NATIONAL INVENTORY REPORT 2017

CROATIAN GREENHOUSE GAS INVENTORY
FOR THE PERIOD 1990-2015

March 2017
CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE
NATIONAL INVENTORY REPORT 2017

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

March, 2017
Ordered by: Croatian Agency for the Environment and Nature

Contract No.: 427-10-03-16-492/01 (I-08-0091)

Title:

NATIONAL INVENTORY REPORT 2017

Croatian greenhouse gas inventory for the period 1990-2015


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<tr>
<td>AD</td>
<td>Activity Data</td>
</tr>
<tr>
<td>ARKOD</td>
<td>Land parcel identification system</td>
</tr>
<tr>
<td>CAA</td>
<td>Croatian Agricultural Agency</td>
</tr>
<tr>
<td>CAEN</td>
<td>Croatian Agency for the Environment and Nature</td>
</tr>
<tr>
<td>CBS</td>
<td>Central Bureau of Statistics</td>
</tr>
<tr>
<td>CEM</td>
<td>Continuous Emission Monitoring</td>
</tr>
<tr>
<td>CFC</td>
<td>Chlorofluorocarbons</td>
</tr>
<tr>
<td>CHC</td>
<td>Croatian Centre for Horse Breeding</td>
</tr>
<tr>
<td>CLC</td>
<td>CORINE Land Cover</td>
</tr>
<tr>
<td>CLRTAP</td>
<td>Convention on Long-range Transboundary Air Pollution</td>
</tr>
<tr>
<td>CNG</td>
<td>Compressed Natural Gas</td>
</tr>
<tr>
<td>COP</td>
<td>Conference of Parties</td>
</tr>
<tr>
<td>COPERT</td>
<td>Computer Programme to Calculate Emissions from Road Transport</td>
</tr>
<tr>
<td>CORINAIR</td>
<td>Core Inventory of Air Emissions in Europe</td>
</tr>
<tr>
<td>CORINE</td>
<td>Coordination Of Information On The Environment</td>
</tr>
<tr>
<td>CPS Molve</td>
<td>Central Gas Station Molve</td>
</tr>
<tr>
<td>CRF</td>
<td>Common Reporting Format</td>
</tr>
<tr>
<td>CRONFI</td>
<td>Croatian National Forest Inventory</td>
</tr>
<tr>
<td>EAF</td>
<td>Electric Arc Furnace</td>
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<tr>
<td>EEA</td>
<td>European Environment Agency</td>
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<tr>
<td>EF</td>
<td>Emission Factor</td>
</tr>
<tr>
<td>EIA</td>
<td>Energy Institute “Hrvoje Požar”</td>
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<tr>
<td>EKONERG</td>
<td>Energy Research and Environmental Protection Institute</td>
</tr>
<tr>
<td>EMEP</td>
<td>Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe</td>
</tr>
<tr>
<td>EOR Project</td>
<td>Enhanced Oil Recovery Project</td>
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<tr>
<td>EU ETS</td>
<td>European Union Emissions Trading Scheme</td>
</tr>
<tr>
<td>ERT</td>
<td>Expert Review Team</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
</tr>
<tr>
<td>FAOSTAT</td>
<td>FAO statistical database</td>
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<tr>
<td>FAS</td>
<td>Forest Advisory Service</td>
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<tr>
<td>FMAP</td>
<td>Forest Management Area Plan</td>
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<tr>
<td>FSC</td>
<td>Forest Stewardship Council</td>
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<tr>
<td>GHG</td>
<td>Greenhouse gas</td>
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<tr>
<td>GIS</td>
<td>Gas Insulated Switchgear</td>
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<tr>
<td>GWP</td>
<td>Global Warming Potential</td>
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<tr>
<td>HEP</td>
<td>Croatian Electricity Utility Company</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
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<tr>
<td>HEP ODS</td>
<td>- HEP Distribution System Operator; subsidiary company of HEP</td>
</tr>
<tr>
<td>HEP OPS</td>
<td>- HEP Transmission System Operator; subsidiary company of HEP</td>
</tr>
<tr>
<td>HFC</td>
<td>- Hydrofluorocarbons</td>
</tr>
<tr>
<td>HPP</td>
<td>- Hydro Power Plant</td>
</tr>
<tr>
<td>HRK</td>
<td>- Croatian currency; kuna</td>
</tr>
<tr>
<td>IACS</td>
<td>- Integrated Administration and Control System</td>
</tr>
<tr>
<td>IEA</td>
<td>- International Energy Agency</td>
</tr>
<tr>
<td>INA</td>
<td>- Croatian Oil and Gas Company</td>
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<tr>
<td>IPCC</td>
<td>- Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>ISWA</td>
<td>- International Solid Waste Association</td>
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<tr>
<td>KP-LULUCF</td>
<td>- Kyoto Protocol Land Use, Land Use Change and Forestry</td>
</tr>
<tr>
<td>LPG</td>
<td>- Liquefied Petroleum Gas</td>
</tr>
<tr>
<td>LRATAP</td>
<td>- Long-range Transboundary Air Pollution</td>
</tr>
<tr>
<td>LULUCF</td>
<td>- Land-use, Land Use Change and Forestry</td>
</tr>
<tr>
<td>MENP</td>
<td>- Ministry of Environment and Nature Protection</td>
</tr>
<tr>
<td>MEE</td>
<td>- Ministry of Environment and Energy</td>
</tr>
<tr>
<td>MSW</td>
<td>- Municipal Solid Waste</td>
</tr>
<tr>
<td>NCV</td>
<td>- Net Calorific Values</td>
</tr>
<tr>
<td>NGGIP</td>
<td>- National Greenhouse Gas Inventories Programme</td>
</tr>
<tr>
<td>NIR</td>
<td>- National Inventory Report</td>
</tr>
<tr>
<td>NMVOC</td>
<td>- Non-methane Volatile organic Compounds</td>
</tr>
<tr>
<td>NPP</td>
<td>- Nuclear Power Plant</td>
</tr>
<tr>
<td>ODS</td>
<td>- Ozone Depleting Substances</td>
</tr>
<tr>
<td>OG</td>
<td>- Official Gazette</td>
</tr>
<tr>
<td>PCP</td>
<td>- Public Cogeneration Plant</td>
</tr>
<tr>
<td>PFC</td>
<td>- Perfluorocarbons</td>
</tr>
<tr>
<td>PHP</td>
<td>- Public Heating Plant</td>
</tr>
<tr>
<td>PRODCOM</td>
<td>- Production Statistics Database</td>
</tr>
<tr>
<td>QA/QC</td>
<td>- Quality Assurance/Quality Control</td>
</tr>
<tr>
<td>SF₆</td>
<td>- Sulphur hexafluoride</td>
</tr>
<tr>
<td>TPP</td>
<td>- Thermal Power Plant</td>
</tr>
<tr>
<td>UNDP</td>
<td>- United Nations Development Program</td>
</tr>
<tr>
<td>UNDP/GEF</td>
<td>- United Nations Development Programme/Global Environment Facility</td>
</tr>
<tr>
<td>UNECE</td>
<td>- United Nations Economic Commission for Europe</td>
</tr>
<tr>
<td>UNFCCC</td>
<td>- United Nations Framework Convention on Climate Change</td>
</tr>
<tr>
<td>WW</td>
<td>- Wastewaters</td>
</tr>
<tr>
<td>int.</td>
<td>- international</td>
</tr>
<tr>
<td>dom.</td>
<td>- domestic</td>
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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) and Ordinance on Greenhouse Gas Emissions Monitoring in the Republic of Croatia (Official Gazette No. 134/12) prescribe obligation and procedure for emissions monitoring, which comprise estimation and/or reporting of all anthropogenic emissions and removals. Monitoring of GHG gases is stipulated by Article 75 of the Air Protection Act (Official Gazette No. 130/11, 47/14).

In this NIR, the inventory of the emissions and removals of the greenhouse gases (GHG) is reported for the period from 1990 to 2015. 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 (CO₂), methane (CH₄), nitrous oxide (N₂O), halogenated carbons (HFCs, PFCs), sulphur hexafluoride (SF₆), nitrogen fluoride (NF₃) and indirect greenhouse gases: carbon monoxide (CO), oxides of nitrogen (NOx), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO₂). The greenhouse gases covered by Montreal Protocol on the pollutants related to ozone depletion (freons) are reported in the framework of this protocol and therefore are excluded from this Report.

Greenhouse gas emission sources and sinks are divided into 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.1.2.3. 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.1.2.4. INFORMATION ON KYOTO PROTOCOL UNITS

Calculation of AAUs and CPR

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.


According to Commission implementing Decision (2013/634/EC) of 31 October 2013 on the adjustments to Member States’ annual emission allocations for the period from 2013 to 2020 pursuant to Decision 406/2009/EC of the European Parliament and of the Council Adjustment to Annual Emissions Allocation for Croatia for the period from 2013 to 2020 are presented in Table ES1.2-1.

Table ES1.2-1: Annual Emission Allocation and its Adjustment for the period from 2013 till 2020

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Emission Allocation</td>
<td>21,196,005</td>
<td>21,358,410</td>
<td>21,520,815</td>
<td>21,683,221</td>
<td>21,845,626</td>
<td>22,008,031</td>
<td>22,170,436</td>
<td>22,332,841</td>
</tr>
<tr>
<td>Adjustment</td>
<td>1,582,200</td>
<td>1,553,154</td>
<td>1,524,107</td>
<td>1,495,060</td>
<td>1,466,014</td>
<td>1,436,968</td>
<td>1,407,921</td>
<td>1,378,875</td>
</tr>
<tr>
<td>Total</td>
<td>19,613,805</td>
<td>19,805,256</td>
<td>19,996,708</td>
<td>20,188,161</td>
<td>20,379,612</td>
<td>20,571,063</td>
<td>20,762,515</td>
<td>20,953,966</td>
</tr>
<tr>
<td>AAU for Croatia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>162,271,086</td>
</tr>
</tbody>
</table>

Assigned amount unit for Croatia for the period from 2013 till 2020 is 162,271,086 t CO2-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 ES1.2-2 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 ES1.2-2: Commitment period reserve

<table>
<thead>
<tr>
<th>Reporting Item</th>
<th>t CO₂-eq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigned amount for second commitment period</td>
<td>162,271,086</td>
</tr>
<tr>
<td>90% of assigned amount</td>
<td>146,043,977</td>
</tr>
<tr>
<td>Emission from last submitted inventory</td>
<td>23,502,150</td>
</tr>
<tr>
<td>100% of most recently reviewed* inventory multiplied by 8</td>
<td>183,191,024</td>
</tr>
<tr>
<td><strong>Commitment period reserve</strong></td>
<td><strong>146,043,977</strong></td>
</tr>
</tbody>
</table>

**Information from national registry**

Changes to the national registry of HR in 2015 are presented in ES1.2-3.

### Table ES1.2-3: Information on Kyoto Protocol units

<table>
<thead>
<tr>
<th>Reporting Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)</td>
<td>The Standard Electronic Format report for 2016 has been submitted to the UNFCCC Secretariat electronically.</td>
</tr>
<tr>
<td>15/CMP.1 annex I.E paragraph 12: List of discrepant transactions</td>
<td>No discrepant transactions occurred in 2016.</td>
</tr>
<tr>
<td>15/CMP.1 annex I.E paragraph 13 &amp; 14: List of CDM notifications</td>
<td>No CDM notifications occurred in 2016.</td>
</tr>
<tr>
<td>15/CMP.1 annex I.E paragraph 15: List of non-replacements</td>
<td>No non-replacements occurred in 2016.</td>
</tr>
<tr>
<td>15/CMP.1 annex I.E paragraph 16: List of invalid units</td>
<td>No invalid units exist as at 31 December 2016.</td>
</tr>
<tr>
<td>15/CMP.1 annex I.E paragraph 17 Actions and changes to address discrepancies</td>
<td>No actions were taken or changes made to address discrepancies for the period under review.</td>
</tr>
<tr>
<td>15/CMP.1 annex I.E Publicly accessible information</td>
<td>The public website of Croatian National registry can be found at <a href="http://www.azo.hr/RegistarUnije">http://www.azo.hr/RegistarUnije</a> in Croatian language and at <a href="http://www.azo.hr/GHGRegistry">http://www.azo.hr/GHGRegistry</a> in English language. <a href="https://ets-registry.webgate.ec.europa.eu/euregistry/HR/index.xhtml">https://ets-registry.webgate.ec.europa.eu/euregistry/HR/index.xhtml</a></td>
</tr>
</tbody>
</table>
There has not been any issuance, acquisition, holding, transfer, cancellation, retirement and/or carry-over of CP2 AAUs, RMUs, ERUs, CERs, tCERs and ICERs in 2016.

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 2016. 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.1.2.5. CHANGES IN NATIONAL SYSTEM

In 2015 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.1.2.6. CHANGES IN NATIONAL REGISTRY

Changes in national registry are given in the table ES1.2.4.

#### Table ES1.2.4: Changes in national registry

<table>
<thead>
<tr>
<th>Reporting Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact</td>
<td>Addition of national administrator team member: Mr. Dino Križnjak  Senior Adviser in Climate Change Unit, Croatian Agency for the environment and nature  Radnička cesta 80, 10 000 Zagreb, Croatia  Phone: +385 1 5581 676  Fax: +385 1 4886 850  E-mail: <a href="mailto:dino.kriznjak@azo.hr">dino.kriznjak@azo.hr</a></td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement</td>
<td>No change of cooperation arrangement occurred during the reported period.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry</td>
<td>New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality.  Versions of the CSEUR released after 6.7.3 (the production version at the time of the last Chapter 14 submission) introduced other 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, including the new tables, is provided in the document Annex A, available upon request due to the confidentiality of the data.  No change to the capacity of the national registry occurred during the reported period.</td>
</tr>
<tr>
<td>Reporting Item</td>
<td>Description</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards</td>
<td>Changes introduced since version 6.7.3 of the national registry are listed in the document Annex B, available upon request due to the confidentiality of the data. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). Annex H testing was completed in January 2017 and the test report (document Annex H) is available upon request, due to the confidentiality of the data. No other change in the registry’s conformance to the technical standards occurred for the reported period.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures</td>
<td>No change of discrepancies procedures occurred during the reported period.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(f) Change regarding security</td>
<td>The mandatory use of hardware tokens for authentication and signature was introduced for registry administrators.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information</td>
<td>No change in the list of publicly available information with regards to confidentiality of information occurred during the reporting period.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address</td>
<td>No change of the registry internet address occurred during the reporting period.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures</td>
<td>No change of data integrity measures occurred during the reporting period.</td>
</tr>
<tr>
<td>Reporting Item</td>
<td>Description</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| 15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results | Changes introduced since version 6.7.3 of the national registry are listed in the document Annex B, available upon request due to the confidentiality of the data. 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 and the report (document Annex B) is available upon request due to the confidentiality of the data.

Testing was carried out in January 2017 and the test report (document Annex H) is available upon request due to the confidentiality of the data. |
| 1/CMP.8 paragraph 23 PPSR account | Previous period surplus reserve (PPSR) account will be established in the Consolidated System of European Registries (CSEUR). |

The Annexes A, B and H are considered as confidential and are available upon request.
ES.1.2.7. 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 2015. 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 warming potential values for certain gases (100- year time horizon) are presented below.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Global Warming Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO$_2$)</td>
<td>1</td>
</tr>
<tr>
<td>Methane (CH$_4$)</td>
<td>25</td>
</tr>
<tr>
<td>Nitrous oxide (N$_2$O)</td>
<td>298</td>
</tr>
<tr>
<td>HFC-23</td>
<td>14800</td>
</tr>
<tr>
<td>HFC-32</td>
<td>675</td>
</tr>
<tr>
<td>HFC-125</td>
<td>3500</td>
</tr>
<tr>
<td>HFC-134a</td>
<td>1430</td>
</tr>
<tr>
<td>HFC-143a</td>
<td>4470</td>
</tr>
<tr>
<td>HFC-152a</td>
<td>124</td>
</tr>
<tr>
<td>HFC-227ea</td>
<td>3220</td>
</tr>
<tr>
<td>HFC-236fa</td>
<td>9810</td>
</tr>
<tr>
<td>CF$_4$</td>
<td>7390</td>
</tr>
<tr>
<td>CF$_6$</td>
<td>12200</td>
</tr>
<tr>
<td>CF$_8$</td>
<td>8830</td>
</tr>
<tr>
<td>SF$_6$</td>
<td>22800</td>
</tr>
</tbody>
</table>

Source: 24/CP.19

The results of the greenhouse gas (GHG) emission calculation are presented for the period from 1990 to 2015. Total emissions/removals of GHG and their trend in sectors are given in Tables ES.2-1,
ES.2-2 and in Figure ES.2-1 while the contribution of the individual gases is given in Tables ES.2-3, ES.2-4 and Figure ES.2-2.

Table ES.2-1: Emissions/removals of GHG by sectors for the every five years from 1990 to 2005 (kt CO₂-eq)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>21,831.8</td>
<td>16,122.0</td>
<td>18,350.8</td>
<td>21,730.0</td>
</tr>
<tr>
<td>Industrial processes and product use</td>
<td>4,628.8</td>
<td>2,440.5</td>
<td>3,127.5</td>
<td>3,507.6</td>
</tr>
<tr>
<td>Agriculture</td>
<td>4,039.1</td>
<td>3,008.2</td>
<td>2,888.0</td>
<td>3,029.7</td>
</tr>
<tr>
<td>Land use, land-use change and forestry</td>
<td>-6,643.7</td>
<td>-9,081.0</td>
<td>-7,443.2</td>
<td>-7,728.9</td>
</tr>
<tr>
<td>Waste</td>
<td>654.0</td>
<td>739.5</td>
<td>889.0</td>
<td>1,045.0</td>
</tr>
<tr>
<td>Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td><strong>Total (with LULUCF)</strong></td>
<td>24,510.0</td>
<td>13,229.2</td>
<td>17,812.1</td>
<td>21,583.5</td>
</tr>
<tr>
<td><strong>Total (without LULUCF)</strong></td>
<td>31,153.7</td>
<td>22,310.2</td>
<td>25,255.3</td>
<td>29,312.4</td>
</tr>
</tbody>
</table>

Table ES.2-2: Emissions/removals of GHG by sectors for the period from 2010-2015 (kt CO₂-eq)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>19,903.9</td>
<td>19,634.8</td>
<td>18,187.4</td>
<td>17,415.7</td>
<td>16,459.8</td>
<td>16,728.0</td>
</tr>
<tr>
<td>Industrial processes and product use</td>
<td>3,315.3</td>
<td>3,083.7</td>
<td>2,809.2</td>
<td>2,538.6</td>
<td>2,688.0</td>
<td>2,665.5</td>
</tr>
<tr>
<td>Agriculture</td>
<td>2,717.5</td>
<td>2,785.6</td>
<td>2,704.6</td>
<td>2,537.0</td>
<td>2,427.0</td>
<td>2,555.3</td>
</tr>
<tr>
<td>Land use, land-use change and forestry</td>
<td>-7,163.8</td>
<td>-6,161.6</td>
<td>-5,899.4</td>
<td>-6,476.2</td>
<td>-6,530.9</td>
<td>-4,984.5</td>
</tr>
<tr>
<td>Waste</td>
<td>1,392.4</td>
<td>1,424.6</td>
<td>1,420.7</td>
<td>1,431.3</td>
<td>1,474.1</td>
<td>1,553.3</td>
</tr>
<tr>
<td>Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td><strong>Total (with LULUCF)</strong></td>
<td>20,165.2</td>
<td>20,767.0</td>
<td>19,222.6</td>
<td>17,446.4</td>
<td>16,518.1</td>
<td>18,517.7</td>
</tr>
<tr>
<td><strong>Total (without LULUCF)</strong></td>
<td>27,329.0</td>
<td>26,928.7</td>
<td>25,121.9</td>
<td>23,922.5</td>
<td>23,049.0</td>
<td>23,502.1</td>
</tr>
</tbody>
</table>
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 2015 excluding LULUCF has the Energy sector with 71.2 percent, followed by Industrial Processes and product use with 11.3 percent, Agriculture with 10.9 percent and Waste with 6.6 percent. This structure is with minor changes consistent through all the observed period from 1990 to 2015. In the year 2015, the total GHG emissions in Croatia was 23,502.1 kt CO$_2$-eq excluding LULUCF sector while the total emission was 18,517.7 kt CO$_2$-eq including the LULUCF sector which represents removals by sink from 21.2 percent in that year.
Croatian NIR 2017
Zagreb, March 2017

Table ES.2-3: Emissions/removals of GHG by gases for the every five years from 1990 to 2005 (kt CO₂-eq)

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>CO₂ emissions without net CO₂ from LULUCF</td>
<td>23,390.1</td>
<td>16,992.8</td>
<td>19,789.1</td>
<td>23,451.8</td>
</tr>
<tr>
<td>CO₂ emissions with net CO₂ from LULUCF</td>
<td>16,713.2</td>
<td>7,866.9</td>
<td>12,147.0</td>
<td>15,643.3</td>
</tr>
<tr>
<td>CH₄ emissions without CH₄ from LULUCF</td>
<td>3,744.2</td>
<td>3,033.7</td>
<td>2,887.9</td>
<td>3,173.8</td>
</tr>
<tr>
<td>CH₄ emissions with CH₄ from LULUCF</td>
<td>3,745.4</td>
<td>3,041.2</td>
<td>2,984.8</td>
<td>3,176.5</td>
</tr>
<tr>
<td>N₂O emissions without N₂O from LULUCF</td>
<td>2,768.7</td>
<td>2,243.3</td>
<td>2,418.8</td>
<td>2,407.9</td>
</tr>
<tr>
<td>N₂O emissions with N₂O from LULUCF</td>
<td>2,800.6</td>
<td>2,280.7</td>
<td>2,520.9</td>
<td>2,484.8</td>
</tr>
<tr>
<td>HFCs</td>
<td>NO</td>
<td>29.3</td>
<td>147.9</td>
<td>265.8</td>
</tr>
<tr>
<td>PFCs</td>
<td>1,240.2</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Unspecified mix of HFCs and PFCs</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>SF₆</td>
<td>10.5</td>
<td>11.1</td>
<td>11.6</td>
<td>13.0</td>
</tr>
<tr>
<td>NF₃</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Total (without LULUCF)</td>
<td>31,153.7</td>
<td>22,310.2</td>
<td>25,255.3</td>
<td>29,312.4</td>
</tr>
<tr>
<td>Total (with LULUCF)</td>
<td>24,510.0</td>
<td>13,229.2</td>
<td>17,812.1</td>
<td>21,583.5</td>
</tr>
<tr>
<td>Total (without LULUCF, with indirect)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Total (with LULUCF, with indirect)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Table ES.2-4: Emissions/removals of GHG by gases for the for the period from 2010-2015 (kt CO₂-eq)

<table>
<thead>
<tr>
<th>GREENHOUSE GAS EMISSIONS</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ emissions without net CO₂ from LULUCF</td>
<td>21,203.7</td>
<td>20,759.4</td>
<td>19,172.4</td>
<td>18,525.4</td>
<td>17,777.1</td>
<td>17,918.7</td>
</tr>
<tr>
<td>CO₂ emissions with net CO₂ from LULUCF</td>
<td>13,952.7</td>
<td>14,481.0</td>
<td>13,122.8</td>
<td>11,961.2</td>
<td>11,160.9</td>
<td>12,829.7</td>
</tr>
<tr>
<td>CH₄ emissions without CH₄ from LULUCF</td>
<td>3,415.1</td>
<td>3,384.4</td>
<td>3,311.2</td>
<td>3,267.6</td>
<td>3,226.5</td>
<td>3,430.6</td>
</tr>
<tr>
<td>CH₄ emissions with CH₄ from LULUCF</td>
<td>3,416.8</td>
<td>3,403.1</td>
<td>3,350.1</td>
<td>3,269.5</td>
<td>3,226.8</td>
<td>3,442.0</td>
</tr>
<tr>
<td>N₂O emissions without N₂O from LULUCF</td>
<td>2,322.3</td>
<td>2,379.2</td>
<td>2,231.9</td>
<td>1,714.5</td>
<td>1,624.9</td>
<td>1,727.6</td>
</tr>
<tr>
<td>N₂O emissions with N₂O from LULUCF</td>
<td>2,407.8</td>
<td>2,477.4</td>
<td>2,343.2</td>
<td>1,800.6</td>
<td>1,709.9</td>
<td>1,820.8</td>
</tr>
<tr>
<td>HFCs</td>
<td>378.9</td>
<td>396.2</td>
<td>397.3</td>
<td>408.9</td>
<td>413.6</td>
<td>419.9</td>
</tr>
<tr>
<td>PFCs</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Unspecified mix of HFCs and PFCs</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>SF₆</td>
<td>9.0</td>
<td>9.4</td>
<td>9.2</td>
<td>6.1</td>
<td>6.8</td>
<td>5.3</td>
</tr>
<tr>
<td>NF₃</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Total (without LULUCF)</td>
<td>27,329.0</td>
<td>26,928.7</td>
<td>25,121.9</td>
<td>23,922.5</td>
<td>23,049.0</td>
<td>23,502.1</td>
</tr>
<tr>
<td>Total (with LULUCF)</td>
<td>20,165.2</td>
<td>20,767.0</td>
<td>19,222.6</td>
<td>17,446.4</td>
<td>16,518.1</td>
<td>18,517.7</td>
</tr>
<tr>
<td>Total (without LULUCF, with indirect)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Total (with LULUCF, with indirect)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
Tables ES.2-3, ES.2-4 and Figure ES.2-2 represents the contribution of the individual gases to total emissions and removals of the GHGs. The largest contribution to the GHGs emission in 2015 excluding LULUCF has CO$_2$ emission with 76.2 percent, followed by CH$_4$ with 14.6 percent, N$_2$O with 7.4 percent and HFCs, PFCs and SF$_6$ with 1.8 percent.
ES.3. OVERVIEW OF SOURCE AND SINK CATEGORY EMISSION ESTIMATES AND TRENDS

ES.3.1. GREENHOUSE GAS EMISSIONS BY SECTORS

ENERGY SECTOR

Energy sector is the largest contributor to GHG emissions. In the year 2015, the GHG emission from Energy sector was 1.6 percent higher in relation to 2014 and 23.4 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 CO₂. Looking at its contribution to total emission of carbon dioxide (CO₂), the energy sector accounts for about 90 percent. The contribution of energy in methane (CH₄) in total CO₂-eq emission is substantially smaller (8 percent) while the contribution of energy in nitrous oxide (N₂O) in total CO₂-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>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Energy</td>
<td>21,831.8</td>
<td>16,122.0</td>
<td>18,350.8</td>
<td>21,730.0</td>
<td>19,903.9</td>
<td>19,634.8</td>
<td>18,187.4</td>
<td>17,415.7</td>
<td>16,459.8</td>
<td>16,728.0</td>
</tr>
<tr>
<td>A. Fuel comb.</td>
<td>20,722.4</td>
<td>14,889.9</td>
<td>17,319.5</td>
<td>20,601.1</td>
<td>18,957.8</td>
<td>18,705.3</td>
<td>17,399.6</td>
<td>16,666.9</td>
<td>15,743.1</td>
<td>16,198.8</td>
</tr>
<tr>
<td>1. Energy industries</td>
<td>7,094.3</td>
<td>5,243.2</td>
<td>5,839.4</td>
<td>6,880.9</td>
<td>5,951.1</td>
<td>6,325.2</td>
<td>5,922.3</td>
<td>5,299.8</td>
<td>4,791.0</td>
<td>4,795.4</td>
</tr>
<tr>
<td>2. Manufact. ind.</td>
<td>5,529.0</td>
<td>2,967.9</td>
<td>3,115.6</td>
<td>3,739.0</td>
<td>3,030.1</td>
<td>2,792.1</td>
<td>2,421.9</td>
<td>2,392.8</td>
<td>2,335.0</td>
<td>2,232.0</td>
</tr>
<tr>
<td>3. Transport</td>
<td>3,881.1</td>
<td>3,367.9</td>
<td>4,499.4</td>
<td>5,561.1</td>
<td>5,952.3</td>
<td>5,799.5</td>
<td>5,614.2</td>
<td>5,699.5</td>
<td>5,642.5</td>
<td>5,951.8</td>
</tr>
<tr>
<td>4. Other sectors</td>
<td>4,217.9</td>
<td>3,310.8</td>
<td>3,865.1</td>
<td>4,420.1</td>
<td>4,024.4</td>
<td>3,788.5</td>
<td>3,441.2</td>
<td>3,274.8</td>
<td>2,974.6</td>
<td>3,219.5</td>
</tr>
<tr>
<td>5. Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>B. Fugitive em.</td>
<td>1,109.4</td>
<td>1,232.1</td>
<td>1,031.2</td>
<td>1,129.0</td>
<td>946.0</td>
<td>929.5</td>
<td>787.8</td>
<td>748.8</td>
<td>716.7</td>
<td>529.3</td>
</tr>
<tr>
<td>1. Solid fuels</td>
<td>59.6</td>
<td>28.2</td>
<td>NO,NA</td>
<td>NO,NA</td>
<td>NO,NA</td>
<td>NO,NA</td>
<td>NO,NA</td>
<td>NO,NA</td>
<td>NO,NA</td>
<td>NO,NA</td>
</tr>
<tr>
<td>2. Oil and nat. gas</td>
<td>1,049.8</td>
<td>1,203.9</td>
<td>1,031.2</td>
<td>1,129.0</td>
<td>946.0</td>
<td>929.5</td>
<td>787.8</td>
<td>748.8</td>
<td>716.7</td>
<td>529.3</td>
</tr>
<tr>
<td>C. CO₂ transport and storage</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>
The largest part (35.6 percent in 2015) of the emissions are a consequence of fuel combustion in Transport, then the combustion in Energy industries (28.7 percent in 2015) and the combustion in small stationary energy sources, such as Commercial/ Institutional, Residential and Agriculture/ Forestry/ Fishing (19.3 percent in 2015). Manufacturing Industries and Construction contribute to total emission from Energy sector with 13.3 percent, while Fugitive Emissions from Fuels contribute with about 3.1 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 93.7 percent in total sectoral emission in 2015. 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 N₂O emissions from the nitric acid production after applying abatement technology. In 2015 emissions from industrial processes were decreased by 0.8 percent regarding 2014 and by 42.4 percent regarding 1990. Industrial processes and product use contributes to total GHG emissions with 11.3 percent in 2015. Emission of individual subsectors is presented in the Table ES.3-2.
**AGRICULTURE**

Emission of CH$_4$ and N$_2$O 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 2014, in 2015 CH$_4$ emission from Enteric fermentation increased by 4.83 percent. As for Manure management emissions, CH$_4$ emission increased by 5.31 percent in 2015 compared to 2014 while N$_2$O emission increased by 6.82%. Emissions from Agricultural soils decreased after 1990 and during the war due to specific national circumstances and limited agricultural practice at that time. Afterwards, the emission trend is mostly influenced by the changes in the direct soil emissions; thus, emission increase can be noticed in 1997, 2001 and 2002 due to increase in mineral fertilizer consumption and crop production, later on also due to the increase of livestock population. N$_2$O emission from Agricultural soils increased in 2015 compared to 2014 by 5.22 percent. Overall, in the year 2015 the GHG emission from Agriculture sector increased by 5.02 percent in comparison with 2014. Emission of individual subsectors is presented in the Table ES.3-3.

### Table ES.3-2: Industrial processes subsectors total emissions by gases for the period 1990-2015 (kt CO$_2$-eq)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>2. Industrial processes and product use</td>
<td>4,628.8</td>
<td>2,440.5</td>
<td>3,127.5</td>
<td>3,507.6</td>
<td>3,315.3</td>
<td>3,083.7</td>
<td>2,809.2</td>
<td>2,538.6</td>
<td>2,688.0</td>
<td>2,665.5</td>
</tr>
<tr>
<td>A. Mineral industry</td>
<td>1,280.9</td>
<td>760.0</td>
<td>1,423.1</td>
<td>1,785.4</td>
<td>1,432.3</td>
<td>1,220.1</td>
<td>1,163.7</td>
<td>1,275.9</td>
<td>1,360.2</td>
<td>1,313.1</td>
</tr>
<tr>
<td>B. Chemical industry</td>
<td>1,531.9</td>
<td>1,454.2</td>
<td>1,421.6</td>
<td>1,305.5</td>
<td>1,362.9</td>
<td>1,327.4</td>
<td>1,131.6</td>
<td>726.6</td>
<td>800.9</td>
<td>848.8</td>
</tr>
<tr>
<td>C. Metal industry</td>
<td>1,582.7</td>
<td>39.1</td>
<td>27.3</td>
<td>11.8</td>
<td>27.6</td>
<td>29.4</td>
<td>2.0</td>
<td>16.9</td>
<td>28.6</td>
<td>13.6</td>
</tr>
<tr>
<td>D. Non-energy products</td>
<td>189.4</td>
<td>113.4</td>
<td>62.6</td>
<td>92.7</td>
<td>73.6</td>
<td>68.5</td>
<td>63.0</td>
<td>62.1</td>
<td>58.8</td>
<td>61.0</td>
</tr>
<tr>
<td>E. Electronic Industry</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>F. Product uses as ODS</td>
<td>NO</td>
<td>29.3</td>
<td>147.9</td>
<td>265.8</td>
<td>378.9</td>
<td>396.2</td>
<td>397.3</td>
<td>409.0</td>
<td>413.7</td>
<td>419.9</td>
</tr>
<tr>
<td>G. Other prod. manuf.</td>
<td>43.8</td>
<td>44.5</td>
<td>45.0</td>
<td>46.4</td>
<td>40.0</td>
<td>42.0</td>
<td>51.5</td>
<td>48.2</td>
<td>25.8</td>
<td>9.1</td>
</tr>
<tr>
<td>H. Other</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE

- 48 -
Table ES.3-3: Agriculture subsectors total emissions by gases for the period 1990-2015 (kt CO₂-eq)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>3. Agriculture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Enteric fermentation</td>
<td>4,039.1</td>
<td>3,008.2</td>
<td>2,888.0</td>
<td>3,029.7</td>
<td>2,717.5</td>
<td>2,785.6</td>
<td>2,704.6</td>
<td>2,537.0</td>
<td>2,427.0</td>
<td>2,555.3</td>
</tr>
<tr>
<td>B. Manure management</td>
<td>651.6</td>
<td>528.4</td>
<td>515.7</td>
<td>538.4</td>
<td>524.8</td>
<td>504.4</td>
<td>487.0</td>
<td>469.6</td>
<td>462.9</td>
<td>491.2</td>
</tr>
<tr>
<td>C. Rice cultivation</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>D. Agricultural soils</td>
<td>1,359.8</td>
<td>1,056.9</td>
<td>1,156.4</td>
<td>1,236.3</td>
<td>1,047.5</td>
<td>1,135.4</td>
<td>1,092.1</td>
<td>996.7</td>
<td>919.8</td>
<td>970.4</td>
</tr>
<tr>
<td>E. Presc. burning of sav.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>F. Field burning of agr. resi.</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>G. Liming</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>14.5</td>
<td>21.5</td>
<td>21.3</td>
<td>14.4</td>
<td>14.2</td>
<td>20.0</td>
<td>12.1</td>
</tr>
<tr>
<td>H. Urea application</td>
<td>50.0</td>
<td>46.3</td>
<td>60.9</td>
<td>71.0</td>
<td>66.6</td>
<td>83.9</td>
<td>86.9</td>
<td>60.4</td>
<td>49.5</td>
<td>57.2</td>
</tr>
<tr>
<td>I. Other carbon-cont. fertil.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>J. Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
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</tbody>
</table>

**LULUCF**

The Low on Forest (Official Gazette No. 140/05, 82/06, 129/08, 80/10, 124/10, 25/12, 68/12, 148/13, 94/14) regulates the growing, protection, usage and management of forests and forest land as a natural resource aimed to maintain biodiversity and ensure management based on principles of economic sustainability, social responsibility and ecological acceptability. Moreover, one of its the most important provisions, in the context of climate protection, is that forests should be managed in conformity with the sustainable management criteria, implying the maintenance and enhancement of forest ecosystems and their contribution to the global carbon cycle. Planning activities in forestry sector in Croatia are also regulated by the Low on Forest. Forest management plans determine conditions for harmonious usage of forest and forest land and procedures in that area, necessary scope regarding cultivation and forest protection, possible utilization degree and conditions for wildlife management. The Forest Management Area Plan (FMAP) for the Republic of Croatia determines the ecological, economic and social background for forest improvement in terms of biology and for the increase of forest productivity.

According to Forest Management Area Plan of the Republic of Croatia (2006-2015), the forests and the forest land cover 47.5 percent of the total surface area. By its origin, approximately 95 percent of the forests in Croatia were formed by natural regeneration (according to the national definitions applied in the sector) and the 5 percent of the forests are grown artificially. The Plan determines, for 2006, growing stock of about 398 millions of m³ while its yearly increment amounts...
around 10.5 million of m$^3$. The most frequent species are Common Beech (Fagus sylvatica), Pedunculate Oak (Quercus robur), Sessile Oak (Quercus petrea), Common Hornbeam (Carpinus betulus), Silver Fir (Abies alba), Narrow-leafed Ash (Fraxinus angustifolia), Spruce (Picea abies), Black Alder (Alnus glutinosa), Black Locust (Robinia pseudoacacia), Turkey Oak (Quercus cerris) and other. The methodology used for CO$_2$ removal calculation is taken from the IPCC and it is based on data on increment and fellings. The problem of deforestation in Croatia does not exist. According to present data the total forest area has not been reduced in the last 100 years.

Table ES.3-4 shows the CO$_2$ removal trend in the forestry sector. Removal arisen in LULUCF sector contribute with 28.5 percent to the total emissions of CO$_2$ eq in Croatia in year 2015.

Table ES.3-4: Removal trends in LULUCF sector from 1990-2015 (kt CO$_2$-eq)

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</thead>
<tbody>
<tr>
<td>LULUCF removals</td>
<td>-6,643.7</td>
<td>-9,081.0</td>
<td>-7,443.2</td>
<td>-7,728.9</td>
<td>-7,163.8</td>
<td>-6,161.6</td>
<td>-5,899.4</td>
<td>-6,476.2</td>
<td>-6,530.9</td>
<td>-4,984.5</td>
</tr>
</tbody>
</table>

**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, 80.7 percent of sectoral emissions refer to the emissions from solid waste disposal in 2015, compared to 53.3 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. 18.6 percent of sectoral emissions refer to the emissions from wastewater treatment and discharge in 2015, compared to 46.6 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 6.6 percent in 2015. 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 1990-2015 (kt CO2-eq)

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<tbody>
<tr>
<td>5. Waste</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Solid waste disposal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Biol. treatment of solid waste</td>
<td>NO, NE,IE</td>
<td>NO, NE,IE</td>
<td>NO, NE,IE</td>
<td>NO, NE,IE</td>
<td>1.7</td>
<td>1.7</td>
<td>3.2</td>
<td>4.9</td>
<td>4.9</td>
<td>10.6</td>
</tr>
<tr>
<td>C. Incineration of waste</td>
<td>0.54</td>
<td>0.54</td>
<td>6.26</td>
<td>0.16</td>
<td>0.05</td>
<td>0.05</td>
<td>0.08</td>
<td>0.04</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>D. Waste water treatment</td>
<td>304.9</td>
<td>309.5</td>
<td>312.4</td>
<td>309.6</td>
<td>292.2</td>
<td>291.3</td>
<td>277.2</td>
<td>284.0</td>
<td>290.8</td>
<td>288.8</td>
</tr>
<tr>
<td>E. Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>
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 1990-2015 (kt CO$_2$)

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</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>20,758.8</td>
<td>15,263.4</td>
<td>17,485.2</td>
<td>20,811.7</td>
<td>18,987.5</td>
<td>18,764.8</td>
<td>17,363.4</td>
<td>16,610.0</td>
<td>15,725.6</td>
<td>15,924.6</td>
</tr>
<tr>
<td>Industrial</td>
<td>2,580.7</td>
<td>1,682.5</td>
<td>2,236.9</td>
<td>2,554.6</td>
<td>2,128.2</td>
<td>1,889.4</td>
<td>1,707.7</td>
<td>1,840.8</td>
<td>1,981.9</td>
<td>1,924.8</td>
</tr>
<tr>
<td>Agriculture</td>
<td>50.0</td>
<td>46.3</td>
<td>69.9</td>
<td>85.5</td>
<td>88.0</td>
<td>105.2</td>
<td>101.2</td>
<td>74.6</td>
<td>69.5</td>
<td>69.3</td>
</tr>
<tr>
<td>LULUCF</td>
<td>-6,676.8</td>
<td>-9,125.9</td>
<td>-7,642.2</td>
<td>-7,808.6</td>
<td>-7,251.1</td>
<td>-6,278.4</td>
<td>-6,049.7</td>
<td>-6,564.3</td>
<td>-6,616.2</td>
<td>-5,089.1</td>
</tr>
<tr>
<td>Waste</td>
<td>0.54</td>
<td>0.54</td>
<td>6.15</td>
<td>0.16</td>
<td>0.05</td>
<td>0.05</td>
<td>0.08</td>
<td>0.04</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Total CO$_2$ emission</td>
<td>23,390.1</td>
<td>16,992.8</td>
<td>19,789.1</td>
<td>23,451.8</td>
<td>21,203.7</td>
<td>20,759.4</td>
<td>19,172.4</td>
<td>18,525.4</td>
<td>17,777.1</td>
<td>17,918.7</td>
</tr>
</tbody>
</table>

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 88.9 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: CO₂ emission by sub-sectors from 1990-2015 (kt CO₂)

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Energy Industries</td>
<td>7,071.4</td>
<td>5,226.8</td>
<td>5,816.8</td>
<td>6,853.4</td>
<td>5,925.0</td>
<td>6,297.1</td>
<td>5,895.7</td>
<td>5,274.7</td>
<td>4,769.8</td>
<td>4,771.7</td>
</tr>
<tr>
<td>Manuf. Ind. and Const.</td>
<td>5,501.7</td>
<td>2,954.7</td>
<td>3,103.1</td>
<td>3,723.7</td>
<td>3,015.8</td>
<td>2,779.6</td>
<td>2,409.1</td>
<td>2,380.7</td>
<td>2,324.3</td>
<td>2,222.7</td>
</tr>
<tr>
<td>Transport</td>
<td>3,786.9</td>
<td>3,292.8</td>
<td>4,354.2</td>
<td>5,467.5</td>
<td>5,865.0</td>
<td>5,726.0</td>
<td>5,545.0</td>
<td>5,631.1</td>
<td>5,575.6</td>
<td>5,883.5</td>
</tr>
<tr>
<td>Other sectors</td>
<td>3,718.9</td>
<td>2,856.8</td>
<td>3,418.4</td>
<td>3,898.1</td>
<td>3,506.2</td>
<td>3,281.8</td>
<td>2,941.6</td>
<td>2,779.6</td>
<td>2,530.5</td>
<td>2,719.8</td>
</tr>
<tr>
<td>Fugitive emissions</td>
<td>679.9</td>
<td>932.3</td>
<td>792.7</td>
<td>868.9</td>
<td>675.4</td>
<td>680.2</td>
<td>572.1</td>
<td>543.9</td>
<td>525.3</td>
<td>326.9</td>
</tr>
<tr>
<td>Total CO₂ emis</td>
<td>20,078.9</td>
<td>14,331.1</td>
<td>16,692.6</td>
<td>19,942.8</td>
<td>18,312.0</td>
<td>18,084.5</td>
<td>16,791.3</td>
<td>16,066.1</td>
<td>15,200.3</td>
<td>15,597.7</td>
</tr>
</tbody>
</table>

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 CO₂ emissions are the result of fuel combustion in industry of construction material and petrochemical production, followed by food processing industry, chemical industry, industry of pulp, paper and print, iron and steel industry and non-ferrous metal industry. Furthermore, this sub-sector includes electricity and heat production in manufacturing industry for manufacturing processes.

Transport sector is also one of more important CO₂ emission sources. This sector includes emission from road transport, civil aviation, railways and navigation. In the year 2015, the CO₂ emission from Transport sector contributed with 32.8 percent to the national total CO₂ emission. The largest part of the CO₂ emission from Transport sector arises from road transport (96.3 percent of CO₂ emission from transport sector in 2015) followed by national navigation, domestic civil aviation and railways.

Biomass combustion (fuel wood and waste wood, biodiesel, biogas) also results in greenhouse gas emissions. CO₂ emission from biomass is not included in balance according the Guidelines, due to assumption that life-cycle CO₂ emitted is formerly absorbed for the growth of biomass. Sinks or CO₂ emissions resulted in change of forest biomass is calculated in 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\textsubscript{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\textsubscript{2} emission calculation for industrial processes are shown in Table ES.3.2-3.

![Table ES.3.2-3: CO\textsubscript{2} emission from Industrial Processes and product use for the period from 1990-2015 (kt CO\textsubscript{2})](attachment:table.png)

The most significant CO\textsubscript{2} industrial processes emission sources are production of cement, ammonia and lime. In 2015, mineral industry contributes in total sectoral CO\textsubscript{2} emission with 68.2 percent and chemical industry with 27.9 percent. Generally, CO\textsubscript{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 2015 CO\textsubscript{2} emissions from industrial processes decreased by 2.9 percent, regarding the year 2014.
ES.3.2.2. METHANE EMISSION (CH₄)

The major sources of methane (CH₄) emission are fugitive emission from production, processing, transportation and activities related with fuel use in Energy sector, Agriculture and Waste Disposal on Land. In Table ES.3.2-4, sectoral and total CH₄ emissions are reported.

Table ES.3.2-4: CH₄ emission in Croatia in the period from 1990-2015 (kt CH₄)

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</thead>
<tbody>
<tr>
<td>Energy</td>
<td>33.71</td>
<td>27.16</td>
<td>23.65</td>
<td>27.22</td>
<td>27.25</td>
<td>25.94</td>
<td>24.43</td>
<td>23.86</td>
<td>21.46</td>
<td>23.80</td>
</tr>
<tr>
<td>Industrial processes</td>
<td>0.38</td>
<td>0.24</td>
<td>0.14</td>
<td>0.16</td>
<td>0.12</td>
<td>0.08</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Agriculture</td>
<td>92.22</td>
<td>67.27</td>
<td>59.21</td>
<td>61.00</td>
<td>56.90</td>
<td>55.79</td>
<td>54.60</td>
<td>53.01</td>
<td>52.04</td>
<td>54.75</td>
</tr>
<tr>
<td>LULUCF</td>
<td>0.05</td>
<td>0.30</td>
<td>3.88</td>
<td>0.11</td>
<td>0.07</td>
<td>0.75</td>
<td>1.56</td>
<td>0.08</td>
<td>0.01</td>
<td>0.46</td>
</tr>
<tr>
<td>Waste</td>
<td>23.46</td>
<td>26.68</td>
<td>32.51</td>
<td>38.57</td>
<td>52.34</td>
<td>53.58</td>
<td>53.41</td>
<td>53.83</td>
<td>55.56</td>
<td>58.66</td>
</tr>
<tr>
<td>Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Total CH₄ emission</td>
<td>149.82</td>
<td>121.65</td>
<td>119.39</td>
<td>127.06</td>
<td>136.67</td>
<td>136.12</td>
<td>134.00</td>
<td>130.78</td>
<td>129.07</td>
<td>137.68</td>
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</table>

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 CH₄ emissions. Disposal of domestic and commercial wastewater, particularly in rural areas where
systems such as septic tanks are used, are partly anaerobic without flaring, which results with CH₄ emissions.

**ES.3.2.3. NITROUS OXIDE EMISSION (N₂O)**

The most important sources of N₂O emissions in Croatia are agricultural activities, nitric acid production, but as well, the N₂O emissions occur in energy sector and waste management. In Table ES.3.2-5 the N₂O emission is reported according to sectors.

Table ES.3.2-5: N₂O emission in Croatia for the period from 1990-2015 (kt N₂O)

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</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>0.77</td>
<td>0.60</td>
<td>0.92</td>
<td>0.80</td>
<td>0.79</td>
<td>0.74</td>
<td>0.72</td>
<td>0.70</td>
<td>0.66</td>
<td>0.70</td>
</tr>
<tr>
<td>Industrial Processes</td>
<td>2.64</td>
<td>2.39</td>
<td>2.44</td>
<td>2.25</td>
<td>2.67</td>
<td>2.64</td>
<td>2.33</td>
<td>0.95</td>
<td>0.96</td>
<td>1.06</td>
</tr>
<tr>
<td>Agriculture</td>
<td>5.65</td>
<td>4.30</td>
<td>4.52</td>
<td>4.76</td>
<td>4.05</td>
<td>4.31</td>
<td>4.16</td>
<td>3.82</td>
<td>3.55</td>
<td>3.75</td>
</tr>
<tr>
<td>LULUCF</td>
<td>0.11</td>
<td>0.13</td>
<td>0.34</td>
<td>0.26</td>
<td>0.29</td>
<td>0.33</td>
<td>0.37</td>
<td>0.29</td>
<td>0.29</td>
<td>0.31</td>
</tr>
<tr>
<td>Waste</td>
<td>0.22</td>
<td>0.24</td>
<td>0.24</td>
<td>0.27</td>
<td>0.28</td>
<td>0.29</td>
<td>0.29</td>
<td>0.29</td>
<td>0.29</td>
<td>0.29</td>
</tr>
<tr>
<td>Other</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td><strong>Total N₂O emission</strong></td>
<td>9.40</td>
<td>7.65</td>
<td>8.46</td>
<td>8.34</td>
<td>8.08</td>
<td>8.31</td>
<td>7.86</td>
<td>6.04</td>
<td>5.74</td>
<td>6.11</td>
</tr>
</tbody>
</table>

In the Agricultural sector, three N₂O emission sources are determined: direct N₂O emission from agricultural soils, direct N₂O emission from livestock farming and indirect N₂O emission induced by agricultural activities. 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 N₂O emission occurs in nitric acid production, which is used as a raw material in nitrogen mineral fertilizers. In the framework of the N₂O reduction measure analysis, the possibility for application of non-selective catalytic reduction device was considered, whereby the nitric acid production influence on N₂O emissions would be practically eliminated.

In Energy sector the emission was calculated on the basis of fuel consumption and adequate emission factors (IPCC). The major sources of N₂O emission in Energy sector is use of three-way catalytic converters in road transport motor vehicles.
N₂O emission from the Waste sector indirectly occurs from human sewage. It is calculated on the basis of the total number of inhabitants and annual protein consumption per inhabitant. Data on the annual per capita Protein Intake Value were obtained by the FAOSTAT Statistical Database. Extrapolation method has been used for calculation of insufficient data.

**ES.3.2.3. HALOGENATED CARBONS (HFC, PFC), SF₆ and NF₃ EMISSIONS**

Synthetic GHGs include halogenated carbons (HFCs and PFCs) and sulphur hexafluoride (SF₆). Although on an absolute scale their emissions are not great, due to their high global warming potential (GWP) their contribution to global warming is considerable. 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, SF₆ and NF₃ 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, SF₆ and NF₃ (provided by the MEE) was used for emission calculation which is presented in kt of CO₂-eq and showed in Table ES.3.2-6.

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<thead>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions of HFC, PFC</td>
<td>1,240.2</td>
<td>29.3</td>
<td>147.9</td>
<td>265.8</td>
<td>378.9</td>
<td>396.2</td>
<td>397.3</td>
<td>409.0</td>
<td>413.7</td>
<td>419.9</td>
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<tr>
<td>Emissions of SF₆</td>
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<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
</tr>
<tr>
<td>NF₃ emission</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Total</td>
<td>1,240.2</td>
<td>29.3</td>
<td>147.9</td>
<td>265.8</td>
<td>378.9</td>
<td>396.2</td>
<td>397.3</td>
<td>409.0</td>
<td>413.7</td>
<td>419.9</td>
</tr>
</tbody>
</table>

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

The photochemicaly active gases, carbon monoxide (CO), oxides of nitrogen (NOₓ) and non-methane volatile organic compounds (NMVOCs) indirectly contribute to the greenhouse gas effect. These are generally called indirect greenhouse gases or ozone precursors, because they are involved in creation and degradation of ozone which is also one of the greenhouse gases. Sulphur dioxide
(SO₂), as a precursor of sulphate and aerosols, is believed to contribute negatively to the greenhouse effect. Emissions of indirect GHGs have been taken from the draft of emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 Submission to the Convention on Long-range Transboundary Air Pollution’. The calculations of aggregated results for the emissions of indirect gases in the period 1990-2015 are given in Table ES.4.1-1.

Table ES.4.1-1: Emissions of ozone precursors and SO₂ by sectors (kt)

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>NO\textsubscript{x} Emission</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Energy</td>
<td>87.44</td>
<td>165.47</td>
<td>87.16</td>
<td>68.71</td>
<td>81.10</td>
<td>94.30</td>
<td>58.82</td>
<td>52.73</td>
<td>63.25</td>
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<tr>
<td>Industrial Processes</td>
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<td>2.65</td>
<td>2.41</td>
<td>1.60</td>
<td>1.21</td>
<td>1.10</td>
<td>1.03</td>
<td>1.09</td>
<td>1.10</td>
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<tr>
<td>Agriculture</td>
<td>2.79</td>
<td>3.07</td>
<td>3.15</td>
<td>2.59</td>
<td>2.98</td>
<td>2.80</td>
<td>2.30</td>
<td>1.85</td>
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<tr>
<td>LULUCF</td>
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<td>90.40</td>
<td>2.62</td>
<td>1.63</td>
<td>17.72</td>
<td>36.02</td>
<td>1.86</td>
<td>0.23</td>
<td>10.71</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>CO Emission</td>
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<td>444.17</td>
<td>416.45</td>
<td>299.94</td>
<td>272.95</td>
<td>255.55</td>
<td>231.71</td>
<td>201.97</td>
<td>216.37</td>
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<tr>
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<td>410.41</td>
<td>398.18</td>
<td>298.98</td>
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<td>253.81</td>
<td>231.00</td>
<td>201.20</td>
<td>215.31</td>
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<td>30.87</td>
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<td>0.81</td>
<td>0.63</td>
<td>0.64</td>
<td>0.76</td>
<td>0.71</td>
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</tr>
<tr>
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<td>NO</td>
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<tr>
<td>LULUCF</td>
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<td>2.89</td>
<td>0.09</td>
<td>0.05</td>
<td>0.62</td>
<td>1.11</td>
<td>0.07</td>
<td>0.01</td>
<td>0.36</td>
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<tr>
<td>Waste</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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</tr>
<tr>
<td>NMVOC Emission</td>
<td>141.28</td>
<td>97.35</td>
<td>100.38</td>
<td>77.86</td>
<td>73.51</td>
<td>69.87</td>
<td>64.37</td>
<td>58.18</td>
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<tr>
<td>Energy</td>
<td>62.02</td>
<td>53.89</td>
<td>51.33</td>
<td>40.28</td>
<td>36.75</td>
<td>33.56</td>
<td>31.77</td>
<td>27.26</td>
<td>29.19</td>
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<tr>
<td>Industrial Processes</td>
<td>66.11</td>
<td>25.60</td>
<td>38.21</td>
<td>27.15</td>
<td>25.39</td>
<td>23.83</td>
<td>23.04</td>
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<td>20.58</td>
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<td>8.62</td>
<td>7.80</td>
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<td>7.15</td>
<td>7.09</td>
<td>7.39</td>
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</tr>
<tr>
<td>LULUCF</td>
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<td>7.94</td>
<td>0.21</td>
<td>0.15</td>
<td>1.48</td>
<td>3.22</td>
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<td>0.02</td>
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<td>2.01</td>
<td>2.50</td>
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<td>2.18</td>
<td>2.27</td>
<td>2.10</td>
<td>2.12</td>
<td></td>
</tr>
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<td>SO₂ Emission</td>
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<td>29.48</td>
<td>25.40</td>
<td>17.09</td>
<td>14.01</td>
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<td></td>
</tr>
<tr>
<td>Energy</td>
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<td>58.03</td>
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<td>14.88</td>
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<tr>
<td>Industrial Processes</td>
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<td>0.31</td>
<td>0.22</td>
<td>0.21</td>
<td>0.18</td>
<td>0.22</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>LULUCF</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

Although Parties may now choose to report indirect CO\textsubscript{2}, in accordance with paragraph 29 of the UNFCCC Inventory Reporting Guidelines, Croatia does not choose to report indirect CO\textsubscript{2}
emissions from the atmospheric oxidation of CH\textsubscript{4}, CO and NMVOCs, or indirect N\textsubscript{2}O 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) and Ordinance on Greenhouse Gas Emissions Monitoring in the Republic of Croatia (Official Gazette No. 134/12) prescribe obligation and procedure for emissions monitoring, which comprise estimation and/or reporting of all anthropogenic emissions and removals. Monitoring of GHG gases is stipulated by Article 75 of the Air Protection Act (Official Gazette No. 130/11, 47/14).

In this NIR, the inventory of the emissions and removals of the greenhouse gases (GHG) is reported for the period from 1990 to 2015. 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 (CO2), methane (CH4), nitrous oxide (N2O), halogenated carbons (HFCs, PFCs), sulphur hexafluoride (SF6), nitrogen fluoride (NF3) and indirect greenhouse gases: carbon monoxide (CO), oxides of nitrogen (NOx), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO2). The greenhouse gases covered by Montreal Protocol on the pollutants related to ozone depletion (freons) are reported in the framework of this protocol and therefore are excluded from this Report.

Greenhouse gas emission sources and sinks are divided into 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

Calculation of AAUs and CPR

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.

According to Commission Decision (2013/162/EC) of 26 March 2013 on determining Member States’ annual emission allocations for the period from 2013 to 2020 pursuant to Decision 406/2009/EC
of the European Parliament and of the Council Annual Emission Allocation for Croatia for the period from 2013 to 2020 are presented in Table 1.1-1.

According to Commission implementing Decision (2013/634/EC) of 31 October 2013 on the adjustments to Member States’ annual emission allocations for the period from 2013 to 2020 pursuant to Decision 406/2009/EC of the European Parliament and of the Council Adjustment to Annual Emissions Allocation for Croatia for the period from 2013 to 2020 are presented in Table 1.1-1.

Table 1.1-1: Annual Emission Allocation and its Adjustment for the period from 2013 till 2020

<table>
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<td>Annual Emission Allocation</td>
<td>21,196,005</td>
<td>21,358,410</td>
<td>21,520,815</td>
<td>21,683,221</td>
<td>21,845,626</td>
<td>22,008,031</td>
<td>22,170,436</td>
<td>22,332,841</td>
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<tr>
<td>Adjustment</td>
<td>1,582,200</td>
<td>1,553,154</td>
<td>1,524,107</td>
<td>1,495,060</td>
<td>1,466,014</td>
<td>1,436,968</td>
<td>1,407,921</td>
<td>1,378,875</td>
</tr>
<tr>
<td>Total</td>
<td>19,613,805</td>
<td>19,805,256</td>
<td>19,996,708</td>
<td>20,188,161</td>
<td>20,379,612</td>
<td>20,571,063</td>
<td>20,762,515</td>
<td>20,953,966</td>
</tr>
</tbody>
</table>

AAU for Croatia 162,271,086

Assigned amount unit for Croatia for the period from 2013 till 2020 amount 162,271,086 t CO₂-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 1.1-2 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 1.1-2: Commitment period reserve

<table>
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<tr>
<th></th>
<th>t CO₂-eq</th>
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</thead>
<tbody>
<tr>
<td>Assigned amount for second commitment period</td>
<td>162,271,086</td>
</tr>
<tr>
<td>90 % of assigned amount</td>
<td>146,043,977</td>
</tr>
<tr>
<td>Emission from last submitted inventory</td>
<td>23,502,150</td>
</tr>
<tr>
<td>100% of most recently reviewed* inventory multiplied by 8</td>
<td>183,191,024</td>
</tr>
<tr>
<td><strong>Commitment period reserve</strong></td>
<td><strong>146,043,977</strong></td>
</tr>
</tbody>
</table>

*Data from last submitted inventory is used in calculation. Because last reviewed inventory was NIR 2014, data from last submitted inventory was used to calculate CPR.
Information from national registry

Information on Kyoto Protocol units are given in the Table 1.1-3.

Table 1.1-3: Information on Kyoto Protocol units

<table>
<thead>
<tr>
<th>Reporting Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/CMP.1 annex I.E paragraph 11:</td>
<td>The Standard Electronic Format report for 2016 has been submitted to the UNFCCC Secretariat electronically.</td>
</tr>
<tr>
<td>Standard electronic format (SEF)</td>
<td></td>
</tr>
<tr>
<td>15/CMP.1 annex I.E paragraph 12:</td>
<td>No discrepant transactions occurred in 2016.</td>
</tr>
<tr>
<td>List of discrepant transactions</td>
<td></td>
</tr>
<tr>
<td>15/CMP.1 annex I.E paragraph 13 &amp; 14:</td>
<td>No CDM notifications occurred in 2016.</td>
</tr>
<tr>
<td>List of CDM notifications</td>
<td></td>
</tr>
<tr>
<td>15/CMP.1 annex I.E paragraph 15:</td>
<td>No non-replacements occurred in 2016.</td>
</tr>
<tr>
<td>List of non-replacements</td>
<td></td>
</tr>
<tr>
<td>15/CMP.1 annex I.E paragraph 16:</td>
<td>No invalid units exist as at 31 December 2016.</td>
</tr>
<tr>
<td>List of invalid units</td>
<td></td>
</tr>
<tr>
<td>15/CMP.1 annex I.E paragraph 17:</td>
<td>No actions were taken or changes made to address discrepancies for the period under review.</td>
</tr>
<tr>
<td>Actions and changes to address discrepancies</td>
<td></td>
</tr>
<tr>
<td>CPR Calculation</td>
<td>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 1.2-2).</td>
</tr>
</tbody>
</table>

There has not been any issuance, acquisition, holding, transfer, cancellation, retirement and/or carry-over of CP2 AAUs, RMUs, ERUs, CERs, tCERs and ICERs in 2016.

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 2016. 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 2015 Ministry of Environmental 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 1.1-4.

