



REPUBLIC OF SLOVENIA  
MINISTRY OF THE ENVIRONMENT AND SPATIAL PLANNING  
SLOVENIAN ENVIRONMENT AGENCY

# Slovenia's National Inventory Report 2018

GHG emissions inventories 1986 - 2016

Submitted under the United Nations  
Framework Convention on Climate Change

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## PREFACE

Slovenian Environment Agency (SEA) is in accordance with the Slovenian legislation charged with both the overall coordinating of activities that are necessary for the development of emission inventories and with implementing inventories for the purposes of reporting to the United Nations Framework Convention on Climate Change (UNFCCC) and to the European Commission. The Republic of Slovenia is as a party to the convention obligated to make annual GHG emission inventories and to report them.

The National inventory report (NIR), as established by decision 18/COP.8 and revised by decision 24/CP.19, is one element of the annual greenhouse gas inventory that is required to be submitted to the UNFCCC by Annex I Parties to the Convention on 15 April each year. It includes the main part of the NIR and additional information in five Annexes to the NIR:

- Annex 1: Key sources
- Annex 2: Assessment of Uncertainty
- Annex 3: Detailed methodological descriptions for individual source and sink categories: A.3.Energy, A.3.Agriculture
- Annex 4: The national energy balance
- Annex 5: Additional information – Registry (SEF, Annex A, Annex B)

The other elements of this submission include the reporting of GHG emissions by sources and removals by sinks in the common reporting format (CRF) tables for the period 1986-2016 and accompanied XML file.

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## Executive Summary

An emissions inventory that identifies and quantifies a country's primary anthropogenic sources and sinks of greenhouse gases is essential for addressing climate change. This inventory adheres to both: a comprehensive and detailed set of methodologies for estimating sources and sinks of anthropogenic greenhouse gases, and a common and consistent mechanism that enables Parties to the United Nations Framework Convention on Climate Change (UNFCCC) to compare the relative contribution of different emission sources and greenhouse gases to climate change.

In 1992, the Republic of Slovenia signed and in 1995 ratified the UNFCCC. As stated in Article 2 of the UNFCCC, the ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. Parties to the Convention, by ratifying, "shall develop, periodically update, publish and make available...national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies..." The Republic of Slovenia views this report as an opportunity to fulfil these commitments.

This report summarizes the latest information on Slovenian anthropogenic greenhouse gas emission trends from 1986 through 2016. To ensure that the Slovenian emissions inventory is comparable to those of other UNFCCC Parties, the estimates presented here were calculated using methodologies consistent with those recommended in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) and the IPCC Good Practice Guidance for Land Use, Land-Use Change, and Forestry (IPCC 2003). The structure of this report is consistent with the [UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention](#). The national greenhouse gas inventory has to be submitted to the UNFCCC Secretariat every year no later than 15 April.

The quality of greenhouse gas (GHG) inventories relies on the integrity of the methodologies used, the completeness of reporting, and the procedures for compilation of data. To this end, the Conference of the Parties (COP) has developed standardized requirements for reporting national inventories.

As Annex I Party and the Party to the Kyoto Protocol Slovenia is required to report supplementary information under Article 7, paragraph 1, of the Kyoto Protocol, with the inventory submission due under the Convention, in accordance with paragraph 3(a) of [decision 15/CMP.1](#).





# 1 INTRODUCTION

## 1.1 Background Information on Greenhouse Gas Inventories and Climate Change

At the Second World Climate Conference in Geneva in October and November 1990, a clear need for standard methodology for monitoring emissions of greenhouse gases was expressed; it was to enable comparing and enhancing inventories in individual countries. Under the auspices of OECD and International Energy Agency and with the support of the United States of America, United Kingdom, and Norway, a draft methodology was set up. That document comprised six direct and indirect greenhouse gases: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCs). The methodology was adopted in Paris in March 1991 at the Fifth Session of the Intergovernmental Panel on Climate Change (IPCC) and it became the starting point for individual states in creating their national inventories of greenhouse gases.

The methodology for the calculation of greenhouse gases has been developing all the time and is a project under development even today. In the IPCC inventory of greenhouse gases for Slovenia, first the 1996 version was applied (Intergovernmental Panel on Climate Change: Greenhouse Gas Inventory - Reference manual, UNEP-OECD-IEA-IPCC, Bracknell 1996), which in some parts also takes into account emissions of direct greenhouse gases that have been encompassed by the Kyoto Protocol (CF<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>, PFCs, HFCs and SF<sub>6</sub>). Later the inventory has been permanently improving with implementation of GPG (Intergovernmental Panel on Climate Change: Good practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 2000) and the IPCC Good Practice Guidance for Land Use, Land-Use Change, and Forestry (IPCC 2003).

The Subsidiary Body for Scientific and Technological Advice (SBSTA) at its thirtieth session considered the use by Parties of the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines for national greenhouse gas inventories ([2006 IPCC Guidelines](#)) starting in 2015. Therefore the emission and removals presented since the submission 2015 have been calculated according to the new guidelines and all emission and removals estimates for the period 1986-2012 have been recalculated accordingly.

The guidelines for the implementation of the inventory of greenhouse gases contain prescribed methods for calculation of emissions, providing a unified framework for reporting and documenting sources for all inventories. One of the main aims of this method is to ensure comparability of data gathered in individual states and that calls for a definition of at least a minimum scope of equal methods, criteria, and estimating procedures.

The report presents estimates for the following greenhouse gases included in Annex A to the Kyoto Protocol: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>), as well as estimates for indirect GHGs, including carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), and non-methane volatile organic compounds (NMVOC). Data are also reported for sulphur

oxides (SO<sub>x</sub>) and ammonia (NH<sub>3</sub>). Nitrogen trifluoride (NF<sub>3</sub>) emissions do not occur in Slovenia and, therefore, they are not included in this report.

#### Global warming potential

The global warming potential (GWP) of a greenhouse gas is defined as the ratio of the time-integrated radiative forcing from the instantaneous release of 1 kg of a trace substance relative to that of 1 kg of a reference gas. Direct radiative effects occur when the gas itself is a greenhouse gas. The reference gas used is CO<sub>2</sub> and therefore GWP-weighted emissions are measured in Gg of CO<sub>2</sub> equivalents (Gg CO<sub>2</sub> eq.).

The following table 1.1.1 lists the direct (except for CH<sub>4</sub>) 100-year time horizon GWPs relative to CO<sub>2</sub> for all GHGs included in the Slovenian inventory. This table is adapted from table 2.14 of the IPCC Fourth Assessment Report (4AR) which includes most recent GWP values and is available on the IPCC web page:

[https://www.ipcc.ch/publications\\_and\\_data/ar4/wg1/en/ch2s2-10-2.html#table-2-14](https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html#table-2-14)

Before 2015 the GWPs from the Second assessment report (SAR) have been used for calculation of total GHG emissions in CO<sub>2</sub> equivalents while according to the COP Decision 24/CP.19 the GWPs from 4AR shall be used for all submissions started with 2015. For this reason the both sets of GWPs are presented in the table 1.1.1.

**Table 1.1.1: Global Warming Potentials (100 Year Time Horizon) Used in this Report from the IPCC Second and Forth Assessment Reports.**

Gas – common name	Chemical formula	GWP from SAR - old	GWP from 4AR - new
Carbon dioxide	CO <sub>2</sub>	1	1
Methane*	CH <sub>4</sub>	21	25
Nitrous oxide	N <sub>2</sub> O	310	298
HFC-32	CH <sub>2</sub> F <sub>2</sub>	650	675
HFC-125	CHF <sub>2</sub> CF <sub>3</sub>	2,800	3,500
HFC-134a	CH <sub>2</sub> FCF <sub>3</sub>	1,300	1,430
HFC-143a	CH <sub>3</sub> CF <sub>3</sub>	3,800	4,470
HFC-227ea	CF <sub>3</sub> CHFCF <sub>3</sub>	2,900	3,220
CF <sub>4</sub>	CF <sub>4</sub>	6,500	7,390
C <sub>2</sub> F <sub>6</sub>	C <sub>2</sub> F <sub>6</sub>	9,200	12,200
SF <sub>6</sub>	SF <sub>6</sub>	23,900	22,800

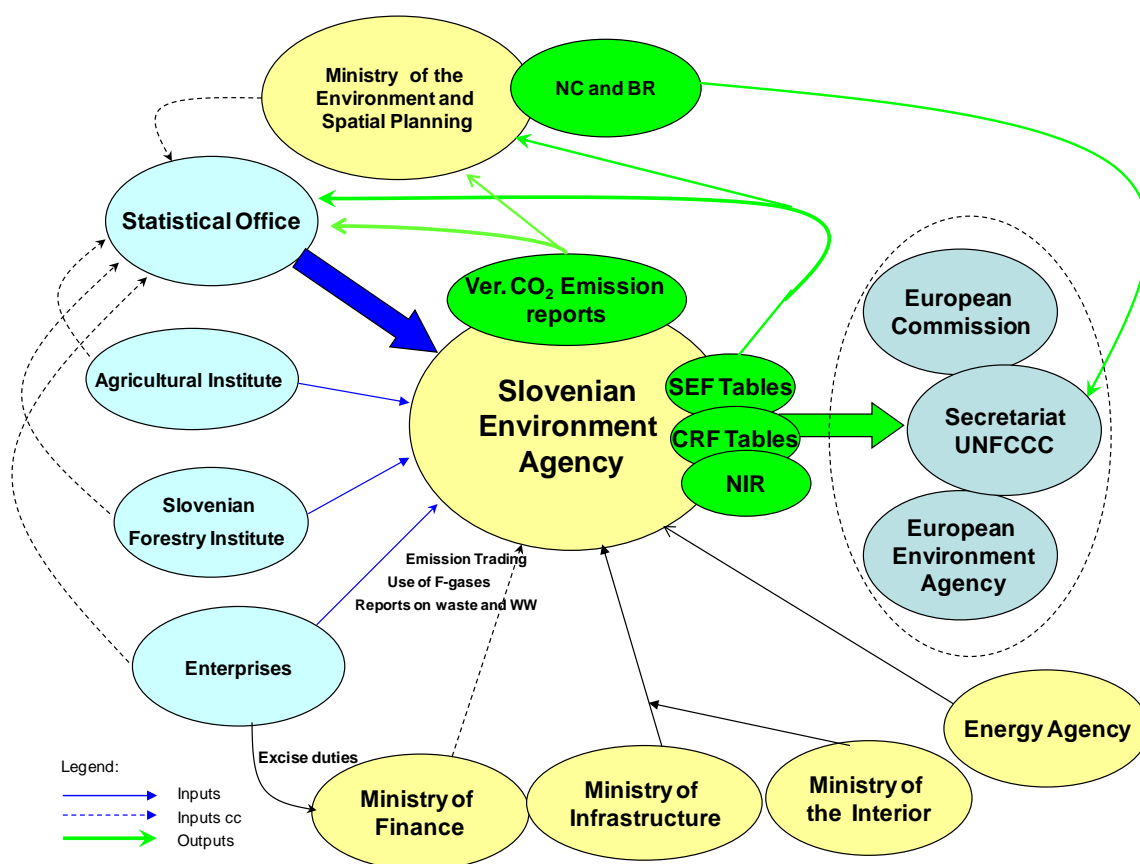
\* The methane GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapour. The indirect effect due to the production of CO<sub>2</sub> is not included.

Global warming potentials are not provided for CO, NO<sub>x</sub>, NMVOCs, SO<sub>2</sub> or aerosols because there is no agreed method to estimate the contribution of gases that are short-lived in the atmosphere, spatially variable, and have only indirect effects on radiative forcing.

## 1.2 A description of the national inventory arrangements

### 1.2.1 Institutional, legal and procedural arrangements

In Slovenia, the institution responsible for GHG inventories is the Slovenian Environment Agency (SEA). In accordance with its tasks and obligations to international institutions, the SEA is charged with making inventories of GHG emissions, as well as emissions that are defined in the Convention on Long Range Transboundary Air Pollution within the specified time limit. In making the inventories, the Environmental Agency cooperates with numerous other institutions and administrative bodies which relay the necessary activity data and other necessary data for the inventories.



**Figure 1.2.1: Data flows in the Slovenian Inventory System**

A Memorandum of Understanding has been concluded with the Statistical Office of the Republic of Slovenia (SORS) to submit quality and verified data to the Environmental Agency in due time, because the time limits for inventories and the NIR have shortened with the entry of Slovenia into the EU, since inventories and part of the NIR for the year before last must be made by 15<sup>th</sup> of January, and with corrections and final submission of the NIR by 15<sup>th</sup> of March. In view of this, an agreement has been reached with the participating institutions to shorten the time limits for submitting data. For reasons of complexity, attention was mostly focused on the Joint Questionnaires of the SORS, on the basis of which the Statistical Office produces the Energy Balance of the Republic of Slovenia, wherein the most important data

on the energy sector are found. All sources of data for GHG inventory are presented in the Table 1.2.1 while the Figure 1.2.1 shows the data flows.

**Table 1.2.1: Data Sources**

IPCC category	IPCC sub-category	Sources of data
1.A – Energy: Fuel Combustion	1 Energy Industry	<ul style="list-style-type: none"> <li>• Statistical Office of the Republic of Slovenia: Joint Questionnaires, Energy Balances, annual energy statistics</li> <li>• Slovenian Environment Agency: ETS data</li> </ul>
	2 Manufacturing Industries and Construction	<ul style="list-style-type: none"> <li>• Statistical Office of the Republic of Slovenia: Joint Questionnaires, Energy Balances, annual energy statistics</li> <li>• Slovenian Environment Agency: ETS data</li> </ul>
	3 Transport	<ul style="list-style-type: none"> <li>• Statistical Office of the Republic of Slovenia: Joint Questionnaires, Energy balances</li> <li>• Ministry of Infrastructure and Spatial Planning, Directorate for National Roads (DRSC)</li> <li>• Ministry of the Interior (vehicle stock)</li> <li>• Plinovodi d.o.o.</li> </ul>
	4 Other Sectors	• Statistical Office of the Republic of Slovenia:
	5 Other	<ul style="list-style-type: none"> <li>• Slovenian Army:</li> <li>• Police</li> </ul>
1.B Energy: Fugitive Emissions		<ul style="list-style-type: none"> <li>• Statistical Office of the Republic of Slovenia:</li> <li>• Slovenian Environment Agency: ETS data</li> </ul>
CRF 2 – Industrial Processes and Product Use	CRF 2A – Mineral Products	<ul style="list-style-type: none"> <li>• Statistical Office of the Republic of Slovenia:</li> <li>• Slovenian Environment Agency</li> </ul>
	CRF 2B – Chemical Industry	• Statistical Office of the Republic of Slovenia:
	CRF 2C – Metal Production	<ul style="list-style-type: none"> <li>• Statistical Office of the Republic of Slovenia:</li> <li>• Slovenian Environment Agency</li> </ul>
	CRF 2D – Non-energy Products	<ul style="list-style-type: none"> <li>• Statistical Office of the Republic of Slovenia:</li> <li>• Slovenian Environment Agency</li> </ul>
	CRF 2F – ODS Substitutes	<ul style="list-style-type: none"> <li>• Slovenian Environment Agency</li> <li>• Ministry of Finance</li> </ul>
	CRF 2G – Other product	<ul style="list-style-type: none"> <li>• Statistical Office of the Republic of Slovenia</li> <li>• Slovenian Environment Agency</li> </ul>
CRF 3 – Agriculture		<ul style="list-style-type: none"> <li>• Statistical Office of the Republic of Slovenia</li> <li>• Agricultural Institute of Slovenia</li> </ul>
CRF 4 – Land Use, Land Use Change, and Forestry		<ul style="list-style-type: none"> <li>• Slovenian Forestry Institute</li> <li>• Agricultural Institute of Slovenia</li> </ul>
CRF 5 – Waste	A. Solid waste disposal	• Slovenian Environment Agency
	B. Biological treatment of solid waste	<ul style="list-style-type: none"> <li>• Slovenian Environment Agency</li> <li>• Statistical Office of the Republic of Slovenia</li> </ul>
	C. Incineration and open burning of waste	• Slovenian Environment Agency
	D. Waste water treatment and discharge	<ul style="list-style-type: none"> <li>• Slovenian Environment Agency</li> <li>• Statistical Office of the Republic of Slovenia</li> </ul>

The year 2003 saw the end of the process of harmonisation of data collection among the Directorate of Energy, Ministry of Agriculture and the Environment, and the Statistical Office of the Republic of Slovenia. An end was put to previous parallel double collecting of data.

The competence of collecting data has, by law, passed to the SORS, which checks the data and eliminates potential reporting errors, and submits consolidated data to the Directorate of Energy, which has been publishing data until 2005 in its Energy Yearbook of the Republic of Slovenia. In terms of content, the data were identical to those submitted in the Joint Questionnaires to the IEA.

At the beginning of 2007, the agreement between Statistical Office of the Republic of Slovenia and the Environmental Agency came into force. Accordingly, all statistical data necessary for preparing GHG inventories are available each year by October 30 at the latest. In exchange, ETS data and emission estimates are reported to the Statistical Office within a defined time frame. In 2014 the new agreement has been signed which includes more data sets and updated time lines.

Experts from the Slovenian Forestry Institute and the Agricultural Institute of Slovenia work on GHG inventories according to the standing rules of institutes (ordinance). Financing is assured by governmental institutions according to the yearly work plan. All data from external institutions are submitted to the Slovenian Environmental Agency, where they are archived.

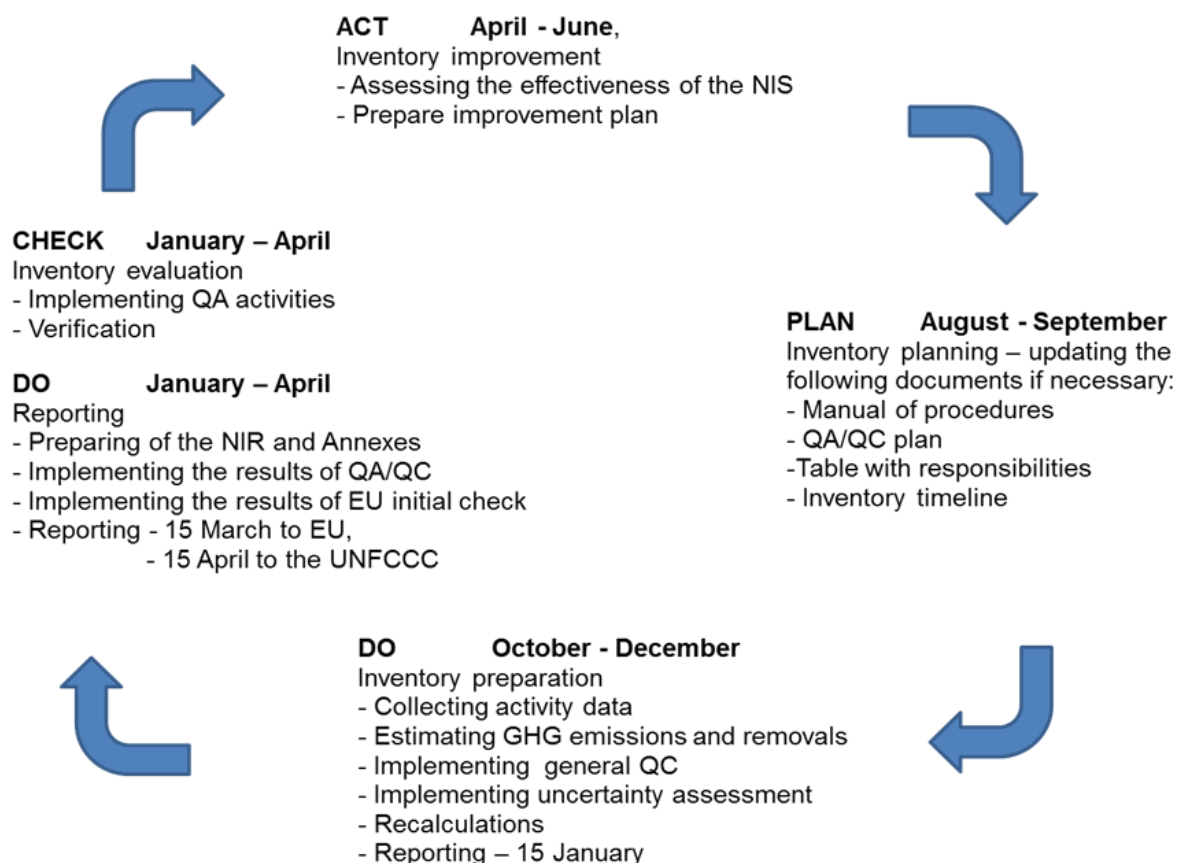
The detailed process from gathering data to emissions calculation and reporting is described in the Manual of Procedures, which was first prepared in 2005 and further updated in 2009. In 2014 a completely new Manual has been prepared, which follows the structure and methodology of 2006 IPCC GL and includes also the new sources of GHG.

### **1.2.2 Overview of inventory planning, preparation and management**

A process of inventory preparation is designed according to the PDCA-cycle (Plan – Do – Check – Act). This is a generally accepted model for pursuing a systematic quality work according to international standards, in order to ensure the maintenance and development of the quality system. This structure is in accordance with structures described in decision 19/CMP.1 and in the 2006 IPCC Guidelines. The system consists of inventory planning, inventory preparation, inventory quality checking and follow-up improvements which are integrated into the annual cycle and preparation as illustrated in the Figure 1.2.2.

Owing to the ever-increasing obligations of Slovenia with regard to reporting, the SEA has decided to implement a unified system of data collection for the purposes of making inventories, as well as secure reliable financing in accordance with the annual program of its work.

For submitting reports to different institutions, various report formats have been devised, since the same data are used to report to the UNFCCC, EEA, EC, and CLRTAP. All external reports of the SEA are prepared in accordance with ISO 9001 via the Agency's reporting service, which keeps inventories of reports. Parallel to this, emissions data are submitted to the SORS, which makes them available in its publications and submits them to EUROSTAT and the IEA.



**Figure 1.2.2: The inventory cycle.**

### Official Consideration and Approval of the Inventory

Before the inventory is reported to the EU, EEA or UNFCCC Secretariat, it goes through an approval process. The institution designated for approval is the Ministry of the Environment and Spatial Planning. The inventory is usually sent to the Ministry according the following plan:

- draft CRF tables on January 3
- final CRF tables and draft NIR on March 1
- final report on April 1

## Public Availability of the Inventory

The inventories are publically available on the web. Every submission is accompanied with a short description in Slovenian language. The estimates are presented in a more simple way with a table similar to Table 2.2.1 from the NIR. GHG emissions are also presented as indicator. It is very common that yearly submission of GHG inventory is followed by a press conference, where our last estimates are presented in connection with our emission reduction goals.

Web page address:

<http://www.arso.gov.si/podnebne%20spremembe/emisije%20toplogrednih%20plinov/>

### 1.2.3 Quality assurance, quality control and verification plan

In 2014, Slovenia developed and implemented a new Quality Assurance and Quality Control Plan as recommended by the IPCC Guidelines (IPCC 2000 and 2006). The QA/QC plan is part of the Manual of Procedures, elaborated in 2005 and updated in 2014. This update was necessary due to the new methodology guidance (IPCC, 2006), which became official guidance for GHG reporting since 2015. The manual is improved and updated regularly.

#### Quality Control (QC)

Quality Control is a system of routine technical activities to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

- provide routine and consistent checks to ensure data integrity, correctness and completeness;
- identify and address errors and omissions;
- document and archive inventory material and record all QC activities.

The final part of this system is incorporated in an Oracle database (ISEE – "Emission inventory" information system). ISEE enables and ensures that all necessary built-in QA/QC checks have been performed before data and emission estimates are entered in the reporting format tables. It also keeps a record of all changes made to data in the database.

As all calculations are performed in the database with software generated for this purpose, no human errors are expected. But for QA/QC purpose all emissions are also calculated in the old way in Excel spreadsheets. Both estimates were then compared and all differences were carefully investigated and corrected.

During development of the database, the following QC was performed:

#### Check of methodological and data changes resulting in recalculations

- Check for temporal consistency in time series input data for each source category.
- Check for consistency in the algorithm/method used for calculations throughout the time series.

#### Completeness checks

- Confirm that estimates are reported for all source categories and for all years from the appropriate base year to the period of the current inventory.
- Check that known data gaps resulting in incomplete source category emissions estimates are documented.
- Compare estimates to previous estimates: for each source category, current inventory estimates should be compared to previous estimates. If there are significant changes or deviations from expected trends, recheck estimates and explain any differences.



### **Check of activity data, emission factors and other parameters**

- Cross-check all input data from each source category for transcription errors.
- Check that units are properly labelled in calculation sheets.
- Check that units are correctly carried through from beginning to end in calculations.
- Check that conversion factors are correct.
- Check that temporal and spatial adjustment factors are used correctly.

In 2006, an additional quality control checking point was introduced by forwarding the assessment of verified emission reports from installations included in the National Allocation Plan to the SORS. The role of SORS is to compare data from installations included in EU-ETS with data from their reporting system and to propose corrective measures if necessary. The outcome of data consistency checks is used as preliminary information for the Ministry of Agriculture and the Environment for performing on-site inspections. The use of (EU) ETS data is described in detail in the relevant chapter on Energy and Industrial Processes sectors.

### **Check of emissions estimates**

Every year emissions are also calculated in the old way using Excel spreadsheets and using built-in formulas in the database. Both estimates were compared and all differences carefully investigated. All errors were corrected and the accuracy of emissions calculations on all levels is assured.

QA/QC checks not performed in the database:

### **Uncertainty**

According to the QA/QC plan checks of uncertainty were performed in 2015. The checks consisted of the following:

- Check that the qualifications of individuals providing expert judgement for uncertainty estimates are appropriate.
- Check that qualifications, assumptions and expert judgements are recorded.
- Check that calculated uncertainties are complete and calculated correctly.
- Check that there is detailed internal documentation to support the uncertainty estimates.

While first two QC have been performed, the last QC shows that detailed documentation is not available for the most of uncertainty estimates. So we decided to use expert judgements except for categories for which uncertainty estimates are available in 2006 IPCC GL.

### **Preparation of NIR**

- Check that all chapters from annotated NIR are included in the NIR
- Check that AD, EF and other numerical information mentioned in the text is correct
- Check all AD data is presented in the tables in the NIR
- Check all EF and other parameters used in the tables in the NIR

- Check all graphs for accuracy and presence in the whole period
- Check all titles for tables and pictures
- Check that all Annexes to the NIR are included and updated

### **Documentation and archiving**

QA/QC checks of documentation and archiving procedures:

- Check that inventory data, supporting data and inventory records are archived and stored to facilitate detailed review.
- Check that all supporting documentation on QA/QC procedures is archived
- Check that results of QC analysis and uncertainty estimates are archived
- Check that there is detailed internal documentation to support the estimates and enable duplication of emissions estimates.
- Check that documentation of the database is adequate and archived.
- Check that bibliographical data references are properly cited in the internal documentation and archived.
- Check that inventory improvements plan is updated and archived.

Following recommendation from 2013 in country review an instruction have been prepared to determine the form and the names of archived documents.

### **Quality assurance (QA)**

QA generally consists of independent third-party review activities to ensure that the inventory represents the best possible estimates of emissions and removals and to support the effectiveness of the QC program. In the past we performed only one peer review. In 2006, we received many useful comments from the team preparing our fourth National Communication Report. Although the comments were not presented as an official report, we accepted many of the suggestions and corrected a number of errors. We are planning a sectoral review of our inventory on a yearly basis – one sector per year.

In May 2009, a peer review of the Slovenian inventory was performed for the Energy sector. Since then the Energy sector and Industrial processes sector is regularly checked by experts from Energy efficiency centre (CEU/IJS).

In 2011, the peer review for the Waste sector was performed, no important errors were found.

For Agriculture and LULUCF sector it is very hard to perform a peer review as the main institutions (Slovenian Forestry Institute and Agricultural Institute of Slovenia) are already involved in the inventory preparation. Due to the lack of relevant independent expert for LULUCF sector in Slovenia, this sector has been reviewed during the two-day visit in JRC Ispra, which took place in April 2012. In the years 2013 and 2014, Slovenia has also been included in EU support project for improving LULUCF inventory.

QA/QC procedures performed by other institutions (Slovenian Forestry Institute and Agricultural Institute of Slovenia) are described in the relevant chapters in the NIR (LULUCF, Agriculture). Data based on forest statistics are produced by the Slovenian Forestry Institute

and SORS. Data based on agricultural statistics are mainly from SORS and the Agricultural Institute. All data have been checked.

The Statistical Office of Slovenia (SORS) is our main data provider. In 2005, the European Statistics Code of Practice was adopted, bringing considerable changes to the SORS QA/QC system. The main pillars (factors) of quality are defined and thoroughly described in the Medium-term Programme of Statistical Surveys 2013-2017.

[http://www.stat.si/doc/drzstat/MediumTerm\\_2013-2017.pdf](http://www.stat.si/doc/drzstat/MediumTerm_2013-2017.pdf).

The strategic directions of Quality in National Statistics are presented in detail at [http://www.stat.si/eng/drz\\_stat\\_kakovost.asp](http://www.stat.si/eng/drz_stat_kakovost.asp).

### **EU expert review of GHG emissions**

According to the [Regulation \(EU\) 525/2015](#) (MMR) the member states' GHG inventories are subject to the annual review. During this review the European commission carry out checks to verify the transparency, accuracy, consistency, comparability and completeness of submitted inventories. In addition the comprehensive review is performed if needed. More details are available in the [Commission implementing regulation \(EU\) 749/2014](#) in the Chapter III.

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

No changes have been made to the national inventory arrangements since the last submission.

## **1.3 Inventory preparation, and data collection, processing and storage**

The chief source of data is the Statistical Office of the Republic of Slovenia (SORS); however, the Slovenian Environmental Agency obtains much of its data through other activities it performs under the Environmental Protection Act. Emissions from Agriculture are calculated in cooperation with the Slovenian Agriculture Institute (KIS), and sinks in the LULUCF sector are calculated by the Slovenian Forestry Institute (GIS).

In 2006 we have started to develop a joint database for GHGs and other pollutants: ISEE – Information system for emission inventories. In broad terms the application has been completed and operational since 2011, but it is still necessary to conduct regular maintenance and improvements. The database contains activity data, emission factors and other parameters together with a description of sources from 1980 on for other pollutants, and from 1986 on for GHG emissions. It contains equations necessary for calculation of emissions and enables a direct bulk import into the CRF Reporter.

The main purpose of ISEE is:

- to enable collection and archiving of activity data, emission factors and other parameters including descriptions of sources from 1980 on for other pollutants, and from 1986 on for GHG emissions;
- to calculate GHG and other pollutant emissions;
- to automatically fill in reporting tables (CRF Reporter).

However in 2015 the UNFCCC Secretariat made available the upgraded CRF Reporter which became operational on 30. April. Due to the changes made in the new reporting tool, data have been imported to the CRF Reporter using excel.

In the last years calculation process for many sources become more and more complicated, therefore emissions for these sources are calculated with the model and AD and final emissions are then transfer to ISEE. This is valid for emission from Road transport, many categories in the Agriculture sector and emissions from Treatment of Solid Waste. In addition LULUCF sector and F-gasses are not included in ISEE.

### **Documentation and archiving**

All inventory data are now stored in a joint database. Supporting data and references are stored in electronic form and/or hard copy form. Inventory submissions are stored mostly in electronic form at various locations and on various media (network server, CD-ROM, computer hard disk). Access to files is limited in accordance with the security policy. Backup copies on the server are made at regular intervals in accordance with the requirements of the information system.

All relevant data from external institutions are also stored at the Environmental Agency in one place. In 2012, all studies have been scanned, transformed to PDF files and stored on network server, CD-ROM and computer hard disk. The studies are available in hard copies and also in electronic format.

## **1.4 Brief General Description of Methodologies and Data Sources**

Inventories of GHG emissions were prepared on the basis of the IPCC methodology as presented in the 2006 IPCC Guidelines for all gases and sectors. Due to the importance of the source and accessible data, different approaches (tiers) from within the IPCC methodology were used (Table 1.4.1).

In the Energy sector, mainly national/plant specific CO<sub>2</sub> emission factors were used for assessment of emissions from solid fuels, petroleum coke and natural gas (Tier 2/3), while default IPCC emission factors were mainly used for other fuels.

Table 1.4.1: Summary report for methods and emission factors used from CRF tables

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO <sub>2</sub>		CH <sub>4</sub>		N <sub>2</sub> O		HFCs		PFCs		SF <sub>6</sub>	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	EF	Method applied	EF	Method applied	EF
1. Energy	M,T1,T2,T3	CS,D,M,PS	M,T1,T2,T3	CS,D,M,PS	M,T1	D,M						
A. Fuel combustion	M,T1,T2,T3	CS,D,M,PS	M,T1	D,M	M,T1	D,M						
1. Energy industries	T1,T2	CS,D,PS	T1	D	T1	D						
2. Manufacturing ind. and const.	T1,T2,T3	CS,DPS	T1	D	T1	D						
3. Transport	M,T1,T2	CS,D,M	M,T1	D,M	M,T1	D,M						
4. Other sectors	T1,T2	CS,D	T1	D	T1	D						
5. Other	T1	D	T1	D	T1	D						
B. Fugitive emissions from fuels	T1,T3	D,PS	T1,T2,T3	CS,D,PS	T1	D						
1. Solid fuels	T1,T3	D,PS	T2,T3	CS,D,PS	NA	NA						
2. Oil and natural gas	T1	D	T1	D	T1	D						
2. Industrial Processes	M, T1,T2,T3	CS,D,M	NA	NA	T1	D	T1,T2	CS,D	T3	CS,D	T2	CS
A. Mineral Products	T2,T3	CS,D	NA	NA	NA	NA						
B. Chemical Industry	T2	D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C. Metal Production	T1, T2	CS, D	NA	NA	NA	NA	NA	NA	T3	CS,D	NA	NA
D. Non-Energy Product	M, T1	D, M										
F. Substitutes for ODS							T1,T2	CS,D	NA	NA	NA	NA
G. Other product man. and use	NA	NA	NA	NA	T1	D	NA	NA	NA	NA	T2	CS, D
3. Agriculture			T1,T2	CS,D	T1, T2	CS,D						
A. Enteric Fermentation			T1,T2	CS,D								
B. Manure Management			T1,T2	CS,D	T1,T2	CS,D						
D. Agricultural Soils			NA	NA	T1	D						
G. Liming	T1	D	NA	NA	NA	NA						
H. Urea application	T1	D	NA	NA	NA	NA						
4. Land use, land use change and forestry	CS,D,T1,T2,T3	CS,D	D,T1	D	D,T1	D						
A. Forest Land	CS,D,T1,T2,T3	CS,D	D,T1	D	D,T1	D						
B. Cropland	D,T1,T2	CS,D	NA	NA	D,T1	D						
C. Grassland	D,T1,T2,T3	CS,D	NA	NA	NA	NA						
D. Wetlands	D,T1,T2	CS, D	NA	NA	NA	NA						
E. Settlements	D,T2	CS,D	NA	NA	NA	NA						
F. Other Land	D,T2	CS,D	NA	NA	NA	NA						
G. HWP	D,T1	D	NA	NA	NA	NA						
5. Waste	D	D	T1,T2	CS,D	D,T1	D						
A. Solid Waste Disposal	NA	NA	T2	CS,D								
B. Biological Treatment			T1	D	T1	D						
C. Incineration	T1	D	T1	D	T1	D						
D. Waste-water Treatment	NA	NA	T1	CS,D	T1	D						

The quantities of fuels and consumed fuel energy values were taken from the SORS. Additional data on the energy use of some types of waste (waste tyres, oils and solvents)

were acquired from the verified ETS reports. Data on fuel consumption in agriculture and forestry refer to mobile sources only, while the rest of the fuel consumption of these sub-sectors is included in the Institutional and commercial sector. GHG emissions in road transport were determined with the COPERT 4 model using default EFs from the model.

Emission factors for fugitive emissions of CO<sub>2</sub> and CH<sub>4</sub> in mining and post mining activities were determined on the basis of measurements of methane concentrations in ventilation shafts in mines and estimated quantities of released methane and, not very common, also a considerable amount of CO<sub>2</sub>. The CH<sub>4</sub> emission factor that was determined in this manner was lower than the default IPCC emission factor. CO<sub>2</sub> emissions in post-mining activities were not assessed, as no estimation method is available. Following 2006 IPCC GL CH<sub>4</sub> emissions from abandoned and closed mines have been also included in the inventory using Tier 2 method and default parameters.

Fugitive emissions from Oil and natural gas have been calculated using average EFs from default range from 2006 IPCC Guidance. The old method for calculating CH<sub>4</sub> emissions from the distribution of natural gas, which were estimated according to the length of individual types of transmission or distribution pipelines with regard to the pipe type, material and pressure, applying specific losses per unit of length has been used only for the QA purpose.

Until 1997 emissions from Industrial processes and Product Use were mostly determined on the basis of statistical data on production and consumption of raw materials and by applying country-specific emission factors. After 1997, the SORS partly changed the method of collecting and presenting these data and therefore most of the data were obtained directly from individual companies. These data have also been used for preparing our National Allocation Plan for EU-ETS. Since 2005, data from verified reports have mostly been used while in some cases (aluminium and ferroalloy production) the plant data had to be obtained. In determining actual emissions caused by the use of HFCs, data were obtained from companies that have such devices and companies that maintain these devices. For SF<sub>6</sub> emissions, the release of this gas from gas-insulated switchgear for electricity was assessed

In Agriculture, methane emissions from enteric fermentation and manure management in bovine animals were determined using Tier 2 approach and the Tier 1 approach was used for other animals that represent a smaller fraction in methane emissions. Input data for N<sub>2</sub>O emissions from manure handling and from direct and indirect emissions from fertilisation with animal fertilisers were obtained in the process of estimating methane emissions. For N<sub>2</sub>O emissions, default IPCC factors were used. A default EF and Tier 1 approach has been used for calculation of CO<sub>2</sub> emissions from liming and application of urea.

Emissions and removals from the LULUCF sector have been calculated for all six types of land use — Forest land, Cropland, Grassland, Wetlands, Settlements and Other land - and are based on the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003) completed by country-specific methodologies. GHG emission and removal estimates in this sector are calculated from carbon stock changes in the five carbon pools (aboveground biomass, belowground biomass, deadwood, litter, and soil), direct N<sub>2</sub>O emissions from N fertilization, N<sub>2</sub>O emissions from drainage of soils, N<sub>2</sub>O emissions from disturbance associated with land-use conversion to cropland, CO<sub>2</sub> emissions from agricultural lime application, and non-CO<sub>2</sub> emissions from biomass burning. Country specific

emission factors and carbon stock values for forests and partially for agricultural land and grassland are derived from surveys and measurements. For other land use categories, IPCC default values or expert judgements are used.

Methane emissions from solid waste handling were determined by the first order decay model from IPCC 2006 GL, which takes into account the difference in the time dynamics of methane release from different types of waste. Emissions of CH<sub>4</sub> and N<sub>2</sub>O from wastewater and composting, as well as GHG from waste incineration were calculated using the default method.

## 1.5 Brief Description of Key Categories

The analysis of key source categories was performed on the basis of sectoral distribution and use of the approach 1. This approach was used both for the base year and for the year 2016. A level assessment was undertaken for 1986 and 2016, and a trend assessment was performed for 2016. The analysis has been performed at a level of IPCC categories as suggested in Table 4.1 in Volume 1 of 2006 IPCC Guidelines. The results are presented on the Table 1.5.1.

The analyses have been performed with and without LULUCF sector. On the basis of the KCA including LULUCF, 26 categories were selected as keys in 2016 according to the level assessment, and additional 11 were chosen as key categories according to the trend assessment only. As many as 20 categories are key sources according to level and trend KC analysis. The most of the 37 key categories are from Energy sector: 13 categories are CO<sub>2</sub> emissions from fuel combustion, two are CH<sub>4</sub> emissions combustion in other sectors, one is CO<sub>2</sub> emissions from SO<sub>2</sub> scrubbing and two are CO<sub>2</sub> and CH<sub>4</sub> fugitive emissions from Coal mining and handling. The second most important sector is LULUCF with 6 key source categories, five KCs are in the Agriculture sector, 2 are related to methane emissions and 3 to N<sub>2</sub>O emissions, five KCs are in the industrial processes and only two KC are in the Waste sector. On the basis of the Tier 1 analysis excluding LULUCF one category, which were KC according to the level become KC according to the trend, and one category which was trend becomes KC according to the level.

In 2010 a Tier 2 key categories analysis has been done for level assessment only and as much as 27 categories have been determined as keys. Mainly due to the large uncertainty, the most KC were in Agriculture sector (9), following by LULUCF (5), Road transport (4), Waste (3), Fuel combustion in Residential sector (2), Fugitive emissions from solid fuels (2), Consumption of HFCs (1) and Electricity and heat production (1).

Following recommendation from the UNFCCC review in 2013, the qualitative approach has been also used to determine key source categories but no additional key categories have been found. For determination the following criteria has been included:

- Mitigation techniques and technologies
- High expected emission growth
- High uncertainty
- Unexpected low or high emissions

Table 1.5.1: IPCC Key Source Categories for 2016, Approach 1

IPCC Category	Gas	w LULUCF	w/o LULUCF additional
1.A.1 Energy Industries, Gaseous Fuels	CO <sub>2</sub>	L	T
1.A.1 Energy Industries, Liquid Fuels	CO <sub>2</sub>	T	
1.A.1 Energy Industries, Solid Fuels	CO <sub>2</sub>	L, T	
1.A.2 Manufacturing Industries and Construction, Gaseous Fuels	CO <sub>2</sub>	L, T	
1.A.2 Manufacturing Industries and Construction, Liquid Fuels	CO <sub>2</sub>	L, T	
1.A.2 Manufacturing Industries and Construction, Other Fuels	CO <sub>2</sub>	T	L
1.A.2 Manufacturing Industries and Construction, Solid Fuels	CO <sub>2</sub>	L, T	
1.A.3.b Road Transportation, Diesel Oil	CO <sub>2</sub>	L, T	
1.A.3.b Road Transportation, Diesel Oil	N <sub>2</sub> O	T	
1.A.3.b Road Transportation, Gasoline	CO <sub>2</sub>	L, T	
1.A.3.b Road Transportation, LPG	CO <sub>2</sub>	T	
1.A.4 Other Sectors, Gaseous Fuels	CO <sub>2</sub>	L, T	
1.A.4 Other Sectors, Liquid Fuels	CO <sub>2</sub>	L, T	
1.A.4 Other Sectors, Solid Fuels	CO <sub>2</sub>	T	
1.A.4 Other Sectors, Solid Fuels	CH <sub>4</sub>	T	
1.A.4 Other Sectors, Biomass	CH <sub>4</sub>	L, T	
1.B.1.a Fugitive Emissions, Coal Mining and Handling	CH <sub>4</sub>	L, T	
1.B.1.a Fugitive Emissions, Coal Mining and Handling	CO <sub>2</sub>	T	
1.B.1.a Fugitive Emissions, Other	CO <sub>2</sub>	T	
2.A.1 Industrial processes, Cement Production	CO <sub>2</sub>	L, T	
2.A.1 Industrial processes, Lime Production	CO <sub>2</sub>	T	
2.C.3 Industrial processes, Aluminium Production	CO <sub>2</sub>	L, T	
2.C.3 Industrial processes, Aluminium Production	PFC	T	
2.F.1 Industrial processes, Refrigeration and AC Equipment	HFC	L, T	
3.A Agriculture, Enteric Fermentation	CH <sub>4</sub>	L, T	
3.B Agriculture, Manure Management	CH <sub>4</sub>	L, T	
3.B Agriculture, Manure Management	N <sub>2</sub> O	L, T	
3.D.1 Agriculture, Direct Soil Emissions	N <sub>2</sub> O	L	
3.D.2 Agriculture, Indirect Emissions	N <sub>2</sub> O	L	
4.A.1 LULUCF, Forest Land remaining Forest Land	CO <sub>2</sub>	L, T	
4.A.2 LULUCF, Land converted to Forest Land	CO <sub>2</sub>	L, T	
4.B.2 LULUCF, Land converted to Cropland	CO <sub>2</sub>	T	
4.B.2 LULUCF, Cropland remaining Cropland	CO <sub>2</sub>	L	
4.C.2 LULUCF, Land converted to Grassland	CO <sub>2</sub>	T	
4.G LULUCF, Harvested wood products	CO <sub>2</sub>	L, T	
5.A.1 Waste, Managed waste disposal sites	CH <sub>4</sub>	L	
5.D.1 Waste, Domestic and Commercial Waste Water	CH <sub>4</sub>	L	



### Key category analysis as a base for prioritizing improvements in GHG inventory

Key source categories have received special considerations in terms of improvements and QA/QC. On the Table 1.5.2 and 1.5.3 methodologies used to calculate emissions from key categories are presented.

