcorr. – 4,906.20178 Gg CO_2 net removals without HWP (instantaneous oxidation) and to FMRLcorr. – 5,384.16933 Gg CO_2 net removals with the HWP.

11.3.1.9. The year of the onset of an activity, if after 2013

During the Second commitment period, Croatia reports afforestation, deforestation and Forest management activities. Reforestation activity has not been performed in Croatia during the reporting period.

11.4. Article 3.3

In the period 1990-2016, afforestation activities resulted in net removals while deforestation presented a net source. The data are presented in Table 11.4-1.

Table 11.4-1: Emissions/removals of Article 3.3 activities [Gg CO_2]

Year		2008	2009	2010	2011	2012	2013	2014	2015	2016
Total		72.08	100.15	78.77	65.95	34.35	31.29	7.16	-6.55	-136.82
		Afforestation								
Biomass*	AGB	-35.23	-26.99	-41.79	-45.91	-75.37	-83.77	-92.70	-113.21	-177.66
	BGB	-7.64	8.04	2.44	7.15	-13.19	-7.49	-7.36	-29.26	-71.31
Dead wood		NO	NO	NO	NO	NO	NO	NO	NO	NO
Litter		-13.14	-16.87	-20.90	-25.79	-29.86	-35.59	-42.37	-47.52	-48.48
Soil		15.67	20.00	24.55	30.29	34.50	40.61	47.67	51.90	53.13

Year		2008	2009	2010	2011	2012	2013	2014	2015	2016
		Deforestation								
Biomass*	AGB	27.35	19.46	12.27	-1.98	7.73	4.30	-7.64	12.03	-7.85
	BGB	8.33	8.28	5.98	2.49	5.08	3.89	0.92	6.12	1.14
Dead wood		IE	IE	IE	IE	IE	IE	IE	IE	IE
Litter		47.30	57.46	63.31	66.52	70.62	73.41	73.17	77.15	77.73
Soil		29.45	30.78	32.91	33.17	34.84	35.93	35.48	36.25	36.48

*AGB=aboveground biomass; BGB=belowground biomass

In period 2008-2016 mentioned activities altogether resulted in removals by sink.

According to 2006 GL the Tier 1 method for Land converted to Forestland assumes that dead wood and litter pools increase linearly over a period of time. Human activities such as fuelwood collection and some silvicultural practices such as frequent thinnings can greatly affect the rate of carbon accumulation in DOM pools. Croatia would like to state that fuelwood collection does not appear in Croatia, woody biomass from commercial thinnings is removed from the site and silvicultural conservation operations in young stands are performed in a way that all removed biomass has been left in the stand. Furthermore areas under Afforestation activities increasing over time. By the age of 20 years old of stands, the dead trees barely occur caused by natural mortality and especially by competition. This leads to a continually increasing number of dead trees. Therefore it is expected that inputs are larger than decomposition. With such argumentation, Croatia conservatively assumes that DW is not a net source of emissions on AR lands and NO notation key has been used.

11.4.1. Information demonstrating that activities under Article 3.3 began on or after 1st January 1990 and before 31nd December 2020 and are directly human-induced

All data regarding the Article 3.3 activities were attained from HS database related to FMAPs. As mentioned previously, there are three main FMAPs. The first FMAP in this sense is the FMAP encompassing the period from 1986-1995 thus including 1990.

As stated earlier, afforestation in national circumstances is the activity within the biological forest renewal and it refers to afforestation of non-forest land and establishing plantations of fast growing species. This activity mentioned is laid down in forest management plans with a clear indication of the time when it is carried out; thus is human induced and not a result of natural succession. As stated before, survey performed under the LULUCF 1 project proved that no afforestation by seeding and planting was performed on areas of state owned forests managed by other legal bodies and private forests. Afforestation by seeding and planting in Croatia has been performed only in state owned forests managed by Croatian forests Ltd. in period 2008-2012 based on forest management plans. This is also valid for years 2013, 2014, 2015 and 2016.

Regarding the afforestation due to natural spreading of forests on new areas, Croatia claims this afforestation is result of human induced promotion of natural seed sources in its entire territory. According to the conducted survey in all Croatian forests regardless the ownership and forest types within the framework of LULUCF 1 project, this type of afforestation does not occur in state owned forests that are managed by other legal bodies. This was expected outcome because forests belonging to this type of ownership are under strict or some kind of protection under the provisions of Law on nature protection, and their area is well known, fixed and can not be changed without very complex legal procedure which implies involvement of many institutions in Croatia.