<table>
<thead>
<tr>
<th>Reporting Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact</td>
<td>Addition of national administrator team member: Mr. Dino Križnjak Senior Adviser in Climate Change Unit, Croatian Agency for the environment and nature Radnička cesta 80, 10 000 Zagreb, Croatia Phone: +385 1 5581 676 Fax: +385 1 4886 850 E-mail: <a href="mailto:dino.kriznjak@azo.hr">dino.kriznjak@azo.hr</a></td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement</td>
<td>No change of cooperation arrangement occurred during the reported period.</td>
</tr>
<tr>
<td>Reporting Item</td>
<td>Description</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(c)</td>
<td>New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality. Versions of the CSEUR released after 6.7.3 (the production version at the time of the last Chapter 14 submission) introduced other 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, including the new tables, is provided in the document Annex A, available upon request due to the confidentiality of the data. No change to the capacity of the national registry occurred during the reported period.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(d)</td>
<td>Changes introduced since version 6.7.3 of the national registry are listed in the document Annex B, available upon request due to the confidentiality of the data. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). Annex H testing was completed in January 2017 and the test report (document Annex H) is available upon request, due to the confidentiality of the data. No other change in the registry’s conformance to the technical standards occurred for the reported period.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(e)</td>
<td>No change of discrepancies procedures occurred during the reported period.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(f)</td>
<td>The mandatory use of hardware tokens for authentication and signature was introduced for registry administrators.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(g)</td>
<td>No change in the list of publicly available information with regards to confidentiality of information occurred during the reporting period.</td>
</tr>
<tr>
<td>Reporting Item</td>
<td>Description</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address</td>
<td>No change of the registry internet address occurred during the reporting period.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures</td>
<td>No change of data integrity measures occurred during the reporting period.</td>
</tr>
<tr>
<td>15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results</td>
<td>Changes introduced since version 6.7.3 of the national registry are listed in the document Annex B, available upon request due to the confidentiality of the data. 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 and the report (document Annex B) is available upon request due to the confidentiality of the data. Testing was carried out in January 2017 and the test report (document Annex H) is available upon request due to the confidentiality of the data.</td>
</tr>
<tr>
<td>1/CMP.8 paragraph 23 PPSR account</td>
<td>Previous period surplus reserve (PPSR) account will be established in the Consolidated System of European Registries (CSEUR).</td>
</tr>
</tbody>
</table>

The Annexes A, B and H 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 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 Commitee.

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

Improvement Plan is document which defines objectives related to the improvement of National Inventory. This document takes into account key category analysis and recommendations outlined in the Annual review report. This document is prepared annually.

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

<table>
<thead>
<tr>
<th>activity</th>
<th>responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of QA/QC plan</td>
<td>QA/QC coordinator (CAEN)</td>
</tr>
<tr>
<td>• Documentation revision and supplement</td>
<td></td>
</tr>
<tr>
<td>Approval of QA/QC plan</td>
<td>CAEN</td>
</tr>
<tr>
<td>Implementation of QC procedures</td>
<td>QA/QC coordinator (CAEN)</td>
</tr>
<tr>
<td>• Internal audit</td>
<td>Sectoral experts (CAEN), Project leader in NIR preparation (CAEN)</td>
</tr>
<tr>
<td>• Corrective and preventive activities</td>
<td></td>
</tr>
<tr>
<td>• Reporting on performed internal audit</td>
<td>Project Coordinator (Authorized Institution)</td>
</tr>
<tr>
<td>• QA/QC coordinator (Authorized Institution)</td>
<td></td>
</tr>
</tbody>
</table>
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 2015 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 2015 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 2016.

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.

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.
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 2014. 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. CO₂, CH₄, N₂O, HFCs, PFCs, SF₆ and NF₃. Emissions of indirect GHGs have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2013 Submission to the Convention on Long-range Transboundary Air Pollution’.

Carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) are principal greenhouse gases and though they occur naturally in the atmosphere, their recent atmospheric build-up appears to be largely the result of human activities. Synthetic gases such as halogenated hydrocarbons (PFCs, HFCs), sulphur hexafluoride (SF₆) and nitrogen trifluoride (NF₃) 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 (SO₂), as a precursor of sulphate and aerosols, is believed to exacerbate the greenhouse effect because the creation of aerosols removes heat from the environment.
Generally, methodology applied to estimate emissions includes the product of activity data (e.g. fuel consumption, cement production, wood stock increment and so forth) and associated emission factor. The use of country-specific emission factors, if available, is recommended but these cases should be based on well-documented research. Otherwise, the 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

<table>
<thead>
<tr>
<th>CRF Sector/Sub-sector</th>
<th>Type of data</th>
<th>Source of data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Registered motor vehicles database</td>
<td>Ministry of Interior</td>
</tr>
<tr>
<td></td>
<td>Fuel consumption and fuel characteristic data for thermal power plants</td>
<td>Pollution Emission Register CAEN - Verified reports of CO₂ emission - Voluntary survey of Power Utility Company</td>
</tr>
<tr>
<td></td>
<td>Fuel characteristic data</td>
<td>Voluntary survey of Oil and Gas Company</td>
</tr>
<tr>
<td></td>
<td>Natural gas processed (scrubbed), CO₂ content before scrubbing and CO₂ emission</td>
<td>Voluntary survey of Central Gas Station</td>
</tr>
<tr>
<td>Industrial Processes</td>
<td>Activity data on production/consumption of material for particular industrial process</td>
<td>CBS, Department of Manufacturing and Mining - CAEN - ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 Submission to the Convention on Long-range Transboundary Air Pollution’</td>
</tr>
</tbody>
</table>
### CRF Sector/Sub-sector

<table>
<thead>
<tr>
<th>Type of data</th>
<th>Source of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity data on production/consumption of halogenated hydrocarbons (PFCs,</td>
<td>- MEE</td>
</tr>
<tr>
<td>HFCs) and sulphur hexafluoride (SF₆)</td>
<td></td>
</tr>
<tr>
<td>Data on consumption and composition of natural gas in ammonia production</td>
<td>- Survey of ammonia manufacturer</td>
</tr>
<tr>
<td>Data on cement and lime production</td>
<td>- Survey of cement and lime manufacturers</td>
</tr>
<tr>
<td></td>
<td>- CAEN</td>
</tr>
<tr>
<td>Solvent and Other Product Use</td>
<td>‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 Submission to the Convention on Long-range Transboundary Air Pollution’</td>
</tr>
<tr>
<td>Activity data on production for particular source category and number of</td>
<td></td>
</tr>
<tr>
<td>inhabitants</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td></td>
</tr>
<tr>
<td>Livestock number</td>
<td>- CBS</td>
</tr>
<tr>
<td></td>
<td>- Croatian Agricultural Agency (CAA)</td>
</tr>
<tr>
<td>Production of N-fixing crops and non N-fixing crops</td>
<td>- CBS</td>
</tr>
<tr>
<td>Area of histosols</td>
<td>- Faculty of Agriculture</td>
</tr>
<tr>
<td>Activity data on mineral fertilisers applied in Croatia</td>
<td>- Voluntary survey of Fertilizer Companies</td>
</tr>
<tr>
<td>Activity data on sewage sludge applied</td>
<td>- Voluntary survey of Food Company</td>
</tr>
<tr>
<td>LULUCF</td>
<td></td>
</tr>
<tr>
<td>Activity data on areas of different land use categories, annual increment and</td>
<td>- Ministry of Agriculture with assistance of public company “Hrvatske šume”</td>
</tr>
<tr>
<td>annual harvest and wildfires</td>
<td>- CAEN</td>
</tr>
<tr>
<td>Activity data on crop production</td>
<td>- CBS</td>
</tr>
<tr>
<td>Waste</td>
<td></td>
</tr>
<tr>
<td>Activity data on municipal solid waste disposed to different types of SWDSs</td>
<td>- MEE</td>
</tr>
<tr>
<td></td>
<td>- CAEN</td>
</tr>
<tr>
<td>Activity data on wastewater treatment and discharge</td>
<td>- State company Croatian Water (Hrvatske vode)</td>
</tr>
<tr>
<td>Activity data on waste incineration</td>
<td>- CAEN</td>
</tr>
</tbody>
</table>

#### 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 2015

<table>
<thead>
<tr>
<th>IPCC Source Categories</th>
<th>GHG</th>
<th>Key</th>
<th>If Column C is Yes, Criteria for Identification</th>
<th>Com.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Energy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ</td>
<td>L₁ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>1.A.1 Fuel combustion - Energy Industries - Liquid Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>1.A.1 Fuel combustion - Energy Industries - Solid Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ</td>
<td>T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ</td>
<td>T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>1.A.3.b Road Transportation</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, L₂ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>1.A.3.b Road Transportation</td>
<td>N₂O</td>
<td>Yes</td>
<td>L₁ₑ</td>
<td>T₂ₑ</td>
</tr>
<tr>
<td>1.A.4 Other Sectors - Biomass</td>
<td>CH₄</td>
<td>Yes</td>
<td>T₁ₑ</td>
<td>L₁ᵢ, L₂ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>1.A.4 Other Sectors - Gaseous Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>1.A.4 Other Sectors - Liquid Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, L₂ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>1.A.4 Other Sectors - Solid Fuels</td>
<td>N₂O</td>
<td>Yes</td>
<td>T₂ₑ</td>
<td></td>
</tr>
<tr>
<td>1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil</td>
<td>CO₂</td>
<td>Yes</td>
<td>T₂ₑ</td>
<td>T₁ᵢ</td>
</tr>
<tr>
<td>1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas</td>
<td>CH₄</td>
<td>Yes</td>
<td>T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, L₂ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>2. Industrial processes and product use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.A.1 Cement Production</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ, T₁ₑ</td>
<td>L₁ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>2.B.1 Ammonia Production</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ₑ, T₁ₑ</td>
<td>L₁ᵢ, T₁</td>
</tr>
<tr>
<td>2.B.2 Nitric Acid Production</td>
<td>N₂O</td>
<td>Yes</td>
<td>L₁ₑ, T₁ᵢ</td>
<td>L₁ᵢ, T₁ᵢ</td>
</tr>
<tr>
<td>2.B.3 Petrochemical and Carbon Black Production</td>
<td>CO₂</td>
<td>Yes</td>
<td>T₁ₑ, T₂ₑ</td>
<td>T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>2.C.2 Ferroalloys Production</td>
<td>CO₂</td>
<td>Yes</td>
<td>T₁ₑ</td>
<td>T₁ᵢ</td>
</tr>
<tr>
<td>2.C.3 Aluminium Production</td>
<td>CO₂</td>
<td>Yes</td>
<td>T₁ₑ</td>
<td>T₁ᵢ</td>
</tr>
<tr>
<td>2.C.3 Aluminium Production</td>
<td>PFCs</td>
<td>Yes</td>
<td>T₁ₑ</td>
<td>T₁ᵢ</td>
</tr>
<tr>
<td>2.D Non-energy Products from Fuels and Solvent Use</td>
<td>CO₂</td>
<td>Yes</td>
<td>T₂ₑ</td>
<td>T₁ᵢ</td>
</tr>
<tr>
<td>2.F.1 Refrigeration and Air conditioning - Aggregate</td>
<td>F-gases</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, L₂ᵢ, T₁ᵢ, T₂ᵢ</td>
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<tr>
<td>3. Agriculture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.A Enteric Fermentation</td>
<td>CH₄</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, L₂ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>3.B Manure Management</td>
<td>CH₄</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ</td>
<td>L₁ᵢ, T₁ᵢ</td>
</tr>
<tr>
<td>3.B Manure Management</td>
<td>N₂O</td>
<td>Yes</td>
<td>L₁ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, T₁ᵢ</td>
</tr>
<tr>
<td>3.D.1 Indirect N₂O Emissions From Managed Soils</td>
<td>N₂O</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, L₂ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>3.D.2 Direct N₂O Emissions From Managed Soils</td>
<td>N₂O</td>
<td>Yes</td>
<td>L₁ₑ, L₂ₑ, T₁ₑ, T₂ₑ</td>
<td>L₁ᵢ, L₂ᵢ, T₁ᵢ, T₂ᵢ</td>
</tr>
<tr>
<td>4. Land use, land use change and forestry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.A.1 Forest Land Remaining Forest Land</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ᵢ, L₂ᵢ, T₁ᵢ, T₂ᵢ</td>
<td></td>
</tr>
<tr>
<td>4.A.2 Land Converted to Forest Land</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ᵢ, L₂ᵢ, L₂ᵢ, T₁ᵢ, T₂ᵢ</td>
<td></td>
</tr>
<tr>
<td>4.B.1 Cropland Remaining Cropland</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁ᵢ, L₂ᵢ, T₁ᵢ, T₂ᵢ</td>
<td></td>
</tr>
</tbody>
</table>
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 CO₂-eq emissions in 2015 was estimated at 23,502.15 Gg CO₂-eq.

The estimate of CO₂-eq emissions in 1990 was estimated at 31,153.70 Gg CO₂-eq.

Monte Carlo analysis shows that with a certainty of 95% we can say that the total simulated emissions of all categories excluding LULUCF for the year 1990 (31,548.64 Gg CO₂-eq) varies between 30,381.83 Gg CO₂-eq (2.5% percentile) and 32,804.17 Gg CO₂-eq (97.5% percentile).
Uncertainty in the trend excluding LULUCF

The Inventory trend excluding LULUCF is -24.56%, simulated trend is -24.44 % and the 95% probability range of the trend is -28.78% (2.5% percentile) to -19.73% (97.5% percentile).

Uncertainty in the emissions including LULUCF

The estimate of CO₂-emissions in 2015 was estimated at 18,517.68 Gg CO₂-eq.

The estimate of CO₂-emissions in 1990 was estimated at 24,509.98 Gg CO₂-eq.

Monte Carlo analysis shows that with a certainty of 95% we can say that the total emissions of categories for the year 2015 (22,822,29 Gg CO₂-eq) according to simulation varies between 15,995.31 Gg CO₂-eq (2.5% percentile) and 29,777.33 Gg CO₂-eq (97.5% percentile).

Monte Carlo analysis shows that with a certainty of 95% we can say that the total simulated emissions of all categories including LULUCF for the year 1990 (28,426.37 Gg CO₂-eq) varies between 22,211.47 Gg CO₂-eq (2.5% percentile) and 34,691.60 Gg CO₂-eq (97.5% percentile).

Uncertainty in the trend including LULUCF

The Inventory trend including LULUCF is -24.45%, simulated trend is -18.71% and the 95% probability range of the trend is -46.54% (2.5% percentile) to 15.05% (97.5% percentile), so the uncertainty introduced in trend varies from -22.09% to 39.49% 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 1990-2015. 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 2015, excluding removals by sinks, amounted 23,502.1 mil. t CO₂-eq (equivalent CO₂ emissions), which represents 24.6 percent emission reduction compared to GHG emission in the year 1990.

Overall decline of economic activities and energy consumption in the period 1991-1994, which was mainly the consequence of the war in Croatia, had directly caused the decline in total emissions of greenhouse gases in that period. With the entire national economy in transition process, some energy intensive industries reduced their activities or phased out certain productions (e.g. blast furnaces in Sisak, primary aluminium production in Šibenik, coke plant in Bakar), which was considerably reflected in GHG emissions reduction. Emissions have started to increase in the 1995 at an average rate of 3 percent per year, till 2008. Due to decreasing of economic activity within the period 2008-2015, emission has been reduced by 9.9 percent in 2011, 15.9 percent in 2012, 20.0 percent in 2013, 22.9 percent in 2014 and 21.4 percent in 2015 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 CO₂ 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 2015, overall emissions from industrial processes dropped by 5.1 percent, regarding 2012 and by 29.1 percent, regarding 2008.

The results of the greenhouse gas (GHG) emission calculation are presented for the period from 1990 to 2015. Total emissions/removals of GHG and their trend in sectors are given in Tables 2.1-1, 2.1-2 and in Figure 2.1-1 while the contribution of the individual gases is given in Tables 2.1-3, 2.1-4 and Figure 2.1-2.

Table 2.1-1: Emissions/removals of GHG by sectors for the every five years from 1990 to 2005 (kt CO₂ eq)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Energy</td>
<td>21,831.8</td>
<td>16,122.0</td>
<td>18,350.8</td>
<td>21,730.0</td>
</tr>
<tr>
<td>2. Industrial processes and product use</td>
<td>4,628.8</td>
<td>2,440.5</td>
<td>3,127.5</td>
<td>3,507.6</td>
</tr>
<tr>
<td>3. Agriculture</td>
<td>4,039.1</td>
<td>3,008.2</td>
<td>2,888.0</td>
<td>3,029.7</td>
</tr>
<tr>
<td>4. Land use, land-use change and forestry</td>
<td>-6,643.7</td>
<td>-9,081.0</td>
<td>-7,443.2</td>
<td>-7,728.9</td>
</tr>
<tr>
<td>5. Waste</td>
<td>654.0</td>
<td>739.5</td>
<td>889.0</td>
<td>1,045.0</td>
</tr>
<tr>
<td>6. Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Total (with LULUCF)</td>
<td>24,510.0</td>
<td>13,229.2</td>
<td>17,812.1</td>
<td>21,583.5</td>
</tr>
<tr>
<td>Total (without LULUCF)</td>
<td>31,153.7</td>
<td>22,310.2</td>
<td>25,255.3</td>
<td>29,312.4</td>
</tr>
</tbody>
</table>

Table 2.1-2: Emissions/removals of GHG by sectors for the period from 2010-2015 (kt CO₂ eq)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Energy</td>
<td>19,903.9</td>
<td>19,634.8</td>
<td>18,187.4</td>
<td>17,415.7</td>
<td>16,459.8</td>
<td>16,728.0</td>
</tr>
<tr>
<td>2. Industrial processes and product use</td>
<td>3,315.3</td>
<td>3,083.7</td>
<td>2,809.2</td>
<td>2,538.6</td>
<td>2,688.0</td>
<td>2,665.5</td>
</tr>
<tr>
<td>3. Agriculture</td>
<td>2,717.5</td>
<td>2,785.6</td>
<td>2,704.6</td>
<td>2,537.0</td>
<td>2,427.0</td>
<td>2,555.3</td>
</tr>
<tr>
<td>4. Land use, land-use change and forestry</td>
<td>-7,163.8</td>
<td>-6,161.6</td>
<td>-5,899.4</td>
<td>-6,476.2</td>
<td>-6,530.9</td>
<td>-4,984.5</td>
</tr>
<tr>
<td>5. Waste</td>
<td>1,392.4</td>
<td>1,424.6</td>
<td>1,420.7</td>
<td>1,431.3</td>
<td>1,474.1</td>
<td>1,553.3</td>
</tr>
<tr>
<td>6. Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Total (with LULUCF)</td>
<td>20,165.2</td>
<td>20,767.0</td>
<td>19,222.6</td>
<td>17,446.4</td>
<td>16,518.1</td>
<td>18,517.7</td>
</tr>
<tr>
<td>Total (without LULUCF)</td>
<td>27,329.0</td>
<td>26,928.7</td>
<td>25,121.9</td>
<td>23,922.5</td>
<td>23,049.0</td>
<td>23,502.1</td>
</tr>
</tbody>
</table>
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 71.2 percent, followed by Industrial Processes and product use with 11.3 percent, Agriculture with 10.9 percent and Waste with 6.6 percent. This structure is with minor changes consistent through all the observed period from 1990 to 2015. In the year 2015, the total GHG emissions in Croatia was 23,502.1 kt CO₂-eq excluding LULUCF sector while the total emission was 18,517.7 kt CO₂-eq including the LULUCF sector which represents removals by sink from 21.2 percent in that year.
Table 2.1-3: Emissions/removals of GHG by gases for the every five years from 1990 to 2005 (kt CO₂-eq)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ emissions without net CO₂ from LULUCF</td>
<td>23,390.1</td>
<td>16,992.8</td>
<td>19,789.1</td>
<td>23,451.8</td>
</tr>
<tr>
<td>CO₂ emissions with net CO₂ from LULUCF</td>
<td>16,713.2</td>
<td>7,866.9</td>
<td>12,147.0</td>
<td>15,643.3</td>
</tr>
<tr>
<td>CH₄ emissions without CH₄ from LULUCF</td>
<td>3,744.2</td>
<td>3,033.7</td>
<td>2,887.9</td>
<td>3,173.8</td>
</tr>
<tr>
<td>CH₄ emissions with CH₄ from LULUCF</td>
<td>3,745.4</td>
<td>3,041.2</td>
<td>2,984.8</td>
<td>3,176.5</td>
</tr>
<tr>
<td>N₂O emissions without N₂O from LULUCF</td>
<td>2,768.7</td>
<td>2,243.3</td>
<td>2,418.8</td>
<td>2,407.9</td>
</tr>
<tr>
<td>N₂O emissions with N₂O from LULUCF</td>
<td>2,800.6</td>
<td>2,280.7</td>
<td>2,520.9</td>
<td>2,484.8</td>
</tr>
<tr>
<td>HFCs</td>
<td>NO</td>
<td>29.3</td>
<td>147.9</td>
<td>265.8</td>
</tr>
<tr>
<td>PFCs</td>
<td>1,240.2</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Unspecified mix of HFCs and PFCs</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>SF₆</td>
<td>10.5</td>
<td>11.1</td>
<td>11.6</td>
<td>13.0</td>
</tr>
<tr>
<td>NF₃</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Total (without LULUCF)</td>
<td>31,153.7</td>
<td>22,310.2</td>
<td>25,255.3</td>
<td>29,312.4</td>
</tr>
<tr>
<td>Total (with LULUCF)</td>
<td>24,510.0</td>
<td>13,229.2</td>
<td>17,812.1</td>
<td>21,583.5</td>
</tr>
<tr>
<td>Total (without LULUCF, with indirect)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Total (with LULUCF, with indirect)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Table 2.1-4: Emissions/removals of GHG by gases for the for the period from 2010-2015 (kt CO₂-eq)

<table>
<thead>
<tr>
<th>GREENHOUSE GAS EMISSIONS</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ emissions without net CO₂ from LULUCF</td>
<td>21,203.7</td>
<td>20,759.4</td>
<td>19,172.4</td>
<td>18,525.4</td>
<td>17,777.1</td>
<td>17,918.7</td>
</tr>
<tr>
<td>CO₂ emissions with net CO₂ from LULUCF</td>
<td>13,952.7</td>
<td>14,481.0</td>
<td>13,122.8</td>
<td>11,961.2</td>
<td>11,160.9</td>
<td>12,829.7</td>
</tr>
<tr>
<td>CH₄ emissions without CH₄ from LULUCF</td>
<td>3,415.1</td>
<td>3,384.4</td>
<td>3,311.2</td>
<td>3,267.6</td>
<td>3,226.5</td>
<td>3,430.6</td>
</tr>
<tr>
<td>CH₄ emissions with CH₄ from LULUCF</td>
<td>3,416.8</td>
<td>3,403.1</td>
<td>3,350.1</td>
<td>3,269.5</td>
<td>3,226.8</td>
<td>3,442.0</td>
</tr>
<tr>
<td>N₂O emissions without N₂O from LULUCF</td>
<td>2,322.3</td>
<td>2,379.2</td>
<td>2,231.9</td>
<td>1,714.5</td>
<td>1,624.9</td>
<td>1,727.6</td>
</tr>
<tr>
<td>N₂O emissions with N₂O from LULUCF</td>
<td>2,407.8</td>
<td>2,477.4</td>
<td>2,343.2</td>
<td>1,800.6</td>
<td>1,709.9</td>
<td>1,820.8</td>
</tr>
<tr>
<td>HFCs</td>
<td>378.9</td>
<td>396.2</td>
<td>397.3</td>
<td>408.9</td>
<td>413.6</td>
<td>419.9</td>
</tr>
<tr>
<td>PFCs</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Unspecified mix of HFCs and PFCs</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>SF₆</td>
<td>9.0</td>
<td>9.4</td>
<td>9.2</td>
<td>6.1</td>
<td>6.8</td>
<td>5.3</td>
</tr>
<tr>
<td>NF₃</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Total (without LULUCF)</td>
<td>27,329.0</td>
<td>26,928.7</td>
<td>25,121.9</td>
<td>23,922.5</td>
<td>23,049.0</td>
<td>23,502.1</td>
</tr>
<tr>
<td>Total (with LULUCF)</td>
<td>20,165.2</td>
<td>20,767.0</td>
<td>19,222.6</td>
<td>17,446.4</td>
<td>16,518.1</td>
<td>18,517.7</td>
</tr>
<tr>
<td>Total (without LULUCF, with indirect)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Total (with LULUCF, with indirect)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
Tables 2.1-3, 2.1-4 and Figure 2.1-2 presents the contribution of the individual gases to total emissions and removals of the GHGs. The largest contribution to the GHGs emission in 2015 excluding LULUCF has CO$_2$ emission with 76.2 percent, followed by CH$_4$ with 14.6 percent, N$_2$O with 7.4 percent and HFCs, PFCs and SF$_6$ with 1.8 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 2015, the GHG emission from Energy sector was 1.6 percent higher in relation to 2014 and 23.4 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\textsubscript{2}), the energy sector accounts for about 90 percent. The contribution of energy in methane (CH\textsubscript{4}) in total CO\textsubscript{2}-eq emission is substantially smaller (8 percent) while the contribution of energy in nitrous oxide (N\textsubscript{2}O) in total CO\textsubscript{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>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Energy</td>
<td>21,831.8</td>
<td>16,122.0</td>
<td>18,350.8</td>
<td>21,730.0</td>
<td>19,903.9</td>
<td>19,634.8</td>
<td>18,187.4</td>
<td>17,415.7</td>
<td>16,459.8</td>
<td>16,728.0</td>
</tr>
<tr>
<td>A. Fuel combustion</td>
<td>20,722.4</td>
<td>14,889.9</td>
<td>17,319.5</td>
<td>20,601.1</td>
<td>18,957.8</td>
<td>18,705.3</td>
<td>17,399.6</td>
<td>16,666.9</td>
<td>15,743.1</td>
<td>16,198.8</td>
</tr>
<tr>
<td>1. Energy industries</td>
<td>7,094.3</td>
<td>5,243.2</td>
<td>5,839.4</td>
<td>6,880.9</td>
<td>5,951.1</td>
<td>6,325.2</td>
<td>5,922.3</td>
<td>5,299.8</td>
<td>4,791.0</td>
<td>4,795.4</td>
</tr>
<tr>
<td>2. Manufact. ind.</td>
<td>5,529.0</td>
<td>2,967.9</td>
<td>3,115.6</td>
<td>3,739.0</td>
<td>3,030.1</td>
<td>2,792.1</td>
<td>2,421.9</td>
<td>2,392.8</td>
<td>2,335.0</td>
<td>2,232.0</td>
</tr>
<tr>
<td>3. Transport</td>
<td>3,881.1</td>
<td>3,367.9</td>
<td>4,499.4</td>
<td>5,561.1</td>
<td>5,952.3</td>
<td>5,799.5</td>
<td>5,614.2</td>
<td>5,699.5</td>
<td>5,642.5</td>
<td>5,951.8</td>
</tr>
<tr>
<td>4. Other sectors</td>
<td>4,217.9</td>
<td>3,310.8</td>
<td>3,865.1</td>
<td>4,420.1</td>
<td>4,024.4</td>
<td>3,788.5</td>
<td>3,441.2</td>
<td>3,274.8</td>
<td>2,974.6</td>
<td>3,219.5</td>
</tr>
<tr>
<td>5. Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>B. Fugitive emissions</td>
<td>1,109.4</td>
<td>1,232.1</td>
<td>1,031.2</td>
<td>1,129.0</td>
<td>946.0</td>
<td>929.5</td>
<td>787.8</td>
<td>748.8</td>
<td>716.7</td>
<td>529.3</td>
</tr>
<tr>
<td>1. Solid fuels</td>
<td>59.6</td>
<td>28.2</td>
<td>NO,NA</td>
<td>NO,NA</td>
<td>NO,NA</td>
<td>NO,NA</td>
<td>NO,NA</td>
<td>NO,NA</td>
<td>NA,NO</td>
<td>NA,NO</td>
</tr>
<tr>
<td>2. Oil and nat. gas</td>
<td>1,049.8</td>
<td>1,203.9</td>
<td>1,031.2</td>
<td>1,129.0</td>
<td>946.0</td>
<td>929.5</td>
<td>787.8</td>
<td>748.8</td>
<td>716.7</td>
<td>529.3</td>
</tr>
<tr>
<td>C. CO\textsubscript{2} transport and storage</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

The largest part (35.6 percent in 2015) of the emissions are a consequence of fuel combustion in Transport, then the combustion in Energy industries (28.7 percent in 2015) and the combustion in small stationary energy sources, such as Commercial/ Institutional, Residential and Agriculture/ Forestry/ Fishing (19.3 percent in 2015). Manufacturing Industries and Construction contribute to total emission from Energy sector with 13.3 percent, while Fugitive Emissions from Fuels contribute with about 3.1 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 93.7 percent in total sectoral emission in
2015. 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 N₂O emissions from the nitric acid production after applying abatement technology. In 2015 emissions from industrial processes were decreased by 0.8 percent regarding 2014 and by 42.4 percent regarding 1990. Industrial processes and product use contributes to total GHG emissions with 11.3 percent in 2015. 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 1990-2015 (kt CO₂-eq)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Industrial processes and product use</td>
<td>4,628.8</td>
<td>2,440.5</td>
<td>3,127.5</td>
<td>3,507.6</td>
<td>3,315.3</td>
<td>3,083.7</td>
<td>2,809.2</td>
<td>2,538.6</td>
<td>2,688.0</td>
<td>2,665.5</td>
</tr>
<tr>
<td>A. Mineral industry</td>
<td>1,280.9</td>
<td>760.0</td>
<td>1,423.1</td>
<td>1,785.4</td>
<td>1,432.3</td>
<td>1,220.1</td>
<td>1,163.7</td>
<td>1,275.9</td>
<td>1,360.2</td>
<td>1,313.1</td>
</tr>
<tr>
<td>B. Chemical industry</td>
<td>1,531.9</td>
<td>1,454.2</td>
<td>1,421.6</td>
<td>1,305.5</td>
<td>1,362.9</td>
<td>1,327.4</td>
<td>1,131.6</td>
<td>726.6</td>
<td>800.9</td>
<td>848.8</td>
</tr>
<tr>
<td>C. Metal industry</td>
<td>1,582.7</td>
<td>39.1</td>
<td>27.3</td>
<td>11.8</td>
<td>27.6</td>
<td>29.4</td>
<td>2.0</td>
<td>16.9</td>
<td>28.6</td>
<td>13.6</td>
</tr>
<tr>
<td>D. Non-energy products</td>
<td>189.4</td>
<td>113.4</td>
<td>62.6</td>
<td>92.7</td>
<td>73.6</td>
<td>68.5</td>
<td>63.0</td>
<td>62.1</td>
<td>58.8</td>
<td>61.0</td>
</tr>
<tr>
<td>E. Electronic Industry</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>F. Product uses as ODS</td>
<td>NO</td>
<td>29.3</td>
<td>147.9</td>
<td>265.8</td>
<td>378.9</td>
<td>396.2</td>
<td>397.3</td>
<td>409.0</td>
<td>413.7</td>
<td>419.9</td>
</tr>
<tr>
<td>G. Other prod. manuf.</td>
<td>43.8</td>
<td>44.5</td>
<td>45.0</td>
<td>46.4</td>
<td>40.0</td>
<td>42.0</td>
<td>51.5</td>
<td>48.2</td>
<td>25.8</td>
<td>9.1</td>
</tr>
<tr>
<td>H. Other</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

**AGRICULTURE**

Emission of CH₄ and N₂O in the Agricultural sector is conditioned by different agricultural activities. For the emission of CH₄, the most important source is livestock farming (Enteric Fermentation) which makes 40.1 percent of sectoral CO₂-eq emission. The number of cattle showed continuous decrease in the period from 1990 to 2000. As a consequence, this led to CH₄ emission reduction. In the year 2000, the number of cattle has started increasing and this trend was mostly retained until 2006. From 2007 to 2010, cattle number decreased and remained at approximately the same level in 2013 and 2014. Compared to 2014, in 2015 CH₄ emission from Enteric fermentation increased by 5.1 percent. As for Manure management emissions, CH₄ emission increased in 2015 compared to 2014 by 6.1 percent while N₂O emission remained at approximately same levels.
Emissions from Agricultural soils decreased after 1990 and during the war due to specific national circumstances and limited agricultural practice at that time. Afterwards, the emission trend is mostly influenced by the changes in the direct soil emissions; thus, emission increase can be noticed in 1997, 2001 and 2002 due to increase in mineral fertilizer consumption and crop production, later on also due to the increase of livestock population. N₂O emission from Agricultural soils increased in 2015 compared to 2014 by 5.5 percent. Overall, in the year 2015 the GHG emission from Agriculture sector increased by 5.3 percent in comparison with 2014. 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 1990-2015 (kt CO₂-eq)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Agriculture</td>
<td>4,039.1</td>
<td>3,008.2</td>
<td>2,888.0</td>
<td>3,029.7</td>
<td>2,717.5</td>
<td>2,785.6</td>
<td>2,704.6</td>
<td>2,537.0</td>
<td>2,427.0</td>
<td>2,555.3</td>
</tr>
<tr>
<td>A. Enteric fermentation</td>
<td>1,977.6</td>
<td>1,376.7</td>
<td>1,155.0</td>
<td>1,169.5</td>
<td>1,057.1</td>
<td>1,040.7</td>
<td>1,024.3</td>
<td>996.0</td>
<td>974.9</td>
<td>1,024.4</td>
</tr>
<tr>
<td>B. Manure management</td>
<td>651.6</td>
<td>528.4</td>
<td>515.7</td>
<td>538.4</td>
<td>524.8</td>
<td>504.4</td>
<td>487.0</td>
<td>469.6</td>
<td>462.9</td>
<td>491.2</td>
</tr>
<tr>
<td>C. Rice cultivation</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>D. Agricultural soils</td>
<td>1,359.8</td>
<td>1,056.9</td>
<td>1,156.4</td>
<td>1,236.3</td>
<td>1,047.5</td>
<td>1,135.4</td>
<td>1,092.1</td>
<td>996.7</td>
<td>919.8</td>
<td>970.4</td>
</tr>
<tr>
<td>E. Presc. burning of sav.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>F. Field burning of agr. resi.</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>G. Liming</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>14.5</td>
<td>21.5</td>
<td>21.3</td>
<td>14.4</td>
<td>14.2</td>
<td>20.0</td>
<td>12.1</td>
</tr>
<tr>
<td>H. Urea application</td>
<td>50.0</td>
<td>46.3</td>
<td>60.9</td>
<td>71.0</td>
<td>66.6</td>
<td>83.9</td>
<td>86.9</td>
<td>60.4</td>
<td>49.5</td>
<td>57.2</td>
</tr>
<tr>
<td>I. Other carbon-cont. fertil.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>J. Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

**LULUCF**

The Low on Forest (Official Gazette No. 140/05, 82/06, 129/08, 80/10, 124/10, 25/12, 68/12, 148/13, 94/14) regulates the growing, protection, usage and management of forests and forest land as a natural resource aimed to maintain biodiversity and ensure management based on principles of economic sustainability, social responsibility and ecological acceptability. Moreover, one of its the most important provisions, in the context of climate protection, is that forests should be managed in conformity with the sustainable management criteria, implying the maintenance and enhancement of forest ecosystems and their contribution to the global carbon cycle. Planning activities in forestry sector in Croatia are also regulated by the Low on Forest. Forest management plans determine conditions for harmonious usage of forest and forest land and procedures in that area, necessary...
scope regarding cultivation and forest protection, possible utilization degree and conditions for wildlife management. The Forest Management Area Plan (FMAP) for the Republic of Croatia determines the ecological, economic and social background for forest improvement in terms of biology and for the increase of forest productivity.

According to Forest Management Area Plan of the Republic of Croatia (2006-2015), the forests and the forest land cover 47.5 percent of the total surface area. By its origin, approximately 95 percent of the forests in Croatia were formed by natural regeneration (according to the national definitions applied in the sector) and the 5 percent of the forests are grown artificially. The Plan determines, for 2006, growing stock of about 398 millions of 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 CO₂ removal calculation is taken from the IPCC and it is based on data on increment and fellings. The problem of deforestation in Croatia does not exist. According to present data the total forest area has not been reduced in the last 100 years.

Table 2.2-4 shows the CO₂ removal trend in the forestry sector. Removal arisen in LULUCF sector contribute with 28.5% to the total emissions of CO₂ eq in Croatia in year 2015.

Table 2.2-4: Emission trends in LULUCF sector from 1990-2015 (kt CO₂-eq)

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LULUCF removals</td>
<td>-6,643.7</td>
<td>-9,081.0</td>
<td>-7,443.2</td>
<td>-7,728.9</td>
<td>-7,163.8</td>
<td>-6,161.6</td>
<td>-5,899.4</td>
<td>-6,476.2</td>
<td>-6,530.9</td>
<td>-4,984.5</td>
</tr>
</tbody>
</table>

**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 CH₄ emission source from that sector. Generally, 80.7 percent of sectoral emissions refer to the emissions from solid waste disposal in 2015, compared to 53.3 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. 18.6 percent of sectoral emissions refer to the emissions from wastewater treatment...
and discharge in 2015, compared to 46.6 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 6.6 percent in 2015. 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 1990-2015 (kt CO2-eq)

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>A. Solid waste disposal</td>
<td>348.6</td>
<td>429.5</td>
<td>570.4</td>
<td>735.3</td>
<td>1,098.5</td>
<td>1,131.6</td>
<td>1,140.2</td>
<td>1,142.4</td>
<td>1,178.4</td>
<td>1,253.8</td>
</tr>
<tr>
<td>B. Biol. treatment of solid waste</td>
<td>NO, NE,IE</td>
<td>NO, NE,IE</td>
<td>NO, NE,IE</td>
<td>NO, NE,IE</td>
<td>1.7</td>
<td>1.7</td>
<td>3.2</td>
<td>4.9</td>
<td>4.9</td>
<td>10.6</td>
</tr>
<tr>
<td>C. Incineration of waste</td>
<td>0.54</td>
<td>0.54</td>
<td>6.26</td>
<td>0.16</td>
<td>0.05</td>
<td>0.05</td>
<td>0.08</td>
<td>0.04</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>D. Waste water treatment</td>
<td>304.9</td>
<td>309.5</td>
<td>312.4</td>
<td>309.6</td>
<td>292.2</td>
<td>291.3</td>
<td>277.2</td>
<td>284.0</td>
<td>290.8</td>
<td>288.8</td>
</tr>
<tr>
<td>E. Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>
CHAPTER 3: ENERGY (CRF SECTOR 1)

3.1. OVERVIEW OF SECTOR

For the emission calculation for the period from 1990 to 2015 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 launched. 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, 1995, 2000, 2005 and period from 2010 to 2015 is presented in the Table 3.1-1.

Table 3.1-1: Primary energy production

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal and coke</td>
<td>4.21</td>
<td>1.96</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Fuel wood</td>
<td>45.77</td>
<td>46.54</td>
<td>41.97</td>
<td>52.27</td>
<td>56.20</td>
<td>59.01</td>
<td>60.39</td>
<td>61.45</td>
<td>57.67</td>
<td>64.19</td>
</tr>
<tr>
<td>Crude oil</td>
<td>104.54</td>
<td>62.81</td>
<td>51.35</td>
<td>40.11</td>
<td>30.69</td>
<td>28.37</td>
<td>25.62</td>
<td>25.71</td>
<td>25.38</td>
<td>28.62</td>
</tr>
<tr>
<td>Natural gas</td>
<td>74.27</td>
<td>69.12</td>
<td>59.40</td>
<td>79.76</td>
<td>93.88</td>
<td>85.02</td>
<td>69.19</td>
<td>63.11</td>
<td>60.52</td>
<td>61.61</td>
</tr>
<tr>
<td>Hydro power</td>
<td>40.08</td>
<td>55.86</td>
<td>62.53</td>
<td>69.20</td>
<td>87.24</td>
<td>47.58</td>
<td>47.32</td>
<td>84.92</td>
<td>88.99</td>
<td>61.63</td>
</tr>
<tr>
<td>Heat</td>
<td>0.22</td>
<td>0.63</td>
<td>0.61</td>
<td>0.62</td>
<td>0.63</td>
<td>0.53</td>
<td>0.64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renewables</td>
<td>0.20</td>
<td>2.63</td>
<td>2.97</td>
<td>5.66</td>
<td>7.70</td>
<td>10.69</td>
<td>11.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>268.88</td>
<td>236.30</td>
<td>215.25</td>
<td>241.77</td>
<td>271.26</td>
<td>223.56</td>
<td>208.80</td>
<td>243.52</td>
<td>243.77</td>
<td>227.75</td>
</tr>
</tbody>
</table>

Figure 3.1-1 presents the trends in the primary energy production from 1990 to 2015.
In 1990 primary energy production was about 268.9 PJ, which is 15.3% higher comparing to 2015. In 2015, the total primary energy production decreased by 6.6% with relation to the 2014. Comparing to 2014, the energy production from renewable sources increased by 3.4% in 2015. The production of natural gas increased 1.8% as well as production of crude (12.8%) and fuel wood (11.3%). Hydro power utilization decreased by 30.7%.

While in 1990 the share of crude oil in primary energy production was the highest one with 38.9%, in 2015 its’ share was only 12.6%. In 2015, the share of fuel wood (28.2%) was the highest one. It was followed by hydro power with the share of 27.1%. The comparison of shares in primary energy productions for the 1990 and 2015 are presented in Figure 3.1-2.
Figure 3.1-2: Shares of individual energy forms in the total production for the 1990 and 2015

**Primary energy supply**

Total primary energy supply is determined by adding the import and subtracting the export of all primary and transformed energy forms to the total primary energy supply. Primary energy supply for the 1990, 1995, 2000, 2005 and period from 2010 to 2015 is presented in the Table 3.1-2.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal and coke</td>
<td>34.07</td>
<td>7.42</td>
<td>17.15</td>
<td>32.95</td>
<td>30.92</td>
<td>31.66</td>
<td>28.37</td>
<td>32.18</td>
<td>31.59</td>
<td>29.86</td>
</tr>
<tr>
<td>Fuel wood</td>
<td>45.77</td>
<td>46.54</td>
<td>41.97</td>
<td>52.27</td>
<td>52.29</td>
<td>51.50</td>
<td>52.10</td>
<td>51.67</td>
<td>45.82</td>
<td>52.59</td>
</tr>
<tr>
<td>Liquid fuels</td>
<td>188.57</td>
<td>146.03</td>
<td>160.52</td>
<td>181.88</td>
<td>152.54</td>
<td>149.30</td>
<td>134.17</td>
<td>128.37</td>
<td>125.80</td>
<td>130.92</td>
</tr>
<tr>
<td>Natural gas</td>
<td>98.22</td>
<td>82.77</td>
<td>94.98</td>
<td>101.06</td>
<td>111.37</td>
<td>108.60</td>
<td>101.78</td>
<td>95.54</td>
<td>84.62</td>
<td>87.16</td>
</tr>
<tr>
<td>Hydro power</td>
<td>40.08</td>
<td>55.86</td>
<td>62.53</td>
<td>69.20</td>
<td>87.24</td>
<td>47.58</td>
<td>47.32</td>
<td>84.92</td>
<td>88.99</td>
<td>61.63</td>
</tr>
<tr>
<td>Heat</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.22</td>
<td>0.63</td>
<td>0.61</td>
<td>0.62</td>
<td>0.63</td>
<td>0.53</td>
<td>0.64</td>
</tr>
<tr>
<td>Renewables</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.20</td>
<td>2.24</td>
<td>2.83</td>
<td>5.72</td>
<td>7.80</td>
<td>10.64</td>
<td>11.44</td>
</tr>
<tr>
<td>Total</td>
<td>430.81</td>
<td>349.71</td>
<td>389.46</td>
<td>453.66</td>
<td>451.50</td>
<td>417.84</td>
<td>396.84</td>
<td>415.04</td>
<td>402.22</td>
<td>398.68</td>
</tr>
</tbody>
</table>

Figure 3.1-3 presents the trends in the primary energy supply from 1990 to 2015.
In 1990 primary energy supply was about 430.8 PJ, which is 7.5% higher comparing to 2015. In 2015, the total primary energy supply decreased by 0.9% with relation to the previous year. There was an increase in renewable energy sources and hydro power while consumption of natural gas, liquid fuels and coal and coke decreased. Due to poor hydrology conditions, hydro power energy supply decreased by 30.7% with relation to the 2014. Figure 3.1-4 presents comparison of the shares of individual energy forms in the total primary energy supply for the 1990 and 2015.
Liquid fuels had the largest share in total primary energy supply in 1990 as well as in 2015 (43.8% in 1990 and 32.8% in 2015). 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.

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 2015 amounted 57.1%. 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 2015 is presented in Annex 4. For easier comparison of data from energy balance the natural units are transformed to energy units using appropriate national net calorific values (Table 3.1-3).

Table 3.1-3: National net calorific values, CO2 emission factors and oxidation factors for 2015

<table>
<thead>
<tr>
<th>Fuel</th>
<th>DOV</th>
<th>2015</th>
<th>CO2 Emission factor (t CO2/TJ)</th>
<th>Oxidation factor (OF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorni benzin</td>
<td>Motor Gasoline</td>
<td>GJ/t</td>
<td>44.5900</td>
<td>69.30</td>
</tr>
<tr>
<td>Aviobenzin</td>
<td>Aviation Gasoline</td>
<td>GJ/t</td>
<td>44.5900</td>
<td>70.00</td>
</tr>
<tr>
<td>Kerozin (Mlazno gorivo)</td>
<td>Jet Kerosene</td>
<td>GJ/t</td>
<td>43.9600</td>
<td>71.50</td>
</tr>
<tr>
<td>Dizel i ekstra lako loživo ulje (plinsko ulje)</td>
<td>Gas/Diesel Oil</td>
<td>GJ/t</td>
<td>42.7100</td>
<td>74.10</td>
</tr>
<tr>
<td>Loživo ulje i srednje loživo ulje</td>
<td>Residual Fuel Oil</td>
<td>GJ/t</td>
<td>40.1900</td>
<td>77.40</td>
</tr>
<tr>
<td>Ukapljeni naftni plin</td>
<td>Liquefield Petroleum Gases</td>
<td>GJ/t</td>
<td>46.8900</td>
<td>63.10</td>
</tr>
<tr>
<td>Maziva</td>
<td>Lubricants</td>
<td>GJ/t</td>
<td>33.5000</td>
<td>73.30</td>
</tr>
<tr>
<td>Naftni koks</td>
<td>Petroleum Coke</td>
<td>GJ/t</td>
<td>31.0000</td>
<td>97.50</td>
</tr>
<tr>
<td>Petroleum</td>
<td>Petroleum</td>
<td>GJ/t</td>
<td>43.9600</td>
<td>73.30</td>
</tr>
<tr>
<td>Antracit</td>
<td>Anthracite</td>
<td>GJ/t</td>
<td>29.3100</td>
<td>98.50</td>
</tr>
<tr>
<td><em>Kameni ugljen-Industrija</em></td>
<td>Other bituminous coal</td>
<td>GJ/t</td>
<td>26.7000</td>
<td>94.60</td>
</tr>
<tr>
<td><em>Kameni ugljen-Termoelektrane</em></td>
<td>Other bituminous coal</td>
<td>GJ/t</td>
<td>25.0000</td>
<td>94.60</td>
</tr>
<tr>
<td>Ugljen za proizvodnju koks (koksnog ugljena)</td>
<td>Coking coal</td>
<td>GJ/t</td>
<td>28.2000</td>
<td>94.60</td>
</tr>
<tr>
<td>Mrki ugljen (smesi ugljena) <em>Industrija</em></td>
<td>Sub bituminous coal</td>
<td>GJ/t</td>
<td>17.0000</td>
<td>96.10</td>
</tr>
<tr>
<td>Lignit</td>
<td>Lignite</td>
<td>GJ/t</td>
<td>10.5000</td>
<td>101.00</td>
</tr>
<tr>
<td>Briketi kamenog ugljena</td>
<td>Brown coal briquettes</td>
<td>GJ/t</td>
<td>20.7000</td>
<td>97.50</td>
</tr>
<tr>
<td>Koks</td>
<td>Coke oven coke</td>
<td>GJ/t</td>
<td>29.3100</td>
<td>107.00</td>
</tr>
<tr>
<td>Prirodni plin</td>
<td>Natural Gas</td>
<td>GJ/10³m³</td>
<td>34.6000</td>
<td>56.10</td>
</tr>
<tr>
<td>Gradski plin</td>
<td>Gas Works Gas</td>
<td>GJ/10³m³</td>
<td>17.1000</td>
<td>44.40</td>
</tr>
<tr>
<td>Koksni plin</td>
<td>Coke Oven Gas</td>
<td>GJ/10³m³</td>
<td>38.7000</td>
<td>44.40</td>
</tr>
<tr>
<td>Rafinerijski plin</td>
<td>Refinery Gas</td>
<td>GJ/t</td>
<td>42.6000</td>
<td>57.60</td>
</tr>
</tbody>
</table>

The structure of energy consumption of fossil fuels from 1990 to 2015 is shown in Figure 3.1-6.
Liquid fossil fuels are mainly used with share between 50 to 65 percent, and natural gas with approximately 30 percent, while share of solid fossil fuels is between 3 to 11 percent. Fuel woods and biomass-based fuels are neutral regarding CO₂ emission, therefore are not shown in the Figure 3.1-6.

### 3.1.2. Overview of emissions

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

The Energy sector is the main cause for anthropogenic emission of greenhouse gases. It accounts approximately 75 percent of the total emission of all greenhouse gases presented as equivalent emission of CO₂. Looking at its contribution to total emission of carbon dioxide (CO₂), the energy sector accounts for about 90 percent. The contribution of energy in methane (CH₄) emission is substantially smaller (8 percent) while the contribution of energy in nitrous oxide (N₂O) emission is quite small (about 2 percent).

During complete combustion, the carbon contained in fuel oxidizes and transforms into CO₂, while through the incomplete combustion the small amounts of CH₄, CO and NMVOC emissions also appear. The CO₂ is the most important greenhouse gas from fuel combustion. The emission of CO₂ depends on the quantity and type of the fuel used. The specific emission is the highest during
combustion of coal, then oil and natural gas. A rough ratio of specific emission during combustion of the stated fossil fuels is $1 : 0.75 : 0.55$ (coal : oil : gas).

There are some other gases generated from fuel combustion such as methane ($\text{CH}_4$) and nitrous oxide ($\text{N}_2\text{O}$), 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 ($\text{SO}_2$) 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 $\text{CH}_4$, and smaller quantities of $\text{CO}_2$ and $\text{N}_2\text{O}$, 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 (2015), is presented in the Table 3.1-4 while contribution of individual subsectors to GHG emission for the period 1990-2015 is presented in Figure 3.1-7.
Table 3.1-4: Contribution of individual subsectors to emission of greenhouse gases, for 2015

<table>
<thead>
<tr>
<th>GHG categories</th>
<th>kt</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO₂</td>
<td>CH₄</td>
<td>N₂O</td>
</tr>
<tr>
<td><strong>ENERGY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Fuel combustion activities</td>
<td>15924.56</td>
<td>595.07</td>
<td>208.40</td>
</tr>
<tr>
<td>1. Energy industries</td>
<td>15597.65</td>
<td>392.91</td>
<td>208.21</td>
</tr>
<tr>
<td>a) Electricity and heat production</td>
<td>3148.82</td>
<td>3.22</td>
<td>17.64</td>
</tr>
<tr>
<td>b) Petroleum refining</td>
<td>1387.39</td>
<td>0.81</td>
<td>1.85</td>
</tr>
<tr>
<td>c) Manufacture of solid fuels</td>
<td>235.45</td>
<td>0.11</td>
<td>0.13</td>
</tr>
<tr>
<td>2. Manufacturing ind. and constr.</td>
<td>2222.70</td>
<td>3.33</td>
<td>5.98</td>
</tr>
<tr>
<td>3. Transport</td>
<td>5883.52</td>
<td>12.41</td>
<td>55.89</td>
</tr>
<tr>
<td>a) Civil aviation</td>
<td>30.80</td>
<td>0.01</td>
<td>0.26</td>
</tr>
<tr>
<td>b) Road transport</td>
<td>5666.95</td>
<td>12.03</td>
<td>48.22</td>
</tr>
<tr>
<td>c) Railways</td>
<td>55.38</td>
<td>0.06</td>
<td>6.37</td>
</tr>
<tr>
<td>d) Navigation (domestic)</td>
<td>130.39</td>
<td>0.31</td>
<td>1.05</td>
</tr>
<tr>
<td>4. Other sectors</td>
<td>2719.76</td>
<td>373.03</td>
<td>126.72</td>
</tr>
<tr>
<td>5. Other</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>B. Fugitive emissions from fuels</td>
<td>326.91</td>
<td>202.17</td>
<td>0.19</td>
</tr>
<tr>
<td>1. Solid fuels</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2. Oil and natural gas</td>
<td>326.91</td>
<td>202.17</td>
<td>0.19</td>
</tr>
<tr>
<td>C. CO₂ transport and storage</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

Figure 3.1-7: CO₂ eq emissions from Energy sector by subsectors in 1990-2015

The largest part (35.6 percent) of the emissions are a consequence of fuel combustion in Transport, then the combustion in Energy industries (28.7 percent in 2015) and the combustion in
small stationary energy sources, such as Commercial/Institutional, Residential and Agriculture/Forestry/Fishing (19.3 percent in 2015). Manufacturing Industries and Construction contribute to total emission from Energy sector with 13.3 percent, while Fugitive Emissions from Fuels contribute with about 3.1 percent. The majority of energy-related GHG emissions belong to CO₂ (91 to 93 percent), then follows CH₄ (6 to 9 percent) and N₂O (less than 1 percent).

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

The emission from fuel combustion in international air and waterborne transport is reported separately and it has not been included in the national emission totals.

**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 2015

<table>
<thead>
<tr>
<th>IPCC Source Categories</th>
<th>GHG</th>
<th>Key</th>
<th>If Column C is Yes, Criteria for Identification</th>
<th>Com.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1 and Tier 2 Analysis - Source Analysis Summary (Croatian Inventory, 2017)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L1e, L2e</td>
<td>T1e</td>
</tr>
<tr>
<td>1.A.1 Fuel combustion - Energy Industries - Liquid Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L1e, L2e</td>
<td>T1e, T2e</td>
</tr>
<tr>
<td>1.A.1 Fuel combustion - Energy Industries - Solid Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L1e, L2e</td>
<td>T1e, T2e</td>
</tr>
<tr>
<td>1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L1e</td>
<td>T1e, T2e</td>
</tr>
<tr>
<td>1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L1e, L2e</td>
<td>T1e, T2e</td>
</tr>
<tr>
<td>1.A.3.b Road Transportation</td>
<td>CO₂</td>
<td>Yes</td>
<td>L1e, L2e</td>
<td>T1e, T2e</td>
</tr>
<tr>
<td>1.A.4 Other Sectors - Biomass</td>
<td>CH₄</td>
<td>Yes</td>
<td>L1e, L2e</td>
<td>T1e, T2e</td>
</tr>
<tr>
<td>1.A.4 Other Sectors - Gaseous Fuels</td>
<td>N₂O</td>
<td>Yes</td>
<td>L2e</td>
<td>T1e, T2e</td>
</tr>
<tr>
<td>1.A.4 Other Sectors - Liquid Fuels</td>
<td>CO₂</td>
<td>Yes</td>
<td>L1e, L2e</td>
<td>T1e, T2e</td>
</tr>
<tr>
<td>1.A.4 Other Sectors - Solid Fuels</td>
<td>N₂O</td>
<td>Yes</td>
<td>L2e</td>
<td>T1e, T2e</td>
</tr>
<tr>
<td>1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil</td>
<td>CO₂</td>
<td>Yes</td>
<td>T1e, T2e</td>
<td></td>
</tr>
<tr>
<td>1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil</td>
<td>CH₄</td>
<td>Yes</td>
<td>T1e, T2e</td>
<td></td>
</tr>
<tr>
<td>1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas</td>
<td>CH₄</td>
<td>Yes</td>
<td>T1e, T2e</td>
<td></td>
</tr>
<tr>
<td>Ozone precursors and SO₂ emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The emissions of indirect greenhouse gases (NOₓ, CO and NMVOC) and SO₂ are described in this chapter. Ozone precursors are cause of greenhouse gas - tropospheric ozone, whereas SO₂ was added to a list of pollutants first time in Revised 1996 IPCC Guidelines for National GHG Inventories due to the importance of this gas from the position of acidification and eutrophication. Emissions of indirect GHGs for whole time period, from 1990 to 2015 was set up according to the EMEP/CORINAIR methodology. Emissions were obtained from the emission inventory report ‘Republic of Croatia Informative Inventory Report for 2015, 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\textsubscript{X} emissions**

The NO\textsubscript{X} emission encompasses nitrogen monoxide and nitrogen dioxide emissions. The emissions are expressed as equivalents of NO\textsubscript{2}. NO\textsubscript{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\textsubscript{X} takes part in ground ozone formation.

The emission of NO\textsubscript{X} from Energy sector (Fuel Combustion Activities) in 2015 was 49.4 kt which is 0.05 percent higher than the year before and 38.8 percent lower compared to 1990. The NO\textsubscript{X} emissions from Energy sector contribute with approximately 95 percent to national total NO\textsubscript{X} emission. The structure of NO\textsubscript{X} emission in Energy sector has not changed significantly in the period from 1990 to 2015 (Figure 3.1-8). The main source of NO\textsubscript{X} emission is transport (51.2 percent of total emission in energy sector in 2015). Other sectors accounted for 19.7 percent and emission from industry sector accounted for 14.9 percent to the energy sector in 2015.

Figure 3.1-8: NO\textsubscript{X} emissions from Energy sector in the period 1990-2015

**CO emissions**

In 2015, the emission of CO from Fuel Combustion Activities was 194.6 kt which is 8.4 percent higher than in the year before and 56.2 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 2015 contribute with approximately 90 percent to national total CO emission. 73.0 percent of CO emission in Energy sector in 2015 was the result of incomplete fossil fuel combustion in Commercial and Residential sector and 19.7 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 1990-2015

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 25.8 kt in 2015 which was 6.8 percent higher than the year before and 53.7 percent lower than 1990.

The structure of NMVOC emission from Energy sector has not changed significantly in the period from 1990 to 2015 (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 (71.5 percent).
Figure 3.1-10: NMVOC emissions from Energy sector in the period 1990-2015

**SO₂ emissions**

In accordance with the calculated results, the level of SO₂ emission from Fuel Combustion Activities in 2015 reached 11.5 kt which is approximately 91 percent of total national SO₂ emission. The trend shows that emissions of SO₂ have increased by 13.4 percent compared to the emission in 2014 and decreased by 91.2 percent since 1990. Since 1990, SO₂ emission has the overall decreasing trend due to consumption of fossil fuel with lower sulphur content. The outstanding high level of SO₂ emission in 1990 is a result of fossil fuel consumption with high sulphur content in Energy Industries and Manufacturing Industries and Construction sectors. In years ahead, emissions from these two sectors were reduced by 50%. During the period from 1990 to 2015, the decrease of SO₂ emissions was achieved in almost all sectors and the greatest decrease of SO₂ emission was in Energy Industries sector. Emission trend for SO₂ in the period of 1990 to 2015 as well as the share of the particular sectors in total emission of SO₂ in Energy sector 1990 and 2015 is presented in Figure 3.1-11.
Figure 3.1-11: SO₂ emissions from Energy sector in the period 1990-2015

- Energy industries
- Industry
- Transport
- Other sectors
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\textsubscript{2} emissions follows the 2006 IPCC Guidelines. The emission of CO\textsubscript{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\textsubscript{2} emissions for chosen years are given in Table 3.2-1.

Table 3.2-1: The fuel consumption and CO\textsubscript{2} emissions from fuel combustion (Reference & Sectoral approach)

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref. appr. Fuel consumption (PJ)</td>
<td>286.9</td>
<td>208.4</td>
<td>235.5</td>
<td>280.1</td>
<td>262.6</td>
<td>257.9</td>
<td>243.2</td>
<td>228.4</td>
<td>215.3</td>
<td>220.1</td>
</tr>
<tr>
<td>Sect. appr. Fuel consumption (PJ)</td>
<td>284.1</td>
<td>207.0</td>
<td>240.0</td>
<td>281.8</td>
<td>262.8</td>
<td>260.4</td>
<td>242.4</td>
<td>229.5</td>
<td>216.1</td>
<td>221.7</td>
</tr>
<tr>
<td>Rel. Diff. (%)</td>
<td>0.96</td>
<td>0.65</td>
<td>-1.90</td>
<td>-0.58</td>
<td>-0.08</td>
<td>-0.97</td>
<td>0.33</td>
<td>-0.51</td>
<td>-0.36</td>
<td>-0.72</td>
</tr>
<tr>
<td>Ref. appr. CO\textsubscript{2} emission (kt)</td>
<td>20187.5</td>
<td>14548.4</td>
<td>16630.3</td>
<td>20020.7</td>
<td>18454.0</td>
<td>18249.6</td>
<td>16718.5</td>
<td>16140.1</td>
<td>15301.1</td>
<td>15709.9</td>
</tr>
<tr>
<td>Sect. appr. CO\textsubscript{2} emission (kt)</td>
<td>20078.9</td>
<td>14331.1</td>
<td>16692.6</td>
<td>19942.8</td>
<td>18312.0</td>
<td>18084.5</td>
<td>16791.3</td>
<td>16066.1</td>
<td>15200.3</td>
<td>15597.7</td>
</tr>
<tr>
<td>Rel. Diff. (%)</td>
<td>0.54</td>
<td>1.52</td>
<td>-0.37</td>
<td>0.39</td>
<td>0.78</td>
<td>0.91</td>
<td>-0.43</td>
<td>0.46</td>
<td>0.66</td>
<td>0.72</td>
</tr>
</tbody>
</table>

The CO\textsubscript{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\textsubscript{2} emissions from liquid fuels combustion (Reference & Sectoral approach)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref. appr. Liquid fuel consumption (PJ)</td>
<td>181.5</td>
<td>144.4</td>
<td>147.9</td>
<td>172.0</td>
<td>142.9</td>
<td>140.5</td>
<td>134.0</td>
<td>122.2</td>
<td>120.5</td>
<td>125.8</td>
</tr>
<tr>
<td>Sect. appr. Liquid fuel consumption (PJ)</td>
<td>179.2</td>
<td>142.6</td>
<td>152.5</td>
<td>173.2</td>
<td>143.0</td>
<td>142.9</td>
<td>133.1</td>
<td>123.2</td>
<td>122.5</td>
<td>127.4</td>
</tr>
<tr>
<td>Rel. Diff. (%)</td>
<td>1.31</td>
<td>1.28</td>
<td>-2.98</td>
<td>-0.70</td>
<td>-0.02</td>
<td>-1.68</td>
<td>0.67</td>
<td>-0.82</td>
<td>-1.63</td>
<td>-1.25</td>
</tr>
<tr>
<td>Ref. appr. CO\textsubscript{2} emission (kt)</td>
<td>13080.7</td>
<td>10646.4</td>
<td>10984.3</td>
<td>12840.7</td>
<td>10593.6</td>
<td>10501.7</td>
<td>9539.3</td>
<td>9055.6</td>
<td>8956.6</td>
<td>9404.9</td>
</tr>
<tr>
<td>Sect. appr. CO\textsubscript{2} emission (kt)</td>
<td>12989.3</td>
<td>10401.9</td>
<td>11062.3</td>
<td>12743.1</td>
<td>10443.8</td>
<td>10331.0</td>
<td>9607.8</td>
<td>8973.8</td>
<td>8858.3</td>
<td>9290.6</td>
</tr>
<tr>
<td>Rel. Diff. (%)</td>
<td>0.70</td>
<td>2.35</td>
<td>-0.70</td>
<td>0.77</td>
<td>1.43</td>
<td>1.65</td>
<td>-0.71</td>
<td>0.91</td>
<td>1.11</td>
<td>1.23</td>
</tr>
</tbody>
</table>
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.