**Table 1.5.2: Methodologies used for key categories according to the level in 2016**

IPCC Category	Gas	Methodology	EF and other parameters
1.A.1 Energy Industries, Gaseous Fuels	CO <sub>2</sub>	Tier 2	CS
1.A.1 Energy Industries, Solid Fuels	CO <sub>2</sub>	Tier 3	PS
1.A.2 Manufacturing Industries and Construction, Gaseous Fuels	CO <sub>2</sub>	Tier 2	CS
1.A.2 Manufacturing Industries and Construction, Liquid Fuels	CO <sub>2</sub>	Tier 1	D
1.A.2 Manufacturing Industries and Construction, Solid Fuels	CO <sub>2</sub>	Tier 3	PS
1.A.2 Manufacturing Industries and Construction, Other Fuels	CO <sub>2</sub>	Tier 1, Tier 3	D, PS
1.A.3.b Road Transportation, Diesel Oil	CO <sub>2</sub>	Model	Model
1.A.3.b Road Transportation, Gasoline	CO <sub>2</sub>	Model	Model
1.A.4 Other Sectors, Gaseous Fuels	CO <sub>2</sub>	Tier 2	CS
1.A.4 Other Sectors, Liquid Fuels	CO <sub>2</sub>	Tier 1	D
1.A.4 Other Sectors, Biomass	CH <sub>4</sub>	Tier 1	D
1.B.1.a Fugitive Emissions, Coal Mining and Handling	CH <sub>4</sub>	Tier 3	PS
2.A.1 Industrial processes, Cement Production	CO <sub>2</sub>	Tier 3	PS
2.C.3 Industrial processes, Aluminium Production	CO <sub>2</sub>	Tier 3	PS
2.F.1 Industrial processes, Refrigeration and AC Equipment	HFC	Tier 2	CS, D
3.A Agriculture, Enteric Fermentation	CH <sub>4</sub>	Tier 1, Tier 2	CS, D
3.B Agriculture, Manure Management	CH <sub>4</sub>	Tier 1, Tier 2	CS, D
3.B Agriculture, Manure Management	N <sub>2</sub> O	Tier 1, Tier 2	CS, D
3.D.1 Agriculture, Direct Soil Emissions	N <sub>2</sub> O	Tier 1	D
3.D.1 Agriculture, Indirect Soil Emissions	N <sub>2</sub> O	Tier 1	D
4.A.1 LULUCF, Forest Land remaining Forest Land	CO <sub>2</sub>	CS, D, Tier 1-3	CS, D
4.A.2 LULUCF, Land converted to Forest Land	CO <sub>2</sub>	D, Tier 1-3	CS, D
4.B.2 LULUCF, Cropland remaining Cropland	CO <sub>2</sub>	D, Tier 1 - 2	CS, D
4.C.2 LULUCF, Land converted to Grassland	CO <sub>2</sub>	D, Tier 1-3	CS, D
4.G LULUCF, Harvested wood products	CO <sub>2</sub>	D	D
5.A.1 Waste, Managed waste disposal sites	CH <sub>4</sub>	Tier 2	CS, D
5.D.1 Waste, Domestic and commercial Waste Waters	CH <sub>4</sub>	Tier 1	CS, D

According to both analyses (Tier 1 and Tier 2), the most important key categories are from LULUCF sector. For 2012 submission the LULUCF sector was highly improved using the newest data from 2012 forest inventory and with additional support from experts from JRC and from EU support project. For the 2016 submission emissions and sinks in LULUCF have been further improved with the introduction of new land transition matrix.

The Energy and Industrial processes sectors have already largely improved with inclusion of big emitters in EU-ETS. The use of default EFs for liquid fuels, mostly fuel oil, represents the main deficiency. Due to the unavailability of resources needed to develop CS EF, the verification of default EFs have been made for the 2014 submission.

The Agriculture sector has also improved in the past but the larger improvements are related to the implementation of 2006 IPCC Guidelines. We will also try to obtain additional data to improve estimates of manure allocation. Unfortunately, methodologies for calculation of emissions from agricultural soils are not planned for further improvement. It has been assessed that resources (financial and personal) for determination of CS N<sub>2</sub>O EFs in this category are unreasonably high for the expected results.

We are planning to improve HFC emissions from Refrigeration and AC with regular updates of the data on stock. This can be regarded as an ongoing process and will probably lead to an improvement of the inventory.

**Table 1.5.3: Methodologies used for key categories according to the trend only in 2016**

IPCC Category	Gas	Methodology	EF and other parameters
1.A.1 Energy Industries, Liquid Fuels	CO <sub>2</sub>	Tier 1	D
1.A.3.b Road Transportation, LPG	CO <sub>2</sub>	Model	Model
1.A.3.b Road Transportation, Diesel	N <sub>2</sub> O	Model	Model
1.A.4 Other Sectors, Solid Fuels	CO <sub>2</sub>	Tier 1	D
1.A.4 Other Sectors, Solid Fuels	CH <sub>4</sub>	Tier 1	D
1.B.1.a Fugitive Emissions, Coal Mining and Handling	CO <sub>2</sub>	Tier 3	PS
1.B.1.a Fugitive Emissions, Other	CO <sub>2</sub>	Tier 3	PS
2.A.1 Industrial processes, Lime Production	CO <sub>2</sub>	Tier 3	PS
2.C.3 Industrial processes, Aluminium Production	PFC	Tier 3	PS
4.B.2 LULUCF, Land converted to Cropland	CO <sub>2</sub>	D, Tier 1 - 2	CS, D
4.B.2 LULUCF, Land converted to Grassland	CO <sub>2</sub>	D, Tier 1 - 2	CS, D

## 1.6 General Uncertainty Evaluation, Including Data on Overall Uncertainty for Inventory Totals

The combined uncertainty was derived from Tier 1 method. The uncertainties of individual activity data and emission factors are based on expert judgment or IPCC 2006 Guidelines. Since expert judgments of individual experts are at variance, the highest individual uncertainties have been taken into account. The total uncertainties have been derived both for Level Uncertainty as well as for Trend Uncertainty.

**Table 1.6.1: Uncertainty in 1986 and 2016 by sectors.**

	1986	2016
1A Energy	5.27%	2.73%
1B Fugitive	17.75%	34.43%
2 Industrial Processes/Product use	10.44%	22.12%
3 Agriculture	48.69%	51.82%
4 LULUCF	47.64%	25.34%
5 Waste	45.92%	29.28%
TOTAL COMBINED UNCERTAINTY	16.06%	12.95%
w/o LULUCF	6.98%	5.96%

TOTAL trend uncertainty (2016/1986) = 11.81% (2.67% w/o LULUCF).

The major part to the lower uncertainty in 2016 was contributed by the energy and LULUCF sector. Uncertainty in Industrial processes was higher than in 1986 due to the high uncertainty of F-gas estimates. The reason for higher uncertainty in agriculture sector is higher share of soil emissions where the same IPCC default EFs with large uncertainty have been used for the base year and for 2016 estimates.

Sectoral uncertainties are presented on Table 1.6.1 while more detailed data are included in the Annex 2 to the NIR.

## 1.7 General Assessment of Completeness

### Sources and sinks

All sources of direct GHG gases, included in the IPCC Guidelines, are covered by the inventory.

### Gases

All direct GHGs as well as the postulated precursor gases are covered by the Slovenian inventory.

### Geographic coverage

The geographic coverage is complete. No territory in Slovenia has been left uncovered by the inventory.

### Notation keys

#### NO (not occurring)

This notation key is used for activities or processes in a particular source or sink category that do not occur within a country. The highest number of source categories marked with NO is found in agriculture and LULUCF sector, but there are some in industrial processes and energy industries as well. In the CRF Reporter we were unable to fill some blank cells with the notation keys. We are waiting on upgrade of CRF Reporter, which will solve this issue. Until then please consider all blank cells in the CRF Tables as they were filled with "NO".

NE (not estimated):

There is no categories marked with NE.

IE (included elsewhere):

There are a few categories marked with IE because relevant data are not available on the reporting level but are included in other category. These sources are:

- GHG emissions from gas diesel oil and gasoline used in domestic navigation and fishing are included in road transport,
- All amounts of bio-diesel and bio-ethanol are reported in the road transport sector under cars,
- All N<sub>2</sub>O emissions from product use are reported under Medical application
- All GHG emissions from forest fires are reported under Forest land remaining Forest Land.

In addition notation key IE is used also for some categories in the LULUCF sector, when IPCC methodology requires that emissions are reported in the Agriculture sector. These sources are:

- Indirect N<sub>2</sub>O emissions from Managed soils (CRF table 4(IV)) are reported in the Agriculture sector under Agriculture Soils – Atmospheric Deposition
- Direct N<sub>2</sub>O emissions from M Mineralization/Immobilization from FL and GL converted to CL are reported under relevant category (3.D.1.5) under Agriculture Soils

NA (not applicable):

This notation key is used for activities in a given source/sink category that do not result in emissions or removals of a specific gas. Categories in the CRF for which “NA” is applicable are shaded so they do not need to be filled in.

C (confidential)

The Statistical law considering confidentiality is very strict in Slovenia. All data gathered by three or less reporting units is confidential. It is a good practise in national statistic that this boundary is even higher (five units). As Slovenia is a small country, almost all relevant categories from industrial processes sector and, to a lesser extent, from energy sector are also confidential. The confidentiality problem in activity data has been solved on individual level with each relevant plant. After 2005, verified reports from installations included in ETS have resolved this problem generally for most cases.

For 2018 submission we were rechecked all activity data considering confidentiality. It comes out that activity data on lead and zinc production are confidential and notation key C has been used in the categories 2C5 and 2C6 for AD. We will try to resolve this issue in the future.

## 2 TRENDS IN GREENHOUSE GAS EMISSIONS

### 2.1 Description and Interpretation of Emission Trends for Aggregated GHG emissions

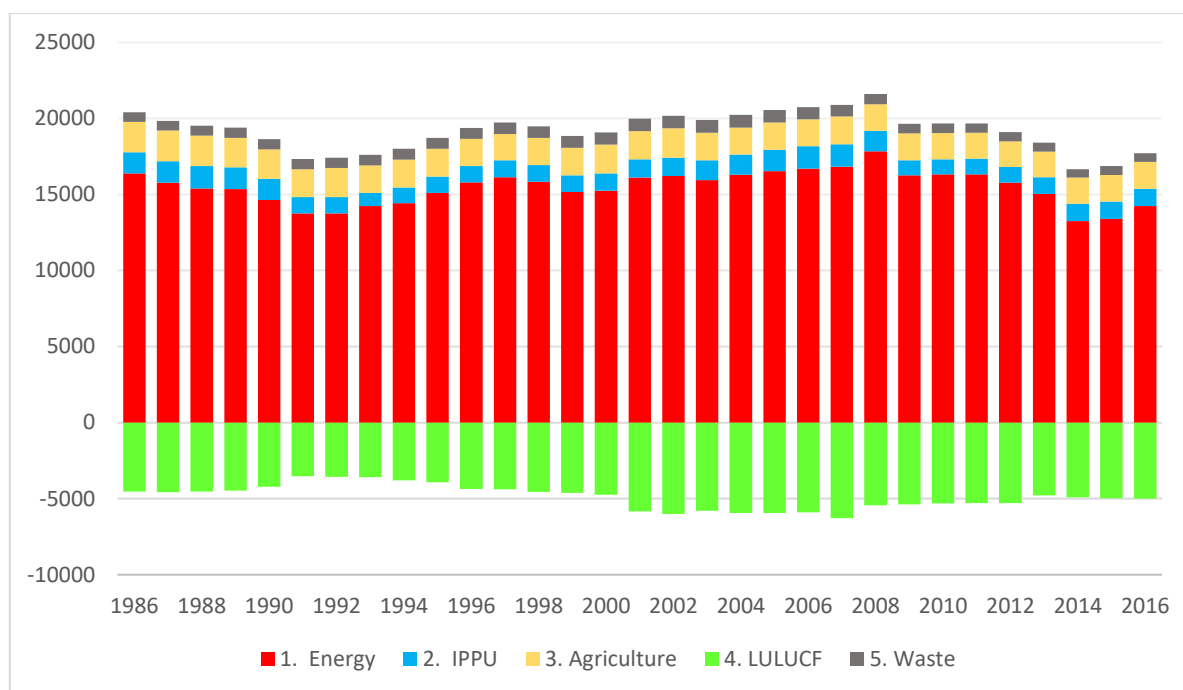
Total emissions of GHG in 2016, sinks not considered, amounted to 17,718 kt CO<sub>2</sub> eq., which represents a 13.1% decrease of emissions compared to the year 1986. In the period 1986-1991, a reduction of emissions was recorded due to the economic conditions at that time and the fact that the Republic of Slovenia was gaining its independence. In the period 1992-1997, a strong increase of emissions was recorded, which was a consequence of increasing economic growth and revival of industrial production. In the second half of that period, the increased emissions were a consequence of "gasoline tourism" (25% of the total sale of motor fuels in the Republic of Slovenia), since the prices of motor fuels in the Republic of Slovenia were appreciably lower than in the neighbouring countries.

In the period 1998-1999, emission decreased due to the measures undertaken by the neighbouring countries to curb the "gasoline tourism" and due to the increased supply of electrical energy from the Krško Nuclear Power Plant. In the period 2000-2002, the emission kept increasing again due to the renewal of the obligatory export of electrical energy from the Krško Nuclear Power Plant to the Republic of Croatia. After joining the EU in 2004 and after acceptance of Romania and Bulgaria into EU in 2007, emissions from road transport have increased drastically and have prevailed over the decrease in other sectors which has occurred due to the policies and measures in manufacturing industry, agriculture and waste sector. In 2009, emissions from fuel used and from industrial processes started to decrease due to the global financial crisis. In 2010 and 2011, emissions stayed almost the same as in 2009, while in the period 2012-2015 a further decrease has been observed. In 2016 emissions increase by 5.1% in comparison with 2015.

CO<sub>2</sub> emissions in 2016 represented 81.3% of overall emissions of greenhouse gases. CO<sub>2</sub> emissions excluding LULUCF followed the consumption of energy and with regard to their fraction exerted a major impact on total emissions. Compared to 1986, they decreased by 13.8% in 2016. CH<sub>4</sub> emissions represented 12.1% of total emissions in 2016 (12.5% in 1986) and were by 16.9% lower than in 1986. N<sub>2</sub>O emissions represented 4.4% of total emissions and were by 15.3% lower than N<sub>2</sub>O emissions in 1986. F-gases represent 2.2% of total emissions and some gases (HFCs and SF<sub>6</sub>) have shown significant increases since 1995 (base year for F-gases), while PFC decreased drastically in 2008 and has continued to decrease in 2009. Since then a slow increase of emissions was observed.

### 2.2 Description and Interpretation of Emission Trends by Sector

According to the UNFCCC Reporting Guidelines, emissions estimates are grouped into five IPCC categories: Energy, Industrial Processes and Product Use, Agriculture, Land Use, Land-Use Change and Forestry, and Waste (Figure 2.3.1 and Table 2.2.1).



**Figure 2.3.1: GHG Emissions in Slovenia by sector**

By far the most important sector is Energy, which in 2016 accounted for 80.4% of total GHG emissions. In this sector emissions have decreased by 13.3%, compared to the 1986. Within this sector, in the period 1986–2016, GHG emissions from the Energy Industry, as the biggest sub-sector, decreased by 27.9%. In the period 1999–2007, steep growth (+27.2%) has been recorded due to the increased consumption of electrical energy. Undoubtedly the greatest increase in GHG emissions was observed in the transport sector, by as much as 203.6% until 2008, due to the increase in road transportation, while emissions from other kinds of traffic slightly declined. In 2009 GHG emissions from transport decreased by 13.5% compared to 2008. The traffic emissions have further decreased by 1.1% in 2010, but increased again in 2011 by 8.2% and by 1.3% in 2012. Since then emissions started to decrease: in 2013 for 5.4%, in 2014 for 1.4%, and in 2015 for 0.5%. In 2016 a sharp increase has been observed by 6.9%. There was an appreciable reduction of GHGs from Manufacturing industry between 1986 and 2001 (-50.3%). After 2001, a stabilisation of emissions was observed until 2008. Due to the global financial crisis, emissions from Manufacturing industry and construction decreased in 2009 by 15.6%, in 2010 by 2.1%, in 2011 by 10.3%, in 2012 by 4.0%, in 2013 by 0.4%, and in 2015 by 3.6% compared to the previous year while in 2014 and 2016 a small increase have been recorded. Altogether since 2008 due to the economic crises emissions from manufacturing industries and construction have decreased by 31.2%.

Fugitive emissions from fuel represent only 2.8% of emissions in the sector and have decreased by 33.0% compared to emissions in 1986.

Since 1986, GHG emissions from Industrial Processes at first fell sharply to reach their lowest value in 1993, but then started to rise again and were in 2007 6.0% above 1986 level. Due to the global financial crises and lower industrial production, emissions in 2009 were 28.2% below the 1986 emissions but in the period 2010 – 2016 slowly increased by 13.3%. The

most important GHG of this sector was carbon dioxide, with 62.1% of emissions from this category, followed by HFCs with 31.2%, N<sub>2</sub>O with 3.4%, and PFC and SF<sub>6</sub> with 1.7% and 1.5%, respectively. In this sector, no CH<sub>4</sub> emissions have occurred since 2011. The main source of emissions is Mineral industry, of which the production of cement and lime alone contributed 35.7% of the emissions in this sector.

In Agriculture as the second most important sector, emissions in 2016 amounted to 1,777 Gg CO<sub>2</sub> eq, which represents 10.0% of all emissions. Agriculture represents the main source of methane and N<sub>2</sub>O emissions, namely 56.4% of all methane emissions and 70.0% of all N<sub>2</sub>O emissions. In the agricultural sector, N<sub>2</sub>O emissions accounted for 30.8% of emissions, and CH<sub>4</sub> emissions accounted for 68.1% of emissions, while CO<sub>2</sub> emissions accounted 1.2%. GHG emissions from agriculture show small oscillations for individual years, but the general trend is on the decrease. In 2016, emissions were 11.8% below the base year. The most important sub-sector represents emissions from enteric fermentation, which contributes 53.5% of all emissions from agriculture, followed by emissions from agricultural soils, with 25.1%; the rest is contributed by emissions of methane and N<sub>2</sub>O from animal manure (20.3%) while CO<sub>2</sub> emissions due to the liming and urea applications represent only 1.2% of emissions in this sector.

In the LULUCF sector, the CO<sub>2</sub> sink was estimated at 4,989.8 Gg CO<sub>2</sub> eq in 2016, which is 10.0% more than in 1986. The increase in sinks was primarily the result of an increase in timber growing stock in existing forests.

Methane emissions from the Waste sector are the second largest source of methane and represents 23.3% of all methane emissions in Slovenia in 2016. The fraction of methane emissions in this sector amounts to 88.3%, while the remaining part represent N<sub>2</sub>O (7.6%) and CO<sub>2</sub> emissions (4.2%). Solid waste handling contributes 62.8% to the total emissions from this sector, wastewater handling 30.8 %, incineration of waste 4.2% and composting 2.3%. Emissions in 2016 were 7.8% lower than in 1986 which is mainly due to the decrease in emissions from waste waters which are 27.4% lower than in the base year what is mostly due to recovery of gas in wastewater treatment plants and the decrease in industrial production. Emissions from solid waste disposal started decreasing in 2005 and since then emissions have decreased by 40.1%. In 2013 the emissions were the first time lower compared to the base year and in 2016 were lower by 4.4%.

**Table 2.2.1: GHG emissions and removals in Slovenia by sectors and sub-sectors 1986-2016.**

	1986	1990	1995	2000	2005	2010	2015	2016	Change to 1986	Change to 2015
<b>1. Energy</b>	<b>16.378</b>	<b>14.645</b>	<b>15.111</b>	<b>15.244</b>	<b>16.535</b>	<b>16.320</b>	<b>13,398</b>	<b>14,242</b>	<b>-13.0</b>	<b>6.3</b>
A. Fuel Combustion	15,787	14,136	14,626	14,774	16.011	15,800	13,029	13,846	-12.3	6.3
1. Energy Industries	6,841	6,375	5,725	5,594	6,448	6,340	4,562	4,935	-27.9	8.2
2. Man. Industries and Construction	4,458	3,150	2,633	2,276	2,485	1,916	1,591	1,592	-64.3	0.1
3. Transport	2,022	2,728	3,792	3,808	4,416	5,255	5,362	5,734	183.5	6.9
4. Other Sectors	2,424	1,851	2,478	3,100	2,629	2,289	1,510	1,581	-34.8	4.7
5. Other	41	32	1	3	3	3	4	4	-91.2	-1.7
B. Fugitive Emissions from Fuels	590	509	485	471	524	520	369	396	-33.0	7.2
1. Solid Fuels	548	459	440	423	472	472	334	358	-34.7	7.3
2. Oil and Natural Gas and other...	42	50	45	48	53	48	36	38	-10.9	6.3
<b>2. Industrial Processes</b>	<b>1,391</b>	<b>1,376</b>	<b>1,068</b>	<b>1,150</b>	<b>1,417</b>	<b>1,001</b>	<b>1,136</b>	<b>1,133</b>	<b>-18.6</b>	<b>-0.3</b>
A. Mineral Industry	743	695	543	599	636	479	453	432	-41.9	-4.6
B. Chemical Industry	81	70	80	100	119	75	48	49	-38.8	2.5
C. Metal Industry	471	551	374	334	425	127	208	218	-53.7	4.5
D. Non-energy products	8	8	7	14	25	12	24	24	201.7	1.7
E. Electronics industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes	NO	NO	35	47	153	260	347	354	100.0	2.0
G. Other product manufacture and use	89	52	29	56	60	47	55	55	-37.4	-0.1
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
<b>3. Agriculture</b>	<b>2,014</b>	<b>1,933</b>	<b>1,837</b>	<b>1,881</b>	<b>1,780</b>	<b>1,723</b>	<b>1,754</b>	<b>1,777</b>	<b>-11.8</b>	<b>1.3</b>
A. Enteric Fermentation	981	935	904	949	916	903	936	951	-3.0	1.7
B. Manure Management	509	498	431	414	389	358	353	360	-29.3	1.9
C. Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils	471	447	460	489	450	439	446	445	-5.4	-0.2
E. Prescribed Burning of Savannahs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agricultural Residues	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Liming	44	44	29	17	14	13	11	11	-74.7	3.3
H. Urea applications	9	9	12	12	12	11	9	9	4.1	8.2
I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO



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	1986	1990	1995	2000	2005	2010	2015	2016	Change to 1986	Change to 2015
4. Land Use, Land-Use Change and Forestry	-4,535	-4,210	-3,926	-4,746	-5,946	-5,317	-4,978	-4,990	10.0	0.2
A. Forest Land	-4,100	-4152	-3,880	-4,575	-5,997	-5,337	-5,094	-5,140	25.4	0.9
B. Cropland	31	23	-173	-194	-180	-175	-130	-127	-508.4	-2.4
C. Grassland	-423	-429	-323	-321	-104	-77	34	43	-110.3	28.4
D. Wetlands	3	3	2	1	6	24	26	26	788.4	0.4
E. Settlements	388	388	389	409	487	349	288	282	-27.2	-2.0
F. Other Land	14	14	20	10	17	21	21	22	56.0	3.1
G. Harvested wood products	-457	-67	28	-85	-185	-129	-129	-102	-77.7	-21.1
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Waste	614	673	713	799	817	621	572	566	-7.8	-1.1
A. Solid Waste Disposal	372	433	483	568	594	394	340	355	-4.4	4.4
B. Biological treatment of solid waste	NO	NO	NO	NO	3	5	12	13	100.0	2.7
C. Incineration and open burning of waste	2	2	1	3	3	7	27	24	1,077.6	-13.8
D. Waste water treatment and discharge	240	238	230	228	217	215	192	174	-27.4	-9.2
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

## Memo Items.

International Bunkers	59	49	58	69	130	133	283	461	687.7	62.9
Aviation	59	49	58	69	61	73	75	61	4.3	-18.3
Navigation	NO	NO	NO	NO	69	60	209	400	100.0	92.0
Multilateral Operations	NO	NO	NO	1	0	0	1	1	100.0	-0.1
CO <sub>2</sub> Emissions from Biomass	2,354	2,181	2,080	1,892	2,771	3,138	2,957	3,008	27.8	1.7
Long term storage of C in waste disposal sites	2,141	2,738	3,662	4,783	5,839	6,642	6,929	6,933	223.8	0.1
Total CO <sub>2</sub> Eq. Emissions without LULUCF	20,397	18,627	18,729	19,075	20,549	19,665	16,860	17,718	-13.1	5.1
Total CO <sub>2</sub> Eq. Emissions with LULUCF	15,862	14,418	14,803	14,329	14,603	14,347	11,882	12,728	-19.8	7.1

## 2.3 Description and Interpretation of Emission Trends for Indirect GHGs and SO<sub>2</sub>

The largest sources of emissions of NO<sub>x</sub> is transport followed by combustion in energy industries. The road transport sector is the sector contributing the most to the emission of NO<sub>x</sub>, in 2016 53% of the Slovenian emissions of NO<sub>x</sub>. The total emissions have decreased by 48% from 1990 to 2016. The largest reduction of emissions has occurred in the road transport sector due to the fitting of three-way catalysts to petrol fuelled vehicles. The reduction has been achieved also due to installation of low-NO<sub>x</sub> burners and denitrifying units in power plants and district heating plants.

CO emissions have decreased between 1990 and 2016 by 64%. CO is mainly emitted from incomplete combustion. Small combustion is responsible for the dominant share of the total CO emissions in the residential sector. Also transport contributes significantly to the total emission of this pollutant. Emission reduction of CO is mainly a result of introduction of vehicle meeting higher emission standards.

The emissions of NMVOC can be divided into two main groups: incomplete combustion and evaporation. They originate from many different sources. The main contributor of NMVOC in the year 2015 was industrial processes and product use, followed by small combustion. Emissions of NMVOC have decreased from 1990 to 2016 by 52%. The decline in emissions has primarily been due to reductions achieved in the road transport sector due to the introduction of vehicle catalytic converters and carbon canisters on gasoline cars for evaporative emission control. The reductions in NMVOC emissions have been enhanced by the switching from petrol to diesel cars and changes in the solvents and product use sector as a result of the introduction of legislative measures limiting the use and emissions of solvents.

The main part of the SO<sub>x</sub> emission originates from combustion of fossil fuels, mainly coal and oil in public power plants and district heating plants. From 1990 to 2016, the total emission decreased by 97%. The large reduction is largely due to installation of desulphurisation process in the plant, use of fuels with lower content of sulphur in public power and district heating plants, introduction of liquid fuels with lower content of sulphur and substitution of high-sulphur solid and liquid fuels to low-sulphur fuels such as natural gas.

In the Table 2.3.1, emissions of pollutants are presented. The data are slightly different from the data reported in the CRF tables because emissions from international aviation are not included in the national total in GHG inventory. The SO<sub>2</sub> emissions from copper production are missing in the CRF Tables.

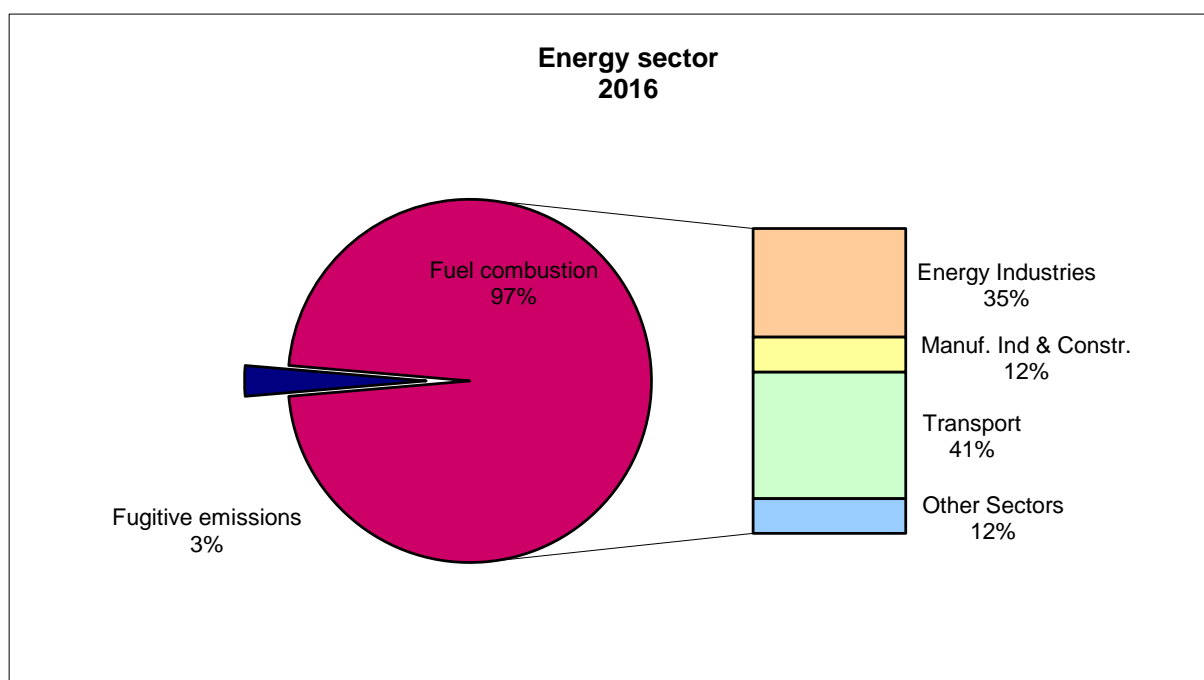
**Table 2.3.1: Emissions of CO, NO<sub>x</sub>, NMVOC and SO<sub>2</sub> (kt)**

	1990	1995	2000	2005	2010	2015	2016	Change
NO <sub>x</sub>	72.2	72.7	59.9	56.2	49.5	36.3	37.2	-48.5
CO	306.0	278.1	182.4	150.0	131.2	107.4	110.0	-64.1
NMVOC	64.2	62.0	51.9	43.3	37.2	30.3	30.7	.52.2
SO <sub>2</sub>	201.1	115.5	63.1	17.2	10.8	5.7	5.1	-97.5

### 3 ENERGY (CRF sector 1)

#### 3.1 Overview over the Sector

The energy sector is the most important sector of GHG emissions in the Republic of Slovenia, since it accounted for 80.4% of overall CO<sub>2</sub> eq. emissions (w/o considering LULUCF) in 2016. Emissions from this sector arise from fuel combustion, accounting for 97.2% emissions from the energy sector, and as fugitive emissions from fuels, accounting for 2.8% of emissions (Figure 3.1.1).



**Figure 3.1.1: Emissions of GHG in Energy Sector by categories in 2016**

Emissions from Energy sector are presented on the Table 3.1.1. Compared to 2015, GHG emissions increased by 6.3% in 2016 but were 13.0% lower than in the 1986 base year.

Until 2014 Energy Industries was the most important sub-sector, while in 2014 a strong decrease of emissions (-23%) was observed. This happened because one thermal power plant was closed in 2014. The most important category in this sector is a production of electricity and heat (IPCC 1.A.1.a). Emissions from this category vary in accordance with the production of electrical energy. It has to be taken into consideration that in the Republic of Slovenia in 2016, 4.7 TWh (i.e. 30.4%) of electrical energy was produced in public hydroelectric power plants, 5.4 TWh (i.e. 34.9%) in the Krško Nuclear Power Plant, 5.1 TWh in thermal power plants (i.e. 32.9%), while the remaining 0.3TWh (i.e. 1.7%) was produced using wind or solar energy. The structure changes slightly from year to year, depending mostly on the changes in the hydrology of Slovenian rivers.

Within this sector, in the period 1986–2016, GHG emissions from the Energy Industry, as the biggest sub-sector, decreased by 27.9%.

In 2014 with 40.6% share a transport sector became the most important source of fuel combustion emissions and was the most important also in 2016 with 41.0% share. For traffic, virtually all emissions are accounted for by road traffic and within this category the growth of the fraction of emissions from goods transport is particularly noticeable, since the goods transport in transit through Slovenia has been, annually increasing by more than 10% since 2000. Due to the recession, the emissions in 2009 decreased drastically and remained almost the same in 2010, while in 2011 the emissions increased by 8.2% compared to previous year and by 1.3% in 2012. Since then emissions decrease again in 2013 for 5.4%, and in 2014 for 1.4%. In 2016 emissions from transport was 6.9% higher as in the previous year and as much as 183.5% higher as in 1986.

There was an appreciable reduction of GHG emissions from industry between 1986 and 2001 (-50.3%). After 2001, a stabilisation of emissions was observed until 2008. Due to the global financial crisis, emissions from Manufacturing industry and construction decreased in 2009 by 15.6%, in 2010 by 1.2%, in 2011 by 10.3%, in 2012 by 4.0%; altogether since 2008 due to the economic crises emissions from manufacturing industries and construction have decreased by 28.8%. In 2013 and 2014 a stabilisation of emissions is observed. Altogether since 2008 mostly due to the economic crises emissions from manufacturing industries and construction have decreased by 31.2% and were in 2016 by 64.3% lower than in 1986.

In the CRF category Other sectors, which accounts for 11.4% of emissions, Residential sector prevails. Mainly due to increasing use of biomass for heating the GHG emissions from this sector decreased by 34.8% since 1986.

Very small emissions (0.03%) have been reported under "Other" and are related to the military use of fuel.

**Table 3.1.1: Emissions from Energy sector by sources in kt CO<sub>2</sub> eq.**

	1986	1990	1995	2000	2005	2010	2015	2016
<b>1. Energy</b>	<b>16,378</b>	<b>14,645</b>	<b>15,111</b>	<b>15,244</b>	<b>16,535</b>	<b>16,320</b>	<b>13,398</b>	<b>14,242</b>
A. Fuel Combustion	15,787	14,136	14,626	14,774	16,011	15,800	13,029	13,846
1. Energy Industries	6,841	6,375	5,725	5,594	6,448	6,340	4,562	4,935
2. Manufac. Ind. and Const.	4,458	3,150	2,633	2,276	2,485	1,916	1,591	1,592
3. Transport	2,022	2,728	3,792	3,808	4,416	5,255	5,362	5,734
4. Other Sectors	2,424	1,851	2,478	3,100	2,629	2,289	1,510	1,581
5. Other	41	32	1	3	3	3	4	4
B. Fugitive Emissions	590	509	485	471	524	520	369	396
1. Solid Fuels	548	459	440	423	472	472	334	358
2. Oil and Natural Gas	42	50	45	48	53	48	36	38

Fugitive emissions in the Republic of Slovenia are of minor importance thus they represent only 2.8% of emissions in the sector and have decreased by 33.0% compare to emissions in 1986. The biggest fraction (90.5%) of GHG emissions from this sector are emissions of carbon dioxide and methane from mining of coal in underground mines. Since base year emissions constantly diminished due to ever-smaller excavation of coal until 2001, when they were stabilized. In the last three years emissions decreased due to the closure of one smaller

coal mine. Since 1992 CO<sub>2</sub> emissions from flue gas desulphurisation (SO<sub>2</sub> scrubbing) are also included in Fugitive emissions under 1.B.1.c Other.

CO<sub>2</sub> emissions from biomass were also computed, but were not included in the calculation of CO<sub>2</sub> emissions; however, all other greenhouse gases (CH<sub>4</sub>, N<sub>2</sub>O) were included in accordance with the IPCC methodology.

### 3.2 Fuel Combustion (CRF 1A)

In Fuel Combustion sector, mainly national/plant specific CO<sub>2</sub> emission factors were used for assessment of the majority emissions from solid fuels, petroleum coke, natural gas and some waste (Tier 2/3), while default IPCC emission factors were used for other fuels. The quantities of fuels and consumed fuel energy values were taken from the SORS. Additional data on the energy use of some types of waste (waste tyres, oils and solvents) were acquired from the verified ETS reports. Data on fuel consumption in agriculture and forestry refer to mobile sources only, while the rest of the fuel consumption of this category is included in the Institutional and commercial sector. GHG emissions from road transport were determined with the COPERT 4 model using default EFs from the model.

#### Country specific CO<sub>2</sub> EF for domestic lignite

With regard to the need to upgrade GHG emissions inventories, national CO<sub>2</sub> emission factors for domestic lignite were developed in 2004. CO<sub>2</sub> emission factors were obtained on the basis of determined carbon contents in the fuel. Data on carbon content in the fuel for the years before 2005 are available only for the biggest pit in Slovenia, the Velenje Lignite Pit. The carbon content of lignite was verified by supplementary chemical analyses of coal samples from this pit in an accredited laboratory in accordance with EN ISO 17025. Additional information is available in the publication from The Milan Vidmar Electric Power Institute, National CO<sub>2</sub> emission factor for lignite from Velenje coalmine; A Review of the Ultimate Analysis of lignite, 2004. Since 2005 the data on carbon content from EU ETS is available what enable the development of country specific and plant specific CO<sub>2</sub> EF for all types of solid fuels.

In the Table 3.2.1 and Figure 3.2.1 the national CO<sub>2</sub> emission factors used for domestic lignite are presented while all other country specific or plant specific CO<sub>2</sub> emission factors for solid fuels are presented under relevant subchapters.

**Table 3.2.1: National CO<sub>2</sub> EFs for domestic lignite from Velenje pit in t CO<sub>2</sub>/TJ.**

1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
109.95	109.25	111.89	107.76	106.98	101.84	101.06	101.48	101.69	100.99
1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
101.85	101.82	99.54	100.21	102.56	106.71	105.44	104.90	105.85	105.78
2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
104.18	106.16	105.64	104.76	104.52	104.48	105.12	103.26	104.75	103.21
2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
103.63									

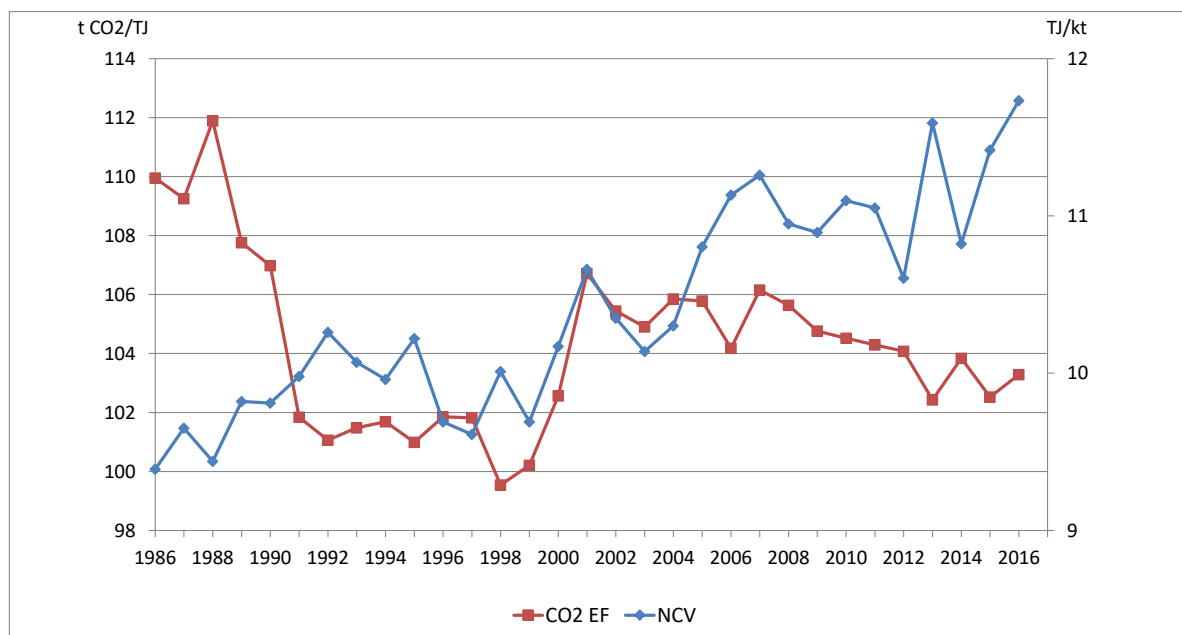


Figure 3.2.1: CO<sub>2</sub> EF and NCV for domestic lignite from Velenje pit for 1986-2016.

### **Country specific CO<sub>2</sub> EF for natural gas**

We have used slightly modified emission factors also for natural gas. CO<sub>2</sub> emission factors were obtained on the basis of the determined carbon contents in the fuel. Detailed results are in the study from 1998, which is available only in Slovene language (Gasperič M, Dornik M.: Določitev emisijskega faktorja CO<sub>2</sub> pri energetski izrabi zemeljskega plina). Because in the study of 1998 only yearly values until 1996 are available, we have used yearly values for the period 1986-1996 and 1996 value for the years since then.

We were planning to obtain data about chemical composition of natural gas used in Slovenia for the period after 1996, calculate actual values of EFs and recalculate emissions back to 1997. Unfortunately, data on chemical composition are not available any more. The natural gas distributor (Geoplin Plinovodi) is not interested in such data and they believe that chemical composition is not changing a lot between the years. The main supplier of natural gas is Russia, while approximately one third of natural gas comes from Algeria. CO<sub>2</sub> emission factors between the years differ for around 0.1% and because composition data from the company are not available, we believe that implementation of regular sampling and analyzing in an accredited laboratory would introduce unreasonable costs. In the Table 3.2.2 a national CO<sub>2</sub> emission factor for natural gas is presented.

Table 3.2.2: National CO<sub>2</sub> EFs for combustion of natural gas in t CO<sub>2</sub>/TJ.

1986-1991	1992	1993	1994	1995	Since 1996
55.332	55.321	55.477	55.389	55.282	55.291

### **Oxidation factor**

Unless otherwise stated we have used default oxidation factors 1 as recommended in the IPCC 2006 Guidelines for all types of fuel. The plant specific oxidation factors which have

been used in very limited cases are available since 2010 from EU ETS database and are presented under relevant sub-chapters/categories.

### Sources of data

An interesting feature of inventories of greenhouse gases for Slovenia is the fact that the chosen base year 1986 goes back to the time when Slovenia was still a part of Yugoslavia. Notwithstanding this fact, at that time Slovenia already had its own electrical energy statistics and annual reports, which have been published annually without any interruptions ever since 1955. Due to the stable functioning system of data collection and economic conditions (no commercially sensitive data) it is correct to say that the energy statistics in particular was exceptionally good and centralized, and the data reliable and trustworthy.