Conducted survey on state owned forests managed by Croatian forests Ltd. regarding the afforestation due to natural spreading of forests on new areas showed that this increase of forest areas happens only from Grassland category of land. As it is presented in Figure 6.16-1 area under the Forest Management plans of Croatian Forest Ltd. encompasses not only area covered by forests but also land without tree cover. The part of area without tree cover which is defined as productive forest land according to national legislation belongs to the grassland category according to the IPCC definitions of land categories.

Basic principle of silviculture in Croatia is implemented in a way that growth of new young forests is encouraged primarily through natural spreading of forests seeds coming from older trees that grow on the area. This principle is considered to be the most important part of forest management practices in Croatia securing by sustainability of all aspects in forest management as well as sustainability of forests ecosystems. According to the Article 36 of the Forest Act even aged forests in Croatia has to be grown naturally using the shelterwood compartment system while uneven aged forest has to be grown naturally using the group selection method of cutting with rotation period that can not be shorter than 5 years. When performing this work in even aged and uneven aged forests due attention has to be given to the seed crop of the main species. Felling of forest trees needs to be performed after the year with a full and good seed crop securing natural spreading of seed on forest areas as a first precondition of natural regeneration of forests in Croatia.

Consequently, natural spreading of forests by promoting seed spreading on grassland without tree cover (that are under the forest management plans and under supervision of Croatian forests Ltd.) makes integral part of practices of growing forests in Croatian and can be considered as human decision to promote natural spreading of forests and as such these areas should be reported as afforested.

In privately owned forests, the total observed natural spreading of forest is recorded on categories of grassland (82.1%), annual Cropland (16.3%) and perennial Cropland (1.6%). As a part of officially prescribed procedure required under the FSC rules, foresters are obliged to get permission of private owners to record their forest area in official forest management programs if the forest is identified as a new forest during the development of forest management program. Only the areas that are officially agreed by the land owners to stay as forests are recorded in the forest management programs and are consequently direct human induced AR areas. Once the area has been recorded as forests it falls under the provisions of Forest Act and can not be changed to other land use categories without strict legal procedures.

For other area of private forests that are so far not covered by official management programs (around 50% of private forests) Croatia claims that increase of forest area in these forests is also result of human decision to land use changes based on the information provided below.

According to the official data[79,] total 105 Settlements in Croatia had no inhabitants in 2001 which makes 1.55% of total settlement area in Croatia. In the same year 2489 Settlements (2.44%) had less than 100 inhabitants. These figures increased in 2011 when Croatia had 150 Settlements (2.22%) without inhabitants and 2653 Settlements (2.66%) with less than 100 inhabitants[80.] According to the same sources of information in same period number of inhabitants increased in area of main town from 25.42% to 26.19% although the total number of inhabitants in Croatia decreased for more than 3%.

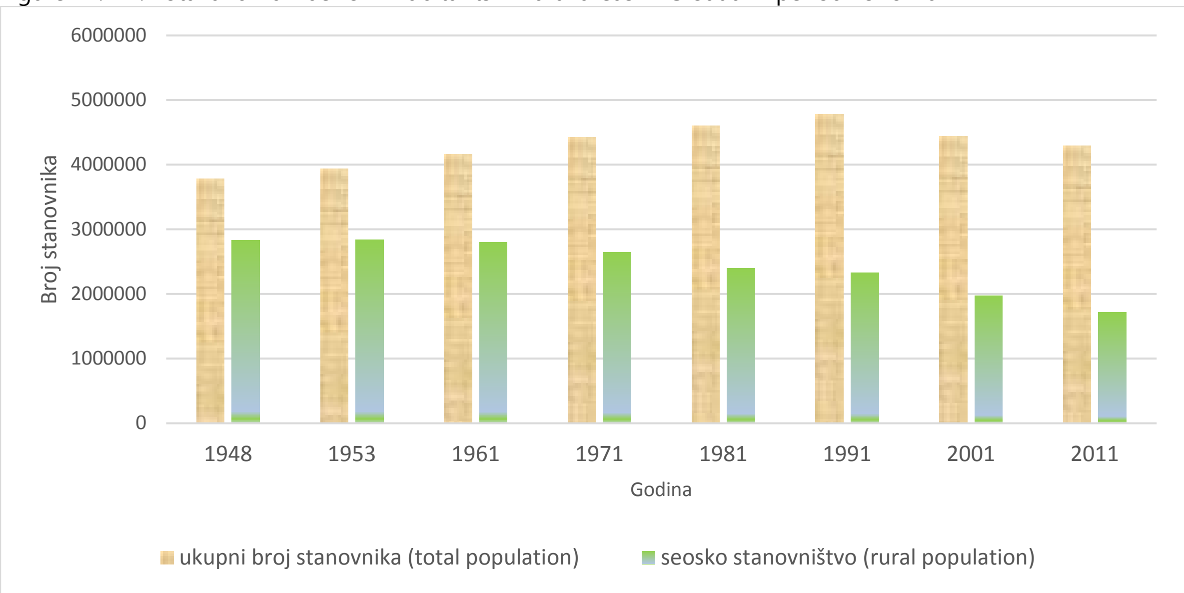
[79] Statistical Yearbook (2011), page 57