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 2015 consumption of solid fuel and CO₂ emission are the same for both approaches while consumption of gaseous fuels is higher in sectoral approach for -0.07% due to consumption of gas works gas in sectoral approach while in reference approach is not accounted.

**Comparison of Croatian balance with IEA balance**

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

Production of liquid fuels in Croatian balance is systematically lower by 4-20 per cent because - there is methodology differences in presenting total consumption of crude oil by IEA and Croatian energy balance. According to IEA only production of LPG, ethane and pentane (natural gas liquids) are reported as products of NGL plant. In Croatian energy balance except output of NGL plant, input of natural gas and gas condensate are noted too.

Imports of sub-bituminous coal and lignite reported in Croatian energy balance appear to all be classified as lignite in the IEA data. In Croatian energy balance there is balance of bituminous coal, balance of hard coal and balance of lignite. Today, all amounts are from the import, while in past smaller production of solid fuels existed in Croatia. In IEA methodology, balance of hard coal and lignite are presented together as lignite.
3.2.2. International bunker fuels

The CO$_2$ emissions from the consumption of fossil fuels for aviation and marine international transport activities, as required by the IPCC methodology, are reported separately and not included in national emission totals. The fuel consumption (PJ) and CO$_2$-eq emissions for International Aviation and Marine Bunkers are shown in the Table 3.2-3.

Table 3.2-3: Fuel consumption and CO$_2$-eq emissions for International aviation and marine bunkers, from 1990 to 2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Aviation bunkers (TJ)</th>
<th>Marine bunkers (TJ)</th>
<th>Total bunkers (TJ)</th>
<th>CO$_2$-eq emissions (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>6,945.7</td>
<td>1,936.8</td>
<td>8,882.5</td>
<td>498.4</td>
</tr>
<tr>
<td>1995</td>
<td>3,428.9</td>
<td>1,356.8</td>
<td>4,785.7</td>
<td>246.0</td>
</tr>
<tr>
<td>2000</td>
<td>2,813.4</td>
<td>757.4</td>
<td>3,570.8</td>
<td>201.9</td>
</tr>
<tr>
<td>2005</td>
<td>3,604.7</td>
<td>1,047.8</td>
<td>4,652.5</td>
<td>258.7</td>
</tr>
<tr>
<td>2010</td>
<td>4,132.2</td>
<td>255.0</td>
<td>4,387.2</td>
<td>296.5</td>
</tr>
<tr>
<td>2011</td>
<td>4,352.0</td>
<td>983.9</td>
<td>5,335.9</td>
<td>312.3</td>
</tr>
<tr>
<td>2012</td>
<td>4,615.8</td>
<td>NO</td>
<td>5,055.4</td>
<td>331.2</td>
</tr>
<tr>
<td>2013</td>
<td>5,077.4</td>
<td>NO</td>
<td>5,077.4</td>
<td>367.8</td>
</tr>
<tr>
<td>2014</td>
<td>4,884.0</td>
<td>NO</td>
<td>4,956.1</td>
<td>369.7</td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
<td>355.7</td>
</tr>
</tbody>
</table>

Total CO$_2$-eq from the international bunker in 2015 amounted to 361.1 kt which is 2.3% lower than in 2014 as a result of lower fuel consumption in the Aviation bunkers.

Marine bunkers

International marine bunkers are included in national energy balance for the period from 1994 to 2015, 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

<table>
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<td>GASDIES</td>
<td>BUNKERS</td>
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<td>14</td>
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<td>12</td>
<td>7</td>
<td>12</td>
<td>14</td>
<td>7</td>
<td>12</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>HR balance</td>
<td></td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>13.6</td>
<td>13.7</td>
<td>13.2</td>
<td>6.9</td>
<td>12.2</td>
<td>13.6</td>
<td>7.1</td>
<td></td>
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<tr>
<td>difference</td>
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<td></td>
<td>-19.0</td>
<td>0.0</td>
<td>0.0</td>
<td>-0.4</td>
<td>-0.3</td>
<td>1.2</td>
<td>-0.1</td>
<td>0.2</td>
<td>-0.4</td>
<td>0.1</td>
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<tr>
<td>BALANCE</td>
<td>RESFUEL</td>
<td>BUNKERS</td>
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<td>28</td>
<td>31</td>
<td>19</td>
<td>17</td>
<td>17</td>
<td>14</td>
<td>14</td>
<td>8</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR balance</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>31.1</td>
<td>19.2</td>
<td>23.9</td>
<td>16.9</td>
<td>13.9</td>
<td>7.5</td>
<td>11.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>difference</td>
<td></td>
<td></td>
<td>-28.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
<td>6.9</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.5</td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 launched. 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 CO₂ 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>
<thead>
<tr>
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<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Electricity and Heat Production</td>
<td>3,768.2</td>
<td>3,028.8</td>
<td>3,840.0</td>
<td>4,794.5</td>
<td>4,037.0</td>
<td>4,217.5</td>
<td>3,851.2</td>
<td>3,673.0</td>
<td>3,094.2</td>
<td>3,169.7</td>
</tr>
<tr>
<td>Petroleum Refining</td>
<td>2,451.9</td>
<td>1,817.7</td>
<td>1,704.3</td>
<td>1,733.8</td>
<td>1,452.7</td>
<td>1,809.3</td>
<td>1,852.7</td>
<td>1,397.3</td>
<td>1,518.7</td>
<td>1,390.1</td>
</tr>
<tr>
<td>Other Energy Industries</td>
<td>874.2</td>
<td>396.7</td>
<td>295.0</td>
<td>352.5</td>
<td>461.5</td>
<td>298.4</td>
<td>218.4</td>
<td>229.5</td>
<td>178.2</td>
<td>235.7</td>
</tr>
<tr>
<td>Total Energy Industries</td>
<td>7,094.3</td>
<td>5,243.2</td>
<td>5,839.4</td>
<td>6,880.9</td>
<td>5,951.1</td>
<td>6,325.2</td>
<td>5,922.3</td>
<td>5,299.8</td>
<td>4,791.0</td>
<td>4,795.4</td>
</tr>
</tbody>
</table>
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 4,107.5 MW (including TPP Plomin and excluding NPP Krško). Total capacities serving the needs of the Croatian electric power system amount to 4,455.5 MW (with 50% of Krško capacities). Out of this amount, 1,906 MW is placed in thermal power plant, 2,220.5 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

<table>
<thead>
<tr>
<th></th>
<th>Available Power (MW)</th>
<th>Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Net Output</td>
<td></td>
</tr>
<tr>
<td>HPPs</td>
<td>2,201.5</td>
<td>-</td>
</tr>
<tr>
<td>NPP Krško*</td>
<td>348.00</td>
<td>uranium oxide (UO₂)</td>
</tr>
<tr>
<td>TPP Plomin 1</td>
<td>105.00</td>
<td>coal</td>
</tr>
<tr>
<td>TPP Plomin 2**</td>
<td>192.00</td>
<td>coal</td>
</tr>
<tr>
<td>TPP Rijeka</td>
<td>303.00</td>
<td>fuel oil</td>
</tr>
<tr>
<td>TPP Sisak</td>
<td>631.00</td>
<td>fuel oil / natural gas</td>
</tr>
<tr>
<td>CHP Zagreb (east)</td>
<td>422.00</td>
<td>fuel oil / natural gas / extra light oil</td>
</tr>
<tr>
<td>CHP Zagreb (west)</td>
<td>89.00</td>
<td>fuel oil / natural gas / extra light oil</td>
</tr>
<tr>
<td>CPP Osijek</td>
<td>90.00</td>
<td>fuel oil / natural gas / extra light oil</td>
</tr>
<tr>
<td>CCGT Jertovec</td>
<td>74.00</td>
<td>natural gas / extra light oil</td>
</tr>
<tr>
<td>Total (HPPs+NPP+TPPs)</td>
<td>4,455.50</td>
<td></td>
</tr>
</tbody>
</table>

* 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 2015 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 2015, the import of electricity was about 50 percent of total electricity consumption in Croatia. Electricity supply for the period from 1990 to 2015 is presented in Figure 3.2-2.
In this subsector there are few types of plants:

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

TPP Plomin 2, which started to operate in 2002, has installation for flue gasses cleaning. By-product from process which cleans flue gasses from sulphur (SO$_2$ scrubbing process) is CO$_2$. CO$_2$ emission is calculated from amount of CaCO$_3$ used for cleaning. Amounts of produced CaCO$_3$ as well as emitted CO$_2$ emission are presented in Industry sector (Limestone and dolomite use).

The CO$_2$-eq emission from public electricity and heat production are presented in Figure 3.2-3 for the whole period from 1990 to 2015.
Production of electricity has increasing trend through the years, from 8 TWh (1990) to 13 TWh (2010) but CO₂ emission does not follow this trend. Approximately 53 percent of electricity is generated in hydro power plants (HPP), but this percent depends on hydrological conditions during the year. If hydrological conditions are unfavorable the lack of electricity must be supplemented by stronger engagement of thermal power plants, which consequently leads to large GHG emissions. Domestic production of electricity by sources for the period from 1990 to 2015 is presented in Figure 3.2-4. In 2015, the total electricity production was 17.5 percent lower than in the former year. Decrease in energy consumption are mostly due to unfavorable hydrological conditions which led to decrease in electricity production from hydro power by 28.2 percent (Table 3.2-7) and increase in electricity production from renewable energy sources (wind and solar) by 11.6%.
Table 3.2-7: Differences between electricity production in 2014 and 2015

<table>
<thead>
<tr>
<th>ENERGY BALANCE</th>
<th>Electricity, GWh</th>
<th>Difference 2015-2014</th>
<th>Difference %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>13,553.8</td>
<td>11,402.0</td>
<td>-2,151.8</td>
</tr>
<tr>
<td>Hydro power plants</td>
<td>9,124.3</td>
<td>6,555.4</td>
<td>-2,568.9</td>
</tr>
<tr>
<td>Wind power plants</td>
<td>730.0</td>
<td>796.3</td>
<td>66.3</td>
</tr>
<tr>
<td>Photovoltaic</td>
<td>35.2</td>
<td>57.3</td>
<td>22.1</td>
</tr>
<tr>
<td>Thermal power plants</td>
<td>2,374.3</td>
<td>2,595.9</td>
<td>221.6</td>
</tr>
<tr>
<td>Public cogeneration plants</td>
<td>951.8</td>
<td>1,087.6</td>
<td>135.8</td>
</tr>
<tr>
<td>Industrial cogeneration plants</td>
<td>338.2</td>
<td>309.5</td>
<td>-28.7</td>
</tr>
<tr>
<td>Import</td>
<td>6,777.1</td>
<td>8,868.5</td>
<td>2,091.4</td>
</tr>
<tr>
<td>Export</td>
<td>-2,824.2</td>
<td>-2,080.1</td>
<td>744.1</td>
</tr>
<tr>
<td>Total consumption</td>
<td>17,506.7</td>
<td>18,190.4</td>
<td>683.7</td>
</tr>
</tbody>
</table>

Figure 3.2-4: Domestic production of electricity by sources for the period from 1990 to 2015

Fuel consumption, net calorific values and emission factors used for estimating GHG emissions for the years 1990, 2000, 2005, 2010 and for period 2011-2015 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

<table>
<thead>
<tr>
<th>PROCESSING CAPACITIES</th>
<th>INSTALLED (1000 t/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oil Refinery Rijeka (Urinj)</strong></td>
<td></td>
</tr>
<tr>
<td>atmospheric distillation</td>
<td>5000</td>
</tr>
<tr>
<td>reforming</td>
<td>730</td>
</tr>
<tr>
<td>fluidized-bed catalytic cracking (FCC)</td>
<td>1000</td>
</tr>
<tr>
<td>visbreaking</td>
<td>600</td>
</tr>
<tr>
<td>isomerization</td>
<td>250</td>
</tr>
<tr>
<td>hydrodesulphurization (HDS)</td>
<td>1040</td>
</tr>
<tr>
<td>mild hydrocracking (MHC)</td>
<td>560</td>
</tr>
<tr>
<td>hydrocracking</td>
<td>2600</td>
</tr>
<tr>
<td><strong>Oil Refinery Sisak</strong></td>
<td></td>
</tr>
<tr>
<td>atmospheric distillation</td>
<td>4000</td>
</tr>
<tr>
<td>reforming</td>
<td>680</td>
</tr>
<tr>
<td>fluidized-bed catalytic cracking (FCC)</td>
<td>470</td>
</tr>
<tr>
<td>coking</td>
<td>270</td>
</tr>
<tr>
<td>vacuum distillation</td>
<td>850</td>
</tr>
<tr>
<td>bitumen</td>
<td>350</td>
</tr>
<tr>
<td><strong>Lube Refinery Zagreb Ltd.</strong></td>
<td></td>
</tr>
<tr>
<td>lubricants</td>
<td>60</td>
</tr>
</tbody>
</table>

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

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

Natural gas is produced from 17 on-shore gas fields and 9 off-shore gas fields, which covers about 70.7 percent of total domestic demand in 2015. The largest share of gas is coming from fields Molve and Kalinovac. They include the units for processing and preparation of gas for transportation to Central Gas Stations (CGS) Molve I, II and III. Their capacities are:

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

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

CO₂-eq emissions from this subsector for the whole period from 1990 to 2015 are presented in Figure 3.2-6.
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$_2$O 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 CO₂ emissions**

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

The national energy balance is based on data from different available sources. The data from Central Bureau of Statistics about production, usage of raw material and consumption of fuels in all industrial facilities in Croatia are used. The data from questionnaires about monthly use of natural gas in certain sectors from all distributive companies in Croatia, about annual consumption of coal in certain sectors and the data from Customs Administration about export and import of fossil fuels are also used. The data from these sources and other necessary data are organised in related database. The estimated uncertainty of data from energy balance is below 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 CO₂ emission factors for fuels are generally well determined within 5 percent, as they are primarily dependent on the carbon content of the fuel.

**Uncertainty of CH₄ and N₂O emissions**

Estimates of CH₄ and N₂O emissions are based on fuel (coal, natural gas, oil and bio-fuels) and aggregate emission factors for different sectors. Uncertainties in estimates are due to the fact that emissions are estimated on the base of emission factors representing only a limited subset of combustion conditions. Using the aggregate emission factors for each sector, the differences between various types of coal and especially liquid fuel are not included, nor are the differences in the
technology and the contribution of equipment for emission reduction. Therefore, the uncertainties associated with emission estimates of these gases are greater than estimates of CO$_2$ emissions from the fossil fuel combustion.

The uncertainty of CH$_4$ emission is estimated to ±40 percent; while the uncertainty of N$_2$O 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

1A1b Petroleum refineries

During ESD revision of NIR 2016 it was observed that GHG emissions from production of H2 were not included in inventory. Production of H2 started in 2007 in Croatia, so GHG emissions were
calculated for the whole period from 2007 to 2014 and included in NIR 2017. Differences between emissions from NIR 2016 and recalculated ones are given in Table 3.2-9.

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>1801.85</td>
<td>1397.16</td>
<td>1646.86</td>
<td>1432.62</td>
<td>1664.17</td>
<td>1456.55</td>
<td>1231.97</td>
<td>1350.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>1863.90</td>
<td>1428.28</td>
<td>1646.86</td>
<td>1452.66</td>
<td>1809.28</td>
<td>1852.73</td>
<td>1397.31</td>
<td>1518.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>62.05</td>
<td>31.12</td>
<td>0.00</td>
<td>20.05</td>
<td>145.10</td>
<td>396.17</td>
<td>165.34</td>
<td>168.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference, %</td>
<td>3.44</td>
<td>2.23</td>
<td>0.00</td>
<td>1.40</td>
<td>8.72</td>
<td>27.20</td>
<td>13.42</td>
<td>12.46</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.2.4.6. Category-specific planned improvements

Inventory team is planning use CO₂ 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 (1A.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 2015 except 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 CO₂-eq emissions (kt) from Manufacturing Industries and Construction

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron and Steel Industry</td>
<td>IE</td>
<td>IE</td>
<td>IE</td>
<td>89.2</td>
<td>93.1</td>
<td>84.3</td>
<td>51.2</td>
<td>58.5</td>
<td>55.9</td>
<td>51.7</td>
</tr>
<tr>
<td>Non-Ferrous Metals</td>
<td>IE</td>
<td>IE</td>
<td>IE</td>
<td>21.2</td>
<td>14.0</td>
<td>18.6</td>
<td>19.8</td>
<td>20.0</td>
<td>18.7</td>
<td>10.9</td>
</tr>
<tr>
<td>Chemicals</td>
<td>IE</td>
<td>IE</td>
<td>IE</td>
<td>581.7</td>
<td>450.2</td>
<td>418.2</td>
<td>280.0</td>
<td>253.5</td>
<td>288.4</td>
<td>294.7</td>
</tr>
<tr>
<td>Pulp, Paper and Print</td>
<td>IE</td>
<td>IE</td>
<td>IE</td>
<td>175.0</td>
<td>162.1</td>
<td>148.8</td>
<td>127.1</td>
<td>113.8</td>
<td>71.5</td>
<td>70.2</td>
</tr>
<tr>
<td>Food Proc., Bev. and Tobac.</td>
<td>IE</td>
<td>IE</td>
<td>IE</td>
<td>594.2</td>
<td>515.4</td>
<td>497.1</td>
<td>430.9</td>
<td>389.1</td>
<td>400.7</td>
<td>351.8</td>
</tr>
<tr>
<td>Non-metallic minerals</td>
<td>IE</td>
<td>IE</td>
<td>IE</td>
<td>192.6</td>
<td>115.5</td>
<td>112.3</td>
<td>100.0</td>
<td>96.6</td>
<td>94.8</td>
<td>81.8</td>
</tr>
<tr>
<td>Other</td>
<td>IE</td>
<td>IE</td>
<td>IE</td>
<td>2,085.2</td>
<td>1,679.8</td>
<td>1,512.9</td>
<td>1,412.9</td>
<td>1,461.4</td>
<td>1,404.9</td>
<td>1,370.9</td>
</tr>
<tr>
<td>Total Manuf. Ind. and Cons.</td>
<td>5,529.0</td>
<td>2,967.9</td>
<td>3,115.6</td>
<td>3,739.1</td>
<td>3,030.1</td>
<td>2,792.2</td>
<td>2,421.9</td>
<td>2,392.9</td>
<td>2,334.9</td>
<td>2,232.0</td>
</tr>
</tbody>
</table>

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

The emissions from this subsector contribute 16-27 percent of the total emission from Energy sector. The largest contributor to emissions is fuel combustion in industry of construction materials and petrochemical production (subsector: Other in Figure 3.2-7), followed by food processing industry, chemical industry, paper industry, iron and steel industry and non-ferrous metal industry.
3.2.5.2. 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 2001-2015 (Industry analysis balance) except 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 CO₂ emissions**

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

The national energy balance is based on data from different available sources. The data from Central Bureau of Statistics about production, usage of raw material and consumption of fuels in all industrial facilities in Croatia are used. The data from questionnaires about monthly use of natural gas in certain sectors from all distributive companies in Croatia, about annual consumption of coal in certain sectors and the data from Customs Administration about export and import of fossil fuels are also used. The data from these sources and other necessary data are 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$_2$O emissions**

Estimates of CH$_4$ and N$_2$O 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$_2$O 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

There were no recalculations in this sector.

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 CO₂ emissions from Manufacturing Industries and Construction. Since industries such as iron and steel industries, industries of non-ferrous metals, chemicals, pulp and paper, food processing, beverages and tobacco, construction and building material industries, petrochemical industries, are in ETS, verified annual emission report of each industrial plant are available. Tier 2 approach is based on bottom-up fuel consumption data from every industrial plant. In verified annual emission reports there are available data about yearly fuel consumption and detailed fuel characteristics data (net calorific value) and plant-specific emission factors.

Also, on long term basis, inventory team is planning apply country-specific carbon content values and oxidation factor values to estimate emissions for the main fuel types.
3.2.6. 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 CO₂-eq emissions (kt) from sector Transport

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil Aviation</td>
<td>6.7</td>
<td>23.1</td>
<td>25.7</td>
<td>38.0</td>
<td>31.7</td>
<td>34.8</td>
<td>31.7</td>
<td>31.7</td>
<td>30.7</td>
<td>31.1</td>
</tr>
<tr>
<td>Road Transport</td>
<td>3,585.2</td>
<td>3,125.9</td>
<td>4,289.8</td>
<td>5,313.6</td>
<td>5,702.4</td>
<td>5,552.6</td>
<td>5,381.9</td>
<td>5,462.1</td>
<td>5,399.1</td>
<td>5,727.2</td>
</tr>
<tr>
<td>Railways</td>
<td>153.5</td>
<td>118.6</td>
<td>96.4</td>
<td>107.7</td>
<td>100.7</td>
<td>93.3</td>
<td>87.6</td>
<td>82.7</td>
<td>74.9</td>
<td>61.8</td>
</tr>
<tr>
<td>Navigation</td>
<td>135.8</td>
<td>100.3</td>
<td>87.5</td>
<td>101.7</td>
<td>117.6</td>
<td>118.9</td>
<td>113.1</td>
<td>123.1</td>
<td>137.8</td>
<td>131.7</td>
</tr>
<tr>
<td><strong>Total Transport</strong></td>
<td><strong>3,881.2</strong></td>
<td><strong>3,367.9</strong></td>
<td><strong>4,499.4</strong></td>
<td><strong>5,561.0</strong></td>
<td><strong>5,952.4</strong></td>
<td><strong>5,799.6</strong></td>
<td><strong>5,614.3</strong></td>
<td><strong>5,699.6</strong></td>
<td><strong>5,642.5</strong></td>
<td><strong>5,951.8</strong></td>
</tr>
</tbody>
</table>

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

The contribution from Transport sector to the total CO₂-eq emissions from Energy sector in 2015 was 35.6%. CO₂-eq emissions from the transport sector in 2015 amounted to 5,951.8 kt, which is 5.2% higher than in 2014 as a result of lower fuel consumption in road transport. Specifically, the emission of CO₂-eq emissions from Road transport sector (CRF 1.A.3.b) was dominant one in the transport sector.
sector (CRF 1.A.3) in 2015 and contributed to the CO₂-eq emissions from the transport sector with 96.2%. In 2015, the Navigation sector was contributed to the CO₂-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, CO₂-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 CO₂-eq emission from the sub-sector domestic civil aviation in 2015 amounted 31.1 kt, which is 1.1% higher than in 2014, as a result of fuel jet kerosene consumption increase. In comparison with 1990, CO₂-eq emission was 4.7 times higher 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 2015 and 11.4% in 1990. In the period from 1990 to 2015 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 CO₂ emission reduction according to National Action plan for energy efficiency for the period from 2014 to 2016.

**Railways (CRF 1.A.3.c)**

The CO₂-eq from the sub-sectors Railways in 2015 was amounted to 61.8 kt, which is 21.1% lower than in 2014 as a result of decrease of fuel diesel consumption. In comparison with 1990, CO₂-eq was decreased by 40.3% as a result of decrease in railways transportation and consequently decreases in fuel consumption.
**Navigation (CRF 1.A.3.d)**

The CO₂-eq from the sub-sectors Navigation in 2015 was amounted to 131.7 kt, which is for 4.6% lower than in 2014 as a result of increase in fuel consumption. In comparison with 1990, CO₂-eq increased by 1.0% as a result of increase in navigation traffic and consequently increase 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 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 2015 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 - 2015 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 2015 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\(_2\)O 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 – 2015 are presented in the Table A2-10 of the Annex 3. Comparing the total number of vehicles in 2015 with the number of vehicles in 1990 it can be notice the increase by 48.8 percent. The increase was largely the result of increase in the number of passenger cars by 35.8 percent, constituting 82.6 percent of the total number of road vehicles in 2015. 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 8.5 percent, motorcycles and mopeds for 5.3 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 N₂O emissions. Fluctuations occur only in Sector Passenger cars, subsector Gasoline 0.8-1.4 l, 1.4-2.0 l and >2.0 l, Technology PC Euro 1. These fluctuations are direct in line with fluctuations in sulphur contained of Gasoline fuel (see figure 3.2-9). Data on sulphur contain in fuels are given from Croatian Oil Company.
For confirmation of this statement, N₂O emission calculation with constant sulfur content for Passenger Euro I Gasoline vehicles was performed. Obtained IEF for N₂O did not have fluctuations (see figure 3.2-10).

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 2011-2015 are shown in Table A3-12 Annex 3.

The CO₂-eq from the sub-sectors Road transport in 2015 amounted to 5,727.2 kt, which is 5.7 percent higher than in 2014 as a result of increase in fuel consumption. In comparison with 1990, CO₂-
eq increased by 59.7 percent as a result of grow in diesel fuel consumption (by 3.3 times compared to 1990). At the same time gasoline consumption was decreased by 31.5%.

Trends of CO2-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 CO2-eq emission from Road transport sub-sector by fossil fuel type for the period from 1990 to 2015

![Graph showing CO2-eq emissions from Road transport sub-sector by fossil fuel type from 1990 to 2015.]

**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 CH4 and N2O 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 - 2015 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 - 2015 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 2015. 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 m³). 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 CO₂ emissions**
The CO₂ emission, from the fossil fuel combustion, depends on amount of fuel consumed (from energy balance), net calorific values (from energy balance), carbon emission factors (IPCC), the fraction of carbon stored (IPCC) and the fraction of carbon oxidised (IPCC).

The estimated uncertainty of data from energy balance is below 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 CO₂ emissions for International Marine and Aviation Transport are not included in nationals totals.

The other data needed for calculation, such as, carbon emission factors, the fraction of carbon stored for non-energy uses of fuel and the fraction of carbon oxidized, are taken from 2006 IPCC Guidelines.

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

**Uncertainty of CH₄ and N₂O emissions**

Estimates of CH₄ and N₂O emissions are based on fuel and aggregate emission factors for different sectors. Uncertainties in estimates are due to the fact that emissions are estimated on the base of emission factors representing only a limited subset of combustion conditions.

The uncertainty of CH₄ emission is estimated to ±40 percent; while the uncertainty of N₂O emission is estimated to factor 2 (the emission could be twice larger or smaller than the estimated one). The largest part of uncertainty refers to the emission factor applied while the fuel consumption data (national energy balance) are rather good.

Implementation of Tier 2/3 approach for estimation of CH₄ and N₂O emissions from Road transport (CRF 1.A.3.b) lead to certain uncertainty reduction.

**Time-series consistency**

Activity data, emission factors and methodology implied for GHG emission calculation from fuel combustion activities is very consistent for entire period.
3.2.6.4. 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\textsubscript{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\textsubscript{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\textsubscript{4} and N\textsubscript{2}O are reliable and accurate as well.

3.2.6.5. Category-specific recalculations

**Road transportation**

In Road transport sector recalculation was performed due to wrong density of CNG used for the period from 2011 to 2014. Recalculated emissions are approximately 0.002% lower than in NIR 2016.

3.2.6.6. Category-specific planned improvements
Civi aviation

In 2014 Croatia launched 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 CO₂ emissions from gasoline and diesel oil, and reasons for high uncertainties of emission factors for CH₄ and N₂O.

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 CO₂-eq emissions (kt) from Small Stationary Energy Sources

<table>
<thead>
<tr>
<th>Year</th>
<th>Commercial/Instit.</th>
<th>Residential</th>
<th>Agric./Fores/Fishing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>858.9</td>
<td>2,437.5</td>
<td>921.5</td>
<td>4,217.9</td>
</tr>
<tr>
<td>1995</td>
<td>664.7</td>
<td>2,025.2</td>
<td>621.0</td>
<td>3,310.8</td>
</tr>
<tr>
<td>2000</td>
<td>644.0</td>
<td>2,304.3</td>
<td>916.9</td>
<td>3,865.1</td>
</tr>
<tr>
<td>2005</td>
<td>792.7</td>
<td>2,862.8</td>
<td>764.5</td>
<td>4,420.1</td>
</tr>
<tr>
<td>2010</td>
<td>674.4</td>
<td>2,578.7</td>
<td>771.2</td>
<td>4,024.4</td>
</tr>
<tr>
<td>2011</td>
<td>621.1</td>
<td>2,397.1</td>
<td>770.3</td>
<td>3,788.5</td>
</tr>
<tr>
<td>2012</td>
<td>545.7</td>
<td>2,177.4</td>
<td>718.1</td>
<td>3,441.2</td>
</tr>
<tr>
<td>2013</td>
<td>512.0</td>
<td>2,060.4</td>
<td>702.3</td>
<td>3,274.8</td>
</tr>
<tr>
<td>2014</td>
<td>474.5</td>
<td>1,798.8</td>
<td>701.2</td>
<td>2,974.6</td>
</tr>
<tr>
<td>2015</td>
<td>587.8</td>
<td>1,930.9</td>
<td>700.8</td>
<td>3,219.5</td>
</tr>
</tbody>
</table>
The CO₂-eq emissions from these subsectors were about 16-20 percent of the total emissions from Energy sector. The most of the emission comes from small household furnaces and boiler rooms (54-62 percent), then from service sector (17-22 percent), while the combustion of fuel in agriculture, forestry and fishing accounts for 18 to 25 percent for the period from 1990 to 2015.

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\textsubscript{2} emissions**

The CO\textsubscript{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\textsubscript{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\textsubscript{4} and N\textsubscript{2}O emissions**

Estimates of CH\textsubscript{4} and N\textsubscript{2}O 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\textsubscript{4} and N\textsubscript{2}O emissions from the fossil fuel combustion.

The uncertainty of CH\textsubscript{4} emission is estimated to ±40 percent; while the uncertainty of N\textsubscript{2}O 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

According to technical correction proposed by TERT during 2016 comprehensive review of national greenhouse gas inventory data emission factors for CH₄ and N₂O for diesel for off road vehicles in 1A4c Agriculture/forestry/fishing subsector were modified. Emission were recalculated for the whole period from 1990-2014 using emission factors from 2006 IPCC guidelines (volume 2, chapter 3, table 3.3.1). Differences between emissions from NIR 2016 and recalculated ones are given in Table 3.2-13.

Table 3.2-13: CO₂ eq difference between emissions of 1A4c sector in NIR 2016 and NIR 2017

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NIR 2016</td>
<td>840.05</td>
<td>565.29</td>
<td>833.67</td>
<td>695.43</td>
<td>701.18</td>
<td>700.16</td>
<td>652.85</td>
<td>638.49</td>
<td>637.44</td>
</tr>
<tr>
<td>NIR 2017</td>
<td>921.51</td>
<td>621.01</td>
<td>916.86</td>
<td>764.55</td>
<td>771.24</td>
<td>770.25</td>
<td>718.08</td>
<td>702.29</td>
<td>701.23</td>
</tr>
<tr>
<td>Difference, kt</td>
<td>81.45</td>
<td>55.72</td>
<td>83.19</td>
<td>69.11</td>
<td>70.06</td>
<td>70.10</td>
<td>65.23</td>
<td>63.79</td>
<td>63.79</td>
</tr>
</tbody>
</table>

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 2015) to total emissions of Croatia while navigation contributes with 0.56 % (in 2015). 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.
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$^3$CH$_4$/t was used and for Post-mining activities 2.5 m$^3$CH$_4$/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 2015. 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 1901-2015

<table>
<thead>
<tr>
<th>Period</th>
<th>Number of abandoned underground mines</th>
<th>Closing technology</th>
<th>CH₄ emission</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fully Flooded Mines</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partially Flooded</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unflooded</td>
<td></td>
</tr>
<tr>
<td>1901-1925</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1926-1950</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1951-1975</td>
<td>35</td>
<td>Fully Flooded Mines</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partially Flooded</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unflooded</td>
<td></td>
</tr>
<tr>
<td>1976-1999</td>
<td>8</td>
<td>Fully Flooded Mines</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partially Flooded</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unflooded</td>
<td></td>
</tr>
<tr>
<td>2000-2015</td>
<td>1</td>
<td>Fully Flooded Mines</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partially Flooded</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unflooded</td>
<td></td>
</tr>
</tbody>
</table>

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” fields.

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. m³.

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 (CO₂, H₂S, 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 CO₂, more than 15 percent, and before coming to commercial pipeline has to be cleaned (scrubbed). Since the maximum volume content of CO₂ in commercial natural gas is 3 percent, it is necessary to clean the natural gas before transporting through pipeline to end-users. Because of that, the Scrubbing Units exist at largest Croatian gas field.

The 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 CO₂ and H₂S from gas with absorption using 40% solution of methyldiethanolamine. Process solution passes the cleaning process (regeneration) in striper- column. Cleaned and freed of CO₂ 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 CO₂ and H₂S released from metyldiatomaceous solution. H₂S is oxidized to the elemental sulphur

• EOR compressors -Part of CO₂ with remaining H₂S 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 CO₂ with remaining H₂S goes to RTO units. In oxidation process at 800-900°C H₂S is converted to SO₂ 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.

CO₂ balance for the period from 2010 till 2015 is given in Table 3.3-2.
Table 3.3-2: CO₂ material balance for the period 2010-2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Average annual amount of CO₂ in input gas, vol%</th>
<th>Average annual amount of CO₂ in the output gas, ppm</th>
<th>Quantity of gas, input, m³/year</th>
<th>Quantity of gas, output, m³/year</th>
<th>water intake gas obtained at stripping MDEA solution m³/ year</th>
<th>CO₂ from balance, m³/year</th>
<th>CO₂ from balance, kg/year</th>
<th>CO₂ obtained by measuring, m³/year</th>
<th>CO₂ obtained by measuring, released to atmosphere, kg/god</th>
<th>CO₂ obtained by calculation, m³/year</th>
<th>Compressed in EOR unit, m³/year</th>
<th>Difference of calculated an measured CO₂, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>25.55</td>
<td>9</td>
<td>1,041,050,600</td>
<td>785,655,500</td>
<td>8,543,900</td>
<td>246,851,200</td>
<td>461,611,744</td>
<td>260,567,592</td>
<td>487,261,397</td>
<td>265,988,428</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>2011</td>
<td>26.88</td>
<td>8</td>
<td>1,010,863,066</td>
<td>653,903,801</td>
<td>7,621,100</td>
<td>349,338,165</td>
<td>653,262,369</td>
<td>275,200,410</td>
<td>514,624,767</td>
<td>271,719,992</td>
<td>0</td>
<td>-27</td>
</tr>
<tr>
<td>2012</td>
<td>24.96</td>
<td>7</td>
<td>932,917,400</td>
<td>576,545,600</td>
<td>6,339,400</td>
<td>350,032,400</td>
<td>654,560,588</td>
<td>229,515,426</td>
<td>429,193,847</td>
<td>232,856,183</td>
<td>0</td>
<td>-53</td>
</tr>
<tr>
<td>2013</td>
<td>25.06</td>
<td>7</td>
<td>962,809,200</td>
<td>696,967,200</td>
<td>6,295,400</td>
<td>259,546,600</td>
<td>485,352,142</td>
<td>218,919,822</td>
<td>409,380,067</td>
<td>241,279,986</td>
<td>0</td>
<td>-19</td>
</tr>
<tr>
<td>2015</td>
<td>28.46</td>
<td>9</td>
<td>786,636,100</td>
<td>561,619,600</td>
<td>4,896,347</td>
<td>220,120,153</td>
<td>411,624,686</td>
<td>223,559,815</td>
<td>192,349,451</td>
<td>223,876,634</td>
<td>120,699,146</td>
<td>2</td>
</tr>
</tbody>
</table>

CO₂ density on 15°C is 1.87 kg/m³
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

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>Central Gas Station</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOLVE</td>
<td>415.9</td>
<td>739.3</td>
<td>633.0</td>
<td>691.2</td>
<td>487.3</td>
<td>509.0</td>
<td>429.2</td>
<td>409.4</td>
<td>397.1</td>
<td>192.3</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Natural gas transport system of the Republic of Croatia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of transmission system operators: 1</td>
</tr>
<tr>
<td>The total length of pipeline gas transport system: 2 693 km</td>
</tr>
<tr>
<td>Interconnection / transmission system operator: Rogatec / Plinovodi d.o.o. (SLO) Drávaszerdahely / FGSZ Ltd. (HU)</td>
</tr>
<tr>
<td>Underground gas storage / gas storage system operator: Okoli / Podzemno skladište plina d.o.o.</td>
</tr>
<tr>
<td>Number of connections for end users connection to the transmission system: 34</td>
</tr>
<tr>
<td>Number of connections to the distribution systems and the number of distribution system operators: Number of ports: 153 Number of operators DS: 37</td>
</tr>
<tr>
<td>Number of balancing zones: 1</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil activities</td>
<td>378.4</td>
<td>211.3</td>
<td>171.8</td>
<td>135.0</td>
<td>102.6</td>
<td>94.8</td>
<td>85.6</td>
<td>85.8</td>
<td>84.3</td>
<td>95.4</td>
</tr>
<tr>
<td>Gas activities</td>
<td>670.1</td>
<td>992.1</td>
<td>858.9</td>
<td>993.5</td>
<td>843.1</td>
<td>834.5</td>
<td>702.0</td>
<td>662.8</td>
<td>632.2</td>
<td>433.7</td>
</tr>
<tr>
<td>Venting and Flaring</td>
<td>1.2</td>
<td>0.5</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Total</td>
<td>1,049.8</td>
<td>1,203.9</td>
<td>1,031.2</td>
<td>1,129.0</td>
<td>946.0</td>
<td>929.5</td>
<td>787.8</td>
<td>748.8</td>
<td>716.7</td>
<td>529.3</td>
</tr>
</tbody>
</table>

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

The CO\(_2\)-eq emissions from this sub-sector were about 8-12 percent of the total emissions from Energy sector. From 2006 oil and gas production are continuously decreasing consequently CO\(_2\)-eq emission is decreasing too. The most of the emission in 1990 arose from oil activities (66 percent) while in 2015 the large majority of emissions arose from gas activities (70 percent).

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

**Fugitive emission of ozone precursors and SO\(_2\)**

Emissions of indirect GHGs for whole time period (1990-2015) was set up according to the EMEP/CORINAIR methodology. Emissions were obtained from the emission inventory report ‘Republic of Croatia Informative Inventory Report for 2015, 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\textsubscript{x}, NMVOC and SO\textsubscript{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 SO\textsubscript{2} from fugitive emissions sector

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CO emission</td>
<td>50.69</td>
<td>34.83</td>
<td>54.39</td>
<td>54.71</td>
<td>40.29</td>
<td>32.86</td>
<td>35.59</td>
<td>22.18</td>
<td>21.84</td>
<td>20.74</td>
</tr>
<tr>
<td>NO\textsubscript{x} emission</td>
<td>0.33</td>
<td>0.24</td>
<td>0.34</td>
<td>0.34</td>
<td>0.24</td>
<td>0.21</td>
<td>0.22</td>
<td>0.15</td>
<td>0.16</td>
<td>0.15</td>
</tr>
<tr>
<td>NMVOC emission</td>
<td>6.40</td>
<td>5.00</td>
<td>5.64</td>
<td>5.40</td>
<td>4.82</td>
<td>4.22</td>
<td>3.86</td>
<td>3.58</td>
<td>3.14</td>
<td>3.43</td>
</tr>
<tr>
<td>SO\textsubscript{2} emission</td>
<td>2.42</td>
<td>1.72</td>
<td>3.57</td>
<td>3.54</td>
<td>2.72</td>
<td>3.77</td>
<td>3.99</td>
<td>3.29</td>
<td>3.71</td>
<td>3.41</td>
</tr>
</tbody>
</table>

Figure 3.3-3: The fugitive emissions of CO, NO\textsubscript{x}, NMVOC and SO\textsubscript{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 10\textsuperscript{3} m\textsuperscript{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 10³ m³ total natural gas production.

**Fugitive emission of CH₄**

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 CO₂ and N₂O**

For estimating the fugitive emission of CO₂ and N₂O from oil and gas the simplest procedure has been used (Tier 1), which is based on production, unloading, processing and consumption of oil and gas. 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 2015.
N₂O emission from Oil production was reported under 1B2c2i section because CRF reporter has no possibility of entering N₂O emissions under 1B2a category.

All N₂O emissions from Natural gas production, Processing and Transmission were reported under 1B2c2ii section because CRF reporter has no possibility of entering N₂O emissions under 1B2b category.

**CO₂ emission from natural gas scrubbing**

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

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

3.3.2.3. Uncertainties and time-series consistency

The simplest procedure (Tier 1) is used to determine fugitive emission from oil and natural gas activities. This approach is based on activity data (production, transport, refining and storage of fossil fuels) and average emission factors. Due to the complexity of the oil and gas industry, it is difficult to quantify the uncertainties. The uncertainty of calculation is linked mostly to the emission factor, just like the determination of fugitive emission of methane from coal mining and handling. The expert estimated that accuracy of calculation of fugitive emission from oil is better than from fugitive emission from gas, but the uncertainty of both estimations is pretty high.

The CO₂ 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 CO\textsubscript{2} 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

**1B2a3 Oil transport by pipelines**

In 1B2a sector, data from JANAF on transported oil through pipelines for 2014 was recalculated because in NIR 2016 this amount was estimated according data for 2013. For this submission real amount of oil transported through pipelines was used.

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. \textit{CO\textsubscript{2} TRANSPORT AND STORAGE (CRF 1.C)}

CO\textsubscript{2} transport and CO\textsubscript{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\textsubscript{2}), methane (CH\textsubscript{4}) or nitrous oxide (N\textsubscript{2}O) 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 1990-2015. 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\textsubscript{2} emissions was identified as significant are production of cement and ammonia. Nitric acid production is a source of N\textsubscript{2}O emissions. Emissions of CH\textsubscript{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\textsubscript{6} is used as an insulation medium in electrical equipment. During SF\textsubscript{6} manipulation and equipment testing, leakage and maintenance losses of the total charge can be present.

Some industrial processes, particularly petrochemical, generate emissions of short-lived ozone and aerosol precursor gases such as carbon monoxide (CO), nitrogen oxides (NO\textsubscript{x}), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO\textsubscript{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 CO₂ emissions reported under EU ETS were available for the years 2012 - 2015 and included in the inventory (process emissions in this chapter). The relevant 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 programme, 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 programme. 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 - 2015 are presented in the Figure 4.1-1.

Figure 4.1-1: Emissions of GHGs from Industrial Processes and Product Use (1990 - 2015)

In 2015, GHG emissions from Sector 2 IPPU amounted to 2,665.5 kt CO$_2$ equivalent, compared to 4,628.8 kt in 1990. These emissions constituted 11.3% of Croatia’s total GHG emissions (excluding
LULUCF) in 2015 and 14.9% of total emissions in 1990. GHG emissions fluctuate during reporting period:

- generally, CO₂ emissions from industrial processes declined from 1990 to 1995, due to the decline in industrial activities caused by the war in Croatia, while in the period 1996 - 2008 emissions slightly increased;
- 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, 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 - 2015 is due to a strong reduction of N₂O 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 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 2015

<table>
<thead>
<tr>
<th>IPCC Source Categories</th>
<th>GHG</th>
<th>Key source</th>
<th>If Column C is Yes, Criteria for Identification</th>
<th>Com.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.A.1 Cement Production</td>
<td>CO₂</td>
<td>Yes</td>
<td>L1e</td>
<td>T1e</td>
</tr>
<tr>
<td>2.B.1 Ammonia Production</td>
<td>CO₂</td>
<td>Yes</td>
<td>L1e</td>
<td>T1e</td>
</tr>
<tr>
<td>2.B.2 Nitric Acid Production</td>
<td>N₂O</td>
<td>Yes</td>
<td>L1e</td>
<td>T1i</td>
</tr>
<tr>
<td>2.B.8 Petrochemical and Carbon Black Production</td>
<td>CO₂</td>
<td>Yes</td>
<td>T1e, T2e</td>
<td>T1i, T2i</td>
</tr>
<tr>
<td>2.C.2 Ferroalloys Production</td>
<td>CO₂</td>
<td>Yes</td>
<td>T1e</td>
<td>T1i</td>
</tr>
<tr>
<td>2.C.3 Aluminium Production</td>
<td>CO₂</td>
<td>Yes</td>
<td>T1e</td>
<td>T1i</td>
</tr>
<tr>
<td>2.C.3 Aluminium Production</td>
<td>PFCS</td>
<td>Yes</td>
<td>T1e</td>
<td>T1i</td>
</tr>
<tr>
<td>2.D Non-energy Products from Fuels and Solvent Use</td>
<td>CO₂</td>
<td>Yes</td>
<td>T2e</td>
<td>T1i</td>
</tr>
<tr>
<td>2.F.1 Refrigeration and Air conditioning - Aggregate</td>
<td>F-gases</td>
<td>Yes</td>
<td>L1e, L2e</td>
<td>T1e, T2e</td>
</tr>
</tbody>
</table>

L1e - Level excluding LULUCF Tier 1
L1i - Level including LULUCF Tier 1
T1e - Trend excluding LULUCF Tier 1
T1i - Trend including LULUCF Tier 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 3.5 percent to the total GHG emissions in Croatia (without LULUCF). In 2015, CO\(_2\) emissions contributed 5.0 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. CO₂ from Cement Kiln Dust (CKD) leaving the kiln system was calculated using the default CFₖₖ₉ (2 percent of the CO₂ 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 programme. 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 - 2015 were defined in line with requirements of the EU ETS. Verified CO₂ 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 - 2015 is defined in line with requirements of the EU ETS. Verified process emissions are included in Cement Production for the period 2012 - 2015.
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 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Clinker production Portland cement (t)</th>
<th>Clinker production Aluminate cement (t)</th>
<th>Actual clinker production (t)</th>
<th>Emission factor Portland cement (t CO₂/t clinker)</th>
<th>Emission factor Aluminate cement (t CO₂/t clinker)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>2,017,840</td>
<td>44,585</td>
<td>2,103,674</td>
<td>0.521</td>
<td>0.313</td>
</tr>
<tr>
<td>1991</td>
<td>1,296,146</td>
<td>40,974</td>
<td>1,336,862</td>
<td>0.521</td>
<td>0.321</td>
</tr>
<tr>
<td>1992</td>
<td>1,538,923</td>
<td>27,378</td>
<td>1,579,627</td>
<td>0.521</td>
<td>0.301</td>
</tr>
<tr>
<td>1993</td>
<td>1,264,565</td>
<td>40,511</td>
<td>1,311,178</td>
<td>0.523</td>
<td>0.306</td>
</tr>
<tr>
<td>1994</td>
<td>1,548,980</td>
<td>34,702</td>
<td>1,615,356</td>
<td>0.526</td>
<td>0.311</td>
</tr>
<tr>
<td>1995</td>
<td>1,148,756</td>
<td>48,854</td>
<td>1,122,612</td>
<td>0.523</td>
<td>0.311</td>
</tr>
<tr>
<td>1996</td>
<td>1,245,692</td>
<td>60,570</td>
<td>1,313,862</td>
<td>0.524</td>
<td>0.306</td>
</tr>
<tr>
<td>1997</td>
<td>1,470,234</td>
<td>72,334</td>
<td>1,564,567</td>
<td>0.515</td>
<td>0.308</td>
</tr>
<tr>
<td>1998</td>
<td>1,571,767</td>
<td>77,344</td>
<td>1,642,106</td>
<td>0.517</td>
<td>0.304</td>
</tr>
<tr>
<td>1999</td>
<td>2,063,838</td>
<td>87,175</td>
<td>2,151,013</td>
<td>0.517</td>
<td>0.305</td>
</tr>
<tr>
<td>2000</td>
<td>2,308,148</td>
<td>83,905</td>
<td>2,290,346</td>
<td>0.518</td>
<td>0.306</td>
</tr>
<tr>
<td>2001</td>
<td>2,645,180</td>
<td>94,065</td>
<td>2,739,245</td>
<td>0.519</td>
<td>0.309</td>
</tr>
<tr>
<td>2002</td>
<td>2,627,934</td>
<td>70,667</td>
<td>2,698,597</td>
<td>0.519</td>
<td>0.309</td>
</tr>
<tr>
<td>2003</td>
<td>2,609,349</td>
<td>82,741</td>
<td>2,712,089</td>
<td>0.510</td>
<td>0.301</td>
</tr>
<tr>
<td>2004</td>
<td>2,764,331</td>
<td>87,911</td>
<td>2,852,242</td>
<td>0.512</td>
<td>0.301</td>
</tr>
<tr>
<td>2005</td>
<td>2,827,258</td>
<td>99,320</td>
<td>2,926,576</td>
<td>0.513</td>
<td>0.293</td>
</tr>
<tr>
<td>2006</td>
<td>3,007,818</td>
<td>96,549</td>
<td>3,104,364</td>
<td>0.508</td>
<td>0.308</td>
</tr>
<tr>
<td>2007</td>
<td>3,046,209</td>
<td>114,311</td>
<td>3,160,520</td>
<td>0.507</td>
<td>0.304</td>
</tr>
<tr>
<td>2008</td>
<td>2,883,266</td>
<td>111,787</td>
<td>3,004,054</td>
<td>0.507</td>
<td>0.305</td>
</tr>
<tr>
<td>2009</td>
<td>2,355,148</td>
<td>83,911</td>
<td>2,439,059</td>
<td>0.499</td>
<td>0.305</td>
</tr>
<tr>
<td>2010</td>
<td>2,229,152</td>
<td>91,332</td>
<td>2,320,484</td>
<td>0.515</td>
<td>0.304</td>
</tr>
<tr>
<td>2011</td>
<td>1,965,307</td>
<td>106,353</td>
<td>2,071,656</td>
<td>0.508</td>
<td>0.301</td>
</tr>
<tr>
<td>2012</td>
<td>1,880,328</td>
<td>99,857</td>
<td>2,019,513</td>
<td>0.515</td>
<td>0.294</td>
</tr>
<tr>
<td>2013</td>
<td>2,093,282</td>
<td>105,014</td>
<td>2,210,296</td>
<td>0.520</td>
<td>0.292</td>
</tr>
<tr>
<td>2014</td>
<td>2,165,514</td>
<td>112,966</td>
<td>2,278,480</td>
<td>0.540</td>
<td>0.278</td>
</tr>
<tr>
<td>2015</td>
<td>2,036,196</td>
<td>122,468</td>
<td>2,158,731</td>
<td>0.546</td>
<td>0.277</td>
</tr>
</tbody>
</table>

1 Clinker production reported by the cement manufacturers
2 Actual clinker productions calculated as a product of clinker production and CFₕₕₕₜₜ.

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

Table 4.2-2: Import/export quantities of clinker (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Clinker import (t)</th>
<th>Clinker export (t)</th>
<th>Change in clinker stocks (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Portland</td>
<td>Aluminate</td>
<td>Portland</td>
</tr>
<tr>
<td>1990</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1991</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1992</td>
<td>0</td>
<td>0</td>
<td>4,376</td>
</tr>
<tr>
<td>1993</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1994</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1995</td>
<td>52,500</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1996</td>
<td>0</td>
<td>0</td>
<td>32,715</td>
</tr>
<tr>
<td>1997</td>
<td>57,973</td>
<td>0</td>
<td>63,529</td>
</tr>
<tr>
<td>1998</td>
<td>116,397</td>
<td>0</td>
<td>82,451</td>
</tr>
<tr>
<td>Year</td>
<td>Clinker import (t)</td>
<td>Clinker export (t)</td>
<td>Change in clinker stocks (t)</td>
</tr>
<tr>
<td>------</td>
<td>--------------------</td>
<td>--------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
<td>Portland</td>
<td>Aluminate</td>
<td>Portland</td>
</tr>
<tr>
<td>1999</td>
<td>0</td>
<td>0</td>
<td>114,868</td>
</tr>
<tr>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>111,226</td>
</tr>
<tr>
<td>2001</td>
<td>0</td>
<td>100</td>
<td>131,565</td>
</tr>
<tr>
<td>2002</td>
<td>0</td>
<td>0</td>
<td>5,029</td>
</tr>
<tr>
<td>2003</td>
<td>112,467</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2004</td>
<td>51,791</td>
<td>0</td>
<td>53,387</td>
</tr>
<tr>
<td>2005</td>
<td>0</td>
<td>0</td>
<td>195,888</td>
</tr>
<tr>
<td>2006</td>
<td>0</td>
<td>0</td>
<td>243,708</td>
</tr>
<tr>
<td>2007</td>
<td>24,000</td>
<td>1,632</td>
<td>309,431</td>
</tr>
<tr>
<td>2008</td>
<td>0</td>
<td>153</td>
<td>234,849</td>
</tr>
<tr>
<td>2009</td>
<td>0</td>
<td>0</td>
<td>169,356</td>
</tr>
<tr>
<td>2010</td>
<td>67</td>
<td>0</td>
<td>124,675</td>
</tr>
<tr>
<td>2011</td>
<td>0</td>
<td>0</td>
<td>65,082</td>
</tr>
<tr>
<td>2012</td>
<td>0</td>
<td>0</td>
<td>283,797</td>
</tr>
<tr>
<td>2013</td>
<td>0</td>
<td>533</td>
<td>274,777</td>
</tr>
<tr>
<td>2014</td>
<td>0</td>
<td>0</td>
<td>398,072</td>
</tr>
<tr>
<td>2015</td>
<td>0</td>
<td>398</td>
<td>316,299</td>
</tr>
</tbody>
</table>

The resulting emissions of CO₂ from Cement Production in the period 1990 - 2015 are presented in the Figure 4.2-1.
CO₂ emissions from cement production declined from the year 1990 to 1995, due to the decline in industrial activities caused by the war in Croatia, while from 1996 to 2008 emissions slightly increased. After that period, due to reduced economic activities, which influenced the cement production in Croatia, the production 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 and 34.6 percent in 2015, regarding the year 2008). In 2013 and 2014, the cement production started increase slightly compared to 2012 while in 2015 decreased slightly. Accordingly, CO₂ emissions was higher 12.2 percent in 2013, 20.4 percent in 2014 and 15.0 percent in 2015, 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>
<thead>
<tr>
<th>Year</th>
<th>Portland cement (t)</th>
<th>Aluminate cement (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>2,598,066</td>
<td>44,698</td>
</tr>
<tr>
<td>1991</td>
<td>1,702,589</td>
<td>33,184</td>
</tr>
<tr>
<td>1992</td>
<td>1,810,780</td>
<td>30,532</td>
</tr>
<tr>
<td>1993</td>
<td>1,596,244</td>
<td>36,895</td>
</tr>
<tr>
<td>1994</td>
<td>2,049,140</td>
<td>31,499</td>
</tr>
<tr>
<td>Year</td>
<td>Portland</td>
<td>Aluminate</td>
</tr>
<tr>
<td>------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>1995</td>
<td>1,571,415</td>
<td>39,731</td>
</tr>
<tr>
<td>1996</td>
<td>1,643,049</td>
<td>51,654</td>
</tr>
<tr>
<td>1997</td>
<td>1,906,133</td>
<td>59,365</td>
</tr>
<tr>
<td>1998</td>
<td>2,161,827</td>
<td>68,503</td>
</tr>
<tr>
<td>1999</td>
<td>2,549,726</td>
<td>79,743</td>
</tr>
<tr>
<td>2000</td>
<td>2,909,466</td>
<td>83,388</td>
</tr>
<tr>
<td>2001</td>
<td>3,152,805</td>
<td>84,655</td>
</tr>
<tr>
<td>2002</td>
<td>3,415,011</td>
<td>76,737</td>
</tr>
<tr>
<td>2003</td>
<td>3,607,840</td>
<td>81,860</td>
</tr>
<tr>
<td>2004</td>
<td>3,553,985</td>
<td>89,563</td>
</tr>
<tr>
<td>2005</td>
<td>3,528,544</td>
<td>100,509</td>
</tr>
<tr>
<td>2006</td>
<td>3,657,889</td>
<td>98,041</td>
</tr>
<tr>
<td>2007</td>
<td>3,613,548</td>
<td>111,624</td>
</tr>
<tr>
<td>2008</td>
<td>3,671,826</td>
<td>108,891</td>
</tr>
<tr>
<td>2009</td>
<td>2,847,053</td>
<td>80,945</td>
</tr>
<tr>
<td>2010</td>
<td>2,687,535</td>
<td>93,128</td>
</tr>
<tr>
<td>2011</td>
<td>2,602,955</td>
<td>104,694</td>
</tr>
<tr>
<td>2012</td>
<td>2,155,356</td>
<td>100,195</td>
</tr>
<tr>
<td>2013</td>
<td>2,333,113</td>
<td>103,036</td>
</tr>
<tr>
<td>2014</td>
<td>2,375,333</td>
<td>112,166</td>
</tr>
<tr>
<td>2015</td>
<td>2,355,903</td>
<td>118,355</td>
</tr>
</tbody>
</table>

SO₂ emissions originate from sulphur in the fuel and in the clay raw material. The fuel emissions are counted as energy emissions (these emissions are presented in the chapter on emissions from energy sources). SO₂ emissions from the clay are counted as process emissions and calculated on the basis of produced quantities of cement. About 70-95 percent of the SO₂ generated in the process is absorbed in the produced alkaline clinker.

Emissions of SO₂, CO, NOₓ, NMVOC and NH₃ have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 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 CO₂ emissions reported in line with requirements of the EU ETS were used for the period 2012 – 2015. 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.

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

4.2.1.5. 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\textsubscript{2} emissions from lime production contributed 0.5 percent to the total GHG emissions in Croatia (without LULUCF). In 2015, CO\textsubscript{2} emissions contributed 0.3 percent to the total GHG emissions.

The production of lime involves a series of steps which include quarrying the raw material, crushing and sizing, calcination and hydration. CO\textsubscript{2} is generated during the calcination stage, when limestone (CaCO\textsubscript{3}) or dolomite (CaCO\textsubscript{3}*MgCO\textsubscript{3}) are burned at high temperature (900 - 1,200°C) in a kiln to produce quicklime (CaO) or dolomitic lime (CaO*MgO) and CO\textsubscript{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 refineries in Croatia, where a certain amount of quicklime is produced.

4.2.2.2. Methodological issues

Calculation of CO\textsubscript{2} emissions from lime production is accomplished by applying an emission factor in tonnes of CO\textsubscript{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 CO₂ and CaO from individual plants. Country-specific emission factor for dolomitic lime was estimated by using data on CaO*MgO content of the lime and stoichiometric ratio between CO₂ and CaO*MgO from one plant. Vertical shaft kilns, which are mostly used, generate relatively small amounts of Lime Kiln Dust (LKD). It is judged that a correction factor for LKD from vertical shaft kilns would be negligible and do not need to be estimated.

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

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

Activity data and emissions for the period 2012 - 2015 were defined in line with requirements of the EU ETS. Verified CO₂ 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 factories of lime are included in 2.A.2 Lime Production in the CRF for the period 2012 - 2015. For the period 2012 – 2015, emissions from sugar refineries are not included in 2.A.2 but in the Energy sector, which is defined in line with requirements of the EU ETS in the verified reports for the combustion. Verification of activity data and emissions for the period 2012 - 2015 is defined in line with requirements of the EU ETS.

Variation in IEFs (since 2011) reflects recent changes in lime production volume and ratio of quicklime and dolomitic lime and the fact that total quicklime production (from factories of lime and sugar refineries) is included in the CRF tables, while emissions only from factories of lime are included in the CRF.