The number of key reporting units prior to 1992 was exceptionally small, since only one enterprise imported natural gas, two enterprises refined petroleum products, while coal import was transacted within the framework of three thermal power plants.

The main source of data for Fuel consumption for all sectors in the Republic of Slovenia for the period 1986-2003 is LEG – Annual Energy Statistics of the Energy Sector of the Republic of Slovenia. As LEG was not published early enough to enable us to calculate GHG inventory on time in 2005, we had received data directly from Statistical Office of the Republic of Slovenia (SORS) in electronic format before they were published for our first calculation.

After 2007, LEG is not published anymore. Since 2005 the verified reports from ETS have also been used.

In addition, SORS also provides us data in Joint questionnaires used mostly for RA and QA/QC. The following files with data for 2015 have been received from the SORS:

**E1L-16-arso** – fuel consumption in public power plants

**E2L-16-arso** – fuel consumption in auto producers

**E2LP-16-arso** – fuel consumption in cogeneration plants

**E3L-16-arso** – fuel consumption in public heat

**epel\_arso16\_NACE2008.xls** – fuel consumption in mining, manufacturing industry and construction

**ZBIRNA E8-E12 ARSO 2016.xls** – data on energy balance

#### Joint questionnaires:

ENERGY\_NTGAS\_A\_SI\_2016 - gaseous fuel

ENERGY\_PETRO\_A\_SI\_2016 - liquid fuel

ENERGY\_RENEW\_A\_SI\_2016 - other fuel

ENERGY\_SOLID\_A\_SI\_2016 - solid fuel

### 3.2.1 Comparison of the Sectoral Approach with the Reference Approach

The total difference of CO<sub>2</sub> emissions between the sectoral approach and the reference approach in 2016 amounted to 3.5 per cent related to the energy consumption (Table 3.2.3) and to 0.2 per cent related to the CO<sub>2</sub> emissions (Table 3.2.4). For reference approach mostly the same data has been used as reported in the Joint questionnaires to IEA. The main disadvantage of these data is that fuel is rounded to 1000 tonnes.

The large difference in consumption of other fossil fuels is due to the fact that in the national statistics the fraction of biomass in waste is not excluded from other fossil fuels.

In the Annex 4 to the NIR the data on Slovenian energy balance for 2016 is presented as reported to the Eurostat in the Joint questionnaires (Tables A4.1-A4.4). In the Table A4.5 the data from RA and EB are compared and all differences are explained.

**Table 3.2.3: Differences in energy consumption, % (Reference approach/National Approach)**

Fuels	1986	1990	1995	2000	2005	2010	2015	2016
Liquid	-2.05	2.83	1.82	-0.07	2.27	1.43	3.79	6.07
Solid	0.24	1.76	0.32	1.18	-0.50	0.08	1.35	-0.07
Gaseous	4.46	-4.97	-2.65	-0.50	0.63	-0.01	0.00	0.01
Other fossil	NA	NA	NA	-90.91	16.46	-24.24	24.52	23.74
<b>Total</b>	<b>-0.02</b>	<b>0.94</b>	<b>0.62</b>	<b>0.17</b>	<b>1.14</b>	<b>0.52</b>	<b>2.68</b>	<b>3.53</b>

**Table 3.2.4: Differences in CO<sub>2</sub> emissions, % (Reference approach/National Approach)**

Fuels	1986	1990	1995	2000	2005	2010	2015	2016
Liquid	-1.72	-3.75	6.15	-3.12	-1.57	-0.21	-0.24	-0.24
Solid	0.24	1.84	0.27	0.88	-0.94	-2.20	-0.25	-0.35
Gaseous	-4.03	-8.26	-0.51	0.33	0.61	-0.49	-0.01	-0.00
Other fossil	NA	NA	NA	-84.22	159.75	55.11	53.89	51.58
<b>Total</b>	<b>-0.83</b>	<b>-1.55</b>	<b>2.98</b>	<b>-1.22</b>	<b>-0.74</b>	<b>-0.11</b>	<b>0.24</b>	<b>0.18</b>

From 1986 to 2006, the terminology in Statistical publications underwent some changes, since after 1991 "Sale to other republics" became „Export“, while „Purchase from other republics“ became „Import“. The terminology related to coal remains somewhat special.

In national publications, "Lignite" is used only for coal excavated in the pit of Velenje. The coal from other pits is entered as „brown coal“ in spite of virtually the same net calorific value (NCV). This brown coal is combined with imported coals that have a considerably higher net calorific value and, in terms of methodology, truly belong to brown coals. To avoid erroneous interpretations in international comparisons of inventories, we have decided to combine the entire production of domestic coal in the CRF table 1.A(b) – Sectoral background data for Energy (Reference Approach) on the basis of net calorific value under „Lignite“.



### 3.2.2 International Bunker Fuels

#### International navigation

Slovenia has only one international port “Luka Koper”, but in the period 1986-2004 no ships were refuelled in that port (mostly the ships were refuelled in the international waters by Italian ships under Panama flags). Since 2005, a small amount of heavy fuel oil has been reported as fuel sold to the international marine bunkers.

Method: Tier 1

Source for AD (amount of heavy fuel oil and NCV): SORS.

Source for EFs: default values from 2006 IPCC Guidelines, Vol. 2. Table 3.5.2 and 3.5.3

The amount of fuel and the corresponding emissions are presented on the table 3.2.5.

**Table 3.2.5: International Navigation Bunkers – fuel used in TJ and GHG emissions in kt CO<sub>2</sub> eq.**

	2005	2010	2011	2012	2013	2014	2015	2016
<b>fuel in TJ</b>	880	768	1354	2096	2586	2383	2668	5122
<b>kt CO<sub>2</sub> eq.</b>	69	60	106	164	202	186	209	400

#### International aviation

In the past the entire consumption of jet kerosene was considered aviation bunker fuel since there were no commercial domestic flights in Slovenia. Following recommendation from ERT since 2008, data about jet kerosene used in Slovenian Army and Police have been obtained and belonging emissions have been excluded from international aviation bunkers and included in 1.A.5.b Other/Mobile. These data are not available for the period 1986-2007. Following the recommendation from ARR 2011, the fuel used in Slovenian army and Police has been estimated using correlation with the number of aircrafts in the Slovenian army. For estimating emissions in the period 1986-1990/91, when Slovenia was still part of Yugoslavia, the fuel used for the international aviation was estimated taking into account a correlation with the number of passengers, and the remaining amount of jet-kerosene was counted as fuel used in the Yugoslavian army over the Slovenian territory.

According to the Eurocontrol data a small amount of jet kerosene has been used since 2006 in domestic aviation. After investigation it was found that this fuel has been used for reallocation of airplanes between the two largest airports. Corresponding GHG emissions have been reallocated from international aviation to domestic aviation accordingly.

Use of jet kerosene in different CRF categories in 2016 is presented in the Table 3.2.6.

**Table 3.2.6: Consumption of jet kerosene in 2016 in different CRF categories.**

Jet kerosene	2016	unit	2016	unit
1A3a Domestic navigation	175	t	7.6	TJ
1A5b Military use of fuel	925	t	50.4	TJ
Memo – international aviation	19,463	t	847.5	TJ
Memo – multilateral operation	163	t	7.1	TJ
<b>Total</b>	<b>20,960</b>	<b>t</b>	<b>912.6</b>	<b>TJ</b>

According to the Eurocontrol data a small amount of jet kerosene has been used since 2006 in domestic aviation. After investigation it was found that this fuel has been used for reallocation of airplanes between the two largest airports. Corresponding GHG emissions have been reallocated from international aviation to domestic aviation accordingly.

In spite of negligible quantities of emissions, the entire consumption of aviation gasoline for piston engine aircraft was counted as consumption and emission in Slovenia, since it was assumed that this was fuel for a small aircraft, which flies between smaller regional airports in Slovenia.

Method: Tier 1

Source for AD: SORS, Slovenian Army and Police

Source for EFs: default values from 2006 IPCC Guidelines, Vol.2, Table 3.6.4 and 3.6.5

In the table 3.2.7 the fuel used in international aviation bunkers and corresponding emissions are presented.

**Table 3.2.7: International Aviation Bunkers – fuel used in TJ and GHG emissions in kt CO<sub>2</sub> eq.**

	1986	1990	1995	2000	2005	2010	2015	2016
<b>fuel in TJ</b>	812	684	799	962	852	1017	1037	847
<b>kt CO<sub>2</sub> eq.</b>	59	49	58	69	61	73	75	61

### **Multilateral operations**

The jet kerosene used in Slovenian Army and Police have been excluded from international aviation bunkers and included in 1.A.5.b Other/Mobile. An exception has been the fuel consumption on international missions since 1997 (Kosovo, Afghanistan...), which has been included in 1.C.2 Multilateral operations. Information about Slovenian cooperation in international operations is available on the following web page:

<http://www.slovenskavojska.si/en/international-cooperation/international-operations-and-missions/>

Method: Tier 1

Source for AD: SORS, Slovenian Army and Police

Source for EFs: default values from 2006 IPCC Guidelines. Table 3.6.4 and 3.6.5

In the table 3.2.8 the fuel used in the multilateral operations and corresponding emissions are presented.

**Table 3.2.8: Multilateral operations - – fuel used in TJ and GHG emissions in kt CO<sub>2</sub> eq.**

	1997	2000	2005	2010	2015	2016
<b>fuel in TJ</b>	3	7	6	5	7	7
<b>kt CO<sub>2</sub> eq.</b>	0.2	0.5	0.4	0.4	0.5	0.5

Emissions from the army are also included in road transportation (diesel), in Institutional sector (heating oil) and in civil aviation (aviation gasoline).

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### 3.2.3 Feedstock and Non-Energy Use of Fuels

#### Natural gas

Source of activity: from 1985 to 1995 Statistical office, LPI  
 from 1995 to 1996, Statistical office, DGP  
 from 1997 to 2003 LEG, Table Tg/6-3  
 since 2004 in SORS excel files and JQ

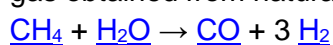


**Figure 3.2.2: Methanol production in Nafta-Petrochem Lendava.**

The biggest fraction of non-energy usage of fuels was the consumption of natural gas for the production of methanol, amounting to 89,475 Sm<sup>3</sup> of natural gas in 2010, when this production stopped, and there has been no methanol production in Slovenia since 2011.

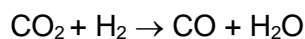
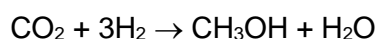
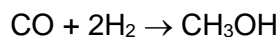
Natural gas was entirely used as the raw material for transformation into methanol. In every cycle only a fifth of it is transformed to the product, while the remaining natural gas is returned into the process. The schematic diagram of the process is shown in the Figure 3.2.3.

In Slovenia, low-pressure Lurgi technology is used. The methanol is produced from synthesis gas obtained from natural gas and steam in reactor.



This reaction, commonly called steam-methane reforming or SMR, is endothermic and the heat transfer limitations place limits on the size of the catalytic reactors used. The carbon monoxide and hydrogen then react on a second catalyst to produce methanol.

The exothermal methanol reactor with three main reactions:



is operated at high pressure and unconverted gas is recycled.

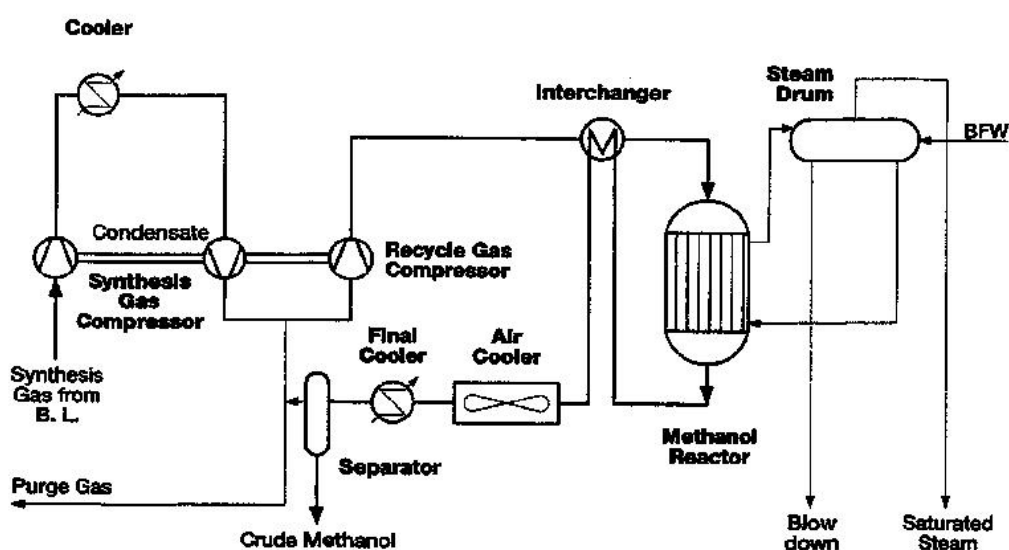


Figure 3.2.3: Schematic diagram of methanol production.

Stored CO<sub>2</sub> has been calculated on the basis of the formula from IPCC guidelines. We have assumed that all methane used for methanol production is stored in the product or in CO in emitted gas. This fact was confirmed also by expert from the company Nafta-Petrochem.

The amount of stored CO<sub>2</sub> is presented in the table 3.2.9.

Table 3.2.9: Non-energy use of natural gas

	unit	1986	1990	1995	2000	2005	2010	2015	2016
Natural Gas	1000 m <sup>3</sup>	67666	69524	91577	136740	164407	97004	6176	6701
Fraction of C stored		1	1	1	1	1	1	1	1
Carbon EF	t C/TJ	15,075	15,075	15,075	15,075	15,075	15,079	15,079	15,079
Stored CO <sub>2</sub>	kt	125.3	131.0	172.6	257.6	292.4	190.3	11.6	12.6

The remaining amount of non-energy use of natural gas is used in the chemical industry also as a raw material for production of organic and inorganic chemicals and plastics. The detailed data on non-energy use of natural gas are presented in the Table 3.2.10.

**Table 3.2.10: Non-energy use of natural gas for different products.**

	unit	2005	2010	2011	2012	2015	2016
Methanol prod.	1000 Sm <sup>3</sup>	145,903	89,475	0	0	0	0
Other org. chem.	1000 Sm <sup>3</sup>	410	0	0	0	0	0
Inorganic chem.	1000 Sm <sup>3</sup>	8,314	7,465	6,164	5,305	5,765	6,695
Rubber and Plastics	1000 Sm <sup>3</sup>	590	64	0	0	0	0
Other	1000 Sm <sup>3</sup>	0	0	0	0	411	6
Total	1000 Sm <sup>3</sup>	155,217	97,004	6,164	5,305	6,176	6,701
Total	TJ	5,290	3,306	210	181	210	229

### **Oil and Lubricants**

According to the Statistical data all lubricants in Slovenia have been used for non-energy purpose only. Data about different types of use are not available. Likely, the largest applications for lubricants are in the form of motor oil. After the end of use, the lubricants which have been used in the engines are collected and mostly used as a fuel. Lubricants reported in the different sectors are presented in the table 3.2.11.

**Table 3.2.11: Oil and Lubricants**

	unit	1986	1990	1995	2000	2005	2010	2015	2016
Apparent consumption	kt	6.6	7.2	4.2	11	28	12	27	29
Road transport	kt	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
IPPU	kt	6.5	7.1	4.1	10.9	27.9	11.9	26.9	29

In the line with the IPCC methodology emissions from lubricants used in the 2-stroke engines are reported in energy sector under road transport, while other emissions from lubricants are reported in the IPPU sector.

The remaining amount of lubricants which is not combusted or oxidised during use is collected as waste oil. Slovenia has been adhering to the basic system of collection, recovery and disposal of waste oil since 1998. The main foci and provisions regarding the programme of waste oil management are stipulated in our legislation, in particular in the Decree on the disposal of waste oils, which is harmonized with the EU directive on the disposal of waste oils. Producers of waste oil are obliged to deliver the oil to collection services. Each collector must have a collection centre and must ensure either recovery or disposal of waste oils. Recovery is the preferred choice, if technically feasible and if its cost is not unreasonably higher than the cost of disposal. One of the forms of recovery is the utilisation of waste oils for energy – co-incineration in accordance with recovery procedure R1. Records by the SEA show that most waste oils have been used for this purpose. The only evidence of such a use is in the cement production. Emissions are already included in the inventory and are reported in the CRF tables in “1.A.2.g.viii Manufacturing industry and construction/Other industries under other fossil fuels”.

A small portion of collected waste oils has also been incinerated (procedure R9) or reformed and then reused (procedure D10). We reported these emissions in waste sector under waste

incineration in submission 2010 for the first time. No other use of lubricants as a fuel has been recorded in Slovenia until now.

The data on import and export as well as data from waste oil combusted in the industry have been obtained from SORS while the data on incineration of waste oils are from SEA.

Stored CO<sub>2</sub> has been calculated on the basis of the formula 6.4 from 2006, IPCC Guidelines, Vol. 2, Ch.6 Reference Approach.

### **Other fuels**

Coke and petroleum coke, used in industry as reduction agent or feedstock, have been subtracted from energy sector and emissions from these fuels are presented in industrial processes sector.

Before 1997, amount of coke, used for production of iron and steel, ferroalloys and carbide was reported as fuel consumption in relevant sectors. After 1997, this fuel started to be collected separately, but it took a while that all non-energy used fuel was reported correctly. Energy and non-energy use of fuels in industry have been presented separately in statistical data since 2000.

To avoid double counting we have subtracted all coke used in iron and steel, ferroalloys and carbide production from energy sector except coke in iron production in the base year 1986. In that time, pig iron was still produced and disaggregated into the consumption of fuel as an additive. Thus the consumption of fuel as an energy product was impossible. For consumption of coke, the decision was taken to attribute all coke, which is consumed in the production of iron and steel in this year, to the energy sector as fuel consumption and no emissions from coke used in iron and steel production are presented in industrial processes.

There are also other uses of fuel in chemical processes not emitting any GHGs, therefore no explanation is included in the CRF tables. In 2016, a small amount of fuel oil, LPG and white spirit was used, mostly for production of lacquers, paintings and other coatings. The same is valid also for bitumen which is used for road paving and for production of roofing material and during this use no GHG emissions are occurring.

### 3.2.4 Energy industries (CRF 1A1)

#### 3.2.4.1 Category description

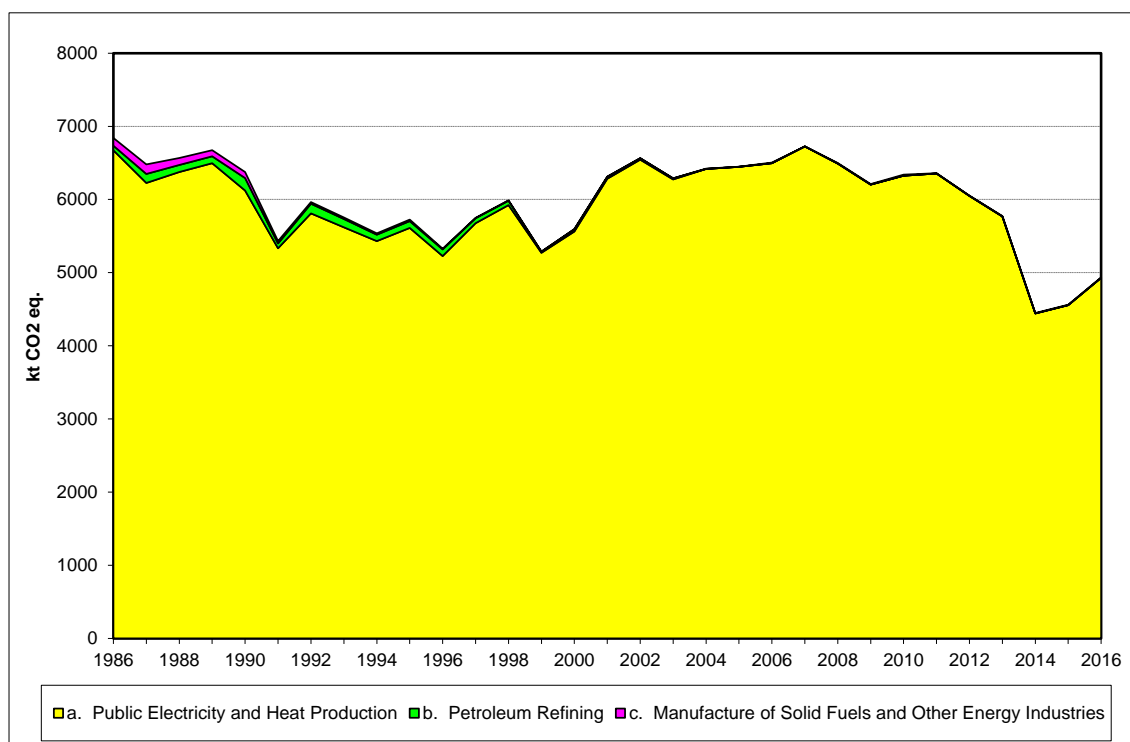
This chapter presents the consumption of fuels and emissions of greenhouse gases in:

- Public Electricity and Heat Production (CRF 1A1a)
- Petroleum Refining (CRF 1A1b)
- Manufacture of solid fuels and Other Energy Industries (CRF 1A1c)

Overview of the methods and EFs used as well as an indication whether a category is a key are presented in the Table 3.2.12 below.

**Table 3.2.12: Method, EF used and key categories indications for the year 2015 in Energy industries.**

	CO <sub>2</sub>			CH <sub>4</sub>			N <sub>2</sub> O		
Fuel type	Method	EF	Key category	Method	EF	Key category	Method	EF	Key category
solid	T3	PS	L, T	T1	D	-	T1	D	-
liquid	T1	D	T	T1	D	-	T1	D	-
gaseous	T2	CS	L, Tsub	T1	D	-	T1	D	-
biomass	T1	D	-	T1	D	-	T1	D	-
other	T1	D	-	T1	D	-	T1	D	-



**Figure 3.2.4: GHG emissions from Energy Industries in kt CO<sub>2</sub> equivalents.**

Public electricity and heat production is the most important category in this sub-sector with 97.5% share in the base year and almost 100% share in 2016. Other two categories consist mainly of fuel consumption in one refinery (closed in 2004) and in fuel consumption for coal mining activities and gas extraction. Emissions are presented on Figure 3.2.4 and in the Table 3.2.13.

**Table 3.2.13: GHG emissions from Energy Industries in kt CO<sub>2</sub> eq.**

	1986	1990	1995	2000	2005	2010	2015	2016
1. Energy Industries	6841	6375	5725	5594	6448	6340	4562	4935
a. Public Electricity and Heat Production	6672	6122	5611	5562	6447	6325	4556	4929
b. Petroleum Refining	63	170	93	32	0	0	0	0
c. Manufacture of Solid Fuels and Other...	106	82	21	0	2	14	6	6

### 3.2.4.2 Methodological issues

To estimate emissions from Energy industries the following methodology has been adopted:

$$\text{Emissions} = \text{Quantity of Fuel Combusted} \times \text{NCV} \times \text{EF per energy of Fuel} \times \text{OF}$$

In the most cases oxidation factor is 1 except in two thermal power plants. (see chapter 3.2.4.2.1 below).

#### **Activity data**

The main source of data for all energy industries in the Republic of Slovenia for the period 1986-2003 is LEG – Annual Energy Statistics of the Energy Sector of the Republic of Slovenia. As LEG was not published early enough to enable us to calculate GHG inventory on time in 2005, we had received data for the first inventory directly from SORS in electronic format before they were published. This excel sheets are going to be our source of data for all fuel consumption in the future. Since 2005, the verified reports from ETS have been used for solid fuel from 3 power plants.

Data on fuel consumption by type and year are reported in the Annex 3 to the NIR.

#### **Net calorific values**

Net calorific values have been taken from SORS (Table 3.2.14) except for solid fuels. Since 2005 all three thermal power plants were included into the ETS and very detailed data on NCV became available. The values for solid fuel varies from year to year but for the liquid and gaseous fuel almost the same values have been used for the entire period as these types of fuel don't change a lot from year to year.



Table 3.2.14: NCVs for the fuel used in energy industry.

Year	Lignite (Velenje)	Sub- bituminous Coal - domestic	Sub- bituminous Coal - imported	Bitu- minous Coal	Gas Oil	Residual Fuel Oil	LPG	Natural Gas	Wood
	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/Mm3	TJ/kt
1986	9.390	11.880			41.820	39.740	46.000	33.500	12.170
1987	9,650	11.820			41.870	39.800	46.000	33,500	12.170
1988	9,440	12.000			41.870	39.800	46.000	34,080	12.170
1989	9,820	12.050			41.870	39.900	46.000	34,100	12.170
1990	9.810	12.760			41.870	39.800	46.000	34.100	12.170
1991	9.980	12.879			41.880	39.800	46.000	34.100	12.170
1992	10.260	12.589			41.900	39.900	46.000	34.100	12.170
1993	10.070	12.050			41.900	39.800	46.000	34.100	12.170
1994	9.960	12.666			41.900	39.860	46.000	34.100	12.170
1995	10.220	11.250	17.410		41.900	40.000	46.000	34.100	12.170
1996	9.690	11.300	17.410		41.900	40.000	46.000	34.100	12.170
1997	9.610	11.300	17.360		41.900	40.000	46.050	34.080	12.170
1998	10.010	11.230	17.760		41.900	40.000	46.050	34.080	12.170
1999	9.690	11.110	17.560		41.900	40.000	46.050	34.080	12.170
2000	10.170	11.230	17.940		41.900	40.000	46.050	34.080	12.170
2001	10.660	10.660	17.940		41.900	40.000	46.050	34.080	12.170
2002	10.350	11.220	18.380		41.900	40.000	46.050	34.080	12.170
2003	10.138	11.560	18.310		41.900	40.000	46.050	34.080	12.170
2004	10.301	11.680	18.676		41.900	40.000	46.050	34.080	12.170
2005	10.803	11.724	18.180		41.900	40.000	46.050	34.080	12.170
2006	11.132	10.880	18.874		42.600	41.420	46.050	34.072	9.764
2007	11.259	11.763	18.275		42.600	41.420	46.050	34.078	9.141
2008	10.949	11.654	17.714		42.600	41.420	46.050	34.096	11.512
2009	10.894	11.094	17.872	28.612	42.600	41.420	46.050	34.074	11.128
2010	11.097	12.815	18.130	28.271	42.600	41.420	46.050	34.080	9.871
2011	11.051	11.935	18.428	28.251	42.600	41.420	46.050	34.087	10.267
2012	10.604	11.778	18.524	26.140	42.600	41.420	46.050	34.093	10.560
2013	11.591	11.946	18.457	25.180	42.600	41.420	46.050	34.079	10.262
2014	10.823	11.727	18.655	26.590	42.600	41.420	46.050	34.083	10.510
2015	11.418	-	18.629	25.800	42.600	41.420	46.050	34.086	10.474
2016	11.733	-	18.595	25.898	42.600	41.420	46.050	34.087	10.519

### **Emission factors**

We have used country specific/plant specific CO<sub>2</sub> EFs for coal and natural gas; a more detailed description is in chapter 3.2. Emission factors for all other fuels have been taken from 2006 IPCC Guidelines, Vol. 2 Energy, Table 2.2. On the table 3.2.15 EFs used in the period 1986-2015 are presented.

Table 3.2.15: EFs used for the period 1986-2016

	Unit	Coal	Gas Oil	Residual Fuel Oil	LPG	Natural Gas	Solid Bio-fuels	Gas Biomass	Wastes (plastics)
CO <sub>2</sub> EF	t/TJ	NIR, Tables: 3.2.1, 3.2.17-20	74.1	77.4	63.1	NIR, Table 3.2.2	112	54.6	73.3
CH <sub>4</sub> EF	t/TJ	0.001	0.003	0.003	0.001	0.001	0.03	0.001	0.01
N <sub>2</sub> O EF	t/TJ	0.0015	0.0006	0.0006	0.0001	0.0001	0.004	0.0001	0.004

### 3.2.4.2.1 Public Electricity and Heat Production (CRF 1A1a)

In this sub-category, there were three big point sources in the Republic of Slovenia, which represent the backbone of electrical energy production from thermal power plants. All three plants use coal for the production of electrical energy (Table 3.2.16). Two of these thermal power plants (the Šoštanj Thermal Power Plant - TEŠ and the Trbovlje Thermal Power Plant - TET) are located beside coal pits. In 2014 the Trbovlje TPP was closed and since then only two plants have remained. Since 2003, CHP Ljubljana – TE-TOL uses exclusively imported coal with high net calorific value and low sulphur contents for the production of electrical energy and heat.

Table 3.2.16: Public electricity and Combined Heat and Power Plants in Slovenia

Power plant	Location	Unit	period	Power (MW)	Main fuel type
TEŠ	Šoštanj	A/1	1956-2010	30.0	Lignite from Velenje
TEŠ	Šoštanj	A/2	1956-2008	30.0	Lignite
TEŠ	Šoštanj	A/3	1960-2014	75.0	Lignite
TEŠ	Šoštanj	Unit 4	1972-today	275.0	Lignite
TEŠ	Šoštanj	Unit 5	1977-today	345.0	Lignite
TEŠ	Šoštanj	Unit 6	2016-today	600.0	Lignite
TEŠ	Šoštanj	Gas units	2008-today	2 x 42.0	Natural gas
TE-TOL	Ljubljana	D/1	1966-today	136.0	Imported coal
TE-TOL	Ljubljana	D/2	1967-today	126.0	Imported coal
TE-TOL	Ljubljana	D/3	1984-today	202.0	Imported coal, since 2008 also wood
TET	Trbovlje	F/4	1968-2014	125.0	Coal, mostly domestic brown coal

In addition to these thermal power plants we also have one small plant Brestanica – TEB which uses natural gas and operates mainly as a back-up plant when more electricity is needed or when any other plant is on refit.

### Solid fuels

Since 2005 all public power plants are included into ETS and therefore plant specific CO<sub>2</sub> EFs are used.

In **Šoštanj Thermo Power Plant -TEŠ** considering solid fuel only lignite from Velenje pit had been combusted in this plant and CO<sub>2</sub> EFs from Table 3.2.1 have been used. Since 2011 the oxidation factor has been determined and is presented in the table 3.2.17.

**Table 3.2.17: Plant specific oxidation factor for coal used in TEŠ.**

	2011	2012	2013	2015	2016
<b>Oxidation factor</b>	0.997	0.989	0.990	0.993	0.997

In **Trbovlje Thermal Power Plant – TET** the low calorific brown coal from Trbovlje-Hrastnik pit was used. Since 2007 also a small amount of imported coal has been used with the same EFs. For calculation of emission CO<sub>2</sub> emissions before 2005 the default EF from IPCC 2006 Guidelines for lignite (101 t/TJ) has been used while since 2005 plant specific EFs presented in the table 2.3.18 from ETS have been used. Since 2010 the oxidation factor has been determined and is presented in the table 3.2.19. At the end of 2014 the plant has ceased the electricity production and since then is **closed**.

**Table 3.2.18: Plant specific CO<sub>2</sub> EFs for domestic brown coal from Trbovlje pit used in TET.**

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
<b>t CO<sub>2</sub>/TJ</b>	101.935	102.890	101.661	101.807	102.707	101.329	101.180	101.186	101.220	103.744

**Table 3.2.19: Plant specific oxidation factor for coal used in TET.**

	2010	2011	2012	2013	2014
<b>Oxidation factor</b>	0.997	0.976	0.979	0.982	0.983

In **CHP Ljubljana – TE-TOL** since 1995 only imported sub-bituminous coal has been used. For calculation CO<sub>2</sub> emission before 2005 the average EF for the period 2005-2013 (99.427 t/TJ) was used while since 2005 plant specific EFs presented in the Table 2.3.20 from ETS have been used. Oxidation factor is 1.

**Table 3.2.20: Plant specific CO<sub>2</sub> EFs for imported sub-bituminous coal used in TE-TOL.**

	2005	2010	2011	2012	2013	2014	2015	2016
<b>t CO<sub>2</sub>/TJ</b>	100.407	100.423	98.837	97.000	97.213	97.085	97.240	96.787

Since 2009 sub-bituminous coal and Bituminous coal are used in one small heat plant. EFs are available from ETS and are presented in the table 2.3.21, the oxidation factor was 1.

**Table 3.2.21: Plant specific CO<sub>2</sub> EFs for imported sub-bituminous and bituminous coal used in one cogeneration heat plant.**

Coal type	Unit	2009	2010	2011	2012	2013	2014	2015	2016
<b>Sub-bituminous</b>	t CO <sub>2</sub> /TJ	99.047	97.310	98.331	99.407	NO	NO	NO	NO
<b>Bituminous</b>	t CO <sub>2</sub> /TJ	92.742	92.829	90.881	92.513	94.022	93.431	94.600	94.600

## **Waste Incineration**

Emissions from the category “Other fossil fuels” have arisen from the only Slovenian waste incineration thermal plant which has started to work in 2009. Data on the amount of incinerated waste, NCVs and the distribution between biogenic and other waste have been obtained directly from the plant. It shows that the most of the non-biogenic fraction of the

waste is plastics. Because plastics are made from fossil fuels, its combustion is considered an anthropogenic source of carbon emissions.

CO<sub>2</sub> emissions from the incineration of plastics depend on the carbon content of the plastic and the amount of carbon that is converted to CO<sub>2</sub> during the combustion process. There is no EF available in the 2006 IPCC guidelines. After a research done on scientific literature, available on the web, the emission factor of 20 t C/TJ has been used (73.3 t CO<sub>2</sub>/TJ). It is the same as the lower value for combustion of non-biomass fraction of municipal waste in 2006 IPCC Guidelines, Table 2.2.

For the calculation of non-CO<sub>2</sub> emissions, the following values have been used: CH<sub>4</sub> EF 0.01 t CH<sub>4</sub> /TJ (industrial waste, lower value) from Table 2.2 and N<sub>2</sub>O EF 0.004 N<sub>2</sub>O/TJ (all types of wastes, default) from Table 2.2.

#### **3.2.4.2.2 Petroleum Refining (CRF 1A1b)**

The main representative of this category was the company Nafta Lendava Refinery – Slovenia's only refinery, which stopped oil refining in 2002. According to the statistical methodology in the period 1986-1996, this sector also included quantities of fuels that were consumed for the production of electric energy in this sector.

##### **Activity data**

Data on the consumption of fuels in this sector for the period 1986-2003 have been collected in LEG – Annual Energy Statistics of the Energy Sector of the Republic of Slovenia:

for the period 1986-1996 under „Oil Industry”

From 1997 – 2004 under „DF–Production of coke, refined petroleum products and nuclear fuel”

- For the consumption of liquid fuels      Table Tg/3 or Table Pg/6 for LPG
- For the consumption of solid fuels      Table Pr/6
- For the consumption of gaseous fuels      Table Pg/6

After 1996, data on the consumption in this sector have been included in the industrial sector DF – Production of coke, refined petroleum products, and nuclear fuel. With regard to the fact that there is neither production of coke nor nuclear fuel in the Republic of Slovenia, data for the period 1997-2003 are comparable to the data from the period 1986-1996.

In 2003, the only petroleum refinery was closed and no emissions have occurred from this category since 2004. Data on the fuel consumption by type and year are reported in the Annex 3 to the NIR.

#### **3.2.4.2.3 Manufacture of Solid Fuels and Other Energy Industries (CRF 1A1c)**

This sector covers the consumption of fuels reported in LEG under “Coal-mining” or, since 1997, under CA – Production of energy commodities and DF – Production of fuels.

**Activity data**

The consumptions according to individual energy products are collected in the LEG tables as follows:

For the period 1986-1996 under „Coal-mining”

From 1997 onwards under „CA–Production of energy commodities”

- For the consumption of liquid fuels                      Table Tg/3 or Table Pg/6 for LPG
- For the consumption of solid fuels                      Table Pr/6
- For the consumption gaseous fuels                      Table Pg/6

Since 2004, data are available in the excel files from SORS (E\_PE-M YYYY.xls).

In the period 2004 -2007 according to the old SKD classification the following SKD categories have been included in this CRF category:

- CA10              Mining of coal and lignite
- CA11              Extraction of crude petroleum and natural gas including support activities
- DF                Production of coke, refined petroleum products and nuclear fuel

Since 2008, the new SKD\_2008 classification has been used and the following categories have been included in this CRF category:

- B05              Mining of coal and lignite
- B06              Extraction of crude petroleum and natural gas
- B09.1            Support activities for petroleum and natural gas mining
- C19.1            Manufacturing of coke oven products - do not exist in Slovenia.
- C19.2            Manufacturing of refined petroleum products – do not exist since 2003

Data on the fuel consumption by type and year are reported in the Annex 3 to the NIR.

**3.2.4.3 Uncertainty and time –series consistency**

Uncertainty estimates for energy industry in the base year are based on an expert judgement. To determine the uncertainties of the AD, consultations with experts from SORS were performed, while values from the IPCC Guidelines have also been taken into account for the uncertainties of EF.

**Table 3.2.22: Uncertainties of activity data and emission factors as used in the 2018 submission for the base year and the last reporting year.**

	1986				2016			
	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF
Liquid	5	2	150	150	5	2	150	150
Solid	10	6.4	135	150	2	2.5	135	150
Gaseous	5	2.5	135	135	2	2.5	135	135
Other	NO	NA	NA	NA	7.7	5	150	170
Biomass	10	NA	150	170	10	NA	150	170

The uncertainty of the activity data is a combination of systematic and random errors. The statistic data which are obtained from the obligatory reporting are usually within 3%. In addition, the activity data are subject to the random errors in the data collection. Countries with good data collection systems may keep the random error to about 2-3%. The experts

believe that for most developed countries the total uncertainties of the activity data are in the range of 5%. After consultation with SORS and taking into account levels of uncertainties associated with stationary combustion recommended in 2006 IPCC GL, we have used different uncertainties for different types of fuel as presented in the Table 3.2.22.

In the calculating of emissions from this sector, the plant-specific emission factors, based on coal sampling and ascertaining the carbon contents have been applied for all solid fuel. All analyses have been done in an accredited laboratory in accordance with the EN ISO 17025 ("General requirements for the competence of testing and calibration laboratories"). The public power plants included in ETS have presented their plan of measures to ensure that the fuel consumption will be measured without intermediate storage before the combustion in the installation, applying measuring devices resulting in a maximum permissible uncertainty of less than  $\pm 2.5\%$  for the measuring process.

#### **3.2.4.4 Category-specific QA/QC and verification**

Starting in 2005, all thermal power plants in the Republic of Slovenia have carried out regular coal sampling and determined the carbon content in accordance with the Monitoring guidelines for monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of European Parliament and of the Council and all amending directive, necessary for CO<sub>2</sub> emission trading on the territory of the European Union. For this reason, the plant specific CO<sub>2</sub> EF have been also used for coal from Trbovlje pit in 2006 for the first time.

The monitoring of the fuel in four plants under EU-ETS is defined in the permit and accompanied monitoring plan. Each fuel is monitored with maximum uncertainty which depends on the total GHG emissions from the plant and typical consumption of a particular fuel. All three plants have to monitor the coal consumption on the higher level of accuracy and determine NCV and C content in the accredited laboratory for every batch of fuel. The fourth plant is using natural gas as a main fuel.

The detailed descriptions of requirements are in the Guidelines for the monitoring and reporting: (COMMISSION REGULATION (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council)

<http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R0601>

#### **Description of the Requests under Particular Tier (Table 3.2.23)**

##### **AD**

Tier 1: The fuel consumption covering the reporting period shall be determined by the operator or fuel supplier within a maximum uncertainty of less than  $\pm 7.5\%$  taking into account the effect of stock changes where applicable.

Tier 2: The fuel consumption covering the reporting period shall be determined by the operator or fuel supplier within a maximum uncertainty of less than  $\pm 5.0\%$  taking into account the effect of stock changes where applicable.

**Tier 3:** The fuel consumption covering the reporting period shall be determined by the operator or fuel supplier within a maximum uncertainty of less than  $\pm 2.5\%$  taking into account the effect of stock changes where applicable.

**Tier 4:** The fuel consumption covering the reporting period shall be determined by the operator or fuel supplier within a maximum uncertainty of less than  $\pm 1.5\%$  taking into account the effect of stock changes where applicable.

**Table 3.2.23: Levels of pretentiousness (Tiers) for fuels used in TPP in Slovenia in 2005-2016.**

	AD	NCV	CO <sub>2</sub> EF
Natural gas	Tier 4	Tier 2a	Tier 2a
Solid fuel	Tier 3	Tier 3	Tier 3
Fuel oil	Tier 1 or 2	Tier 2a	Tier 2a

#### NCV

**Tier 2a:** The operator applies country-specific net calorific values for the respective fuel as reported by the respective Member State in its latest national inventory submitted to the Secretariat of the United Nations Framework Convention on Climate Change.

**Tier 3:** The net calorific value representative for the fuel in an installation is measured by the operator, a contracted laboratory or the fuel supplier in accordance with the provisions of Article 32 to 35 of Commission Regulation 601/2012 on the monitoring and reporting.

#### EF

**Tier 2a:** The operator applies country-specific emission factors for the respective fuel as reported by the respective Member State in its latest national inventory submitted to the Secretariat of the United Nations Framework Convention on Climate Change.

**Tier 3:** Activity-specific emission factors for the fuel are determined by the operator, an external laboratory or the fuel supplier according with the provisions of Article 32 to 35 of Commission Regulation 601/2012 on the monitoring and reporting.

For the thermal power plants the aggregated solid fuel from SORS data are compared with the sum of the fuel used from the verified ETS reports. The NCVs are also checked. In case these numbers are not the same as in ETS, the data from ETS is taken into account and a notification to SORS is made.

Additional QA activity is the reference approach. Before entering data into the database, the sum of each fuel from the disaggregated data is compared with the energy balance data, reported in the Joint Questioner. As data in JQ are rounded to 1000 units, the difference should be 500 units or less. If it is higher, the reasons for this should be found.

#### 3.2.4.5 Category-specific recalculations

No recalculations have been performed for this category.

#### 3.2.4.6 Category-specific planned improvement

No improvement is planned for this category.