[80] Statistical Yearbook (2012), page 57

Based on these arguments and fact that in year 2012 total agricultural plant production decreased for 12.3% comparing to production in 2011 and that employment in agriculture sector decreased for 3.1% comparing to the same year[81], Croatia believes that depopulation of rural areas and abandonment of agricultural practises on agricultural land is a result of human decision caused with economical situation in the country. Additionally, as a consequence of increased demand for use of woody biomass and its prices (total revenues from exports of wood products (excluding furniture) increased from 3.0% in 2011 to 3.4% in 2014), Croatia is sure that all private owners on whose land new forests grow will decide to claim them as forest during the official registration of forest areas in the development process of forest management programs.

Since depopulation of rural areas started from late 1940 in last century (Figure 11.4-2) the fact is that in many cases abounded agricultural land is covered by several decades old forests which are still register as agricultural land in cadastral due to its tardiness[82].

Figure 11.4-2: Total and number of inhabitants in rural areas in Croatia in period 1948-2011



Based on the experiences gained so far in development of programs for private forests when all private owners on whose land new forests appeared as a result of natural spreading of forests decided to register this land as forest land, it is expected this trend will continue in case of remaining new private forest areas.

Additionally, due to the fact that conversion of abounded agricultural land that is already covered with forests again to agricultural purposes is very demanding and financially expensive (especially in cases of several decades old forests) it is much easier to register these areas as new forests.

According to the Forest Act[83], Article[62] all private and physical persons conducting business activity in Croatia are obliged to pay 0.0265% of their yearly profit (so called green tax) to the state budget for

[81] Ministry of Agriculture (2013), Annual report on the state of agriculture in 2012, http://www.mps.hr/default.aspx?id=9567, pages 4-5

[82] Janeš et all (2014) Separation of areas under the Article 3.3 and 3.4 of the Kyoto Protocol, page 15

[83] OG 94/14

managing thee forests (state and private owned). This financial means have to be shared among private forest owners, Croatian forests Ltd. and other legal bodies that manage forests according to their share of areas in total forest area in Croatia.[84] This financial means must be used in private forests for activities that are prescribed by Forest Act such as pre-commercial thinning and thinning. Since private owners can benefit from these activities by selling wood gained through these activities, Croatia believes that this green tax also contributes that private owners decide to register their abounded agricultural land covered with forests as forests.

Croatia believes that above presented expectation is realistic also since new policy of the EU concerning rural development required special measures for forestry sector to be defined under programs for rural development in period 2014-2020. Under rural development program[85], Croatia also defined many measures for forestry sector that are of interest for private forest owners.

It is believed that activities of Croatian union of Private Forest Owners[86] (in which 35 Private forest associations from whole Croatia are joined) will contribute to rising the awareness of relevance of forestry sector and possibilities that are available to private forest owners at EU and national level so that private owners on whose areas forests are naturally spread will decide to keep them as forests.

Therefore, all increases of forest areas in private forests that occure from Cropland and Grassland categories of land due to natural spreading of forests on new areas should be and are reported as afforestation activity under the Article 3.3 of the Kyoto protocol.

Deforestation requires land use change and relies on a strict legal frame as mentioned before. It is mainly performed due to large infrastructure projects.

Therefore, all activities reported under Article 3.3 (afforestation and deforestation) started on or after 1 January 1990 and were human induced.

11.4.2. Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

The main criteria for distinguishing the harvesting or forest disturbance followed by the re-establishment of forest from deforestation is whether or not the land use has changed, which is strictly regulated by the legal framework. More detailed information is provided below.

While comparing and interpreting definitions within the IPCC framework and within national legislation, it was concluded that deforestation in national circumstances referred to clear cutting intended for land use change of forest land in accordance with the spatial planning documents. However, this activity is forbidden except in very specific cases which are regulated by Articles 35 and 51 of the Low on Forests. Since all forest land in Croatia can be considered managed, if a certain forest land area is permanently removed from the forest management area (in specific circumstances, e.g. for road construction), then this event should be reported as deforestation.

The re-establishment of forest on harvested areas or areas affected by forest disturbance is also regulated by the Articles 10 and 28 of the Low on Forests and the Ordinance on Forest Management (OG 111/06, 141/08).