The data on quicklime and dolomitic lime production and emission factors are presented in Table 4.2-4.
Table 4.2-4: Lime production and emission factors (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Quicklime</th>
<th>Dolomitic lime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production (t)</td>
<td>EF (t CO₂/t lime)</td>
</tr>
<tr>
<td>1990</td>
<td>224,830</td>
<td>0.654</td>
</tr>
<tr>
<td>1991</td>
<td>165,397</td>
<td>0.736</td>
</tr>
<tr>
<td>1992</td>
<td>124,493</td>
<td>0.654</td>
</tr>
<tr>
<td>1993</td>
<td>134,482</td>
<td>0.658</td>
</tr>
<tr>
<td>1994</td>
<td>140,116</td>
<td>0.664</td>
</tr>
<tr>
<td>1995</td>
<td>139,701</td>
<td>0.667</td>
</tr>
<tr>
<td>1996</td>
<td>137,667</td>
<td>0.659</td>
</tr>
<tr>
<td>1997</td>
<td>131,741</td>
<td>0.658</td>
</tr>
<tr>
<td>1998</td>
<td>142,018</td>
<td>0.676</td>
</tr>
<tr>
<td>1999</td>
<td>136,408</td>
<td>0.690</td>
</tr>
<tr>
<td>2000</td>
<td>124,437</td>
<td>0.686</td>
</tr>
<tr>
<td>2001</td>
<td>154,526</td>
<td>0.695</td>
</tr>
<tr>
<td>2002</td>
<td>174,893</td>
<td>0.696</td>
</tr>
<tr>
<td>2003</td>
<td>153,146</td>
<td>0.697</td>
</tr>
<tr>
<td>2004</td>
<td>227,322</td>
<td>0.705</td>
</tr>
<tr>
<td>2005</td>
<td>233,235</td>
<td>0.698</td>
</tr>
<tr>
<td>2006</td>
<td>260,584</td>
<td>0.695</td>
</tr>
<tr>
<td>2007</td>
<td>261,276</td>
<td>0.703</td>
</tr>
<tr>
<td>2008</td>
<td>246,700</td>
<td>0.688</td>
</tr>
<tr>
<td>2009</td>
<td>163,210</td>
<td>0.668</td>
</tr>
<tr>
<td>2010</td>
<td>129,900</td>
<td>0.690</td>
</tr>
<tr>
<td>2011</td>
<td>110,380</td>
<td>0.691</td>
</tr>
<tr>
<td>2012</td>
<td>44,752¹</td>
<td>35,525²</td>
</tr>
<tr>
<td>2013</td>
<td>44,92¹</td>
<td>29,213²</td>
</tr>
<tr>
<td>2014</td>
<td>40,042¹</td>
<td>42,174²</td>
</tr>
<tr>
<td>2015</td>
<td>52,033¹</td>
<td>36,001²</td>
</tr>
</tbody>
</table>

¹ production of quicklime in factories of lime
² production of quicklime in sugar rafineries

The resulting emissions of CO₂ from Lime Production in the period 1990 - 2015 are presented in the Figure 4.2-2.
CO₂ 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 percent in 2012, 30.3 percent in 2013, 25.5 percent in 2014 and 26.3 percent in 2015, regarding the year 2011. Accordingly, CO₂ emissions was lower 22.2 percent in 2012, 27.1 percent in 2013, 29.9 percent in 2014 and 28.8 percent in 2015, regarding the year 2011.

Emissions of SO₂, CO, NOₓ, NMVOC and NH₃ have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 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 CO₂ emissions reported in line with requirements of the EU ETS were used for the period 2012 – 2015. 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.

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

4.2.2.5. Category-specific recalculations

During NIR 2017 preparation, new data on quicklime production in sugar rafineries for 2013 and 2014 were submitted (minor differences compared to the NIR 2016), but the verified emissions remained the same (because emissions only from factories of lime are included in the CRF). Activity data were corrected but emissions were not recalculated since they were not changed.
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\textsubscript{2} during the melting process are limestone (CaCO\textsubscript{3}), dolomite CaMg(CO\textsubscript{3})\textsubscript{2} and soda ash (Na\textsubscript{2}CO\textsubscript{3}). Also, emissions from the use of lithium carbonate (Li\textsubscript{2}CO\textsubscript{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\textsubscript{2} emissions from glass production is accomplished by applying an emission factor in tonnes of CO\textsubscript{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 4.2-5) 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 - 2015 were defined in line with requirements of the EU ETS. Verified CO\textsubscript{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 - 2015 is defined in line with requirements of the EU ETS. Verified process emissions are included in Glass Production for the period 2012 - 2015.

Table 4.2-5: Glass production (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Glass production (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>275,490</td>
</tr>
<tr>
<td>1991</td>
<td>252,936</td>
</tr>
<tr>
<td>1992</td>
<td>143,904</td>
</tr>
<tr>
<td>1993</td>
<td>134,413</td>
</tr>
<tr>
<td>1994</td>
<td>162,218</td>
</tr>
<tr>
<td>1995</td>
<td>166,810</td>
</tr>
<tr>
<td>1996</td>
<td>153,761</td>
</tr>
<tr>
<td>1997</td>
<td>127,323</td>
</tr>
<tr>
<td>1998</td>
<td>148,328</td>
</tr>
<tr>
<td>1999</td>
<td>136,263</td>
</tr>
<tr>
<td>2000</td>
<td>139,056</td>
</tr>
<tr>
<td>2001</td>
<td>150,341</td>
</tr>
<tr>
<td>2002</td>
<td>158,539</td>
</tr>
<tr>
<td>2003</td>
<td>186,973</td>
</tr>
<tr>
<td>2004</td>
<td>210,654</td>
</tr>
<tr>
<td>2005</td>
<td>227,810</td>
</tr>
<tr>
<td>2006</td>
<td>228,673</td>
</tr>
<tr>
<td>2007</td>
<td>231,481</td>
</tr>
<tr>
<td>2008</td>
<td>241,749</td>
</tr>
<tr>
<td>2009</td>
<td>236,811</td>
</tr>
<tr>
<td>2010</td>
<td>231,570</td>
</tr>
<tr>
<td>2011</td>
<td>245,959</td>
</tr>
<tr>
<td>2012</td>
<td>227,270</td>
</tr>
<tr>
<td>2013</td>
<td>251,582</td>
</tr>
<tr>
<td>2014</td>
<td>276,562</td>
</tr>
<tr>
<td>2015</td>
<td>237,801</td>
</tr>
</tbody>
</table>

The resulting emissions of CO\textsubscript{2} from Glass Production in the period 1990 - 2015 are presented in the Figure 4.2-3.
Figure 4.2-3: Emissions of CO₂ from Glass Production (1990 - 2015)

Emissions of SO₂, CO, NOₓ, NMVOC and NH₃ have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 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 CO₂ emissions reported in line with requirements of the EU ETS were used for the period 2012 – 2015. 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.

CO₂ 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

During NIR 2017 preparation, new data on glass production for periods 1991 - 1994, 1996 - 2004 and 2006 - 2013 were included (minor differences compared to the NIR 2016 – data are harmonized with data for Informative Inventory Report for LRTAP Convention for the Year 2015), but the verified emissions remained the same. Activity data were corrected but emissions were not recalculated since they were not changed.

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\textsubscript{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 from 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\textsubscript{3}) and dolomite (CaCO\textsubscript{3}·MgCO\textsubscript{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 - 2015 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\textsubscript{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\textsubscript{2} and limestone/dolomite used in a particular process (Tier 2 method, 2006 IPCC Guidelines).

Emissions of CO\textsubscript{2} from the use of limestone have been estimated by using emission factor which equals 440 kg CO\textsubscript{2}/tonne limestone.

Emissions of CO\textsubscript{2} from the use of dolomite have been estimated by using emission factor which equals 477 kg CO\textsubscript{2}/tonne dolomite. A 100 percent purity of raw material was assumed for the purpose of calculations.

Emissions of CO\textsubscript{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\textsubscript{2} and soda ash used. Default emission factor equals 415 kg CO\textsubscript{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 onwards are delivered directly by the manufacturers.

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

For the operators under EU ETS, activity data and emissions for the period 2012 - 2015 were defined in line with requirements of the EU ETS. Verified CO₂ 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 - 2015 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 - 2015.

Data on limestone and dolomite consumption in production of ceramics, data on soda ash consumption in other use and data on limestone 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 4.2.6.
Table 4.2-6: Data on carbonates consumption in production of ceramics, other use of soda ash and other (desulphurization in TPP and insulation materials) (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Ceramics (CRF 2.A.4.a)</th>
<th>Other use of soda ash (CRF 2.A.4.b)</th>
<th>Other (CRF 2.A.4.d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Limestone (t)</td>
<td>Dolomite (t)</td>
<td>Soda ash (t)</td>
</tr>
<tr>
<td>1990</td>
<td>0</td>
<td>12,098</td>
<td>0</td>
</tr>
<tr>
<td>1991</td>
<td>0</td>
<td>10,018</td>
<td>0</td>
</tr>
<tr>
<td>1992</td>
<td>0</td>
<td>9,173</td>
<td>13.75</td>
</tr>
<tr>
<td>1993</td>
<td>677</td>
<td>7,632</td>
<td>10.02</td>
</tr>
<tr>
<td>1994</td>
<td>676</td>
<td>15,722</td>
<td>12.96</td>
</tr>
<tr>
<td>1995</td>
<td>575</td>
<td>6,541</td>
<td>17.05</td>
</tr>
<tr>
<td>1996</td>
<td>731</td>
<td>8,323</td>
<td>13.37</td>
</tr>
<tr>
<td>1997</td>
<td>784</td>
<td>0</td>
<td>13.78</td>
</tr>
<tr>
<td>1998</td>
<td>826</td>
<td>0</td>
<td>10.96</td>
</tr>
<tr>
<td>1999</td>
<td>529</td>
<td>0</td>
<td>12.86</td>
</tr>
<tr>
<td>2000</td>
<td>834</td>
<td>585</td>
<td>14.04</td>
</tr>
<tr>
<td>2001</td>
<td>990</td>
<td>623</td>
<td>14.75</td>
</tr>
<tr>
<td>2002</td>
<td>882</td>
<td>850</td>
<td>16.36</td>
</tr>
<tr>
<td>2003</td>
<td>467</td>
<td>1,180</td>
<td>14.70</td>
</tr>
<tr>
<td>2004</td>
<td>667</td>
<td>1,360</td>
<td>15.71</td>
</tr>
<tr>
<td>2005</td>
<td>658</td>
<td>12,567</td>
<td>14.32</td>
</tr>
<tr>
<td>2006</td>
<td>455</td>
<td>15,564</td>
<td>16.19</td>
</tr>
<tr>
<td>2007</td>
<td>781</td>
<td>15,776</td>
<td>16.86</td>
</tr>
<tr>
<td>2008</td>
<td>720</td>
<td>12,828</td>
<td>15.17</td>
</tr>
<tr>
<td>2009</td>
<td>4,914</td>
<td>9,982</td>
<td>13.99</td>
</tr>
<tr>
<td>2010</td>
<td>13,137</td>
<td>3,880</td>
<td>18.96</td>
</tr>
<tr>
<td>2011</td>
<td>24,564</td>
<td>2,820</td>
<td>21.39</td>
</tr>
<tr>
<td>2012</td>
<td>19,003</td>
<td>1,662</td>
<td>21.23</td>
</tr>
<tr>
<td>2013</td>
<td>4,477</td>
<td>4,086</td>
<td>13.57</td>
</tr>
<tr>
<td>2014</td>
<td>6,586</td>
<td>4,086</td>
<td>14.67</td>
</tr>
<tr>
<td>2015</td>
<td>11,035</td>
<td>7,514</td>
<td>16.27</td>
</tr>
</tbody>
</table>

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 - 2015 are presented in the Figure 4.2-4. The resulting emissions of CO$_2$ from Other use of soda ash in the period 1990 - 2015 are presented in the Figure 4.2-5.
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 CO₂ emissions reported in line with requirements of the EU ETS were used for the period 2012 – 2014. 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

New data for soda ash use for 2013 and 2014 were provided. Accordingly, recalculations were performed for the years 2013 and 2014.

During NIR 2017 preparation, 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. It should be noted that this allocation by categories do not influence on the emissions for entire reporting period for 2.A.4 (emissions were not recalculated since they were not changed, except previous mentioned correction for 2013 and 2014).

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 CO₂ 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 2015, 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 (NH₃). 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 CO₂, the amine solution is preheated and regenerated which results in removing the CO₂ by steam stripping and then by heating. The CO₂ 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. CO₂ emission occurring from natural gas used as feedstock and fuel has been calculated for this subsector. Tier 3 method are used for CO₂ 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/m³) has been estimated from volume fraction of CH₄, C₂H₆, C₃H₈, C₄H₁₀, C₅H₁₂, CO₂ and N₂ in natural gas. Measurements are performed daily, at standard conditions (1 atm, 15°C). Therefore, molar volume were corrected \( V = \frac{R \times T}{p} = 23.64 \text{ dm}^3 \). Natural gas composition is determined by an accredited chromatographic “in house” method COMPOSITION OF NATURAL GAS. CALCULATION OF LOWER CALORIFIC VALUE AND DENSITY. CHROMATOGRAPHIC METHOD NR. 69-08-2-5-9-830/0307. Calculation of lower heating value is done according to norm HRN ISO 6976:2008 Natural gas – Calculation of heating values, density, relative density and Wobbe index from composition.

Data included in emissions estimation are aligned with the data included in the EU ETS reports (2012 – 2015). Methodology used for the CO₂ 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 - 2015 is defined in line with requirements of the EU ETS.

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural gas consumption (m³)</th>
<th>Natural gas consumption (m³)</th>
<th>Natural gas consumption (GJ)</th>
<th>Carbon content factor of the fuel (kg C/GJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feedstock</td>
<td>Fuel</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>242,905,233</td>
<td>158,223,414</td>
<td>13,879,452</td>
<td>15.182</td>
</tr>
<tr>
<td>1991</td>
<td>230,492,226</td>
<td>161,579,316</td>
<td>13,701,332</td>
<td>15.218</td>
</tr>
<tr>
<td>1992</td>
<td>299,567,927</td>
<td>199,801,218</td>
<td>17,272,679</td>
<td>15.235</td>
</tr>
<tr>
<td>1993</td>
<td>238,269,046</td>
<td>173,831,568</td>
<td>14,238,900</td>
<td>14.824</td>
</tr>
<tr>
<td>1994</td>
<td>239,717,137</td>
<td>176,937,060</td>
<td>14,179,159</td>
<td>15.062</td>
</tr>
<tr>
<td>1995</td>
<td>232,773,362</td>
<td>199,321,324</td>
<td>14,759,490</td>
<td>15.080</td>
</tr>
<tr>
<td>1996</td>
<td>254,116,356</td>
<td>172,383,212</td>
<td>14,459,188</td>
<td>15.114</td>
</tr>
<tr>
<td>1997</td>
<td>277,311,935</td>
<td>189,155,505</td>
<td>15,815,579</td>
<td>15.043</td>
</tr>
<tr>
<td>1998</td>
<td>207,973,360</td>
<td>145,686,203</td>
<td>11,991,181</td>
<td>15.044</td>
</tr>
<tr>
<td>1999</td>
<td>262,772,017</td>
<td>190,298,670</td>
<td>15,383,109</td>
<td>15.060</td>
</tr>
</tbody>
</table>
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 (i.e. urea, NPK, dry ice) is substracted from the CO\(_2\) emission.

According to the submitted data, the whole amount of urea, dry ice and fertilizer which are produce in this process actually applied in Agriculture. CO\(_2\) emission are estimated in 3. IPCC Sector.

### Table 4.3-2: CO\(_2\) recovered for downstream use (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>(R_{CO2}) - urea (t)</th>
<th>(R_{CO2}) - NPK (t)</th>
<th>(R_{CO2}) - dry ice, other (t)</th>
<th>(R_{CO2}) - total (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>208,896.5</td>
<td>5,049.0</td>
<td>6,568.0</td>
<td>220,513.5</td>
</tr>
<tr>
<td>1991</td>
<td>248,296.1</td>
<td>5,323.0</td>
<td>6,568.0</td>
<td>260,187.1</td>
</tr>
<tr>
<td>1992</td>
<td>273,809.1</td>
<td>3,182.0</td>
<td>8,772.0</td>
<td>285,763.1</td>
</tr>
<tr>
<td>1993</td>
<td>211,675.7</td>
<td>2,740.0</td>
<td>8,872.0</td>
<td>223,287.7</td>
</tr>
<tr>
<td>1994</td>
<td>213,692.4</td>
<td>2,089.0</td>
<td>5,421.0</td>
<td>221,202.4</td>
</tr>
<tr>
<td>1995</td>
<td>241,286.6</td>
<td>1,146.0</td>
<td>7,022.0</td>
<td>249,454.6</td>
</tr>
<tr>
<td>1996</td>
<td>270,528.1</td>
<td>1,411.0</td>
<td>7,984.0</td>
<td>279,923.1</td>
</tr>
<tr>
<td>1997</td>
<td>283,199.6</td>
<td>1,476.0</td>
<td>9,948.0</td>
<td>294,623.6</td>
</tr>
<tr>
<td>1998</td>
<td>219,196.8</td>
<td>558.0</td>
<td>8,543.0</td>
<td>228,297.8</td>
</tr>
</tbody>
</table>
The resulting emissions of CO$_2$ from Ammonia Production in the period 1990 - 2015 are presented in the Figure 4.3-1.

Figure 4.3-1: Emissions of CO$_2$ from Ammonia Production (1990 – 2015)
Tier 1 method are used for CH$_4$ and N$_2$O 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$_2$O/TJ are used (2006 IPCC Guidelines).

<table>
<thead>
<tr>
<th>Year</th>
<th>CH$_4$ from fuel (kt)</th>
<th>N$_2$O from fuel (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>0.005475</td>
<td>0.000547</td>
</tr>
<tr>
<td>1991</td>
<td>0.005647</td>
<td>0.000565</td>
</tr>
<tr>
<td>1992</td>
<td>0.006911</td>
<td>0.000691</td>
</tr>
<tr>
<td>1993</td>
<td>0.006006</td>
<td>0.000601</td>
</tr>
<tr>
<td>1994</td>
<td>0.006021</td>
<td>0.000602</td>
</tr>
<tr>
<td>1995</td>
<td>0.006808</td>
<td>0.000681</td>
</tr>
<tr>
<td>1996</td>
<td>0.005844</td>
<td>0.000584</td>
</tr>
<tr>
<td>1997</td>
<td>0.006413</td>
<td>0.000641</td>
</tr>
<tr>
<td>1998</td>
<td>0.004940</td>
<td>0.000494</td>
</tr>
<tr>
<td>1999</td>
<td>0.006461</td>
<td>0.000646</td>
</tr>
<tr>
<td>2000</td>
<td>0.006837</td>
<td>0.000684</td>
</tr>
<tr>
<td>2001</td>
<td>0.005434</td>
<td>0.000543</td>
</tr>
<tr>
<td>2002</td>
<td>0.004632</td>
<td>0.000463</td>
</tr>
<tr>
<td>2003</td>
<td>0.005519</td>
<td>0.000552</td>
</tr>
<tr>
<td>2004</td>
<td>0.006378</td>
<td>0.000638</td>
</tr>
<tr>
<td>2005</td>
<td>0.006315</td>
<td>0.000631</td>
</tr>
<tr>
<td>2006</td>
<td>0.006068</td>
<td>0.000607</td>
</tr>
<tr>
<td>2007</td>
<td>0.006540</td>
<td>0.000654</td>
</tr>
<tr>
<td>2008</td>
<td>0.006602</td>
<td>0.000660</td>
</tr>
<tr>
<td>2009</td>
<td>0.005747</td>
<td>0.000575</td>
</tr>
<tr>
<td>2010</td>
<td>0.007547</td>
<td>0.000755</td>
</tr>
<tr>
<td>2011</td>
<td>0.007522</td>
<td>0.000752</td>
</tr>
<tr>
<td>2012</td>
<td>0.005862</td>
<td>0.000586</td>
</tr>
<tr>
<td>2013</td>
<td>0.006077</td>
<td>0.000608</td>
</tr>
<tr>
<td>2014</td>
<td>0.006715</td>
<td>0.000672</td>
</tr>
<tr>
<td>2015</td>
<td>0.006708</td>
<td>0.000671</td>
</tr>
</tbody>
</table>

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 2015 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 programme 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$_2$O emission estimate associated with activity data amounts to 5 percent, based on information provided by manufacturer. Uncertainty of N$_2$O 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

There are no source-specific recalculations in this report.

4.3.1.6. Category-specific planned improvements

More detailed information about use of urea and dry ice are planned to be investigated for future reports (long-term goal).

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

4.3.2.1. Category description

In 1990, N₂O emissions from nitric acid production contributed 2.4 percent to the total GHG emissions in Croatia (without LULUCF). In 2014, N₂O emissions contributed 1.3 percent to the total GHG emissions.

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 N₂O 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 \(\text{N}_2\text{O}/\text{tonne nitric acid}\) for UNIT 1 and 7.8 kg \(\text{N}_2\text{O}/\text{tonne nitric acid}\) for UNIT 2) have been obtained from the manufacturer (Fertilizer Company). Abatement technology ‘catalytic decomposition’ is used for \(\text{N}_2\text{O}\) emission reduction in nitric acid production. \(\text{N}_2\text{O}\) emission reduction up to 88\% can be achieved by installing the catalyst. The operator use measurement-based methodologies on continuous emission measurement systems for \(\text{N}_2\text{O}\) 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 (\(\text{N}_2\text{O}\)) include Analyzer: ABB, model EL 3020 Uras 26. Principle of measurement for the \(\text{N}_2\text{O}\) 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 - 2015 were defined in line with requirements of the EU ETS. Verified \(\text{N}_2\text{O}\) 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 - 2015.

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 production unit were performed. Verification of activity data and emissions for the period 2012 - 2015 is defined in line with requirements of the EU ETS.

### Table 4.3-4: Nitric acid production (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Nitric acid production UNIT 1 (t)</th>
<th>Nitric acid production UNIT 2 (t)</th>
<th>Nitric acid production TOTAL (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>206,962</td>
<td>125,497</td>
<td>332,459</td>
</tr>
<tr>
<td>1991</td>
<td>178,267</td>
<td>113,730</td>
<td>291,997</td>
</tr>
</tbody>
</table>

\(^2\) Determined on the basis of measurements done in previous years.
<table>
<thead>
<tr>
<th>Year</th>
<th>Nitric acid production UNIT 1 (t)</th>
<th>Nitric acid production UNIT 2 (t)</th>
<th>Nitric acid production TOTAL (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>248,601</td>
<td>133,196</td>
<td>381,797</td>
</tr>
<tr>
<td>1993</td>
<td>187,465</td>
<td>100,339</td>
<td>287,805</td>
</tr>
<tr>
<td>1994</td>
<td>192,133</td>
<td>119,103</td>
<td>311,236</td>
</tr>
<tr>
<td>1995</td>
<td>199,251</td>
<td>100,046</td>
<td>299,297</td>
</tr>
<tr>
<td>1996</td>
<td>179,387</td>
<td>99,296</td>
<td>278,683</td>
</tr>
<tr>
<td>1997</td>
<td>175,990</td>
<td>116,902</td>
<td>292,892</td>
</tr>
<tr>
<td>1998</td>
<td>132,760</td>
<td>87,749</td>
<td>220,509</td>
</tr>
<tr>
<td>1999</td>
<td>163,204</td>
<td>96,994</td>
<td>260,198</td>
</tr>
<tr>
<td>2000</td>
<td>199,027</td>
<td>107,174</td>
<td>306,201</td>
</tr>
<tr>
<td>2001</td>
<td>181,263</td>
<td>76,271</td>
<td>257,534</td>
</tr>
<tr>
<td>2002</td>
<td>160,789</td>
<td>89,203</td>
<td>249,992</td>
</tr>
<tr>
<td>2003</td>
<td>132,470</td>
<td>103,176</td>
<td>235,646</td>
</tr>
<tr>
<td>2004</td>
<td>189,608</td>
<td>97,959</td>
<td>287,567</td>
</tr>
<tr>
<td>2005</td>
<td>176,988</td>
<td>103,758</td>
<td>280,746</td>
</tr>
<tr>
<td>2006</td>
<td>177,916</td>
<td>99,673</td>
<td>277,590</td>
</tr>
<tr>
<td>2007</td>
<td>204,984</td>
<td>101,635</td>
<td>306,619</td>
</tr>
<tr>
<td>2008</td>
<td>196,676</td>
<td>116,252</td>
<td>312,928</td>
</tr>
<tr>
<td>2009</td>
<td>163,042</td>
<td>98,436</td>
<td>261,478</td>
</tr>
<tr>
<td>2010</td>
<td>199,650</td>
<td>137,145</td>
<td>336,794</td>
</tr>
<tr>
<td>2011</td>
<td>217,288</td>
<td>115,425</td>
<td>332,713</td>
</tr>
<tr>
<td>2012</td>
<td>196,200</td>
<td>92,007</td>
<td>288,207</td>
</tr>
<tr>
<td>2013</td>
<td>186,777</td>
<td>110,768</td>
<td>297,545</td>
</tr>
<tr>
<td>2014</td>
<td>196,873</td>
<td>110,424</td>
<td>307,296</td>
</tr>
<tr>
<td>2015</td>
<td>236,151</td>
<td>108,487</td>
<td>344,638</td>
</tr>
</tbody>
</table>

The resulting emissions of N₂O from Nitric Acid Production in the period 1990 - 2015 are presented in the Figure 4.3-2.
Figure 4.3-2: Emissions of N₂O from Nitric Acid Production (1990 - 2015)

Emissions of NOₓ and NH₃ have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 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 N₂O from nitric acid production are due to applied emission factor. This plant-specific EF does not completely outline the real value, because Fertilizer Company does not continuously measure N₂O emissions. In the future, this company will perform continuously measurement of N₂O emissions.

Activity data and emission factor uncertainty was calculated in detail. 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 2014, 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 CO₂ emissions reported in line with requirements of the EU ETS were used for the period 2012 – 2015. Methodology proposed by the Guidelines for the

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

4.3.2.5. 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 N₂O 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.
4.3.5. Carbide production (2.B.5)

This category does not exist in Croatia.

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

This category does not exist in Croatia.

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

This category does not exist in Croatia.

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

4.3.8.1. 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.

4.3.8.2. 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. 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 - 2015 are reported in the Table 4.3-6.
### Table 4.3-5: Annual production of chemicals (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Carbon black (t)</th>
<th>Ethylene (t)</th>
<th>Ethylene dichloride (t)</th>
<th>Methanol (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>30,624</td>
<td>72,631</td>
<td>72,653</td>
<td>0.00</td>
</tr>
<tr>
<td>1991</td>
<td>18,783</td>
<td>66,871</td>
<td>68,325</td>
<td>0.00</td>
</tr>
<tr>
<td>1992</td>
<td>13,479</td>
<td>68,318</td>
<td>92,089</td>
<td>0.00</td>
</tr>
<tr>
<td>1993</td>
<td>17,123</td>
<td>68,634</td>
<td>79,608</td>
<td>0.00</td>
</tr>
<tr>
<td>1994</td>
<td>21,468</td>
<td>65,285</td>
<td>97,528</td>
<td>0.00</td>
</tr>
<tr>
<td>1995</td>
<td>27,185</td>
<td>67,547</td>
<td>84,374</td>
<td>0.00</td>
</tr>
<tr>
<td>1996</td>
<td>26,735</td>
<td>64,782</td>
<td>48,631</td>
<td>0.00</td>
</tr>
<tr>
<td>1997</td>
<td>24,214</td>
<td>63,554</td>
<td>26,264</td>
<td>0.00</td>
</tr>
<tr>
<td>1998</td>
<td>24,087</td>
<td>60,148</td>
<td>31,308</td>
<td>0.00</td>
</tr>
<tr>
<td>1999</td>
<td>20,627</td>
<td>60,295</td>
<td>47,686</td>
<td>0.00</td>
</tr>
<tr>
<td>2000</td>
<td>20,029</td>
<td>38,918</td>
<td>71,364</td>
<td>0.00</td>
</tr>
<tr>
<td>2001</td>
<td>21,180</td>
<td>46,632</td>
<td>64,442</td>
<td>0.00</td>
</tr>
<tr>
<td>2002</td>
<td>19,416</td>
<td>43,554</td>
<td>0.00</td>
<td>3.72</td>
</tr>
<tr>
<td>2003</td>
<td>21,295</td>
<td>41,252</td>
<td>0.00</td>
<td>3.80</td>
</tr>
<tr>
<td>2004</td>
<td>20,272</td>
<td>49,886</td>
<td>0.00</td>
<td>2.93</td>
</tr>
<tr>
<td>2005</td>
<td>18,498</td>
<td>50,263</td>
<td>0.00</td>
<td>2.95</td>
</tr>
<tr>
<td>2006</td>
<td>26,264</td>
<td>48,824</td>
<td>0.00</td>
<td>2.03</td>
</tr>
<tr>
<td>2007</td>
<td>23,724</td>
<td>45,438</td>
<td>0.00</td>
<td>2.00</td>
</tr>
<tr>
<td>2008</td>
<td>16,904</td>
<td>43,045</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>2009</td>
<td>3,976</td>
<td>38,797</td>
<td>0.00</td>
<td>0.87</td>
</tr>
<tr>
<td>2010</td>
<td>0.00</td>
<td>36,271</td>
<td>0.00</td>
<td>1.92</td>
</tr>
<tr>
<td>2011</td>
<td>0.00</td>
<td>23,323</td>
<td>0.00</td>
<td>3.17</td>
</tr>
<tr>
<td>2012</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.01</td>
</tr>
<tr>
<td>2013</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.94</td>
</tr>
<tr>
<td>2014</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.95</td>
</tr>
<tr>
<td>2015</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.95</td>
</tr>
</tbody>
</table>

### Table 4.3-6: Emissions of CO₂ and CH₄ from Petrochemical and Carbon Black Production (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Carbon black (t)</th>
<th>Ethylene (t)</th>
<th>Ethylene dichloride (t)</th>
<th>Methanol (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ (kt)</td>
<td>CH₄ (kt)</td>
<td>CO₂ (kt)</td>
<td>CH₄ (kt)</td>
<td>CO₂ (kt)</td>
</tr>
<tr>
<td>1990</td>
<td>80.235</td>
<td>0.002</td>
<td>125.652</td>
<td>0.218</td>
</tr>
<tr>
<td>1991</td>
<td>49.211</td>
<td>0.001</td>
<td>115.687</td>
<td>0.201</td>
</tr>
<tr>
<td>1992</td>
<td>35.315</td>
<td>0.001</td>
<td>118.190</td>
<td>0.205</td>
</tr>
<tr>
<td>1993</td>
<td>44.862</td>
<td>0.001</td>
<td>118.737</td>
<td>0.206</td>
</tr>
<tr>
<td>1994</td>
<td>56.246</td>
<td>0.001</td>
<td>112.943</td>
<td>0.196</td>
</tr>
<tr>
<td>1995</td>
<td>71.225</td>
<td>0.002</td>
<td>116.856</td>
<td>0.203</td>
</tr>
<tr>
<td>1996</td>
<td>70.046</td>
<td>0.002</td>
<td>112.073</td>
<td>0.194</td>
</tr>
<tr>
<td>1997</td>
<td>63.441</td>
<td>0.001</td>
<td>109.948</td>
<td>0.191</td>
</tr>
<tr>
<td>1998</td>
<td>65.108</td>
<td>0.001</td>
<td>104.056</td>
<td>0.180</td>
</tr>
<tr>
<td>1999</td>
<td>54.043</td>
<td>0.001</td>
<td>104.310</td>
<td>0.181</td>
</tr>
<tr>
<td>2000</td>
<td>52.476</td>
<td>0.001</td>
<td>67.328</td>
<td>0.117</td>
</tr>
<tr>
<td>2001</td>
<td>55.492</td>
<td>0.001</td>
<td>80.673</td>
<td>0.140</td>
</tr>
</tbody>
</table>
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 2015 Submission to the Convention on Long-range Transboundary Air Pollution’.

4.3.8.3. 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.
4.3.8.4. 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.

4.3.8.5. Category-specific recalculations

A mistake has been made for the data on ethylene production in 2014. There was no production on ethylene in 2014 and value amounted to zero. Accordingly, recalculation were performed for the year 2014.

4.3.8.6. Category-specific planned improvements

As explained, 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 the data for using higher tier methodology. It was included in the Annual data collection programme 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.

4.3.9. 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.

Steel Production

$^3$ 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.
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.

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:

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

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 - 2015 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 - 2015 is defined in line with requirements of the EU ETS. Verified process emissions are included in Steel Production for the period 2012 - 2015.

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. 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>
<thead>
<tr>
<th>Year</th>
<th>Scrap iron (t)</th>
<th>Steel scrap (t)</th>
<th>EAF carbon electrodes (t)</th>
<th>EAF charge carbon (t)</th>
<th>Petroleum coke (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>2,500</td>
<td>173,588</td>
<td>1,180</td>
<td>121</td>
<td>0</td>
</tr>
<tr>
<td>1991</td>
<td>13,221</td>
<td>119,396</td>
<td>982</td>
<td>106</td>
<td>600</td>
</tr>
<tr>
<td>1992</td>
<td>17,866</td>
<td>96,221</td>
<td>927</td>
<td>88</td>
<td>327</td>
</tr>
<tr>
<td>1993</td>
<td>23,557</td>
<td>60,799</td>
<td>627</td>
<td>63</td>
<td>253</td>
</tr>
<tr>
<td>1994</td>
<td>14,892</td>
<td>56,777</td>
<td>550</td>
<td>122</td>
<td>68</td>
</tr>
<tr>
<td>Year</td>
<td>Scrap iron (t)</td>
<td>Steel scrap (t)</td>
<td>EAF carbon electrodes (t)</td>
<td>EAF charge carbon (t)</td>
<td>Petroleum coke (t)</td>
</tr>
<tr>
<td>------</td>
<td>----------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>----------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>1995</td>
<td>10,559</td>
<td>41,661</td>
<td>346</td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td>1996</td>
<td>12,858</td>
<td>38,966</td>
<td>312</td>
<td>12</td>
<td>191</td>
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<tr>
<td>1997</td>
<td>18,233</td>
<td>61,114</td>
<td>468</td>
<td>7</td>
<td>369</td>
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<tr>
<td>1998</td>
<td>31,968</td>
<td>84,281</td>
<td>698</td>
<td>100</td>
<td>246</td>
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<tr>
<td>1999</td>
<td>11,743</td>
<td>72,647</td>
<td>557</td>
<td>78</td>
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<td>2000</td>
<td>7,845</td>
<td>70,363</td>
<td>462</td>
<td>67</td>
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<td>2001</td>
<td>7,003</td>
<td>55,100</td>
<td>375</td>
<td>60</td>
<td>118</td>
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<td>2002</td>
<td>5,324</td>
<td>29,121</td>
<td>213</td>
<td>292</td>
<td>115</td>
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<tr>
<td>2003</td>
<td>15,934</td>
<td>29,777</td>
<td>223</td>
<td>240</td>
<td>215</td>
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<tr>
<td>2004</td>
<td>20,409</td>
<td>76,594</td>
<td>417</td>
<td>737</td>
<td>274</td>
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<tr>
<td>2005</td>
<td>7,818</td>
<td>77,641</td>
<td>286</td>
<td>745</td>
<td>99</td>
</tr>
<tr>
<td>2006</td>
<td>5,510</td>
<td>87,978</td>
<td>331</td>
<td>886</td>
<td>177</td>
</tr>
<tr>
<td>2007</td>
<td>4,523</td>
<td>85,054</td>
<td>351</td>
<td>967</td>
<td>97</td>
</tr>
<tr>
<td>2008</td>
<td>31,421</td>
<td>130,815</td>
<td>713</td>
<td>1,418</td>
<td>399</td>
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<tr>
<td>2009</td>
<td>25,531</td>
<td>26,293</td>
<td>333</td>
<td>4</td>
<td>376</td>
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<tr>
<td>2010</td>
<td>82,659</td>
<td>38,797</td>
<td>649</td>
<td>283</td>
<td>1,550</td>
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<tr>
<td>2011</td>
<td>83,790</td>
<td>25,331</td>
<td>396</td>
<td>973</td>
<td>1,637</td>
</tr>
<tr>
<td>2012</td>
<td>1,233</td>
<td>0</td>
<td>5</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>2013</td>
<td>59,448</td>
<td>4,785</td>
<td>221</td>
<td>558</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
<td>186,197</td>
<td>14,238</td>
<td>580</td>
<td>1,774</td>
<td>2,247</td>
</tr>
<tr>
<td>2015</td>
<td>152,405</td>
<td>12,707</td>
<td>479</td>
<td>1,894</td>
<td>240</td>
</tr>
</tbody>
</table>

* data have not been submitted, verified CO₂ emissions are only submitted

Table 4.4-2: Consumption of other carbon donors (input materials) and reducing fuels in EAFs (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Lime (t)</th>
<th>Other carbon donors* (t)</th>
<th>Natural gas (m³)</th>
<th>Diesel oil (t)</th>
<th>Liquefied petroleum gases (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>2,970</td>
<td>603</td>
<td>8,470,000</td>
<td>1,624</td>
<td>0</td>
</tr>
<tr>
<td>1991</td>
<td>2,095</td>
<td>262</td>
<td>5,310,000</td>
<td>960</td>
<td>0</td>
</tr>
<tr>
<td>1992</td>
<td>1,484</td>
<td>256</td>
<td>1,331,000</td>
<td>756</td>
<td>0</td>
</tr>
<tr>
<td>1993</td>
<td>2,737</td>
<td>286</td>
<td>1,547,000</td>
<td>379</td>
<td>0</td>
</tr>
<tr>
<td>1994</td>
<td>1,530</td>
<td>629</td>
<td>1,242,000</td>
<td>444</td>
<td>0</td>
</tr>
<tr>
<td>1995</td>
<td>848</td>
<td>235</td>
<td>687,000</td>
<td>398</td>
<td>0</td>
</tr>
<tr>
<td>1996</td>
<td>1,322</td>
<td>496</td>
<td>908,000</td>
<td>252</td>
<td>0</td>
</tr>
<tr>
<td>1997</td>
<td>1,729</td>
<td>695</td>
<td>1,119,000</td>
<td>429</td>
<td>0</td>
</tr>
<tr>
<td>1998</td>
<td>2,606</td>
<td>1,103</td>
<td>2,032,000</td>
<td>617</td>
<td>0</td>
</tr>
<tr>
<td>1999</td>
<td>1,468</td>
<td>518</td>
<td>1,976,000</td>
<td>495</td>
<td>0</td>
</tr>
<tr>
<td>2000</td>
<td>861</td>
<td>530</td>
<td>1,146,000</td>
<td>509</td>
<td>0</td>
</tr>
<tr>
<td>2001</td>
<td>1,047</td>
<td>449</td>
<td>1,264,000</td>
<td>334</td>
<td>0</td>
</tr>
<tr>
<td>2002</td>
<td>670</td>
<td>280</td>
<td>570,000</td>
<td>0</td>
<td>438</td>
</tr>
<tr>
<td>2003</td>
<td>1,226</td>
<td>500</td>
<td>1,505,000</td>
<td>0</td>
<td>371</td>
</tr>
<tr>
<td>2004</td>
<td>1,641</td>
<td>564</td>
<td>1,818,000</td>
<td>0</td>
<td>1,221</td>
</tr>
<tr>
<td>2005</td>
<td>555</td>
<td>289</td>
<td>1,036,000</td>
<td>0</td>
<td>1,392</td>
</tr>
<tr>
<td>2006</td>
<td>592</td>
<td>315</td>
<td>1,446,000</td>
<td>0</td>
<td>1,642</td>
</tr>
<tr>
<td>Year</td>
<td>Lime (t)</td>
<td>Other carbon donors* (t)</td>
<td>Natural gas (m3)</td>
<td>Diesel oil (t)</td>
<td>Liquefied petroleum gases (t)</td>
</tr>
<tr>
<td>------</td>
<td>----------</td>
<td>-------------------------</td>
<td>-----------------</td>
<td>--------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>2007</td>
<td>386</td>
<td>180</td>
<td>1,033,000</td>
<td>0</td>
<td>1,661</td>
</tr>
<tr>
<td>2008</td>
<td>2,559</td>
<td>366</td>
<td>2,311,000</td>
<td>0</td>
<td>2,041</td>
</tr>
<tr>
<td>2009</td>
<td>2,327</td>
<td>317</td>
<td>2,839,000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2010</td>
<td>5,229</td>
<td>463</td>
<td>4,016,000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2011</td>
<td>4,891</td>
<td>1188</td>
<td>4,016,000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2012</td>
<td>47</td>
<td>30</td>
<td>40,266</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2013</td>
<td>2,449</td>
<td>1,985</td>
<td>2,061,350</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
<td>7,993</td>
<td>5,518</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2015</td>
<td>6,263</td>
<td>5,020</td>
<td>2,967,484</td>
<td>0.4</td>
<td>0</td>
</tr>
</tbody>
</table>

* 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

<table>
<thead>
<tr>
<th>Carbon donors</th>
<th>EF (t CO(_2)/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrap iron</td>
<td>0.15</td>
</tr>
<tr>
<td>Steel scrap</td>
<td>0.008</td>
</tr>
<tr>
<td>EAF carbon electrodes</td>
<td>3.00</td>
</tr>
<tr>
<td>EAF charge carbon</td>
<td>3.04</td>
</tr>
<tr>
<td>Petroleum coked</td>
<td>3.19</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Reducing fuels</th>
<th>EF (t CO(_2)/TJ)</th>
<th>NCV (TJ/Gg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>56.10</td>
<td>34.00</td>
</tr>
<tr>
<td>Gas/Diesel oil</td>
<td>74.07</td>
<td>42.71</td>
</tr>
<tr>
<td>Liquefied petroleum gases</td>
<td>63.07</td>
<td>46.89</td>
</tr>
</tbody>
</table>

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 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Steel production (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>171,148</td>
</tr>
<tr>
<td>1991</td>
<td>119,734</td>
</tr>
<tr>
<td>1992</td>
<td>101,944</td>
</tr>
</tbody>
</table>

\(^4\) 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)
<table>
<thead>
<tr>
<th>Year</th>
<th>Steel production (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>74,082</td>
</tr>
<tr>
<td>1994</td>
<td>63,355</td>
</tr>
<tr>
<td>1995</td>
<td>45,370</td>
</tr>
<tr>
<td>1996</td>
<td>45,754</td>
</tr>
<tr>
<td>1997</td>
<td>69,895</td>
</tr>
<tr>
<td>1998</td>
<td>103,204</td>
</tr>
<tr>
<td>1999</td>
<td>75,877</td>
</tr>
<tr>
<td>2000</td>
<td>69,641</td>
</tr>
<tr>
<td>2001</td>
<td>56,169</td>
</tr>
<tr>
<td>2002</td>
<td>32,789</td>
</tr>
<tr>
<td>2003</td>
<td>40,942</td>
</tr>
<tr>
<td>2004</td>
<td>86,105</td>
</tr>
<tr>
<td>2005</td>
<td>73,640</td>
</tr>
<tr>
<td>2006</td>
<td>80,517</td>
</tr>
<tr>
<td>2007</td>
<td>76,252</td>
</tr>
<tr>
<td>2008</td>
<td>138,865</td>
</tr>
<tr>
<td>2009</td>
<td>46,264</td>
</tr>
<tr>
<td>2010</td>
<td>103,427</td>
</tr>
<tr>
<td>2011</td>
<td>95,907</td>
</tr>
<tr>
<td>2012</td>
<td>5,896</td>
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<tr>
<td>2013</td>
<td>65,258</td>
</tr>
<tr>
<td>2014</td>
<td>174,620</td>
</tr>
<tr>
<td>2015</td>
<td>148,583</td>
</tr>
</tbody>
</table>

The resulting emissions of CO\textsubscript{2} from Steel Production in the period 1990 - 2015 are presented in the Figure 4.4-1. CO\textsubscript{2} emissions from limestone and dolomite use in steel production are included in total CO\textsubscript{2} emissions for this category.
CO₂ emissions fluctuated over the period. It is mainly a result of discontinuous operation, which requires increasing consumption of input materials.

Emissions of SO₂, CO, NOₓ, NMVOC and NH₃ have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 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 2014, 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 2015, accordingly to values reported in 2006 IPCC Guidelines and based on expert judgement (detailed in Annex 1).

Emissions from Steel Production have been calculated using the same method and data sets for the period 1990 – 2011. Verified CO₂ emissions reported in line with requirements of the EU ETS were used for the period 2012 – 2015. 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

New data for CO$_2$ emissions from limestone and dolomite use in steel production are included in total CO$_2$ emissions for the period 2012 – 2014. Accordingly, recalculation were performed for the period 2012 – 2014.

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)

<table>
<thead>
<tr>
<th>Year</th>
<th>Ferromanganese (t)</th>
<th>Silicon manganese (t)</th>
<th>Ferrochromium (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>20,535</td>
<td>48,561</td>
<td>60,859</td>
</tr>
<tr>
<td>1991</td>
<td>13,053</td>
<td>38,365</td>
<td>72,845</td>
</tr>
<tr>
<td>1992</td>
<td>0</td>
<td>25,572</td>
<td>56,058</td>
</tr>
<tr>
<td>1993</td>
<td>0</td>
<td>8,577</td>
<td>28,028</td>
</tr>
<tr>
<td>1994</td>
<td>562</td>
<td>22,071</td>
<td>31,704</td>
</tr>
<tr>
<td>1995</td>
<td>0</td>
<td>0</td>
<td>26,081</td>
</tr>
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<td>1996</td>
<td>0</td>
<td>0</td>
<td>10,559</td>
</tr>
<tr>
<td>1997</td>
<td>47</td>
<td>416</td>
<td>24,231</td>
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<tr>
<td>1998</td>
<td>57</td>
<td>697</td>
<td>11,861</td>
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<td>1999</td>
<td>64</td>
<td>271</td>
<td>13,807</td>
</tr>
<tr>
<td>2000</td>
<td>29</td>
<td>330</td>
<td>15,753</td>
</tr>
<tr>
<td>2001</td>
<td>43</td>
<td>297</td>
<td>361</td>
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<td>2002</td>
<td>28</td>
<td>190</td>
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</tr>
<tr>
<td>2003</td>
<td>62</td>
<td>660</td>
<td>2</td>
</tr>
</tbody>
</table>

In previous reports CO₂ 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 used 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 CO₂ and CH₄ 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 CO₂ and CH₄ from Ferroalloys Production (1990 - 2003)

<table>
<thead>
<tr>
<th>Year</th>
<th>CO₂ emissions (kt)</th>
<th>CH₄ emissions (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ferromanganese</td>
<td>Silicon</td>
</tr>
<tr>
<td>1990</td>
<td>26.70</td>
<td>67.99</td>
</tr>
<tr>
<td>1991</td>
<td>16.97</td>
<td>53.71</td>
</tr>
<tr>
<td>1992</td>
<td>0.00</td>
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<td>1993</td>
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<td>12.01</td>
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<td>1994</td>
<td>0.73</td>
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<td>0.00</td>
</tr>
<tr>
<td>1996</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1997</td>
<td>0.06</td>
<td>0.58</td>
</tr>
<tr>
<td>1998</td>
<td>0.07</td>
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<td>0.38</td>
</tr>
<tr>
<td>2000</td>
<td>0.04</td>
<td>0.46</td>
</tr>
<tr>
<td>2001</td>
<td>0.06</td>
<td>0.42</td>
</tr>
<tr>
<td>2002</td>
<td>0.04</td>
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<td>2003</td>
<td>0.08</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Annual data on reducing agents and emissions of CO₂ 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 CO₂ from Ferroalloys Production (1990 - 2003) – Tier 2

<table>
<thead>
<tr>
<th>Year</th>
<th>Coke from coal (t)</th>
<th>Coal electrodes (t)</th>
<th>CO₂ emissions (kt) Ferroalloys total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>36,216.00</td>
<td>1,824.00</td>
<td>126.03</td>
</tr>
<tr>
<td>1991</td>
<td>41,981.00</td>
<td>2,533.00</td>
<td>147.50</td>
</tr>
<tr>
<td>1992</td>
<td>25,619.00</td>
<td>1,645.00</td>
<td>90.37</td>
</tr>
<tr>
<td>1993</td>
<td>8,519.00</td>
<td>799.00</td>
<td>30.94</td>
</tr>
<tr>
<td>1994</td>
<td>8,566.00</td>
<td>988.00</td>
<td>31.77</td>
</tr>
<tr>
<td>1995</td>
<td>9,529.00</td>
<td>650.00</td>
<td>33.75</td>
</tr>
<tr>
<td>1996</td>
<td>3,860.00</td>
<td>266.00</td>
<td>13.68</td>
</tr>
<tr>
<td>1997</td>
<td>11,867.00</td>
<td>817.78</td>
<td>42.06</td>
</tr>
<tr>
<td>1998</td>
<td>5,166.00</td>
<td>356.00</td>
<td>18.31</td>
</tr>
<tr>
<td>1999</td>
<td>6,054.10</td>
<td>417.20</td>
<td>21.46</td>
</tr>
<tr>
<td>2000</td>
<td>3,624.40</td>
<td>249.76</td>
<td>12.84</td>
</tr>
<tr>
<td>2001</td>
<td>1,194.69</td>
<td>82.33</td>
<td>4.23</td>
</tr>
<tr>
<td>2002</td>
<td>4.00</td>
<td>0.28</td>
<td>0.01</td>
</tr>
<tr>
<td>2003</td>
<td>13.00</td>
<td>0.90</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Emissions of \(\text{SO}_2\), \(\text{CO}\), \(\text{NO}_x\), \(\text{NMVOC}\) and \(\text{NH}_3\) have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 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 (Al₂O₃). Following this, the alumina is electrically reduced to aluminium by smelting in large pots. This process results in emission of several greenhouse gases including CO₂, and two PFCs: CF₄ and C₂F₆.

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

4.4.3.2. Methodological issues

The quantity of CO₂ released was estimated from the production of primary aluminium and the specific consumption of carbon which is oxidized to CO₂ in the process. During alumina reduction using prebaked anodes approximately 1.5 tonnes of CO₂ is emitted for each tonne of primary aluminium produced (2006 IPCC Guidelines).

Data on primary aluminium production were collected by survey of aluminium manufacturer⁶. 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 CO₂ from Aluminium Production in 1990 amounted to about 111 kt CO₂. In 1991 about 76 kt CO₂ was emitted.

PFCs emissions from Aluminium Production could represent a significant source of emissions due to high GWP values. Since only aluminium production statistics were available, emissions of CF₄ (PFC-14) and C₂F₆ (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 CF₄ and 0.17 kg/t Al for C₂F₆ (Side Worked Prebaked Anodes). 820 kt CO₂-eq of CF₄ and

⁶ Primary aluminium production (electrolysis) were closed at the end of 1991 mainly due to war activities near the location of aluminium plant.
116 kt CO₂-eq of C₆F₆ were emitted in 1990. 563 kt CO₂-eq of CF₄ and 80 kt CO₂-eq of C₂F₆ were emitted in 1991.

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

4.4.3.3. Uncertainties and time-series consistency

Uncertainties related to calculation of CO₂ emissions are primarily due to applied emission factor. A less uncertain method to calculate CO₂ emissions would be based upon the amount of reducing agent, i.e. amount of prebaked anodes used in 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 CO₂ emissions amounts to 2 percent, based on expert judgements. Uncertainty estimate associated with default emission factor for CO₂ 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 programme 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 FUELS 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 - 2015.

The annual consumption of lubricants (see Table 4.5-1) was extracted from Energy Balance.
### Table 4.5-1: Consumption of lubricants (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumption of lubricants (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>147.46</td>
</tr>
<tr>
<td>1991</td>
<td>126.14</td>
</tr>
<tr>
<td>1992</td>
<td>89.71</td>
</tr>
<tr>
<td>1993</td>
<td>109.95</td>
</tr>
<tr>
<td>1994</td>
<td>122.26</td>
</tr>
<tr>
<td>1995</td>
<td>119.08</td>
</tr>
<tr>
<td>1996</td>
<td>128.74</td>
</tr>
<tr>
<td>1997</td>
<td>140.92</td>
</tr>
<tr>
<td>1998</td>
<td>105.53</td>
</tr>
<tr>
<td>1999</td>
<td>33.50</td>
</tr>
<tr>
<td>2000</td>
<td>30.00</td>
</tr>
<tr>
<td>2001</td>
<td>31.10</td>
</tr>
<tr>
<td>2002</td>
<td>33.60</td>
</tr>
<tr>
<td>2003</td>
<td>29.00</td>
</tr>
<tr>
<td>2004</td>
<td>39.40</td>
</tr>
<tr>
<td>2005</td>
<td>35.40</td>
</tr>
<tr>
<td>2006</td>
<td>38.10</td>
</tr>
<tr>
<td>2007</td>
<td>45.10</td>
</tr>
<tr>
<td>2008</td>
<td>38.90</td>
</tr>
<tr>
<td>2009</td>
<td>37.30</td>
</tr>
<tr>
<td>2010</td>
<td>33.20</td>
</tr>
<tr>
<td>2011</td>
<td>33.40</td>
</tr>
<tr>
<td>2012</td>
<td>29.70</td>
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<tr>
<td>2013</td>
<td>28.70</td>
</tr>
<tr>
<td>2014</td>
<td>29.80</td>
</tr>
<tr>
<td>2015</td>
<td>32.20</td>
</tr>
</tbody>
</table>

Emissions of CO₂ from Lubricants in the period 1990 - 2015 are presented in the Table 4.5-2.

### Table 4.5-2: Emissions of CO₂ from Lubricant (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>CO₂ emissions from lubricants use (kt CO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>72.60</td>
</tr>
<tr>
<td>1991</td>
<td>61.98</td>
</tr>
<tr>
<td>1992</td>
<td>44.08</td>
</tr>
<tr>
<td>1993</td>
<td>54.02</td>
</tr>
<tr>
<td>1994</td>
<td>60.07</td>
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<tr>
<td>1995</td>
<td>53.04</td>
</tr>
<tr>
<td>1996</td>
<td>63.26</td>
</tr>
<tr>
<td>1997</td>
<td>69.95</td>
</tr>
<tr>
<td>1998</td>
<td>52.57</td>
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<tr>
<td>1999</td>
<td>16.46</td>
</tr>
<tr>
<td>2000</td>
<td>14.74</td>
</tr>
<tr>
<td>2001</td>
<td>15.28</td>
</tr>
<tr>
<td>2002</td>
<td>16.51</td>
</tr>
</tbody>
</table>
### Yearly CO₂ emissions from lubricants use (kt CO₂)

<table>
<thead>
<tr>
<th>Year</th>
<th>CO₂ emissions from lubricants use (kt CO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>14.25</td>
</tr>
<tr>
<td>2004</td>
<td>19.36</td>
</tr>
<tr>
<td>2005</td>
<td>17.39</td>
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<tr>
<td>2006</td>
<td>18.72</td>
</tr>
<tr>
<td>2007</td>
<td>22.16</td>
</tr>
<tr>
<td>2008</td>
<td>19.11</td>
</tr>
<tr>
<td>2009</td>
<td>18.33</td>
</tr>
<tr>
<td>2010</td>
<td>16.31</td>
</tr>
<tr>
<td>2011</td>
<td>16.41</td>
</tr>
<tr>
<td>2012</td>
<td>14.59</td>
</tr>
<tr>
<td>2013</td>
<td>14.10</td>
</tr>
<tr>
<td>2014</td>
<td>14.64</td>
</tr>
<tr>
<td>2015</td>
<td>15.82</td>
</tr>
</tbody>
</table>

**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 CO₂ emissions calculation resulting by consumption of all types of lubricants amounts to 5 percent, based on expert judgement.

Uncertainty estimate associated with default CO₂ 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**

In the previous report, aggregate data for lubricant and paraffin wax have been used for CO₂ emission calculation. In this report, activity data for lubricant use have been separated by data for paraffin wax use that is in line with 2006 IPCC Guidelines. Accordingly, recalculation were performed for entire period 1990 - 2014.
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. Paraffin 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\textsubscript{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\textsubscript{2}/C (44/12) have been used for CO\textsubscript{2} emission calculation for entire period 1990 - 2015.

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumption of paraffin wax (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>46.34</td>
</tr>
<tr>
<td>1991</td>
<td>39.64</td>
</tr>
<tr>
<td>1992</td>
<td>28.19</td>
</tr>
<tr>
<td>1993</td>
<td>34.55</td>
</tr>
<tr>
<td>1994</td>
<td>38.42</td>
</tr>
<tr>
<td>1995</td>
<td>37.42</td>
</tr>
<tr>
<td>1996</td>
<td>40.46</td>
</tr>
<tr>
<td>1997</td>
<td>44.28</td>
</tr>
<tr>
<td>1998</td>
<td>33.17</td>
</tr>
<tr>
<td>1999</td>
<td>9.80</td>
</tr>
<tr>
<td>2000</td>
<td>10.50</td>
</tr>
</tbody>
</table>
#### Table 4.5-4: Emissions of CO$_2$ from Paraffin Wax Use (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>CO$_2$ emissions from paraffin wax use (kt CO$_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>22.82</td>
</tr>
<tr>
<td>1991</td>
<td>19.48</td>
</tr>
<tr>
<td>1992</td>
<td>13.85</td>
</tr>
<tr>
<td>1993</td>
<td>16.98</td>
</tr>
<tr>
<td>1994</td>
<td>18.88</td>
</tr>
<tr>
<td>1995</td>
<td>16.67</td>
</tr>
<tr>
<td>1996</td>
<td>19.88</td>
</tr>
<tr>
<td>1997</td>
<td>21.98</td>
</tr>
<tr>
<td>1998</td>
<td>16.52</td>
</tr>
<tr>
<td>1999</td>
<td>4.82</td>
</tr>
<tr>
<td>2000</td>
<td>5.16</td>
</tr>
<tr>
<td>2001</td>
<td>4.91</td>
</tr>
<tr>
<td>2002</td>
<td>4.82</td>
</tr>
<tr>
<td>2003</td>
<td>5.55</td>
</tr>
<tr>
<td>2004</td>
<td>5.31</td>
</tr>
<tr>
<td>2005</td>
<td>5.40</td>
</tr>
<tr>
<td>2006</td>
<td>5.45</td>
</tr>
<tr>
<td>2007</td>
<td>5.36</td>
</tr>
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<td>2008</td>
<td>4.67</td>
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<td>2009</td>
<td>4.47</td>
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<td>2010</td>
<td>3.88</td>
</tr>
<tr>
<td>2011</td>
<td>3.78</td>
</tr>
<tr>
<td>2012</td>
<td>3.05</td>
</tr>
</tbody>
</table>
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\textsubscript{2} emissions calculation resulting by consumption of paraffin wax amounts to 5 percent, based on expert judgement.

Uncertainty estimate associated with default CO\textsubscript{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

In the previous report, aggregate data for lubricant and paraffin wax have been used for CO\textsubscript{2} emission calculation. In this report, activity data for paraffin wax use have been separated by data for lubricant use that is in line with 2006 IPCC Guidelines. Accordingly, recalculation were performed for entire period 1990 - 2014.

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 2015 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 – 2015.

The resulting emissions of CO$_2$ from Solvent Use in the period 1990 - 2015 are presented in the Table 4.5-5.

Table 4.5-5: Emissions of CO$_2$ from Solvent Use (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>CO$_2$ emission (kt CO$_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>93.994</td>
</tr>
<tr>
<td>1991</td>
<td>63.604</td>
</tr>
<tr>
<td>1992</td>
<td>43.253</td>
</tr>
<tr>
<td>1993</td>
<td>43.766</td>
</tr>
<tr>
<td>1994</td>
<td>44.550</td>
</tr>
<tr>
<td>1995</td>
<td>43.648</td>
</tr>
<tr>
<td>1996</td>
<td>46.816</td>
</tr>
<tr>
<td>1997</td>
<td>49.081</td>
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<tr>
<td>1998</td>
<td>46.086</td>
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<tr>
<td>1999</td>
<td>39.531</td>
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<td>2000</td>
<td>40.063</td>
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<td>2001</td>
<td>41.984</td>
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<td>2002</td>
<td>52.241</td>
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<td>2004</td>
<td>61.766</td>
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<td>2005</td>
<td>65.323</td>
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<td>2006</td>
<td>72.702</td>
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<td>2007</td>
<td>78.553</td>
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<td>2008</td>
<td>76.506</td>
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<td>2009</td>
<td>52.215</td>
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<tr>
<td>2010</td>
<td>48.143</td>
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<tr>
<td>2011</td>
<td>43.141</td>
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<tr>
<td>2012</td>
<td>40.286</td>
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<td>2013</td>
<td>39.835</td>
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<tr>
<td>2014</td>
<td>35.355</td>
</tr>
<tr>
<td>2015</td>
<td>35.547</td>
</tr>
</tbody>
</table>
Drop in NMVOC emissions (from which CO₂ 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 SO₂, CO, NOₓ and NH₃ have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 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 2015 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 CO₂/C (44/12), have been used for CO₂ emission calculation.

Emissions of CO₂ from Road paving with asphalt and Asphalt roofing in the period 1990 - 2015 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 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Road paving with asphalt</th>
<th>Asphalt roofing</th>
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</thead>
<tbody>
<tr>
<td>1990</td>
<td>0.005</td>
<td>0.009</td>
</tr>
<tr>
<td>1991</td>
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<tr>
<td>2001</td>
<td>0.010</td>
<td>0.004</td>
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<td>2003</td>
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<td>0.018</td>
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<tr>
<td>2015</td>
<td>0.020</td>
<td>0.015</td>
</tr>
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</table>

**Urea based catalytic converters**

This source category encompasses CO\(_2\) emissions from the use of urea containing in diesel engines with SCR-catalysts in road transportation (Euro V/VI).

Emissions of CO\(_2\) from urea based catalytic converters have been calculated using Tier 1 methodology (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 2015 data on total diesel fuel consumed was used.
Emissions of CO\textsubscript{2} from Urea Based Catalytic Converters in the period 1990 - 2015 are presented in the Table 4.5-7.

Table 4.5-7: Emissions of CO\textsubscript{2} from Urea Based Catalytic Converters (1990 – 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>CO\textsubscript{2} emission (kt CO\textsubscript{2})</th>
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</thead>
<tbody>
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<td>1990</td>
<td>NO</td>
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<tr>
<td>1991</td>
<td>NO</td>
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<td>2014</td>
<td>5.340</td>
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<tr>
<td>2015</td>
<td>5.805</td>
</tr>
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</table>

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\textsubscript{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**

There are no source-specific recalculations in this report.

**Road paving with asphalt and Asphalt roofing**

There are no source-specific recalculations in this report.

**Urea based catalytic converters**

New data for 2014 have been included. Accordingly, recalculation were performed for the year 2014.

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 2015, HFCs and PFCs emissions contributed 15.8 percent to the sectoral GHG emission, as well 1.8 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.


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 1995-2015, 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 - 2015 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) (1995-2015)

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Table 4.7-1: Emissions of HFCs and PFCs used in Refrigeration and Air Conditioning Equipment (t) (1995-2015), cont.

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</tbody>
</table>

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 - 2015 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 - 2015), (kt CO\textsubscript{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

In the previous report, for category 2F1d Transport refrigeration all trucks were taken as the basis for estimating the emissions, and not only those equipped with refrigeration equipment which caused overestimation of emissions. According to the technical correction calculated by the TERT during ESD review, roughly assessment of the share of refrigerated transport in the total number of trucks (20%) are included in the revised estimates. Accordingly, recalculation were performed for entire period 1995 - 2014.

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.

Regarding the technical correction for category 2F1d Transport refrigeration, 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 programme (short-term goal).