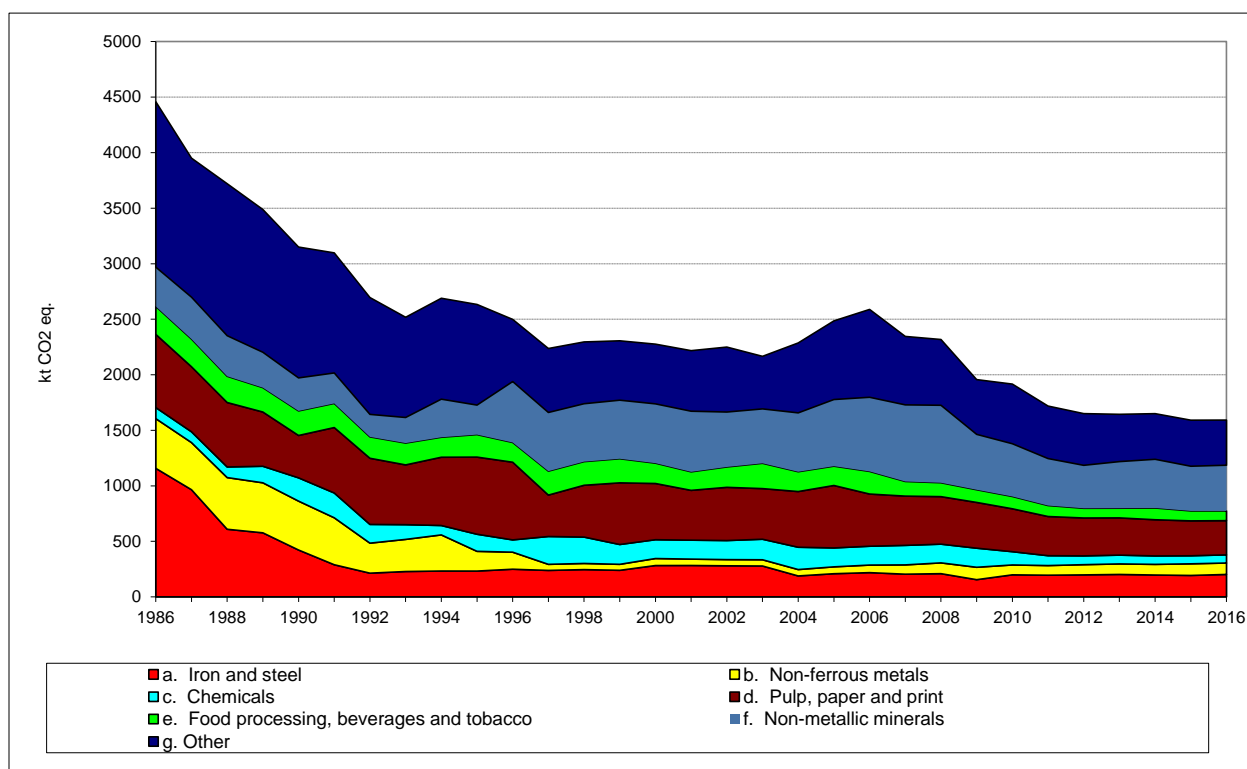
### 3.2.5 Manufacturing Industries and Construction (CRF 1A2)

#### 3.2.5.1 Category description

This chapter presents the consumption of fuels and emissions of greenhouse gases in six specific types of industry, all others are covered by other industry, which includes also fuel for construction industry. An overview of the methods and EFs used as well as an indication whether a category is a key are presented in the Table 3.2.24 below.

**Table 3.2.24: Method, EF used and key categories indications for the year 2016 in Energy industries.**

	CO <sub>2</sub>			CH <sub>4</sub>			N <sub>2</sub> O		
Fuel type	Method	EF	Key category	Method	EF	Key category	Method	EF	Key category
solid	T3	PS	L,T	T1	D	-	T1	D	-
liquid	T1	D	L, T	T1	D	-	T1	D	-
gaseous	T2	CS	L, T	T1	D	-	T1	D	-
biomass	T1	D	-	T1	D	-	T1	D	-
other	T1	D	Lsub, T	T1	D	-	T1	D	-



**Figure 3.2.5: GHG Emissions from Manufacturing Industries and Construction**

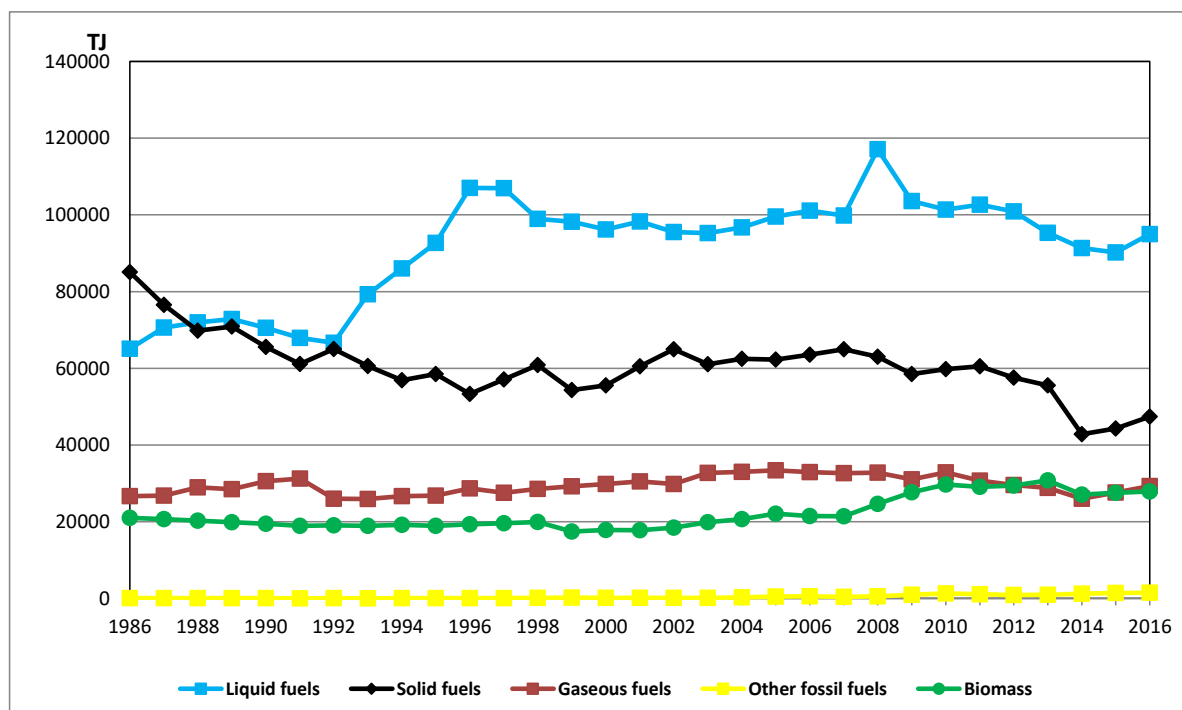


There was an appreciable reduction of GHG from the industry in 1986-1997; after that, a stabilisation of the emission was observed until 2008, with the slight increase in the period 2004-2006. Due to the global financial crisis emissions from Manufacturing industry and construction started to decrease and were in 2012 36.3% lower than in 2006. In the last four years a stabilisation of the emissions has occurred. In the Table 3.2.25 and Figure 3.2.5 the GHG emissions from seven CRF categories are presented.

**Table 3.2.25: GHG emissions from Manufacturing Industries and Construction in kt CO<sub>2</sub> eq.**

	1986	1990	1995	2000	2005	2010	2015	2016
<b>2. Manufacturing Ind. and Constr.</b>	<b>4458</b>	<b>3150</b>	<b>2633</b>	<b>2276</b>	<b>2485</b>	<b>1916</b>	<b>1591</b>	<b>1592</b>
a. Iron and Steel	1157	422	232	282	209	199	193	202
b. Non-Ferrous Metals	448	440	178	63	62	89	105	103
c. Chemicals	100	210	154	170	170	120	72	73
d. Pulp, Paper and Print	659	381	694	506	562	386	314	308
e. Food Processing, Beverages and Tob.	251	221	203	183	174	111	89	88
f. Non-metallic minerals	354	297	266	534	600	475	402	412
g. Other	1489	1178	906	538	708	536	415	406

In the Figure 3.2.6 energy from different types of fuel used in the manufacturing industries and construction is presented. While the use of liquid and solid fuels is decreasing, the use of natural gas stays rather constant. The use of waste fuels (other) is slowly increasing but it is still almost negligible.



**Figure 3.2.6: Energy of fuel used in manufacturing industries and construction in TJ**

### 3.2.5.2 Methodological issues

The emissions from the combustion in the sector Manufacturing industries and construction were estimated using the Tier 1 methodology described in the 2006 IPCC GL. The following basic formula was used:

$$\text{Emissions} = \text{Quantity of Fuel Combusted} \times \text{NCV} \times \text{EF per energy of Fuel} \times \text{OF}$$

In all cases oxidation factor is 1.

#### Activity data

The consumption in each category has to be determined in accordance with the classification of activities applied in IPCC guidelines.

#### PERIOD 1986-1996

**Table 3.2.26: Conversion table between national energy statistics (LEG) and CRF**

CRF category	LEG Classification (1986-1996)
Iron and Steel	Iron and Steel Production
Non-Ferrous Metals	Non-Ferrous Metals
Chemicals	Chemical Industry
Pulp, Paper and Print	Pulp and Paper Industry, Print Industry
Food Processing, Beverages and Tobacco	Food Processing Industry, Tobacco Industry
Non-metallic minerals	Non-metal industry
Other	Metal Industry Shipbuilding Electrical Industry Construction Timber Industry Textile Industry Leather Industry Rubber Industry Recycling Other Industry

The classification applied in LEG has been taken as the basis and the conversion table between LEG and CRF is presented in the table 3.2.26.

#### PERIOD 1997-2003

In 1997, LEG began to publish data according to the Standard Classification of Activities, (SCA) which in some categories differs from the classification, which had been used until 1996. Most of the activities are defined in a similar manner, but this is not possible for all activities. The table 3.2.27 shows the distribution of activities in accordance with the IPCC classification.

For the consumption in individual industrial sectors there are detailed (disaggregated) data, the values of which was strongly dependant on the mode of reporting and features of the individual industrial sectors characterized by high concentration (values depending on the consumption in one or two factories) in Slovenia. The data from the basic sources shows some relatively big changes in the consumption of fuels in some sectors.

**Table 3.2.27: Conversion table between national energy statistics (LEG) and CRF**

CRF category	LEG Classification – SCA category
Iron and Steel	DJ - Production of metals and metal products
Non-Ferrous Metals	
Chemicals	DG - Production of chemicals
Pulp, Paper and Print	DE - Production of fibres, pulp, paper, and cardboard
Food Processing, Beverages and Tobacco	DA – Production of food, beverages, and tobacco products
Non-metallic Minerals	DI - Production of non-metal mineral products
Other	DB - Production of textiles DC - Production of leather and leather goods DD – Wood-processing and woodworking DH - Production of rubber products DK - Production of machines and devices DL - Production of electrical and optical equipment DM – Production of vehicles and vessels DN - Production of furniture. not included elsewhere F - Construction

#### YEARS 2004 - 2007

Since 2004 very detailed data about the fuel consumption in the industry became available in electronic format. The non-energy and energy use of fuels are reported separately. The data about the fuel consumption and NCV are reported on the lowest level of disaggregation possible. For this reason, from 2004 on the fuel consumption in iron and steel industry and in non-ferrous metals industry can be separated according to the rules presented in the following Table 3.2.28.

**Table 3.2.28: Table for disaggregation of fuel in DJ sector (manufacture of basic metals and fabricated metal products)**

SCA category	CRF category	Description
DJ 27.1	Iron and Steel	Manufacture of basic iron and steel and of ferrous alloys
DJ 27.2	Iron and Steel	Manufacture of tubes
DJ 27.3	Iron and Steel	Other first processing of iron and steel
DJ 27.4	Non-ferrous Metal	Manufacture of basic precious and non-ferrous metals
DJ 27.510	Iron and Steel	Casting of iron
DJ 27.520	Iron and Steel	Casting of steel
DJ 27.530	Non-ferrous Metal	Casting of light metal
DJ 27.540	Non-ferrous Metal	Casting of other non-ferrous metal
DJ 28	Other industry	Manufacture of fabricated metal products, except machinery and equipment

YEARS 2008 - 2016**Table 3.2.29: Conversion table between the CRF categories and The Standard Classification of Activities (SKD).**

CRF category	Description
1.A.2.a Iron and Steel	C 24.1 Manufacture of basic iron and steel and of ferrous alloys
	C 24.2 Manufacture of tubes, pipes, hollow profiles and related fittings, of steel
	C 24.3 Manufacture of other products of first processing of steel
	C 24.51 Casting of iron
	C 24.52 Casting of steel
1.A.2.b Non-ferrous Metal	C 24.4 Manufacture of basic precious and non-ferrous metals
	C 24.53 Casting of light metal
	C 24.54 Casting of other non-ferrous metal
1.A.2.c Chemicals	C 20 Manufacture of chemicals and chemical products
1.A.2.d Pulp, Paper and Print	C 17 Manufacture of paper and paper products
	C 18 Printing and reproduction of recorded media
1.A.2.e Food Processing, Beverages and Tobacco	C 10 Manufacture of food products
	C 11 Manufacture of beverages
	C 12 Manufacture of tobacco products
1.A.2.f Non-metallic Minerals	C 23 Manufacture of other non-metallic mineral products
1.A.2.g.vii Off road vehicles and other machinery	F Construction (only gasoline and diesel fuel)
1.A.2.g.viii Other	C 13 Manufacture of textiles
	C 14 Manufacture of wearing apparel
	C 15 Manufacture of leather and related products
	C 16 Manufacture of wood and of products of wood and cork, except furniture, manufacture of articles of straw and plaiting materials
	C 21 Manufacture of basic pharmaceutical products and pharmaceutical preparations
	C 22 Manufacture of rubber and plastic products
	C 25 Manufacture of metallic products
	C 26 Production of electrical and optical equipment
	C 27 Production of electrical equipment
	C 28 Production of machines and devices
	C 29 Production of vehicles
	C 30 Production of vessels
	C 31 Production of furniture
	C 32 Other manufacturing
	C 33 Repair and installation of machinery and equipment
	F Construction (all other fuels except diesel and gasoline)

In 2008 the new SCA (Standard Classification of Activities) was applied by SORS which is used until present. The main advantage is that the new classification enables the disaggregation of data on much more detailed level. An important difference is that "Manufacture of basic pharmaceutical products and pharmaceutical preparations" industry is no longer part of the Chemical industry and is included under category "Other". The conversion table between CRF and the national energy statistics is presented in the Table 3.2.29 on the previous page.

### **Net calorific values**

**Table 3.2.30: Average NCVs for solid fuels and petroleum coke used in manufacturing industry and construction**

Year	Lignite – domestic (Velenje)	Sub-bituminous Coal - domestic	Lignite - imported	Sub-bituminous Coal - imported	Other Bituminous Coal	Anthracite	Coke	Petroleum coke
	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt
1986	9.390	11.880			27.57	29.25	29.30	31.000
1987	9.650	11.820			27.57	29.25	29.30	31.000
1988	9.440	12.000			27.57	29.25	29.30	31.000
1989	9.820	12.050			27.57	29.25	29.30	31.000
1990	9.810	12.760			27.57	29.25	29.30	31.000
1991	9.980	12.879			25.00	29.25	29.30	31.000
1992	10.260	12.589			25.00	29.25	29.30	31.000
1993	10.070	13.351			25.00	29.25	29.30	31.000
1994	9.960	12.666			25.00	29.25	29.30	31.000
1995	10.220			17.404	25.00	29.31	29.31	31.000
1996	9.690			16.353	25.00	29.31	29.31	31.000
1997	9.610			17.712	25.00	29.31	29.31	31.000
1998	10.010			20.664	25.00	29.31	29.31	31.000
1999	9.690			20.806	25.00	29.31	29.31	31.000
2000	10.170			20.782	25.00	29.31	29.31	31.000
2001	10.660			20.947	25.00	29.31	29.31	31.000
2002	10.350			21.000	25.00	29.31	29.31	31.000
2003	10.138			21.570	25.00	29.31	29.31	31.000
2004	10.301			19.908		29.40	28.49	29.927
2005				20.381	25.15		27.90	29.927
2006				20.108	25.77		29.44	32.223
2007				20.387	24.46		29.37	31.949
2008				18.623	24.31		29.87	31.949
2009			10.078	17.972	23.896		29.67	32.498
2010			9.763	16.325	25.290		29.42	30.644
2011			10.717	15.138	25.422		29.62	31.684
2012			10.159	18.847	25.409		29.41	31.813
2013			10.085	19.224	26.264		29.59	31.721
2014			9.837	19.047	24.915		29.605	31.602
2015			9.885	18.890	25.000		28.859	31.663
2016			9.327	19.194	25.000		29.568	31.236

**Table 3.2.31: NCVs for the energy use of solid fuels in manufacturing industry and construction in 2016.**

Industry - 2015	Unit	Lignite – imported	Sub-bituminous Coal - imported	Other Bituminous Coal	Coke	Petroleum coke
Iron and steel	TJ/kt				30.063	
Non-Ferrous metals	TJ/kt			25.000		
Pulp. Paper and Print	TJ/kt	9.327	19.197			
Non-metallic minerals	TJ/kt				29.300	31.236
Other	TJ/kt		18.000			

**Table 3.2.32: NCVs for the liquid fuels used in manufacturing industry and construction**

Year	Gas Oil	Residual Fuel Oil	Diesel	Gasoline	LPG	Natural Gas	Wood
	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/Mm3	TJ/kt
1986	41.82	39.74	42.70	43.18	46.00	33.50	12.17
1987	41,78	39,80	42.70	43.10	46.00	33,50	12.17
1988	41,71	39,80	42.70	43.10	46.00	34,08	12.17
1989	41,85	39,80	42.70	43.10	46.00	34,10	12.17
1990	41.87	39.80	42.70	43.07	46.00	34.10	12.17
1991	41.88	39.80	42.70	43.17	46.00	34.10	12.17
1992	41.90	39.90	42.70	43.10	46.00	34.10	12.17
1993	41.90	39.80	42.70	43.08	46.00	34.10	12.17
1994	41.90	39.86	42.70	43.08	46.00	34.10	12.17
1995	41.90	40.00	42.70	43.08	46.00	34.10	12.17
1996	41.90	40.00	42.70	43.08	46.00	34.10	12.17
1997	41.90	40.00	42.70	43.08	46.05	34.08	12.17
1998	41.90	40.00	42.70	43.08	46.05	34.08	12.17
1999	41.90	40.00	42.70	43.08	46.05	34.08	12.17
2000	41.90	40.00	42.70	43.08	46.05	34.08	12.17
2001	41.90	40.00	42.70	43.08	46.05	34.08	12.17
2002	41.90	40.00	42.70	43.08	46.05	34.08	12.17
2003	41.90	40.00	42.70	43.08	46.05	34.08	12.17
2004	41.90	40.00	42.70	43.08	46.05	34.08	12.17
2005	42.60	41.42	42.70	43.08	46.05	34.08	12.17
2006	42.60	41.42	42.70	43.08	46.05	34.072	12.17
2007	42.60	41.42	42.70	43.08	46.05	34.08	12.17
2008	42.60	41.42	42.70	43.85	46.05	34.096	12.17
2009	42.60	41.42	42.70	43.85	46.05	34.08	12.17
2010	42.60	41.42	42.70	43.85	46.05	34.08	10.77
2011	42.60	41.42	42.60	43.85	46.05	34.087	10.79
2012	42.60	41.42	42.60	43.85	46.05	34.093	10.41
2013	42.60	41.42	42.60	43.85	46.05	34.079	10.58
2014	42.60	41.42	42.60	43.85	46.05	34.083	11.57
2015	42.60	41.42	42.60	43.85	46.05	34.086	11.46
2016	42.60	41.42	42.60	43.85	46.05	34.087	11.10

Table 3.2.30 presents the net calorific values (NCV) which have been used for solid fuels and petroleum coke combusted in the manufacturing industries. In the past they have been mostly taken from SORS while since 2005 the ETS data are used, if available. The plant specific data for 2015 for solid fuels are presented in the Table 3.2.31. The values for liquid fuels excluding petrol coke, natural gas and biomass have been taken from SORS for the entire period (Table 3.2.32)

### **Emission factors**

The emission factors used in the sector Manufacturing industries and construction are presented in the Table 3.2.33. Until 2005, we had used country specific CO<sub>2</sub> EF for domestic lignite and natural gas, while default values from the 2006 IPCC Guidelines were used for other fuels.

**Table 3.2.33: EFs for the fuels used in manufacturing industry and construction.**

	Unit	Lignite - domestic (Velenje)	Sub-bituminous Coal - domestic	Lignite – imported	Sub-bituminous Coal - imported	Other Bituminous Coal	Anthracite	Coke
CO <sub>2</sub> EF	t/TJ	Table 3.2.1	101*	101*	96.1*	94.6*	98.3*	107.0*
CH <sub>4</sub> EF	t/TJ	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N <sub>2</sub> O EF	t/TJ	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015

	Unit	Petroleum coke	Gas Oil	Residual Fuel Oil	Diesel	Gasoline	LPG	Natural Gas
CO <sub>2</sub> EF	t/TJ	97.9*	74.1	77.4	74.1	69.3	63.1	Table 3.2.2
CH <sub>4</sub> EF	t/TJ	0.003	0.003	0.0030	0.00415	0.05	0.001	0.001
N <sub>2</sub> O EF	t/TJ	0.0006	0.0006	0.0006	0.0286	0.002	0.0001	0.0001

	Unit	Wood	Gaseous Biomass	Other Biomass	Waste oils	Waste Solvents	Waste tyres	Other Solid Waste
CO <sub>2</sub> EF	t/TJ	112.0	54.6	100.0	73.3	102.168	85.0	143.0
CH <sub>4</sub> EF	t/TJ	0.03	0.001	0.03	0.03	0.03	0.03	0.03
N <sub>2</sub> O EF	t/TJ	0.004	0.0001	0.004	0.004	0.004	0.004	0.004

*\* Since 2005, CO<sub>2</sub> EFs for solid fuels and petrol coke have mostly been taken from EU-ETS. CO<sub>2</sub> IEFs which have been used in 2015 and were calculated from plant-specific data are presented in the Table 3.2.34.*

**Table 3.2.34: Plant-specific CO<sub>2</sub> EF for solid fuel used in manufacturing industry and construction in 2016.**

	Unit	Lignite	Sub-bituminous Coal - imported	Petroleum Coke
Pulp. Paper and Print	t/TJ	106.928	98.286	
Non-metallic minerals	t/TJ			93.502

### **Other fuels**

In the industry, particularly in the cement industry, in addition to commonly used fuel, a fraction of waste is also being incinerated, because of the very high temperature in the oven.

We have obtained very detailed data on the amount and composition of waste from one cement plant, where the main process of waste incineration in Slovenia occurs. This data has been available since 1996 and are presented on tables 3.2.35 to 3.2.36.

Since 2005, all waste fuels have also been included in ETS and

**Table 3.2.35: Amount of waste incinerated in manufacturing industries.**

	waste industrial oils	waste cooking fat and oils	Waste solvents	waste tyres	other waste	biomass waste (includes black liquor)
	t	t		t	t	t
<b>1996</b>	1058	0		1649	725	
<b>1997</b>	1629	0		1390	760	
<b>1998</b>	1526	0		2695	800	
<b>1999</b>	3459	0		2744	835	
<b>2000</b>	1854	0		4551	619	
<b>2001</b>	2382	2124		2014	957	
<b>2002</b>	1626	2214		3138	230	
<b>2003</b>	2229	3319		4346	110	
<b>2004</b>	3598	5225		6051	0	283137
<b>2005</b>	4193	4496		10258	0	282807
<b>2006</b>	4294	2177	801	10978	0	195984
<b>2007</b>	4277	2535	433	8645	0	9
<b>2008</b>	4204	3074	1724	12163	3092	57094
<b>2009</b>	4570	2280	1701	11436	8025	56192
<b>2010</b>	4709	2071	2054	18801	16517	60774
<b>2011</b>	3531	1950	2578	15776	12442	63412
<b>2012</b>	2477	1691	1900	18018	17507	60403
<b>2013</b>	1288	1532	2355	19802	21948	63711
<b>2014</b>	141	944	2664	28094	28077	63589
<b>2015</b>	1398	789	3251	28094	29723	64805
<b>2016</b>	3368	107	2250	26606	28056	66636



**Table 3.2.36: NCVs for waste incinerated in the manufacturing industries.**

	waste industrial oils	waste cooking fat	Waste solvents	waste tyres	other waste	waste biomass
	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt
1996	37.00			27.21	11.00	
1997	37.00			27.21	11.00	
1998	37.00			27.21	11.00	
1999	37.00			27.21	11.00	
2000	37.00			27.21	11.00	
2001	37.00	39.20		27.21	11.00	
2002	37.00	39.20		27.21	11.00	
2003	37.00	39.20		27.21	11.00	
2004	41.90	40.41		27.21		
2005	34.64	39.20		27.21		15.00
2006	34.53	39.20	25.00	27.21		15.00
2007	33.76	39.95	25.00	27.21		15.00
2008	34.48	39.81	25.00	27.21	17.52	16.11
2009	37.65	39.81	25.00	27.19	26.67	15.14
2010	36.95	39.20	25.00	27.23	22.34	15.36
2011	36.25	39.20	25.00	27.26	19.52	13.78
2012	37.09	39.20	25.00	27.21	20.25	13.50
2013	37.13	39.20	25.00	27.21	19.44	12.74
2014	33.03	39.20	25.00	27.20	18.87	11.72
2015	35.495	39.20	25.00	27.20	19.32	12.14
2016	36.544	39.20	25.00	27.20	18.19	10.23

The EFs used for the estimation emissions from other fuels are mostly taken from 2006 IPCC Guidelines and are presented on Table 3.2.37. The exceptions are the combustion of waste tyres and waste organic solvents.

The tyres have been combusted in one cement plant which is included in ETS and CO<sub>2</sub> EF from ETS legislation (Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council, Annex VI) is used. Biodegradable part of tyres was reported under biomass.

Waste organic solvents have been combusted in pharmaceutical industry and CO<sub>2</sub> EF was determined in the accredited laboratory in 2005. Since then the same value has been used.

Since 2010 a plant specific CO<sub>2</sub> EFs have been used for calculation of emissions from waste combustion in the cement plant. EFs are obtained from ETS and presented in the Table 3.2.38.

**Table 3.2.37: EFs for waste incinerated in the manufacturing industries**

Year	waste industrial oils	waste cooking fat and oils	waste solvents	Other biomass	waste tyres	other waste	Biomass waste
	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ
CO <sub>2</sub> EF	73.3	100	103,2	100	85	143	100
CH <sub>4</sub> EF	0.030	0.030	0.030	0.030	0.030	0.030	0.030
N <sub>2</sub> O EF	0.004	0.004	0.004	0.004	0.004	0.004	0.004

**Table 3.2.38: Plant specific CO<sub>2</sub> EFs for waste incinerated in the cement plant since 2010**

	Unit	2010	2011	2012	2013	2014	2015	2016
CO <sub>2</sub> EF	t CO <sub>2</sub> /TJ	60.427	49.473	49.437	60.735	60.735	58.685	55.994

We had also obtained data from pulp and paper industry about the consumption of black liquor from 2004 to 2006. NCV was between 6.1 and 6.4 TJ/kt. We used the same EF for GHG calculation as for wood. From 2007, there has been no consumption of black liquor any more.

### **Inclusion of auto producers into Manufacturing Industries sector**

In accordance with IPCC Reference manual, the item Industry reports the consumption of fuels in the group of industrial power plants (auto producers – enterprises that generate electric energy for internal consumption and/or heat for sale) as well as other consumption in industry (except in production processes) .

In the period 1986 -1996, the consumption of fuels by auto producers in LEG was recorded under Electric utilities – Industry, and in the period 1997- 2003 under Conversion – Auto producers.

#### Period 1986-2000

Because there are no published data on auto producers at the level of industrial branches for the period 1986-2000, on the basis of which it would be possible to assign the consumption of fuel to each individual industrial branch, for each kind of fuel a different (most appropriate) approach was used.

#### ➤ Lignite

The total consumption is attributed to the pulp and paper industry. The paper mill in Krško uses lignite in its power cogeneration plant. In the documents of the SORS, the total consumption is attributed to the consumption in thermal power plants, while in LEG one half of the consumption is attributed to the consumption in industry, the other half to industrial thermal power plants. In this report, a half is reported as consumption in pulp and paper industry (heat) and the other half as consumption in industrial power plants in pulp and paper industry. The consumption of lignite in other sectors has not been reported.

➤ **Brown Coal**

The consumption of brown coal in the industrial power plants in the monitored period was reported only in 1986. Since the quantities are quite small, the consumption is reported in the sector "Other".

➤ **Residual Fuel Oil**

The consumption of residual fuel oil in the industrial power plants in the monitored period was low (from 0 to 10176 t). Since the quantities are quite small, the consumption is reported in sector "Other".

➤ **Gas Oil and Natural Gas**

The majority of industrial thermal power plants use gas oil or natural gas. The total quantities of consumed gas oil and natural gas are disaggregated according to the produced quantities of electric energy in those power plants.

Period 2000-2015

Since 2000 we have commenced to treat auto producers individually, since the SORS, which prepares data for LEG, has completed its database. Now, the aggregated data on the consumption of fuels by auto producers at the level of industrial branches are available, where the sums of the individual fuels correspond to the consumption of auto producers from LEG.

Following the recommendations of the expert review team, the data on fuel consumption by industry type, fuel type and year are reported in the Annex 3 to the NIR.

**Off road vehicle and other machinery**

Following the new CRF categorisation the CRF category 1A2gvii Off road vehicle and other machinery has been introduced. Here all emissions from the combustion of gasoline and diesel from the Manufacturing industries and construction and from the Energy industries are included. EFs used are presented in the Table 3.2.39 and have been taken from the 2006 IPCC Guidelines, Vol 2, Table 3.3.1, Industry. We have assumed that mostly 4-stroke gasoline motors have been used.

**Table 3.2.39: Default EFs for gasoline and diesel oil used in the off road machinery.**

Year	Diesel	Motor gasoline
	t/TJ	t/TJ
CO <sub>2</sub> EF	74.1	69.3
CH <sub>4</sub> EF	0.00415	0.05
N <sub>2</sub> O EF	0.0286	0.002

### 3.2.5.3 Uncertainty and time –series consistency

The uncertainty estimates for the manufacturing industry in the base year are based on the expert judgement. To determine the uncertainties of the AD, consultations with experts from SORS were performed, while values from the IPCC Guidelines have also been taken into account for the uncertainties of EF.

**Table 3.2.40: Uncertainties of activity data and emission factors as used in the 2018 submission for the base year and the last reporting year in per cents**

	1986				2016			
	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF
Liquid	5	3	150	150	5	2	150	150
Solid	10	7	135	150	2	2.5	135	150
Gaseous	5	2.5	135	135	2	2.5	135	135
Other	10	25	150	170	7.7	5	150	170
Biomass	10	NA	150	170	10	NA	150	170

The uncertainty of activity data is a combination of systematic and random errors. The statistic data which are obtained from the obligatory reporting are usually within 3%. In addition, the activity data are subject to the random errors in the data collection. Countries with good data collection systems may keep the random error to about 2-3%. The experts believe that for most developed countries the total uncertainties of the activity data are in the range of 5%. After consultation with SORS and taking into account levels of uncertainties associated with stationary combustion recommended in 2006 IPCC GL, we have used different uncertainties for different types of fuel as presented in the Table 3.2.40.

During the calculation of the emissions from this sector, the plant specific emission factors based on coal sampling and ascertaining the carbon content, have also been applied for large part of solid fuels, petrol coke and some other fuels. All analyses have been done in an accredited laboratory in accordance with the EN ISO 17025 ("General requirements for the competence of testing and calibration laboratories").

### 3.2.5.4 Category-specific QA/QC and verification

The source category QA/QC is covered by the general QC procedures described in the chapter 1.2.3. Our main source specific QA/QC activity is comparison of the ETS data with the statistical data.

The aggregated fuel from SORS data is compared with the sum of the fuel used from verified ETS reports and where the connection between both set of data is uniform, the data from Statistical office are substituted with data from the verified reports from installations included in ETS, if necessary. ETS data are also used for different types of waste used as fuel. The list of waste types is not always complete in the SORS data.

Additional QA activity is the reference approach. Before entering data into the database, the sum of each fuel from the disaggregated data is compared with the energy balance data,

reported in the Joint Questioner. As data in JQ are rounded to 1000 units, the difference should be 500 units or less. If it is higher, the reasons for this should be found.

#### **3.2.5.5 Category-specific recalculations**

CO<sub>2</sub> EF for waste solvents combusted in 1.A.2.gii Other manufacturing industries have been corrected and corresponding CO<sub>2</sub> emissions have been recalculated for the entire period.

#### **3.2.5.6 Category-specific planned improvement**

No improvement is planned for this category.

### 3.2.6 Transport (CRF 1.A.3)

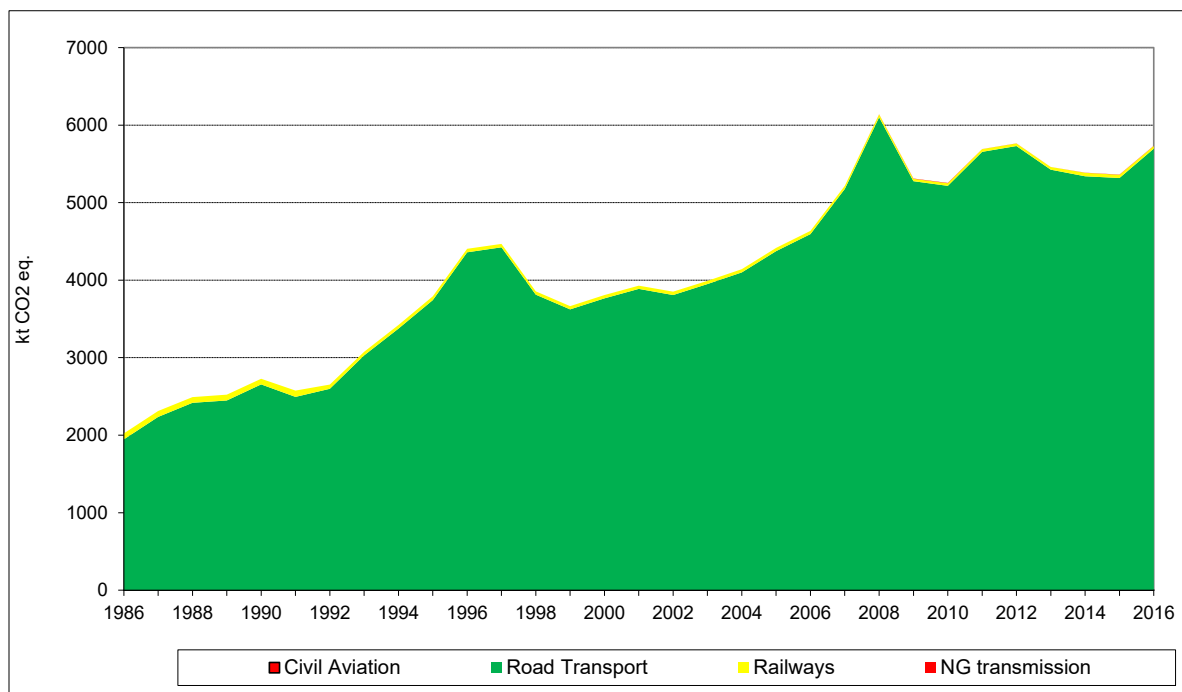
This chapter presents the consumption of fuels and emissions of greenhouse gases in:

- Domestic Aviation (CRF 1A3a)
- Road Transportation (CRF 1A3b)
- Railways (CRF 1A3c)
- Other Transportation / Pipeline transport (CRF 1A1e.i)

**Table 3.2.41: Method, EFs used and key categories indications for the year 2016 in the Transport sector.**

	CO <sub>2</sub>			CH <sub>4</sub>			N <sub>2</sub> O		
Road transport	Method	EF	Key category	Method	EF	Key category	Method	EF	Key category
Diesel	Model	Model	L,T	Model	Model	-	Model	Model	T
Gasoline	Model	Model	L,T	Model	Model	-	Model	Model	-
LPG	Model	Model	T	Model	Model	-	Model	Model	-

The only key categories in this sector are from the Road transport where Diesel and Gasoline are key sources according to the level and have a strong increasing trend (Table 3.2.41). The emissions have been calculated with the COPERT 4 model. The emissions from the other categories accounted for less than 1 per cent and have been calculated using Tier 1 approach. GHG emissions from this sector are presented in the Figure 3.2.7 and on the Table 3.2.42.



**Figure 3.2.7: GHG emissions from Transport.**

Undoubtedly the greatest increase in GHG emissions took place in the transport sector, by as much as 203.6% until 2008 (6,158 kt CO<sub>2</sub> eq.), due to an increase in the road

transportation, while emissions from other kinds of traffic slightly declined. In 2009, GHG emissions from transport decreased by 13.5% compared to 2008 due to the economic crisis. Since then the emissions fluctuate from year to year, but never reach the 2008 peak again.

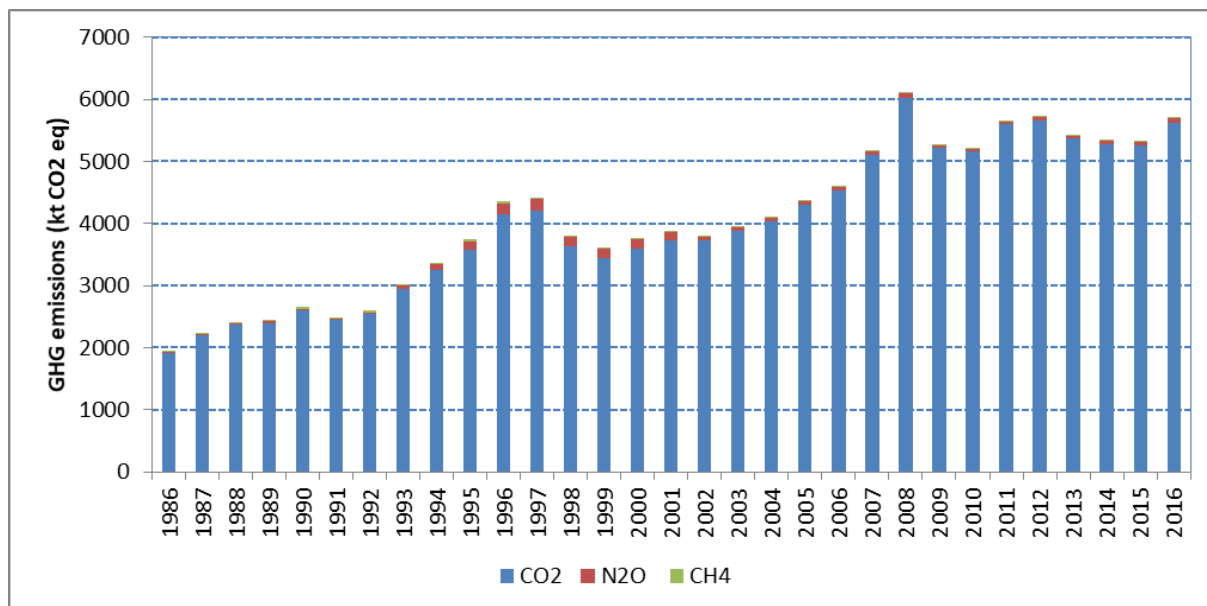
**Table 3.2.42: GHG emissions from Transport in kt CO<sub>2</sub> eq.**

	1986	1990	1995	2000	2005	2010	2015	2016
3. Transport	2022	2728	3792	3808	4416	5255	5362	5734
a. Civil Aviation	1	1	2	3	3	2	2	2
b. Road Transportation	1945	2654	3741	3763	4372	5215	5316	5695
c. Railways	77	73	49	43	42	33	41	35
e. NG transmission	NO	NO	NO	NO	IE	4	3	3

### 3.2.6.1 Road transportation (1.A.3.b)

#### 3.2.6.1.1 Category description

Road traffic is an important source of emissions of greenhouse gases, mostly carbon dioxide and nitrous oxide, and also an important source of emissions which cause problems in terms of air quality, such as sulphur oxides (SO<sub>x</sub>), nitrous oxides (NO<sub>x</sub>), carbon monoxide (CO), non-volatile organic compounds (NMVOC), particulate matters (PM<sub>2.5</sub> and PM<sub>10</sub>) and are, consequently, indirectly responsible for the formation of ozone (O<sub>3</sub>) in lower troposphere.



**Figure 3.2.8: CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> emissions for road transport 1986–2016.**

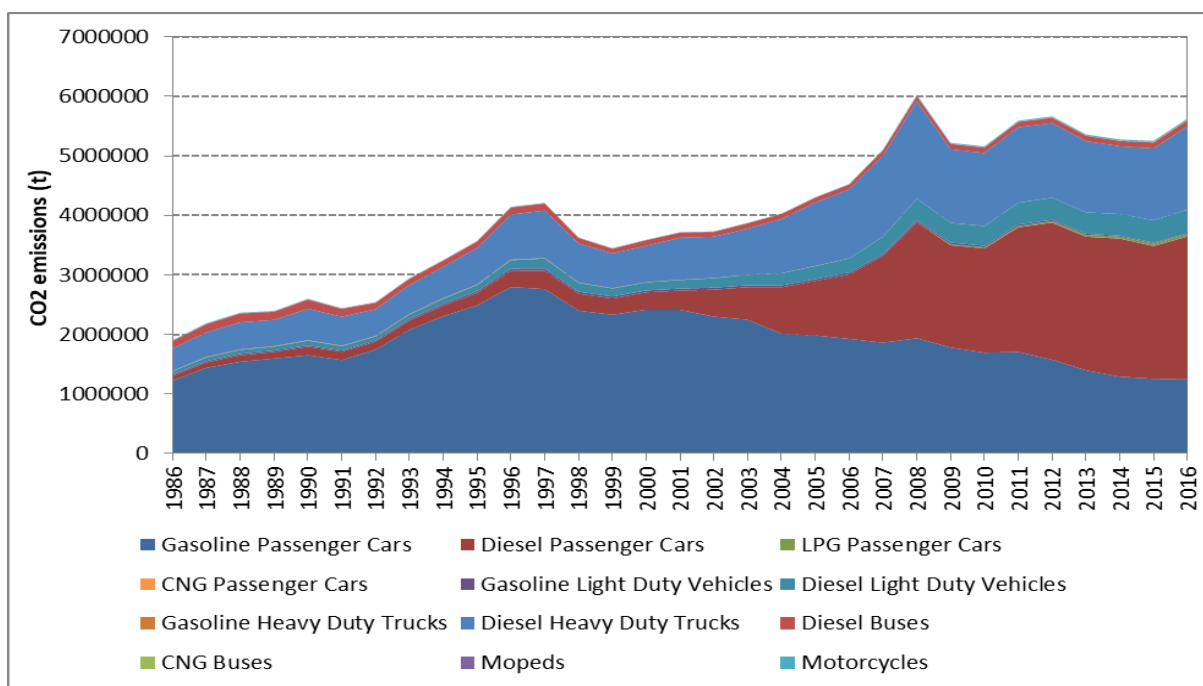
From 1986 to 2016 the road transport emissions of CO<sub>2</sub> and N<sub>2</sub>O increased by 195% and 198%, respectively. Emissions of CH<sub>4</sub> have decreased by 69%. Due to the world economic crises and consecutively smaller fuel consumption emissions of all GHG considerably decreased in 2009. In view of difficult economic situation even slightly lower emissions of all GHG were observed in the year 2010. In the years 2011 and 2012 emissions of GHG were on the rise again and slowly approaching pre-crisis values, but in the period 2013 - 2015 slightly lower emissions could be observed again. In 2016 were emissions on a rise again

due to bigger amount of diesel sold. Referring to the fourth IPCC assessment report, 1 g CH<sub>4</sub> and 1 g N<sub>2</sub>O have the greenhouse effect of 25 and 298 g CO<sub>2</sub>, respectively. In spite of the relatively large CH<sub>4</sub> and N<sub>2</sub>O global warming potentials, the largest contribution to the total CO<sub>2</sub> emission equivalents for road transport comes from CO<sub>2</sub> (Figure 3.2.8).

Due to the direct dependency of CO<sub>2</sub> emissions on fuel consumption, the total growth in CO<sub>2</sub> emissions reflects the trend of increased fuel consumption till 2008. In 2009 significant drop of CO<sub>2</sub> emissions occurred due to the smaller fuel consumption due to economic crisis. As shown in Figures 3.2.9 and 3.2.10, the most important emission source for road transport is passenger cars, followed by heavy duty trucks, light-duty vehicles, buses and 2-wheelers in decreasing order. In 2016, the emission shares were about 66, 25, 7, 1.9 and 0.4%, respectively.