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[84] Regulations on the procedure for granting funds from fees for the use of beneficial functions of forests for work performed in private forests (OG 66/06, 25/11), Article 3

[85] Ministry of Agriculture (2014), Program of rural development of the Republic Croatia 2014-2020 (draft).

[86] http://www.hsups.hr/udruge.html

The FMAPs make a clear distinction between areas that are deforested and areas that are cleared for forest management purposes, all consistent with the provisions of the Forest Act. By that, both activities can be easily distinguished.

11.4.3. Information on the size and geographical location of forest areas that have lost forest cover but which have not yet been classified as deforested

Generally, forest cover can be lost through harvesting or forest disturbance which represent a temporary loss. Permanent loss of forest cover includes land use change. Therefore, there are no forest areas that have permanently lost forest cover but which have not yet been classified as deforested.

11.5. Article 3.4

11.5.1. Information demontrting that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

Croatia has a very long forest management tradition. As stated before, all data have been obtained from FMAPs, the first covering the period from 1986-1995 (thus including 1990). Since forest management area under the KP is all managed based on the FMAPs, if human induced is assumed equivalent with the managed, then it is demonstrated that the forest management as an activity under Article 3.4 of the KP is human induced. Croatia has stock and harvest data in an annual resolution. Therefore, an easy assessment of the year of activity is possible.

11.5.2. Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year

Not applicable. Croatia did not elect these activities for the First and Second commitment period.

11.5.3. Conversion of natural forest to planted forest

In Croatia, conversion from natural forests to plantations do not occur. According to the Forest Act and as it has been reported by Croatia, all forests in Croatia are managed. Emissions and removals in lands that are subject of forest management activity cover the emissions and removals of whole Croatian forests decresed by those emissions and removals resulting from Afforestation and Deforestation activities which are accounted under Art. 3.3.

11.5.4. Information related to the Forest Management

As stated before, all forest management area within the national frame is managed based on the FMAP and is even wider than the forest management area under the KP because it includes, for example, afforested area and also “forest land” (in Croatian sense) that is covered with vegetation which does not reach the selected thresholds for the KP definition of forest (all land under FMAPs, see Figure 6.16-1).

Forest management resulted in net removals in all years within the reporting period. Carbon stock changes in living biomass resulted in removals presented in Table 6.16-13.

Table 11.5-1: Emissions/removals of Article 3.4 activity

Activity	Net emissions/removals (kt CO_2)								
Forest management	2008	2009	2010	2011	2012	2013	2014	2015	2016
	-7,683.8	-7,863.4	-7,624.5	-6,717.0	-6,574.2	-6,631.3	-6,312.2	-5,651.0	-5,629.5

11.5.5. Information on the extent to which GHG removals by sinks offset the debit incurred under Article 3.3.

According to the estimation performed for activities subject of Article 3.3 of the Kyoto protocol, removals by sink achieved through afforestation activities are higher than emissions incurred due to deforestation activities during the period 2008-2014. Consequently, there are no debits that should be offset from the GHG removals by sink in this period.

11.6. Other information

There is no other information.

11.6.1. Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

Table 11.6-1 shows that Forest management and Afforestation activities are consider as a key category.

Table 11.6-1 Summary overview of key categories for LULUCF activities under the Kyoto Protocol (CRF – NIR 2018 table NIR-3)

KEY CATEGORIES OF EMISSIONS AND REMOVALS	Gas	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			Comments[4]
		Associated category in UNFCCC inventory[1] is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory[2] (including LULUCF)	Other[3]	
Specify key categories according to the national level of disaggregation used[1]					
Afforestation and Reforestation					
CO2	CO2	Land converted to forest land	Yes		Level 1, Level 2, Trend 1, Trend 2
Deforestation					
CO2	CO2	Land converted to settlements	Yes		Level 1, Level 2, Trend 1, Trend 2
Forest Management					
CO2	CO2	Forest land remaining forest land	Yes		Level 1, Level 2, Trend 1, Trend 2

(1) See section 2.3.6 of the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.
(2) If the emissions or removals of the category exceed the emissions of the smallest category identified as key in the UNFCCC inventory (including LULUCF), Parties should indicate YES. If not, Parties should indicate NO.
(3) This should include qualitative assessment as per section 4.3.3 of the 2006 IPCC Guidelines or any other criteria.
(4) Indicate the criteria (level, trend of both) identifying the category as key.

11.7. Information relating to article 6

Croatia does not participate in any project under Article 6.

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14. 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 Environment and Nature Protection
MEE	- Ministry of Environment and Energy
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
SF6	- 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