Currently, the category 2F1e Mobile air-conditioning includes only mobile air conditioning in passenger cars. According to TERT recommendation during 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 programme (short-term goal).
According to TERT recommendation during 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 programme (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 1995-2014, 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). These emissions data were generated by means of a mass balance approach.

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 - 2015)

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</thead>
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<td>NO</td>
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<td>NO</td>
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Table 4.7-2: Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 (t) (1995 - 2015), cont.

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</table>

Emissions of HFCs used in 2.F.2, 2.F.3 and 2.F.4 in the period 1990 - 2015 are presented in the Figure 4.7-2.
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

There are no source-specific recalculations in this report.

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 review, for category 2F2 Foam blowing agents, analysis of the type of foam application used (open cells or closed cells) should be verified. For now is assumed to be open cells, according to the ERT recommendation in the DRAFT Report on the individual review of the annual submission of Croatia submited in 2016 (FCCC/ARR/2016/HRV).

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 SF₆ in electrical equipment. Data on SF₆ have been compiled by the MEE.

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

4.8.1.2. Methodological issues

Emissions of SF₆ have been calculated using data on total charge of SF₆ contained in the existing stock of equipment and leakage and maintenance losses as a fixed percentage of the total charge (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 1990-2015 are presented in the Table 4.8-1.

Table 4.8-1: Emissions of SF$_6$ (kt CO$_2$-eq), (1990 - 2015)

<table>
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<td>10.45</td>
</tr>
<tr>
<td>1991</td>
<td>10.33</td>
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<tr>
<td>1992</td>
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<td>10.64</td>
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<td>1996</td>
<td>11.57</td>
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</table>
4.8.1.3. Uncertainties and time-series consistency

Uncertainty estimate associated with calculation of SF₆ 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 SF₆ and leakage and maintenance loses for the period 2012 - 2014 were provided. Accordingly, recalculation were performed for the period 2012 - 2014.

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 SF₆ and Customs Departments Tariff Number to distinguish these compounds from other fluorinated chemicals which are controlled with Montreal Protocol.

Activity data regarding SF₆ emissions should be analysed and reviewed for the entire reporting period. Any potential changes in data should be included in the inventory.

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. SFs and PFCs from other product use (2.G.2)

This category does not exist in Croatia.

4.8.3. N₂O from product uses (2.G.3)

4.8.3.1. Category description

This category encompasses use of N₂O for anaesthesia and use of N₂O for aerosol cans. According to available data, there is no use of N₂O in fire extinguishers or other uses. Data on use of N₂O have been compiled by the CAEN. Data are obtained by distributors of N₂O in Croatia who delivered a confirmation on use of N₂O to the CAEN.

4.8.3.2. Methodological issues

N₂O emissions have been calculated by multiplying annual quantity of N₂O used for anaesthesia and aerosol cans with default emission factor proposed by 2006 IPCC Guidelines.

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

There is significantly decrease of quantity of N₂O used in 2014 and 2015. In the confirmations distributors indicated that N₂O was used only for anaesthesia in 2014 and 2015.

Emissions of N₂O from Product Use in the period 1990 - 2015 are presented in the Figure 4.8-1.
4.8.3.3. Uncertainties and time-series consistency

Uncertainty estimate associated with calculation of N₂O 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 N₂O used for anaesthesia for 2014 were provided. Accordingly, recalculation were performed for the year 2014.
4.8.3.6. Category-specific planned improvements

Data for N₂O 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.

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 beverage industry
- Wood processing

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

Emissions of SO₂, CO, NOₓ, NMVOC and NH₃ have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 Submission to the Convention on Long-range Transboundary Air Pollution.’

4.9.2. Food and beverages 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 2015 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 2015 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 breakdown in the emission calculation:

- Livestock: enteric fermentation (CH₄) and manure management (CH₄, N₂O)
- Agricultural soils (N₂O)
- Liming and urea application (CO₂)

The total emission in 2015 caused by agricultural activities was 2,555.32 kt CO₂-eq, which represents 10.9 percent of the total inventory emission. Methane (CH₄) and nitrous oxide (N₂O) 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 (CH₄) emission. The result of agricultural soil management, manure management and agricultural engineering are relatively high in emission of nitrous oxide (N₂O). 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.
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 1990-2015.

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Methane emission (kt CH₄)</th>
<th>Nitrous oxide emission (kt N₂O)</th>
<th>Carbon dioxide emission (kt CO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enteric fermentation</td>
<td>Manure management</td>
<td>Total</td>
</tr>
<tr>
<td>1990</td>
<td>79.10</td>
<td>13.11</td>
<td>92.22</td>
</tr>
<tr>
<td>1991</td>
<td>75.38</td>
<td>13.39</td>
<td>88.77</td>
</tr>
<tr>
<td>1992</td>
<td>64.67</td>
<td>11.80</td>
<td>76.47</td>
</tr>
<tr>
<td>1993</td>
<td>64.20</td>
<td>12.50</td>
<td>76.70</td>
</tr>
<tr>
<td>1994</td>
<td>57.68</td>
<td>12.45</td>
<td>70.14</td>
</tr>
<tr>
<td>1995</td>
<td>55.07</td>
<td>12.20</td>
<td>67.27</td>
</tr>
<tr>
<td>1996</td>
<td>52.83</td>
<td>12.34</td>
<td>65.17</td>
</tr>
<tr>
<td>1997</td>
<td>50.89</td>
<td>12.43</td>
<td>63.32</td>
</tr>
<tr>
<td>1998</td>
<td>49.21</td>
<td>12.57</td>
<td>61.77</td>
</tr>
<tr>
<td>Year</td>
<td>Year</td>
<td>Methane emission</td>
<td>Nitrous oxide emission</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td>Year</td>
<td>kt CH₄</td>
<td>kt N₂O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enteric fermentation</td>
<td>Manure management</td>
</tr>
<tr>
<td>1999</td>
<td>1999</td>
<td>47.78</td>
<td>13.33</td>
</tr>
<tr>
<td>2000</td>
<td>2000</td>
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<td>46.21</td>
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<td>2002</td>
<td>44.86</td>
<td>13.45</td>
</tr>
<tr>
<td>2003</td>
<td>2003</td>
<td>44.86</td>
<td>14.02</td>
</tr>
<tr>
<td>2004</td>
<td>2004</td>
<td>47.75</td>
<td>15.06</td>
</tr>
<tr>
<td>2005</td>
<td>2005</td>
<td>46.78</td>
<td>14.22</td>
</tr>
<tr>
<td>2006</td>
<td>2006</td>
<td>45.83</td>
<td>15.50</td>
</tr>
<tr>
<td>2007</td>
<td>2007</td>
<td>43.33</td>
<td>14.73</td>
</tr>
<tr>
<td>2008</td>
<td>2008</td>
<td>42.19</td>
<td>14.02</td>
</tr>
<tr>
<td>2009</td>
<td>2009</td>
<td>42.11</td>
<td>14.73</td>
</tr>
<tr>
<td>2010</td>
<td>2010</td>
<td>42.28</td>
<td>14.61</td>
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<td>2011</td>
<td>2011</td>
<td>41.63</td>
<td>14.16</td>
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<td>2012</td>
<td>2012</td>
<td>40.97</td>
<td>13.63</td>
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<tr>
<td>2013</td>
<td>2013</td>
<td>39.84</td>
<td>13.17</td>
</tr>
<tr>
<td>2014</td>
<td>2014</td>
<td>38.99</td>
<td>13.05</td>
</tr>
<tr>
<td>2015</td>
<td>2015</td>
<td>40.97</td>
<td>13.78</td>
</tr>
</tbody>
</table>

Table 5.1-2: Emission of greenhouse gases from agriculture in CO₂-eq
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 2015

<table>
<thead>
<tr>
<th>IPCC Source Categories</th>
<th>Direct GHG</th>
<th>Criteria for Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGRICULTURE SECTOR</td>
<td></td>
<td>If Column C is Yes, Criteria for Identification</td>
</tr>
<tr>
<td>A. Enteric Fermentation</td>
<td>CH₄</td>
<td>Excluding LULUCF</td>
</tr>
<tr>
<td></td>
<td>L₁e, L₂e, T₁e, T₂e</td>
<td>Including LULUCF</td>
</tr>
<tr>
<td>B. Manure Management</td>
<td>N₂O</td>
<td>L₁e, L₁i, L₂e, T₁e, T₁i</td>
</tr>
<tr>
<td>3.1 Direct N₂O Emissions From Managed Soils</td>
<td>N₂O</td>
<td>L₁e, L₁i, L₂e, T₁e, T₁i</td>
</tr>
<tr>
<td>3.2 Indirect N₂O Emissions From Managed Soils</td>
<td>N₂O</td>
<td>L₁e, L₂e, T₁e, L₁i, L₂i, T₁i</td>
</tr>
</tbody>
</table>

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

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

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CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE
5.2. **CH₄ 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 CH₄ emission from Enteric fermentation in 2013, followed by young representing about 28%. Cattle livestock in total is responsible for around 84% of total CH₄ emission from Enteric fermentation.

Figure 5.2-1 shows emission of methane from Enteric fermentation for the period from 1990-2015. 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).
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. 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 annually (NAPA) are the Central Bureau of Statistics (CBS) and FAO database. See Table 5.2-1 for detailed information. Numbers on dairy cattle category was provided by Croatian Agricultural Agency (CAA) for the years 2008-2015. Animal number for the rest of the dataset (years 1990 to 2007) was extrapolated based on the 2008-2015 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. The number of animals produced annually (NAPA) is reported in Table 5.2-2. Conversion of NAPA to annual average population (AAP) was performed using Equation 10.1 (2006 IPCC Guidelines for National Greenhouse Gas Inventories) and expert judgement data provided by expert from the Faculty of Agriculture, University of Zagreb, as detailed in Table 5.2-3. NAPA to AAP conversion was performed on the most detailed segregation level for which data was available, before the livestock categories were reclassified.

---

8 Poultry is not a source of CH₄ emissions from Enteric Fermentation, however it is a shared activity data with other source categories (Manure Management)
Table 5.2-1: Sources of activity data regarding animal population

<table>
<thead>
<tr>
<th>Animal category</th>
<th>CBS</th>
<th>FAO</th>
<th>Croatian Agricultural Agency</th>
<th>Extrapolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other cattle</td>
<td>1990-2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>1990-2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1999-2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swine</td>
<td>1990-2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poultry</td>
<td>1990-2015</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.2-2: Number of animals produced annually in the period from 1990 – 2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Dairy cattle</th>
<th>Total Non-dairy</th>
<th>Sheep</th>
<th>Goats</th>
<th>Horses</th>
<th>Mules/asses</th>
<th>Total Swine</th>
<th>Total Poultry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>488</td>
<td>370</td>
<td>751</td>
<td>172</td>
<td>39</td>
<td>17</td>
<td>1573</td>
<td>17102</td>
</tr>
<tr>
<td>1991</td>
<td>468</td>
<td>335</td>
<td>753</td>
<td>133</td>
<td>36</td>
<td>13</td>
<td>1621</td>
<td>16512</td>
</tr>
<tr>
<td>1992</td>
<td>448</td>
<td>221</td>
<td>539</td>
<td>114</td>
<td>26</td>
<td>13</td>
<td>1182</td>
<td>13142</td>
</tr>
<tr>
<td>1993</td>
<td>430</td>
<td>256</td>
<td>525</td>
<td>105</td>
<td>22</td>
<td>12</td>
<td>1262</td>
<td>12697</td>
</tr>
<tr>
<td>1994</td>
<td>412</td>
<td>191</td>
<td>444</td>
<td>108</td>
<td>21</td>
<td>7</td>
<td>1347</td>
<td>12503</td>
</tr>
<tr>
<td>1995</td>
<td>395</td>
<td>185</td>
<td>453</td>
<td>107</td>
<td>5</td>
<td>2</td>
<td>1175</td>
<td>12024</td>
</tr>
<tr>
<td>1996</td>
<td>379</td>
<td>178</td>
<td>427</td>
<td>105</td>
<td>5</td>
<td>2</td>
<td>1197</td>
<td>10993</td>
</tr>
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<td>1997</td>
<td>364</td>
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<td>453</td>
<td>100</td>
<td>6</td>
<td>2</td>
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<td>10945</td>
</tr>
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<td>1998</td>
<td>349</td>
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<td>427</td>
<td>84</td>
<td>7</td>
<td>2</td>
<td>1166</td>
<td>9959</td>
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<td>1999</td>
<td>335</td>
<td>170</td>
<td>488</td>
<td>78</td>
<td>7</td>
<td>2</td>
<td>1362</td>
<td>10871</td>
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<tr>
<td>2000</td>
<td>321</td>
<td>164</td>
<td>529</td>
<td>79</td>
<td>10</td>
<td>3</td>
<td>1234</td>
<td>11256</td>
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<tr>
<td>2001</td>
<td>308</td>
<td>184</td>
<td>539</td>
<td>93</td>
<td>11</td>
<td>3</td>
<td>1234</td>
<td>11747</td>
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<td>2002</td>
<td>295</td>
<td>170</td>
<td>580</td>
<td>97</td>
<td>14</td>
<td>3</td>
<td>1286</td>
<td>11665</td>
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<tr>
<td>2003</td>
<td>283</td>
<td>192</td>
<td>587</td>
<td>86</td>
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<td>3</td>
<td>1347</td>
<td>11778</td>
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<td>3</td>
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<td>2005</td>
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<td>134</td>
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<td>2006</td>
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<td>19</td>
<td>3</td>
<td>1488</td>
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<td>2007</td>
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<td>646</td>
<td>92</td>
<td>18</td>
<td>3</td>
<td>1348</td>
<td>10053</td>
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<td>643</td>
<td>84</td>
<td>20</td>
<td>4</td>
<td>1104</td>
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<tr>
<td>2009</td>
<td>225</td>
<td>235</td>
<td>619</td>
<td>76</td>
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<td>4</td>
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<td>10787</td>
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<td>629</td>
<td>75</td>
<td>21</td>
<td>4</td>
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<td>9469</td>
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<tr>
<td>2011</td>
<td>206</td>
<td>263</td>
<td>639</td>
<td>70</td>
<td>22</td>
<td>3</td>
<td>1233</td>
<td>9523</td>
</tr>
<tr>
<td>2012</td>
<td>191</td>
<td>270</td>
<td>679</td>
<td>72</td>
<td>22</td>
<td>3</td>
<td>1182</td>
<td>10160</td>
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<tr>
<td>2013</td>
<td>181</td>
<td>276</td>
<td>620</td>
<td>69</td>
<td>21</td>
<td>3</td>
<td>1110</td>
<td>9307</td>
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<tr>
<td>2014</td>
<td>179</td>
<td>264</td>
<td>605</td>
<td>61</td>
<td>21</td>
<td>2</td>
<td>1156</td>
<td>10317</td>
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<tr>
<td>2015</td>
<td>175</td>
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<td>608</td>
<td>62</td>
<td>22</td>
<td>2</td>
<td>1167</td>
<td>10190</td>
</tr>
</tbody>
</table>
Table 5.2-3: Livestock categories and “days alive” estimate used for NAPA to AAP conversion for year 2015

<table>
<thead>
<tr>
<th>Disagregated livestock categories</th>
<th>Days alive</th>
<th>Disagregated Livestock categories</th>
<th>Days alive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Market swine</strong> (nursery, finishers, fattening pigs)</td>
<td></td>
<td>Poultry</td>
<td></td>
</tr>
<tr>
<td>0-20 kg</td>
<td>70 days</td>
<td>Layers</td>
<td>365 days</td>
</tr>
<tr>
<td>20-50 kg</td>
<td>112 days</td>
<td>Broilers</td>
<td>51 days</td>
</tr>
<tr>
<td>50-80 kg</td>
<td>160 days</td>
<td>Turkeys</td>
<td>240 days</td>
</tr>
<tr>
<td>80-110 kg</td>
<td>202 days</td>
<td>Geese</td>
<td>180 days</td>
</tr>
<tr>
<td>110+ kg</td>
<td>365 days</td>
<td>Ducks</td>
<td>180 days</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td>365 days</td>
</tr>
</tbody>
</table>

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 1990-2015, 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 (1995-2014) and mules/asses (1995-2014). For the missing years, CBS data was used for horse population and CBS / FAOSTAT data for mules/asses 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 5.2-5). CAA data of fat percentage indicated that the default 4% can continue to be used and in accordance to national value on milk fat percentage available for the years 2010-2014. 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 5.2-4 contains information on how CBS categories for...
cattle were reclassified into the appropriate IPCC categories. Over time, it is expected that this CBS
categorization will be uniform across the dataset.

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 5.2-4: Non-dairy cattle classification into main IPPC subcategories

<table>
<thead>
<tr>
<th>IPPC categories</th>
<th>CBS categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mature non-dairy cattle</td>
<td>Heifers</td>
</tr>
<tr>
<td></td>
<td>Other (bull, ox)</td>
</tr>
<tr>
<td></td>
<td>Other cows</td>
</tr>
<tr>
<td>Young cattle</td>
<td>Bovine animals aged under 2 years</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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-
2015 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 2015 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 2015. 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 2014/2015 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 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 than 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, inluding: intensive fattening cattle to produce so calded "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 emission. 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 5.2-5: National data used in emission factor calculation for cattle for 2015

<table>
<thead>
<tr>
<th>Animal</th>
<th>weight (kg)</th>
<th>Cfi</th>
<th>Ca</th>
<th>WG (kg/day)</th>
<th>fat (%)</th>
<th>C_pregnancy</th>
<th>DE (%)</th>
<th>Ym</th>
</tr>
</thead>
<tbody>
<tr>
<td>mature dairy</td>
<td>562.82</td>
<td>0.386</td>
<td>0.009</td>
<td>0.00</td>
<td>4.00</td>
<td>0.10</td>
<td>69.00</td>
<td>0.061</td>
</tr>
<tr>
<td>mature non-dairy</td>
<td>529.06</td>
<td>0.322</td>
<td>0.097</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>57.00</td>
<td>0.066</td>
</tr>
<tr>
<td>young</td>
<td>301.64</td>
<td>0.322</td>
<td>0.000</td>
<td>1.20</td>
<td>-</td>
<td>-</td>
<td>75.00</td>
<td>0.046</td>
</tr>
</tbody>
</table>
Milk yield per cow per day for the period from 1990-2015 is presented in Table 5.2-6. AD set on milk yield per cow was provided by CAA for the years 2008-2015, 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 5.2-6: Milk yield per cow

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</tr>
</thead>
<tbody>
<tr>
<td>Milk yield (kg/day)</td>
<td>7.83</td>
<td>8.09</td>
<td>8.35</td>
<td>8.60</td>
<td>8.86</td>
<td>9.12</td>
<td>9.51</td>
<td>9.91</td>
<td>10.30</td>
<td>10.70</td>
<td>11.09</td>
<td>11.47</td>
<td>11.84</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Milk yield (kg/day)</td>
<td>12.22</td>
<td>12.59</td>
<td>12.97</td>
<td>13.50</td>
<td>14.04</td>
<td>14.57</td>
<td>15.11</td>
<td>15.64</td>
<td>15.57</td>
<td>15.83</td>
<td>16.15</td>
<td>16.15</td>
<td>16.32</td>
</tr>
</tbody>
</table>

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, 2010⁹).

<table>
<thead>
<tr>
<th>Category</th>
<th>Weight (kg)</th>
<th>Food intake (kg/day)</th>
<th>DE (%)</th>
<th>Ym</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mated sows - intensive</td>
<td>200</td>
<td>3.4</td>
<td>82</td>
<td>0.6</td>
</tr>
<tr>
<td>Mated sows - extensive</td>
<td>200</td>
<td>3.45</td>
<td>76</td>
<td>0.6</td>
</tr>
<tr>
<td>Fattening pigs</td>
<td>50</td>
<td>2.25</td>
<td>85</td>
<td>0.6</td>
</tr>
</tbody>
</table>

*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 5.2-8.

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 5.2-8: Ym and digestibility of meal in different sheep breeding systems

<table>
<thead>
<tr>
<th>Category</th>
<th>DE (%)</th>
<th>Ym</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigenous breeds on rudimentary pastures</td>
<td>55</td>
<td>0.07</td>
</tr>
<tr>
<td>Meat sheep breeds from lowland pastures</td>
<td>60</td>
<td>0.0675</td>
</tr>
<tr>
<td>Sheep for milk production</td>
<td>65</td>
<td>0.065</td>
</tr>
</tbody>
</table>
For other animals (goats, horses, mules and asses) default emission factors for developed countries were used for the entire data series. See Table 5.2-9.

Table 5.2-9: National enteric fermentation emission factors for other animal categories

<table>
<thead>
<tr>
<th>Animal Category</th>
<th>Methodology used</th>
<th>EF / kg per head per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goats</td>
<td>Tier1</td>
<td>5.00 (default)</td>
</tr>
<tr>
<td>Horses</td>
<td>Tier1</td>
<td>18 (default)</td>
</tr>
<tr>
<td>Mules/asses</td>
<td>Tier1</td>
<td>10.00 (default)</td>
</tr>
</tbody>
</table>

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 year 2014 for dairy and mature non-dairy cattle categories due to a correction of error in calculation.

In addition, emissions were recalculated for the entire 1990-2014 period due to implementation of rounding of activity data following NAPA to AAP animal number conversion and extrapolation procedures. This resulted in a insignificant change of emission for dairy cattle and market pigs.

5.2.6. Category specific planned improvement

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

- Continued improvements and investigation of activity data with the purpose of more detailed explanation of the activity data trends and further verification of source data and investigation into existing and additional annual population subcategorization for animal species that present a significant share in emissions. This applies particularly 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, particularly of sheep annual population subcategorization.
- Continued improvements and verifications of parameters for Tier 2 emission calculation for historical years, particularly for cattle subcategories.
5.3. MANURE MANAGEMENT (CRF 3.B.)

Management of livestock manure produces both methane (CH₄) and nitrous oxide (N₂O) emissions. CH₄ produced during the storage and treatment of manure, and from manure deposited on pasture is estimated, and the main factors affecting CH₄ emissions are the amount of manure produced and the portion of the manure that decomposes anaerobically. This occurs most readily when large numbers of animals are managed in a confined area and where manure is disposed of in liquid-based systems.

N₂O 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 N₂O 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 N₂O 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 – CH₄ 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 2014 is presented in Figure 5.3-1. The emission trend depends on the animal population trend.
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 2015

<table>
<thead>
<tr>
<th>Animal Category</th>
<th>VS</th>
<th>B0</th>
<th>CH4 emission, per head (FE)</th>
<th>MMS Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MCF</td>
</tr>
<tr>
<td>Mature dairy cattle</td>
<td>4.50</td>
<td>0.24</td>
<td>34.00</td>
<td>5.0%</td>
</tr>
<tr>
<td>Other mature cattle</td>
<td>2.70</td>
<td>0.17</td>
<td>9.93</td>
<td>0.0%</td>
</tr>
</tbody>
</table>
### 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.

---

<table>
<thead>
<tr>
<th></th>
<th>VS</th>
<th>B0</th>
<th>CH4 emission, per head (FE)</th>
<th>Anaerobic lagoon</th>
<th>Liquid system</th>
<th>Daily spread</th>
<th>Solid storage and dry lot</th>
<th>Pasture range and paddock</th>
<th>Digesters</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growing cattle</td>
<td>2.70</td>
<td>0.17</td>
<td>9.93</td>
<td>0.0%</td>
<td>34.5%</td>
<td>0.0%</td>
<td>54.5%</td>
<td>5.0%</td>
<td>5.0%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Sheep</td>
<td>0.34</td>
<td>0.14</td>
<td>0.14</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>18.0%</td>
<td>82.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Market swine</td>
<td>0.30</td>
<td>0.45</td>
<td>6.30</td>
<td>2.0%</td>
<td>83.4%</td>
<td>0.0%</td>
<td>9.6%</td>
<td>0.0%</td>
<td>5.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Breeding swine</td>
<td>0.50</td>
<td>0.45</td>
<td>9.43</td>
<td>2.0%</td>
<td>73.7%</td>
<td>0.0%</td>
<td>18.3%</td>
<td>1.0%</td>
<td>5.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Goats</td>
<td>0.30</td>
<td>0.14</td>
<td>0.11</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>5.0%</td>
<td>95.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Horses</td>
<td>2.09</td>
<td>0.27</td>
<td>1.79</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>30.0%</td>
<td>70.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Mules and Asses</td>
<td>2.09</td>
<td>0.27</td>
<td>1.52</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>10.0%</td>
<td>90.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Poultry</td>
<td>0.02</td>
<td>0.37</td>
<td>0.07</td>
<td>0.0%</td>
<td>8.6%</td>
<td>0.0%</td>
<td>88.5%</td>
<td>1.8%</td>
<td>0.0%</td>
<td>1.1%</td>
</tr>
</tbody>
</table>
5.3.1.5. Category specific recalculations

Following the review of the NIR 2015, TERT has determined that CH$_4$ emission factors from IPCC 2000 GPG were used for the emission calculation apparently and that a technical correction for CH$_4$ emission from MMS for all animal categories is necessary. Recalculation of estimates have been performed based on default values and average VS excretion rates from the 2006 IPCC Guidelines for all animal categories and all years.

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$_2$O emissions (CRF 3.B.2.)

5.3.2.1. Category description

There are two emission pathways of nitrous oxide (N$_2$O) as a result of manure management. Direct N$_2$O 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$_2$O) 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$_2$O) emissions from Manure management for the period from 1990 to 2015 are presented in Figure 5.3-2.
5.3.2.2. Methodological issues

**Direct N₂O 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 N₂O emissions. The emission trend depends on the animal population trend. Activity data regarding livestock population are the same as for the calculation of CH₄ emission from Enteric fermentation and Manure management.
Table 5.3-2: Manure management emission factors for each animal category and AWMS for the year 2015

<table>
<thead>
<tr>
<th>Livestock Type</th>
<th>Nitrogen Excretion Nex kg/head/(yr)</th>
<th>Fraction of Manure Nitrogen per AWMS (%/100)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anaerob. lagoon</td>
<td>Liquid system</td>
</tr>
<tr>
<td>Dairy Cattle</td>
<td>89.37</td>
<td>5.00</td>
</tr>
<tr>
<td>Other Cattle</td>
<td>49.93</td>
<td>34.60</td>
</tr>
<tr>
<td>Sheep</td>
<td>8.03</td>
<td>0.00</td>
</tr>
<tr>
<td>Goats</td>
<td>16.53</td>
<td>0.00</td>
</tr>
<tr>
<td>Horses</td>
<td>41.61</td>
<td>0.00</td>
</tr>
<tr>
<td>Mules</td>
<td>41.61</td>
<td>0.00</td>
</tr>
<tr>
<td>Market swine</td>
<td>9.76</td>
<td>2.00</td>
</tr>
<tr>
<td>Breeding swine</td>
<td>30.76</td>
<td>1.80</td>
</tr>
<tr>
<td>Layers</td>
<td>0.55</td>
<td>11.00</td>
</tr>
<tr>
<td>Broilers</td>
<td>0.55</td>
<td>1.00</td>
</tr>
<tr>
<td>Turkeys</td>
<td>0.40</td>
<td>0.00</td>
</tr>
<tr>
<td>Ducks</td>
<td>1.62</td>
<td>1.00</td>
</tr>
<tr>
<td>Other poultry</td>
<td>0.76</td>
<td>10.00</td>
</tr>
</tbody>
</table>

Indirect N₂O Emissions from Manure Management

Tier 1 methodology (Equation 10.26, 2006 IPCC guidelines) has been used. Volatized N in forms of NH₃ and NOx was calculated for each manure management systems from all livestock categories, summing all N losses. Final N₂O 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


5.3.2.6. Category specific planned improvement

Emissions were recalculated for the entire 1990-2014 period due to implementation of rounding of activity data following NAPA to AAP animal number conversion and extrapolation procedures. This resulted in a insignificant change of emission for dairy cattle and market pigs.

5.4. RICE CULTIVATION (CRF 3.C.)

5.4.1. Category description

Anaerobic decomposition of organic material in flooded rice fields produces methane (CH₄) which escapes into the atmosphere by diffusive transport through the plants during the growing season. Rice cultivation does not occur in Croatia, so there is no possible emissions from this source.
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 N₂O 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 N₂O Emissions from Managed Soils (CRF 3.D.1.)
- Indirect N₂O Emissions from Managed Soils (CRF 3.D.2.)

Direct N₂O emissions are estimated separately from indirect emission, thought both use the same set of activity data. Emissions of nitrous oxide (N₂O) 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.
5.5.1. Direct N₂O Emission from Managed Soils (CRF 3.D.1.)

5.5.1.1. Category description

Direct N₂O emissions from agricultural soils include total amount of nitrogen applied to soils through human induced N additions and/or change of 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 N₂O from Managed Soils for the period from 1990 to 2015 are shown in Figure 5.5-2.

Figure 5.5-2: Direct N₂O 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 1992-2015. 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 1990-2015 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 1990-2015

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 1990-2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Urea</th>
<th>Calcium ammonium nitrate</th>
<th>NPK</th>
<th>Ammonium nitrate</th>
<th>Urea ammonium nitrate</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>31,376.02</td>
<td>39,030.12</td>
<td>36,285.99</td>
<td>721.27</td>
<td>0.00</td>
<td>107,413.40</td>
</tr>
<tr>
<td>1991</td>
<td>31,957.26</td>
<td>38,643.46</td>
<td>37,441.72</td>
<td>672.22</td>
<td>0.00</td>
<td>108,714.66</td>
</tr>
<tr>
<td>1992</td>
<td>41,093.64</td>
<td>43,521.03</td>
<td>39,921.42</td>
<td>282.41</td>
<td>0.00</td>
<td>124,818.50</td>
</tr>
<tr>
<td>1993</td>
<td>32,705.54</td>
<td>27,743.58</td>
<td>29,856.30</td>
<td>1,053.58</td>
<td>0.00</td>
<td>91,358.99</td>
</tr>
<tr>
<td>1994</td>
<td>29,839.28</td>
<td>36,707.85</td>
<td>29,814.55</td>
<td>549.07</td>
<td>0.00</td>
<td>96,910.74</td>
</tr>
<tr>
<td>1995</td>
<td>29,038.88</td>
<td>35,701.02</td>
<td>28,395.91</td>
<td>279.73</td>
<td>0.00</td>
<td>93,415.53</td>
</tr>
<tr>
<td>1996</td>
<td>32,897.76</td>
<td>43,609.05</td>
<td>35,924.21</td>
<td>920.92</td>
<td>0.00</td>
<td>123,351.94</td>
</tr>
<tr>
<td>1997</td>
<td>27,755.94</td>
<td>38,790.63</td>
<td>28,358.87</td>
<td>341.03</td>
<td>0.00</td>
<td>95,246.47</td>
</tr>
<tr>
<td>1998</td>
<td>31,669.16</td>
<td>34,221.42</td>
<td>39,495.69</td>
<td>235.17</td>
<td>0.00</td>
<td>110,337.88</td>
</tr>
<tr>
<td>1999</td>
<td>34,219.56</td>
<td>39,921.66</td>
<td>39,861.79</td>
<td>41.80</td>
<td>0.00</td>
<td>119,028.86</td>
</tr>
<tr>
<td>2000</td>
<td>37,768.64</td>
<td>37,933.11</td>
<td>32,340.63</td>
<td>300.50</td>
<td>0.00</td>
<td>128,342.88</td>
</tr>
<tr>
<td>2001</td>
<td>50,655.66</td>
<td>38,065.68</td>
<td>31,650.89</td>
<td>96.82</td>
<td>0.00</td>
<td>120,469.05</td>
</tr>
<tr>
<td>2002</td>
<td>42,176.48</td>
<td>31,017.33</td>
<td>33,360.69</td>
<td>5,203.22</td>
<td>1,863.30</td>
<td>113,621.02</td>
</tr>
<tr>
<td>2003</td>
<td>45,109.44</td>
<td>32,069.52</td>
<td>33,626.10</td>
<td>5,126.17</td>
<td>1,647.30</td>
<td>117,578.53</td>
</tr>
<tr>
<td>2004</td>
<td>41,939.58</td>
<td>36,264.78</td>
<td>36,438.61</td>
<td>4,983.13</td>
<td>1,682.70</td>
<td>121,308.80</td>
</tr>
<tr>
<td>2005</td>
<td>37,505.18</td>
<td>36,121.41</td>
<td>34,055.42</td>
<td>2,729.58</td>
<td>1,390.20</td>
<td>111,801.79</td>
</tr>
<tr>
<td>2006</td>
<td>44,424.04</td>
<td>37,700.91</td>
<td>38,342.62</td>
<td>3,415.66</td>
<td>777.30</td>
<td>124,660.53</td>
</tr>
<tr>
<td>2007</td>
<td>46,659.18</td>
<td>39,456.18</td>
<td>34,110.03</td>
<td>332.99</td>
<td>589.50</td>
<td>121,147.88</td>
</tr>
<tr>
<td>2008</td>
<td>39,667.18</td>
<td>36,485.91</td>
<td>31,102.13</td>
<td>18.76</td>
<td>737.40</td>
<td>108,011.38</td>
</tr>
<tr>
<td>2009</td>
<td>40,999.13</td>
<td>34,811.64</td>
<td>23,196.56</td>
<td>21.11</td>
<td>498.00</td>
<td>99,526.43</td>
</tr>
<tr>
<td>2010</td>
<td>51,674.69</td>
<td>35,651.19</td>
<td>26,631.44</td>
<td>17.76</td>
<td>603.53</td>
<td>114,578.60</td>
</tr>
<tr>
<td>2011</td>
<td>53,465.65</td>
<td>31,327.41</td>
<td>22,413.62</td>
<td>0.00</td>
<td>661.99</td>
<td>107,868.67</td>
</tr>
<tr>
<td>2012</td>
<td>37,397.93</td>
<td>32,440.15</td>
<td>18,356.24</td>
<td>0.00</td>
<td>314.58</td>
<td>88,508.90</td>
</tr>
<tr>
<td>2013</td>
<td>30,539.66</td>
<td>31,633.10</td>
<td>18,212.75</td>
<td>0.00</td>
<td>321.60</td>
<td>80,707.11</td>
</tr>
<tr>
<td>2014</td>
<td>35,377.73</td>
<td>32,176.82</td>
<td>19,825.93</td>
<td>8.38</td>
<td>347.04</td>
<td>87,735.90</td>
</tr>
</tbody>
</table>

**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 Guidelines for National Greenhouse Gas Inventories. In the Republic of Croatia, manure is not used as fuel, feed or for construction, so adjustment of annual amount of animal manure in regards to these fractions was not necessary.

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

Sufficient activity data was provided for the period 2005-2013, while for the period 1990-2004 no data was not provided or could be estimated. Current AD set is limited to data provided by private owned companies to the Croatian Agency for the Environment and Nature. 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>
<thead>
<tr>
<th>Year</th>
<th>Amount of sludge applied (tons dry matter)</th>
<th>Average nitrogen percentage (N % in dry matter mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>3</td>
<td>11%</td>
</tr>
<tr>
<td>2006</td>
<td>6</td>
<td>11%</td>
</tr>
<tr>
<td>2007</td>
<td>7</td>
<td>11%</td>
</tr>
<tr>
<td>2008</td>
<td>16</td>
<td>11%</td>
</tr>
<tr>
<td>2009</td>
<td>459</td>
<td>3.89%</td>
</tr>
<tr>
<td>2010</td>
<td>434</td>
<td>3.89%</td>
</tr>
<tr>
<td>2011</td>
<td>683</td>
<td>3.89%</td>
</tr>
<tr>
<td>2012</td>
<td>956</td>
<td>3.89%</td>
</tr>
<tr>
<td>2013</td>
<td>1567</td>
<td>3.89%</td>
</tr>
</tbody>
</table>
### Urine and Dung deposited by Grazing Animals (3.D.1.3)

Annual amount of N input deposited on pasture, range and paddock soils by grazing animals. Equation 11.5 from 2006 IPCC Guidelines for National Greenhouse Gas Inventories was used for the estimation calculation. Data on N deposited was obtained from the Direct N₂O emission from Manure Management (see Chapter 5.3.2.2 for details) using country-specific data on nitrogen excretion rates for each livestock species. Emissions of N₂O follow the trend of livestock number and is are shown in Figure 5.5-4.

#### Crop Residues (3.D.1.4)

Tier 1 method using Equation 11.6 from 2006 IPCC Guidelines 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 annually. The data on

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount of sludge applied (tons dry matter)</th>
<th>Average nitrogen percentage (N % in dry matter mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>1567</td>
<td>3.89%</td>
</tr>
<tr>
<td>2015</td>
<td>1567</td>
<td>3.89%</td>
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</table>
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

<table>
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<tr>
<th>Crop</th>
<th>Crop yield CBS</th>
<th>Crop yield FAO</th>
<th>Crop yield Extrapolation*</th>
<th>Crop area CBS</th>
<th>Crop area FAO</th>
<th>Crop area Extrapolation*</th>
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<tbody>
<tr>
<td>Rape seed</td>
<td>1990-2015</td>
<td></td>
<td></td>
<td>1990-2015</td>
<td></td>
<td></td>
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<tr>
<td>Crop</td>
<td>CBS</td>
<td>FAO</td>
<td>Extrapolation*</td>
<td>CBS</td>
<td>FAO</td>
<td>Extrapolation*</td>
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<td>------</td>
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*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 – 2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Maize</th>
<th>Potatoes</th>
<th>Sugar beets</th>
<th>Tobacco</th>
<th>Sunflowers</th>
<th>Rape seed</th>
<th>Tomatoes</th>
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<td>tonnes</td>
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**CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE**

- 280 -
Table 5.5-4: Production and harvest data for crops in the period from 1990 – 2015 (cont.)

<table>
<thead>
<tr>
<th>Year</th>
<th>Barley (tonnes)</th>
<th>Oats (ha)</th>
<th>Cabbages and other brassicas (tonnes)</th>
<th>Garlic (ha)</th>
<th>Onions (ha)</th>
<th>Rye (tonnes)</th>
<th>Sorghum (ha)</th>
<th>Watermelons (tonnes)</th>
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<td>3,053</td>
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Table 5.5-4: Production and harvest data for crops in the period from 1990 – 2015 (cont.)

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<th>Cow peas, dry</th>
<th>Lentils</th>
<th>Peas, dry</th>
<th>Vetches</th>
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<th>Alfalfa</th>
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<tr>
<td>2007</td>
<td>90,637</td>
<td>46,506</td>
<td>2,503</td>
<td>4,451</td>
<td>400</td>
<td>100</td>
<td>100</td>
<td>64</td>
</tr>
<tr>
<td>2008</td>
<td>107,558</td>
<td>35,789</td>
<td>3,263</td>
<td>2,147</td>
<td>1,149</td>
<td>371</td>
<td>41</td>
<td>41</td>
</tr>
<tr>
<td>2009</td>
<td>115,159</td>
<td>44,292</td>
<td>2,460</td>
<td>1,947</td>
<td>1,468</td>
<td>656</td>
<td>74</td>
<td>41</td>
</tr>
<tr>
<td>2010</td>
<td>153,580</td>
<td>56,456</td>
<td>1,641</td>
<td>1,276</td>
<td>1,197</td>
<td>577</td>
<td>29</td>
<td>16</td>
</tr>
<tr>
<td>2011</td>
<td>147,271</td>
<td>58,896</td>
<td>1,059</td>
<td>1,232</td>
<td>1,939</td>
<td>614</td>
<td>82</td>
<td>56</td>
</tr>
<tr>
<td>2012</td>
<td>96,718</td>
<td>54,109</td>
<td>472</td>
<td>788</td>
<td>1,863</td>
<td>798</td>
<td>22</td>
<td>11</td>
</tr>
<tr>
<td>2013</td>
<td>111,316</td>
<td>47,156</td>
<td>1,480</td>
<td>1,097</td>
<td>1,378</td>
<td>721</td>
<td>80</td>
<td>44</td>
</tr>
<tr>
<td>2014</td>
<td>131,424</td>
<td>47,104</td>
<td>1,329</td>
<td>1,483</td>
<td>1,413</td>
<td>678</td>
<td>83</td>
<td>29</td>
</tr>
<tr>
<td>2015</td>
<td>196,431</td>
<td>88,867</td>
<td>1,156</td>
<td>1,475</td>
<td>1,346</td>
<td>600</td>
<td>83</td>
<td>29</td>
</tr>
</tbody>
</table>

CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE
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

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

- GPG default values
- Expert judgement (Faculty of Agriculture)
- Values 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 N₂O 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 Guidelines was applied:

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

Where:

- \( F_{SOM} \) = 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]
- \( \Delta C_{Mineral,LU} \) = 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 N₂O 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: N₂O Emissions due to Loss/Gain of Soil Organic Content 1990-2015
**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 Environment and Nature, based on information available from ARKOD (Croatian Land Parcel Identification System – LPIS). Resulting total histosol area amounts to 2685.49 ha. According to CEA expert judgment this value is accurate on a national level and can be used for each year in the entire period from 1990-2015.

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, higher for 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 replacement of FAO activity data on harvested area of crops with national sources (CBS) and updating the AD on crop yield with new CBS values, emissions were recalculated for the entire 1990-2014 period, as follows.

Crop area:

Crop yield:

During the review of NIR 2015, TERT have found that subtracting the N reported in source 3B volatilisation and leaching from the total N in source 3B Manure Management Systems gives a value that is lower than the value for source 3.D.2.a Organic N applied to soils.

Inventory team confirmed that the discrepancy is due to an error in the calculation spreadsheet, which resulted in double counting of Pasture range and paddock emission (FPRP value was also included in FON) in the estimate of N₂O emissions from Agricultural soils. The TERT checked and verified the source of the discrepancy. It has been assumed that this is the origin of the error noted for all years of the time series, so as a part of the provided technical correction this N₂O emissions from 3.D.2.a animal manure applied to soils was recalculated for all years.
5.5.1.6. Category specific planned improvement

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

- 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) with the purpose of more detailed explanation of the activity data trends and further verification of source data.

5.5.2. Indirect N₂O Emissions from Managed Soils (CRF 3.D.2.)

5.5.2.1. Category description

Calculations of indirect N₂O emission from nitrogen used in agriculture are based on two pathways. These are:

- volatilization and subsequent atmospheric deposition of NH₃
- leaching and runoff of the nitrogen that is applied to or deposited on soils

Volatilisation of N as NH₃ and oxides of N (NOx), and the deposition of these gases and their products NH₄⁺ and NO₃⁻ 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 NO₃⁻ 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 N₂O from managed soils for the period from 1990 to 2015 are shown in Figure 5.6-6.
5.5.2.2. Methodological issues

**Atmospheric deposition due to volatilization**

N$_2$O 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$_2$O 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 N₂O emissions from Manure Management 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 N₂O 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. (N₂O emissions from Manure Management 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 – N₂O Emissions (CRF 3.B.2.) and Direct N₂O 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 N₂O 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 occasionally 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 cereal residues, crop processing residues) in the fields is common practice in developing countries and is present in some developed countries. This activity is strictly prohibited by Croatian legislative regulations (“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 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.

CO₂ emissions from liming for the period from 1990 to 2015 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 CO₂ emissions from Liming

![Graph showing CO₂ emissions from liming from 1990 to 2015]

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\textsubscript{2}O emissions from managed soils, adding urea during fertilization results in conversion of (CO(NH\textsubscript{2})\textsubscript{2}) into ammonium (NH\textsubscript{4}\textsuperscript{+}), hydroxyl ion (OH\textsuperscript{-}), and bicarbonate (HCO\textsubscript{3}\textsuperscript{-}), in the presence of water and urease enzymes. Similar to the soil reaction following addition of lime, bicarbonate that is formed evolves into CO\textsubscript{2} and water. This source category is included because the CO\textsubscript{2} removal from the atmosphere during urea manufacturing is estimated in the Industrial Processes and Product Use Sector (IPPU Sector). Emission of CO\textsubscript{2} from urea application for the period from 1990 to 2015 is shown in Figure 5.9-1.

![Figure 5.9-1: Direct CO\textsubscript{2} emissions from Urea Application](image)

5.9.2. Methodological issues

CO\textsubscript{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\textsubscript{2}O emission from Agricultural Soils emission estimates for inorganic N Fertilizers. See Chapter 5.5.1.2 for details. Entire proportion of urea and urea ammonium nitrate solutions was assumed to be urea for
conversion of CO₂-C emissions to CO₂, 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 N₂O emissions from Manure Management and Direct N₂O Emissions from Agricultural Soils). Uncertainty estimate associated with emission factors amounts to ±50 percent, according to information on default factors uncertainty range provided in the IPCC Guidelines. Emissions have been calculated using the same method and data sets for every year in the time series.

5.9.4. 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 N₂O 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 N₂O 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 afterwards. 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 2015

<table>
<thead>
<tr>
<th>IPCC Source Categories</th>
<th>GHG</th>
<th>Key</th>
<th>If Column C is Yes, Criteria for Identification</th>
<th>Com.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4(III) Direct N₂O emissions from N₂O mineralization/immobilization</td>
<td>N₂O</td>
<td>Yes</td>
<td>L₂i</td>
<td>T₂i</td>
</tr>
<tr>
<td>4.A.1 Forest Land Remaining Forest Land</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁i, L₂i</td>
<td>T₁i, T₂i</td>
</tr>
<tr>
<td>4.A.2 Land Converted to Forest Land</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁i, L₂i</td>
<td>T₁i, T₂i</td>
</tr>
<tr>
<td>4.B.1 Cropland Remaining Cropland</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₂i</td>
<td>T₁i, T₂i</td>
</tr>
<tr>
<td>4.B.2 Land Converted to Cropland</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₂i</td>
<td>T₂i</td>
</tr>
<tr>
<td>4.C.2 Land Converted to Grassland</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₂i</td>
<td>T₂i</td>
</tr>
<tr>
<td>4.D.2 Land Converted to Wetlands</td>
<td>CO₂</td>
<td>Yes</td>
<td></td>
<td>T₂i</td>
</tr>
<tr>
<td>4.E.2 Land Converted to Settlements</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₁i, L₂i</td>
<td>T₁i, T₂i</td>
</tr>
<tr>
<td>4.G Harvested Wood Products</td>
<td>CO₂</td>
<td>Yes</td>
<td>L₂i</td>
<td>T₁i, T₂i</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>LAND USE CATEGORIES</th>
<th>Net CO₂ emissions/removals</th>
<th>CH₄</th>
<th>N₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Forest land</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>1. Forest land</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2. Land converted</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>B. Cropland</td>
<td>x</td>
<td>NO</td>
<td>x</td>
</tr>
<tr>
<td>1. Cropland</td>
<td>x</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2. Land converted</td>
<td>x</td>
<td>NO</td>
<td>x</td>
</tr>
<tr>
<td>C. Grassland</td>
<td>x</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>1. Grassland</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2. Land converted</td>
<td>x</td>
<td>NO</td>
<td>x</td>
</tr>
<tr>
<td>D. Wetlands</td>
<td>x</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>1. Wetlands</td>
<td>NE</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2. Land converted</td>
<td>x</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>E. Settlements</td>
<td>x</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>1. Settlements</td>
<td>NE</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2. Land converted</td>
<td>x</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>F. Other land</td>
<td>x</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>1. Other land</td>
<td>NE</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2. Land converted</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

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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\textsubscript{2} removals, while every other category represents an emission source.

Figure 6.1-1: Emission/removal trend for LULUCF

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\(^\text{10}\) 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 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
- grassland converted to wetlands
- wetlands converted to settlements

The area of Other land is reported in accordance with the IPCC methodology. It was interpreted as the difference of the area of all other categories and the whole area of Croatia. Conducted survey

\(^{10}\) Forest Act (OG 140/05, 82/06, 129/08, 80/10, 124/10, 25/12, 68/12, 148/13, 94/14)
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.

Based on annual land use changes, a matrix for LUC transition period was developed (Table 6.1-4). The table describes the initial and final areas of each land-use categories in transition period of 20 years and the identified annual land use changes among categories of land. It should be noted that in matrix the annual totals for the individual years do not match annual totals in CRF tables where the changes are reported in transition period of 20 years.

The table 6.1-3 presents land use data and land use changes in the reporting period.

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<td>2,370</td>
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### Area in kha

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Table 6.1-4 Land use matrixes for the years 1990-2015

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CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE

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CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE
### Croatian NIR 2017

Zagreb, March 2017

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CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE

- 305 -
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 2017, 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\textsuperscript{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.

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

\textsuperscript{11} Ordinance on forest management (OG 79/15)
• 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\textsuperscript{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)

\textsuperscript{12} (OG 140/05, 82/06, 129/08, 80/10, 124/10, 25/12, 68/12, 148/13, 94/14)
- 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.

The Ministry of Agriculture supervises the decision making process 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, currently in the approval procedure).

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. Even-aged forest stands make regular forests which cover about 83% of forest land with tree cover (excluding maquis, shrub, garigue and scrub). Uneven-aged forests make about 17% of forest land with tree cover (excluding maquis, shrub, garigue and scrub).

State forests are managed either by “Croatian Forests Ltd.” or by other legal bodies. As regarding the private forests, the Forest Advisory Service (FAS) was established in 2006 (began

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13 Ibid
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)
Therefore, it should be emphasized again that the basic unit for forest management in Croatia is the sub-compartment for which, based on field measurements on a 0.05 ha grid and the analysis of the related results, data on area, land category, growing stock and increment on diameter class (above 10 cm in diameter at 130 cm above ground, classes by 5 cm), age, ecological and management type, crown cover, height above sea level, the level of fire vulnerability, tree species and related number of
trees etc. are determined. Furthermore, for each sub-compartment a felling and silvicultural treatment rule is prepared which is recorded each year.

**Forest land**

The Forest Act regulates the growing, protection, usage and management of forest land as a natural resource aimed to maintain biodiversity and ensure management based on principles of economic sustainability, social responsibility and ecological acceptability. It prohibits the renewal of forests by clear cutting, thus natural rejuvenation is the principal method for renewal of all natural forests.

The following figures are based on data for 2006 provided in the Forest Management Area Plan for the period 2006-2015 (FMAP 2006-2015) and present forest area in Croatia as defined by Forest Act and Ordinance on Forest management.

Figure 6.3-7: The share of categories of land under the forest management (LUFM)

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

- High forests
- Plantations
- Forest cultures
- Coppice
According to the Forest Act forests are classified in three categories:

- management forests (which made about 90% of total forest area in 2006)
- protection forests (which made about 6% of total forest area in 2006)
- forests with special purpose (which made about 4% of total forest area in 2006).

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

a) State forests owned by the state and managed by
   - the public enterprise “Hrvatske šume d.o.o.” (Croatian Forests Ltd.)
   - legal bodies owned by the state (e.g. national parks, Faculty of Forestry, Ministry of Defence, “Croatian Waters” etc.)

b) Private forests
State forests make about 78% of total forest area, while the remaining 22% are privately owned (Figure 6.3-9).

Figure 6.3-9: The ownership structure of forest area in Croatia, year 2006

The area of forests is determined based on all available cadastral maps in various scales. However, while preparing the FMAP 2006-2015, it was noticed that cadastral data on forest area did not match real conditions – private forests were larger than those presented in the cadastre. Since private forests are highly fragmented and scattered over the entire Croatian territory, most precise determination of their area and their spatial position was accomplished by applying the remote sensing methods for the forest area extraction and field work to determine forests’ condition. The forest area was extracted in three ways:

1. by using the ortophoto (scale 1:5,000)
2. by using the satellite images (scale 1: 1,000,000)
3. by using the CORINE data.

The FMAP 2006-2015 determines total growing stock of about 398 mil. m³ in 2006 by calculation based on the following measured data:

- diameters at breast height
- 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 6.3-10: The share of growing stock in state and private forests, year 2006

Figure 6.3-11: Share of main species in total growing stock, year 2006

At least 2% in even-aged stands of the second age class regarding the high forests in area that is subject of FMAP, forests with limited management, coppices, protection forests and private forests.
At least 5% in even-aged stands of high forests (age classes above the second age class) in area that is subject of FMAP and in uneven-aged forests.

For example, planned work normative for state forests managed by „Croatian Forests” for the year 2010 included:

- Extracting the sub-compartment at 143,000 ha
- Measurements of breast diameters at 69,000 sample plots of the 5% sample trees
- Measurements of breast diameters at 25,000 sample plots of the 2% sample trees
- Measurements of breast diameters of all trees at 6,000 ha
- Measurements of 123,000 tree heights
- Taking 43,000 bores.

Based on the legislation\textsuperscript{14}, 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 6.3-12.

Figure 6.3-12: The share of increment in state and private forests, year 2006

\textsuperscript{14} Ordinance on Forest Management
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.  

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.

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15 Croatian Agency for Environment and Nature, Corine Land Cover database. See list of References
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 1960-2000 were used. Although these CBS data are consistent during the period 1960-2000, a deviation in data series 1992-1997 due to War influences was recorded. In order to adjust this period, linear interpolation of the CBS data from the period 1991-1998 was used.

The CBS data in the period after 2000 needed to be adjusted due to significant changes in cropland area compared to data from previous periods and data obtained from other data sources. The adjustment was done using the relative trend of the CLC.

The significant changes in cropland and grassland area in the period after 2000 were caused by difference in the CBS data collection and application of new EUROSTAT methodology, as follows: "In 2005, the Croatian Bureau of Statistics gathered for the first time crop production statistics data concerning private family farms by using the interview method on a selected sample with the help of interviewer. This meant abandoning a long lasting method of collecting data by using the estimation method done by agricultural estimators on the basis of cadastre data. The sample for agricultural households was selected from the 2003 Agricultural Census data basis and was completely random: the only condition was that at least three
households were situated in the same settlement. The sample size was conditioned by inimical means allotted from the State Budget of the Republic of Croatia. As much as 11 000 households were selected in the sample. The criterion for the sample selection was based on seven sizes: the total used agricultural land area, size of arable land, size of garden area, size of meadow area, size of pasture area, size of orchard area and size of vineyard area. All obtained data were expanded, compared to data from previous years, to data from the 2003 Agricultural Census and available administrative sources (the Register of Agricultural Holdings of the Ministry of Agriculture, Fisheries and Rural Development). If necessary, corrections have been made on the basis of all available data.

Due to abandoning of a long-standing method of compiling data through estimates done by agricultural estimators on the basis of cadastral data, there emerged significant differences in data on land areas of some crops, vineyards and orchards. They mostly relate to the reduction of land areas, which could have been caused by the tardiness of the cadastre.

Data on area for the period from 2000 to 2004 were revised according to the Agricultural Census 2003 data. Since there were Agricultural Census data and estimates of statistical experts available for 2003, that year was selected as the most suitable to be 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 recommendations16.

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

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16 Statistical Yearbook of the Republic of Croatia 2012. See list of References
grassland areas and explains the difference between the CBS data series for the period 1990-1999 and the period 2000-2010.

The area data adjustment after 2000 for the necessity of this report due to the changes in the CBS data collection approach and application of new EUROSTAT methodology is presented in Figure 6.3-13.

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, 1981-1989, 1990-2000, 2000-2006 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) 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)

In this report CLC data were used to present grassland area in Croatia in the years 1980, 1990, 2000, 2006 and 2013. 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 2.1 kha annually and had been continuously decreasing since the year 2001: in the period 2001-2006 by 6.1 kha annually and in 2006-2015 by 0.7 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 between the CLC assessment years was carried out. For the years after 2012 extrapolation of the CLC trend 2006-2012 was applied.

According to CLC trends the wetland area increased 196 ha per year in the period 1980-1990, 197 ha per year in the period 1991-2000, 21 ha per year in the period 2001-2006 and 12 ha per year in the period 2007-2015. 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 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 $-(0.031 \times 0.45 \times \text{total area of Croatia})$ 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 between the assessment years was carried out. 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 CLC 2000-2006 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 79 and 54 kha in the period 1990-2015, which does not match the available area of the total area of Croatia due to area consistency with the area of total Croatia and those of the other sub-categories. The difference between the CLC other land area and available area under the total area ranged between 154 and 107 kha in the reporting period\(^{17}\).

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 168 and 246 kha.

\(^{17}\) When developing land use matrix (first time in 2012) Croatia used information of different land covers that were available in CLC databases. All classes in CLC database were compared and attributed to the corresponding UNFCCC categories of land. Since Burn areas (defined as Level 3 in CLC nomenclature) make part of Forests and semi-natural areas (CLC Level 1) and Open spaces with less or no vegetation (CLC Level 2) it was concluded these areas should be assigned to the UNFCCC Other land category.
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, CO₂ emissions/removals from soil and living biomass 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. CO₂ and non-CO₂ 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 so called random yield and it refers 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.

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18 Below ground biomass is combined with the above ground and thus the notation key IE is used for below ground biomass.
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)\textsuperscript{19}.

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\textsubscript{2} removals from forest land remaining forest land in 2015 are -5,419 kt CO\textsubscript{2} and from Land converted to Forest land -268.56 kt CO\textsubscript{2}. Therefore, the share of removals from land conversion in total Forest land removals makes only 4.72%. 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\textsubscript{2} in Forest land category (kt CO\textsubscript{2})

\textsuperscript{19} 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).
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<td>-268.56</td>
<td>2.71</td>
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### Table 6.4.2: CO2 emissions from wildfires

<table>
<thead>
<tr>
<th>Year</th>
<th>Area burnt (ha)</th>
<th>CO2 emission (kt)</th>
<th>CH4 emission (CO2 eq (kt))</th>
<th>N2O emission (CO2 eq (kt))</th>
</tr>
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<tr>
<td>1990</td>
<td>482</td>
<td>8.99</td>
<td>0.04</td>
<td>0.00</td>
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<td>1991</td>
<td>1,291</td>
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<tr>
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<td>5,864</td>
<td>109.30</td>
<td>0.55</td>
<td>0.03</td>
</tr>
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<td>1993</td>
<td>14,102</td>
<td>262.86</td>
<td>1.31</td>
<td>0.07</td>
</tr>
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<td>4,591</td>
<td>85.58</td>
<td>0.43</td>
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<td>3,011</td>
<td>56.12</td>
<td>0.28</td>
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<td>1996</td>
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<td>0.60</td>
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</tr>
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<td>17,093</td>
<td>318.61</td>
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<td>44.99</td>
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<td>15.64</td>
<td>0.08</td>
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<td>2005</td>
<td>913</td>
<td>17.01</td>
<td>0.08</td>
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<td>2,322</td>
<td>43.28</td>
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<td>0.19</td>
<td>0.01</td>
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<td>688</td>
<td>12.82</td>
<td>0.06</td>
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<td>1.42</td>
<td>0.08</td>
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<td>11.46</td>
<td>0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>2014</td>
<td>79</td>
<td>1.47</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>2015</td>
<td>4,068</td>
<td>75.83</td>
<td>0.38</td>
<td>0.02</td>
</tr>
</tbody>
</table>

### 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 2006-2015). 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:

$$\Delta C_{FFLB} = (\Delta C_{FFG_{CFj}} \cdot \Delta C_{FFL_{CFj}}) + (\Delta C_{FFG_{Otherj}} \cdot \Delta C_{FFL_{Otherj}}) + (\Delta C_{FFG_{Privatej}} \cdot \Delta C_{FFL_{Privatej}})$$

Where:

$$\Delta C_{FFLB} = \text{annual change in carbon stocks in living biomass (includes above and below ground biomass) in the Forest land remaining forest land, Cyr}^{-1}$$

$$\Delta C_{FFG_{CFj}} = \text{annual increase in carbon stocks due to biomass growth, in state forests managed by “Croatian Forests” (CF), by forest types (j=1,2), Cyr}^{-1}$$

$$\Delta C_{FFG_{Otherj}} = \text{annual increase in carbon stocks due to biomass growth, in other state forests (Other) and private forests (Private), by forest types (j=1,2), Cyr}^{-1}$$

$$\Delta C_{FFG_{Privatej}} = \text{annual increase in carbon stocks due to biomass growth, in private forests (Private), by forest types (j=1,2), Cyr}^{-1}$$

$$\Delta C_{FFL_{CFj}} = \text{annual decrease in carbon stocks due to biomass loss, in state forests managed by “Croatian Forests” (CF), by forest types (j=1,2), Cyr}^{-1}$$

$$\Delta C_{FFL_{Otherj}} = \text{annual decrease in carbon stocks due to biomass loss, in other state forests (Other) and private forests (Private), by forest types (j=1,2), Cyr}^{-1}$$

$$\Delta C_{FFL_{Privatej}} = \text{annual decrease in carbon stocks due to biomass loss, in private forests (Private), by forest types (j=1,2), Cyr}^{-1}$$

Where

$$j = \begin{cases} 1 & \text{broadleaved} \\ 2 & \text{coniferous} \end{cases}$$

The activity data for CO₂ emission/removal calculation includes data on forest area, increment and fellings. Methodological issues are explained in detail below.

**Forest area**

Data on forest area are in line with the relevant definitions and therefore exclude afforested area.

**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\textsuperscript{20} which makes difficult to follow difference in area based on ownership structure which was one of reasons for performing estimation of emissions/removals for whole Croatia without separating forests based on forests ownership.

The carbon loss due to felling is calculated using Tier 2 and equation 2.12 from IPCC 2006 Guidelines.

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

<table>
<thead>
<tr>
<th></th>
<th>tonnes d.m.m$^{-3}$</th>
<th>dimensionless</th>
<th>dimensionless</th>
<th>dimensionless</th>
<th>(tonnes d.m.)$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D</td>
<td>BEF1</td>
<td>R/S</td>
<td>BEF2</td>
<td>CF</td>
</tr>
<tr>
<td>Deciduous</td>
<td>0.56</td>
<td>1.20</td>
<td>0.23</td>
<td>1.197</td>
<td>0.48</td>
</tr>
<tr>
<td>Coniferous</td>
<td>0.39</td>
<td>1.15</td>
<td>0.29</td>
<td>1.0387</td>
<td>0.51</td>
</tr>
<tr>
<td>Out of Yield (maquies and shrub)</td>
<td>0.68</td>
<td>1.1</td>
<td>0.46</td>
<td>1.15</td>
<td>0.47</td>
</tr>
</tbody>
</table>

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\textsuperscript{21} and share of species in total growing stock in Croatia\textsuperscript{22}, it is estimated that wood density in deciduous species is 0.558 t d.m/ha and 0.395 t d.m/ha in case of coniferous species. For these estimations, wood densities of absolute dry wood per fresh volume (m$_0$/VWET) were used

\textsuperscript{20} Draft strategy for management and disposal of property of the Republic of Croatia 2013-2017. See list of References
\textsuperscript{21} Scientific papers of Badjun, Horvat,Sinković, Govorčin, Štajduhar. See list of References
\textsuperscript{22} Forest Management Area Plan of the Republic of Croatia 2006-2015. See list of References
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%.