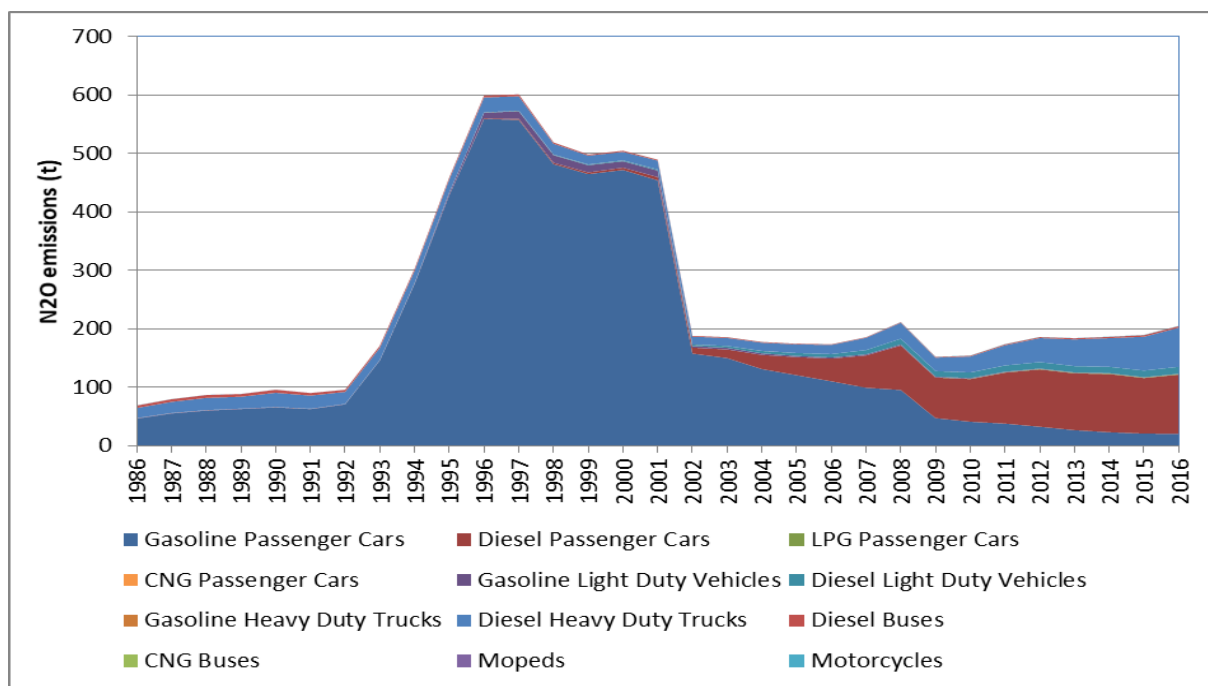
CO<sub>2</sub> emissions of passenger cars were gradually increasing from 1991 to 1996 mainly due to the fuel being sold to foreigners as a consequence of the lower fuel prices in Slovenia. During the period 2000–2008, an extensive switch from petrol powered to diesel powered cars could be observed. The better energy efficiency of diesel cars and a general improvement in fuel efficiency for all new vehicles diminished a considerable increase in fuel consumption which led to a slower increase of CO<sub>2</sub> emissions in this period.

The road transportation sector also includes CO<sub>2</sub> emissions of lubricant use in two-stroke engines. The emissions from lubricants that are intentionally mixed with fuel and combusted in road vehicles should be captured as mobile source emissions. Those emissions have been reported under 1.A.3.b.iv Motorcycles/ Other Liquid Fuels. In the year 2016 CO<sub>2</sub> emissions from lube oil in two-stroke engines represent only 0.001% of total CO<sub>2</sub> emissions from road transportation.



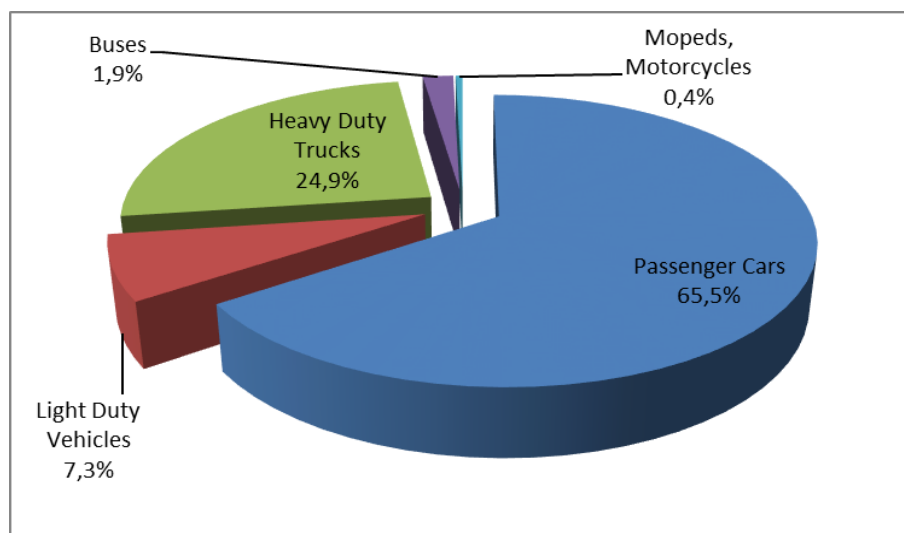
**Figure 3.2.9: CO<sub>2</sub> emissions (t) per vehicle type for road transport 1986–2016.**





**Figure 3.2.10: CO<sub>2</sub> emission share per vehicle type for road transport for 2016.**

N<sub>2</sub>O emissions are not dependent only on the fuel consumption, but also on vehicle technology, operating characteristics, fuel characteristics, the combustion and emission control technology.



**Figure 3.2.11: N<sub>2</sub>O emissions (t) per vehicle type for road transport 1986–2016.**

An undesirable environmental side effect of the introduction of catalyst cars is the increase in the emissions of N<sub>2</sub>O. N<sub>2</sub>O emissions have increased significantly from 1991 onwards, mostly due to the growing number of passenger cars with catalysts. In 2002, a huge drop of N<sub>2</sub>O emissions occurred due to switching to a lower sulphur fuel. The lower sulphur fuel helps improve catalyst performance. The sulphur content in the fuel has an important impact on N<sub>2</sub>O emissions. The sulphur content dropped between 2001 and 2002 from 0.05% to 0.015% for gasoline and 0.2% to 0.035% for diesel.

In 2016 emission shares for passenger cars, heavy duty trucks and light duty vehicles were about 60, 33 and 6%, of the total road transport N<sub>2</sub>O, respectively. The emission shares for buses, mopeds and motorcycles are smaller. (Figures 3.2.11 and 3.2.12).

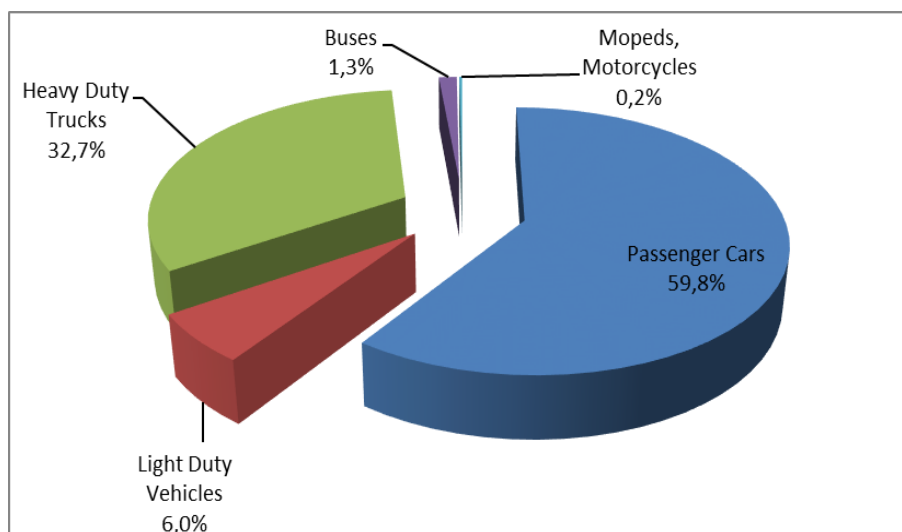


Figure 3.2.12: N<sub>2</sub>O emission share per vehicle type for road transport for 2016.

CH<sub>4</sub> emissions, similarly to N<sub>2</sub>O, do not depend only on the fuel consumption but also on vehicle technology, operating characteristics, fuel characteristics, the combustion and emission control technology.

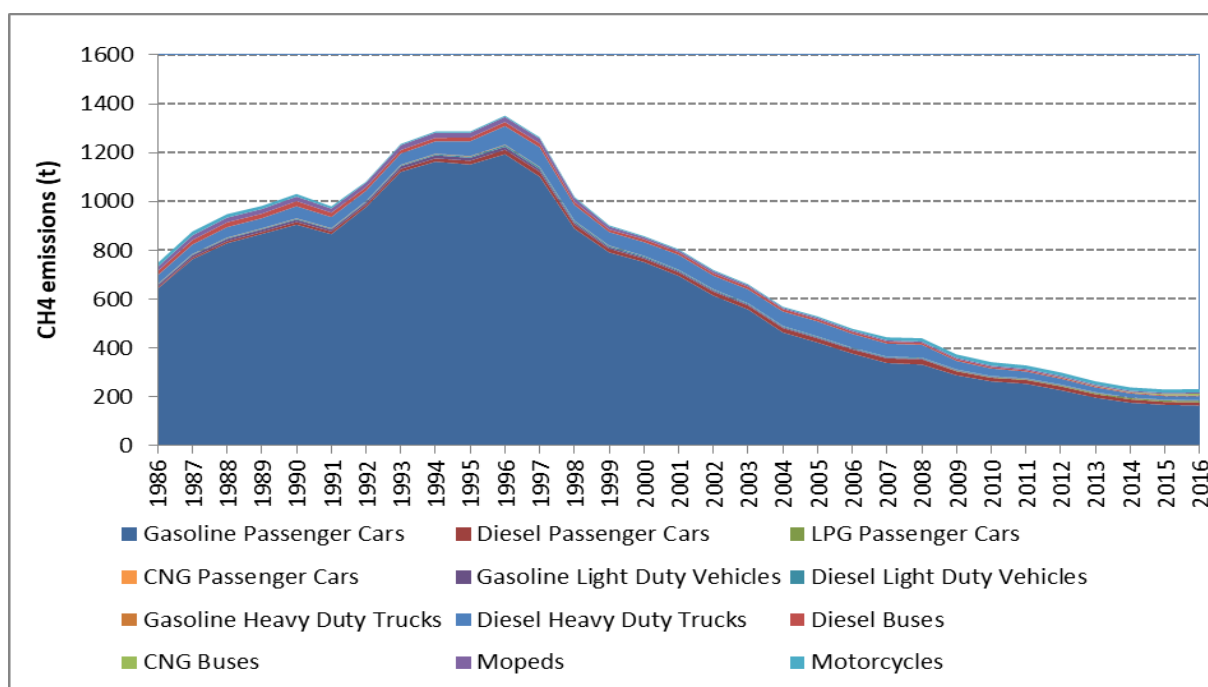
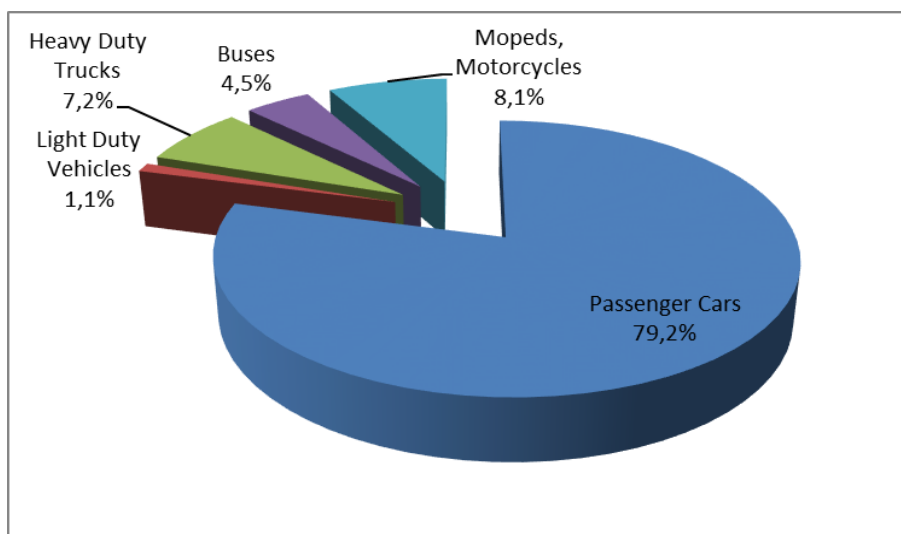


Figure 3.2.13: CH<sub>4</sub> emissions (t) per vehicle type for road transport 1986–2016.



**Figure 3.2.14: CH<sub>4</sub> emission share per vehicle type for road transport for 2016.**

The majority of CH<sub>4</sub> emissions from road transport come from the gasoline passenger cars. The emission increase in 1991–1996 for this vehicle category is a result of a higher fuel consumption. The emission drop from 1997 onwards is explained by the penetration of catalyst cars into the Slovenian fleet. The newer technology stages have lower CH<sub>4</sub> emission factors than conventional gasoline vehicles. The 2016 emission shares for CH<sub>4</sub> were about 79, 8, 7, 5 and 1% for passenger cars, 2-wheelers, heavy duty trucks, buses and light duty vehicles, respectively (Figures 3.2.13 and 3.2.14).

### **3.2.6.1.2 Methodological issues**

COPERT 4 (version 11.4) methodology has been used for the calculation of the national greenhouse gas emissions from road transport for the entire 1986-2016 period. The methodology is fully incorporated in the computer software programme COPERT 4 (version 11.4) which facilitates its application. The actual calculations have been therefore performed by using this computer software.

COPERT 4 estimates the emissions of all major air pollutants (CO, NO<sub>x</sub>, NMVOC, particulate matter (PM<sub>2.5</sub>, PM<sub>10</sub>, TSP, Black carbon), NH<sub>3</sub>, SO<sub>x</sub>, heavy metals) as well as greenhouse gas emissions (CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>) produced by the different vehicle categories (passenger cars, light duty vehicles, heavy duty trucks, buses, mopeds and motorcycles). The programme also provides speciation of polyaromatic hydrocarbons (PAHs) and Dioxins/Furans. Emissions of HCB and PCB are given as a total emissions from road transport. The emissions estimated are divided between the three sources: emissions produced during thermally stabilized engine operation (hot emissions), emissions occurring during engine start from ambient temperature (cold-start and warming-up effects) and NMVOC emissions due to a fuel evaporation. The total emissions are calculated as a product of the activity data, provided by the user and speed-dependent emission factors calculated by the software.

COPERT 4 also provides CO<sub>2</sub> emission estimates for lubricant use in road transportation. In the case of 2- stroke engines, where the lubricant is mixed with another fuel and thus on purpose co-combusted in the engine, the emissions should be estimated and reported as part of the combustion emissions in the Energy Sector/ Road transportation.

The COPERT 4 methodology is in accordance with 2006 IPCC Guidelines for the National Greenhouse Gas Inventories. COPERT 4 methodology is also a part of the EMEP/EEA air pollutant emission inventory guidebook (formerly referred to as the EMEP CORINAIR Guidebook). The Guidebook is prepared by the UNECE/EMEP Task Force on Emission Inventories and Projections (TFEIP) and published by the European Environment Agency. It is intended to support reporting under the UNECE Convention on Long-Range Transboundary Air Pollution and the EU directive on national emission ceilings as well as under United Nations Framework Convention on Climate Change (UNFCCC). The COPERT 4 methodology is fully consistent with the Road Transport chapter of the EMEP/EEA air pollutant emission inventory guidebook. The use of a software tool to calculate road transport emissions allows for a transparent and standardized, hence consistent and comparable data collecting and emissions reporting procedure, in accordance with the requirements of international conventions and protocols and the EU legislation.

The applied methodology is fully described in the following literature:

- COPERT 4 Computer programme to calculate emissions from road transport - User manual (version 5.0), Dimitrios Gkatzoflias, Chariton Kouridis, Leonidas Ntziachristos and Zissis Samaras, ETC/AEM, December 2007,
- EMEP/EEA air pollutant emission inventory guidebook–2016, Chapters: 1.A.3.b.i-iv Exhaust emissions from road transport, 1.A.3.b.v Gasoline evaporation.

To calculate the emissions using the COPERT 4 software, at least the following input data are necessary: vehicle fleet data, mileage data per vehicle category and type of roads, speed data, fuel consumption and fuel characteristic, monthly air minimum and maximum temperatures, fuel vapour pressure.

### **Activity data**

#### **Vehicle fleet**

The COPERT 4 methodology requires a detailed knowledge of the structure of the vehicle fleet composition. Table 3.2.43 provides a summary of all vehicle categories and technologies covered by the applied methodology.

**Table 3.2.43: Summary of vehicle classes covered by the methodology**

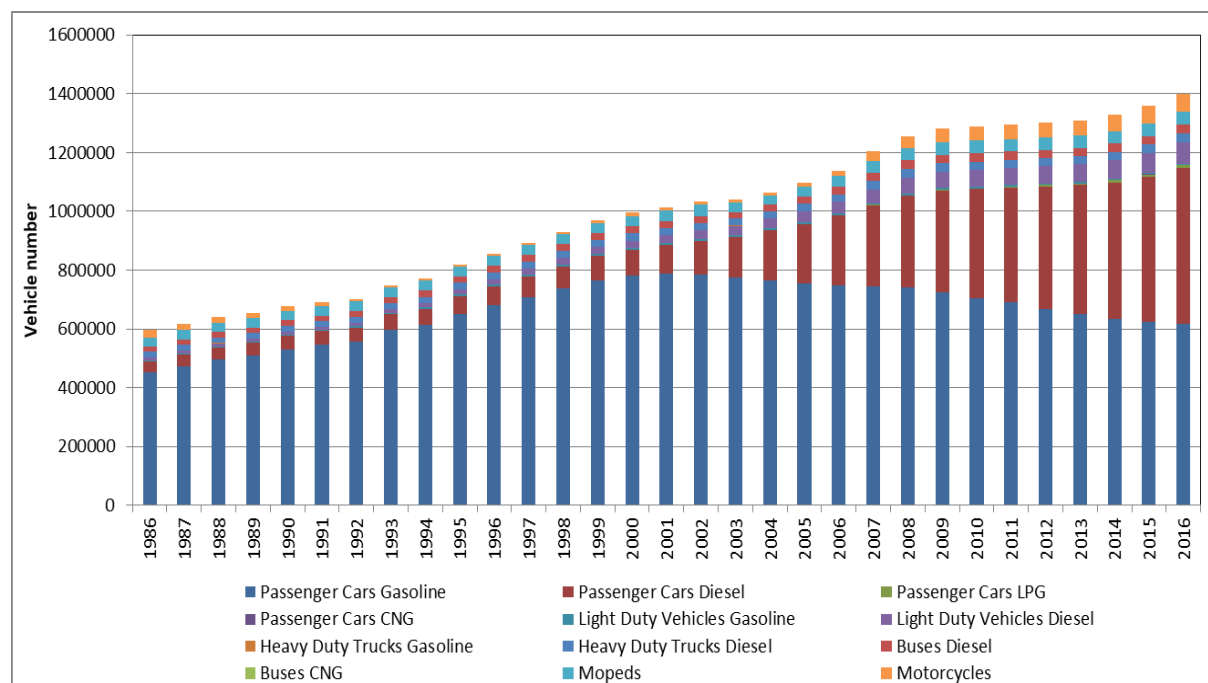
Vehicle Type	Class	Legislation
Passenger Cars	Gasoline <1.4l	PRE ECE ECE 15/00-01 ECE 15/02 ECE 15/03
	Gasoline 1.4 - 2.0l	ECE 15/04 Improved Conventional Open Loop
	Gasoline >2.0l	Euro 1 - 91/441/EEC Euro 2 - 94/12/EEC Euro 3 - 98/69/EC Stage 2000 Euro 4 - 98/69/EC Stage 2005 Euro 5 - EC 715/2007 Euro 6 - EC 715/2007 Euro 6c - EC 715/2007
	Diesel <2.0l	Conventional Euro 1 - 91/441/EEC Euro 2 - 94/12/EEC
	Diesel >2.0l	Euro 3 - 98/69/EC Stage 2000 Euro 4 - 98/69/EC Stage 2005 Euro 5 - EC 715/2007 Euro 6 - EC 715/2007 Euro 6c - EC 715/2007
	LPG	Conventional Euro 1 - 91/441/EEC Euro 2 - 94/12/EC Euro 3 - 98/69/EC Stage 2000 Euro 4 - 98/69/EC Stage 2005 Euro 5 — EC 715/2007 Euro 6 — EC 715/2007
	2 Stroke	Conventional
Light Duty Vehicles	Hybrids Gasoline <1.4l Hybrids Gasoline 1.4-2.0l Hybrid Gasoline >2.0l	Euro 4 - 98/69/EC Stage 2005
	Gasoline <3.5t	Conventional Euro 1 - 93/59/EEC Euro 2 - 96/69/EEC Euro 3 - 98/69/EC Stage 2000 Euro 4 - 98/69/EC Stage 2005 Euro 5 - EC 715/2007 Euro 6 - EC 715/2007 Euro 6c - EC 715/2007
	Diesel <3.5t	Conventional Euro 1 - 93/59/EEC Euro 2 - 96/69/EC Euro 3 - 98/69/EC Stage 2000 Euro 4 - 98/69/EC Stage 2005 Euro 5 - EC 715/2007 Euro 6 - EC 715/2007 Euro 6c - EC 715/2007

Vehicle Type	Class	Legislation
Heavy Duty Trucks	Gasoline >3.5t	Conventional
	Rigid <=7.5t	Conventional Euro I - 91/542/EEC Stage I Euro II - 91/542/EEC Stage II Euro III - 1999/96/EC Stage I Euro IV - 1999/96/EC Stage II Euro V - 1999/96/EC Stage III Euro VI - Regulation EC 595/2009
	Rigid 7.5-12t	
	Rigid 12-14t	
	Rigid 14-20t	
	Rigid 20-26t	
	Rigid 26-28t	
	Rigid 28-32t	
	Rigid >32t	
	Articulated 14-20t	
	Articulated 20-28t	
	Articulated 28-34t	
	Articulated 34-40t	
	Articulated 40-50t	
	Articulated 50-60t	
Buses	Urban <=15t	Conventional Euro I - 91/542/EEC Stage I Euro II - 91/542/EEC Stage II Euro III - 1999/96/EC Stage I Euro IV - 1999/96/EC Stage II Euro V - 1999/96/EC Stage III Euro VI - Regulation EC 595/2009
	Urban 15-18t	Euro I - 91/542/EEC Stage I Euro II - 91/542/EEC Stage II Euro III - 1999/96/EC Stage I Euro IV - 1999/96/EC Stage II Euro V - 1999/96/EC Stage III Euro VI - Regulation EC 595/2009
	Urban >18t	
	Coaches articulated >18t	
	Coaches standard <=18t	
	CNG	Euro I - 91/542/EEC Stage I Euro II - 91/542/EEC Stage II Euro III - 1999/96/EC Stage I EEV- 1999/96/EC
Mopeds	2-stroke, < 50 cm <sup>3</sup>	Conventional Euro 1 - 97/24/EC Stage I Euro 2 - 97/24/EC Stage II Euro 3 - Directive 2002/51/EC Euro 4 - Regulation EC 168/2013 Euro 5 - Regulation EC 168/2013
	4-stroke, < 50 cm <sup>3</sup>	Conventional 97/24/EC – Euro 1 2002/51/EC Stage I - Euro 2 2002/51/EC Stage II - Euro 3 Euro 4 - Regulation EC 168/2013 Euro 5 - Regulation EC 168/2013
Motorcycles	2-stroke, > 50 cm <sup>3</sup>	
	4-stroke, 50–250 cm <sup>3</sup>	
	4-stroke, 250–750 cm <sup>3</sup>	
	4-stroke, > 750 cm <sup>3</sup>	

The fleet composition for the years 1992–2009 was taken from the official database of registered motor and trailer vehicles in the Republic of Slovenia provided by the Ministry of the Interior. Since 2010, those data have been collected by the Ministry of Infrastructure of the Republic of Slovenia. Since no database exists on licensed motor and trailer vehicles in the Republic of Slovenia for the years 1986–1991, an expert estimate has been made on the basis of the annual Statistical Yearbooks, published by the Statistical Office of the Republic of Slovenia (SORS).

The vehicle numbers per all vehicle classes for period 1986–2016 are shown in Annex 3 Energy (Table 1.4: Road transport: Fleet data (number of vehicles) 1986–2016).

The vehicle fleet structure is presented in Figure 3.2.15. The increase in the total number of the passenger cars is mostly due to a growth in the number of diesel passenger cars. After the year 2001 a considerable decline in the number of gasoline passenger cars is observed, and at the same time a rise in the number of diesel passenger cars. LPG and CNG passenger cars represent only a small share of all passenger cars.



**Figure 3.2.15: Vehicle fleet 1986–2016.**

### Mileage

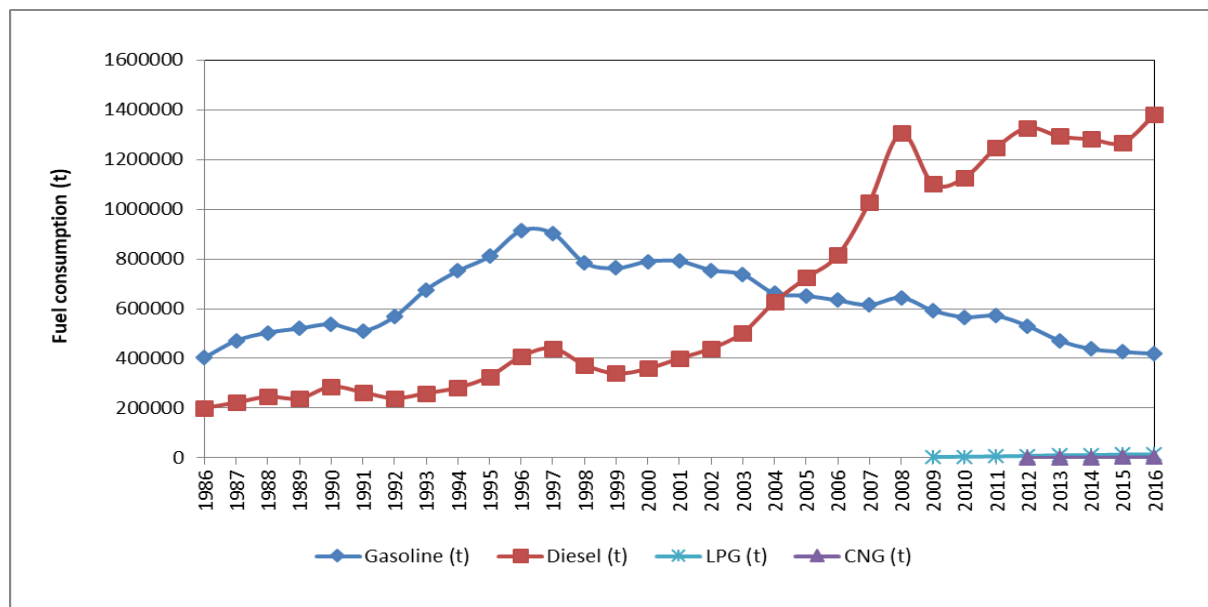
Annual mileage (km/year) for each vehicle category have been obtained from the Ministry of Infrastructure of the Republic of Slovenia, SORS and official database of registered motor and trailer vehicles in the Republic of Slovenia provided by the Ministry of Infrastructure of the Republic of Slovenia. The values used are shown in the Annex 3 (Table 1.5: Road transport: Mileage data 1986–2016).

### Speed

Three driving modes are individualized in accordance with COPERT 4 methodology: urban, rural and highway. For each specific driving mode average speeds has to be set by vehicles type whereas vehicle exhaust emissions and fuel consumption are strongly dependent on speed. Speeds in specific driving modes have been assessed on the basis of the Road Transport: Speed Data of the Republic of Slovenia publication, published by the Ministry of Transport. The values used are shown in the Annex 3 Energy (Table 1.6: Road transport: Speed data 1986–2016).

## Fuel Consumption

The statistical data on the total volume of the fuel consumed in the Republic of Slovenia has been obtained from SORS. From the total volume of the fuel sold, the consumption in the fields of agriculture, forestry and construction has been excluded.



**Figure 3.2.16: Fuel consumption in road transport for 1986–2016.**

Figure 3.2.16 shows the total fuel consumption in road transport. Diesel, gasoline, liquefied petroleum gas (LPG) and compressed natural gas (CNG) have been used as fuels in road transportation. The fuel consumption began to grow markedly during the years 1991–1997 due to fuel being sold to foreigners as a consequence of the lower fuel prices in Slovenia. During the years 2000–2008 an extensive growth in usage of diesel fuel can be observed. Transit of heavy duty trucks has been an important factor for the increase of diesel consumption. In the year 2005, the sale of diesel exceeded the sale of gasoline. In 2009, a significant decline of gasoline and diesel consumption appeared. In comparison with the year 2008 consumption of gasoline dropped by 8% and diesel by 16%. The lower consumption of fuel was due to the world economic crisis. In the years 2011 and 2012 the fuel consumption was on the rise again and slowly approaching pre-crisis values, but in the period 2013–2016 slightly lower fuel consumption could be observed. In 2016, the fuel use shares for diesel and gasoline were about 76% and 23%, respectively. The share of LPG was below 0.8%. CNG was reported for the first time in 2012. Share of CNG is only 0.1%.

As shown in Figures 3.2.17 and 3.2.18, the passenger cars represent the most fuel-consuming vehicle category, followed by heavy duty trucks, light duty vehicles, buses, motorcycles and mopeds, in decreasing order. The passenger cars dominate the overall gasoline consumption trend. The development in the diesel fuel consumption in recent years is characterised by an increasing fuel use for diesel passenger cars and heavy duty trucks, while the fuel use for buses and light duty vehicles is less distinctive. To meet the data quality objective of transparency, the fuel consumption by types of vehicles is shown in the Annex 3 Energy to the NIR (Table 1.7: Road transport: Fuel Consumption by types of vehicles 1986–2016).



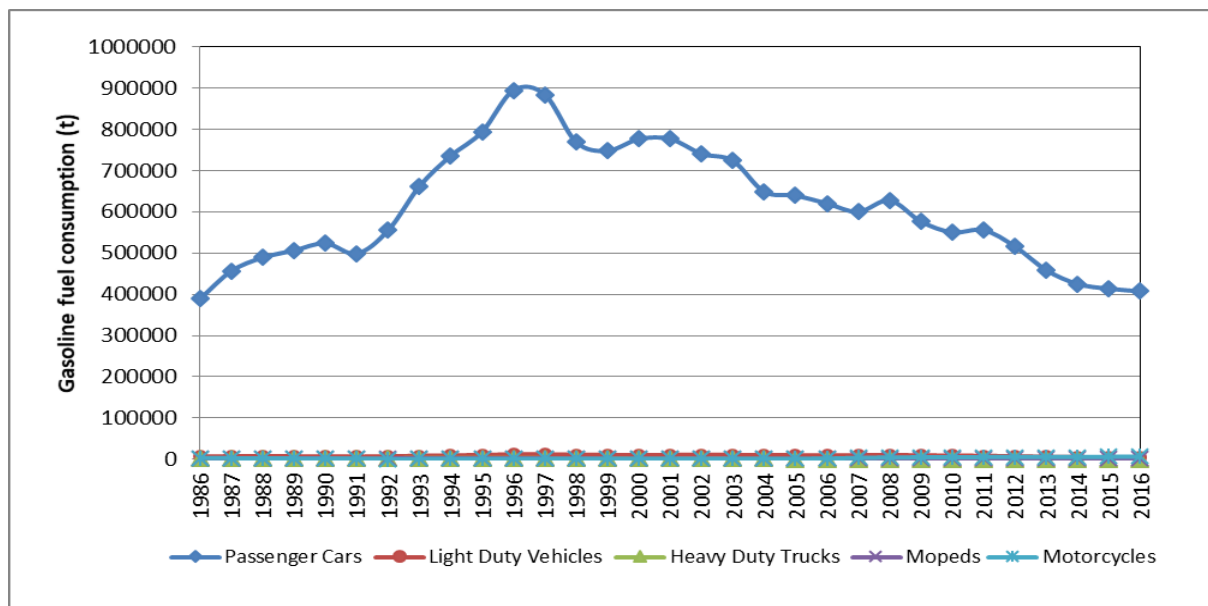


Figure 3.2.17: Gasoline fuel consumption per vehicle type for road transport 1986–2016.

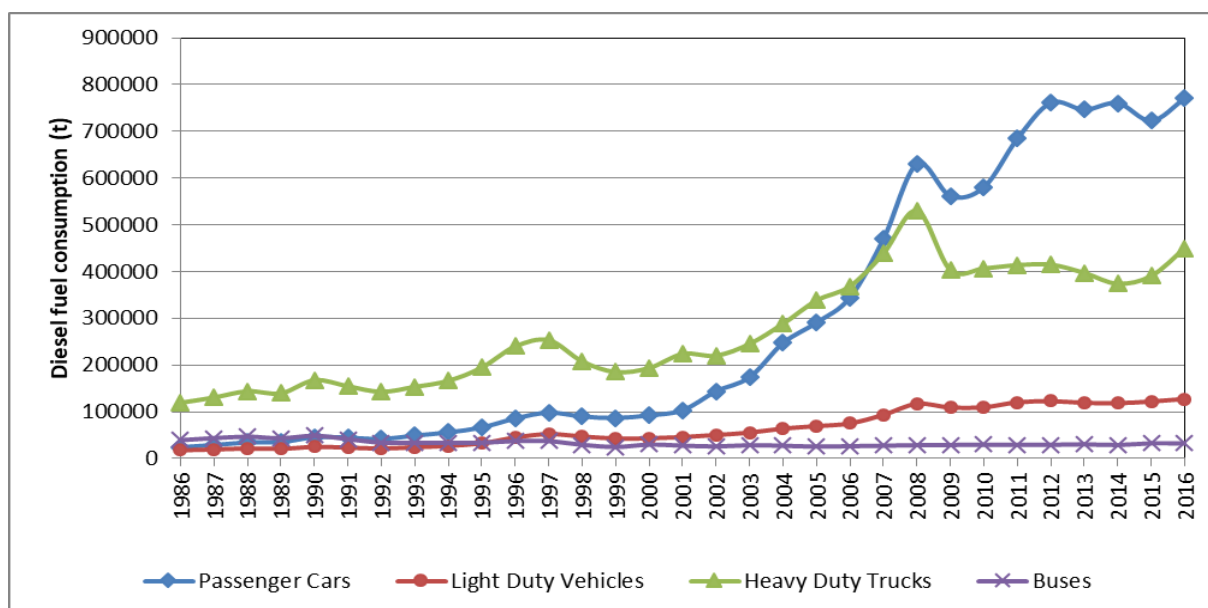
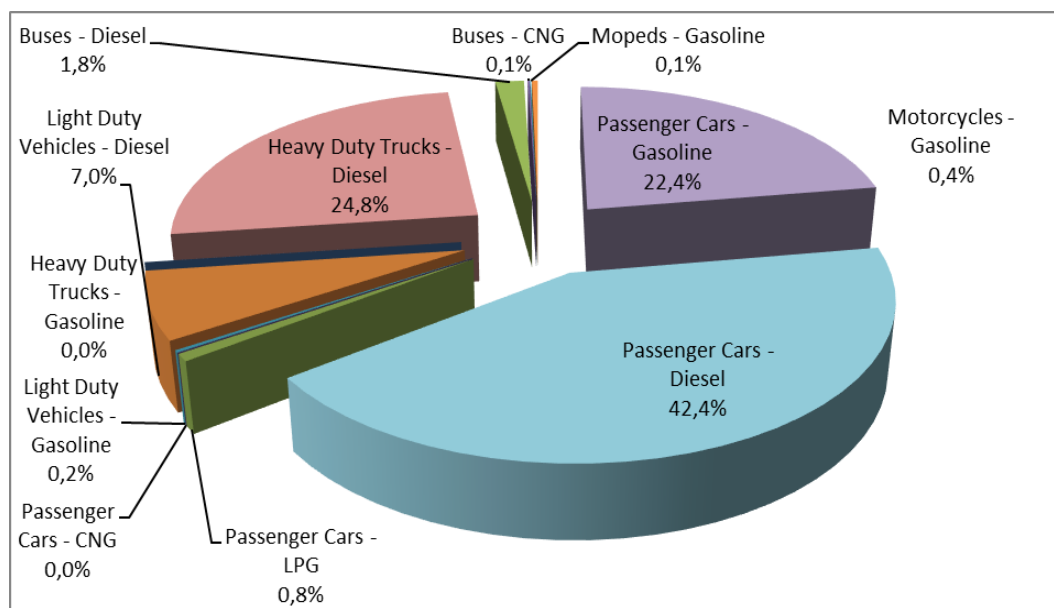


Figure 3.2.18: Diesel fuel consumption per vehicle type for road transport 1986–2016.

In 2016, the fuel consumption shares for diesel passenger cars, diesel heavy duty trucks and gasoline passenger cars were about 42, 25, and 22%, respectively (Figure 3.2.19).

In addition to fossil fuels biofuels have also been used in road transportation in Slovenia. Biodiesel has been used since 2006 and bioethanol since 2008. Biodiesel in road transportation is mostly blended into fossil diesel, bioethanol into fossil gasoline. The amount of biofuel used in road transport is in steady increase also due to the national legislation on promotion of biofuel use in road transport. The emissions from biofuels have been calculated

using the COPERT 4 model as well, based on the total amount of fossil fuels and biofuels used.



**Figure 3.2.19: Fuel consumption share per vehicle type for road transport in 2016.**

### Fuel Characteristics

The sulphur and lead content of liquid fuels and the monthly values of the fuel volatility (RVP – Reid Vapour Pressure) were taken from the Slovene national legislation related to the quality of liquid fuels. The leaded gasoline was removed from the market in 2002. All the other physical and chemical data used was proposed as default values by the COPERT 4.

RVP values used were 70 kPa for the winter period (1 October – 30 April) and 60 kPa for the summer period (1 May – 30 September). The lead and sulphur contents were set as presented in Tables 3.2.44 and 3.2.45.

**Table 3.2.44: Levels of lead content in gasoline.**

Fuel	Period	Lead [g/l]
Gasoline Leaded	1986-1994	0.6
	1995	0.4
	1996-2001	0.15
Gasoline Unleaded	1986-1994	0.026
	1995-2001	0.013
	2002-2016	0.005

**Table 3.2.45: Levels of sulphur content in gasoline and diesel fuel.**

Fuel	Period	Sulphur [% wt]
Gasoline Leaded	1986-1994	0.1
	1995-2001	0.05
Gasoline Unleaded	1986-1994	0.1
	1995-2001	0.05
	2002-2004	0.015
	2005-2008	0.005
	2009-2016	0.001
Diesel	1986-1994	1
	1995	0.25
	1996-2001	0.20
	2002-2004	0.035
	2005-2008	0.005
	2009-2016	0.001

#### Monthly minimum and maximum air temperatures

The meteorological data necessary for evaporative emission calculation (annual average minimum temperature and maximum temperature) is obtained from the Slovenian Environment Agency. The data for Ljubljana were taken into consideration with the assumption that they are representative enough for the whole Slovenia. The data are publicly available on the Slovenian Environment Agency's website.

#### Other input data

The average trip length (Ltrip) value corresponds to the mean distance covered in trips started with an engine of ambient temperature (cold start). The mean daily trip distance was set at 12 km in accordance with the recommendation of the COPERT 4. Ltrip value is introduced for the calculation of the Beta value which represents the fraction of the monthly mileage driven before the engine and any exhaust components have reached their nominal operation temperature. Beta values calculated according to the COPERT 4 methodology were used.

All the other required input data used for calculation of emissions using COPERT 4 program were default COPERT 4 data.

### **Emission factors**

All emission factors used in the emission inventory for road transport were default emission factors offered by the COPERT 4 (version 11.4) program.

#### ***3.2.6.1.3 Uncertainties and time-series consistency***

The uncertainty based on an expert judgement is 5% for fuel used and 20% for other activity data. The uncertainties of the emission factors are defined by the COPERT 4 program since all emission factors applied were default COPERT 4 emission factors.

#### ***3.2.6.1.4 Category-Specific QA/QC and Verification***

Thorough examination of all input data, the model calculation and the data reported in CRF tables as part of QA/QC procedure was performed.

One of the required model input data is the annual amount (in tonnes) of consumed gasoline and consumed diesel fuel. The output of the model are calculated CO<sub>2</sub> emissions distributed according to fuel type, vehicle category and type of roads. The CRF Tables require separate reporting of emissions arising from the consumption of gasoline and diesel fuel. The CO<sub>2</sub> emissions have to be reported in kt. In the CRF Tables, the fuel consumption has to be presented as energy (in TJ), not in mass (in tonnes). Implied CO<sub>2</sub> emission factors, expressed in t CO<sub>2</sub>/ TJ fuel, are calculated automatically by CRF Reporter and used for reporting requirements only.

The CO<sub>2</sub> emission factors (g CO<sub>2</sub>/ kg fuel) used for the emission calculation are comparable with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The differences between CO<sub>2</sub> emissions factors (t CO<sub>2</sub>/ TJ) presented in CRF Tables and those stated in the 2006 IPCC Guidelines arise from differences in applied net calorific values. In the period 2006-2016, additional slight deviations occurred due to the use of biofuels.

The decreasing trend of the CO<sub>2</sub> IEF for gasoline from 1986 to 2016 is attributed to the introduction of unleaded gasoline in the country, which has lower carbon content than leaded gasoline. Leaded and unleaded gasoline has different H:C and O:C ratios. The value for H:C ratio in unleaded gasoline compared to the leaded one is 1.89 vs. 1.92. The value for O:C ratio in unleaded gasoline compared to the leaded one is 0.016 vs. 0.

We also conducted a verification exercise for the CO<sub>2</sub> emissions. We estimated the CO<sub>2</sub> emissions of road transport category by applying a Tier 1 with a default EF from 2006 IPCC Guidelines. The comparison showed differences in emission calculation between COPERT 4 and Tier 1 method. COPERT 4 gives slightly lower emissions from diesel, but rather higher emissions from gasoline. In general, the emissions calculated with COPERT 4 are not underestimated.

Information on CO<sub>2</sub> implied emission factors (IEFs) for gasoline and diesel is presented in Annex 3 Energy (Table 1.8: Road transport: CO<sub>2</sub> implied emission factors 1986–2016).

CH<sub>4</sub> and N<sub>2</sub>O emissions were thoroughly examined as well, including the emissions arising from biofuels. The new version of COPERT 4 (version 11.4) delivers some improvements in the emission calculations and also corrects some bugs in the software performance. CH<sub>4</sub> and N<sub>2</sub>O emissions reported in the CRF Tables are accurate. CH<sub>4</sub> and N<sub>2</sub>O emissions from biofuels have been calculated using the COPERT 4 model as well, based on the total amount of fossil fuels and biofuels used. Since disaggregation of the emission from biomass among different vehicle type is not possible, all emissions from biodiesel and bioethanol have been reported under 1A3bi Cars/ Biomass.

#### **3.2.6.1.5 Category-specific recalculations**

Emissions of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O have been recalculated for the period 1986-2015 due to new version of model COPERT 4 applied. The latest version of COPERT 4, that is version 11.4 was used for emission calculation for the entire period. Updated activity data on vehicle fleet was introduced in the model and used for emission calculation.