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. Since there is no exact data about area of common fir on silicate and limestone, mean value of 0.387 t d.m/m$^3$ was used when calculating contribution of common fir wood density to the wood density of coniferous species in general.

It was concluded by expert judgement that oriental hornbeam should be used as representative specie of maquies and scrub forests. Wood density of hornbeam in absolute dry 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.

The detailed overview of the approach is shown below:

$$\Delta C_B = \Delta C_G - \Delta C_L$$
$$\Delta C_G = \sum_{i,j} (A_{i,j} x I_v x BEF_{i} x D_{i} x (1+R) x CF)$$

Where:

- $\Delta C_B$ = annual change in carbon stocks in biomass, tonnes C yr$^{-1}$
- $\Delta C_G$ = annual increase in carbon stocks due to biomass growth, C yr$^{-1}$
- $\Delta C_L$ = annual decrease in carbon stocks due to biomass losses, C yr$^{-1}$
- $\Delta C_G$ = 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$^{-1}$
- $BEF_{i}$ = biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to above ground biomass growth for

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23 Scientific paper of Sinković, Govorčin and Sedlar. See list of References
24 Scientific paper of Horvat. See list of References
25 Scientific paper of Govorčin, Sinković, Trajković, Šefc. See list of References
26 Mali šumarsko-tehnički priručnik. See list of References
specific vegetation type, tonnes above-ground biomss growth (m³ annual increment)\(^{-1}\)

\[ D_1 = \text{basic wood density} \]

\[ R = \text{ration of below-ground biomass to above-ground biomass for a specific vegetation type, in tonne d. m. below ground biomass (tonne d. m. above-ground biomass)} \]

\[ CF = \text{carbon fraction of dry matter (tonne d.m)} \]

\[ \Delta C = \text{annual decrease in carbon stocks due to biomass losses in forest land remaining forest land} \]

\[ H = \text{annual wood removal, roundwood, m}^3\text{yr}^{-1} \]

\[ \text{BEF}_2 = \text{biomass expansion factor for conversion for wood removal (m}^3\text{ of removals)} \]

\[ D_R = \text{basic wood density} \]

\[ R = \text{ration of below-ground biomass to above-ground biomass for a specific vegetation type, in tonne d. m. below ground biomass (tonne d. m. above-ground biomass)} \]

\[ \text{L}_{\text{fuelwood}} = \text{annual biomass loss due to fuelwood removals, tonnes C yr}^{-1} \text{ (Equation 2.13)} \]

\[ \text{L}_{\text{disturbance}} = \text{annual biomass loss due to fuelwood removals, tonnes C yr}^{-1} \text{ (Equation 2.14)} \]

**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 1990-2015.

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 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 afforestation 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 Law of nature protection and their area is fixed, well

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27 Janes et al. (2014), Separation of areas under the Article 3.3 and 3.4 of the Kyoto protocol. See list of References
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\textsuperscript{28} 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\textsuperscript{29}, funds can be obtained by private owners only for works performed on area that is registered in cadastre as forest or land under the forest management. Comparison between national definition of land under the forest management and IPCC definitions of categories of land shows that partially the IPCC category of Grasslands falls under the definition of land under the forest management according to the national definition. Potentially, this meant that some of afforestation work could occur on grasslands owned by private owners. The type of land that is without real forest cover on private lands and which is in cadastre registered as forest land is mainly present in karst region in Croatia. Based on the facts that afforestation works in karst region are very demanding, expensive and require to be performed by adequate species which are mostly economically less valid, it is understandable that afforestation in private forests in karst region on land that has not been forested for a period of at least 50 years did not occur.

\textsuperscript{28} 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.

\textsuperscript{29} Ordinance on amendments to the Ordinance on the Register of forest owners (OG 84/2008). See list of References.
Through the conducted survey detailed data and information about conversion to forest land category through seeding and planting measures were collected and areas of conversion are well know (Figure 6.4-2)

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)

<table>
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<tr>
<td>2013</td>
<td>296.62</td>
<td>29.12</td>
<td>6,815.74</td>
</tr>
<tr>
<td>2014</td>
<td>388.76</td>
<td>38.16</td>
<td>7,920.78</td>
</tr>
<tr>
<td>2015</td>
<td>681.49</td>
<td>66.89</td>
<td>6,817.77</td>
</tr>
</tbody>
</table>

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 2016, 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 CO₂ and non-CO₂ 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, 2014, 2015.

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 2013-2015.

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 2013-2015.

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 (1.53 for AGB and 0.612 for BGB) and 1.97 tC/ha in age class ≥ 20 years (1.53 for AGB and 0.4437 for BGB). Value of 2.8 tC/ha (AGB+BGB) was used s average biomass growth for deciduous forests (separately, 1.92 for AGB and 0.8832 for BGB). Average biomass growth was calculated to be 0.34 tC/ha (AGB+BGB) for maquies and shrub forests (separately, 0.235 for AGB and 0.1081 for BGB).

In order to calculate the biomass carbon stock losses as a result of grassland and cropland conversion to the forestland, the nationally determined value of 4.29 tC/ ha annually for grassland category and 5.67 tC/ha annually for annual Cropland category were used. When estimating carbon
stock losses due to conversion of perennial Cropland to forestland IPCC 2006 Guidelines value of 63.0 tC/ha annually was used.

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

B) Soil

The soil data were analyzed and it was concluded that the median values determined for each land use category need to be taken into calculation, because they are less influenced by outliers.

For the purposes of soil carbon content determination the analyse using the dry combustion method was applied. The estimation was performed using the national value of 10 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:

\[ \Delta C_{\text{LF Mineral}} = \left( (\text{SOC}_{\text{ref}} - \text{SOC}_{\text{Non Forest Land}}) \times A_{\text{Aff}} \right) / T_{\text{Aff}} \]

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

The median values of soil carbon stock for the soil depth of 0-20 cm determined through the national scientific soil survey were used in order to present the carbon stock changes in soil (see chapter 6.5.2.1). It should be noted that the forest land soil C stock includes also the C stock of the litter layer (humus layer), the C stock change of the litter layer is therefore reported as IE (covered by the soil C stock changes). The results of national survey and determined median values of carbon stock changes in soil are:

\[ \Delta C_{\text{LF Mineral}} \]
• Cropland (annual): 46.35 t C/ha
• Cropland (perennial): 77.81 t C/ha
• Forest land: 84.54 t C/ha
• Grassland: 70.64 t C/ha
• Settlements: 55.04 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.

<table>
<thead>
<tr>
<th>Year</th>
<th>Biomass carbon stocks gains</th>
<th>Biomass carbon stocks losses</th>
<th>Biomass net carbon stock change</th>
<th>Net soil carbon stock change</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>8.073</td>
<td>0.000</td>
<td>8.073</td>
<td>2.462</td>
<td>10.536</td>
</tr>
<tr>
<td>1991</td>
<td>8.145</td>
<td>-0.916</td>
<td>7.228</td>
<td>2.481</td>
<td>9.710</td>
</tr>
<tr>
<td>1992</td>
<td>8.081</td>
<td>-0.698</td>
<td>7.383</td>
<td>2.464</td>
<td>9.848</td>
</tr>
<tr>
<td>1993</td>
<td>8.339</td>
<td>-1.279</td>
<td>7.060</td>
<td>2.542</td>
<td>9.602</td>
</tr>
<tr>
<td>1995</td>
<td>8.599</td>
<td>-0.994</td>
<td>7.604</td>
<td>2.623</td>
<td>10.228</td>
</tr>
<tr>
<td>1996</td>
<td>8.830</td>
<td>-1.234</td>
<td>7.596</td>
<td>2.694</td>
<td>10.290</td>
</tr>
<tr>
<td>1997</td>
<td>8.866</td>
<td>-0.842</td>
<td>8.024</td>
<td>2.700</td>
<td>10.724</td>
</tr>
<tr>
<td>1998</td>
<td>9.039</td>
<td>-1.117</td>
<td>7.922</td>
<td>2.752</td>
<td>10.674</td>
</tr>
<tr>
<td>1999</td>
<td>9.349</td>
<td>-1.424</td>
<td>7.924</td>
<td>2.852</td>
<td>10.777</td>
</tr>
<tr>
<td>2003</td>
<td>10.164</td>
<td>-1.220</td>
<td>8.943</td>
<td>3.085</td>
<td>12.029</td>
</tr>
<tr>
<td>2004</td>
<td>11.491</td>
<td>-3.007</td>
<td>8.484</td>
<td>3.443</td>
<td>11.927</td>
</tr>
<tr>
<td>2006</td>
<td>15.112</td>
<td>-12.750</td>
<td>2.363</td>
<td>7.430</td>
<td>9.793</td>
</tr>
<tr>
<td>2007</td>
<td>17.515</td>
<td>-17.554</td>
<td>-0.038</td>
<td>10.143</td>
<td>10.105</td>
</tr>
</tbody>
</table>
### 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 uncertainty 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>
<thead>
<tr>
<th>Year</th>
<th>Biomass carbon stocks gains</th>
<th>Biomass carbon stocks losses</th>
<th>Biomass net carbon stock change</th>
<th>Net soil carbon stock change</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>55.737</td>
<td>-32.788</td>
<td>22.948</td>
<td>30.968</td>
<td>53.917</td>
</tr>
<tr>
<td>2014</td>
<td>63.417</td>
<td>-38.626</td>
<td>24.791</td>
<td>37.048</td>
<td>61.840</td>
</tr>
<tr>
<td>2015</td>
<td>67.654</td>
<td>-37.358</td>
<td>30.295</td>
<td>42.949</td>
<td>73.245</td>
</tr>
</tbody>
</table>

Table 6.4-6 Uncertainties of the emissions factors and the activity data and sources of information

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Uncertainty</th>
<th>Source of information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of Forest land</td>
<td>10%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>Increment</td>
<td>7%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>Fellings</td>
<td>5%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>Afforestation area</td>
<td>2%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>Deforestation area</td>
<td>2%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>Wood density</td>
<td>30%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>R/S (Root to Shoot ratio) for coniferous in Forestland</td>
<td>Range 0.12-0.49</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>Inputs</td>
<td>Uncertainty</td>
<td>Source of information</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
<td>------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>R/S (Root to Shoot ratio) for deciduous in Forestland</td>
<td>Range 0.17-0.30</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>R/S (Root to Shoot ratio) for coniferous in afforested areas</td>
<td>42%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>BEF 1 for coniferous</td>
<td>Range 1-1.3</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>BEF 1 for deciduous</td>
<td>Range 1.1-1.3</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>BEF 2 for coniferous</td>
<td>Range 1.15-4.2</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>BEF 2 for deciduous</td>
<td>Range 1.15-3.2</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>CF factor</td>
<td>3%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>Soil C stock in Forestland</td>
<td>92%</td>
<td>Empirical data</td>
</tr>
<tr>
<td><strong>Area of Cropland</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>aCL area</td>
<td>12%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>pCL area</td>
<td>12%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>LUC area aCL-pCL</td>
<td>500%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>LUC area pCL-aCL</td>
<td>500%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>LUC area GL - aCL</td>
<td>100%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>LUC area GL - pCL</td>
<td>500%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>Yield biomass at LUC areas to and from aCL</td>
<td>156%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>Other aboveground biomass at LUC areas to and from aCL</td>
<td>156%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>Belowground biomass at LUC areas to and from aCL</td>
<td>75%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>pCL aboveground biomass</td>
<td>75%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>Organic soil area</td>
<td>12%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>Soil C stock in annual Cropland</td>
<td>57.1%</td>
<td>Empirical data</td>
</tr>
<tr>
<td>Soil C stock in perennial Cropland</td>
<td>76.3%</td>
<td>Empirical data</td>
</tr>
<tr>
<td>Emission factor for organic Grassland soils</td>
<td>90%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>Emission factor for organic Cropland soils</td>
<td>90%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td><strong>Area of Grassland</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LUC area aCL-GL</td>
<td>100%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>LUC area pCL-GL</td>
<td>100%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>R/S factor in Grassland</td>
<td>95%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>Organic soil area</td>
<td>30%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>Soil C stock in Grassland</td>
<td>61.2%</td>
<td>Empirical data</td>
</tr>
<tr>
<td>Emission factor for organic Grassland soils</td>
<td>90%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>C/N ratio grassland soils</td>
<td>10.6%</td>
<td>Empirical data</td>
</tr>
<tr>
<td>Yield biomass at LUC areas to and from Grassland</td>
<td>75%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td><strong>Area of Wetland</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LUC area aCL-WL</td>
<td>300%</td>
<td>Expert judgment</td>
</tr>
<tr>
<td>LUC area pCL-WL</td>
<td>300%</td>
<td>Expert judgment</td>
</tr>
</tbody>
</table>
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 2015, the relative uncertainty of CO\(_2\) equivalent emission/removal ranges between -52.40 and 194.14 % 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 -179.77% and 170.70%.

### 6.4.4. Category-specific QA/QC and verification

During the preparation of inventory submission, all activity data were checked. The emission calculation was performed by one person and afterwards independently checked by another person within the institution that prepared the inventory. Institution that leads the technical work has approval of the Ministry of Environmental and Nature protection for carrying out the GHG calculations. Activities related to quality control were also focused on completeness and consistency of emission estimates and also on the proper use of notation keys in the CRF tables.

The input data, estimates and results were checked as follows:

1) Bottom-up check
   a. Input data
      - Check for the plausibility of the activity data and their trend
- Check for plausibility of the emission factors as well as the related input data and their trends
- Check of input data for completeness

b. Estimations
- Check of the correctness of all equations in the estimate files
- Check of the correctness of all interim results
- Check of the plausibility of the results and their trends
- Check of the correctness of all data and results transfer

2) Top-down check

During the preparation of inventory, experts from all relevant fields were included. All input data were checked by the experts. The definitions, factors and methods applied in the report were agreed with the experts in relevant fields, ensuring in that way consistency and completeness of input data. The final calculated data were sent to the experts for their approval. The used activity data and emission factors were also compared with the data from other data sources (e.g. from literature, results in NIRs of other comparable regions, IPCC default values).

6.4.5. Category-specific recalculations

Recalculations needed in this category of land coming due to use of new 2006 IPCC Guidelines and some improvements done by Croatia (See Chapter 10). Since the last submission, the emission estimates were recalculated for the entire category and reporting period. The recalculation was performed due to a) better application of 2006 Guidelines and b) correction in volume harvested based on harvest practices applied in Croatia (BEF 2) (Table 6.4.7).

Table 6.4.7 Changes in estimation parameters used for category 4.A

<table>
<thead>
<tr>
<th></th>
<th>Forest type</th>
<th>BEF 1 (dimensionless)</th>
<th>R (dimensionless)</th>
<th>BEF 2 (dimensionless)</th>
<th>CF (tonnes d.m)^{-1}</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NIR 2015</strong></td>
<td>Deciduous</td>
<td></td>
<td>0.26</td>
<td>1.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coniferous</td>
<td></td>
<td>0.32</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Out of Yield (maquies and shrub)</td>
<td>1.0</td>
<td>0.26</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td><strong>NIR</strong></td>
<td>Deciduous</td>
<td></td>
<td>0.23</td>
<td>1.197</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td>Coniferous</td>
<td></td>
<td>0.29</td>
<td>1.0387</td>
<td>0.51</td>
</tr>
</tbody>
</table>
The result of the performed recalculation can be seen in Figure 6.4-3. On average, removals increased by 13.6% compared to the previously reported estimates.

Figure 6.4-3: Current and previously reported emissions for category 4.A (kt CO₂)

<table>
<thead>
<tr>
<th>Forest type</th>
<th>BEF 1 (dimensionless)</th>
<th>R (dimensionless)</th>
<th>BEF 2 (dimensionless)</th>
<th>CF (tonnes d.m)⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016 Out of Yield (maquies and shrub)</td>
<td>1.1</td>
<td>0.46</td>
<td>NA</td>
<td>0.47</td>
</tr>
</tbody>
</table>

6.4.6. Category-specific planned improvements

Further investigation on BEFs is part of a new project proposal within the LULUCF sector. Improvements are to be implemented in timeframe as it is presented in Chapter 10.

The Croatian National Forest Inventory (CRONFI) is still under consideration among the forestry society and has no official character. In that respect, the Ministry of Agriculture and the Ministry of Environmental and Nature Protection agree that preparation of the annual GHG Inventory in respect of LULUCF sector should be based on the forest management plans. Once CRONFI becomes official, it could be used to fill the gaps in reporting.
By taking into consideration the consistency requirements for this reporting, it should be mentioned that the forest management in Croatia from its beginning relies on the forest management plans while CRONFI was conducted for the first time.

6.5. **CROPLAND (CRF CATEGORY 4.B)**

6.5.1. **Description**

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

Cropland area ranged from 1,587.03 kha to 1,623.77 kha in the period 1990-2015. Emissions from the change in carbon stock in biomass and soil ranged from 10.85 kt CO\textsubscript{2}eq to 345.77 kt CO\textsubscript{2}eq 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 1990-2015.

<table>
<thead>
<tr>
<th>Year</th>
<th>4.B Total Cropland</th>
<th>4.B.1 Cropland remaining cropland</th>
<th>4.B.1a Annual cropland remaining cropland</th>
<th>4.B.1b Perennial cropland remaining cropland</th>
<th>4.B.1c Perennial cropland converted to annual cropland</th>
<th>4.B.1d Annual cropland converted to perennial cropland</th>
<th>4.B.2 Land converted to Cropland</th>
<th>4.B.2.2a Grassland converted to annual cropland</th>
<th>4.B.2.2b Grassland converted to perennial cropland</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>1,623.77</td>
<td>1,623.66</td>
<td>1,479.11</td>
<td>144.51</td>
<td>0.019</td>
<td>0.018</td>
<td>0.103</td>
<td>0.100</td>
<td>0.003</td>
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<td>4.B.1.a Annual cropland remaing annual cropland</td>
<td>4.B.1.b Perennial cropland remaining perennial cropland</td>
<td>4.B.1.c Annual cropland converted to annual cropland</td>
<td>4.B.1.d Cropland converted to perennial cropland</td>
<td>4.B.2.1a Grassland converted to cropland</td>
<td>4.B.2.1b Grassland converted to perennial cropland</td>
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Table 6.5-2: Emissions (+) / removals (-) of CO2 in Cropland from 1990 to 2015 (Gg CO2 equivalent)
### 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\(^{31}\)) in presenting carbon stock changes in this land use category.

#### A) Biomass

\(^{31}\) Bulgaria’s National Inventory Report for 2012; Austria’s National Inventory Report 2012; Luxembourg’s National Inventory Report 2012. See list of References.
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 annually 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:

\[ \text{Annual change in biomass} = (\text{area of perennial cropland remaining perennial cropland} \times \text{carbon accumulation rate}) \]  
\[ - (\text{area of perennial cropland 30 years ago} \times 0.033 \times \text{biomass carbon stock at harvest}) \]  

* 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:

\[ \text{Annual change in carbon stock in biomass} = \text{conversion area for a transition period of 20 years} \times \Delta C_{\text{Growth}} + \text{annual area of currently converted land} \times L_{\text{Conversion}} \]

where:

\[ L_{\text{Conversion}} = C_{\text{After}} - C_{\text{Before}} \]
\[ \Delta C_{\text{Growth}} = \text{Carbon accumulation rate of perennial cropland} = 2.1 \text{ tC/ha annually (IPCC default value)} \]
\[ C_{\text{Before}} = \text{biomass carbon stock of annual cropland before conversion is: 5.67 tC/ha annually} \]
\[ C_{\text{After}} = \text{carbon stock immediately after conversion} = 0 \text{ tC/ha (IPCC default value)} \]

The country 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\textsuperscript{32}), as well as expansion factors from the Austrian Expert Panel for Soil Fertility\textsuperscript{33}. 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 basis 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:

\[
\text{Annual change in carbon stock in biomass} = \text{Annual area of converted land} \times (L_{\text{Conversion}} + \Delta C_{\text{Growth}})
\]

where:

\[
L_{\text{Conversion}} = C_{\text{After}} - C_{\text{Before}}
\]

\[
\Delta C_{\text{Growth}} = \text{annual cropland carbon accumulation rate: 1) 5.7 tC/ha for annual cropland}
\]

\[
C_{\text{Before}} = \text{carbon stock of perennial cropland biomass before conversion: 63 tC/ha (IPCC default value) (accounted only for the year of LUC)}
\]

\[
C_{\text{After}} = \text{carbon stock immediately after conversion is 0 t C/ ha (IPCC default value)}
\]

\textsuperscript{32} Bulgaria’s National Inventory Report for 2012; Austria’s National Inventory Report 2012; Luxembourg’s National Inventory Report 2012. See list of References

\textsuperscript{33} Bulgaria’s National Inventory Report for 2012; Austria’s National Inventory Report 2012; Luxembourg’s National Inventory Report 2012. See list of References
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

The results of the scientific research program named “Geological Maps of Croatia” were analysed for the purpose of this report and presenting the soil carbon stock changes. The work performed in the period 1997-2003 presents a continuation of former researches in this field in Croatia and has a perennial character.

In that period the whole Croatian territory was covered by setting samples sites in a grid of 5x5 km. Soil samples were collected at depths of 0 to 20 cm (surface horizon A0-20) in such a way that the whole humus layer was included. By this method 2,571 soil samples were taken in different land use categories. Each sample was composed of five sub-samples, thus reducing the probability of random errors which appear mainly as a result of local enrichment/depletion of a certain chemical element. The samples were dried, sieved to the fraction of <0.063 mm, homogenized and analyzed on a set of 41 chemical elements. During the evaluation process of carbon content the contribution of rock fragments to the soil’s total carbon content was not considered.

The performed statistical analysis included all samples with basic statistical parameters about 27 chemical elements. For the construction of geochemical maps scientists used: 5th, 10th, 25th (lower quartile), 50th (median), 75th (upper quartile), 90th and 98th percentile.

These soil data were analyzed with the conclusion that median values determined for each land use category need to be taken into calculation, because they are less influenced by outliers.

For the needs of future reports the results of this scientific research need to be compared with the results of other studies on similar issues (see Chapter 6.11).

According to expert judgment there was no change in the relative stock change factors (tillage factor FMG; land use factor FLU, input factor FI) during the past 20 years; these factors are set by default to 1. Thus there was no change in carbon stocks in soils of annual cropland remaining annual cropland and perennial cropland remaining perennial cropland due to management.
For the purposes of the reporting, additional analyze was conducted in 2013 using dry combustion method\textsuperscript{34} for the soil carbon content determination since this method has been found more accurate than previously used wet combustion method. National value for C/N ratio (10) was used for the estimation in case of Grassland mineral soils that are converted to Cropland.

The land use change area from annual cropland converted to perennial cropland in the conversion status of 20 years changed from 0.002 kha to 0.018 kha from 1990 to 2015.

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:

\[
\text{Annual change in carbon stock in soil} = \text{conversion area for a transition period of 20 years} \times \Delta \text{SOC}
\]

\[
\Delta \text{SOC} = (\text{SOC}_0 - \text{SOC}_{0:T})/20 = 1.57 \text{ tC/ha annually}
\]

where:

- $\Delta \text{SOC}$ = annual change in carbon stock soil
- $\text{SOC}_0$ = Croatian soil organic carbon stock in the inventory year = 77.81 tC/ha for perennial cropland
- $\text{SOC}_{0:T}$ = Croatian soil organic carbon stock $T$ years prior to the inventory = 46.35 tC/ha for annual cropland
- $T$ = Assessment period (20 years)

Emission/removals due to changes of carbon stock in soils of perennial cropland converted to annual cropland were calculated using the same national figures for the soil carbon content in perennial cropland as in annual cropland. The equation used for this purposes is the same as above:

\[
\text{Annual change in carbon stock in soil} = \text{conversion area for a transition period of 20 years} \times \Delta \text{SOC}
\]

\[
\Delta \text{SOC} = (\text{SOC}_0 - \text{SOC}_{0:T})/20 = -1.57 \text{ tC/ha annually}
\]

\textbf{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 2015 in case of annual

\textsuperscript{34}Work performed by Croatian Geological Institute. See list of References
cropland was 2.23 kha and 0.23 kha in case of perennial cropland and with emissions of 22.32 and 2.27 kt CO$_2$ 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:

$$\Delta C_{CC\ Organic} = A \times EF$$

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 1990-2015. 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 growth 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: 77.8 tC/ha
- Forestland: 84.5 tC/ha

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

In case of Forest land that is converted to Cropland, Croatia currently cannot perform estimation of carbon stock changes in dead organic matter (DOM) pool since the lack of the data on national level. Data and information that are available in forest national inventory process regarding the carbon stock in dead wood pool need to be checked and their usefulness for this reporting yet need to be confirmed. Regarding the estimation in litter pool, Croatia reported that carbon stock from this pool is included in the soil carbon stock. At this moment, it is not possible to report separately on carbon stock changes in this pool. Croatia initiated a project that deals with the soil carbon stocks in LULUCF categories of land. After the finalization of the project data and information gathered through it will be examined and checked for the purposes of this reporting.

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, 10.67 kha of grassland area were converted to cropland in 2015. 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 23.65 kt CO$_2$ and in 2015 in emissions of 25.42 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:

\[ \text{Annual change in carbon stock in biomass} = \text{annual area of converted land} \times (L_{\text{Conversion}} + \Delta C_{\text{Growth}}) \]

where:

\[ L_{\text{Conversion}} = C_{\text{After}} - C_{\text{Before}} \]

\[ \Delta C_{\text{Growth}} = \text{carbon accumulation rate which amounts to:} \]

1) 5.7 tC/ha for annual cropland
2) 2.1 tC/ha for perennial cropland = (IPCC GPG default value)

\[ C_{\text{Before}} = \text{carbon stock of grassland biomass before conversion} = 4.3 \text{ tC/ha} \]
\[ C_{\text{After}} = \text{carbon stock immediately after conversion} = 0 \text{ tC/ha} \]

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:

\[ \Delta SOC = (SOC_0 - SOC_{0-T})/20 \]

\[ \Delta SOC = \text{annual change in carbon stock soil} \]
\[ SOC_0 - T = \text{soil organic carbon stock in the inventory year, which amounts to:} \]

1) 46.35 tC/ha for annual cropland
2) 77.81 tC/ha for perennial cropland

\[ SOC_T = \text{soil organic carbon stock } T \text{ years prior to the inventory, equals } 70.64 \text{ tC/ha} \]

\[ T = \text{Assessment period (20 years)} \]
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 emissions in the range of 0.09 to 0.67 Gg C for grassland converted to perennial cropland for the period 1990-2015. In case of grassland converted to annual cropland, removals were from -5.17 to -10.89 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:

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

where:
- \( EF_1 \) = the emission factor for calculating emissions of \( N_2O \) from N in the soil = 0.01 kg \( N_2O \)- N/kg N (IPCC default value)
- \( \Delta C_{\text{LCmineral}} \) = change in the carbon stock in mineral soils in land to cropland
- \( C/N \) = ratio by mass of C to N in the soil organic matter (10 in case of grassland converted to cropland and 12 in case of forest land converted to cropland)

6.5.3. Uncertainties and time-series consistency

The uncertainty values for total CO\(_2\) eq in category Land converted to Cropland ranges from -1007.25% to 921.73% 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-1489.83% and 1431.69%.

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: a) better application of 2006 IPCC Guidelines (the change in emission factor for calculating emissions of N₂O from N in the soil, N₂O conversion factor) and b) revision of activity data on land areas based on newly delivered CLC data for years 1980, 1990, 2000, 2006 and 2012, as well as the new data on land use changes from CLC change databases, accordingly.

The result of the performed recalculation can be seen in Figure 6.5-1. On average, emissions increased by 0.61% compared to the previously reported estimates.

Figure 6.5-1: Current and previously reported emissions for category 4.B (Gg CO₂ eqv)
6.5.6. Category-specific planned improvements

- New activity data on land use changes from/to Cropland category are expected this year as a result of a new database changes development based on data available in CLC 1980, 1990, 2000, 2006 and 2012 databases. New areas will be presented in NIR 2017 Resumbission.
- 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.
- All data regarding the C stock in soils will be reviewed under the scope of new project “SOC stock changes, total nitrogen and total organic carbon trends, C:N ratio”

6.6. GRASSLAND (CRF CATEGORY 4.C)

6.6.1. Description

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 1,210.35 kha to 1,192.00 kha in the period 1990-2015. Removals from the change in carbon stock in biomass and soil ranges from -120.32 ktCO₂ to -115.77 ktCO₂ in period 1990-2015.

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 2015.

Table 6.6-1: Activity Data of Grassland in the period 1990-2015 in kha
### Table 6.6-2: Emissions (+) / removals (-) of CO₂ in Grassland 1990-2015 (kt CO₂ equivalent)

<table>
<thead>
<tr>
<th>Year</th>
<th>4.C Grassland - Total</th>
<th>4.C.1 Grassland remaining grassland</th>
<th>4.C.2 Land converted to grassland</th>
<th>4.C.2.1 Forest land converted to grassland</th>
<th>4.C.2.2.1 Annual cropland converted to grassland</th>
<th>4.C.2.2.2 Perennial cropland converted to grassland</th>
<th>4.C.2.3 Wetlands converted to grassland</th>
<th>4.C.2.4 Settlements converted to grassland</th>
<th>4.C.2.5 Other land converted to grassland</th>
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<td></td>
<td></td>
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<td></td>
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<td>5.84</td>
<td>0.58</td>
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</tr>
</tbody>
</table>
CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE

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 2015 amounts to 1,120.02 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 1990-2015.

According to expert judgment liming does not occur in the grassland category.

6.6.2.2. Land use change to Grassland (4.C.2)

6.6.2.2.1. Forest land converted to Grassland (4.C.2.1)

There has not been conversion from the Forestland to Grassland in the last decades

6.6.2.2.2. Cropland converted to Grassland (4.C.2.2)

According to the CLC results it is concluded that the LUCs into Grassland come from the Cropland area. The area coming from this category of land needed to be also divided into annual Cropland and perennial Cropland. This was done directly on basis of specific CLC subcategories representing annual or perennial cropland or according to the share of these land uses in total cropland (0.9 vs. 0.1) for mixed CLC categories which include both, annual and perennial cropland in one CLC category.

With respect to the LUC transition period of 20 years, 6.41 kha of Cropland area were converted into Grassland in year 2015. The changes of carbon stocks during the conversion from one category to another vary between years. In year 1990 LUCs in this category resulted in removal of -122.39 kt CO₂ and in year 2015 in removal of -117.84 kt CO₂.

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:

\[
\text{Annual change in carbon stock in biomass} = \text{Annual area of converted land} \times (L_{\text{Conversion}} + \Delta C_{\text{Growth}})
\]

where:

\[
L_{\text{Conversion}} = C_{\text{After}} - C_{\text{Before}}
\]

\[
\Delta C_{\text{Growth}} = \text{Carbon accumulation rate in Grasslands in Croatia} = 4.29 \text{ t C/ha}
\]

\[
C_{\text{Before}} = \text{Carbon stock of Cropland biomass before conversion is: 1) 5.7 t C/ha for annual Cropland and 2) 63 t C/ha for perennial Cropland (IPCC default value)}
\]

\[
C_{\text{After}} = \text{Carbon stock immediately after conversion} = 0 \text{ t C/ha (IPCC default value)}
\]

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:

\[
\Delta SOC = (SOC_0 - SOC_{0-T})/20
\]

\[
\Delta SOC = \text{annual change in carbon stock soil}
\]

\[
SOC_0 = \text{soil organic carbon stock in the inventory year, which is: 1) 46.4 tC/ha for annual Cropland 2) 77.8 tC/ha for perennial Cropland}
\]

\[
SOC_{0-T} = \text{soil organic carbon stock T years prior to the inventory, which is 70.6 tC/ha for grassland}
\]

The change in carbon stock in soils of annual and perennial Cropland converted to Grassland was further calculated by multiplying the emission factor by the area of the converted territory in transition of 20 years. Soil emission factor for the annual Cropland converted to grassland in Croatia is calculated to be 1.21 tC/ha annually, and -0.36 tC/ha annually for the perennial Cropland converted to grassland.

Net carbon stock change change in soils when annual cropland converted to grassland in 2015 was 76.04 GgC and for perennial cropland converted to grassland was -2.08 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 -265.19% to 343.59% 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 -95.84 to 95.71%.

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: a) revision of activity data on land areas based on newly delivered CLC data for years 1980, 1990, 2000, 2006 and 2012, as well as the new data on land use changes from CLC change databases, accordingly and b) better application of 2006 IPCC Guidelines (the change in emission factor for calculating emissions of N$_2$O from N in the soil, conversion factor for N$_2$O). The result of the performed recalculation can be seen in Figure 6.6-1. On average, removals increased by 0.03% compared to the previously reported estimates.
Figure 6.6-1: Current and previously reported emissions for category 4.C (kt CO₂)

6.6.6. Category-specific planned improvements

- New activity data on land use changes from/to Grassland category are expected this year as a result of a new database changes development based on data available in CLC 1980, 1990, 2000, 2006 and 2012 databases. New areas will be presented in NIR 2017 Resubmission.

- 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 improvements needed in Croatian reporting.

- Further analyses of data collected through the project “Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol” needs to be performed in order to investigate possibility to use higher Tier in estimation of emissions due to forest fires.
6.7. **WETLANDS (CRF CATEGORY 4.D)**

6.7.1. **Description**

In this category only emissions/removals from the sub-categories “Land Converted to Wetland” were considered.

Due to lack of information it was assumed that the carbon stock in biomass, dead organic matter and soil of surface waters was 0.

Peat extraction does not occur in Croatia.

The wetland area ranged from 72.32 ha in 1990 to 74.53 ha in 2015.

The land use change and removals/emissions from the IPCC land use categories to wetland in the period 1990-2015 are presented in Tables 6.7-1 and 6.7-2.

### Table 6.7-1: Activity data of wetland in the period 1990-2015 in kha

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Wetland</th>
<th>Remaining Wetland</th>
<th>Land converted to Wetland</th>
<th>Forest land converted to Wetland</th>
<th>Annual Cropland converted to Wetland</th>
<th>Perennial Grassland converted to Wetland</th>
<th>Grassland converted to Wetland</th>
<th>Settlements converted to Wetland</th>
<th>Other land converted to Wetland</th>
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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 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):

\[
\Delta C_{LW \text{ flood}} = \sum A_i \times (B_{\text{after}} - B_{\text{before}})
\]

\(A_i\) = area of land converted annually to flooded land from original land use \(i\), ha \(\text{yr}^{-1}\)

\(B_{\text{before}}\) = living biomass in land immediately before conversion to wetland: 1) for annual cropland 5.7 t C/ha; 2) for perennial cropland 63 t C/ha (IPCC default value)

\(B_{\text{after}}\) = living biomass in land immediately before conversion to wetland (default = 0 t C/ha a)

**Changes in carbon stocks in soil of cropland converted to wetland**

\[
\Delta C_{LW \text{ flood}} = \sum A_i \times (B_{\text{after}} - B_{\text{before}})/20
\]

\(A_i\) = area of land converted to flooded land for a transition period of 20 years, ha

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**B**<sub>Before</sub> = carbon stock in soil immediately before conversion to wetland: 1) for annual cropland 46.4 t C/ha a, and 2) for perennial cropland 77.8 t C/ha a (see Chapter 6.4.1.)

**B**<sub>After</sub> = carbon stock in soil immediately after conversion to wetland (default = 0 t C/ha)

**N<sub>2</sub>O Emissions in Soils of Land Converted to Wetland**

The annual release of N<sub>2</sub>O due to the conversion of Cropland to Wetland were calculated using the IPCC default value (Tier 1) and equation 11.8 as follows:

\[
N_2O_{oneth-min} - N = EF1 \times \Delta CLC_{mineral} \times 1/(C/N \text{ ratio})
\]

where:

- \(EF1\) = the emission factor for calculating emissions of N<sub>2</sub>O from N in the soil = 0.01 kg N<sub>2</sub>O-N/kg N (IPCC GPG default value)
- \(\Delta CLC_{mineral}\) = 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

**6.7.3. Uncertainties and time-series consistency**

The uncertainty for the total CO<sub>2</sub> eq in category Land converted Wetland ranges between -200.54 and 467.22% 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: a) revision of activity data on land areas based on newly delivered CLC data for years 1980, 1990, 2000, 2006 and 2012, as well as the new data on land use changes from CLC change databases, accordingly and b) better application of 2006 IPCC Guidelines (the change in emission factor for calculating emissions of N₂O from N in the soil, conversion factor for N₂O). The result of the performed recalculation can be seen in Figure 6.7-1. On average, emissions increased by 21.3% compared to the previously reported estimates.

![Figure 6.7-1: Current and previously reported emissions for category 4.D (Gg CO₂ eqv)](image_url)

6.7.6. Category-specific planned improvements

New activity data on land use changes from/to Wetland category are expected this year as a result of a new database changes development based on data available in CLC 1980, 1990, 2000, 2006 and 2012 databases. New areas will be presented in NIR 2017 Resubmission.
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 263.59 kha in 2015. Emissions from the change in the carbon stock in biomass and soil ranges from 220.02 to 734.28 kt CO₂.

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 2015.

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### 6.8.2. Methodological issues

#### 6.8.2.1. Land Use Change to Settlements (5.E.2)

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<td>NO</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>727.77</td>
<td>NE</td>
<td>727.77</td>
<td>57.22</td>
<td>142.41</td>
<td>450.82</td>
<td>NO</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>723.93</td>
<td>NE</td>
<td>723.93</td>
<td>54.97</td>
<td>141.20</td>
<td>450.11</td>
<td>NO</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>724.17</td>
<td>NE</td>
<td>724.17</td>
<td>52.59</td>
<td>142.06</td>
<td>451.58</td>
<td>NO</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>723.01</td>
<td>NE</td>
<td>723.01</td>
<td>46.95</td>
<td>143.46</td>
<td>454.36</td>
<td>NO</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>734.28</td>
<td>NE</td>
<td>734.28</td>
<td>57.46</td>
<td>143.26</td>
<td>455.04</td>
<td>NO</td>
<td>NO</td>
<td></td>
</tr>
</tbody>
</table>
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 5.7 t C/ha. The GPG default value of 63 t C/ha for perennial cropland was used to calculate the biomass carbon stock change in perennial cropland converted to settlements. In case of Grassland converted to Settlement national value of 4.3 tC/ha in Grassland before LUC was used in estimation.

For the calculation of the annual change in carbon stocks of living biomass in forest land converted to settlements, specific harvest data for these deforestation areas delivered by the Croatian Forests Ltd were used.

In reporting period emissions ranged from 2.84 ktCO\textsubscript{2}eq to 90.62 ktCO\textsubscript{2} eq due to LUC from Forestland to Settlements.
B) Soil

The approach follows exactly the method in the other LUC categories. The calculation of emissions from soil carbon stock changes due to land use changes from other subcategories refer to a soil depth of 0-20 cm. Research on carbon stock in Croatian soils was done so that the skeleton and whole humus layers were included into the soil analysis. The calculation of the emissions from soils as a result of the conversion of other subcategories to settlements was made using national data for carbon stocks in the soils of the land use categories involved in the LUCs (forest land, annual and perennial cropland, grassland, settlement). The soil carbon stocks in unsealed areas of settlements were assessed by this soil survey to be on average 55.0 t C/ha, corrected as per the relative share of the unsealed areas of settlements in Croatia. By expert judgment the median value of the carbon stock was used, because it is less influenced by outliers (see Chapter 6.2). The used soil C stocks of the previous land uses are the same as represented in the other LUC chapters.

According to GPG, the carbon stock change calculation in the litter pool had to be done in the way to include the whole humus layer. Consequently, in case of Croatia, the carbon stock change in litter is included in the soil C stock change results because the soil C stock of forest land used for the estimates includes also the C stock in the litter layer.

6.8.2.1.1. Forest Land Converted to Settlements (4.E.2.1)

The area in conversion status from forest land to settlements for the time period of 20 years ranged from 0.19 kha to 3 kha.

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 -0.011 to -13.635 Gg C in the period 1990-2015.

Changes in Carbon Stocks in Soil and Dead Wood of Forest Land Converted to Settlements.

The calculation of the emissions from soils as a result of the conversion of forest land to settlements was made by using national data for carbon stocks in soils in forest land (84.7 t C/ha) and carbon stocks in soils of settlements (55.04 t C/ha for the unsealed settlement area or 2.5 t C/ha for the total settlement area).
Annual net change rates due to carbon stock changes in soil ranged from -0.8 to -12.4 Gg C in the period 1990 to 2015.

The average annual carbon stock change in dead wood in forest land deforested in Croatia is included in the stem wood loss of deforestation areas and therefore included in the biomass results.

6.8.2.1.2. Cropland Converted to Settlements (4.E.2.2)
The area in conversion status from cropland to settlements for the time period of 20 years ranged from 4.71 kha to 15.31 kha in the years 1990-2015.

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 Gg C in annual cropland and -1.34 to -10.45 Gg C in perennial cropland converted to settlements in the years 1990-2015.

Changes in Carbon Stocks in Soil of Cropland Converted to Settlements
The calculation of the emissions from soils as a result of the conversion of cropland to settlements was made by using national data for carbon stocks in soils in annual cropland (46.4 t C/ha) and perennial cropland (77.8 t C/ha), as well as carbon stocks in soils of settlements (55.0 t C/ha for the unsealed settlement area or 2.5 t C/ha for the total settlement area).

Annual net rates due to carbon stock changes in soil ranged from -9.4 to -30.5 Gg C in annual cropland converted to settlements and from -1.6 to -5.2 Gg C in perennial cropland converted to settlements in the years 1990-2015.

6.8.2.1.3. Grassland Converted to Settlements (4.E.2.3)
The area in conversion status from grassland to settlements for the time period of 20 years ranged from 10.98 kha to 35.71 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 -2.00 to -17.14 Gg C during the period 1990-2015.
Changes in Carbon Stocks in Soil of Grassland Converted to Settlements

The calculation of emissions from soils as a result of conversion of grassland to settlements was made by using national data for carbon stocks in soils in grassland (70.6 t C/ha) and carbon stocks in soils of settlements (55.0 t C/ha for the unsealed settlement area or 2.5 t C/ha for the total settlement area).

Annual net rates due to carbon stock changes in soil ranged from -37.4 to -121.6 Gg C in the period 1990-2015.

N₂O Emissions in Soils of Land Converted to Settlements

The annual release of N₂O 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:

\[ \text{N}_2\text{O}_{\text{net-min}} \cdot \text{N} = \text{EF}_1 \times \Delta \text{CLC}_{\text{mineral}} \times \frac{1}{(\text{C/N ratio})} \]

where:

\( \text{EF}_1 \) = the emission factor for calculating emissions of N₂O from N in the soil = 0.01 kg N₂O-N/kg N (IPCC GPG default value)

\( \Delta \text{CLC}_{\text{mineral}} \) = change in the carbon stock in mineral soils in land to cropland

\( \text{C/N} \) = ratio by mass of C to N in the soil organic matter (10 for Grassland and Cropland converted to Settlements and 12 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 CO₂ eq in category Land converted to Settlements ranges between -92.92% and 150.83%. 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: a) revision of activity data on land areas based on newly delivered CLC data for years 1980, 1990, 2000, 2006 and 2012, as well as the new data on land use changes from CLC change databases, accordingly; b) changes in share of Cropland and Grassland categories of land that are converted to Settlement category (changes from 50:50 share to 70:30 for Grassland); c) changes in share of traffic lines in CLC databases and share of total settlement category of land presented in total land in Croatia presented in CLC databases and d) better application of 2006 IPCC Guidelines (the change in emission factor for calculating emissions of N\textsubscript{2}O from N in the soil, conversion factor for N\textsubscript{2}O). The result of the performed recalculation can be seen in Figure 6.8-1. On average, emissions increased by 32.7% compared to the previously reported estimates.

Figure 6.8-1: Current and previously reported emissions for category 4.E (Gg CO\textsubscript{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
- New activity data on land use changes from/to Settlement category are expected this year as a result of a new database changes development based on data available in CLC 1980, 1990, 2000, 2006 and 2012 databases. New areas will be presented in NIR 2017 Resubmission.

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

<table>
<thead>
<tr>
<th>Year</th>
<th>4.E Total Other land</th>
<th>4.E.1 Other land remaining other land</th>
<th>4.E.2 Land converted to Other land</th>
<th>4.E.2.1 Forest and converted to Other land</th>
<th>4.E.2.2 Cropland converted to Other land</th>
<th>4.E.2.3 Cropland converted to Other land</th>
<th>4.E.2.4 Wetland converted to Other land</th>
<th>4.E.2.5 Settlement converted to Other land</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>232.91</td>
<td>232.91</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>1991</td>
<td>246.04</td>
<td>246.04</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>1992</td>
<td>245.38</td>
<td>245.38</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>1993</td>
<td>244.59</td>
<td>244.59</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>1994</td>
<td>243.9</td>
<td>243.9</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
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<td>1995</td>
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<td>243.18</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
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<td>1996</td>
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<td>NO</td>
<td>NO</td>
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<td>1997</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
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</tr>
<tr>
<td>1998</td>
<td>241.14</td>
<td>241.14</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>1999</td>
<td>234.29</td>
<td>234.29</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2000</td>
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<td>NO</td>
</tr>
<tr>
<td>2001</td>
<td>231.83</td>
<td>231.83</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
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<tr>
<td>2002</td>
<td>230.94</td>
<td>230.94</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2003</td>
<td>229.93</td>
<td>229.93</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2004</td>
<td>228.81</td>
<td>228.81</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2005</td>
<td>225.3</td>
<td>225.3</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>
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 1990-2015. 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 1990-2015 [kt CO₂]

<table>
<thead>
<tr>
<th>Year</th>
<th>HWP (produced and consumed domestically)</th>
<th>Sawn wood</th>
<th>Wood panels</th>
<th>Paper and paper board</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>-301.54</td>
<td>-338.61</td>
<td>-62.53</td>
<td>99.60</td>
</tr>
<tr>
<td>1991</td>
<td>222.39</td>
<td>-52.70</td>
<td>-6.75</td>
<td>281.84</td>
</tr>
<tr>
<td>1992</td>
<td>324.54</td>
<td>-114.62</td>
<td>1.19</td>
<td>437.98</td>
</tr>
<tr>
<td>1993</td>
<td>111.24</td>
<td>-163.41</td>
<td>-16.95</td>
<td>291.60</td>
</tr>
<tr>
<td>1994</td>
<td>-16.42</td>
<td>-70.05</td>
<td>6.57</td>
<td>47.06</td>
</tr>
<tr>
<td>1995</td>
<td>-55.59</td>
<td>-30.18</td>
<td>18.78</td>
<td>-44.19</td>
</tr>
<tr>
<td>1996</td>
<td>5.35</td>
<td>-23.36</td>
<td>22.74</td>
<td>5.97</td>
</tr>
</tbody>
</table>
### Table 6.10-2: Production of HWP in Croatia in the period between 1990-2015 according to the FAO Statistics

<table>
<thead>
<tr>
<th>Year</th>
<th>Sawn wood [m³]</th>
<th>Wood panels [m³]</th>
<th>Paper and paper board [t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>861,180</td>
<td>152,239</td>
<td>473,626</td>
</tr>
<tr>
<td>1991</td>
<td>586,923</td>
<td>98,603</td>
<td>306,427</td>
</tr>
<tr>
<td>1992</td>
<td>651,000</td>
<td>90,000</td>
<td>100,000</td>
</tr>
<tr>
<td>1993</td>
<td>699,000</td>
<td>108,000</td>
<td>114,000</td>
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<tr>
<td>1994</td>
<td>601,000</td>
<td>83,400</td>
<td>247,000</td>
</tr>
<tr>
<td>1995</td>
<td>578,000</td>
<td>73,000</td>
<td>324,000</td>
</tr>
<tr>
<td>1996</td>
<td>598,000</td>
<td>71,000</td>
<td>304,000</td>
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<tr>
<td>1997</td>
<td>644,000</td>
<td>80,000</td>
<td>393,000</td>
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<tr>
<td>1998</td>
<td>676,000</td>
<td>84,000</td>
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<td>1999</td>
<td>685,000</td>
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<tr>
<td>2000</td>
<td>642,000</td>
<td>78,000</td>
<td>406,000</td>
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<tr>
<td>2001</td>
<td>574,000</td>
<td>85,000</td>
<td>451,000</td>
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<tr>
<td>2002</td>
<td>640,000</td>
<td>81,000</td>
<td>467,000</td>
</tr>
<tr>
<td>2003</td>
<td>585,000</td>
<td>96,000</td>
<td>463,000</td>
</tr>
<tr>
<td>2004</td>
<td>582,000</td>
<td>103,000</td>
<td>464,000</td>
</tr>
<tr>
<td>2005</td>
<td>624,000</td>
<td>128,000</td>
<td>592,000</td>
</tr>
<tr>
<td>2006</td>
<td>669,000</td>
<td>161,000</td>
<td>564,000</td>
</tr>
<tr>
<td>2007</td>
<td>702,000</td>
<td>175,000</td>
<td>545,000</td>
</tr>
<tr>
<td>2008</td>
<td>721,000</td>
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<td>535,000</td>
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<tr>
<td>2009</td>
<td>653,000</td>
<td>143,000</td>
<td>524,000</td>
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<tr>
<td>2010</td>
<td>677,000</td>
<td>153,000</td>
<td>560,000</td>
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<tr>
<td>2011</td>
<td>754,000</td>
<td>143,000</td>
<td>540,000</td>
</tr>
<tr>
<td>2012</td>
<td>851,000</td>
<td>151,900</td>
<td>499,700</td>
</tr>
<tr>
<td>2013</td>
<td>1,191,804</td>
<td>212,350</td>
<td>299,285</td>
</tr>
</tbody>
</table>
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.\(^{35}\)

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.

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\(^{36}\), 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.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sawn wood [m(^3)]</th>
<th>Wood panels [m(^3)]</th>
<th>Paper and paper board [t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>1,362,804</td>
<td>209,520</td>
<td>270,398</td>
</tr>
<tr>
<td>2015</td>
<td>846,528</td>
<td>148,909</td>
<td>272,515</td>
</tr>
</tbody>
</table>

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\(^{35}\) 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)

\[ V_t = V^{1961} \cdot e^{(U \cdot (t - 1961))} \]

Where:
- \( V_t \) = 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 2013 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):

\[ f_{IRW(i)} = \frac{IRWp(i) - IRWex(i)}{IRWp(i) + IRWim(i) - IRWex(i)} \]

Where:
- \( f_{IRW(i)} \) = share of wood from domestic harvest for year \( i \)
- \( IRWp(i) \) = production of industrial roundwood in year \( i \), [m³]
- \( IRWim(i) \) = import of industrial roundwood in year \( i \), [m³]
- \( IRWex(i) \) = export of industrial roundwood in year \( i \), [m³]

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:

\[ y = 21582 \cdot t - 42231736 \]

where:
\[ t = \text{year} \]
\[ y = \text{value of the variable 10 tons (paper and paperboard)} \]

The correlation coefficient \( r = 0.99202183 \) and the coefficient of determination \( R^2 = 0.98410732 \) 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):

\[
C(i + 1) = e^{-k} \cdot C(i) + \left[ \frac{1 - e^{-k}}{k} \right] \cdot \text{Inflow}(i + 1)
\]

Where:

- \( i = \text{year} \)
- \( C(i) = \text{the carbon stock of the HWP pool in the beginning of year } i \ [\text{Gg C}] \)
- \( k = \text{decay constant of first-order decay for each HWP category given in units, yr}^{-1} \)
  \( (k = \ln(2)/HL \text{ where } HL \text{ is half-life of the HWP pool in years}) \)
- \( \text{Inflow } i = \text{the inflow to the HWP pool during year } i \ [\text{Gg C/yr}] \)

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 -130.39% to 131.66%.

6.10.4. Recalculations

Croatia submitted its HWP values in CRF database for NIR 2015 submission. Since the last submission, Croatia performed recalculation for the entire category and reporting period. This was due to: a) the correction associated with the share of wood that comes from the category Forest land remaining Forest land and Forest land converted to Settlement and Cropland categories of land in period 1990-2015. b) the adopted revised activity data on HWPs for year 2013.

Figure 6.10-1: Current and previously reported emissions/removals in HWP (kt CO₂)

6.10.5. Planned Improvements

New uncertainty estimation for harvested wood products will be performed for NIR 2017 Resubmission.
6.11. DIRECT N₂O EMISSIONS FROM N INPUTS TO MANAGED SOILS (CRF CATEGORY 4 I)

N₂O 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 ANDREWETTING 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 \( \text{N}_2\text{O} \) 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

\( \text{N}_2\text{O} \) 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 Guidelines, \( \text{N}_2\text{O} \) 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 Settlements.

6.13.2. Methodological issues

The annual release of \( \text{N}_2\text{O} \) due to the above mentioned conversions was calculated using the IPCC default value (Tier 1) and equation 11.8:

\[
\text{N}_2\text{O}_{\text{net-min}} = \text{EF}_1 \times \Delta C_{\text{Lcmineral}} \times 1/(\text{C/N ratio})
\]

where:

\[
\text{EF}_1 = \text{the emission factor for calculating emissions of } \text{N}_2\text{O} \text{ from N in the soil} = 0.01 \text{ kg } \text{N}_2\text{O}-\text{N/kg N} \text{ (IPCC GPG default value)}
\]

\[
\Delta C_{\text{Lcmineral}} = \text{change in the carbon stock in mineral soils in forestland converted to cropland}
\]

\[
\text{C/N} = \text{ratio by mass of C to N in the soil organic matter} = 12 \text{ (national value for forestland) and 10 (national value for Grassland and Cropland category)}
\]

6.13.3. Category-specific recalculations

Since NIR 2015 where \( \text{N}_2\text{O} \) emissions coming from forestland and grassland converted to Cropland were reported, for this year submission \( \text{N}_2\text{O} \) emissions that come from land use changes from other categories of land (Chapter 6.13.1) are also reported.
6.14. INDIRECT N₂O EMISSIONS FROM MANAGED SOILS (CRF CATEGORY 4 IV)

Under land use change, N₂O emissions from leaching and run-offs are considered not occurring 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 and at that time relevant Ordinance. 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 agricultural lands in Croatia. This Register is currently running based on new legislative act 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.

Based on the conducted analyses it was determined that Cropland areas were not affected by fires in the period 19902-014. Cropland areas were affected by fires in 2015 and the estimation of emissions were performed for this year for this year.

37 Forest Act (OG 140/05), Article 40
38 Ordinance on the method of data collection, conducting the Register and requirements for using data on forest fires (OG 126/06)
39 Ordinance on the method of data collection, conducting the Register and requirements for using data on forest fires (OG 175/13)
40 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
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\(^1\). 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 concerning 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\(^2\) and Ordinance\(^3\) 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.

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\(^1\) Ibid
\(^2\) Ibid
\(^3\) Ibid
Recording the forest fires on maps has not been requested by national legislation so far. However, in many occasions sketches of areas affected by fires were kept. By 2005, the majority of the sketches were drawn up by hand on a topographic map presenting forest divisions into compartments and sub-compartments at 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).

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)
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$_2$O (0.26). Data on areas of forest fires are the only nationally determined values for this estimation.

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$_2$O).

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 14.98 and 1,160.75 ktCO$_2$ equivalents, CH$_4$ emissions ranged between 0.01 and 3.48 while N$_2$O emissions ranged from 0 to 0.19 ktCO$_2$ equivalent in the reporting period. 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 erformed 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\textsubscript{2}O emission uncertainty vary between -14.60 and 73.03%, between -31.64% and 26.31% for CH\textsubscript{4} emission and between -27.50% and 30.05% for CO\textsubscript{2}.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Uncertainty (%)</th>
<th>Source of information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area destroyed by fire (A)</td>
<td>30%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>Quantity of wood burnt down<em>Burning efficiency (B</em>C)</td>
<td>75%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>Emission factor for CO\textsubscript{2} (D)</td>
<td>75%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>Emission factor for CH\textsubscript{4} (D)</td>
<td>75%</td>
<td>Default, IPCC 2006</td>
</tr>
<tr>
<td>Emission factor for N\textsubscript{2}O (D)</td>
<td>75%</td>
<td>Default, IPCC 2006</td>
</tr>
</tbody>
</table>

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

Recalculations needed are result of using 2006 Guidelines. Relevant data and information will be provided in NIR 2016 Resubmission.

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 2016 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\(_2\)O).

CH\(_4\) and N\(_2\)O emissions as a result of disposal and biological treatment of solid waste, CO\(_2\) and N\(_2\)O emissions resulting from incineration of waste (without energy recovery), CH\(_4\) and N\(_2\)O 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 44 and Waste Management Plan45. 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 Directive46 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

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44 Sustainable Waste Management Act (OG 94/2013)
45 Waste Management Plan of the Republic of Croatia for the period 20017 - 2022 (OG 5/2017)
demolition waste. Ordinance on construction waste and asbestos-containing waste (OG 69/2016) (succeeding 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 reuse. 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 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 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.

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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 - 2015 are presented in the Figure 7.1-1.

Figure 7.1-1: Emissions of GHGs from Waste sector (1990 - 2015)

In 2015, GHG emissions from Sector 5 Waste amounted to 1,553.28 kt CO$_2$ equivalent, compared to 654.01 kt in 1990. These emissions constituted 6.6% of Croatia’s total GHG emissions (without LULUCF) in 2015 and 2.1% of total emissions in 1990. GHG emissions from this sector increases during the reporting period:

- 80.7% of sectoral emission refer to the emission from solid waste disposal in 2015, compared to 53.3% 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;
- 18.6% of sectoral emission refer to the emission from wastewater treatment and discharge in 2015, compared to 46.6% 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 2015

<table>
<thead>
<tr>
<th>IPCC Source Categories</th>
<th>GHG</th>
<th>Key</th>
<th>If Column C is Yes, Criteria for Identification</th>
<th>Com.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.A Solid Waste Disposal</td>
<td>CH₄</td>
<td>Yes</td>
<td>L1e, L2e T1e, T2e</td>
<td>L1i, L2i T1i, T2i</td>
</tr>
<tr>
<td>5.D Wastewater Treatment and Discharge</td>
<td>CH₄</td>
<td>Yes</td>
<td>L1e, L2e</td>
<td>L1i</td>
</tr>
<tr>
<td>5.D Wastewater Treatment and Discharge</td>
<td>N₂O</td>
<td>Yes</td>
<td>L2e</td>
<td>T2e</td>
</tr>
</tbody>
</table>

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. The quantity of generated and disposed industrial waste was increased in the period from 2010 to 2012, and after that, until 2015, an increasing trend was not significant. 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 -2015. In 2015, there was 76% municipal waste and 24% industrial waste in total waste landfilled at official landfills. From total municipal waste landfilled in

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48 Data on key categories are taken from Annex 1 Key categories (Tier 1 and Tier 2)
2015, 63% were biodegradable. From total industrial waste landfilled in 2015, 2% were biodegradable and 5% were sludge from wastewater treatment.

Before 2010, data reported for landfills 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 2015 was 1,653,918 tonnes, which is in average 393 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 2015, 24 percent (391,074 tonnes) was separately collected fractions. The largest separately collected fraction was paper and cardboard waste (37 percent) followed by bulky waste (16 percent) and biowaste (15 percent). The recovery rate of MSW in 2015 was 18 percent. Of the total amount of waste landfilled in 2015 (1,627,490 tonnes) 1,318,740 tonnes was MSW. The largest share in the total amount of landfilled MSW was mixed municipal waste (about 93 percent). Landfill operators report data on each waste type landfilled. Additional information on separate collection and landfilling (by waste code) is available in a 2015 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\(^49\) and Ordinance on the waste management\(^50\), 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. In 2015, the municipal and industrial waste was actively landfilled at 131 official sites (thereof 74 are managed, 43 are unmanaged deep and 14 are unmanaged shallow SWDSs); 91 SWDSs have been closed (thereof 37 are managed, 4 are unmanaged deep and 50 are unmanaged shallow SWDSs) and the waste removed completely from 83 closed managed SWDSs.

During the period until 2018, remediation and closure of the existing landfills or their conversion into transfer stations or recycling yards will continue in parallel with the construction of the new waste management centres (implementing mechanical-biological treatment), complying with

\(^{49}\) Ordinance on the methods and conditions for the landfill of waste, categories and operational requirements for waste landfills (OG 117/07, 111/11, 17/13, 62/13)

\(^{50}\) Ordinance on the waste management (OG 23/14)
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 2015, 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 2015, there have been a total of 141 active landfills, while there were a total of 174 closed landfills. Out of the total number of closed landfills, on 83 location the waste has been totally removed (ex-situ remediation method).

Till the end of the year 2015 remediation has been completed on 53 locations of active municipal landfills, while on 17 locations of active municipal landfills were undergoing process of remediation and 61 locations of active municipal landfills were in the preparation state. Till the end of the same year, remediation has been completed on 118 locations of closed municipal landfills, remediation processes have been undergoing on 5 locations of closed municipal landfills and 50 locations of closed municipal landfills 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 CH₄ 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 - 2015.

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.
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\(^{51}\) adopted according to Environment Protection Act, the CAEN is collecting data on the quantities and types of waste produced, collected, recovered or disposed. Data on quantities are available for each waste code (based on European LoW- List of Waste) and NACE activity. Four forms are available for data delivery (for waste producer, waste collector of municipal waste, waste collector for industrial waste and operator of waste treatment facility). Waste data are reported by operators electronically, using internet based application, on annual basis. Validation and verification of data is done first by county offices (with appropriate support from the environment protection inspectors), and then by the CAEN. CAEN is cooperating with competent offices in counties and with companies collecting municipal and industrial waste or operating landfills, in order to strengthen data quality. Data is checked for completeness, correctness and consistency in time-series. In cases that collected or disposed waste is not reported, quantities are determined on the basis of previous year report or calculation on the basis of average waste production per capita. Quality of municipal data is gradually improving as scales are installed at landfills, but still large amount of municipal and industrial waste is not being weighted, which usually lead to overestimation of collected and disposed quantities.

Main source for activity data on municipal and industrial waste is Environmental Pollution Register database and 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\(_i\)) and fractions of municipal solid waste disposed at SWDS (MSW\(_f\)) are reported in the Table 7.2-1.

\(^{51}\) Ordinance on the Environmental Pollution Register (OG 87/15)
Table 7.2-1: MSW$_T$ and MSW$_F$ in 1955, 1960, 1970 and 1980

<table>
<thead>
<tr>
<th>Year</th>
<th>MSW$_T$ (kt)</th>
<th>MSW$_F$ (fraction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>492</td>
<td>0.27</td>
</tr>
<tr>
<td>1960</td>
<td>594</td>
<td>0.32</td>
</tr>
<tr>
<td>1970</td>
<td>740</td>
<td>0.41</td>
</tr>
<tr>
<td>1980</td>
<td>920</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Total annual municipal solid waste disposed to SWDSs for the period 1990-1998 has been evaluated from available relevant data compiled into Report; Fundurulja, D., Mužinić, M. (2000) *Estimation of the Quantities of Municipal Solid Waste in the Republic of Croatia in the period 1990 – 1998 and 1998 – 2010*, Zagreb. Insufficient data for the quantity of disposed municipal solid waste in 1999 were evaluated by interpolation method. Data for the quantity of disposed municipal solid waste in 2000 were obtained from *Report of Environment Condition*, Ministry of Environmental and Nature Protection. Data for the quantity of disposed municipal solid waste in 2005 were obtained from *Waste Management Plan in the Republic of Croatia for 2007 - 2015 (OG 85/07, 126/10, 31/11)*. 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 - 2015 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 - 2015 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 - 2015 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; Fundurulja, D., Mužinić, M. (2000) Estimation of the Quantities of Municipal Solid Waste in the Republic of Croatia in the period 1990 – 1998 and 1998 – 2010, Zagreb. Due to fact that data for 1999 are not available, proportion of waste in each type of site (managed, unmanaged deep and unmanaged shallow) has been assessed by interpolation method. Information on proportion of waste (by weight) disposed on “Official” and “Unofficial” site
in 2000 was obtained from Report of Environment Condition, Ministry of Environmental and Nature Protection. Distribution of quantity of municipal solid waste disposed on all three IPCC categories (managed, unmanaged deep and unmanaged shallow) has been made by applying a factor of increasing disposed municipal solid waste on managed and unmanaged deep SWDS in the amount of 25 % compared to 1998 (according to expert judgement). Distribution of quantity of municipal solid waste disposed on managed, unmanaged deep and unmanaged shallow SWDSs for 2005 and 2006 has been made by information provided in Waste Management Plan in the Republic of Croatia 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 - 2015 (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) and second half of 2015 (for 2015) 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 - 2015 (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) and second half of 2015 (for 2015) 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 - 2015 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 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Generated municipal solid waste (kt)</th>
<th>Fraction of disposed solid waste</th>
<th>Solid waste disposed on managed SWDSs (kt)</th>
<th>Solid waste disposed on unmanaged SWDSs (&gt;5m) (kt)</th>
<th>Solid waste disposed on unmanaged SWDSs (&lt;5m) (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>1,000</td>
<td>0.59</td>
<td>18</td>
<td>277</td>
<td>295</td>
</tr>
<tr>
<td>1991</td>
<td>980</td>
<td>0.61</td>
<td>19</td>
<td>280</td>
<td>300</td>
</tr>
<tr>
<td>1992</td>
<td>970</td>
<td>0.63</td>
<td>20</td>
<td>284</td>
<td>309</td>
</tr>
<tr>
<td>1993</td>
<td>985</td>
<td>0.65</td>
<td>22</td>
<td>297</td>
<td>324</td>
</tr>
<tr>
<td>1994</td>
<td>1,005</td>
<td>0.67</td>
<td>26</td>
<td>322</td>
<td>329</td>
</tr>
<tr>
<td>1995</td>
<td>1,060</td>
<td>0.70</td>
<td>31</td>
<td>364</td>
<td>342</td>
</tr>
<tr>
<td>1996</td>
<td>1,100</td>
<td>0.72</td>
<td>35</td>
<td>392</td>
<td>361</td>
</tr>
<tr>
<td>1997</td>
<td>1,150</td>
<td>0.74</td>
<td>40</td>
<td>433</td>
<td>375</td>
</tr>
<tr>
<td>1998</td>
<td>1,205</td>
<td>0.76</td>
<td>45</td>
<td>470</td>
<td>398</td>
</tr>
<tr>
<td>1999</td>
<td>1,253</td>
<td>0.78</td>
<td>54</td>
<td>538</td>
<td>383</td>
</tr>
<tr>
<td>2000</td>
<td>1,173</td>
<td>0.80</td>
<td>60</td>
<td>618</td>
<td>260</td>
</tr>
<tr>
<td>2001</td>
<td>1,259</td>
<td>0.80</td>
<td>131</td>
<td>627</td>
<td>250</td>
</tr>
<tr>
<td>2002</td>
<td>1,346</td>
<td>0.80</td>
<td>202</td>
<td>635</td>
<td>240</td>
</tr>
<tr>
<td>2003</td>
<td>1,434</td>
<td>0.80</td>
<td>273</td>
<td>644</td>
<td>230</td>
</tr>
<tr>
<td>2004</td>
<td>1,439</td>
<td>0.85</td>
<td>344</td>
<td>652</td>
<td>220</td>
</tr>
<tr>
<td>2005</td>
<td>1,449</td>
<td>0.89</td>
<td>415</td>
<td>661</td>
<td>210</td>
</tr>
<tr>
<td>2006</td>
<td>1,627</td>
<td>0.89</td>
<td>528</td>
<td>720</td>
<td>200</td>
</tr>
<tr>
<td>2007</td>
<td>1,683</td>
<td>0.96</td>
<td>822</td>
<td>612</td>
<td>175</td>
</tr>
<tr>
<td>2008</td>
<td>1,788</td>
<td>0.97</td>
<td>1,011</td>
<td>564</td>
<td>156</td>
</tr>
<tr>
<td>2009</td>
<td>1,743</td>
<td>1.02*</td>
<td>1,126</td>
<td>516</td>
<td>136</td>
</tr>
<tr>
<td>2010</td>
<td>1,630</td>
<td>0.98</td>
<td>1,030</td>
<td>461</td>
<td>109</td>
</tr>
<tr>
<td>2011</td>
<td>1,645</td>
<td>0.96</td>
<td>1,045</td>
<td>437</td>
<td>102</td>
</tr>
<tr>
<td>2012</td>
<td>1,670</td>
<td>0.84</td>
<td>874</td>
<td>411</td>
<td>116</td>
</tr>
<tr>
<td>2013</td>
<td>1,723</td>
<td>0.84</td>
<td>989</td>
<td>405</td>
<td>59</td>
</tr>
<tr>
<td>2014</td>
<td>1,637</td>
<td>0.82</td>
<td>972</td>
<td>305</td>
<td>72</td>
</tr>
<tr>
<td>2015</td>
<td>1,654</td>
<td>0.82</td>
<td>1,093</td>
<td>244</td>
<td>23</td>
</tr>
</tbody>
</table>
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 an 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 \(\text{CH}_4\) 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 - 2015. 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 - 2015, are reported in the Table 7.2-3.

Table 7.2-3: The total weighted average MCF (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>MCF (fraction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>0.606</td>
</tr>
<tr>
<td>1991</td>
<td>0.606</td>
</tr>
<tr>
<td>1992</td>
<td>0.605</td>
</tr>
<tr>
<td>1993</td>
<td>0.606</td>
</tr>
<tr>
<td>1994</td>
<td>0.613</td>
</tr>
<tr>
<td>1995</td>
<td>0.623</td>
</tr>
<tr>
<td>1996</td>
<td>0.625</td>
</tr>
<tr>
<td>1997</td>
<td>0.632</td>
</tr>
<tr>
<td>1998</td>
<td>0.636</td>
</tr>
<tr>
<td>1999</td>
<td>0.654</td>
</tr>
<tr>
<td>2000</td>
<td>0.702</td>
</tr>
<tr>
<td>2001</td>
<td>0.727</td>
</tr>
<tr>
<td>2002</td>
<td>0.748</td>
</tr>
<tr>
<td>2003</td>
<td>0.767</td>
</tr>
<tr>
<td>2004</td>
<td>0.784</td>
</tr>
<tr>
<td>2005</td>
<td>0.799</td>
</tr>
<tr>
<td>2006</td>
<td>0.818</td>
</tr>
<tr>
<td>2007</td>
<td>0.859</td>
</tr>
<tr>
<td>2008</td>
<td>0.881</td>
</tr>
<tr>
<td>2009</td>
<td>0.896</td>
</tr>
<tr>
<td>2010</td>
<td>0.902</td>
</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th>Year</th>
<th>MCF (fraction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>0.906</td>
</tr>
<tr>
<td>2012</td>
<td>0.892</td>
</tr>
<tr>
<td>2013</td>
<td>0.920</td>
</tr>
<tr>
<td>2014</td>
<td>0.923</td>
</tr>
<tr>
<td>2015</td>
<td>0.954</td>
</tr>
</tbody>
</table>

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.

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52 Waste Management Strategy of the Republic of Croatia (OG 130/05)
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.

Table 7.2-5: Composition of MSW and DOC for 2015

<table>
<thead>
<tr>
<th>Waste stream</th>
<th>Percent in the MSW (2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper/cardboard</td>
<td>23.19</td>
</tr>
<tr>
<td>Textiles</td>
<td>3.71</td>
</tr>
<tr>
<td>Food waste</td>
<td>30.93</td>
</tr>
<tr>
<td>Wood</td>
<td>0.98</td>
</tr>
<tr>
<td>Garden and Park waste</td>
<td>5.68</td>
</tr>
<tr>
<td>Nappies</td>
<td>3.97</td>
</tr>
<tr>
<td>Rubber and Leather</td>
<td>0.67</td>
</tr>
<tr>
<td>Plastics</td>
<td>22.87</td>
</tr>
<tr>
<td>Metal</td>
<td>2.07</td>
</tr>
<tr>
<td>Glass</td>
<td>3.65</td>
</tr>
<tr>
<td>Other, inert waste</td>
<td>2.28</td>
</tr>
<tr>
<td><strong>DOC</strong></td>
<td><strong>17.58</strong></td>
</tr>
</tbody>
</table>

The decomposition of DOC does not occur completely and some of the potentially degradable materials always remain in the site over a long period of time. According to 2006 IPCC Guidelines the recommended default values for DOC\textsubscript{i} 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\textsubscript{i}, in order to CH\textsubscript{4} emissions estimation from SWDSs.

The CH\textsubscript{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\textsubscript{4} that is recovered and burned in a flare (without energy
recovery) in the period 2004 - 2015 have been included in emission estimation and subtracted from generated CH₄. Information on recovered CH₄ in the period 2004 - 2015 is presented in the Table 7.2-6.

A fluctuating trend for recovered CH₄ during the period 2004 - 2015 was due to remediation of the landfills, which is explained in Chapter 7.2.1. It should be noted that all landfills are not equipped with the system for the collection and treatment of landfill gas. Significant reduction of recovered (flared) CH₄ in 2015 is due to the use of methane for electricity generation at the largest landfill (emissions are included in the Energy sector).

Table 7.2-6: Recovered CH₄ (2004 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Recovered CH₄ (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>0.242</td>
</tr>
<tr>
<td>2005</td>
<td>2.723</td>
</tr>
<tr>
<td>2006</td>
<td>1.615</td>
</tr>
<tr>
<td>2007</td>
<td>1.370</td>
</tr>
<tr>
<td>2008</td>
<td>1.144</td>
</tr>
<tr>
<td>2009</td>
<td>1.239</td>
</tr>
<tr>
<td>2010</td>
<td>3.818</td>
</tr>
<tr>
<td>2011</td>
<td>4.851</td>
</tr>
<tr>
<td>2012</td>
<td>5.817</td>
</tr>
<tr>
<td>2013</td>
<td>6.920</td>
</tr>
<tr>
<td>2014</td>
<td>4.057</td>
</tr>
<tr>
<td>2015</td>
<td>1.650</td>
</tr>
</tbody>
</table>

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 CH₄ from disposal of solid waste in the period 1990 - 2015 are presented in the Figure 7.2-1.

Figure 7.2-1: Emissions of CH₄ from Solid Waste Disposal (1990 - 2015)
Emissions of NMVOC have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 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 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 programme, 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

New data for amount of CH₄ flared have been provided for the period 2011 – 2014. Accordingly, recalculation were performed for the period 2011 - 2014.

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;
- modification of Environmental Pollution Register and Waste Management Information System database regarding to solid waste with additional information (provided on regular basis) on technical and environmental protection measures implemented at landfills, waste quantities disposed to different types of SWDS (managed, unmanaged deep and unmanaged shallow) and waste composition;
- to 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, CH₄ and N₂O 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 methane is used for electricity generation.

CH₄ and N₂O emissions from composting of municipal and industrial solid waste, sludge and other organic waste are included in emissions estimates for the period 2007 – 2015. Data for previous years are not available. Data on the total amount of CH₄ recovered are not available for entire period 1990 - 2015.

7.3.2. Methodological issues

7.3.2.1. Composting

CH₄ 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 CH₄ emission factor (4 kg CH₄/t waste treated).

N₂O 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 N₂O emission factor (0.24 kg N₂O/t waste treated).

Data on different types of waste (dry weight) that treated by Composting are presented in the Table 7.3-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Municipal solid waste (t)</th>
<th>Industrial waste (t)</th>
<th>Sludge (t)</th>
<th>Other organic waste (t)</th>
<th>TOTAL WASTE (t)</th>
</tr>
</thead>
<tbody>
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<td>1990</td>
<td>NE</td>
<td>NE</td>
<td>NE</td>
<td>NE</td>
<td>NE</td>
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<td>1991</td>
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<td>NE</td>
</tr>
<tr>
<td>Year</td>
<td>Municipal solid waste (t)</td>
<td>Industrial waste (t)</td>
<td>Sludge (t)</td>
<td>Other organic waste (t)</td>
<td>TOTAL WASTE (t)</td>
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<tr>
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<td>9,705.6</td>
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<td>NE</td>
<td>18,691.2</td>
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<td>6,151.5</td>
<td>907.2</td>
<td>297.0</td>
<td>28,516.5</td>
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<td>2014</td>
<td>24,099.4</td>
<td>3,954.9</td>
<td>323.6</td>
<td>215.6</td>
<td>28,593.5</td>
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<td>2015</td>
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<td>41,465.7</td>
<td>241.4</td>
<td>148.5</td>
<td>61,606.6</td>
</tr>
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</table>

The resulting emission of CH₄ and N₂O from Composting are presented in the Table 7.3-2.

### Table 7.3-2: Emissions of CH₄ and N₂O from Composting (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>CH₄ emission (kt)</th>
<th>N₂O emission (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>NE</td>
<td>NE</td>
</tr>
<tr>
<td>1991</td>
<td>NE</td>
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</tr>
<tr>
<td>1992</td>
<td>NE</td>
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<td>1993</td>
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<td>2002</td>
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<td>2004</td>
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</tr>
<tr>
<td>2005</td>
<td>NE</td>
<td>NE</td>
</tr>
<tr>
<td>Year</td>
<td>CH₄ emission (kt)</td>
<td>N₂O emission(kt)</td>
</tr>
<tr>
<td>------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
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<td>2006</td>
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<tr>
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<td>0.044</td>
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<td>2008</td>
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<td>2009</td>
<td>0.036</td>
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<tr>
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</tr>
<tr>
<td>2011</td>
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<td>0.002</td>
</tr>
<tr>
<td>2012</td>
<td>0.075</td>
<td>0.004</td>
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<tr>
<td>2015</td>
<td>0.246</td>
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</tbody>
</table>

Emissions of CO and NH₃ have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 Submission to the Convention on Long-range Transboundary Air Pollution’.

7.3.2.2. Anaerobic Digestion at Biogas Facilities

Emissions from anaerobic digestion of organic waste at biogas facilities are included in the Energy sector, because methane is used for electricity generation. IE notation key for emissions, with explanation provided in the comment tables, have been included in the CRF for entire period in which electricity was generated (2009 – 2015).

Activity data on amount of waste treated (kt dry matter) for the last three years (2013 – 2015) are included in the CRF table 5.B.2.a, as follows: 7.1 kt for 2013; 43.5 kt for 2014 and 59.9 kt for 2015. Activity data for the period 2009 – 2012 are not available and NE notation key, with explanation provided in the comment tables, have been included in the CRF.

7.3.3. Uncertainties and time-series consistency

The uncertainties contained in CH₄ and N₂O 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 programme, 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\textsubscript{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\textsubscript{2}O 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**

In the previous report, emissions from anaerobic digestion of organic waste at biogas facilities are included in this category for 2013 and 2014. For the period 1990 – 2012 was defined that data are not available. In this report, emissions from anaerobic digestion of organic waste at biogas facilities are included in the Energy sector, because methane is used for electricity generation. Correct notation keys have been included in the CRF for entire period in which electricity was generated (2009 – 2015). Accordingly, recalculation were performed for 2013 and 2014 and notation key have been corrected.

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\textsubscript{4} and N\textsubscript{2}O emission calculations for entire period 1990 - 2015.

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\textsubscript{2}, CH\textsubscript{4} and N\textsubscript{2}O 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 \textsuperscript{54} 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 - 2015 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\textsubscript{2} and N\textsubscript{2}O 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\textsubscript{2} emission from incineration of clinical
waste are included in emission estimates for the period 1990 - 2015.

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

\textsuperscript{54} Ordinance on the Environmental Pollution Register (OG 87/15)
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$_2$O 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 – 2015 is defined as NA.

2006 IPCC Guidelines, Volume 5, not define default emission factor for N$_2$O 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 N₂O emission factors for incineration of MSW, industrial waste, sludge and sewage sludge is presented (Table 5.6, Page 5.22). Regarding to this, N₂O emission for incineration of clinical waste for entire period 1990 – 2015 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 - 2015.

Data for quantity of incinerated clinical waste for the period 1990 - 2015 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 - 2015.

Data for CO₂ and N₂O emission calculation from Incineration of Waste (without energy recovery) for the period 1990 - 2015 are presented in the Table 7.4-1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Incinerated waste (t)</th>
<th>Industrial waste</th>
<th>Clinical waste</th>
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</thead>
<tbody>
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<td>250.00</td>
<td>140.00</td>
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</tr>
<tr>
<td>1991</td>
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<td>2007</td>
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The resulting annual emissions of CO₂ from Incineration of Waste in the period 1990 - 2015 are presented in the Figure 7.4-1.

The resulting annual emissions of N₂O from Incineration of Waste in the period 1990 - 2008 are presented in the Figure 7.4-2.

Figure 7.4-1: Emissions of CO₂ from Incineration of Waste (1990 - 2015)

Figure 7.4-2: Emissions of N₂O from Incineration of Waste (1990 - 2015)
Emissions of SO2, CO, NOx, NMVOC and NH3 have been taken from the emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 Submission to the Convention on Long-range Transboundary Air Pollution’.

7.4.3. Uncertainties and time-series consistency

The uncertainties contained in CO2 and N2O 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 programme, 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 CO2 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 N₂O 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

Activity data for incineration of clinical waste has been corrected for 2014. Accordingly, recalculation of CO₂ emission were performed for 2014.

7.4.6. Category-specific planned improvements

Improvements in the sub-sector Waste Incineration are related primarily to aggregation of accurate data for CO₂ and N₂O 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 CH₄ 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. It is estimated that slightly more than half of the population (about 51%) is connected to the existing public wastewater systems. Observing the total population of the Republic of Croatia, the share of the population whose wastewater is collected in public wastewater systems is around 46%.

7.5.2. Methodological issues

7.5.2.1. Domestic wastewater

Methane (CH₄) and nitrous oxide (N₂O) emissions from treatment of domestic wastewater are included in emission estimates for the period 1990 - 2015.

Methane (CH₄) 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 2003-2015. 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 - 2015. Data for CH₄ emission calculation for the period 1990 - 2015 are presented in the Table 7.5-1.

Table 7.5-1: Data for CH₄ emission calculation from Domestic Wastewater (1990 - 2015)
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 - 2015.

Default value for maximum methane producing capacity (Bo) of 0.6 kg CH₄/kg BOD, proposed by 2006 IPCC Guidelines, has been used for emission calculation for entire period 1990 - 2015.

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 - 2015.

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. At this moment Croatia is not able to provide more detailed explanation for above mentioned fraction of treated wastewater. Proposed values of 30% have been used for methane emission calculation for entire period 1990 - 2015.

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 - 2015 are presented in the Figure 7.5-1.
Nitrous oxide (N₂O) emissions from wastewater

Nitrous oxide (N₂O) 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 - 2015 were taken from Statistical Yearbook. Croatian data on the annual per capita Protein intake value (PIV), for the period 1992-2011, 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 2007 to 2011 has been used for calculation of insufficient data for the period 2012 - 2015. Data on Population and PIV for the period 1990 - 2015 are presented in the Table 7.5-2.

Table 7.5-2: Data on population and PIV (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Protein intake (kg/person/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>4,778,000</td>
<td>21.39</td>
</tr>
<tr>
<td>1991</td>
<td>4,513,000</td>
<td>21.43</td>
</tr>
<tr>
<td>1992</td>
<td>4,470,000</td>
<td>21.72</td>
</tr>
<tr>
<td>1993</td>
<td>4,641,000</td>
<td>20.99</td>
</tr>
<tr>
<td>1994</td>
<td>4,649,000</td>
<td>21.79</td>
</tr>
<tr>
<td>1995</td>
<td>4,669,000</td>
<td>23.54</td>
</tr>
<tr>
<td>1996</td>
<td>4,494,000</td>
<td>23.32</td>
</tr>
<tr>
<td>Year</td>
<td>Population</td>
<td>Protein intake (kg/person/yr)</td>
</tr>
<tr>
<td>------</td>
<td>-----------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>1997</td>
<td>4,572,500</td>
<td>23.10</td>
</tr>
<tr>
<td>1998</td>
<td>4,501,000</td>
<td>22.85</td>
</tr>
<tr>
<td>1999</td>
<td>4,554,000</td>
<td>24.31</td>
</tr>
<tr>
<td>2000</td>
<td>4,381,000</td>
<td>24.35</td>
</tr>
<tr>
<td>2001</td>
<td>4,305,494</td>
<td>26.39</td>
</tr>
<tr>
<td>2002</td>
<td>4,305,384</td>
<td>27.81</td>
</tr>
<tr>
<td>2003</td>
<td>4,305,725</td>
<td>27.63</td>
</tr>
<tr>
<td>2004</td>
<td>4,310,861</td>
<td>27.45</td>
</tr>
<tr>
<td>2005</td>
<td>4,312,487</td>
<td>28.51</td>
</tr>
<tr>
<td>2006</td>
<td>4,313,530</td>
<td>29.53</td>
</tr>
<tr>
<td>2007</td>
<td>4,311,967</td>
<td>29.93</td>
</tr>
<tr>
<td>2008</td>
<td>4,309,796</td>
<td>30.40</td>
</tr>
<tr>
<td>2009</td>
<td>4,302,847</td>
<td>31.03</td>
</tr>
<tr>
<td>2010</td>
<td>4,289,857</td>
<td>29.53</td>
</tr>
<tr>
<td>2011</td>
<td>4,280,622</td>
<td>30.08</td>
</tr>
<tr>
<td>2012</td>
<td>4,267,558</td>
<td>30.02</td>
</tr>
<tr>
<td>2013</td>
<td>4,255,689</td>
<td>29.96</td>
</tr>
<tr>
<td>2014</td>
<td>4,238,389</td>
<td>29.90</td>
</tr>
<tr>
<td>2015</td>
<td>4,203,604</td>
<td>29.84</td>
</tr>
</tbody>
</table>

Default values of factors and parameters proposed by *2006 IPCC Guidelines* (Table 6.11) has been used for emission calculation for entire period 1990 - 2015:

- emission factor (EF_{EFFLUENT}) = 0.005 kg N$_2$O-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.

The resulting annual N$_2$O emissions from wastewater in the period 1990 - 2015 are presented in the Figure 7.5-2.
7.5.2.2. Industrial wastewater

Methane (CH$_4$) emissions from treatment of industrial wastewater are included in emission estimates for the period 1990 - 2015.

Methane emissions from industrial wastewater have been calculated using the IPCC Tier 1 methodology proposed by 2006 IPCC Guidelines.

Data on industrial output (tonne/yr) for 3 industries with the largest potential for wastewater methane emissions (Manufacture of food products and beverages, Manufacture of pulp, paper and paper products and Manufacture of chemicals and chemical products) were provided by Croatian Chamber of Economy. Insufficient data were assessed by interpolation/extrapolation method. Data on industrial output for the year 2015 is taken from previous year due to insufficient data. Gathering data on industrial output (tonne/yr) for 3 industries with the largest potential for wastewater methane emissions for the year 2014 and 2015 is a planned improvement.

Data on industrial output for the period 1990 - 2015 are presented in the Table 7.5-3.
Table 7.5-3: Data on industrial output (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total industrial output (tonne)</th>
<th>Manufacture of food products and beverages</th>
<th>Manufacture of pulp, paper and paper products</th>
<th>Manufacture of chemicals and chemical products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>5,315,793*</td>
<td>339,150*</td>
<td>3,318,280*</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>5,351,454*</td>
<td>333,635*</td>
<td>3,255,152*</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>5,387,114*</td>
<td>368,120*</td>
<td>3,192,024*</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>5,422,775*</td>
<td>382,605*</td>
<td>3,128,896*</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>5,458,436*</td>
<td>453,729</td>
<td>3,065,768*</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>5,494,097*</td>
<td>412,203</td>
<td>3,147,255</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>5,529,757*</td>
<td>371,798</td>
<td>2,915,042</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>5,446,749</td>
<td>425,155</td>
<td>2,957,173</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>5,824,329</td>
<td>416,693</td>
<td>2,370,884</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>5,544,368</td>
<td>461,676</td>
<td>2,773,894</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>5,658,938</td>
<td>540,973</td>
<td>2,907,306</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>3,131,009</td>
<td>542,469</td>
<td>2,414,577</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>3,335,776*</td>
<td>568,227</td>
<td>2,325,925</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>3,544,664*</td>
<td>544,932</td>
<td>2,342,540</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>3,757,680</td>
<td>566,745</td>
<td>2,784,861</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>4,969,306</td>
<td>468,791</td>
<td>3,066,741</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>5,455,702</td>
<td>538,793</td>
<td>2,939,226</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>5,179,332</td>
<td>583,172</td>
<td>3,282,811</td>
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<tr>
<td>2008</td>
<td>5,173,879</td>
<td>595,836</td>
<td>3,127,388</td>
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</tr>
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<td>2009</td>
<td>4,332,625</td>
<td>406,574</td>
<td>2,369,124</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>4,246,800</td>
<td>427,943</td>
<td>2,400,562</td>
<td></td>
</tr>
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<td>2011</td>
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<tr>
<td>2012</td>
<td>4,316,793</td>
<td>373,123</td>
<td>2,103,609</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>4,923,120</td>
<td>464,916</td>
<td>1,883,015</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>5,529,447*</td>
<td>556,709*</td>
<td>1,662,421*</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>5,529,447</td>
<td>556,709</td>
<td>1,662,421</td>
<td></td>
</tr>
</tbody>
</table>

* 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; data for 2014 were assessed by extrapolation method taking into account the pattern from 2012 to 2013; data for 2015 is taken from the previous year

- 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; data for 2014 were assessed by extrapolation method taking into account the pattern from 2012 to 2013; data for 2015 is taken from the previous year
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 for 2014 were assessed by extrapolation method taking into account the pattern from 2012 to 2013; data for 2015 is taken from the previous year.

Data on wastewater output (m³/yr) for 3 industries with the largest potential for wastewater methane emissions (Manufacture of food products and beverages, Manufacture of pulp, paper and paper products and Manufacture of chemicals and chemical products) were taken from Statistical Yearbooks. Data for 1997 are insufficient and assessed by interpolation. Data for the period 1990-1993 are available in different (aggregated) form. These data also assessed by extrapolation to enable usage of same methodology during the time series. Data on wastewater output for the period 1990 - 2015 are presented in the Table 7.5-4.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total wastewater output (m³)</th>
<th>Manufacture of food products and beverages</th>
<th>Manufacture of pulp, paper and paper products</th>
<th>Manufacture of chemicals and chemical products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>7,237,300</td>
<td>3,207,500</td>
<td>2,875,490</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>7,018,240</td>
<td>2,950,800</td>
<td>2,890,992</td>
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</tr>
<tr>
<td>1993</td>
<td>6,908,710</td>
<td>2,822,450</td>
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<td></td>
</tr>
<tr>
<td>1994</td>
<td>5,911,000</td>
<td>679,000</td>
<td>2,115,000</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>6,157,000</td>
<td>5,224,000</td>
<td>1,806,000</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>5,274,000</td>
<td>3,817,000</td>
<td>6,896,000</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>6,470,590</td>
<td>2,309,050</td>
<td>2,929,747</td>
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</tr>
<tr>
<td>1998</td>
<td>9,348,000</td>
<td>1,130,000</td>
<td>1,571,000</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>9,759,000</td>
<td>1,065,000</td>
<td>2,371,000</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>4,914,000</td>
<td>1,169,000</td>
<td>2,189,000</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>4,715,000</td>
<td>1,808,000</td>
<td>1,577,000</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>5,630,000</td>
<td>132,000</td>
<td>3,619,000</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>5,037,000</td>
<td>3,695,000</td>
<td>4,936,000</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>4,767,000</td>
<td>2,213,000</td>
<td>3,519,000</td>
<td></td>
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<tr>
<td>2005</td>
<td>6,440,000</td>
<td>681,000</td>
<td>1,864,000</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>5,045,000</td>
<td>1,692,000</td>
<td>3,375,000</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>4,941,000</td>
<td>1,646,000</td>
<td>1,624,000</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>2,570,000</td>
<td>1,574,000</td>
<td>1,007,000</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>2,553,000</td>
<td>1,766,000</td>
<td>1,332,000</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>3,086,000</td>
<td>2,508,000</td>
<td>1,437,000</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>2,279,000</td>
<td>171,000</td>
<td>728,000</td>
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<tr>
<td>2012</td>
<td>2,084,000</td>
<td>1,881,000</td>
<td>471,000</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>2,692,000</td>
<td>1,744,000</td>
<td>483,000</td>
<td></td>
</tr>
</tbody>
</table>
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).

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 - 2015 (Table 7.5-5).

Table 7.5-5: Data on degradable organic component and wastewater produced (1990 - 2015)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Manufacture of food products and beverages</th>
<th>Manufacture of pulp, paper and paper products</th>
<th>Manufacture of chemicals and chemical products</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOC (kg COD/m$^3$ wastewater)*</td>
<td>4.66</td>
<td>9.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Wastewater produced (m$^3$/tonne product)**</td>
<td>15.55</td>
<td>162.00</td>
<td>67.00</td>
</tr>
</tbody>
</table>

* 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 m³/tonne product);
- manufacture of pulp, paper and paper products: Pulp&Paper (combined): 162.00 m³/tonne product;
- manufacture of chemicals and chemical products: Organic chemicals: 67.00 m³/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 - 2015.

Organic wastewater from industrial sources (kg COD/yr) for the period 1990 - 2015 are presented in the Table 7.5-6.

Table 7.5-6: Organic wastewater from industrial sources (1990 - 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Organic wastewater from industrial sources (kg COD/yr)</th>
<th>Total organic wastewater (kg COD/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manufacture of food products and beverages</td>
<td>Manufacture of pulp, paper and paper products</td>
</tr>
<tr>
<td>1990</td>
<td>384,830,928</td>
<td>494,480,700</td>
</tr>
<tr>
<td>1991</td>
<td>387,412,545</td>
<td>515,599,830</td>
</tr>
<tr>
<td>1992</td>
<td>389,994,161</td>
<td>536,718,960</td>
</tr>
<tr>
<td>1993</td>
<td>392,575,778</td>
<td>557,838,090</td>
</tr>
<tr>
<td>1994</td>
<td>395,157,395</td>
<td>661,536,882</td>
</tr>
<tr>
<td>1995</td>
<td>397,739,012</td>
<td>600,991,974</td>
</tr>
<tr>
<td>1996</td>
<td>400,320,628</td>
<td>542,081,484</td>
</tr>
<tr>
<td>1997</td>
<td>394,311,342</td>
<td>619,875,990</td>
</tr>
<tr>
<td>1998</td>
<td>421,645,826</td>
<td>607,538,394</td>
</tr>
<tr>
<td>1999</td>
<td>401,378,361</td>
<td>673,123,608</td>
</tr>
<tr>
<td>2000</td>
<td>409,672,529</td>
<td>788,738,634</td>
</tr>
<tr>
<td>2001</td>
<td>226,665,918</td>
<td>790,919,802</td>
</tr>
<tr>
<td>2002</td>
<td>241,489,797</td>
<td>828,474,966</td>
</tr>
<tr>
<td>2003</td>
<td>256,612,012</td>
<td>794,510,856</td>
</tr>
<tr>
<td>2004</td>
<td>272,033,068</td>
<td>826,314,210</td>
</tr>
<tr>
<td>2005</td>
<td>359,747,391</td>
<td>683,497,278</td>
</tr>
<tr>
<td>2006</td>
<td>394,959,469</td>
<td>785,560,194</td>
</tr>
<tr>
<td>2007</td>
<td>374,951,975</td>
<td>850,264,776</td>
</tr>
<tr>
<td>2008</td>
<td>374,557,194</td>
<td>868,728,888</td>
</tr>
<tr>
<td>2009</td>
<td>313,655,582</td>
<td>592,784,892</td>
</tr>
<tr>
<td>2010</td>
<td>307,442,357</td>
<td>623,940,894</td>
</tr>
</tbody>
</table>
Organic wastewater from industrial sources (kg COD/yr)

<table>
<thead>
<tr>
<th>Year</th>
<th>Manufacture of food products and beverages (kg COD/yr)</th>
<th>Manufacture of pulp, paper and paper products (kg COD/yr)</th>
<th>Manufacture of chemicals and chemical products (kg COD/yr)</th>
<th>Total organic wastewater (kg COD/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>318,721,230</td>
<td>590,667,876</td>
<td>471,817,350</td>
<td>1,381,206,456</td>
</tr>
<tr>
<td>2012</td>
<td>312,509,464</td>
<td>544,013,334</td>
<td>422,825,409</td>
<td>1,279,348,207</td>
</tr>
<tr>
<td>2013</td>
<td>356,403,798</td>
<td>677,847,528</td>
<td>378,486,015</td>
<td>1,412,737,341</td>
</tr>
<tr>
<td>2014</td>
<td>400,298,172</td>
<td>811,681,722</td>
<td>334,146,621</td>
<td>1,546,127,515</td>
</tr>
<tr>
<td>2015</td>
<td>400,298,172</td>
<td>811,681,722</td>
<td>334,146,621</td>
<td>1,546,127,515</td>
</tr>
</tbody>
</table>

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 aerobiocally, 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 - 2015.

Default value for maximum methane producing capacity (Bo) of 0.25 kg CH₄/kg COD, proposed by 2006 IPCC Guidelines, has been used for emission calculation for entire period 1990 - 2015.

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 - 2015.

The resulting annual emissions of CH₄ from Industrial Wastewater in the period 1990 – 2015 are presented in the Figure 7.5-3.
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\(_2\)O 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\(_2\)O Emissions from Wastewater amounts 50 percent, based on expert judgements. Uncertainty estimate associated with N\(_2\)O emission factor amounts 50 percent, according to provided uncertainty assessment in 2006 IPCC Guidelines (detailed in Annex 1).
CH₄ Emissions from Domestic and Industrial Wastewater and N₂O 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.

CH₄ and N₂O 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

No category-specific recalculations were made.

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 CH₄ 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;

- activity data for industrial output (tonne/yr) for 2014 and 2015 to be used for methane emission calculation from industrial wastewater, in order to improve transparency.

More information for uncertainty estimation is required, regarding more accurate and transparent uncertainty analysis.
CHAPTER 8: OTHER (CRF SECTOR 6)

UNFCCC Reporting Guidelines (Decision 24/CP.19) paragraph 29 indicates that Annex I Parties should report and explicitly describe the details of emissions from each country-specific source of gases which are not part of the IPCC Guidelines.

Among CO$_2$, CH$_4$, N$_2$O, HFCs, PFCs, SF$_6$, NF$_3$, no emissions and removals are reported in Other sector.
CHAPTER 9: INDIRECT CO₂ AND NITROUS OXIDE EMISSIONS

9.1. DESCRIPTION OF SOURCES OF INDIRECT EMISSIONS IN GHG INVENTORY

Although Parties may now choose to report indirect CO₂, in accordance with paragraph 29 of the UNFCCC Inventory Reporting Guidelines, Croatia does not choose to report indirect CO₂ emissions from the atmospheric oxidation of CH₄, CO and NMVOCs, or indirect N₂O emissions arising from sources other than those in the agriculture and LULUCF sectors.

Information on the following precursor gases: carbon monoxide (CO), nitrogen oxides (NOₓ) and non-methane volatile organic compounds (NMVOCs), as well as sulphur oxides (SO₂) are given in the Chapter 9.2.

9.2. METHODOLOGICAL ISSUES

The photochemical active gases, carbon monoxide (CO), oxides of nitrogen (NOX) and non-methane volatile organic compounds (NMVOCs) indirectly contribute to the greenhouse gas effect. These are generally called indirect greenhouse gases or ozone precursors, because they are involved in creation and degradation of ozone which is also one of the greenhouse gases. Sulphur dioxide (SO₂), as a precursor of sulphate and aerosols, is believed to contribute negatively to the greenhouse effect. Emissions of indirect GHGs have been taken from the draft of emission inventory report ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 Submission to the Convention on Long-range Transboundary Air Pollution’. The calculations of aggregated results for the emissions of indirect gases in the period 1990-2015 are given in table 9.2-1.
### Table 9.2-1: Emissions of ozone precursors and SO₂ by sectors (kt)

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>Emissions (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOₓ Emission</td>
<td>87.44</td>
</tr>
<tr>
<td>Energy</td>
<td>81.13</td>
</tr>
<tr>
<td>Industrial Processes</td>
<td>2.78</td>
</tr>
<tr>
<td>Agriculture</td>
<td>2.79</td>
</tr>
<tr>
<td>LULUCF</td>
<td>0.74</td>
</tr>
<tr>
<td>Waste</td>
<td>0.00</td>
</tr>
<tr>
<td>CO Emission</td>
<td>535.90</td>
</tr>
<tr>
<td>Energy</td>
<td>495.29</td>
</tr>
<tr>
<td>Industrial Processes</td>
<td>40.57</td>
</tr>
<tr>
<td>Agriculture</td>
<td>NO</td>
</tr>
<tr>
<td>LULUCF</td>
<td>0.04</td>
</tr>
<tr>
<td>Waste</td>
<td>0.00</td>
</tr>
<tr>
<td>NMVOC Emission</td>
<td>141.28</td>
</tr>
<tr>
<td>Energy</td>
<td>62.02</td>
</tr>
<tr>
<td>Industrial Processes</td>
<td>66.11</td>
</tr>
<tr>
<td>Agriculture</td>
<td>12.12</td>
</tr>
<tr>
<td>LULUCF</td>
<td>0.10</td>
</tr>
<tr>
<td>Waste</td>
<td>0.92</td>
</tr>
<tr>
<td>SO₂ Emission</td>
<td>135.10</td>
</tr>
<tr>
<td>Energy</td>
<td>133.41</td>
</tr>
<tr>
<td>Industrial Processes</td>
<td>1.68</td>
</tr>
<tr>
<td>Agriculture</td>
<td>NO</td>
</tr>
<tr>
<td>LULUCF</td>
<td>NO</td>
</tr>
<tr>
<td>Waste</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### 9.3. Uncertainties and Time-series Consistency

For detailed information refer to ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 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 2015 Submission to the Convention on Long-range Transboundary Air Pollution’.

CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE
9.5. CATEGORY-SPECIFIC RECALCULATIONS

For detailed information refer to ‘Republic of Croatia Informative Inventory Report for LRTAP Convention for the Year 2015 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 2015 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 1990-2014 are described in each chapter of Inventory. Difference between emissions NIR 2017 and NIR 2016 for 1990 are shown in the Table 10.1-1 while for 2014 are shown in Table 10.1-2.

Table 10.1-1: Difference between emissions estimated in NIR 2017 and NIR 2016 for 1990

<table>
<thead>
<tr>
<th>Difference between NIR 2017 and NIR 2016 submission for 1990</th>
<th>CO₂(1)</th>
<th>CH₄</th>
<th>N₂O</th>
<th>HFCs, PFCs, SF₆, NF₃</th>
<th>Total CO₂ equivalent (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (net emissions)(1)</td>
<td>4.11</td>
<td>-26.53</td>
<td>-24.40</td>
<td>0.00</td>
<td>-46.82</td>
</tr>
<tr>
<td><strong>1. Energy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Fuel combustion (sectoral approach)</td>
<td>0.00</td>
<td>-1.44</td>
<td>82.89</td>
<td>0.00</td>
<td>81.45</td>
</tr>
<tr>
<td>B. Fugitive emissions from fuels</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>2. Industrial processes and product use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Mineral industry</td>
<td>0.00</td>
<td>NO</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>B. Chemical industry</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>C. Metal industry</td>
<td>0.00</td>
<td>0.00</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>D. Non-energy products from fuels and solvent use</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>0.00</td>
<td>NO</td>
</tr>
<tr>
<td>E. Electronic industry</td>
<td>NO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Product uses as ODS substitutes</td>
<td>NO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Other product manufacture and use</td>
<td>NO</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>3. Agriculture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Enteric fermentation</td>
<td>NO</td>
<td>0.00</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>B. Manure management</td>
<td>NO</td>
<td>-25.09</td>
<td>0.00</td>
<td>-25.09</td>
<td>-25.09</td>
</tr>
<tr>
<td>C. Rice cultivation</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>0.00</td>
<td>NO</td>
</tr>
<tr>
<td>D. Agricultural soils</td>
<td>NO</td>
<td>NO</td>
<td>-107.30</td>
<td>NO</td>
<td>-107.30</td>
</tr>
<tr>
<td>E. Prescribed burning of savannas</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>0.00</td>
<td>NO</td>
</tr>
<tr>
<td>F. Field burning of agricultural residues</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>0.00</td>
<td>NO</td>
</tr>
<tr>
<td>G. Liming</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>H. Urea application</td>
<td>0.00</td>
<td>NO</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>4. Land use, land-use change and forestry(1)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Forest land</td>
<td>4.11</td>
<td>0.00</td>
<td>0.00</td>
<td>4.11</td>
<td>4.11</td>
</tr>
<tr>
<td>B. Cropland</td>
<td>0.00</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>C. Grassland</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>D. Wetlands</td>
<td>0.00</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>E. Settlements</td>
<td>0.00</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>F. Other land</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>G. Harvested wood products</td>
<td>0.00</td>
<td>NO</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>5. Waste</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Solid waste disposal</td>
<td>NO</td>
<td>0.00</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>B. Biological treatment of solid waste</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>C. Incineration and open burning of waste</td>
<td>0.00</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>D. Waste water treatment and discharge</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Total CO₂: equivalent emissions without land use, land-use change and forestry -50.93
Total CO₂: equivalent emissions with land use, land-use change and forestry -46.82
Table 10.1-2: Difference between emissions estimated in NIR 2017 and NIR 2016 for 2014

<table>
<thead>
<tr>
<th>Difference between NIR 2017 and NIR 2016 submission for 2014</th>
<th>CO₂[^{(1)}]</th>
<th>CH₄</th>
<th>N₂O</th>
<th>HFCs, PFCs, SF₆, NF₃</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total (net emissions)</strong>[^{(1)}]</td>
<td>153.94</td>
<td>146.12</td>
<td>3.44</td>
<td>-169.20</td>
<td>134.30</td>
</tr>
<tr>
<td><strong>1. Energy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Fuel combustion (sectoral approach)</td>
<td>168.10</td>
<td>-13.93</td>
<td>64.21</td>
<td></td>
<td>218.38</td>
</tr>
<tr>
<td>B. Fugitive emissions from fuels</td>
<td>0.00</td>
<td>-0.06</td>
<td>0.00</td>
<td></td>
<td>-0.06</td>
</tr>
<tr>
<td><strong>2. Industrial processes and product use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Mineral industry</td>
<td>0.97</td>
<td>#VALUE!</td>
<td>#VALUE!</td>
<td></td>
<td>0.97</td>
</tr>
<tr>
<td>B. Chemical industry</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>C. Metal industry</td>
<td>0.68</td>
<td>#VALUE!</td>
<td>#VALUE!</td>
<td></td>
<td>0.68</td>
</tr>
<tr>
<td>D. Non-energy products from fuels and solvent</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td></td>
<td>NO</td>
</tr>
<tr>
<td>E. Electronic industry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Product uses as ODS substitutes</td>
<td>NO</td>
<td>NO</td>
<td>-15.77</td>
<td>-169.20</td>
<td>-183.32</td>
</tr>
<tr>
<td>G. Other product manufacture and use</td>
<td>NO</td>
<td>NO</td>
<td>-15.77</td>
<td>-169.17</td>
<td>-15.80</td>
</tr>
<tr>
<td><strong>3. Agriculture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Enteric fermentation</td>
<td>21.02</td>
<td></td>
<td></td>
<td></td>
<td>21.02</td>
</tr>
<tr>
<td>B. Manure management</td>
<td>150.90</td>
<td>0.00</td>
<td></td>
<td></td>
<td>150.90</td>
</tr>
<tr>
<td>C. Rice cultivation</td>
<td>NO</td>
<td></td>
<td></td>
<td></td>
<td>NO</td>
</tr>
<tr>
<td>D. Agricultural soils</td>
<td>NO</td>
<td></td>
<td>-44.99</td>
<td>-15.80</td>
<td>-44.99</td>
</tr>
<tr>
<td>E. Prescribed burning of savannas</td>
<td>NO</td>
<td>NO</td>
<td></td>
<td></td>
<td>NO</td>
</tr>
<tr>
<td>F. Field burning of agricultural residues</td>
<td>NO</td>
<td>NO</td>
<td></td>
<td></td>
<td>NO</td>
</tr>
<tr>
<td>G. Liming</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>H. Urea application</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td><strong>4. Land use, land-use change and forestry</strong>[^{(1)}]</td>
<td>-15.80</td>
<td>-0.01</td>
<td>-0.01</td>
<td></td>
<td>-15.82</td>
</tr>
<tr>
<td>A. Forest land</td>
<td>-2.65</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td>-2.65</td>
</tr>
<tr>
<td>B. Cropland</td>
<td>-0.02</td>
<td>NO</td>
<td>0.00</td>
<td></td>
<td>-0.02</td>
</tr>
<tr>
<td>C. Grassland</td>
<td>0.00</td>
<td>-0.01</td>
<td>-0.01</td>
<td></td>
<td>-0.02</td>
</tr>
<tr>
<td>D. Wetlands</td>
<td>0.00</td>
<td>NO</td>
<td>0.00</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>E. Settlements</td>
<td>-13.14</td>
<td>NO</td>
<td>0.00</td>
<td></td>
<td>-13.14</td>
</tr>
<tr>
<td>G. Harvested wood products</td>
<td>0.00</td>
<td>NO</td>
<td>NO</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td><strong>5. Waste</strong></td>
<td>0.00</td>
<td>-11.87</td>
<td>0.00</td>
<td></td>
<td>-11.87</td>
</tr>
<tr>
<td>A. Solid waste disposal</td>
<td>NO</td>
<td>-11.00</td>
<td>NO</td>
<td></td>
<td>-11.00</td>
</tr>
<tr>
<td>B. Biological treatment of solid waste</td>
<td>NO</td>
<td>-0.87</td>
<td>0.00</td>
<td></td>
<td>-0.87</td>
</tr>
<tr>
<td>C. Incineration and open burning of waste</td>
<td>0.00</td>
<td>NO</td>
<td>NO</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>D. Waste water treatment and discharge</td>
<td>NO</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td>0.00</td>
</tr>
</tbody>
</table>

Total CO₂: equivalent emissions without land use, land-use change and forestry 150.12
Total CO₂: equivalent emissions with land use, land-use change and forestry 134.30

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 2016)
In 2017 Inventory recalculations are mainly made according to ESD and UNFCCC experts review teams. Detailed information on reasons for recalculations of the 1990 and 2014 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 2017 Inventory recalculations are mainly made according to ESD and UNFCCC experts review teams and because of correction of errors and usage of higher tier method 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 2017.
Table 10.4-1: Recommendations from the last draft of ARR with the status of implementation

<table>
<thead>
<tr>
<th>CRF category / issue</th>
<th>Review recommendation</th>
<th>MS response / status of implementation</th>
<th>Chap. NIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy sector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.A. Fuel Combustion-Sectoral Approach – Liquid fuels – CO₂, Accuracy</td>
<td>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</td>
<td>E.14 Implemented</td>
<td>3.2.1</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1.A.2 Manufacturing Industries and Construction – CO₂, CH₄, N₂O (22, 2014) Consistency</td>
<td>Improve on the consistency of the NIR, time-series consistency is necessary from the base year</td>
<td>E.8 embedded in Annual Improvement Plan</td>
<td>3.2.5.6.</td>
</tr>
<tr>
<td>Fuel combustion-reference approach – [natural gas] – CO₂</td>
<td>ERT recommends the party to provide a more detailed and transparent explanation for the observed CO₂ emission differences between the reference approach and the sectoral approach</td>
<td>E.2 Implemented</td>
<td>3.2.1</td>
</tr>
<tr>
<td>International bunkers and multilateral operations – Liquid fuels – [CO₂] (26, 2014) ([27, 2013]) Transparency</td>
<td>ERT recommends the party to provide a detailed explanation of the factors contributing to decreases in bunker fuel consumption and associated CO₂ emissions.</td>
<td>E.6 Implemented</td>
<td>3.2.2</td>
</tr>
<tr>
<td>1.A.1.a Public electricity and heat production – [Coal, Fuel oil, natural gas] – CO₂, CH₄, N₂O (28, 2014) Accuracy</td>
<td>ERT recommends the party to take steps to obtain and use plant-specific CO₂ EFs to improve the accuracy of emission estimates</td>
<td>E.15 embedded in Annual Improvement Plan</td>
<td>3.2.4.6</td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>MS response / status of implementation</td>
<td>Chap. NIR</td>
</tr>
<tr>
<td>----------------------</td>
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<td>-----------</td>
</tr>
<tr>
<td>1.A.3.a. Domestic aviation-liquid fuels CO₂</td>
<td>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</td>
<td>E.17. Implemented</td>
<td>3.2.6.2.</td>
</tr>
<tr>
<td>1.B.2 Natural gas – CO₂, CH₄, N₂O Transparency</td>
<td>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</td>
<td>- Implemented</td>
<td>3.3.2.</td>
</tr>
<tr>
<td>Other (mobile) – Liquid fuels – CO₂, CH₄, N₂O (35, 2014) Transparency</td>
<td>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.</td>
<td>E.11 Implemented</td>
<td>3.2.8.</td>
</tr>
</tbody>
</table>

**Industrial processes and product use**

**Issues and/or problems raised in the previous review report of Croatia: issues not solved**

<p>| IPPU, 2.C.2 Ferroalloys production – CO₂ 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 41, 2013 | Information is provided in the NIR 2017. 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 2017. Ministry of Environment and Energy (MEE) is responsible for data collection. For now, data are not collected. | 4.7.1.1. |</p>
<table>
<thead>
<tr>
<th>CRF category / issue</th>
<th>Review recommendation</th>
<th>MS response / status of implementation</th>
<th>Chap. NIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste, 5.C.1 Waste incineration – CO₂, CH₄, N₂O Transparency</td>
<td>Identify the technologies applied in the incineration of hazardous waste and estimate N₂O emissions from waste incineration.</td>
<td>Information is provided in the NIR 2017. Partly solved. Croatian Agency for the Environment and Nature (CAEN) is responsible for data collection. Explanation on incineration of clinical waste is provided.</td>
<td>7.4.2.</td>
</tr>
<tr>
<td><strong>Provisional main findings made during the 2016 technical review</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPPU, 2.B.8 Petrochemical and carbon black production – CO₂, Accuracy</td>
<td>A tier 1 approach is used to estimate CO₂ 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.</td>
<td>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 programme and would be collected in the future if it will be possible.</td>
<td>4.3.8.6.</td>
</tr>
<tr>
<td>IPPU, 2.C.2 Ferroalloys production – CO₂, Accuracy</td>
<td>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.</td>
<td>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.</td>
<td>4.4.2.6.</td>
</tr>
<tr>
<td>IPPU, 2.D Non-energy products from fuels and solvents use – CO₂, Accuracy</td>
<td>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.</td>
<td>Separate data for lubricant and paraffin wax use are reported in the Energy Balance for the period 1999 – 2015. 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</td>
<td>4.5.1.6. 4.5.2.6. 4.5.3.2.</td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>MS response / status of implementation</td>
<td>Chap. NIR</td>
</tr>
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</tr>
<tr>
<td>IPPU, 2.C.3 Aluminium production – CO2, PFC, Accuracy</td>
<td>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.</td>
<td>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 programme and would be collected in the future if it will be possible.</td>
<td>4.4.3.6.</td>
</tr>
<tr>
<td>IPPU, 2.F.2 Foam blowing agents – HFC 152-a, Accuracy</td>
<td>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.</td>
<td>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 programme.</td>
<td>4.7.2.6.</td>
</tr>
<tr>
<td>IPPU, 2.A.4 Other process uses of carbonates – CO2, Transparency</td>
<td>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.</td>
<td>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.</td>
<td>4.2.4.1.  4.2.4.2.</td>
</tr>
</tbody>
</table>

Agriculture

<p>| General (agriculture) – CH4, 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. Inter-annual changes are not explained in the inventory, recommends that Croatia correct the errors in the next inventory submission | Implemented                                                                                           | 5.2.5     |</p>
<table>
<thead>
<tr>
<th>CRF category / issue</th>
<th>Review recommendation</th>
<th>MS response / status of implementation</th>
<th>Chap. NIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.B Manure management – CH₄ Adherence to UNFCCC Annex I inventory reporting guidelines</td>
<td>Fill the additional information CRF table 3.B(a) for the livestock species whose CH₄ 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.</td>
<td>A.10 Under implementation</td>
<td>5.2.2</td>
</tr>
<tr>
<td>3.D.a.2 Organic N fertilizers – N₂O, Transparency</td>
<td>In table 5.5-2 in the NIR, Croatia included values for the average nitrogen content in the sewage sludge applied to 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.</td>
<td>A.11 Implemented</td>
<td>5.5.1.2</td>
</tr>
<tr>
<td>3.D.a.3 Crop residues – N₂O, Transparency</td>
<td>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.</td>
<td>A.12 Implemented</td>
<td>5.5.1.2</td>
</tr>
<tr>
<td>LULUCF – general</td>
<td>The ERT recommends that Croatia continue enhancing the transparency of its reporting, including in the category-specific recalculation chapter of the inventory report detailed information on all recalculation performed in comparison to the previous inventory submission.</td>
<td>Planned to be performed for NIR 2017 Resubmission</td>
<td></td>
</tr>
<tr>
<td>LULUCF - general</td>
<td>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.</td>
<td>L.12 Croatia intends to perform suggested improvements in NIR 2018</td>
<td></td>
</tr>
<tr>
<td>4.A.1</td>
<td>The ERT recommends that Croatia make significant efforts to use the results of National Forest Resources Inventory to improve the accuracy of carbon stock changes in dead wood pool in case of forest</td>
<td>Croatia intends to use NFI data for the estimation of carbon stock changes in dead wood pool in case of forest</td>
<td></td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>MS response / status of implementation</td>
<td>Chap. NIR</td>
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</tr>
<tr>
<td></td>
<td>estimations. Further, the ERT recommends that Croatia provide detailed information on the progress made in the official approval procedures of the NFI results in the next annual submission.</td>
<td>land converted to Cropland and Settlements for NIR 2018</td>
<td></td>
</tr>
<tr>
<td>4.A.2</td>
<td>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.</td>
<td>L.16 Croatia intends to perform requested estimation for NIR 2018 Submission</td>
<td></td>
</tr>
<tr>
<td>LULUCF-general</td>
<td>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.</td>
<td>L.13 This will be presented in NIR 2017 Resubmission</td>
<td></td>
</tr>
<tr>
<td></td>
<td>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 neighboring 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.</td>
<td>L.17 Croatia intends to make progress in this part of the report for NIR 2018</td>
<td></td>
</tr>
<tr>
<td>4.B.2</td>
<td>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.</td>
<td>Planned to be performed for NIR 2017 Resubmission</td>
<td></td>
</tr>
<tr>
<td>LULUCF-General</td>
<td>The ERT recommends that Croatia improve its QA/QC system and correct the land use matrices for the different land use, land-use change</td>
<td>Planned to be performed for NIR 2017 Resubmission</td>
<td></td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>MS response / status of implementation</td>
<td>Chap. NIR</td>
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<tr>
<td></td>
<td>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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 (V) Biomass burning</td>
<td>The ERT recommends that Croatia estimate and report CO₂ 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.</td>
<td>L.19 Implemented</td>
<td>6.15.1</td>
</tr>
<tr>
<td>4 (IV) Indirect N₂O emissions from managed soils</td>
<td>The ERT recommends that Croatia estimate indirect N₂O 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</td>
<td>L.18 Implemented</td>
<td>6.14</td>
</tr>
<tr>
<td>4.A.1</td>
<td>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.</td>
<td>L.15 Croatia intends to present more information about “Out of yield forests” that proves there is no harvest in these forests</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td></td>
<td>W.8 Implemented</td>
<td>7.1</td>
</tr>
<tr>
<td>Waste, 5.A Solid waste disposal on land, Transparency</td>
<td>Clarification on the practices adopted for the disposal of construction and demolition solid waste material.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>MS response / status of implementation</td>
<td>Chap. NIR</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Waste, 5.A Solid waste disposal on land – CH₄, Transparency</td>
<td>Clarification on the procedures associated to solid waste separation process regarding the Croatian policy for waste prevention and management.</td>
<td>Implemented</td>
<td>7.1</td>
</tr>
<tr>
<td>Waste, 5.A Solid waste disposal on land – CH₄, Transparency</td>
<td>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.</td>
<td>Implemented</td>
<td>7.2.1</td>
</tr>
<tr>
<td>Waste, 5.A Solid waste disposal on land – CH₄, Transparency</td>
<td>Clarification of the particular instable trend of solid waste disposal on site by types of SWDS from 1990-2014.</td>
<td>Implemented</td>
<td>7.2.1.</td>
</tr>
<tr>
<td>KP-LULUCF</td>
<td>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.</td>
<td>General</td>
<td>Planned to be performed for NIR 2017 Resubmission</td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td>KL.6</td>
<td>Croatia intends to present more information about “Out of yield forests” that proves there is no harvest in these forests</td>
</tr>
<tr>
<td></td>
<td>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</td>
<td></td>
<td>Implemented</td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>MS response / status of implementation</td>
<td>Chap. NIR</td>
</tr>
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</tr>
<tr>
<td></td>
<td>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.</td>
<td>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.</td>
<td>KL.8</td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td>Implemented</td>
<td>11.3.1.4</td>
</tr>
<tr>
<td></td>
<td>The ERT recommends that Croatia estimate carbon stock changes in the dead wood pool in forest land converted to cropland and include them in the dead wood pool carbon stock changes estimations from deforestation activity in the next submission. For that purpose Croatia can either use national data as a first choice, or can further examine the use of data from neighboring countries with similar ecological, climatic, and management practices regime. Further the ERT recommends that Croatia provide</td>
<td>KL.9 Croatia intends to perform this estimation for NIR 2018.</td>
<td></td>
</tr>
</tbody>
</table>
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 2017**