#### **3.2.6.1.6 Category-specific planned improvements**

Following the recommendation of the expert review team we are looking for options to obtain more information on characterization of the properties of gasoline and diesel used for road transportation.

### **3.2.6.2 All other types of transportations (CRF categories 1.A.3.a, c, d, e)**

#### **3.2.6.2.1 Category description**

This chapter presents emissions of greenhouse gases in:

- Domestic Aviation (CRF 1A3a)
- Railways (CRF 1A3c)
- Domestic navigation (CRF 1A3d)
- Other Transportation / Pipeline transport (CRF 1A1e.i)

##### Domestic aviation

The emissions from aviation are included in many CRF categories. The main source of emissions is the consumption of jet kerosene while the quantity of aviation gasoline is much smaller. Slovenia is a small country and there is no need for domestic aviation transport between the cities. All civil domestic flights are for sport or touristic purpose only and have been made by small planes with reciprocating engine using aviation gasoline. For this reason all aviation gasoline sold in Slovenia is considered to be used for domestic aviation and the emissions are reported in this category. However, according to the Eurocontrol data a small amount of jet kerosene has been used since 2005 in domestic aviation. After investigation it was found that this fuel has been used for reallocation of airplanes between the two largest airports (Ljubljana and Maribor). The amount of jet kerosene used for this purpose is very small.

The remaining emissions from jet kerosene are reported in the category 1.A.5 (Fuel used in the Slovenian army and Police) or in Memo under International Bunkers and Multilateral Operations. The fuel used in TJ and GHG emissions from domestic aviation are presented on the table 3.2.46.

**Table 3.2.46: GHG Emissions from domestic aviation in the period 1986-2016.**

	1986	1990	1995	2000	2005	2010	2015	2016
Gasoline in TJ	9	15	28	40	24	23	20	21
Jet kerosene in TJ	NO	NO	NO	NO	15	4	8	8
Gg CO <sub>2</sub> eq.	1	1	2	3	3	2	2	2

### Railways

The main source of emissions is the consumption of gas oil. The consumption of brown coal in the railway transportation in the recent years is small as it is used in only one "archaic" steam driven locomotive which is almost 100 years old. Fuel in TJ and GHG emissions from the railways are presented in table 3.2.47.

There was a strong increase in diesel consumption in 2014. The reason for this increase is a severe ice storm which destroyed electrical infrastructure for the supply of trains on the route Ljubljana - Koper in the February 2014. The repair was going on until the summer 2015. In meantime, the trains on this line were using diesel locomotives what resulted in the higher consumption of diesel oil in 2014 and relatively high consumption in 2015.

**Table 3.2.47: GHG Emissions from railways in the period 1986-2016.**

	1986	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
fuel in TJ	931	879	588	514	505	403	424	402	414	543	498	417
Gg CO <sub>2</sub> eq.	77	73	49	43	42	33	35	33	34	45	41	35

### Domestic navigation

The emissions from 1.A.d Domestic Navigation are included into the road transport and the notation key IE has been used. The fuel for small boats and yachts (diesel oil) is sold on four petrol stations at Adriatic coast (Izola Pier, Lucija Pier, Marina Koper and Piran Pier). As those stations are selling fuel to road vehicle also, a division between road and marine traffic is not possible. For this reason we have reported all fuel in sub-sector road traffic.

### Other transportation

In the category 1.A.3.e Other transportations only emissions from natural gas combusted in the compressor station have been reported. As data are available since 2008 the notation key IE has been used for the period 2005-2007. There was no compression station in Slovenia before 2005. Fuel in TJ and GHG emissions are presented in table 3.2.48.

Table 3.2.48: GHG Emissions from compressor station in the period 1986-2016.

	1986	1990	1995	2000	2005	2010	2015	2016
fuel in TJ	NO	NO	NO	NO	IE	79	53	50
Gg CO <sub>2</sub> eq.	NO	NO	NO	NO	IE	4	3	3

### 3.2.6.2.2 Methodology issues

To estimate emissions from these categories, the following methodology has been adopted:

$$\text{Emissions} = \text{Quantity of Fuel used} \times \text{Net Calorific value} \times \text{EF per energy of Fuel}$$

#### Activity data and NCV

The data on the fuel consumption as well as NCVs have been obtained from SORS except for natural gas, which has been obtained from the company Plinovodi which is the owner of this compressor station. The net calorific values used for the 2015 inventory are presented in table 3.2.49.

Table 3.2.49: NCVs for fuel used in all other transportation in 2016.

	Unit	Aviation Gasoline	Jet kerosene	Gas Oil	Coal	Natural gas
NCV	TJ/kt or TJ/ 10 <sup>6</sup> Sm <sup>3</sup>	43.54	43.54	42.6	11.775	34.086

#### Emission factors

All emission factors have been taken from the 2006 IPCC Guidelines except for CO<sub>2</sub> EF for natural gas which is country specific (Table 3.2.50).

Table 3.2.50: EFs for fuel used in all other transportations in the period 1986-2016.

	Unit	Aviation Gasoline	Jet kerosene	Gas Oil	Coal	Natural gas
CO <sub>2</sub> EF	t/TJ	69.3	71.5	74.0	101	Table 3.2.2
CH <sub>4</sub> EF	t/TJ	0.0005	0.0005	0.00415	0.002	0.001
N <sub>2</sub> O EF	t/TJ	0.002	0.002	0.0286	0.0015	0.0001
Source	CO <sub>2</sub>	IPCC, Table 3.6.4	IPCC, Table 3.6.4	IPCC, Table 3.4.1	IPCC, Table 2.2	CS
Source	CH <sub>4</sub> , N <sub>2</sub> O	IPCC, Table 3.6.5	IPCC, Table 3.6.5	IPCC, Table 3.4.1	IPCC, Table 3.4.1	IPCC, Table 2.4

IPCC = 2006 IPCC Guidelines for National GHG Inventories, Vol. 2

According to the information from Railway Company, a very low calorific brown coal with NCVs in the range 10-13 TJ/kt had been used in the “archaic” steam driven locomotive due

to safety reasons, durability and preservation this piece of history. For this reason the default EF for lignite has been applied in the calculations.

### 3.2.6.2.3 Uncertainty and time –series consistency

The uncertainty estimates for the transport sector are mostly based on an expert judgement. To determine the uncertainties of the AD, consultations with experts from SORS were performed, while values from the 2006 IPCC GL have also been taken into account for the uncertainties of EFs.

**Table 3.2.51: Uncertainties of activity data and emission factors as used in the 2018 submission for the base year and the last reporting year in per cents.**

	1986 and 2016			
	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF
Aviation Gasoline	5	4	150	150
Railways/Liquid	5	1.5	150	150
Railways/Solid (1986)	10	10	135	150
Other/Gaseous (2015)	5	3	135	135

The uncertainty of activity data is a combination of systematic and random errors. The statistical data which are obtained from the obligatory reporting are usually within 3%. In addition, the activity data are subject to the random errors in the data collection. Countries with good data collection systems may keep the random error to about 2-3%. The experts believe that for most developed countries the total uncertainties of activity data are in the range of 5%. After consultation with SORS and taking into account the levels of uncertainties associated with transportation recommended in the 2006 IPCC GL, we have used different uncertainties for different types of fuel as presented in the Table 3.2.51.

### 3.2.6.2.4 Category-specific QA/QC and verification

This category has been checked by the general QC procedures described in the Chapter 1.2.3 while QA is applied with the comparison with the energy balance data in RA.

### 3.2.6.2.5 Category-specific recalculations

Emissions of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O have been recalculated for the period 2005-2015 due to inclusion of more precise data on fuel oil used in the railways. In addition for the same time period a very small amount of brown coal used in one old steam driven locomotive was included in the inventory and GHG emissions have been recalculated accordingly.

### 3.2.6.2.6 Category-specific planned improvements

No improvement is planned for this category.



### 3.2.7 Other Sectors (CRF 1A4)

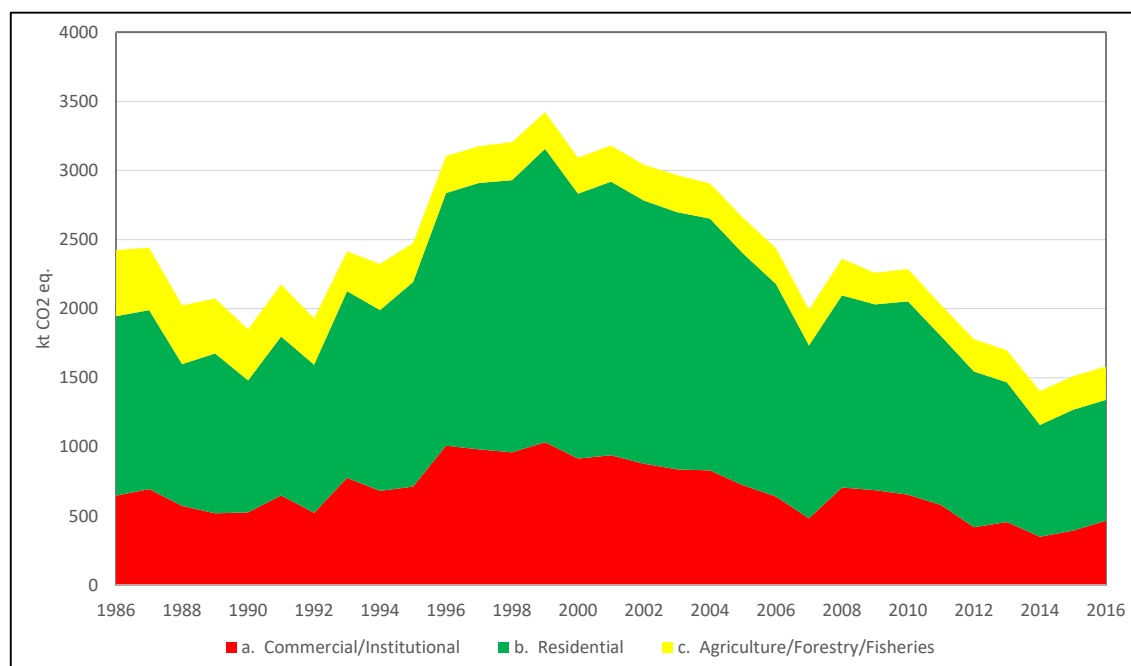
This chapter presents the consumption of fuels and emissions of greenhouse gases in:

- Commercial / Institutional sector (CRF 1A4a)
- Residential sector (CRF 1A4b)
- Agriculture and forestry (CRF 1A4c)

Emissions from Fishing are not included in this sector, because the data on the fuel used for this purpose are not available separately. According to [The European Community Fishing Fleet Register](#) there have been only 169 active fishing vessels in Slovenia at the end of 2016. Majority of them (144) are less than 10 m long and the longest boat has only 18 m. Due to the problems with the sea border with Croatia and due to the EU legislation on Common Fisheries Policy (the subsidies are given to fishermen if they give up fishing and destroy the vessels) the numbers of vessel is decreasing from year to year. The fuel used from this vessels and corresponding GHG emissions which are almost negligible, are included in the road transport.

**Table 3.2.52: Method, EF used and key categories indications for the year 2016 in the Other sectors.**

	CO <sub>2</sub>			CH <sub>4</sub>			N <sub>2</sub> O		
Fuels	Method	EF	Key category	Method	EF	Key category	Method	EF	Key category
Gaseous	T2	CS	L,T	T1	D	-	T1	D	-
Liquid	T1	D	L,T	T1	D	-	T1	D	-
Solid	T1	D	T	T1	D	T	T1	D	-
Biomass	T1	D	-	T1	D	L, T	T1	D	-



**Figure 3.2.20: GHG emissions from Other Sectors.**

In this sector the use of gaseous and liquid fuel is a key category according to the level and trend while the solid fuel is key category according to trend. The amount of solid fuel which is used in the residential sector is small and CO<sub>2</sub> emissions are almost negligible, thus the use of default EF seems appropriate (table 3.2.52). The GHG emissions are presented in the Table 3.2.53 and on the Figure 3.2.20.

**Table 3.2.53: GHG emissions from Other Sectors in kt CO<sub>2</sub> eq..**

	1986	1990	1995	2000	2005	2010	2015	2016
<b>4. Other Sectors</b>	2424	1851	2478	3100	2629	2289	1510	1581
<b>a. Commercial/Institutional</b>	646	525	721	934	721	653	393	464
<b>b. Residential</b>	1299	955	1474	1906	1649	1401	874	875
<b>c. Agriculture/Forestry/Fisheries</b>	479	371	283	261	258	234	243	242

### **3.2.7.1 Commercial / Institutional and Residential Sector (CRF categories 1.A.4.a and 1.A.4.b)**

#### **3.2.7.1.1 Category description**

Emissions from these two subsectors were in 2015 for 37.7 % lower than in 1986 despite that the energy of the fuel used was nearly the same. The reason for this is the shift in the fuel mix from solid fuels to natural gas and in the last years to biomass. Since 2010 the emissions have decreased also due to the warmer winters and due to an improved thermal insulation of the buildings.

#### **3.2.7.1.2 Methodology issues**

To estimate the emissions from these categories, the following methodology has been adopted:

$$\text{Emissions} = \text{Quantity of Fuel used} \times \text{Net Calorific value} \times \text{EF per energy of Fuel}$$

#### **Activity data**

The data on the fuel used in these two sectors have been obtained from the SORS.

Before 2005 the consumption of fuels in the commercial sector and households has been combined under "Široka potrošnja" in our basic source of data (Statistical Yearbook of Electricity Generating Industries). The disaggregation into these two categories has been done within the framework of the research project done at the end of the year by the Institute of Energy Industries (Gasperič, Dornik 1998).

Data from that research project have been corrected in the following points:

- Quantities of fuel oil which have been consumed in the road transport as gas oil and which have been estimated in the research project "Assessment of Emissions of Greenhouse Gases in Road Traffic" (Institute of Transport Technology, 1999) are

subtracted from the sector "Široka Potrošnja", namely 80 % from sector Consumption in Households and 20 % from Consumption in Commercial Sector (see Table 3.2.54).

- All quantities of residual fuel oil, reported as consumed in Other consumption in LEG, are presented as consumption in the commercial/institutional sector in this report. In the energy statistics of Slovenia, this item is a balance category; consequently, it will be positive in some years, negative in other years. The quantities used in the calculating of emissions for this report (either positive or negative values) have been taken from LEG.

Since 2005, the data on the fuel used in commercial and residential sector have been available from Joint questionnaires.

**Table 3.2.54: Estimates of Inappropriate Consumption of Fuel Oil in Commercial Sector and Households**

Year	Other Consu. (LEG)	Estimate of "Inappropriate" Use of Res.Fuel Oil. subtracted from Other Cons (LEG) & added to Road Transport	Other Consumption (NIR)	Split of "Inappropriate" Use of Fuel Oil		Actual Consumption of Res. Fuel Oil in Other Consumption	
				Resid.	Comm./ Institution	Resid. (NIR)	Comm./ Inst (NIR)
	A	B	C=A-B	D=0.8 x B	E=0.2 x B	F+G=C	
	(tonnes)	(tonnes)	(tonnes)	80%	20%	(tonnes)	(tonnes)
1986	157835	36121	121714	28897	7224	72117	49597
1990	310342	96020	214322	76816	19204	121803	92519
1991	327577	80733	246844	64586	16147	145063	101781
1992	300726	59608	241118	47686	11922	144779	96339
1993	411782	744	411038	595	149	262945	148093
1994	432591	1141	431450	913	228	275945	155505
1995	512171	-23212	535383	-	-	342645	192738
1996	625621	-79731	705352	-	-	451425	253927
1997	697066	0	697066	-	-	446084	250982
1998	718587	0	718587	-	-	459896	258691
1999	755417	0	755417	-	-	483467	271950
2000	674464	0	674464	-	-	431657	242807
2001	684636	0	684636	-	-	438167	246469
2002	658761	0	658761	-	-	421607	237154
2003	633476	0	633476	-	-	405425	228051
2004	620586	0	620586	-	-	397175	223411
2005	553409	0	553409	-	-	345255	208154

**Net calorific values**

The net calorific values have been taken from SORS. The values for solid fuel varies from year to year but for the liquid and gaseous fuel almost the same values have been used for the entire period, as these types of fuel don't change a lot from year to year. All NCVs are presented in the Table 3.2.55.

**Table 3.2.55: NCVs for the fuel used in Commercial Sector and Households.**

Year	Lignite (Velenje)	Sub- bituminous Coal - domestic	Sub- bituminous Coal - imported	Fuel Oil	Residual Fuel Oil	LPG	Natural Gas	Wood and Other Biomass
	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/kt	TJ/Mm3	TJ/kt
1986	9.390	11.880		41.82	39.74	46.00	33.500	12.17
1987	9,650	11.820		41,78	39.80	46.00	33.500	12.17
1988	9,440	12.000		41,71	39.80	46.00	34.080	12.17
1989	9,820	12,050		41,85	39.90	46.00	34.100	12.17
1990	9.810	12.760		41.87	39.80	46.00	34.100	12.17
1991	9.980	12.879		41.88	39.80	46.00	34.100	12.17
1992	10.260	12.589		41.90	39.90	46.00	34.100	12.17
1993	10.070	13.351		41.90	39.80	46.00	34.100	12.17
1994	9.960	12.666		41.90	39.86	46.00	34.100	12.17
1995	10.220		17.404	41.90	40.00	46.00	34.100	12.17
1996	9.690		16.353	41.90	40.00	46.00	34.100	12.17
1997	9.610		18.203	41.90	40.00	46.05	34.080	12.17
1998	10.010		18.531	41.90	40.00	46.05	34.080	12.17
1999	9.690		18.563	41.90	40.00	46.05	34.080	12.17
2000	10.170		17.983	41.90	40.00	46.05	34.080	12.26
2001	10.660		18.834	41.90	40.00	46.05	34.080	12.51
2002	10.350		19.000	41.90	40.00	46.05	34.080	12.77
2003	10.138		19.000	41.90		46.05	34.080	13.03
2004	10.301		19.000	41.90		46.05	34.080	13.29
2005	10.803		17.000	42.60		46.05	34.080	13.56
2006			17.318	41.90		46.05	34.072	13.84
2007			16.863	42.60		46.05	34.076	14.12
2008			16.407	42.60		46.05	34.096	14.41
2009			15.952	42.60		46.05	34.080	14.74
2010			16.155	42.60		46.05	34.080	14,75
2011			15.985	42.60		46.05	34.087	14,78
2012			16.032	42.60		46.05	34.093	14,80
2013			16.457	42.60		46.05	34.079	14.80
2014			15.734	42.60		46.05	34.083	14.81
2015			16.360	42.60		46.05	34.086	14.81
2016			16.575	42.60		46.05	34.087	14.82

**Emission factors****Table 3.2.56: EFs for the fuel used in Commercial Sector.**

	Unit	Lignite (Velenje)	Sub- bituminous Coal - domestic	Fuel Oil	Residual Fuel Oil	LPG	Natural Gas	Wood and other solid biomass	Gaseous biomass
CO <sub>2</sub> EF	t/TJ	Table 3.2.1	101	74.0	77.1	63.1	Table 3.2.2	112	54.6
CH <sub>4</sub> EF	t/TJ	0.01	0.01	0.01	0.03	0.005	0.005	0.30	0.005
N <sub>2</sub> O EF	t/TJ	0.0015	0.0014	0.0006	0.0006	0.0001	0.0001	0.0040	0.0001

**Table 3.2.57: EFs for the fuel used in Residential Sector if different from Commercial.**

	Unit	Lignite (Velenje)	Sub- bituminous Coal - domestic
CH <sub>4</sub> EF	t/TJ	0.3	0.3

We have used country specific CO<sub>2</sub> EF for domestic lignite and natural gas, the emission factors for all other fuels have been taken from 2006 IPCC Guidelines, Vol. 2 Table 2.4 and are presented in the Table 3.2.56 and 3.2.57.

**3.2.7.1.3 Uncertainty and time –series consistency**

The uncertainty estimates for residential and institutional/commercial sector are mostly based on an expert judgement. To determine the uncertainties of the AD, consultations with experts from SORS were performed, while values from the 2006 IPCC GL have also been taken into account for the uncertainties of EF.

**Table 3.2.58: Uncertainties of activity data and emission factors as used in the 2018 submission for the base year and the last reporting year in per cents.**

	1986 and 2016			
	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF
Liquid	5	2	150	150
Solid	10	6.4	135	150
Gaseous	5	2.5	135	135
Biomass	20	NA	150	170

The uncertainty of the activity data is a combination of systematic and random errors. The statistic data which are obtained from the obligatory reporting are usually within 3%. In addition, the activity data are subject to the random errors in the data collection. Countries with good data collection systems may keep the random error to about 2-3%. The experts

believe that for most developed countries the total uncertainties of the activity data are in the range of 5%. After consultation with SORS and taking into account levels of uncertainties associated with stationary combustion recommended in the 2006 IPCC GL, we have used different uncertainties for different types of fuel as presented in the Table 3.2.58.

#### **3.2.7.1.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3 while QA is applied with the comparison with the energy balance data in RA.

#### **3.2.7.1.5 Category-specific recalculations**

Activity data on biomass used in the commercial and residential sector have been improved and GHG emissions for the period 1990 - 2014 have been recalculated. Since 2008 the updated values from SORS have been used while for the period 1990-2007 we have decided that the interpolation is the best option.

#### **3.2.7.1.6 Category-specific planned improvements**

No improvement is planned for these two categories

### **3.2.7.2 Agriculture and Forestry (CRF category: 1.A.4.c)**

#### **3.2.7.2.1 Category description**

This chapter should present all consumption of fuel in agriculture, forestry, and fishing. However, only the consumption of fuel for mobile sources in this sector is presented here. Not enough data are available for the consumption of fuel in stationary sources in Slovenia; consequently, these quantities are included in the Commercial / Institutional sector while emissions from fishing are included in the Road transport.

#### **3.2.7.2.2 Methodology issues**

To estimate emissions from these categories, the following methodology has been adopted:

$$\text{Emissions} = \text{Quantity of Fuel used} \times \text{Net Calorific value} \times \text{EF per energy of Fuel}$$

#### **Activity data**

The consumption of fuels until year 2000 has been calculated from the data on fuel consumption in state owned agriculture enterprises and corresponding agriculture land. The same energy intensity have been used to calculate the fuel used on the total agricultural land. For estimation of the fuel consumption in Agriculture from year 2000 onwards, we used the same energy intensity (fuel consumption/ha of land) as observed in 2000. The results of the calculation are presented in the Table 3.2.59 for gasoline and Table 3.2.60 for diesel.

**Table 3.2.59: Estimation of the Consumption of Gasoline in Agriculture.**

	1986	1990	1995	2000	2005	2010	2015	2016
Cultivated Land in State owned Agriculture ent. (1000 ha)	70	77	62	31	-	-	-	-
Total Cultivated Land (1000 ha)	647	653	634	509	485	483	477	478
Consumption of Gasoline in State owned Agriculture ent. (1000 t)	1.3	1.1	0.7	0.4	-	-	-	-
Consumption of Gasoline per ha of Cultivated Land (t/1000 ha)	18.6	14.1	10.5	7.1	7.1	7.1	7.1	7.1
Estimated Consumption of Gasoline in Total Agriculture (1000 t)	12.016	9.227	6.647	3.626	3.458	3.440	3.397	3.403

**Table 3.2.60: Estimation of the Consumption of Diesel in Agriculture.**

	1986	1990	1995	2000	2005	2010	2015	2016
Consumption of Diesel in State owned Agriculture ent. (1000 t)	11.7	10.1	6.4	3.5	-	-	-	-
Consumption of Diesel per Hectare of Cultivated Land in State owned Agriculture ent. (t/1000 ha)	167.4	130.6	103.1	123	123	123	123	123
Estimated consumption of Diesel Fuels in Total Agriculture (1000 t)	108.326	85.255	65.353	62.596	59.702	59.364	58.648	58.749

The consumption of fuels in the entire forestry is estimated on the basis of the consumption of fuel in state-owned logging enterprises. The data used are presented in the Table 3.2.61.

**Table 3.2.61: The Calculation of the Consumption of Fuels in State Owned Forest**

	1986	1990	1995	2000	2005	2010	2015	2016
Consumption of Fuel in State owned Forest (1000 t)	6.902	5.922	3.680	2.808				
Cut in State owned Forest (1000 m <sup>3</sup> )	1438	1230	862	907	919	1138	2116	2007
Consumption of Fuel per Cut Quantities (tons per 1000 m <sup>3</sup> )	4.8	4.8	4.3	3.1				
Consumption of gasoline per Cut Quantities (tons per 1000 m <sup>3</sup> )					0.28	0.18	0.20	0.17
Consumption of diesel per Cut Quantities (tons per 1000 m <sup>3</sup> )					2.95	1.03	1.02	0.96
Total Cut (1000 m <sup>3</sup> )	3501	2435	2092	2609	3236	3374	6031	6103
Total Consumption of Fuel in Forestry (1000 t)	16.804	11.720	8.931	8.077				
Gasoline (1000 tonnes)	1.680	1,172	0.893	0.808	0.917	0.616	1.198	1.042
Diesel (1000 tonnes)	15.124	10.548	8.038	7.272	9.536	3.486	6.135	5.841

For the state-owned sector, data are available for the consumption of fuel and cut, for the private sector only data on cut are available. Firstly; the consumption per m<sup>3</sup> of cut in the state-owned logging enterprises is estimated. Based on these estimates and the data on the total cut, an estimation of the consumption in the whole of forestry is calculated. Before 2005 there were no separate data on the consumption of gasoline and diesel, only the total

consumption. Consequently, the split is done considering the split in agriculture (10 % gasoline, 90 % gas oil), presuming that the same amount of fuels is consumed per m<sup>3</sup> of felled wood in the private forestry as in the state forestry.

The data needed for the estimation of the consumption of fuels in Agriculture and Forestry is available for all years and are obtained from the SORS.

### **Net calorific values**

We have used value 43.850 TJ/1000t for gasoline and 42.6 TJ/1000t for gas diesel oil as reported by SORS

### **Emission factors**

In calculating emissions, the emission factors, recommended in 2006 IPCC Guidelines, Vol 2, Table 3.3.1, Agriculture were used. We have assumed that mostly 4-stroke gasoline motors have been used. EFs are presented in the Table 3.2.62.

**Table 3.2.62: Default EFs for gasoline and diesel oil used in the agriculture and forestry.**

	Diesel	Motor gasoline
	t/TJ	t/TJ
CO <sub>2</sub> EF	74.1	69.3
CH <sub>4</sub> EF	0.00415	0.08
N <sub>2</sub> O EF	0.0286	0.002

#### ***3.2.7.2.3 Uncertainty and time –series consistency***

The uncertainty estimates for this category are the same as for residential and commercial/sector, because the same estimates have been used for whole “Other Sectors” (Table 3.2.63).

**Table 3.2.63: Uncertainties of activity data and emission factors as used in the 2018 submission for the base year and the last reporting year in per cents.**

	1986 and 2016			
	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF
Liquid	5	2	150	150

#### ***3.2.7.2.4 Category-specific QA/QC and verification***

This category has been checked by the general QC procedures described in the Chapter 1.2.3 while QA is applied with the comparison with the energy balance data in RA.

#### ***3.2.7.2.5 Category-specific recalculations***

No recalculations have been performed.



### 3.2.7.2.6 Category-specific planned improvements

No improvement is planned for this category.

## 3.2.8 Other (CRF 1A5)

### 3.2.8.1.1 Category description

This chapter presents the consumption of fuels and emissions of greenhouse gases in:

- Other mobile (CRF 1A5b)

The emissions from jet kerosene in Slovenian Army and Police have been included in this category. The fuel used (TJ) and GHG emissions are presented in the Table 3.2.64.

**Table 3.2.64: GHG Emissions in the period 1986-2016.**

	1986	1990	1995	2000	2005	2010	2015	2016
fuel in TJ	575	444	19	43	46	40	51	50
Gg CO <sub>2</sub> eq.	41	32	1	3	3	3	4	4

### 3.2.8.1.2 Methodology issues

To estimate the emissions from these categories, the following methodology has been adopted:

$$\text{Emissions} = \text{Quantity of Fuel used} \times \text{Net Calorific value} \times \text{EF per energy of Fuel}$$

### Activity data

Since 2008, the consumption of jet kerosene in Slovenian army and police has been obtained. These data are not available for the period 1986-2007. Following the recommendation from ARR 2011, the fuel used in Slovenian army and Police has been estimated using correlation with the number of aircrafts in the Slovenian army. To estimate emissions in the period 1986-1990/91, when Slovenia was still part of Yugoslavia, the fuel used for the international aviation has been estimated taking into account the correlation with the number of passengers on commercial flights and the remaining amount of jet-kerosene was counted as fuel used in the Yugoslavian army on Slovenian territory.

### Net calorific values

We have used value 43.54 TJ/1000t for jet kerosene. This value was obtained from SORS.

### **Emission factors**

For the calculation of emissions and individual gases, the emission factors from 2006 IPCC Guidelines, Vol 2, Table 3.6.4 and 3.6.5 for jet kerosene were used as presented on the Table 3.2.65

**Table 3.2.65: Default EFs for gasoline and diesel oil used in the agriculture and forestry.**

	Jet kerosene
	t/TJ
CO <sub>2</sub> EF	71.5
CH <sub>4</sub> EF	0.0005
N <sub>2</sub> O EF	0.002

#### ***3.2.8.1.3 Uncertainty and time –series consistency***

The high uncertainty of the AD for the base year is due to the unavailability of data. The uncertainties of the EFs are from the 2006 IPCC GL (Table 3.2.66).

**Table 3.2.66: Uncertainties of activity data and emission factors as used in the 2018 submission for the base year and the last reporting year in per cents.**

	1986				2016			
	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF
liquid	30	3	150	150	10	3	150	150

#### ***3.2.8.1.4 Category-specific QA/QC and verification***

This category has been checked by the general QC procedures described in the Chapter 1.2.3 while QA is applied with the comparison with the energy balance data in RA.

#### ***3.2.8.1.5 Category-specific recalculations***

No recalculations have been performed for this category.

#### ***3.2.8.1.6 Category-specific planned improvements***

No improvement is planned for this category.

### 3.3 Fugitive emissions from solid fuels and oil and natural gas and other emissions from energy production, (CRF 1.B)

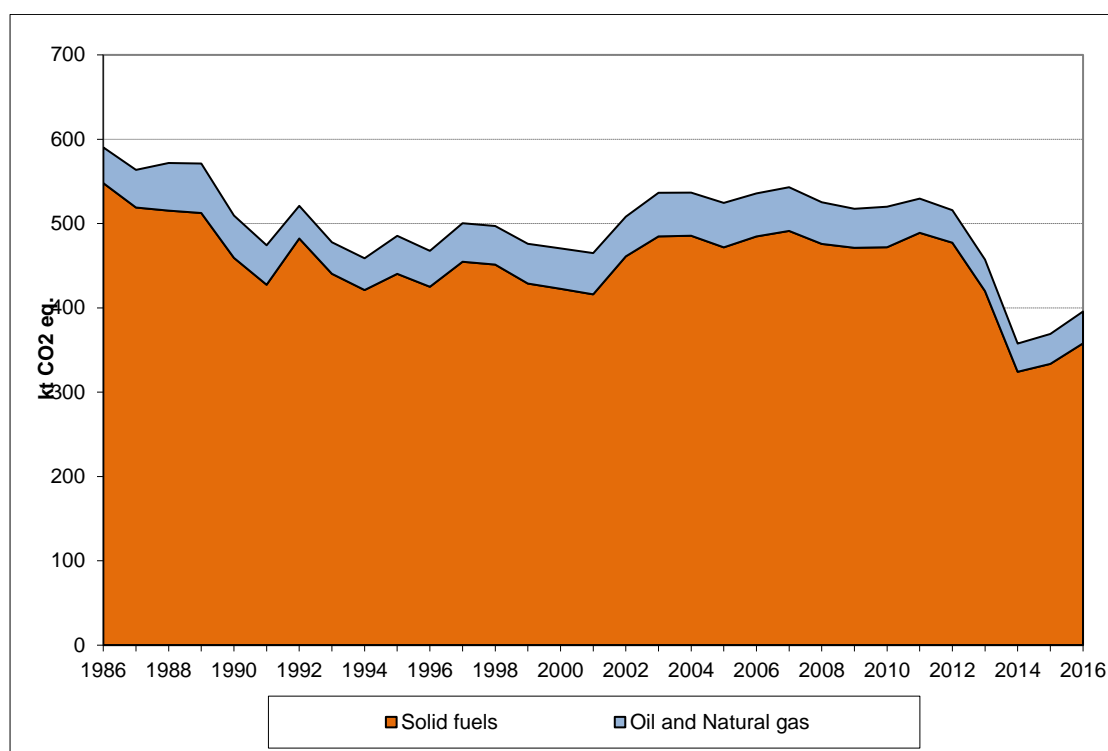
This chapter presents the fugitive emissions of greenhouse gases from:

- Solid fuels (CRF 1.B.1)
- Oil and natural gas (CRF 1.B.2)

Coal mining and handling is a key category and the emissions have been calculated using Tier 3 methodology with EFs specific for each mine. For the methane emissions from abandoned and close coal mines we have used Tier 2 approach. All other emissions have been calculated using Tier 1 approach and default EFs as indicated on the Table 3.3.1 below.

**Table 3.3.1: Method, EF used and key categories indications for the year 2016 in the Fugitive emissions sectors.**

	CO <sub>2</sub>			CH <sub>4</sub>			N <sub>2</sub> O		
Fuels	Method	EF	Key category	Method	EF	Key category	Method	EF	Key category
Coal Mining and Handling	T3	PS	T	T2, T3	D, PS	L,T	NO	NO	NA
SO <sub>2</sub> scrubbing	T3	PS	T	NO	NO	NA	NO	NO	NA
Oil and Natural Gas	T1	D	-	T1	D	-	T1	D	-



**Figure 3.3.1: Fugitive emissions in Gg CO<sub>2</sub> eq.**

GHG emissions in CO<sub>2</sub> equivalent for each category are presented in the table 3.3.2 and on the Figure 3.3.1.

**Table 3.3.2: Fugitive emissions of GHGs in kt CO<sub>2</sub> eq.**

in Gg CO <sub>2</sub> eq.	1986	1990	1995	2000	2005	2010	2015	2016
<b>Total</b>	<b>590</b>	<b>509</b>	<b>485</b>	<b>471</b>	<b>524</b>	<b>520</b>	<b>369</b>	<b>396</b>
Solid Fuels	548	459	440	423	471	472	334	358
Oil and Natural gas	42	50	45	48	53	46	36	38

### 3.3.1 Solid Fuels (CRF 1.B.1)

#### 3.3.1.1 Category description

This sub-chapter presents the fugitive emissions of greenhouse gases from:

- 1.B.1.a.i Coal mining and handling / Underground mines
  - Mining activities
  - Post-mining activities
  - Abandoned underground mines
- 1.B.1.c Other
  - SO<sub>2</sub> scrubbing

This chapter encompasses emissions arising from underground coal mines due to the production, processing, and storage of coal. The most important component of those emissions are CH<sub>4</sub> emissions that arise during mining and post-mining activities although CO<sub>2</sub> emissions occur as well. In 2015 submission CH<sub>4</sub> emissions from abandoned coal mines have been estimated for the first time following methodology described in 2006 IPCC GL. The emissions due to the flu-gases desulphurization have been reallocated from the IPPU sector to the energy sector as recommended in the 2006 ICC GL and reported under 1.B.1.c Other. The emissions from these categories are presented in the Table 3.3.3 and Table 3.3.4.

**Table 3.3.3: Emission from Coal mining and handling 1986 – 2016 in kt CO<sub>2</sub> eq.**

	1986	1990	1995	2000	2005	2010	2015	2016
<b>Mining Activities (CH<sub>4</sub>)</b>	103.3	53.1	256.0	200.4	208.2	208.6	159.2	168.3
<b>Mining Activities (CO<sub>2</sub>)</b>	120.4	98.4	86.2	79.0	81.3	80.6	60.1	63.5
<b>Post-Mining Activities (CH<sub>4</sub>)</b>	324.0	307.4	67.9	99.7	96.0	88.3	53.1	56.1
<b>Abandoned coal mines (CH<sub>4</sub>)</b>	0.2	0.4	0.2	6.7	4.0	2.8	5.8	5.2
<b>Total</b>	<b>547.9</b>	<b>459.2</b>	<b>410.3</b>	<b>385.9</b>	<b>389.4</b>	<b>380.3</b>	<b>278.2</b>	<b>293.1</b>

**Table 3.3.4: Emission of CO<sub>2</sub> from SO<sub>2</sub> scrubbing 1986 – 2016 in kt CO<sub>2</sub>.**

	1986	1990	1995	2000	2005	2010	2015	2016
<b>SO<sub>2</sub> scrubbing</b>	NO	NO	30.0	36.7	82.3	91.5	55.3	64.8

### 3.3.1.2 Methodology issues

#### Mining and post mining

*Methane emission (t) = (EF1 (m<sup>3</sup> CH<sub>4</sub>/t) + EF2 (m<sup>3</sup> CH<sub>4</sub>/t)) \* excavated coal (t/year) \* 0.67*  
*CO<sub>2</sub> emission (t) = EF3 (m<sup>3</sup> CO<sub>2</sub>/t) \* excavated coal (t/year) \* 1.8*

EF1 = Methane emission factor in coal excavation (m<sup>3</sup> CH<sub>4</sub>/t)

EF2 = Methane emission factors in post-mining activities for coal (m<sup>3</sup> CH<sub>4</sub>/t)

EF3 = CO<sub>2</sub> emission factor in coal excavation (m<sup>3</sup> CO<sub>2</sub>/t)

The methodology follows Tier 3 approach as the EFs in the equation above are specific for each mine.

#### Activity data

The data on excavated quantities of coal according to the individual coalmines are taken from SORS and are presented in the Table 3.3.5.

**Table 3.3.5: Excavation of Coal in Slovenia 1986 – 2016**

Pit	1986	1990	1995	2000	2005	2010	2015	2016	Closed in
Velenje	5,001	4,210	3,917	3,743	3945	4,011	3,168	3,349	
Trbovlje - Hrastnik	1,242	905	812	737	594	419			2013
Zagorje	315	244	75						1997
Senovo	120	108	45						1996
Kanižarica	126	94	35						1996
Laško	25								1990
<b>Total Coal Excavation (Gg)</b>	<b>6,828</b>	<b>5,561</b>	<b>4,883</b>	<b>4,480</b>	<b>4,540</b>	<b>4,430</b>	<b>3,168</b>	<b>3,349</b>	

#### Emission factors

The estimates of the emission factors for the individual coalmines in Slovenia were done at the Ecological Research Institute (Zapušek A., Orešnik K., Avberšek F: Assessment of methane emission factors in coal excavation in 1986 and in the period 1990-1996, Velenje: ERICO - Ecological Research Institute, 1999).

Due to the rather small emissions from this sector, no special research project has been done, thus, since 1997, the emission factor recommended in the study period has been assumed.

#### Details from the ERICO study:

The data on the amount of exhaust air used for ventilation of the mines and methane content in the outlet air was obtained from the technical services in each mine. For the coal mines with more ventilation stations, the data from each ventilation station was considered. The chemical analysis of all samples was done in Chemical-technological laboratory in the coal mine Trbovlje-Hrastnik. Air sampling at the exit valves was held once a month in the middle of the month and in the middle of the working week, when the CH<sub>4</sub> concentrations are

generally the highest. The air flow was measured with congestive pressure (Pittot Prandt tube). The proportions of CH<sub>4</sub> were determined on the basis of IR detection. The range of the uncertainties of EFs for mining was from 8 to 100%, it depended on the amount of methane in the air.

From the measurement of methane de-sorption in samples it was found that, after long enough period, all methane is released. It was assumed that the total EF for the type of coal or for the coal from the particular mine was constant. The total EF was determined as EF from mining plus EF from post-mining activities. For Velenje and Trbovlje coal mine the total EF was determined to be 4 m<sup>3</sup>/t coal.

In 1994, the new method of excavation has been introduced in the Velenje Coal mine which affected EFs from mining activities. Due to the new technology of mining, the coal is broken into smaller pieces what causes more methane to be released from the coal during mining and, consequently, less methane is available for the emissions during post-mining activities. This excavation methodology in the Velenje coal mine has been applied until now, while no major changes of mining practice have occurred in the Trbovlje-Hrastnik coal mine in the reporting period. In the same study, the CO<sub>2</sub> EFs for mining activities have been determined using the same sampling method. Due to a large variation between years, the average value for 1986-1996 has been used for all reporting years (Table 3.3.8)

**Table 3.3.6: Emission Factors for CH<sub>4</sub> in Coal Excavation 1986 – 2016 (m<sup>3</sup> CH<sub>4</sub>/t coal)**

Pit	1986	1990	1995	1997-2016
Velenje	0.95	0.33	3,56	3.00
Trbovlje - Hrastnik	0.62	0.88	0,46	1.00 (Closed since 2013)
Zagorje	1.39	3.59	11.30	Closed since 1997
Senovo	0.57	0.63	1.53	Closed since 1996
Kanižarica	0.33	0.45	1.21	Closed since 1996
Laško	3.82	Closed since 1990		

**Table 3.3.7: Emission Factors for CH<sub>4</sub> in Post Mining Activities 1986 – 2016 (m<sup>3</sup> CH<sub>4</sub>/t coal)**

Pit	1986	1990	1995	1997-2016
Velenje	3.05	3.67	0.44	1.00
Trbovlje - Hrastnik	2.38	2.12	2.54	3.00 (Closed since 2013)
Zagorje	1.61	2.00	2.00	Closed since 1996
Senovo	2.43	2.37	1.47	Closed since 1996
Kanižarica	2.67	2.52	1.79	Closed since 1996
Laško	0.18	Closed since 1990		

**Table 3.3.8: Emission Factors for CO<sub>2</sub> in Coal Excavation 1986 – 2016 (m<sup>3</sup> CO<sub>2</sub>/t coal)**

Pit	1986-2016
Velenje	10.54
Trbovlje - Hrastnik	6.03
Zagorje	9.51
Senovo	16.16
Kanižarica	8.21
Laško	30.80

Methane emission factors for mining and post-mining activities for each particular coal mine are presented in the table 3.3.6 and 3.3.7, respectively.

### **Abandoned underground mines**

The data on abandoned and close mines have been obtained from the study made by Geological Survey of Slovenia in 2004 for coordination with activities of the European Union (Budkovič, 2005). This study contained register of 44 opened, closed and abandoned coal mines in Slovenia. From this list we have chosen 7 closed coal mines which are gassy or are not fully flooded.

For 4 closed mines data on measured emissions on the last year of operation are available, while for other 3 these emissions have been estimated with correlation with the data on probable coal reserve. All data from this register are available in the Table 3.3.9.

**Table 3.3.9: Closed and abandoned coal mines – data from the registry.**

Coal mine	type of coal	Opened in the year	Closed in the year	Maximal yearly production in tonnes	in the year	Average probable reserves in million tones	Measured emissions on the last year of operation in kt CH <sub>4</sub>
Trbovlje-Hrastnik	brown	1804	2013	1,000,000	1929	35	0.22
Zagorje	brown	1736	1997	685,000	1960	18.5	0.39
Senovo	brown	1819	1995	250,000	1943	4.65	0.07
Kanižarica	brown	1854	1995	143,000	1969	4.35	0.04
Laško	brown	1800	1989	132,000	1962	1.2	0.01
Šega	brown	1863	1963	18,000	1957	0.8	0.01
Krmelj	brown	1809	1962	11,000	1950	3.6	0.043
Leše	brown	1824	1936	4,000	1850	0.5	0.006

**Table 3.3.10: EFs used for calculating emissions from Closed and abandoned coal mines in 2016.**

Coal mine	type of coal	Measured emissions on the last year of operation in kt CH <sub>4</sub>	T (years since abandonment)	EF
Trbovlje-Hrastnik	brown	0.22	3	0.552
Zagorje	brown	0.39	19	0.163
Senovo	brown	0.07	21	0.150
Kanižarica	brown	0.04	21	0.150
Laško	brown	0.01	27	0.121
Šega	brown	0.01	53	0.065
Krmelj	brown	0.043	54	0.064
Leše	brown	0.006	80	0.044

The emissions are calculated using Tier 2 equation 4.1.12 from 2006 IPCC GL, and coefficients have been taken from the Table 4.1.9 from 2006 IPCC GL. All mines were sub-bituminous coal mines ( $A = 0.27$ ,  $b = -1$ )

$$CH_4 \text{ emissions} = CH_4 \text{ emissions prior to abandonment} * EF$$

$$EF = (1 + a * T)^b$$

a and b are constants determining the declining curve

T = years elapsed since abandonment and inventory year

T and EFs calculated from equation above for 2016 are presented in the Table 3.3.10.

### **SO2 scrubbing**

Using a technology for reduction of SO<sub>2</sub> emissions in the process of consumption of coal is causing the emissions of CO<sub>2</sub>. CO<sub>2</sub> emissions from the scrubbing have been calculated from consumption of additive CaCO<sub>3</sub> and the appropriate emission factor.

The activity data on CaCO<sub>3</sub> consumption for the period 1995-2004 have been taken from the documents of Milan Vidmar Electro-institute. Prior to 1995, there were no wet flue gas desulphurisation units installed for reducing emission of SO<sub>2</sub> in Slovenia. THE Data on CaCO<sub>3</sub> and MgCO<sub>3</sub> for the period 2005–2016 have been obtained from the verified ETS reports. The default emission factors, 439,71 kg CO<sub>2</sub>/ton limestone and 521,97 kg CO<sub>2</sub>/ton magnesium carbonate, have been applied for the whole period.

#### **3.3.1.3 Uncertainty and time –series consistency**

The uncertainty estimates for fugitive emissions from Mining and post mining activities have been made by the experts from ERICO institute and are presented in the same study as the EFs. For CH<sub>4</sub> emissions uncertainties have been taken from 2006 IPCC Guidelines, while for other the other sources (SO<sub>2</sub> scrubbing) are based on an expert judgement. They are presented in the Table 3.3.11.

**Table 3.3.11: Uncertainties of activity data and emission factors as used in the 2016 submission for the base year and the last reporting year.**

	1986				2016			
	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF
Coal Mining and Handling	10	150	30	NA	10	150	30	NA
Other – SO2 scrubbing	NO	NO	NA	NA	5	2	NA	NA

#### **3.3.1.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.



### 3.3.1.5 Category-specific recalculations

No recalculations have been performed for this category.

### 3.3.1.6 Category-specific planned improvements

No improvement is planned for this category.

## 3.3.2 Oil and natural gas (CRF 1.B.2)

### 3.3.2.1 Category description

Fugitive emissions of GHG from Oil and Natural Gas in the period 1986-2015 are presented in the Table 3.3.12. Methane emissions from the production of crude oil and refined petroleum products were insignificant in the period 1986-2002 and have not occurred since 2003. There was also one oil refinery in Slovenia which was closed in 2001. Since then no oil is refined in the country. According to the 2006 IPCC GL fugitive CH<sub>4</sub> emissions due to transport of LPG have been also reported under this category.

Natural gas transmission and distribution is the main source of emissions in this category while fugitive emissions from natural gas production are less important. The gasification of Slovenia began in the early 1970s and in 1978 the newly constructed pipeline system enabled the transportation of Russian natural gas for Croatia and delivered gas to the first two consumers in Slovenia. Today, the total length of the gas pipeline transport network in Slovenia, which is constantly growing, exceeds 1000 km.

Besides Russia, in 1992, natural gas deliveries from the second source, namely, from Algeria, started, which essentially increased the reliability of the supply and enabled the growth of natural gas consumption also in households and for commercial use. Since 2001, natural gas from a third source, Austria, has been delivered.

There is no processing of natural gas in Slovenia. A very small amount, which is produced, is transported directly without processing to the chemical plant nearby the production place.

**Table 3.3.12: Fugitive emissions of GHG from Oil and Natural gas in 1986 – 2016 (kt CO<sub>2</sub> eq.)**

		1986	1990	1995	2000	2005	2010	2015	2016
OIL	Production	0.00004	0.00004	0.00003	0.00001	NO	NO	NO	NO
	Transport	0.011	0.008	0.009	0.020	0.022	0.021	0.020	0.020
	Refining	0.341	0.341	0.331	0.093	NO	NO	NO	NO
	Venting	0.055	0.053	0.040	0.018	NO	NO	NO	NO
	Flaring	0.149	0.145	0.108	0.050	NO	NO	NO	NO
NATURAL GAS	Production	2.247	7.204	4.141	0.968	0.142	0.224	0.101	0.161
	Transmission	9.980	10.705	9.814	11.300	12.654	11.178	7.747	8.219
	Distribution	22.911	24.576	24.052	27.937	31.436	29.185	22.482	23.859
	Venting	6.655	7.139	6.545	7.536	8.439	7.455	5.166	5.481
	Flaring	0.011	0.034	0.025	0.010	0.005	0.008	0.004	0.006
TOTAL		42.359	50.205	45.065	47.931	52.697	48.070	35.519	37.747

### 3.3.2.2 Methodology issues

GHG emissions in this category include:

- emissions1: venting, flaring and fugitive GHG emissions from crude oil production,
- emissions2: fugitive CO<sub>2</sub> and CH<sub>4</sub> emissions from crude oil refining,
- emissions3: CO<sub>2</sub> emissions from the transport of LPG
- emissions4: flaring and fugitive GHG emissions from natural gas production,
- emissions5: venting and fugitive CO<sub>2</sub> and CH<sub>4</sub> emissions from NG transmission,
- emissions6: fugitive CO<sub>2</sub> and CH<sub>4</sub> emissions from NG distribution.

The emissions have been calculated using Tier 1 approach as describe in 2006 IPCC GL with the equations below:

*emissions1= crude oil produced (ton) x density (t/1000 m<sup>3</sup>) x EFs (Gg/1000 m<sup>3</sup>)*

*emissions2= oil refined (ton) x density (t/1000 m<sup>3</sup>) x EFs (Gg/1000 m<sup>3</sup>)*

*emissions3= LPG consumed (ton) x density (t/1000 m<sup>3</sup>) x EFs (Gg/1000 m<sup>3</sup>)*

*emissions4= natural gas production (1000 m<sup>3</sup>) x EFs (Gg/10<sup>6</sup> m<sup>3</sup>)*

*emissions5= marketable gas (1000 m<sup>3</sup>) x EFs (Gg/10<sup>6</sup> m<sup>3</sup>)*

*emissions6= natural gas utility sale (1000 m<sup>3</sup>) x EFs (Gg/10<sup>6</sup> m<sup>3</sup>)*

#### **Activity data**

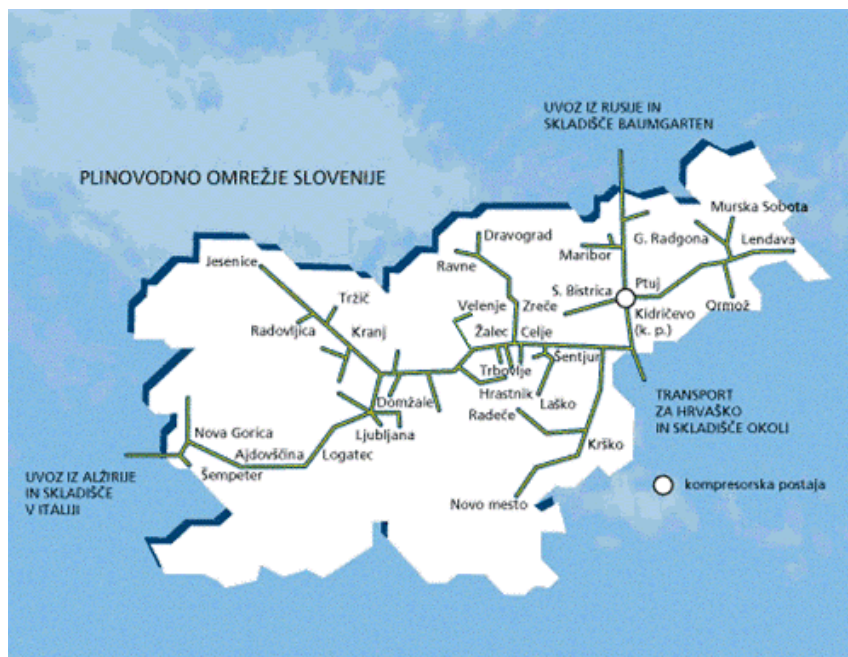
The data on the amount of crude oil produced and refined and LPG consumed have been obtained from SORS. As all data are available in tonnes the following densities have been used to transform ton to m<sup>3</sup>: crude oil: 0.85 t/m<sup>3</sup> and LPG: 0.58 t/m<sup>3</sup>.

The data on the natural gas production and amount of marketable gas/ utility sale are also from SORS and are available in the standard m<sup>3</sup>. In Slovenia the amount of marketable gas is the same as utility sale, because no export of natural gas has occurred in the reporting period and there is no storage facility.

For the better estimation of EFs used we have also used the yearly data on length of transmission and distribution pipelines. From 1986 to 1996 the data on the length of transmission pipelines have been taken from the research project of the Institute of Energy Industries (Gasperič M., Dornik M.: Determining the CO<sub>2</sub> Emission Factor in Energy Use and CH<sub>4</sub> Emission Factor in Transport and Distribution of Natural Gas, Ljubljana: Institute of Energy Industries, 1998). For the period 1997 - 2007, the data have been obtained directly from the company Geoplin Plinovodi, and since 2008 from the Energy Agency. The data are presented in Table 3.3.13 and the transmission network is presented on Figure 3.3.2.

**Table 3.3.13: Length of transport pipelines in km and share with regard to the period of construction.**

	1986	1990	1995	2000	2005	2010	2015	2016
<b>Length (km)</b>	740	784	927	948	960	1,018	1,155	1,155
<b>Built before 1992</b>	100%	100%	85%	83%	82%	78%	68%	68%
<b>Built between 1992 and 2004</b>			15%	17%	18%	17%	15%	15%
<b>Built since 2005</b>						6%	17%	17%



**Figure 3.3.2: Network of pipes for transportation of natural gas.**

In 2016, Plinovodi d.o.o. operates and owns 1155 kilometres of the Slovenian gas transmission network which is a part of the European gas network. The network is composed of longitudinally welded steel pipes, which are protected with anticorrosive isolative material and dug in the ground approximately 1.5 m deep. It has a nominal pressure between 50 and 67 bar. As the demand for natural gas is increasing, the compressor station in Kidričevo began to work in 2002. Emissions from natural gas used on this compressor station are reported under the Fuel consumption sector (1.A.3.e Other transportation)

**Table 3.3.14: Distribution pipelines in km and share with regard to the period of construction.**

	1986	1990	1995	2000	2005	2010	2015	2016
<b>Length (km)</b>	401	514	903	2,079	3,413	4,246	4,633	4,672
<b>Built before 1992</b>	100%	100%	61%	26%	16%	13%	12%	12%
<b>Built between 1992 and 2004</b>			39%	74%	75%	60%	55%	55%
<b>Built since 2005</b>					9%	27%	33%	33%

The activity data for the period 1986 to 2005 for the distribution of natural gas have been taken from the research project, prepared by the Economic Interest Association of Natural Gas Distributors. Since 2008 these data are available from the Energy Agency. Data for 2006 and 2007 have been interpolated (Table 3.3.14).

### **Emission factors**

The emission factors have been taken from 2006 IPCC GL, Vol. 2, Chapter 4, partly from the Table 4.2.4 which is relevant for developed countries and partly from the Table 4.2.5 which is appropriate for the countries with the economy in transition.

For the calculation of fugitive emissions from oil production and refining as well as corresponding emissions from venting and flaring the default values for countries with the economy in transition have been used. In case there was a range, the average values have

been taken into account. As these emissions are not occurring any more since 2002 the EFs used seem appropriate. For the fugitive emissions from LPG transport only one default value is available for developed which is the same as for countries with the economy in transition thus there was no dilemma which EF should be chosen. EFs used are presented in the Table 3.3.15.

**Table 3.3.15: EFs used in Fugitive emissions from oil in g/m<sup>3</sup>.**

		CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF	Source, 2006 IPCC GL
Oil Production	Fugitives	0.043	0.59		Table 4.2.5
	Venting	112.50	855		Table 4.2.5, average
	Flaring	48,500	29.50	0.76	Table 4.2.5, average
Oil Refining	Fugitives		21.80		Table 4.2.4
LPG Transport	All	430		(0.0022)*	Table 4.2.4

*\*N<sub>2</sub>O emissions from transport of LPG have not been reported because CRF tables do not enable to import N<sub>2</sub>O emissions under relevant category 1.B.2.a.iii.3 Transport.*

To better estimate the fugitive emissions from natural gas 3 different periods have been introduced:

1986 – 1991: Slovenia is part of Yugoslavia

1992 – 2004: independent Slovenia, before joining EU

Since 2005: Slovenia is part of EU

The first period covers the time when Slovenia was still part of Yugoslavia. Slovenia was always the most developed and west oriented republic but despite this fact the system of control wasn't as rigorous as it is nowadays. After the separation we have started to change the Slovenian legislation to be in line with the EU. For this time period an important fact is that the consciousness of the people, involved in the building and maintenance of the pipelines was on a higher level in independent Slovenia than it was in the past. Since 2005 in Slovenia all legislation and relevant standards are the same as in other EU countries, additionally the system of control is on the highest level possible.

For the calculation of fugitive emissions from natural gas, except for natural gas production EFs for developed countries have been used. Despite the fact that we were not developed country in the past, the complete natural gas network has been build according to the West European standards. Before 1974, the companies used different standards. The material for pipelines was made according to the JUS (Yugoslav standard), which was transferred from DIN (West Germany standard) to a high degree. In some domains also East German standard TGL (Technische Güte und Lieferbedingungen) was used. In 1974, all companies together with body of inspectors made an agreement to use west German standards (DVGW, DIN, VDI), because more than 90% gas devices were made according to these standards, particularly DVGW standard (Deutsche Vereinigung des Gas und Wasserfaches e.V.). Until 2002, when a new regulation was passed, DVGW had been the main directive for planning, construction, operation and maintenance of the pipeline system. Today standard SIST EN 12007, completely in line with CEN (standard of European Committee for Standardization), is used in Slovenia.

On the following tables EFs used for the calculation of fugitive emissions, and emissions due to the venting and flaring from natural gas are presented. For the natural gas production the

average value for countries with economy in transition was used for the first period and average value for developed countries for the last period, while EFs in between have been interpolated following linear decreasing trend (Table 3.3.16).

**Table 3.3.16: EFs used for emissions from Natural gas production in g/m<sup>3</sup>.**

		gas	1986-1991	1992-2004	2005-2016
Gas production	Fugitives	CO <sub>2</sub>	0.097	interpolation	0.048
	Flaring	CO <sub>2</sub>	1.4	interpolation	1.2
Gas production	Fugitives	CH <sub>4</sub>	12.19	interpolation	1.34
	Flaring	CH <sub>4</sub>	0.00088	interpolation	0.00076
Gas production	Fugitives	N <sub>2</sub> O	NO	NO	NO
	Flaring	N <sub>2</sub> O	0.000025	interpolation	0.000021
Source		2006 IPCC Guidelines	Table 4.2.5, average		Table 4.2.4, average

**Table 3.3.17: EFs used for emissions from Natural gas transmission and distribution in g/m<sup>3</sup>.**

		gas	Built before 1992	Built between 1992 and 2004	Built since 2005
Transmission	Fugitives	CO <sub>2</sub>	0.00088	0.00088	0.00088
	Venting	CO <sub>2</sub>	0.0031	0.0031	0.0031
Transmission	Fugitives	CH <sub>4</sub>	0.48	0.273	0.066
	Venting	CH <sub>4</sub>	0.32	0.182	0.044
Distribution	All	CO <sub>2</sub>	0.051	0.051	0.051
	All	CH <sub>4</sub>	1.1	1.1	1.1
Source		2006 IPCC Guidelines	Table 4.2.4, the highest value	Table 4.2.4, average	Table 4.2.4, the lowest value

For the natural gas transmission and distribution the default values from 2006 IPCC GL, Table 4.2.4 for developed countries have been used, except for calculation of CH<sub>4</sub> emissions from natural gas transmission, for which a range of Tier 1 EF is available. For this cases it has been taken into account the length of transmission pipelines built in the each period (see Table 3.3.13). For the pipelines, which were built in the first period the highest values from the range of EFs has been taking into account, for the pipelines which were built in the last period the lowest EFs has been used, while for the time in-between the average value from the range has been used. EFs used are presented in the table 3.3.17 above.

### 3.3.2.3 Uncertainty and time –series consistency

The uncertainty are based on an expert judgements taking into account suggested values from 2006 IPCC GL for default values. They are presented on the Table 3.3.18.

**Table 3.3.18: Uncertainties of activity data and emission factors as used in the 2018 submission for the base year and the last reporting year in per cents.**

	1986 and 2016			
	AD	CO <sub>2</sub> EF	CH <sub>4</sub> EF	N <sub>2</sub> O EF
Oil	5	100	100	NA
Natural gas	2	200	200	NA
Venting and Flaring	3.5	50	50	50

### 3.3.2.4 Category-specific QA/QC and verification

This category has been checked by the general QC procedures described in the Chapter 1.2.3. In addition the verification of the fugitive emissions (including venting and flaring) from natural gas have been performed and the results are presented in the Table 3.3.19 below. In these calculations the low emission factors from the 2006 IPCC GL from Table 4.2.8 have been used to calculate the emissions from the production and transmission and use of natural gas. The CH<sub>4</sub> emissions for 2016 from GHG inventory are 20% higher than the total emissions calculated by this simplified method.

**Table 3.3.19: Data used for verification of fugitive emissions from natural gas.**

	AD	unit	EF	unit	CH <sub>4</sub> (1000 m <sup>3</sup> )
production	4,812	1000 m <sup>3</sup>	0.05	% of net prod.	2
transmission	1,155	km	200	m <sup>3</sup> /km	231
Compressor stations	19.5	MW	6000	m <sup>3</sup> /MW	117
MRS	447	stations	1000	m <sup>3</sup> /station	447
distribution	4,672	km	100	m <sup>3</sup> /km	463
gas use	266,624	appliances	2	m <sup>3</sup> /appliance	533
<b>TOTAL</b>					<b>1,795</b>
<b>TOTAL CH<sub>4</sub> emissions in 2016 from NIR (1.2878 kt CH<sub>4</sub>, density: 0.6788 t/1000m<sup>3</sup>)</b>					<b>1,897</b>

It is important to know that the Slovenian distribution network is very new. More than 80 per cent of the network has been built in the last 20 years and more than a half after the year 2000. All old steel and cast iron pipes were already replaced with the new PE or PVC pipes with very low leakages. In addition, the reasons for low emissions also the strict EU legislation in this field which requires good maintenance and, last but not least, the high price of natural gas, which is almost entirely imported.

### 3.3.2.5 Category-specific recalculations

No recalculations have been performed for this category

### 3.3.2.6 Category-specific planned improvements

No improvement is planned for this category.

## 3.4 CO<sub>2</sub> capture from flue gases and subsequent CO<sub>2</sub> storage

There are no plants for recovery and storage of CO<sub>2</sub> in Slovenia.

## 4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF sector 2)

### 4.1 Overview of Sector

This chapter presents the processes emissions of greenhouse gases in:

- Mineral industry (CRF 2.A) ,
- Chemical industry (CRF 2.B),
- And Metal Industry (CRF 2.C),

and emissions due to the product use:

- Non-energy products from fuels and solvent use (CRF 2.D),
- Product uses as substitutes for ODS (CRF 2.F),
- and Other product manufacture and use (CRF 2.G).

The processes emissions from electronic industry have not occurred in the county.

Industrial activities unrelated to energy produce various GHG emissions. The emission sources are the industrial production processes in which raw materials are chemically or physically transformed. In this transformation, many different GHGs can be released, such as CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and PFCs. Some industrial sources also produce NO<sub>x</sub>, NMVOCs, CO, and SO<sub>2</sub>.

Some fluorinated compounds (Hydro-fluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur Hexafluoride (SF<sub>6</sub>)) are consumed in industrial processes or used in different applications as substitutes for ozone depleting substances (ODS). They have also been considered in the inventory.

Further, this sector comprises emissions from other product manufacture and use. An evaporative emissions of nitrous oxide (N<sub>2</sub>O) can arise from various types of product use. Medical applications and use as a propellant in aerosol products, primarily in food industry are likely to be dominant sources.

Due to the intertwined nature of procedures in the industry and the characteristics of the individual reported units, it is in some cases difficult to distinguish if certain emissions originate from the consumption of fuels for energy purposes or from the consumption of raw materials in the industrial processes. The main criterion is the purpose for which a raw material or fuel is used.

An overview of the methods and EFs used as well as an indication whether a category is a key are presented in the Table 4.1.1 below.



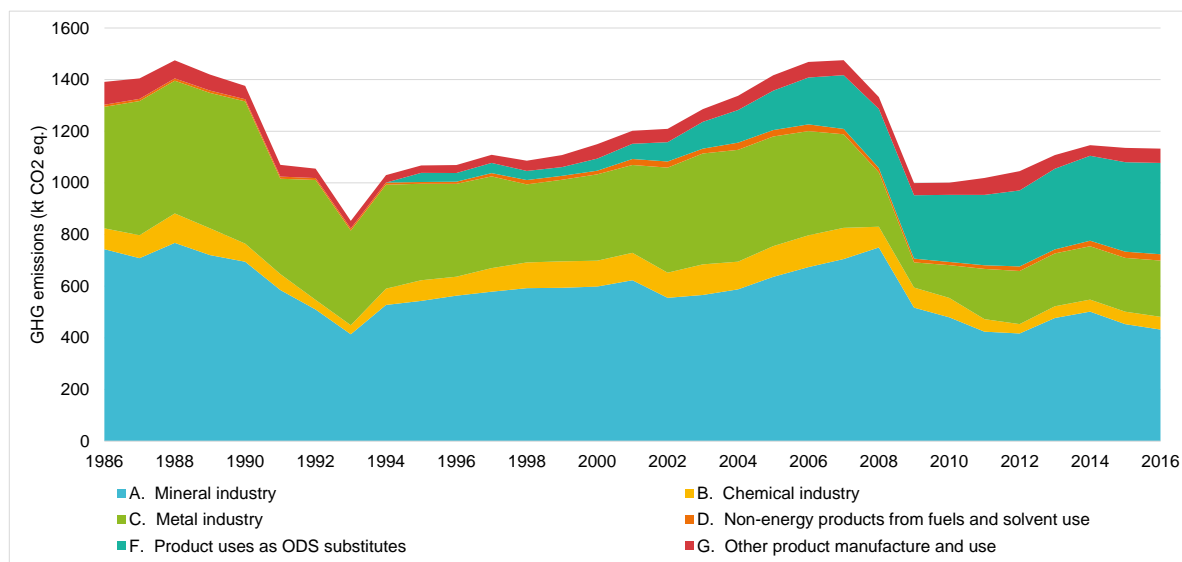
**Table 4.1.1: Method, EF used and key categories indications for the year 2016 in the IPPU.**

		CO <sub>2</sub>		
		Method	EF	Key category
A. Mineral industry	1. Cement production	T3	PS	L,T
	2. Lime production	T3	PS	T
	3. Glass production	T3	D	-
	4. Other process uses of carbonates	T2	D	-
B. Chemical industry	6. Titanium dioxide production	T2	D	-
C. Metal industry	1. Iron and steel production	T2	PS	-
	3. Aluminium production	T3	PS	L, T
	5. Lead production	T1	D	-
	6. Zinc production	T1	D	-
	7. Other	T2	D	-
D. Non-energy products from fuels...	1. Lubricant use	M	M	-
	2. Paraffin wax use	T1	D	-
	3. Other	M	M	-
		N <sub>2</sub> O		
		Method	EF	Key category
G. Other product manufacture and use	3. N <sub>2</sub> O from product use	T1	D	-
		HFC		
		Method	EF	Key category
F. Product uses as substitutes for ODS	1. Refrigeration and AC	T2	CS,D	L, T
	2. Foam blowing agents	T2	CS,D	-
	3. Fire protection	T2	CS,D	-
	4. Aerosols	T1	D	-
		PFC		
		Method	EF	Key category
C. Metal industry	3. Aluminium production	T3	CS, D	T
		SF <sub>6</sub>		
		Method	EF	Key category
G. Other product manufacture and use	1. Electrical equipment	T2	CS	-

The emissions from Industrial processes and product use (CRF sector 2) in Slovenia account for 6.4% of the total national GHG emissions, excluding LULUCF. They amounted to 1,391 kt CO<sub>2</sub> equivalents in 1986 and 1,133 kt CO<sub>2</sub> equivalents in 2016. The main source of emissions is mineral industry with about 38.1% of emissions, followed by consumption of F-gases (product uses as substitutes for ODS) with 31.2% and metal production with 19.2%. Significantly smaller are the contributions from chemical industry (4.4%) and non-energy products from fuels and solvent use (2.2%). Other product manufacture and use contributes 4.9% to the total emissions from this sector. The main source of emissions from industrial



processes and product use sector is cement industry, which is responsible for 30.3% of the GHG emissions from this sector. Due to the world economic crises, the total emissions of GHG from industrial processes and product use considerably decreased in 2009 and remained at approximately the same level until 2012. In the years 2013 - 2014, an increase of the total emissions was observed. The process emissions of GHG (in kt CO<sub>2</sub> eq.) for 1986-2016 are shown in Figure 4.1.1.



**Figure 4.1.1: Process emissions of GHG from different types of industries and product use.**

## 4.2 MINERAL INDUSTRY (CRF 2.A)

### 4.2.1 Cement Production (CRF 2.A.1)

#### 4.2.1.1 Category descriptions

Carbon dioxide emissions arising in the production of cement are a major industrial process source of emissions of greenhouse gases. There are two producers of cement in Slovenia, producing mostly Portland cement.

The basic raw material for the production of cement is marl, which is a homogeneous mixture of limestone and clay and which was formed in the past geological periods through sedimentation. As there is no longer enough natural marl for a mass production, a cement production mix, which must contain 75-78% of calcium carbonate ( $\text{CaCO}_3$ ), is prepared by mixing limestone and clay components: from such with 35% of  $\text{CaCO}_3$  to limestone with more than 95% of  $\text{CaCO}_3$ . The limestone, which is a source of  $\text{CaO}$ , normally has an admixture of dolomite, which introduces  $\text{MgO}$  into the system. The clay components are bearers of  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$ . Blast furnace slag, silica sand, bauxite, and gypsum are added to the homogenized mix during grinding.

Raw meal powder is fed into the cement kiln through a heat exchange unit. Natural gas, fuel oil, petroleum coke, coal dust, waste oils, and tyres are used as fuels in the clinker calcination process.

Carbon dioxide emissions from cement production result from the conversion of  $\text{CaCO}_3$ , the main constituent of limestone, to lime ( $\text{CaO}$ ), while  $\text{CO}_2$  as a by-product is let out into the atmosphere.

#### 4.2.1.2 Methodological issues

##### CARBON DIOXIDE EMISSIONS

Separate emissions are estimated from carbon originally present in the fuel and carbon present in the raw materials, although they are in fact emitted at the same place and are inseparable in concept.  $\text{CO}_2$  from carbon in the fuel has been estimated from the fuel consumption for each fuel type. Emissions of this kind have already been included in the sector Manufacturing Industries and Construction (CRF code: 1A2).

$\text{CO}_2$  emissions from carbon present in the raw materials is reported under category Cement Production (CRF code: 2A1) and described in the following paragraph. In Slovenia, there have been two cement producers until 2015. In the year 2016 only one cement plant has been in operation. The activity data are data on the annual production of clinker. The clinker production data have been obtained from the Statistical Office of the Republic of Slovenia (SORS) for the period 1986–1998, and directly from the two plants producing cement for the period 1999–2004. The activity data on clinker produced in the period 2005–2016 have been

obtained from these cement plants in the scope of GHG Emission Trading System (ETS) delivered in verified reports.

For national allocation plan purposes linked to the ETS more detailed data have been obtained for the period 1999–2004. The data on the fraction of CaO and MgO in clinker from both cement plants for the period 1999–2004 enabled us to determine our own emission factor. The average implied emission factor for the period 1999–2004 is 528 kg CO<sub>2</sub>/t of clinker. As the location of quarries is the same as in the base year, we have applied this emission factor for calculating emissions from the base year 1986 to 1998. For calculating emissions for the years 1999–2004, we have used year-specific EFs obtained from these two plants. For the period 2005–2016 we have obtained plants data on CaO and MgO composition of clinker and EFs from verified ETS reports. Country specific EFs from these reports have been used to calculate CO<sub>2</sub> emissions using IPCC methodology. In the year 2016 only one plant has been in operation.

EFs from both periods before and after 2005 are based on plant specific production conditions. There have been two producers of cement in Slovenia and the data for both periods were obtained from these two cement plants. The same sources of raw material and methodology were used for calculation of EFs both before and after 2005. Detailed data on EFs is presented in Table 4.2.1. Inter-annual variations of EFs are due to a different annual ratio of CaO and MgO in clinker.

**Table 4.2.1: Emission factors used for calculation emissions from cement production.**

Year	Implied emission factor (t CO <sub>2</sub> /t of clinker)		
	Producer 1	Producer 2	TOTAL
1986 - 1998			0.528
1999	0.520	0.544	0.528
2000	0.518	0.544	0.528
2001	0.518	0.544	0.528
2002	0.518	0.544	0.527
2003	0.519	0.544	0.529
2004	0.517	0.541	0.527
2005	0.518	0.542	0.528
2006	0.517	0.539	0.526
2007	0.517	0.545	0.528
2008	0.518	0.545	0.527
2009	0.517	0.549	0.526
2010	0.516	0.549	0.526
2011	0.517	0.531	0.519
2012	0.520	0.547	0.522
2013	0.518	0.547	0.526
2014	0.512	0.546	0.518
2015	0.514	0.547	0.515
2016	0.515	-	0.515

Cement kiln dust (CKD) is not included in the emission calculation as in both cement plants CKD is returned into the process. A group of experts had visited both cement plants in the process of acquisition of the permits for greenhouse gas emissions and accompanied

monitoring plans. Together with experts from the plants they defined a method for calculation of CO<sub>2</sub> emissions. It is in accordance with methods from Guidelines for the monitoring and reporting. For both plants it was confirmed that CKD is 100% returned to the process. This is also evident from plant specific monitoring plan which has been issued by the competent authority.

To calculate emissions from cement production after 2005 we have been using data obtained by ETS. The data on clinker production and plant specific emission factors for both cement factories have been annually verified by independent verifiers. The expert review team (ERT) recommended showing that the estimated CO<sub>2</sub> process emissions from cement production are comparable and consistent with the emissions reported under the ETS. ETS reports cannot be publicly revealed due to the sensitivity of the information. All documentation is available for internal communication with ERT only. However, the total emissions from cement production, that is sum of process emissions and emissions from fuel combustion, reported under the ETS, are publicly available on the web site of Environment Agency of the Republic of Slovenia.

[http://www.arso.gov.si/podnebne%20spremembe/Register%20emisij%20kuponov/Javno%20dostopna%20poročila/lzpolnitev%20obveznosti%20za%20leto%202016\\_sprememba%2021.6.2017.pdf](http://www.arso.gov.si/podnebne%20spremembe/Register%20emisij%20kuponov/Javno%20dostopna%20poročila/lzpolnitev%20obveznosti%20za%20leto%202016_sprememba%2021.6.2017.pdf)

The annual amount of clinker produced and CO<sub>2</sub> emissions arising from cement production are shown in Figures 4.2.1 and 4.2.2.

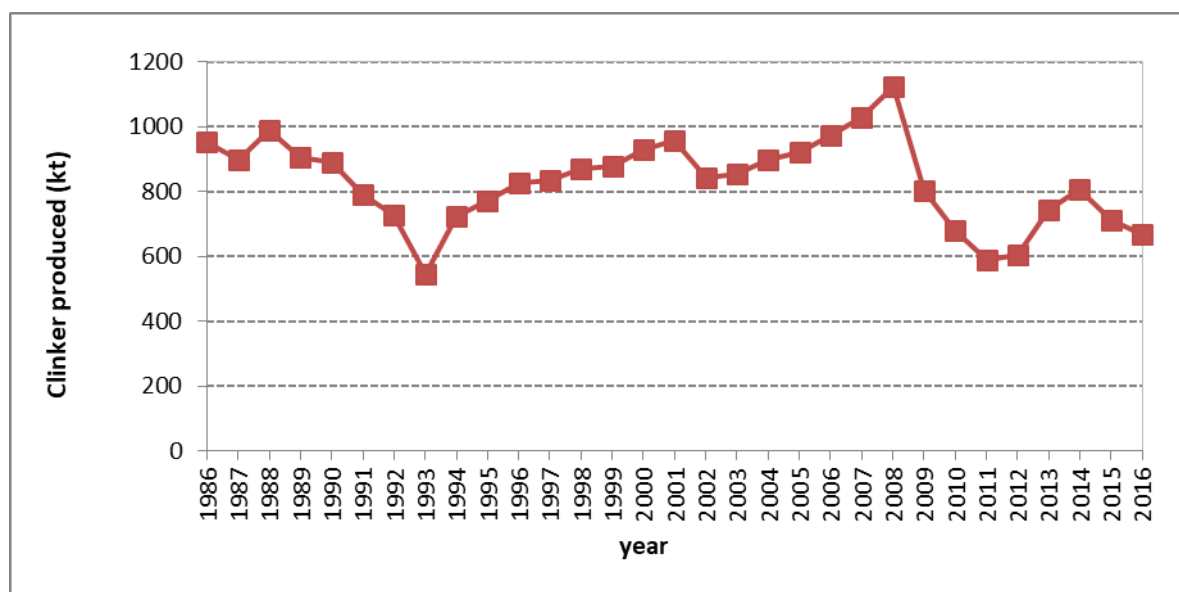


Figure 4.2.1: Clinker production in kilotons/year.

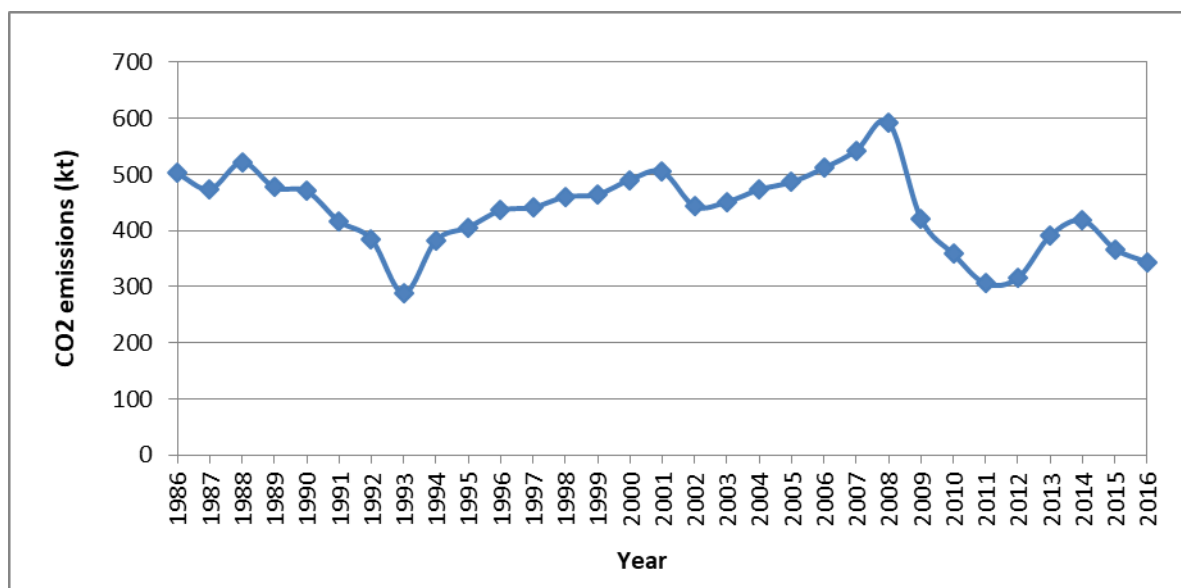


Figure 4.2.2: CO<sub>2</sub> emissions from cement production.

#### 4.2.1.3 Uncertainties and time-series consistency

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factor amounts to 10%.

#### 4.2.1.4 Category-specific QA/QC and verification

QC procedures for the two plants data collected under the ETS have been performed for the period 2005–2015. In the year 2016 only one cement plant has been in operation. The amount of clinker produced, composition of clinker and calculated EFs for the whole period have been thoroughly examined. An error in the correction factor for CaO and MgO content in the raw material for one of the cement plant was found. The emission factors for that plant had to be revised. The corrected emission estimates for plant 1 are reflected in the changed emissions for the total 2A1 Cement production and IEFs. The activity data on clinker production obtained from verified ETS reports were cross checked through a direct communication with plant representatives. We also compared data on cement production and clinker production. The clinker production does not entirely track cement production due to additional clinker imports. Cement has been produced not only from domestically produced clinker but also from imported clinker.

#### 4.2.1.5 Category-specific recalculations

No recalculation have been performed since last submission.

#### 4.2.1.6 Category-specific improvements

No improvements are planned for next submission.

## 4.2.2 Lime Production (CRF 2.A.2)

### 4.2.2.1 Category descriptions

CO<sub>2</sub> emissions from the production of lime are reported under Lime Production (CRF Code: 2A2). In Slovenia, there have been three lime producers until 2013. One of the lime plants had been closed down in the end of 2012. In the year 2016 therefore only two lime plants have been in operation.

Lime is generated by heating the input raw material (limestone and dolomite) to a high temperature (900°C-1200°C). During this process, limestone is converted into CaO and emits CO<sub>2</sub>.

### 4.2.2.2 Methodological issues

#### CARBON DIOXIDE EMISSIONS

The estimation of CO<sub>2</sub> emissions for the period 2005-2016 have been based on the data provided by the lime plants in the scope of ETS scheme delivered in verified ETS reports. The amount of CaO and MgO in the lime produced or the amount of carbonates from the raw material were used as an activity data for the emission calculations. The emission factors used for emission calculation are based on stoichiometric ratio of CO<sub>2</sub> and CaO, CO<sub>2</sub> and MgO or CO<sub>2</sub> and CaCO<sub>3</sub>.

An annual implied emission factor was then calculated from the total CO<sub>2</sub> emissions for all plants, and the total amount of lime produced in these plants. A detailed description of the emissions calculation is presented in the following paragraph. The data used for the emission calculations are shown in the Tables 4.2.2-4.2.5. One of the lime plants (producer 3) had been closed down in the end of 2012 (Table 4.2.4).

The monitoring and reporting guidelines for EU ETS installations were adopted in the Commission decision 2004/156/EC. Activity-specific guidelines for installations for the production of lime are in Annex VIII.

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:059:0001:0074:EN:PDF>

On installation level, calcination CO<sub>2</sub> can be calculated in two ways:

- (1) based on the amount of carbonates from the raw material (mainly limestone, dolomite) converted in the process (calculation method A),
- (2) based on the amount of alkali oxides in the lime produced (calculation method B). The two approaches are considered to be equivalent.

Producer 1 and producer 2 have chosen the calculation method B, while producer 3 had chosen calculation method A. The annual implied emission factor (IEF) was then derived from the total emissions from all plants and the activity data on annual production of quicklime in these lime plants (Table 4.2.5).

**Table 4.2.2: Lime production emissions from producer 1.**

Year	CaO (t)	MgO (t)	EF (t CO <sub>2</sub> /t CaO)	EF (t CO <sub>2</sub> /t MgO)	Emissions CO <sub>2</sub> (t)
2005	87142	1597	0.785	1.092	70150
2006	105200	1885	0.785	1.092	84641
2007	94178	1291	0.785	1.092	75340
2008	90633	1393	0.785	1.092	72668
2009	65411	1257	0.785	1.092	52721
2010	87423	1463	0.785	1.092	70225
2011	80298	6471	0.785	1.092	70101
2012	55425	5456	0.785	1.092	49467
2013	53670	4065	0.785	1.092	46570
2014	52889	3063	0.785	1.092	44863
2015	52419	5201	0.785	1.092	46828
2016	51421	4318	0.785	1.092	45081

**Table 4.2.3: Lime production emissions from producer 2.**

Year	CaO (t)	MgO (t)	EF (t CO <sub>2</sub> /t CaO)	EF (t CO <sub>2</sub> /t MgO)	Emissions CO <sub>2</sub> (t)
2005	13869	249	0.785	1.092	11159
2006	13788	228	0.785	1.092	11072
2007	17222	332	0.785	1.092	13882
2008	9256	215	0.785	1.092	7500
2009	8733	213	0.785	1.092	7089
2010	11504	333	0.785	1.092	9394
2011	12230	291	0.785	1.092	9918
2012	15737	343	0.785	1.092	12729
2013	14781	322	0.785	1.092	11955
2014	14073	316	0.785	1.092	11393
2015	16281	360	0.785	1.092	13173
2016	19167	425	0.785	1.092	15509

**Table 4.2.4: Lime production emissions from producer 3.**

Year	CaCO <sub>3</sub> (t)	EF (t CO <sub>2</sub> /t CaCO <sub>3</sub> )	Emissions CO <sub>2</sub> (t)
2005	90993	0.43971	40037
2006	88068	0.43971	38750
2007	77738	0.43971	34205
2008	67816	0.43971	29839
2009	25432	0.43971	11190
2010	24156	0.43971	10629
2011	24355	0.43971	10716
2012	26831	0.43971	11806

**Table 4.2.5: Total CO<sub>2</sub> emissions of all three producers, total lime production and calculated implied emission factor for the last few years.**

Year	2010	2011	2012	2013	2014	2015	2016
Lime Produced (t)	125117	124219	99528	79570	76019	79507	80060
Total emissions CO <sub>2</sub> (t)	90248	90735	74001	58525	56256	60001	60591
Implied emission factor (kg CO <sub>2</sub> /t of lime)	721	730	743	736	740	755	757

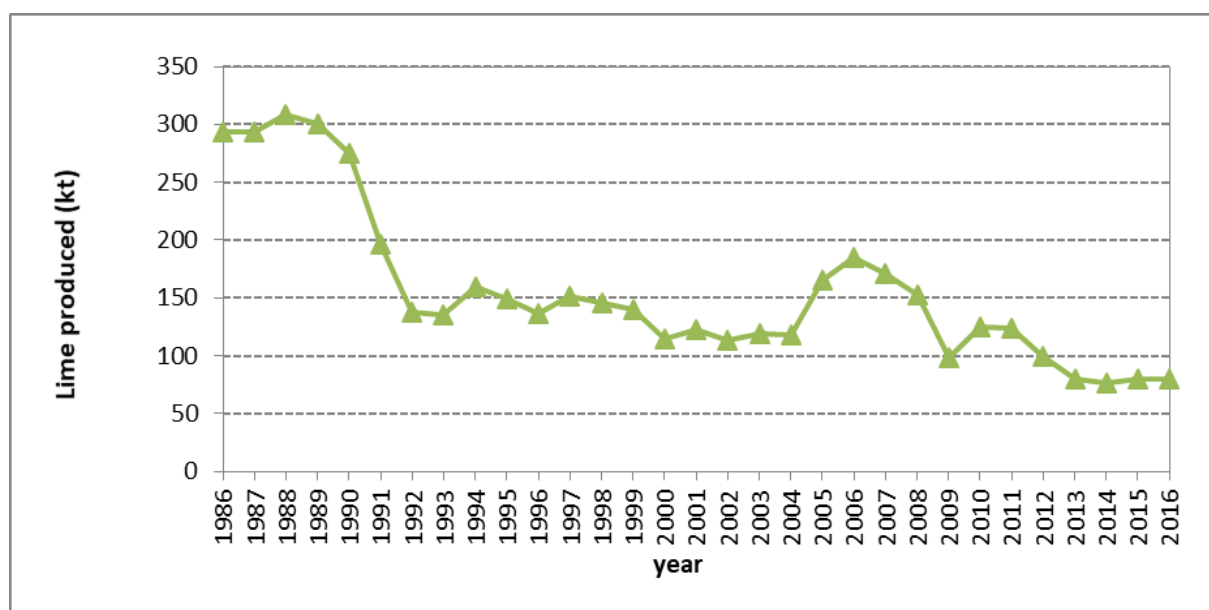
CO<sub>2</sub> emissions for the period 1986-2004 have been calculated using the average implied emission factor for the period 2005–2013 and data on annual production of lime obtained from SORS. The average emission factor for the period 2005–2013 is 729 kg CO<sub>2</sub> /t of lime. Data on implied emissions factors is presented in Table 4.2.6.