<table>
<thead>
<tr>
<th>CRF category / issue</th>
<th>Review recommendation</th>
<th>MS response / status of implementation</th>
<th>Chap. NIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy sector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1A1b Petroleum refineries</td>
<td>During ESD revision of NIR 2016 it was observed that GHG emissions from production of H₂ were not included in inventory. Production of H₂ started in 2007 in Croatia, so GHG emissions were calculated for the whole period from 2007 to 2014 and included in NIR 2017</td>
<td></td>
<td>3.2.4.</td>
</tr>
<tr>
<td>1A3b Road transportation</td>
<td>In Road transport sector recalculation was performed due to wrong density of CNG used for the period from 2011 to 2014</td>
<td></td>
<td>3.2.6.</td>
</tr>
<tr>
<td>1A4c Agriculture/forestry/fishing</td>
<td>According to technical correction proposed by TERT during 2016 comprehensive review of national greenhouse gas inventory data emission factors for CH₄ and N₂O for diesel for off road vehicles in 1A4c Agriculture/forestry/fishing subsector were modified. Emission were recalculated for</td>
<td></td>
<td>3.2.7.</td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>Error detected by Expert</td>
<td>Chapter/section in the NIR</td>
</tr>
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</tr>
<tr>
<td><strong>UNFCCC</strong></td>
<td><strong>ESD</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1A5 Other (military component)</td>
<td>ERT 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. Emissions from military are all included in 1A3b sector. For transparency purposes in subsector 1A5b, two subsectors were created: 1A5b-military aviation component and 1A5b-military water-borne component</td>
<td>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. Emissions from military are all included in 1A3b sector. For transparency purposes in subsector 1A5b, two subsectors were created: 1A5b-military aviation component and 1A5b-military water-borne component</td>
<td>3.2.8.</td>
</tr>
<tr>
<td>Industrial processes and product use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.A.4 Other uses of soda ash</td>
<td>During NIR 2017 preparation, 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. It should be noted that this allocation by categories do not influence on the emissions for entire reporting period for 2.A.4 (emissions were not recalculated since they were not changed).</td>
<td>New data for soda ash use for 2013 and 2014 were provided. Accordingly, recalculations were performed for the years 2013 and 2014.</td>
<td>4.2.4.5.</td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>Error detected by Expert</td>
<td>Chapter/section in the NIR</td>
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</tr>
<tr>
<td>2.B.8.b Ethylene production</td>
<td>A mistake has been made for the data on ethylene production in 2014. There was no production on ethylene in 2014 and value amounted to zero. Accordingly, recalculation were performed for the year 2014.</td>
<td>4.3.8.5.</td>
<td></td>
</tr>
<tr>
<td>2.C.1.a Steel production</td>
<td>New data for CO2 emissions from limestone and dolomite use in steel production are included in total CO2 emissions for the period 2012 – 2014. Accordingly, recalculation were performed for the period 2012 – 2014.</td>
<td>4.4.1.5.</td>
<td></td>
</tr>
<tr>
<td>2.D.1 Lubricant use</td>
<td>In the previous report, aggregate data for lubricant and paraffin wax have been used for CO2 emission calculation. In this report, activity data for lubricant use have been separated by data for paraffin wax use that is in line with 2006 IPCC Guidelines. Accordingly, recalculation were performed for entire period 1990 - 2014.</td>
<td>4.5.1.5.</td>
<td></td>
</tr>
<tr>
<td>2.D.2 Paraffin wax use</td>
<td>In the previous report, aggregate data for lubricant and paraffin wax have been used for CO2 emission calculation. In this report, activity data for paraffin wax use have been separated by data for lubricant use that is in line with 2006 IPCC Guidelines. Accordingly, recalculation were performed for entire period 1990 - 2014.</td>
<td>4.5.2.5.</td>
<td></td>
</tr>
<tr>
<td>2.D.3 Other, Urea based CC</td>
<td>New data for 2014 have been included. Accordingly, recalculation were performed for the year 2014.</td>
<td>4.5.3.5.</td>
<td></td>
</tr>
<tr>
<td>2.F.1.d Transport refrigeration</td>
<td>In the previous report, for category 2F1d Transport refrigeration all trucks were taken as the basis for estimating the emissions, and not only those equipped with refrigeration equipment which caused overestimation of emissions. According to the technical correction calculated by the TERT during ESD review, roughly assessment of the share of refrigerated transport in the total</td>
<td>4.7.1.5.</td>
<td></td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>Error detected by Expert</td>
<td>Chapter/section in the NIR</td>
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<td></td>
<td>number of trucks (20%) are included in the revised estimates. Accordingly, recalculation were performed for entire period 1995 – 2014.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.G.1 Electrical equipment</td>
<td>New data on total charge of SFs and leakage and maintenance loses for the period 2012 - 2014 were provided. Accordingly, recalculation were performed for the period 2012 - 2014.</td>
<td></td>
<td>4.8.1.5.</td>
</tr>
<tr>
<td>2.G.3 N₂O from product uses, 2.G.3.a Medical applications</td>
<td>New data for quantity of N₂O used for anaesthesia for 2014 were provided. Accordingly, recalculation were performed for the year 2014.</td>
<td></td>
<td>4.8.3.5.</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Emissions were recalculated for the year 2014 for dairy and mature non-dairy cattle categories due to a correction of error in calculation. In addition, emissions were recalculated for the entire 1990-2014 period due to implementation of rounding of activity data following NAPA to AAP animal number conversion and extrapolation procedures. This resulted in a insignificant change of emission for dairy cattle and market pigs.</td>
<td></td>
<td>Chapter 5.2. Enteric fermentation - domestic livestock, 5.2.5 - recalculation s</td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>Chapter/section in the NIR</td>
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<tr>
<td>3.B.1</td>
<td>Following the review of the NIR 2015, TERT has determined that CH₄ emission factors from IPCC 2000 GPG were used for the emission calculation apparently and that a technical correction for CH₄ emission from MMS for all animal categories is necessary. Recalculation of estimates have been performed based on default values and average VS excretion rates from the 2006 IPCC Guidelines for all animal categories and all years.</td>
<td>Chapter 5.3. Manure management, 5.3.1- Manure management – CH₄ emissions, 5.3.1.5-recalculation</td>
<td></td>
</tr>
<tr>
<td>3.B.2</td>
<td>Emissions were recalculated for the entire 1990-2014 period due to implementation of rounding of activity data following NAPA to AAP animal number conversion and extrapolation procedures. This resulted in a insignificant change of emission for dairy cattle and market pigs.</td>
<td>Chapter 5.3. Manure management, 5.3.2- Manure management – N₂O emissions, 5.3.2.6 - recalculation</td>
<td></td>
</tr>
<tr>
<td>3.D.1</td>
<td>Due to replacement of FAO activity data on harvested area of crops with national sources (CBS) and updating the AD on crop yield with new CBS values, emissions were recalculated for the entire 1990-2014 period.</td>
<td>Chapter 5.5. Agricultural solis, 5.5.1- Direct N₂O Emission from Managed Soils, 5.5.1.5-</td>
<td></td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>Chapter/section in the NIR</td>
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<tr>
<td><strong>UNFCCC</strong></td>
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<td><strong>ESD</strong></td>
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<tr>
<td>Error detected by Expert</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>recalculation s</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>3.D.1</strong></td>
<td>Double counting of Pasture range and paddock emission (FPRP value was also included in FON) in the estimate of ( \text{N}_2\text{O} ) emissions from Agricultural soils. The TERT checked and verified the source of the discrepancy. It has been assumed that this is the origin of the error noted for all years of the time series, so as a part of the provided technical correction this ( \text{N}_2\text{O} ) emissions from 3.D.2.a animal manure applied to soils was recalculated for all years.</td>
<td>Chapter 5.5. Agricultural soils, 5.5.1- Direct ( \text{N}_2\text{O} ) Emission from Managed Soils, 5.5.1.5- recalculation s</td>
<td></td>
</tr>
<tr>
<td><strong>4 (V) Biomass burning</strong></td>
<td>The ERT recommends that Croatia estimate and report CO2 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.</td>
<td>6.15.1</td>
<td></td>
</tr>
<tr>
<td><strong>4 (IV) Indirect ( \text{N}_2\text{O} ) emissions from managed soils</strong></td>
<td>The ERT recommends that Croatia estimate indirect ( \text{N}_2\text{O} ) 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</td>
<td>6.14.</td>
<td></td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>Chapter/section in the NIR</td>
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</tr>
<tr>
<td><strong>Waste</strong></td>
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<td></td>
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</tr>
<tr>
<td>5.A.1 Managed waste disposal sites, 5.A.1.a Anaerobic</td>
<td>New data for amount of CH₄ flared have been provided for the period 2011 – 2014. Accordingly, recalculation were performed for the period 2011 - 2014.</td>
<td>7.2.5.</td>
<td></td>
</tr>
<tr>
<td>5.B.2 Anaerobic digestion at biogas facilities</td>
<td>In the previous report, emissions from anaerobic digestion of organic waste at biogas facilities are included in this category for 2013 and 2014. For the period 1990 – 2012 was defined that data are not available. In this report, emissions from anaerobic digestion of organic waste at biogas facilities are included in the Energy sector, because methane is used for electricity generation. Correct notation keys have been included in the CRF for entire period in which electricity was generated (2009 – 2015). Accordingly, recalculation were performed for 2013 and 2014 and notation key have been corrected.</td>
<td>7.3.5.</td>
<td></td>
</tr>
<tr>
<td>5.C.1 Waste incineration, 5.C.1.2.b Other, Clinical waste</td>
<td>Activity data for incineration of clinical waste has been corrected for 2014. Accordingly, recalculation of CO₂ emission were performed for 2014.</td>
<td>7.4.5.</td>
<td></td>
</tr>
</tbody>
</table>

Footnotes (2), (4), and guidance provided in 2006 IPCC guidelines.
<table>
<thead>
<tr>
<th>CRF category / issue</th>
<th>Review recommendation</th>
<th>Chapter/section in the NIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>5D Wastewater treatment and discharge, CH4, 2014</td>
<td>For category 5D Wastewater treatment and discharge, CH4 emissions for the years 2005-2014, the TERT noted that the methane emissions from septic tanks are relatively low. In response to a question raised during the review, Croatia explained that 70% of the waste water treated in septic tanks is returned to the drainage system (overflows) and does not add to methane generation. The TERT partly agreed with the explanation provided by Croatia, because of the lack of guidance for methane generation from overflows in the 2006 IPCC Guidelines. The TERT recommends that Croatia provide an improved justification of this assumption in its next submission.</td>
<td>7.5.2.</td>
</tr>
<tr>
<td><strong>KP-LULUCF</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KP-LULUCF</td>
<td>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.</td>
<td>6.15.1</td>
</tr>
<tr>
<td>KP-LULUCF</td>
<td>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</td>
<td>11.3.1.3</td>
</tr>
<tr>
<td>CRF category / issue</td>
<td>Review recommendation</td>
<td>Chapter/section in the NIR</td>
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<tr>
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<td>UNFCCC</td>
<td>ESD</td>
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<tr>
<td>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.</td>
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</tbody>
</table>
Table 10.4-3: Indication on timeline of implementation

**Sector-specific planned improvements**

**Energy**

<table>
<thead>
<tr>
<th>Category</th>
<th>Recommendation</th>
<th>NIR 2017</th>
<th>NIR 2018</th>
<th>Long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector overview</td>
<td>Take steps to ensure consistency of AD in the areas of fuel use in manufacturing industries and construction and in the type of AD used for the estimation of CO2 emissions from gas transmission</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Comparison of the reference approach with the sectoral approach and international statistic</td>
<td>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</td>
<td></td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>International bunker fuels</td>
<td>Provide a detailed explanation of the factors contributing to decreases in bunker fuel consumption and associated CO2 emissions</td>
<td></td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Stationary combustion</td>
<td>Harmonization of data on fuel consumption from the National Energy Balance, and data from the emissions trading scheme</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td></td>
<td>Take steps to obtain and use plant-specific CO2 EFs to improve accuracy of the emission estimates</td>
<td></td>
<td></td>
<td>●</td>
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<tr>
<td></td>
<td>Development of Industry analysis balance for the period from 1990 to 2000</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Road transportation:</td>
<td>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</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Category</td>
<td>Recommendation</td>
<td>NIR 2017</td>
<td>NIR 2018</td>
<td>Long-term</td>
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</tr>
<tr>
<td>liquid and gaseous fuels – CO₂</td>
<td>producers/suppliers and with experts from other EU countries to derive future country specific EFs for future submissions.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.A.3.a Domestic aviation</td>
<td>provide a description of the methodology used to determine the fuel consumption on domestic and international aviation in the NIR</td>
<td></td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Coal mining and handling: solid fuels – CH₄</td>
<td>Use the actual coal production figures for estimating emissions</td>
<td></td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Other (mobile): liquid fuels – CO₂, CH₄ and N₂O</td>
<td>Indicate in the NIR the category under which military fuel use has been included</td>
<td></td>
<td>•</td>
<td></td>
</tr>
</tbody>
</table>

**Industrial Processes and Product Use**

<table>
<thead>
<tr>
<th>Category</th>
<th>Recommendation</th>
<th>NIR 2017</th>
<th>NIR 2018</th>
<th>Long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.A.4 Other Process Uses of Carbonates</td>
<td>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. It should be noted that this allocation by categories do not influence on the emissions for entire reporting period for 2.A.4.</td>
<td></td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>2.B.8 Petrochemical and carbon black production – CO₂</td>
<td>Use a higher tier to calculate emissions for this category.</td>
<td></td>
<td></td>
<td>•</td>
</tr>
<tr>
<td>2.C.2 Ferroalloys production – CO₂</td>
<td>Increase the transparency and accuracy - comparison the estimates of Tier 1 and Tier 2.</td>
<td></td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>2.D Non-energy products from fuels and solvents use – CO₂</td>
<td>Collect the necessary activity data in order to separate lubricants from paraffin wax.</td>
<td></td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Recommendation</td>
<td>NIR 2017</td>
<td>NIR 2018</td>
<td>Long-term</td>
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<td>--------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>2.D Non-energy products from fuels and solvents use – CO₂</td>
<td>Trend analysis of separated data for lubricants and paraffin wax.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>2.D Non-energy products from fuels and solvents use – CO₂</td>
<td>Investigation and collection more detailed information about use of paraffin wax.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>2.C.3 Aluminium production – CO₂, PFC</td>
<td>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.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>2.F. Product uses as substitutes for ozone depleting substances – PFCs, HFCs</td>
<td>Continue conducting surveys on the status of disposal of refrigeration and air-conditioning equipment</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>2.F.1 Refrigeration and air conditioning equipment</td>
<td>Refrigeration and air conditioning equipment containing &lt;3 kg of refrigerants, such as for example residential air conditioners, should be included in the estimated emissions.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>2.F.1.d Transport refrigeration – HFC 134a</td>
<td>Increase the accuracy of emission estimation - assessment of the share of refrigerated transport in the total number of trucks.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>2.F.1.d Transport refrigeration</td>
<td>Investigation the actual share of trucks with refrigeration equipment.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>2.F.1.e Mobile air-conditioning</td>
<td>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.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>2.F.2 Foam blowing agents – HFC 152-a</td>
<td>Research the type of foam application used to verify if the foam cell application is of open cell or closed cell application.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
</tbody>
</table>
### Agriculture

<table>
<thead>
<tr>
<th>Category</th>
<th>Recommendation</th>
<th>NIR 2017</th>
<th>NIR 2018</th>
<th>Long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector overview</td>
<td>Provide detailed explanations in the NIR on the data sources and recalculation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sector overview</td>
<td>Continue its efforts to improve country-specific EFs to estimate CH4 emissions from enteric fermentation and CH4 and N2O emissions from manure management.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Sector overview</td>
<td>Improve the agricultural information provided in the inventory and explain the national conditions more thoroughly in the NIR.</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Sector overview</td>
<td>Continued investigation of activity data (livestock population) with the purpose of gathering more detailed activity data.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Manure management</td>
<td>Revision of the methodology and development of updated national emission factors for the CH4 emission estimate.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Agricultural soils</td>
<td>Improving emission calculation from agricultural soils due to mineral fertilizers.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Waste

<table>
<thead>
<tr>
<th>Category</th>
<th>Recommendation</th>
<th>NIR 2017</th>
<th>NIR 2018</th>
<th>Long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste, 5.A Solid</td>
<td>Clarification on the practices adopted for the disposal of construction and demolition solid waste material.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>waste disposal on land</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste, 5.A Solid</td>
<td>Clarification on the procedures associated to solid waste separation process regarding the Croatian policy for waste prevention and management.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>waste disposal on land – CH4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste, 5.A Solid</td>
<td>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.</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>waste disposal on land</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Waste, 5.A Solid waste disposal on land – CH₄
- Clarification of the particular instable trend of solid waste disposal on site by types of SWDSs.
- Harmonization of data for DOC for the period 1995 – 2014 with the data for 2015.
- 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.B.2 Anaerobic digestion at biogas facilities
- Including of emissions from anaerobic digestion of organic waste at biogas facilities in the Energy sector, because methane is used for electricity generation.

### 5.C.1 Waste incineration – CO₂, CH₄, N₂O
- Identify the technologies applied in the incineration of hazardous waste and more detailed information on and N₂O emission calculation.

### LULUCF

<table>
<thead>
<tr>
<th>Category</th>
<th>Recommendation</th>
<th>NIR 2016</th>
<th>NIR 2017</th>
<th>Long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector overview</td>
<td>Adequately explain recalculation to improve transparency in the sector</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sector overview</td>
<td>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</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest land remaining</td>
<td>Make significant efforts to use the results of CRONFI to improve the LULUCF sector inventory</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest land</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest land – CO₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land converted to forest</td>
<td>Make significant efforts to use the results of CRONFI to improve the LULUCF sector inventory</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land converted to forest</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Land converted to forest</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Land converted to forest</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

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<table>
<thead>
<tr>
<th>Category</th>
<th>Recommendation</th>
<th>NIR 2016</th>
<th>NIR 2017</th>
<th>Long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land converted to forest land – CO₂</td>
<td>Report the correct notation key in the CRF tables</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Cropland remaining cropland – CO₂</td>
<td>Implement the tier 2 approach to perennial cropland remaining perennial cropland</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Land converted to cropland – CO₂</td>
<td>Improve the cropland biomass estimates to enable it to implement a tier 2 method for estimating cropland biomass in this category</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Land converted to cropland – CO₂</td>
<td>Work towards using a higher tier method for reporting estimates for DOM in this category</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Land converted to grassland – CO₂</td>
<td>Improve cropland biomass estimates to enable the implementation of a tier 2 method for estimating cropland biomass in this category</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Settlements – CO₂</td>
<td>Improve cropland biomass estimates to enable the implementation of a tier 2 method for estimating cropland biomass in this category</td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
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 Nature Protection undertakes different activities in order to streamline and strengthen flow of data and information relevant for accounting of LULUCF activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol.

This 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>
<thead>
<tr>
<th>UNFCCC Land Use Category</th>
<th>UNFCCC Subcategories</th>
<th>KP Activities</th>
<th>KP Article</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest land</td>
<td>Land converted to Forest land</td>
<td>Aforestation</td>
<td></td>
</tr>
<tr>
<td>Cropland</td>
<td>Land converted to Cropland</td>
<td>Forest land converted to perennial Cropland</td>
<td>Deforestation</td>
</tr>
<tr>
<td>Settlements</td>
<td>Land converted to Settlements</td>
<td>Forest land converted to Settlements</td>
<td></td>
</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Selected value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum land area</td>
<td>0.05 - 1 ha</td>
<td>0.1 ha</td>
</tr>
<tr>
<td>Minimum crown cover</td>
<td>10 - 30 %</td>
<td>10 %</td>
</tr>
<tr>
<td>Minimum tree height</td>
<td>2 - 5 m</td>
<td>2 m</td>
</tr>
</tbody>
</table>

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\(^{55}\) (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.

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\(^{55}\) Forest Act (OG 140/05, 82/06, 129/08, 80/10, 124/10, 25/12, 68/12, 148/13, 94/14)
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 is equal to 0.265 Mt C (0.972 Mt CO\textsubscript{2}) per year, or to 1.325 Mt C (4.858 Mt CO\textsubscript{2}) for the whole commitment period. For the second commitment period Forest management reference level defined for Croatia is -6.289 MtCO\textsubscript{2eq}/year.

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 was collected for the entire period from 1990–2015 based on definitions presented further in this subchapter. Applied definitions are as follows.

11.1.3.1 Definition and identification of Afforestation/Reforestation areas since 1990.

Following request given by the ERT in ARR 2012 to trace and identify all lands under the Article 3.3 and Article 3.4 of the KP, Croatia conducted special survey under the framework of project “Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol” (abbreviated LULUCF 1).

In the part of survey that concerns identification and traceability of areas that were subject of afforestation, by the survey both types of afforestation as defined by IPCC 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.

Pursuant to Article 27 of the Ordinance on forest management\textsuperscript{56}, 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.

\textsuperscript{56} Ordinance on forest management (OG 79/15)
Forest regeneration is a part of the Forest Management plans/programs (FMAPs) and thus afforestation done by seeding and planting is clearly human induced.

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 1990-2015 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.
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.
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.

Afforestation 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)
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*\(^{57}\), 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\(^{58}\). 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\(^{59}\) as one of outcomes of the LULUCF 1 project. The same procedure was applied for identification of these areas in years 2013, 2014 and 2015.

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\(^{57}\) Ibid
\(^{58}\) OG 12/2008, Article 1.
\(^{59}\) 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
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
- digital ortho-photo
- digital cadastral maps

In order to avoid situation that some of deforested areas are not identified because they were not subject of permitting (i.e. due to War disturbance), additional checking was performed on fields on a level of single management unit. Identified deforested areas not covered by permitting had to be officially mapped and registered for the purposes of this reporting.

An example on identified deforested area presented in different maps is shown in Figures 11.1.-13.
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.

Results of work performed on complete forest management area are presented in Table 11.1-3 and Figure 11.1-14.

Table 11.1-3: Area deforested in Croatia in period 1990-2015 (ha/year)

<table>
<thead>
<tr>
<th>Year</th>
<th>Deciduous</th>
<th>Coniferous</th>
<th>Maquies and shrub</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1991</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1992</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1993</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1994</td>
<td>23.79</td>
<td>34.56</td>
<td>0.96</td>
<td>59.31</td>
</tr>
<tr>
<td>1995</td>
<td>0.00</td>
<td>3.01</td>
<td>0.00</td>
<td>3.01</td>
</tr>
<tr>
<td>1996</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1997</td>
<td>3.68</td>
<td>8.02</td>
<td>66.80</td>
<td>78.50</td>
</tr>
<tr>
<td>1998</td>
<td>55.84</td>
<td>48.92</td>
<td>0.00</td>
<td>104.76</td>
</tr>
<tr>
<td>1999</td>
<td>27.56</td>
<td>0.48</td>
<td>4.39</td>
<td>32.43</td>
</tr>
<tr>
<td>2000</td>
<td>143.60</td>
<td>23.22</td>
<td>1.43</td>
<td>168.25</td>
</tr>
<tr>
<td>2001</td>
<td>50.65</td>
<td>28.44</td>
<td>275.24</td>
<td>354.33</td>
</tr>
<tr>
<td>2002</td>
<td>85.42</td>
<td>109.16</td>
<td>32.90</td>
<td>227.48</td>
</tr>
<tr>
<td>2003</td>
<td>46.50</td>
<td>19.08</td>
<td>29.89</td>
<td>95.47</td>
</tr>
<tr>
<td>2004</td>
<td>136.89</td>
<td>52.02</td>
<td>158.63</td>
<td>347.54</td>
</tr>
<tr>
<td>2005</td>
<td>106.17</td>
<td>37.50</td>
<td>221.13</td>
<td>364.80</td>
</tr>
<tr>
<td>2006</td>
<td>51.24</td>
<td>17.59</td>
<td>283.43</td>
<td>352.26</td>
</tr>
<tr>
<td>2007</td>
<td>56.38</td>
<td>39.21</td>
<td>129.56</td>
<td>225.15</td>
</tr>
<tr>
<td>2008</td>
<td>122.57</td>
<td>69.80</td>
<td>217.18</td>
<td>409.55</td>
</tr>
<tr>
<td>2009</td>
<td>92.52</td>
<td>18.77</td>
<td>494.68</td>
<td>605.97</td>
</tr>
<tr>
<td>2010</td>
<td>69.00</td>
<td>57.12</td>
<td>223.25</td>
<td>349.37</td>
</tr>
<tr>
<td>2011</td>
<td>18.37</td>
<td>19.03</td>
<td>154.14</td>
<td>191.54</td>
</tr>
<tr>
<td>2012</td>
<td>49.54</td>
<td>94.32</td>
<td>101.01</td>
<td>244.87</td>
</tr>
<tr>
<td>2013</td>
<td>79.12</td>
<td>3.39</td>
<td>84.08</td>
<td>166.59</td>
</tr>
<tr>
<td>2014</td>
<td>17.14</td>
<td>0.81</td>
<td>26.57</td>
<td>44.52</td>
</tr>
<tr>
<td>2015</td>
<td>128.80</td>
<td>8.02</td>
<td>104.23</td>
<td>241.05</td>
</tr>
<tr>
<td>Total</td>
<td>1,364.78</td>
<td>692.47</td>
<td>2,609.50</td>
<td>4,666.75</td>
</tr>
</tbody>
</table>
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 Guidelines. 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 1990-2015 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\textsuperscript{60} 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.

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.).

\textsuperscript{60} The Regulation on amendments to the Law on Forests (OG 14/93, Article 18) and Law on amendments to the Law on Forests (OG 76/93, Article 22)
11.2.2 Methodology used to develop the land transition matrix

Activity matrices are presented for 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) 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 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 and forests are presented. Out of yield (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. 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 1996. Forest Administrations consist of Forest offices, currently of 169 altogether. 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 afforestation in Croatia has been done strictly on land under

61 OG 111/06, OG 141/08,
62 Ordinance on Forest Management (OG 111/06 ( Article 63), OG 141/08)
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 regulation63 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 and 2015.

Table 11.2-1: Land transition matrix for year 2008, kha

<table>
<thead>
<tr>
<th>Article 3.3 activities</th>
<th>Article 3.4 activities</th>
<th>Other</th>
<th>TOTAL 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/R</td>
<td>D</td>
<td>FM</td>
<td>CM</td>
</tr>
<tr>
<td>Article 3.3 activities</td>
<td>13.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>2.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Article FM</td>
<td>0.41</td>
<td>2,312.90</td>
<td></td>
</tr>
</tbody>
</table>

63 The Regulation on amendments to the Law on Forests (OG 14/93, Article 18) and Law on amendments to the Law on Forests (OG 76/93, Article 22)
Table 11.2-2: Land transition matrix for year 2009, kha

<table>
<thead>
<tr>
<th>Article 3.3 activities</th>
<th>Article 3.4 activities</th>
<th>Other (end of 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/R</td>
<td>D 2.82</td>
<td>3,327.99</td>
</tr>
<tr>
<td>D</td>
<td>2.82</td>
<td>3,329.82</td>
</tr>
<tr>
<td>FM</td>
<td>0.61 2,312.30</td>
<td>2,312.30</td>
</tr>
<tr>
<td>CM</td>
<td>NA NA NA NA NA NA NA</td>
<td>NA</td>
</tr>
<tr>
<td>GM</td>
<td>NA NA NA NA NA NA NA</td>
<td>NA</td>
</tr>
<tr>
<td>RV</td>
<td>NA NA NA NA NA NA NA</td>
<td>NA</td>
</tr>
<tr>
<td>Other</td>
<td>1.83 0.00 0.00 0.00 0.00 3,327.99</td>
<td>3,329.82</td>
</tr>
<tr>
<td>TOTAL (end of 2008)</td>
<td>15.69 2.82 2,312.90 0.00 0.00 0.00 3,327.99</td>
<td>5,659.40</td>
</tr>
</tbody>
</table>

Table 11.2-3: Land transition matrix for year 2010, kha

<table>
<thead>
<tr>
<th>Article 3.3 activities</th>
<th>Article 3.4 activities</th>
<th>Other (end of 2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/R</td>
<td>D 3.43</td>
<td>3,318.73</td>
</tr>
<tr>
<td>D</td>
<td>3.43</td>
<td>3,325.54</td>
</tr>
<tr>
<td>FM</td>
<td>0.35 2,311.95</td>
<td>2,312.30</td>
</tr>
<tr>
<td>CM</td>
<td>NA NA NA NA NA NA NA</td>
<td>NA</td>
</tr>
<tr>
<td>GM</td>
<td>NA NA NA NA NA NA NA</td>
<td>NA</td>
</tr>
<tr>
<td>RV</td>
<td>NA NA NA NA NA NA NA</td>
<td>NA</td>
</tr>
<tr>
<td>Other</td>
<td>4.81 0.00 0.00 0.00 0.00 3,318.73</td>
<td>3,325.54</td>
</tr>
<tr>
<td>TOTAL (end of 2010)</td>
<td>24.94 3.78 2,311.95 0.00 0.00 0.00 3,318.73</td>
<td>5,659.40</td>
</tr>
</tbody>
</table>

Table 11.2-4: Land transition matrix for year 2011, kha
<table>
<thead>
<tr>
<th>Article 3.3 activities</th>
<th>Article 3.4 activities</th>
<th>Other</th>
<th>TOTAL 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/R 24.94</td>
<td>D 3.78</td>
<td></td>
<td>24.94</td>
</tr>
<tr>
<td>FM 0.19</td>
<td>2,311.76</td>
<td></td>
<td>2,311.76</td>
</tr>
<tr>
<td>CM NA</td>
<td>NA NA NA</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>GM NA</td>
<td>NA NA NA</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>RV NA</td>
<td>NA NA NA</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Other 6.04</td>
<td>0.00 0.00 0.00 0.00 0.00</td>
<td>3,312.68</td>
<td>3,318.73</td>
</tr>
<tr>
<td>TOTAL (end of 2011)</td>
<td>30.99 3.97 2,311.76 0.00 0.00 0.00</td>
<td>3,312.68</td>
<td>5,659.40</td>
</tr>
</tbody>
</table>

Table 11.2-5: Land transition matrix for year 2012, kha

<table>
<thead>
<tr>
<th>Article 3.3 activities</th>
<th>Article 3.4 activities</th>
<th>Other</th>
<th>TOTAL 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/R 30.99</td>
<td>D 3.97</td>
<td></td>
<td>30.99</td>
</tr>
<tr>
<td>FM 0.24</td>
<td>2,311.51</td>
<td></td>
<td>2,311.76</td>
</tr>
<tr>
<td>CM NA</td>
<td>NA NA NA</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>GM NA</td>
<td>NA NA NA</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>RV NA</td>
<td>NA NA NA</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Other 5.03</td>
<td>0.00 0.00 0.00 0.00 0.00</td>
<td>3,307.66</td>
<td>3,312.68</td>
</tr>
<tr>
<td>TOTAL (end of 2012)</td>
<td>36.02 4.21 2,311.51 0.00 0.00 0.00</td>
<td>3,307.66</td>
<td>5,659.40</td>
</tr>
</tbody>
</table>

Table 11.2-6: Land transition matrix for year 2013, kha

<table>
<thead>
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<th>Article 3.3 activities</th>
<th>Article 3.4 activities</th>
<th>Other</th>
<th>TOTAL 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/R 36.02</td>
<td>D 4.21</td>
<td></td>
<td>36.02</td>
</tr>
<tr>
<td>FM 0.17</td>
<td>2,311.35</td>
<td></td>
<td>2,311.51</td>
</tr>
<tr>
<td>CM NA</td>
<td>NA NA NA</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>GM NA</td>
<td>NA NA NA</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>RV NA</td>
<td>NA NA NA</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Other</td>
<td>7.14</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>TOTAL (end of 2013)</td>
<td>43.16</td>
<td>4.38</td>
<td>2,311.35</td>
</tr>
</tbody>
</table>

Table 11.2-7: Land transition matrix for year 2014, kha

<table>
<thead>
<tr>
<th>Article 3.3 activities</th>
<th>Article 3.4 activities</th>
<th>Other</th>
<th>TOTAL 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/R</td>
<td>D</td>
<td>FM</td>
<td>CM</td>
</tr>
<tr>
<td>Article 3.3 activities</td>
<td>FM</td>
<td>0.04</td>
<td>2,311.30</td>
</tr>
<tr>
<td>Article 3.4 activities</td>
<td>CM</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Article 3.4 activities</td>
<td>GM</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Article 3.4 activities</td>
<td>RV</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Other</td>
<td>8.35</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>TOTAL (end of 2014)</td>
<td>51.51</td>
<td>4.43</td>
<td>2,311.30</td>
</tr>
</tbody>
</table>

Table 11.2-8: Land transition matrix for year 2015, kha

<table>
<thead>
<tr>
<th>Article 3.3 activities</th>
<th>Article 3.4 activities</th>
<th>Other</th>
<th>TOTAL 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/R</td>
<td>D</td>
<td>FM</td>
<td>CM</td>
</tr>
<tr>
<td>Article 3.3 activities</td>
<td>FM</td>
<td>0.24</td>
<td>2,311.06</td>
</tr>
<tr>
<td>Article 3.4 activities</td>
<td>CM</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Article 3.4 activities</td>
<td>GM</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Article 3.4 activities</td>
<td>RV</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Other</td>
<td>7.57</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL (end of 2015)</td>
<td>59.07</td>
<td>4.67</td>
<td>2,311.06</td>
</tr>
</tbody>
</table>
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 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 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

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64 Ordinance on Forest Management (OG 111/06 and 141/08)
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 project “Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol” (abbreviated LULUCF 1) Croatia managed to identify and trace lands that should be reported under paragraphs 3.3 and 3.4 of the Kyoto Protocol (see points 11.1.3.1-11.1.3.3 of the report). The survey was conducted on 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 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 during the analyse forest management plans and programs valid in previous periods and making field checks in forms of site visits on a level of forest sub-compartment when it was needed.

All identified areas 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

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65 Janeš et al. Separation of areas under the Article 3.3 and 3.4 of the Kyoto Protocol
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.

Figure 11.2-1: A map of one forest district in Croatia presenting areas that are afforested in period 1990-2010 (marked green) and areas that are foreseen for the afforestation in period 2011-2020 (marked yellow)
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 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) 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. For the reporting the CO₂ emissions due to forest fires on Forest management area in CRF database notation key IE was used since wood affected by fires has been removed from forests and included in total biomass harvested while N₂O and CH₄ emissions are reported in CRF tables.

Detailed description of method used for estimation has been described in Chapter 6.15.2.
CO₂ 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 in case of 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>
<thead>
<tr>
<th>Forest type</th>
<th>Age class</th>
<th>Annual increment in biomass (TOTAL)</th>
<th>Annual increment in biomass (AGB)</th>
<th>Annual increment in biomass (BGB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coniferous</td>
<td>&lt;20</td>
<td>2.14</td>
<td>1.53</td>
<td>0.6120</td>
</tr>
<tr>
<td></td>
<td>&gt;20</td>
<td>1.97</td>
<td>1.53</td>
<td>0.4437</td>
</tr>
<tr>
<td>Other Broadleaves</td>
<td>&lt;20</td>
<td>2.80</td>
<td>1.92</td>
<td>0.8832</td>
</tr>
<tr>
<td></td>
<td>&gt;20</td>
<td>2.80</td>
<td>1.92</td>
<td>0.8832</td>
</tr>
<tr>
<td>Out of yield (maquies and shrub)</td>
<td>NS</td>
<td>0.34</td>
<td>1.15</td>
<td>0.1081</td>
</tr>
</tbody>
</table>
The value of 107 m³/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 m³/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 1990-2015 by forest type and wood densities and also IPCC values (IPCC 2006 Guidelines) as presented in Table 11.3-2.

<table>
<thead>
<tr>
<th>Forest type</th>
<th>Average harvested volume (m³/ha)</th>
<th>Wood density (t.d.m./m³)</th>
<th>BEF 2</th>
<th>R/S</th>
<th>CF ( tC/t d.m)^-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciduous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coniferous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out of yield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(maqies and shrub)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 Guidelines’ 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 2008-2015 harvesting rates were as presented in below Table 11.3-3.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciduous</td>
<td>114.45</td>
<td>42.38</td>
<td>180.28</td>
<td>182.80</td>
<td>180.74</td>
<td>181.37</td>
<td>242.24</td>
<td>143.62</td>
</tr>
<tr>
<td>Coniferous</td>
<td>123.04</td>
<td>48.43</td>
<td>20.22</td>
<td>14.08</td>
<td>12.12</td>
<td>356.34</td>
<td>211.11</td>
<td>103.89</td>
</tr>
</tbody>
</table>

Values of carbon stock in total biomass (AGB+BGB) are determined based on nationally determined average values for deforested volume in period 1990-2015 by each forest type as follows:

1. 56.1 tC/ha for deciduous forests
2. 28.1 tC/ha for coniferous forests
3. 7.6 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 “Improving Croatian Reporting in the Land use, Land use change and Forestry Sector in the First Commitment Period of the Kyoto
Protocol” (abbreviated: LULUCF 1) suggest that deforestation happens in Mediterranean (on 50.3% of all deforested areas with the 26.6 m³/ha average volume deforested) and continental part of Croatia (on 49.7% of all deforested areas with the 180.1 m³/ha average volume deforested). Most of harvested coniferous species 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. 2.10 t 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

It should be noted that the C stock of the litter in accounted in the overall C stocks of soil on the forest land according to the national scientific (complete organic humus layer (O1, Oř, Oh)). Therefore, the changes of the C stocks of the litter layer at ARD lands are included in the C stock changes of the soil pool and IE is reported for the litter pool.


C) Soil

The estimates of the soil carbon stock changes at ARD areas follow the equation below:

\[ \Delta C_{LF_{Mineral}} = \frac{(SOC_{ref} - SOC_{before ARD}) \times AARD}{T_{ARD}} \]

where:

- \( \Delta C_{LF_{Mineral}} \) = annual change in carbon stock in mineral soils for inventory year
- \( SOC_{ref} \) = reference carbon stock
- \( SOC_{before ARD} \) = stable soil organic carbon on previous land use
- \( T_{ARD} \) = duration of the transition from SOC before ARD to SOC_{ref} (20 years)
- \( AARD \) = total AR or D area after conversion still in SOC transition of 20 years

The values of soil carbon stock determined through national scientific investigation were used in order to estimate the carbon stock changes in soil due to afforestation activity. Conversion that happens in the Croatian case refers to grassland and perennial cropland converted to forestland with following soil C stocks:

- Grassland: 70.6 tC/ha
- Forestland: 84.5 tC/ha
- Annual Cropland: 46.4 tC/ha
- perennial Cropland: 77.8 tC/ha

Soil removal factors determined in this cases were 0.695 tC/ha, 0.191 tC/ha and 0.336 tC/ha annually.

The values of soil carbon stock determined through national scientific investigation were used in order to estimate the carbon stock changes in soil due to conversion Forest land to perennial Cropland. Soil C stocks are:

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

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

For determination of soil carbon stock changes due to deforestation activity to settlement, the used values for soil carbon stocks are presented below, and emission factor was calculated to be -4.1 tC/ha annually:
• Settlements: 2.5 tC/ha
• Forestland: 84.5 tC/ha

Detailed description of the methodologies and the underlying assumptions used are presented in Chapters 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, CO₂ emissions/removals in period 2008 – 2015 were estimated using the per ha values for increment and harvest for all types of forest ownerships. Comparing to the last year submission, estimation for NIR 2016 has been performed using the per ha values for increment and harvest that corresponds to all forest areas using the new parameters defined in 2006 IPCC Guidelines (i.e. new value for CF). Additionally, Croatia performed estimation for maquies and shrub forests for this submission.

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 Ordinance on Forest management

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66 Ordinance on Forest management

CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE
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\textsuperscript{67}, 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\textsubscript{2}O 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\textsubscript{2}O emissions from drainage of soils

Drainage of soils does not occur in Croatia.

Table 5(KP-II)3. N\textsubscript{2}O emissions from disturbance associated with land use conversion to cropland.

The annual release of N\textsubscript{2}O 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:

\[
\text{N}_2\text{O}_{\text{net-min}} - N = \text{EF}_1 \times \Delta C_{\text{C_{mineral}}} \times 1/(C/N \text{ ratio})
\]

where:

\(\text{EF}_1\) = the emission factor for calculating emissions of N\textsubscript{2}O from N in the soil = 0.0125 kg N\textsubscript{2}O-N/kg N (IPCC GPG default value)

\(\Delta C_{\text{C_{mineral}}}\) = 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.

\textit{Controlled biomass burning}

\textsuperscript{67} Forest Act
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.

When determining the carbon stocks in forest soils, it is considered that the whole litter layer is implied when samples were taken for an analysis. This is the conclusion of a group of soil experts based on the fact that soil samples were taken at different time intervals throughout the area of forest soils in Croatia that is geomorphologically very different (lowlands, mountainous and karst area). Therefore, the litter carbon stock changes at ARD lands are included in the reported soil C stock.
changes. This expert judgement is in line with the provisions of new legislative act that prescribes monitoring on agricultural lands\textsuperscript{68}.

Emissions on deforested areas are estimated based on harvest volumes of living and already dead trees (dead wood, being part of the amount of harvested biomass) expanded to tree biomass following the equations in the IPCC. 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 during 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

\textsuperscript{68} Ministry of Agriculture (2014), Ordinance on monitoring of agricultural lands (OG 43/14), Article 14
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\(^{69}\), 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 2006-2015 conversion to high form of forests and reconstruction of maquies and shrub forests is prescribed to be executed on more than 10 000 ha in 10 year period). The main role of these forests is protection, so this is the reason that, according to the national legislation, there is no biomass harvest in maquis and shrub forests, but sporadic measures of planting to convert such forests into higher form of forests.

As one of the measures for 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

\(^{69}\) Ordinance on Forest management (OG 111/06), Article 13
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\(^7\) (i.e. completion of gas pipelines for Dalmatia (Mediterranean region) and supporting measures to the production of electricity that originates from wind farms and solar panels both of which are most suitable for this region), 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\(^7\) 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

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\(^7\) 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

\(^7\) Ibid
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.

\[ b) \quad \text{Omitted pools in subcategories Deciduous and Coniferous forest} \]

\[ b.1) \quad \text{Dead wood} \]

According to the Croatian report for FAO Forest Resources Assessment 2005 (FRA 2005)\(^\text{72}\), carbon stock in this pool for forest land has increased in Croatia within the period 1990-2005:

\[ \begin{array}{|c|c|c|c|}
\hline
\text{FRA 2005} & 1990 & 2000 & 2005 \\
\hline
\text{dead wood / Mt C} & 20.8 & 26 & 27 \\
\hline
\end{array} \]

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 11.3-3) 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.

\[ \begin{array}{|c|c|c|c|c|c|c|c|c|}
\hline
\text{2008} & \text{2009} & \text{2010} & \text{2011} & \text{2012} & \text{2013} & \text{2014} & \text{2015} \\
\hline
\text{Growing stock (m}^3\text{/ha)} & & & & & & & & \\
\hline
\text{Deciduous} & 211.5 & 212.6 & 213.7 & 214.7 & 215.8 & 216.9 & 219.2 & 228.1 \\
\hline
\text{Coniferous} & 247.4 & 249.4 & 251.5 & 253.5 & 255.6 & 257.6 & 260.8 & 250.9 \\
\hline
\end{array} \]

\(^{72}\) FAO, Forest Resources Assessment Croatia 2005 (FRA 2005), [http://www.fao.org/forestry/8405-0ae983caa45ca038755a439ceae4f532e.pdf](http://www.fao.org/forestry/8405-0ae983caa45ca038755a439ceae4f532e.pdf)
Out of yield forests | 50.0* | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0
---|---|---|---|---|---|---|---|---
Harvest (m³/ha)
Deciduous | 2.707 | 2.620 | 2.709 | 3.014 | 3.050 | 3.000 | 3.100 | 3.400
Out of yield forests | NO** | NO | NO | NO | NO | NO | NO | NO
---|---|---|---|---|---|---|---|---
Increment (m³/ha)
Deciduous | 5.604 | 5.576 | 5.549 | 5.522 | 5.495 | 5.500 | 5.500 | 5.6
Coniferous | 5.527 | 5.564 | 5.601 | 5.637 | 5.674 | 5.700 | 5.800 | 5.4
Out of yield forests | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2
---|---|---|---|---|---|---|---|---
FM area (kha)
Deciduous | 1,674.64 | 1,674.55 | 1,674.48 | 1,674.46 | 1,674.41 | 1,674.34 | 1,674.32 | 1,619.55
Coniferous | 199.83 | 199.81 | 199.75 | 199.73 | 199.64 | 199.63 | 199.63 | 207.82
Out of yield forests | 438.43 | 437.94 | 437.71 | 437.56 | 437.46 | 437.38 | 437.35 | 483.69

*According to the expert judgement growing stock ranges between 20 to 50 m³/ha in these forests
**Not occurring (NO)

Also, it should be mentioned that the forest management practice is governed by the strict legal framework which prohibits, for example, 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\(^23\) 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\(^24\) and special audit has to be

\(^{23}\) Croatian Mine Action Centre, [http://www.hcr.hr/hr/minSituac.asp](http://www.hcr.hr/hr/minSituac.asp)

\(^{24}\) OG (140/05,82/06,129/08,80/10,124/10, 25/12, 68/12, 148/13), Article 21
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 2006-2015 (FMAP 2006-2015) was subject of official approval of other relevant institutions in Croatia. Requirements of the Ministry of Environment (Nature Protection Directorate) to ensure that a constant number (3-5 trees/ha) of old and dry, standing and fallen trees, especially trees with hollows are left on logging sites, are incorporated into the FMAP 2006-2015.

Additionally, according to the Article 26 of Forest Act, all forest management plans that need to be developed for forest incorporated in one of areas protected under the Law of Nature Protection (i.e national park), have to be approved by the Ministry of Environment and in order to be in line with the requirements of nature protection. Securing biological diversity through leaving certain number of dead trees on logging sites is one of constant requirement requested by the Ministry of Environment.

Since Forest Act was published in 2005 according to the Article 8, Croatian Forests Ltd. and private forest owners are obliged to manage forests by maintaining and enhancing biological and landscape diversity and promote the protection of forest ecosystems in a way that due attention must be given to other species in the ecosystem that are associated with dry and dead trees through leaving the required number of old dead wood, hollow and decayed trees, in spatial distribution and number which preserves biological biodiversity.
Since 2002 Croatian Forests Ltd disposes with FSC (Forest Stewardship Council) certificate for forest management which proves that forests are managed according to strict environmental, social and economic standards. Since the first certificate was gained, certificate has been renewed on regular basis every 5 years. According to the available information, FSC certificate refers to more than 2.0 million ha of Croatian forests and land under the forest management\textsuperscript{75}.

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\textsuperscript{76}. 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\textsuperscript{77}, 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)\textsuperscript{78} claimed that dead wood pool is not source of emissions in their countries and presented exact data proving this.

b.2) Litter

\textsuperscript{75} Croatian Forests Ltd, \url{http://split.hrzume.hr/index.php/hr/component/content/article/1-latest-news/472-10-godina-fsc-certifikata-u-hrvatskim-umama}

\textsuperscript{76} State Institute for Nature Protection, \url{http://www.dzzp.hr/eng/protected-areas/protected-areas-in-croatia/protected-areas-in-croatia-national-categories-1137.html}

\textsuperscript{77} Law on Nature Protection (OG 80/13), Articles 112 and 113

\textsuperscript{78} UNFCCC, National Inventory Submissions 2013, \url{http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/7383.php}
According to the recent scientific paper, carbon stock in litter pool in penduculate oak forests increases with the forest age and reaches its maximum (10.34 tC/ha) in age of 137 years.

According to the FMAP 2006-2015, penduculate oak forests are spread on the largest area when in the fifth (100 years) and sixth age class (120 years). Since Ordinance on Forest management 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) 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.

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79 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
80 FMAP 2006-2015, table 93, page 293
81 OG (OG 111/06, 141/08), Article 24
82 FMAP 2006-2015, table 72, page 276
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.

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 results of the whole process as described above are:

1. Background level: 1.12 kt CO₂eq
2. Margin: 3.98 kt CO₂eq
3. Background level plus margin: 5.10 kt CO$_{2\text{eq}}$
4. Total number of years with fires: 14
5. Number of excluded years: 8

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).

The emission estimation arising from the listed ND (sub)types are calculated for FM areas using the Gain-Loss method from the IPCC 2006 Guidelines and Tier 2.

In order to perform the emission estimation due to extreme weather events, a proxy was used. Based on the so called salvage logging (refers to volume cut due to natural disturbance which is removed from the site) on FM areas and shares between FM and the ND areas without salvage logging as defined above (for the moment only on areas polluted with mines) wood volumes and t C of biomass on ND areas remaining at site were estimated. For the moment (before the exact data will be available) it was assumed that the emissions due to the extreme weather events happen with the same share (50%) in case of windbreaks and snow-breaks and ice-breaks types of ND.

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 FM areas. The background level and the margin have been determined by applying the IPCC default method.
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 results of the whole process as described above are:

1. Background level: 65.44 kt CO\textsubscript{2}eq.
2. Margin: 121.86 kt CO\textsubscript{2}eq.
3. Background level plus margin: 187.294 kt CO\textsubscript{2}eq.
4. Total number of years: 20
5. Number of excluded years: 5

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 Forest management area under Article 3, paragraph 4 of the KP in respect to: (i) forest fires; (ii) extreme weather events (additionally presented as: 1) windbreaks; 2) snow-breaks and ice-breaks (presented together)).

For the purposes of defining background and margin level for ND provisions in FM and afforestation areas a special project has been initiated in Croatia. Through this project Croatia intends to collect detailed data on natural disturbances type, year of its occurrence and species (deciduous, coniferous, maquies and shrub) affected by it. The data that has been collected refers to areas listed in part iii), 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 is no need for additional check about data on this type of natural disturbance.

After the relevant data will be collected through the project, and using the already existing data on forest fire emissions, Croatia intends to perform 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 will be defined in accordance with footnotes 7 and 9 of annex Decision 2/CMP.7 and the guidance provided by the KP Supplement.

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.

Based on the Croatian forest’s exact data on FM and D areas and corresponding volumes that are harvested, ratio was defined for the determination of volume harvested on deforested areas. Since in cases of deforested areas there is also harvested volume that belongs to maquies and shrub forests also (which is not a case in FM areas), this volume was added to deciduous category of forests. 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.

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)

Recalculation made since last report:

1) ARD and FM areas are reported according to results of conducted survey through LULUCF 1 project. According to the conducted analyses increase of forests area that happened before 1990 were identified under the specific years and shifted and reported as FM area in 1990. In period 1990-2015 it was determined increase of forest area that amounts of 317,038.660 ha in this case. Following requests and recommendations given by the ERT in 2012 regarding the identification and traceability of land, the project designed to resolve these issues was implemented in Croatia in 2014-2015. (“Improving Croatian reporting in Land use, Land use change and Forestry (LULUCF) sector in the First commitment period of the Kyoto Protocol”, project LULUCF 1). Through this project Croatia applied Approach 3 in identification of lands that are subject to
afforestation and deforestation activities (reforestation does not occur in Croatia). This approach continued to be applied for the identification of AD lands and reporting of emissions/removals under the Article 3.3. of the Kyoto protocol after the project ended. Detailed information about applied approach is presented in NIR 2016, Chapters 11.1.3.1 and 11.1.3.2.

By this approach, Croatia secured that all lands that are coming from and to forest land are well identified and known.

Regarding the identification of areas that belong to the category Forest land remaining forest land Croatia uses data and information that are coming from different types of forest management plans and that are presented in Forest Management Area Plans for the Republic of Croatia (FMAPs). Areas presented in these documents are identified using the different methods (NIR 2016, Chapter 6.3) depending on the type of forest ownership. The area of state forests are determined based on all available cadastral maps in various scales while the area of the private owned forest was defined using the: a) ortophoto (scale 1:5,000) b) satellite images (scale 1: 1,000,000) c) CORINE LAND COVER data. FMAPs and other forest plans and programs are valid for the period of 10 years, and after that new plans/programs need to be created. In addition, the development of forest programs for the management of private forests (for some of forest areas, these programs will be defined for the first time) is ongoing process in Croatia. Since the NIR 2015 and NIR 2016, some of the management plans and programs ceased to be valid and new plans/programs were developed. When developing new plans a due attention has to be given to the identification and traceability of forests that are result of human induced afforestation before 1990. When these areas are identified, changes in forest areas occur and these areas are registered and reported under the 1990 forest areas. The change in forest areas that comes from the forest areas defined under the two consecutive plans/programs led to the difference between areas reported under the FL-FL category in NIR 2015, and FL-FL category of land in NIR 2016. 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.

2) Better application of 2006 Guidelines (GWP for N₂O and emission factor)

3) Changes in parameters used for previous and this year estimation are presented as follows:

<table>
<thead>
<tr>
<th>Forest type</th>
<th>BEF 1 (dimensionless)</th>
<th>R (dimensionless)</th>
<th>BEF 2 (dimensionless)</th>
<th>CF (tonnes d.m)³</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NIR 2015</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deciduous</td>
<td>0.26</td>
<td>1.40</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>Coniferous</td>
<td>0.32</td>
<td>1.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out of Yield (maquies and shrub)</td>
<td>1.0</td>
<td>0.26</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td><strong>NIR 2016</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deciduous</td>
<td>0.23</td>
<td>1.197</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>Coniferous</td>
<td>0.29</td>
<td>1.0387</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>Out of Yield (maquies and shrub)</td>
<td>1.1</td>
<td>0.46</td>
<td>NA</td>
<td>0.47</td>
</tr>
</tbody>
</table>

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 CO₂ eq emissions for ARD
activities are determined in range of ± 247 to ± 681% in period 2008-2012. In the same period
uncertainty of total CO₂ 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 2\textsuperscript{nd} 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 11.3-7: Methodological Improvements in FM input data, FM estimates and FM figures of historic years

<table>
<thead>
<tr>
<th>Factor subject to the change</th>
<th>Old (period 2005 – 2009 at the time of FMRL submission)</th>
<th>New (period 2005 – 2009 at the time of submission 2016)</th>
<th>Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average annual FM increment, high forests (mil. m3)</td>
<td>10.04</td>
<td>10.97</td>
<td>+8.5 %</td>
</tr>
<tr>
<td>Average annual FM harvest, high forests (mil. m3)</td>
<td>5.19</td>
<td>5.12</td>
<td>-1.4 %</td>
</tr>
<tr>
<td>Maquies and shrub forests</td>
<td>Not considered</td>
<td>Estimated</td>
<td></td>
</tr>
<tr>
<td>Wood density deciduous</td>
<td>0.588</td>
<td>0.558</td>
<td>-5.4 %</td>
</tr>
<tr>
<td>Wood density coniferous</td>
<td>0.400</td>
<td>0.395</td>
<td>-1.3 %</td>
</tr>
<tr>
<td>Wood density Maquies and shrub forests</td>
<td>Not considered</td>
<td>0.683</td>
<td></td>
</tr>
<tr>
<td>Root/shoot ratio for increment - deciduous</td>
<td>0.24</td>
<td>0.23</td>
<td>-4.3 %</td>
</tr>
<tr>
<td>Root/shoot ratio for increment - coniferous</td>
<td>0.23</td>
<td>0.29</td>
<td>+20.7 %</td>
</tr>
<tr>
<td>Root/shoot ratio for increment - Maquies and shrub forests</td>
<td>Not considered</td>
<td>0.46</td>
<td></td>
</tr>
<tr>
<td>Root/shoot ratio for harvest</td>
<td>Root biomass losses not considered (in line with IPCC 2003 GPG)</td>
<td>Root biomass losses considered (in line with IPCC 2006 GL)</td>
<td></td>
</tr>
<tr>
<td>Biomass expansion factor for increment - Maquies and shrub forests</td>
<td>Not considered</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>Biomass expansion factor for harvest - deciduous</td>
<td>1.4</td>
<td>1.197</td>
<td>-16.9%</td>
</tr>
<tr>
<td>Biomass expansion factor for harvest - coniferous</td>
<td>1.3</td>
<td>1.0387</td>
<td>-25.2%</td>
</tr>
<tr>
<td>Biomass expansion factor for</td>
<td>Not considered</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
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 8158,15 kt CO₂ at the time of FMRL submission (2011) to 7287,79 kt CO₂ 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 11.3-8: Average changes in the FMRL input data for the 2nd CP

<table>
<thead>
<tr>
<th></th>
<th>Old</th>
<th>New</th>
<th>Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increment, high forests 2020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1000 m3)</td>
<td>10676</td>
<td>10068</td>
<td>-6.0 %</td>
</tr>
<tr>
<td>Harvest, high forests 2020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1000 m3)</td>
<td>8000</td>
<td>7903</td>
<td>-1.2 %</td>
</tr>
<tr>
<td>Stock change Maquies and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrub 2020 (1000 m3)</td>
<td>0</td>
<td>+89</td>
<td></td>
</tr>
<tr>
<td>Wood density deciduous</td>
<td>0.588</td>
<td>0.558</td>
<td>-5.4 %</td>
</tr>
<tr>
<td>Wood density coniferous</td>
<td>0.400</td>
<td>0.395</td>
<td>-1.3 %</td>
</tr>
<tr>
<td>Wood density Maquies and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>shrub forests</td>
<td>Not considered</td>
<td>0.683</td>
<td></td>
</tr>
<tr>
<td>Root/shoot ratio for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>increment deciduous</td>
<td>0.24</td>
<td>0.23</td>
<td>-4.3%</td>
</tr>
<tr>
<td>Root/shoot ratio for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>increment coniferous</td>
<td>0.23</td>
<td>0.29</td>
<td>+20.7 %</td>
</tr>
<tr>
<td>Root/shoot ratio for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>increment - Maquies and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>shrub forests</td>
<td>Not considered</td>
<td>0.46</td>
<td></td>
</tr>
<tr>
<td>Root/shoot ratio for harvest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(deciduous)</td>
<td>0</td>
<td>0.23</td>
<td>+23 %</td>
</tr>
<tr>
<td>Root/shoot ratio for harvest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(coniferous)</td>
<td>0</td>
<td>0.29</td>
<td>+29 %</td>
</tr>
</tbody>
</table>
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 kt CO₂ net removals to FMRLcorr. – 4,906.20178 kt CO₂ net removals without HWP (instantaneous oxidation) and to FMRLcorr. – 5,384.16933 kt CO₂ net removals with the HWP.

11.3.1.9. The year of the onset of an activity, if after 2008

For 2008-2012, Croatia reports afforestation, deforestation and Forest management activities. Reforestation activity has not been performed in Croatia during the reporting period.

11.4 ARTICLE 3.3

In the period 1990-2015, 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 [kt CO₂] |
|------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| **Year**               | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
| **Biomass**            | **AGB** | **BGB** | **AGB** | **BGB** | **AGB** | **BGB** | **AGB** | **BGB** |
| Reforestation AGB      | -35.23  | -26.99  | -41.79  | -45.91  | -75.37  | -83.77  | -92.70  | -101.47  |
| Reforestation BGB      | -7.64   | 8.04    | 2.44    | 7.15    | -13.19  | -7.49   | -7.36   | -20.61   |
| Dead wood              | NO      | NO      | NO      | NO      | NO      | NO      | NO      | NO       |
| Litter                 | IE      | IE      | IE      | IE      | IE      | IE      | IE      | IE       |
| **Biomass**            | **AGB** | **BGB** | **AGB** | **BGB** | **AGB** | **BGB** | **AGB** | **BGB** |
| Deforestation AGB      | 26.94   | 19.29   | 11.98   | -2.07   | 7.31    | 4.20    | -7.66   | 11.85    |
| Deforestation BGB      | 8.22    | 8.24    | 5.90    | 2.46    | 4.96    | 3.87    | 0.91    | 6.08     |
| Dead wood              | IE      | IE      | IE      | IE      | IE      | IE      | IE      | IE       |
| Litter                 | IE      | IE      | IE      | IE      | IE      | IE      | IE      | IE       |
| Soil                   | 37.22   | 39.62   | 42.52   | 43.09   | 45.33   | 46.80   | 46.28   | 47.48    |

CROATIAN AGENCY FOR THE ENVIRONMENT AND NATURE
In period 2008-2015 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 31st December 2012 and are directly human-induced

All data regarding the Article 3.3 activities were attained from HS database related to FMAPs. As mentioned previously, there are three main FMAPs. The first FMAP in this sense is the FMAP encompassing the period from 1986-1995 thus including 1990.

As stated earlier, afforestation in national circumstances is the activity within the biological forest renewal and it refers to afforestation of non-forest land and establishing plantations of fast growing species. This activity mentioned is laid down in forest management plans with a clear indication of the time when it is carried out; thus is human induced and not a result of natural succession. As 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, and 2015.
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 data85, 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 inhabitants84. According to the same sources of information in same period number of inhabitants increased in area of main town from 25.42% to 26.19% although the total number of inhabitants in Croatia decreased for more than 3%. Based on these arguments and fact that in year 2012 total agricultural plant production decreased for 12.3% comparing to production in 2011 and that employment in agriculture sector decreased for 3.1% comparing to the same year85, 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

83 Statistical Yearbook (2011), page 57
84 Statistical Yearbook (2012), page 57
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\(^\text{86}\).

\(^{86}\) Janeš et al (2014) Separation of areas under the Article 3.3 and 3.4 of the Kyoto Protocol, page 15
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 abandoned 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\textsuperscript{87}, Article\textsuperscript{88} 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 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.\textsuperscript{88} This financial means must be used in private forests for activities that are prescribed by Forest Act such as pre-commercial thinning and

\textsuperscript{87} OG 94/14
\textsuperscript{88} 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
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 program89, 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 Owners90 (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 occur 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

90 http://www.hsups.hr/udruge.html
and 51 of the Low on Forests. Since all forest land in Croatia can be considered managed, if a certain forest land area is permanently removed from the forest management area (in specific circumstances, e.g. for road construction), then this event should be reported as deforestation.

The re-establishment of forest on harvested areas or areas affected by forest disturbance is also regulated by the Articles 10 and 28 of the Low on Forests and the Ordinance on Forest Management (OG 111/06, 141/08).

The FMAPs make a clear distinction between areas that are deforested and areas that are cleared for forest management purposes, all consistent with the provisions of the Forest Act. By that, both activities can be easily distinguished.

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 demonstrating 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

NA

Croatia did not elect these activities for the First and Second commitment period.

11.5.3 Information related to the Forest Management

As stated before, all forest management area within the national frame is managed based on the FMAP and is even wider than the forest management area under the KP because it includes, for example, afforested area and also “forest land” (in Croatian sense) that is covered with vegetation which does not reach the selected thresholds for the KP definition of forest (all land under FMAPs, see Figure 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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest management</td>
<td>-7,683.8</td>
<td>-7,863.4</td>
<td>-7,624.5</td>
<td>-6,717.0</td>
<td>-6,574.2</td>
<td>-6,631.3</td>
<td>-6,312.2</td>
<td>-5,653.4</td>
</tr>
</tbody>
</table>

11.5.4 Information on the extent to which GHG removals by sinks offset the debit incurred under Article 3.3.

According to the estimation performed for activities subject of Article 3.3 of the Kyoto protocol, removals by sink achieved through afforestation activities are higher than emissions incurred due to deforestation activities during the period 2008-2014. 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 2014 table)

<table>
<thead>
<tr>
<th>KEY CATEGORIES OF EMISSIONS AND REMOVALS</th>
<th>GAS</th>
<th>CRITERIA USED FOR KEY CATEGORY IDENTIFICATION</th>
<th>OTHER (4)</th>
<th>COMMENTS (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specify key categories according to the national level of disaggregation used (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest Management</td>
<td>CO2</td>
<td>Forest land remaining forest land</td>
<td>Yes</td>
<td>No other criteria. No.</td>
</tr>
<tr>
<td>Afforestation and Reforestation</td>
<td>CO2</td>
<td>Conversion to forest land</td>
<td>Yes</td>
<td>NO</td>
</tr>
<tr>
<td>Deforestation</td>
<td>CO2</td>
<td>Conversion to cropland, Conversion to settlements</td>
<td>No</td>
<td>NO</td>
</tr>
</tbody>
</table>

11.7 INFORMATION RELATING TO ARTICLE 6

Croatia does not participate in any project under Article 6.