**Table 4.2.6: Emission factors used for calculation emissions from lime production.**

Year	Implied emission factor (t CO <sub>2</sub> /t of lime)
1986-2004	0.729
2005	0.735
2006	0.726
2007	0.724
2008	0.723
2009	0.725
2010	0.721
2011	0.730
2012	0.743
2013	0.736
2014	0.740
2015	0.755
2016	0.757

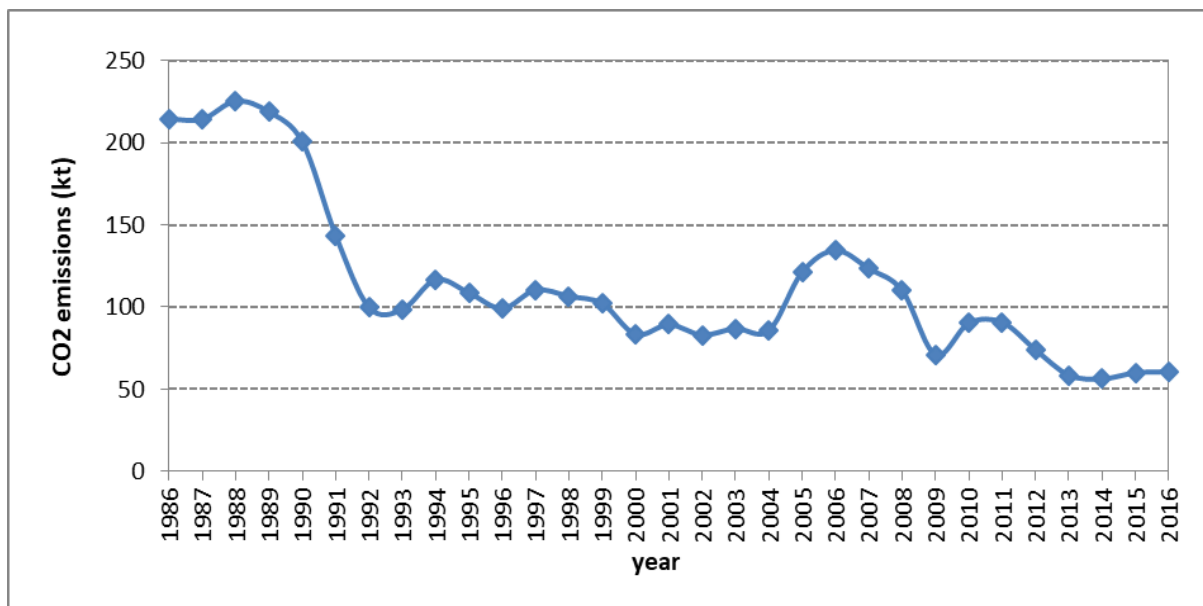
The limestone used for lime production contains mostly CaCO<sub>3</sub>. In the limestone there is also a small amount of dolomite, which, in addition to CaCO<sub>3</sub>, consists also of MgCO<sub>3</sub>. A high-calcium lime is the main type of lime. Quicklime and hydrated lime are the main types of lime produced in Slovenia. The lime kiln dust (LKD) is included in the final amount of the lime produced and therefore included in the calculation of the CO<sub>2</sub> emissions.

Annual amount of lime produced and CO<sub>2</sub> emissions arising from the lime production are shown in Figures 4.2.3 and 4.2.4.



**Figure 4.2.3: Lime production in kilotons/year.**





**Figure 4.2.4: CO<sub>2</sub> emissions from lime production.**

#### **4.2.2.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on expert judgement.

The uncertainty of the activity data amounts to 15%.

The uncertainty of the emission factor amounts to 5%.

#### **4.2.2.4 Category-specific QA/QC and verification**

QC procedures for the three lime plants data collected under the ETS have been performed. In the year 2016 therefore only two lime plants have been in operation. The amount of lime produced and the composition of lime and the raw material have been thoroughly examined. The methodology of emission calculation was checked. There were no errors found, all data checked were accurate. To calculate emissions from lime production after 2005 we have been using the data obtained by ETS. These data have been annually verified by independent verifiers. Thorough examination of the activity data and emission factors were performed also for the data before entering the ETS scheme. Time series consistency was assured since the same lime plants with the same raw material were taken in account in both periods.

#### **4.2.2.5 Category-specific recalculations**

No recalculations were performed since the last submission.

#### **4.2.2.6 Category-specific planned improvements**

No improvements are planned for the next submission.

## 4.2.3 Glass Production (CRF 2.A.3)

### 4.2.3.1 Category description

This chapter comprises CO<sub>2</sub> emissions from glass manufacturing and from the production of glass wool, where the production process is similar to glass making. The emissions are reported under Glass Production (CRF Code: 2A3). There are five glass and glass wool producers in Slovenia.

CO<sub>2</sub> is emitted during the melting process of glass raw materials. The calcination of carbonates at high temperatures yields CO<sub>2</sub>. Major raw materials in the glass production which emit CO<sub>2</sub> during the melting process are limestone, dolomite and soda ash.

### 4.2.3.2 Methodological issues

CO<sub>2</sub> emissions from glass production for the period 1999-2016 have been calculated taking into account the consumption of all carbonates in the glass production. The data on the carbonate use in the glass production have been obtained from glass producers. The amount of all carbonates used in the glass production is included in this sector. Those carbonates are: limestone (CaCO<sub>3</sub>), magnesium carbonate (MgCO<sub>3</sub>), soda ash (Na<sub>2</sub>CO<sub>3</sub>), potash (K<sub>2</sub>CO<sub>3</sub>) and barium carbonate (BaCO<sub>3</sub>).

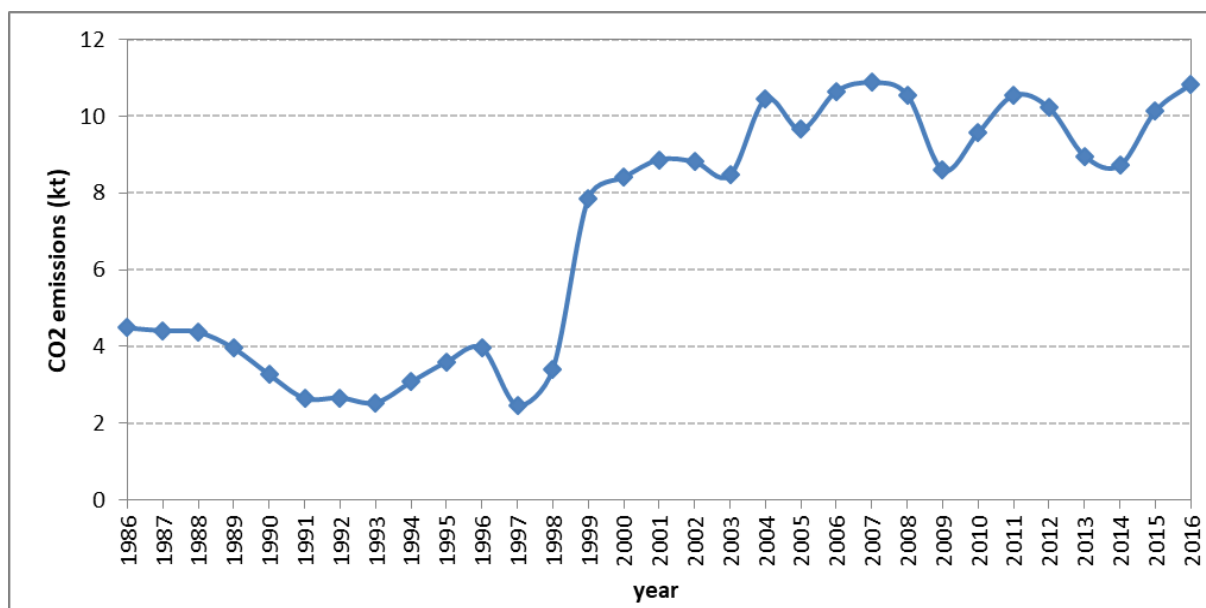


Figure 4.2.5: CO<sub>2</sub> emissions from glass production.

Default 2006 IPCC emission factors have been used for the calculation of CO<sub>2</sub> emissions from calcium carbonate, magnesium carbonate and sodium carbonate (Chapter 2: Mineral Industry Emissions, Table 2.1, pg. 2.7). They are 0.43971 t CO<sub>2</sub>/t calcium carbonate, 0.52197 t CO<sub>2</sub>/t magnesium carbonate and 0.41492 t CO<sub>2</sub>/t sodium carbonate.

The emission factors for potassium carbonate and barium carbonate are based on stoichiometric ratio of CO<sub>2</sub> and K<sub>2</sub>CO<sub>3</sub> and CO<sub>2</sub> and BaCO<sub>3</sub>. They are 0.318 t CO<sub>2</sub>/t potassium carbonate and 0.223 t CO<sub>2</sub>/t barium carbonate.

The calculation of CO<sub>2</sub> emissions from the glass production for the period 1986-1998 has been performed in another way due to a lack of data on carbonate consumption. The average implied emission factor for the years 1999-2013 has been multiplied with the annual glass production data. The data on glass production have been obtained from glass producers.

CO<sub>2</sub> emissions arising from glass production for the whole period are shown in Figure 4.2.5.

#### **4.2.3.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on expert judgement.

The uncertainty of the activity data amounts to 20%.

The uncertainty of the emission factor amounts to 10%.

#### **4.2.3.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

#### **4.2.3.5 Category-specific recalculations**

No recalculations were performed the since last submission.

#### **4.2.3.6 Category-specific planned improvements**

No improvements are planned for the next submission.

## 4.2.4 Other Process Uses of Carbonates

### 4.2.4.1 Category description

Carbonates are used in many industries. During heating to a high temperature, carbonates convert to oxides, emitting CO<sub>2</sub>. Most limestone and dolomite are thus consumed in the production of cement and lime, as described above. Along with other carbonates, they are also used in the other production of mineral products.

This sector comprises use of carbonates in Ceramics (CRF code: 2A4a), Other Uses of Soda Ash (CRF Code: 2A4b) and Other (CRF Code: 2A4d). CRF Code: 2A4d, Other comprises emissions from mineral wool production.

### 4.2.4.2 Methodological issues

#### Ceramics

Ceramics include the production of bricks and roof tiles, household ceramics, sanitary ware and technical ceramics. Process related CO<sub>2</sub> emissions from ceramics result from the calcination of carbonates in the clay, as well as the addition of carbonate additives.

CO<sub>2</sub> emissions for the period 2005-2016 have been calculated from the use of CaCO<sub>3</sub>, MgCO<sub>3</sub> and BaCO<sub>3</sub> in ceramics production. The data on carbonates used have been obtained from verified ETS reports. Default 2006 IPCC emission factors have been used for the calculation of CO<sub>2</sub> emissions from calcium carbonate and magnesium carbonate. They are 0.43971 t CO<sub>2</sub>/t calcium carbonate and 0.52197 t CO<sub>2</sub>/t magnesium carbonate. The emission factor for barium carbonate based on stoichiometric ratio of CO<sub>2</sub> and BaCO<sub>3</sub>. It is 0.223 t CO<sub>2</sub>/t barium carbonate.

CO<sub>2</sub> emissions for the period 1995-2004 have been estimated in another way due to a lack of data on carbonate consumption. There are no detailed data on the use of carbonates before entering the ETS scheme. An estimation of emissions based on parameter "Gross value added - glass, pottery and buildings materials industry, Bio Euro (EC95)" obtained from SORS was performed. The data for 2005 were used as a reference year.

Estimated emission for 1995 was applied for the period 1986-1994 as well due to a lack of data on carbonate consumption and statistical parameter which was used for the emission estimation for the period 1995-2004.

#### Other Uses of Soda Ash

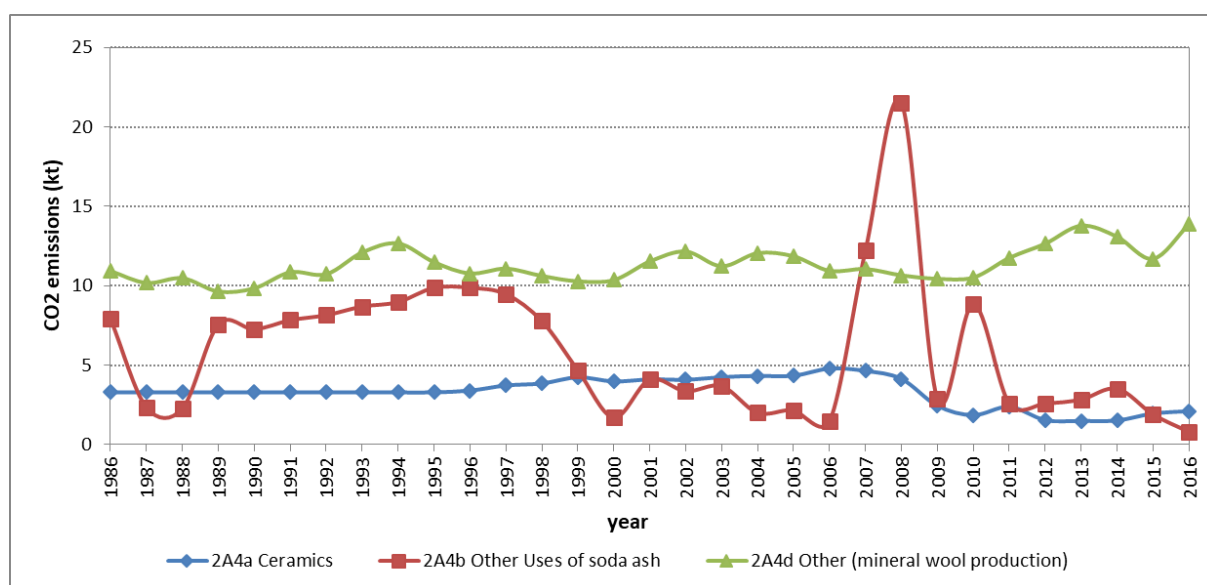
Soda ash is used as a raw material in numerous industrial processes: production of glass, soap and detergent, production of paper, chemicals and other common consumer products. This sector comprises all uses of soda ash except use in the glass production. Use of soda ash in the glass production is reported in sector Glass Production (CRF Code: 2A3).

CO<sub>2</sub> emissions for the period 1986-2016 have been calculated from the difference in the amount of total soda ash consumed and soda ash consumed in the glass production. The

data on the total consumption of soda ash for the period 1986-1997 was obtained from SORS. Later on these data were not available anymore. The consumption of the total soda ash for the period 1998-2016 was calculated from the data on import and export published by SORS as well. The use of soda ash in glass production has been subtracted. The default emission factor from 2006 IPCC GL has been used for the calculation of CO<sub>2</sub> emissions for the whole period (0.41492 t CO<sub>2</sub>/t Na<sub>2</sub>CO<sub>3</sub>).

#### Other

This sector comprises CO<sub>2</sub> emissions arising from mineral wool production. Dolomite is used as a raw material in mineral wool production. The activity data have been obtained from the producer of mineral wool used for insulation purposes. The default 2006 IPCC emission factor 0.47732 t CO<sub>2</sub>/t dolomite has been used for the whole period 1986-2016.



**Figure 4.2.6: CO<sub>2</sub> emissions from other process uses of carbonates.**

Figure 4.2.6 shows CO<sub>2</sub> emissions from ceramics, other uses of soda ash and mineral wool production.

#### 4.2.4.3 Uncertainties and time-series consistency

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factor amounts to 10%.

#### 4.2.4.4 Category-specific QA/QC and verification

We carried out a survey to determine that all carbonates use in the country was accounted for. We approached Tax administration of the Republic of Slovenia and The Agency of the Republic of Slovenia for Public Legal Records and Related Services to examine other

potential carbonate users. No new sources were found. Completeness in emission estimation was confirmed.

#### **4.2.4.5 Category-specific recalculations**

No recalculations were performed since the last submission.

#### **4.2.4.6 Category-specific planned improvements**

No improvements are planned for the next submission.

## **4.3 CHEMICAL INDUSTRY (CRF 2.B)**

### **4.3.1 Nitric Acid Production (CRF 2.B.2)**

#### **4.3.1.1 Category description**

The production of nitric acid ( $\text{HNO}_3$ ) generates nitrous oxide ( $\text{N}_2\text{O}$ ) as a by-product of the high temperature catalytic oxidation of ammonia ( $\text{NH}_3$ ).  $\text{N}_2\text{O}$  emissions from nitric acid production are reported under Nitric Acid Production (CRF code: 2B2).

#### **4.3.1.2 Methodological issues**

Nitric acid production existed in Slovenia in the period 1997-2005. Since 2006 there is no production of nitric acid in Slovenia. No emissions of  $\text{N}_2\text{O}$  have originated from this sector since 2006.  $\text{N}_2\text{O}$  emissions have been calculated from the amount of nitric acid produced. Nitric acid production data was obtained from SORS. Following the ERT recommendations an examination of the emission factor used was performed. We used 2006 IPCC emission factor for the emission calculations. The emission factor of 7 kg  $\text{N}_2\text{O}$ /ton nitric acid was used since the production based on medium pressure combustion process.

#### **4.3.1.3 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

#### **4.3.1.4 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factor amounts to 10%.

#### **4.3.1.5 Category-specific recalculations**

No recalculations were performed since the last submission.

#### **4.3.1.6 Category-specific planned improvements**

No improvement is planned for this category.

## 4.3.2 Carbide Production (CRF 2.B.5)

### 4.3.2.1 Category description

The greenhouse gas emissions are associated with a production of silicon carbide (SiC) and calcium carbide (CaC<sub>2</sub>). The production of carbide can result in emissions of carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>). Silicon carbide is a significant artificial abrasive. It is produced from silica sand or quartz and petroleum coke. Calcium carbide is made from two carbon-containing raw materials: calcium carbonate and petroleum coke. It is mostly used as a reductant in electric arc steel furnaces.

There had been only one carbide producer in Slovenia. This factory was closed down in the first quarter of 2008. The production of calcium carbide was discontinued in 2008, while the production of silicon carbide had been discontinued as early as in 1995. CO<sub>2</sub> and CH<sub>4</sub> emissions from carbide production are reported under Carbide Production (CRF code: 2B5).

### 4.3.2.2 Methodological issues

#### Silicon carbide production

Silicon carbide (SiC) is produced from silicon dioxide and petroleum coke. Petroleum coke is used as a source of carbon. CO<sub>2</sub> is released as a by-product. CO<sub>2</sub> emissions had been estimated for the period 1986-1994. From 1995 onwards there has been no production of silicon carbide in Slovenia. CO<sub>2</sub> emissions had been calculated from the amount of petroleum coke consumed. The data on the consumption of petrol coke was provided by the factory. The 2006 IPCC emission factor of 2.3 t CO<sub>2</sub>/t petroleum coke had been used for the CO<sub>2</sub> emission calculations.

The petroleum coke used in the process may contain volatile compounds which will form methane. CH<sub>4</sub> emissions had been calculated from the amount of petroleum coke consumed obtained from the producer. The 2006 IPCC emission factor of 10.2 kg CH<sub>4</sub>/t petroleum coke had been used for the CH<sub>4</sub> emission calculations.

#### Calcium carbide production

Calcium carbide (CaC<sub>2</sub>) is produced by heating calcium carbonate and subsequently reducing CaO with carbon (petroleum coke). Both steps lead to emissions of CO<sub>2</sub>. In Slovenia, calcium carbide was not produced from limestone but from lime, hence CO<sub>2</sub> emissions arose only in the reduction with carbon.

CO<sub>2</sub> emissions had been estimated for the period 1986-2008. Since the only carbide factory had been closed down in 2008, there was no production of calcium carbide from this year onwards. CO<sub>2</sub> emissions had been calculated from amount of calcium carbide produced. The data on CaC<sub>2</sub> production was obtained from the carbide producer. The 2006 IPCC emission



factor of 1.09 t CO<sub>2</sub>/t calcium carbide produced had been used for the CO<sub>2</sub> emission calculations.

#### **4.3.2.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factors amounts to 10%.

#### **4.3.2.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

#### **4.3.2.5 Category-specific recalculations**

No recalculations were performed since the last submission.

#### **4.3.2.6 Category-specific planned improvements**

No improvements are planned for this category.

### **4.3.3 Titanium dioxide production (CRF 2.B.6)**

#### **4.3.3.1 Category description**

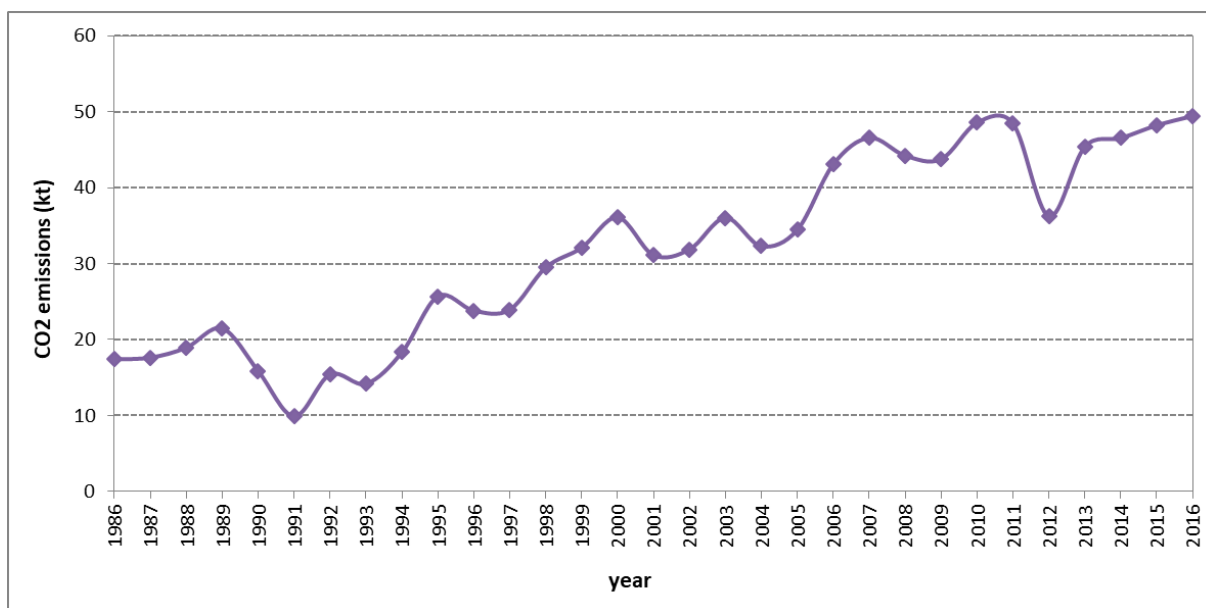
Titanium dioxide (TiO<sub>2</sub>) is one of the most commonly used white pigments. The main use is in paint manufacture followed by paper, plastics, rubber, ceramics, fabrics, floor covering, printing ink, and other miscellaneous uses. In Slovenia there is one producer of TiO<sub>2</sub>. The production of TiO<sub>2</sub> is based on the sulphate route process. The CO<sub>2</sub> emissions from titanium dioxide production are reported under Titanium Dioxide Production (CRF code: 2B6).

#### **4.3.3.2 Methodological issues**

According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories sulphate route process does not give rise to the process greenhouse gas emissions. But in the manufacturing of TiO<sub>2</sub> limestone has been used for neutralization of sulphuric acid used in sulphate process. The use of limestone is a source of CO<sub>2</sub> emissions.

CO<sub>2</sub> emissions have been estimated for the period 1986-2016. The CO<sub>2</sub> emissions have been calculated from the amount of calcium carbonate consumed. The data on the

consumption of  $\text{CaCO}_3$  has been provided by the producer. The 2006 IPCC emission factor of 0.43971 t  $\text{CO}_2$ /t of calcium carbonate has been used for the  $\text{CO}_2$  emission calculations for the whole period (Figure 4.3.1).



**Figure 4.3.1: CO<sub>2</sub> emissions from titanium dioxide production.**

#### 4.3.3.3 Uncertainties and time-series consistency

The uncertainty estimates are based on an expert judgement.  
 The uncertainty of the activity data amounts to 20%.  
 The uncertainty of the emission factor amounts to 10%.

#### 4.3.3.4 Category-specific QA/QC and verification

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

#### 4.3.3.5 Category-specific recalculations

No recalculations were performed since the last submission.

#### 4.3.3.6 Category-specific planned improvements

No improvements are planned for this category.

## **4.3.4 Petrochemical and carbon black production (CRF 2.B.8)**

### **4.3.4.1 Category description**

This category includes emissions arising from production of petrochemicals (methanol, ethylene and propylene, ethylene dichloride, ethylene oxide, acrylonitrile). The petrochemical industry uses fossil fuels (e.g., natural gas) or petroleum refinery products (e.g., naphtha) as feedstock. In Slovenia, there was only production of methanol. There is no other production of other petrochemicals in the country. CH<sub>4</sub> and CO<sub>2</sub> emissions from methanol production are reported under subcategory Methanol (CRF code: 2B8a).

### **4.3.4.2 Methodological issues**

CH<sub>4</sub> and CO<sub>2</sub> emissions had been estimated for the period 1986-1991 and 1994-2010. For the years 1992, 1993 and from 2010 onwards there was no production of methanol in Slovenia. CH<sub>4</sub> and CO<sub>2</sub> emissions had been calculated from the amount of methanol produced. The production data of methanol have been obtained from SORS. The 2006 IPCC emission factors of 2.3 kg CH<sub>4</sub>/t methanol produced and 0.267 t CO<sub>2</sub>/t methanol produced had been used for the emissions calculations.

### **4.3.4.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.  
The uncertainty of the activity data amounts to 30%.  
The uncertainty of the emission factors amounts to 10%.

### **4.3.4.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

### **4.3.4.5 Category-specific recalculations**

No recalculations were performed since the last submission.

### **4.3.4.6 Category-specific planned improvements**

No improvements are planned for this category.

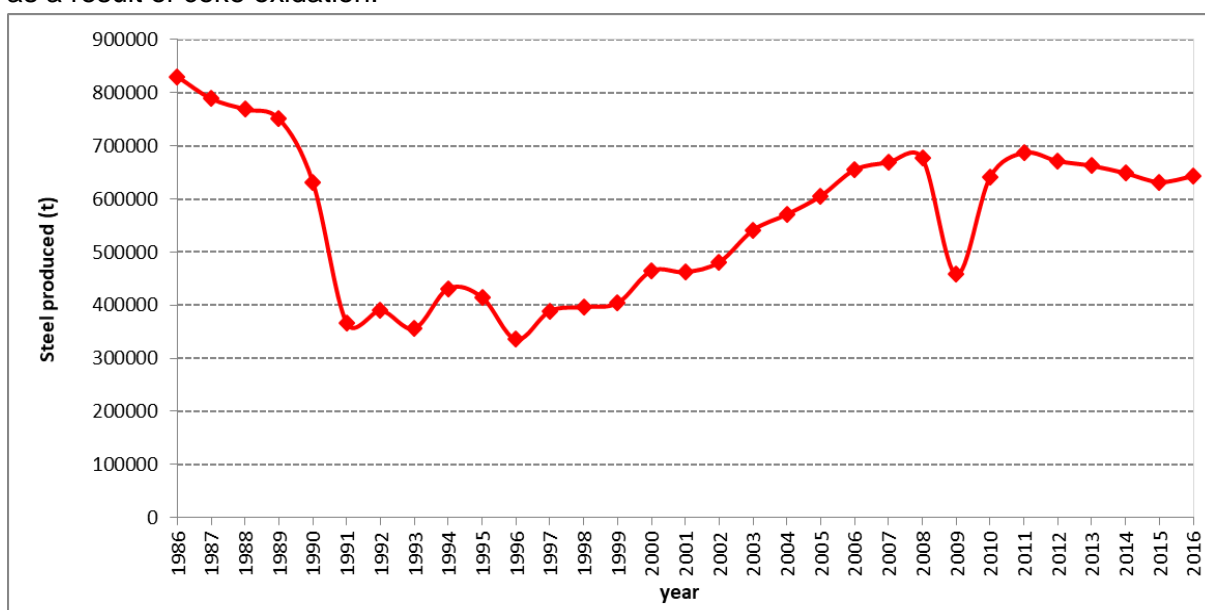
## 4.4 METAL PRODUCTION (CRF 2.C)

### 4.4.1 Iron and Steel Production (CRF 2.C.1)

#### 4.4.1.1 Category description

Iron is produced through the reduction of iron oxide (ore) using metallurgical coke as the reducing agent in a blast furnace. Steel is subsequently made from iron and scrap in other furnaces.

In the production of iron CO<sub>2</sub> emissions are associated with the use of carbon to convert iron ore to iron. Carbon is supplied to the blast furnace mainly in the form of coke. Carbon serves a dual purpose in the iron making process, primarily as a reducing agent to convert iron oxides to iron, but also as an energy source to provide heat when carbon and oxygen react exothermically. The process emissions of carbon dioxide in the production of iron take place as a result of coke oxidation.



**Figure 4.4.1: Production of steel in ton/year.**

The production of steel is a multiphase process and some phases give rise to emissions of CO<sub>2</sub>. Most emissions occur in smelting iron scrap in electric arc furnace (EAF). The furnace is first filled with steel scrap then limestone and/or dolomite are added to allow the slag to form. The furnace utilizes electric heating through graphite electrodes. For an increased productivity in the initial phase of melting, oxygen lances and a carbon injection system are used. From a metallurgical point of view, oxygen is used to reduce the carbon content in the molten metal and for removing other undesired elements. Decarburising is performed also in secondary phases in a ladle furnace. During steel production, the CO<sub>2</sub> emissions take place as a result of graphite electrode consumption in the EAF. CO<sub>2</sub> emissions originate also in consumption of limestone and dolomite and carbon containing additives.

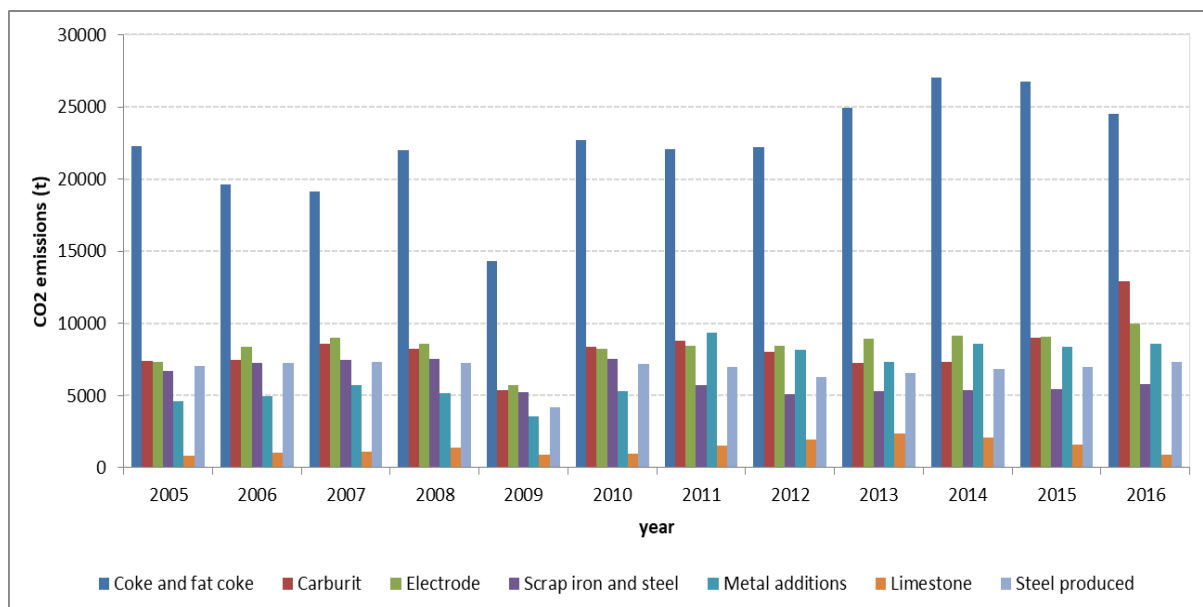
In Slovenia, there are three steel production plants. Primary production of iron from ore existed only in the 1986 and 1987. CO<sub>2</sub> emissions from iron and steel production are reported under Iron and Steel Production (CRF code: 2C1).

Annual amount of steel produced is shown in Figure 4.4.1.

#### 4.4.1.2 Methodological issues

CO<sub>2</sub> emissions from iron production were calculated for the years 1986 and 1987. CO<sub>2</sub> emissions had been calculated from the amount of pig iron produced. The production data were obtained from the producers. The emission factor used for emission calculation was calculated from carbon content data obtained from the 2006 IPCC Guidelines. The emission factor applied was 0.146 t CO<sub>2</sub>/t pig iron produced.

The CO<sub>2</sub> emissions from steel production for the period 2005-2016 have been calculated from the amount and carbon content of input and output materials. In our case, the input materials were mostly graphite electrodes, coke, FAT coke, carburet, scrap iron and steel, metal additions, limestone and dolomite. The output material is the amount of steel produced. An individual data for all three steel producers have been obtained from the verified ETS reports. Figure 4.4.2 shows CO<sub>2</sub> emissions contributed by the different input materials and steel produced for 2005-2016.



**Figure 4.4.2: CO<sub>2</sub> emissions contributed by different input material and steel produced.**

The calculation of CO<sub>2</sub> emissions from steel production for the period 1988-2004 has been performed in another way due to a lack of precise data on the amount and carbon content of the input materials. We calculated an average implied emission factor for the years 2005-2013. This emission factor was then multiplied with the annual steel production data. This

emission factor was not appropriate for the base year because of a different type of steel production (from ore). The data on steel production have been obtained from the producers.

In the period 1986–1987 production of pig iron from ore still occurred. The disaggregation into the consumption of fuel as an additive and the consumption of fuel as an energy product was impossible. Consequently, for these two years a decision was made to attribute all coke, which is consumed in the production of iron and steel, to the energy sector as fuel consumption. When this production was discontinued and a new electric arc furnace started production in 1988, the only source of process emissions in this category was the production of steel from scrap iron in the EAF. We assumed that the energy source in this type of industry is only electricity and the emissions from coke and other material are all process emissions. The consequence is that all coke consumption for the years 1986–1987 is allocated to the energy sector, whereas for the period 1988–2016 all coke consumption is included in the industrial processes sector. The CO<sub>2</sub> emissions from steel production for the years 1986 and 1987 were therefore calculated from the amount of electrodes consumed only. Coke was not taken into account for the process emissions calculation for that period. The emission factor used for the emission calculation was calculated from carbon content data obtained from the 2006 IPCC Guidelines. The emission factor applied was 3.006 t CO<sub>2</sub>/t carbon electrodes.

#### **4.4.1.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factor amounts to 10%.

#### **4.4.1.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

#### **4.4.1.5 Category-specific recalculations**

No recalculations were performed since the last submission.

#### **4.4.1.6 Category-specific planned improvements**

No improvements are planned for this category.

## 4.4.2 Ferroalloys Production (CRF 2.C.2)

### 4.4.2.1 Category description

Ferroalloys are concentrated alloys of iron and one or more metals such as silicon, manganese, chromium, molybdenum, vanadium and tungsten. These alloys are used for deoxidising and altering material properties of steel. Ferroalloy production involves a metallurgical reduction process which results in significant carbon dioxide emissions.

In ferroalloy production, raw ores, coke and slagging materials are smelted together under a high temperature. Usually, alloy formation occurs in electric arc furnaces, where heating is accomplished by passing current through graphite electrodes. A carbon reduction of metallic oxides occurs as both coke and graphite electrodes are consumed. The carbon captures oxygen from metal oxides to form carbon monoxide, while ores are reduced to molten base metals. The component metals then combine in the solution. The carbon monoxide is then converted to carbon dioxide.

There had been only one ferroalloy producer in Slovenia. This factory was closed down in the first quarter of 2008 and consequently the production of ferroalloys was discontinued in 2008 as well. No ferroalloys were produced since 2008. This subsector contributed no emissions from 2009 onwards. CO<sub>2</sub> and CH<sub>4</sub> emissions from ferroalloy production are reported under Ferroalloys Production (CRF code: 2C2).

### 4.4.2.2 Methodological issues

CO<sub>2</sub> emissions had been estimated for the period 1986-2008. From 2009 onwards there was no production of ferroalloys in Slovenia. The CO<sub>2</sub> emissions have been calculated from the amount of reducing agents used. Coke, petroleum coke and graphite electrodes were used as reducing agents in the production of ferroalloys. The data on the consumption of reducing agents was provided by the factory. The 2006 IPCC emission factors had been used for the CO<sub>2</sub> emission calculations. These were 3.3 t CO<sub>2</sub>/t coke, 3.5 t CO<sub>2</sub>/t petroleum coke and 3.4 t CO<sub>2</sub>/t electrodes.

CH<sub>4</sub> emissions had been estimated for the period 1986-2008 as well. The CH<sub>4</sub> emissions have been calculated from the amount of ferroalloys produced. The data on the production of ferroalloys was provided by the factory. The 2006 IPCC emission factors had been used for the CH<sub>4</sub> emission calculations. These were 1.2 kg CH<sub>4</sub>/t Si-metal and 1.1 kg CH<sub>4</sub>/t FeSi 65-75.

The trend in the CO<sub>2</sub> implied emission factor has not been stable due to different annual shares of fuels split between the energy sector (coal and natural gas) and the process emission sector (coke, petroleum coke and graphite electrodes). The emissions from the consumption of coal and natural gas have been reported in the Energy Sector/Manufacturing

industry and Construction/Iron and Steel (CRF sector 1A2a), and the emissions from coke and graphite electrodes have been reported in the process emission sector. Changing levels of annual consumption of coke and electrodes over time and the different amounts and type of annual ferroalloys produced have also caused variation in the implied emission factors. Different ferroalloys have different CO<sub>2</sub> emissions factors.

#### **4.4.2.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factor amounts to 10%.

#### **4.4.2.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

In addition, a quality control was performed in the estimation of CO<sub>2</sub> emissions. The CO<sub>2</sub> emissions were calculated by using two different methods. According to the first method the consumption of reducing agents was used as an activity data. The second method was used for comparison. It applied the amount of ferroalloys as an activity data. The both methods yielded very similar results.

#### **4.4.2.5 Category-specific recalculations**

No recalculations were performed since the last submission.

#### **4.4.2.6 Category-specific planned improvements**

No improvements are planned for this category.



### 4.4.3 Aluminium Production (CRF 2.C.3)

#### 4.4.3.1 Category description

Aluminium is produced in two phases. In the first phase alumina ( $\text{Al}_2\text{O}_3$ ) is extracted from bauxite ore. Aluminium is then produced in the second phase in an electrochemical process in electrolysis cells, where alumina disintegrates into its components: aluminium and oxygen. Molten aluminium gathers on the cathode while oxygen reacts with carbon in the anode and carbon dioxide is released. This causes the consumption of anodes, which have to be replaced.

In addition to  $\text{CO}_2$ , perfluorocarbons (PFCs) also arise in the production of aluminium. This occurs during anode effect when the alumina content of the electrolyte falls below 1-2% and a gas film is formed in the anode. This stops the production of the metal and increases the cell voltage. The factors that affect the generation of PFCs are frequency and duration of anode effects and operating current of the cell.

The most significant process emissions are therefore:

- carbon dioxide emissions from the consumption of carbon anodes in the reaction to convert aluminium oxide to aluminium metal;
- perfluorocarbons emissions of tetrafluoromethane ( $\text{CF}_4$ ) and hexafluoroethane ( $\text{C}_2\text{F}_6$ ) during anode effects.

In Slovenia, there is only one aluminium producer. Since the base year, the production of aluminium has undergone numerous modernisations, resulting in reduced GHG emissions from this source in spite of an increased production.

Exact information on technological changes and improved operating conditions in the aluminium production process is presented.

Technology used in production of aluminium since Slovenian aluminium plant has been established:

- 1954 start of electrolysis unit A,
- 1963 start of electrolysis unit B,
- 1988 start of electrolysis unit C and technological reconstruction in electrolysis unit B,
- 1991 discontinuance of electrolysis unit A,
- 2002 start of operation of doubled electrolysis unit C,
- 2007 (21<sup>st</sup> Dec) discontinuance of electrolysis unit B,
- 2010 reduction of production in electrolysis unit C due to economic crisis.

In 1986, aluminium producer had two electrolysis units, A and B, both using Söderberg Horizontal Stud anode reduction cells. The annual production of aluminium in electrolysis unit A amounted to 17000 t, in electrolysis unit B to 27400 t, the total annual production amounted to 44400 t of aluminium. In 1986, the production of aluminium included a

production of alumina. This production that was discontinued in 1991 due to economical and ecological reasons, and ever since then alumina has been purchased on foreign markets. In 1991, the production in electrolysis unit A was discontinued as well.

In 1988, a new electrolysis unit C with an annual production capacity of about 40000 t of aluminium was built and its electrolysis technology was taken from Aluminium Pechiney. Simultaneously, the reduction cells in electrolysis unit B were reconstructed to use prebaked anodes.

In 2002, upgrading the aluminium production that includes construction of the second half of the electrolysis unit C with an annual production capacity of 40000 t of aluminium was carried out. Due to high costs for electricity used, the plant had to wind up the production in pot B in the end of 2007. Since 2008, only doubled electrolysis unit C with technologically improved point feeding prebaked anode Pechiney has been in operation. The annual production of aluminium in 2009 and 2010 were halved compared to 2008. A significant drop in aluminium production occurred due to the world economic crisis. In 2016, the production of aluminium increased considerably and reached pre-crises values.

The emissions of CO<sub>2</sub>, CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> from aluminium production are reported under Aluminium Production (CRF code: 2C3).

#### 4.4.3.2 Methodological issues

##### Carbon dioxide emissions

The data on the amount of primary aluminium produced, consumption of anodes, sulphur and ash content and CO<sub>2</sub> emissions are submitted to the Slovenian Environment Agency by producer expert service on a regular basis.

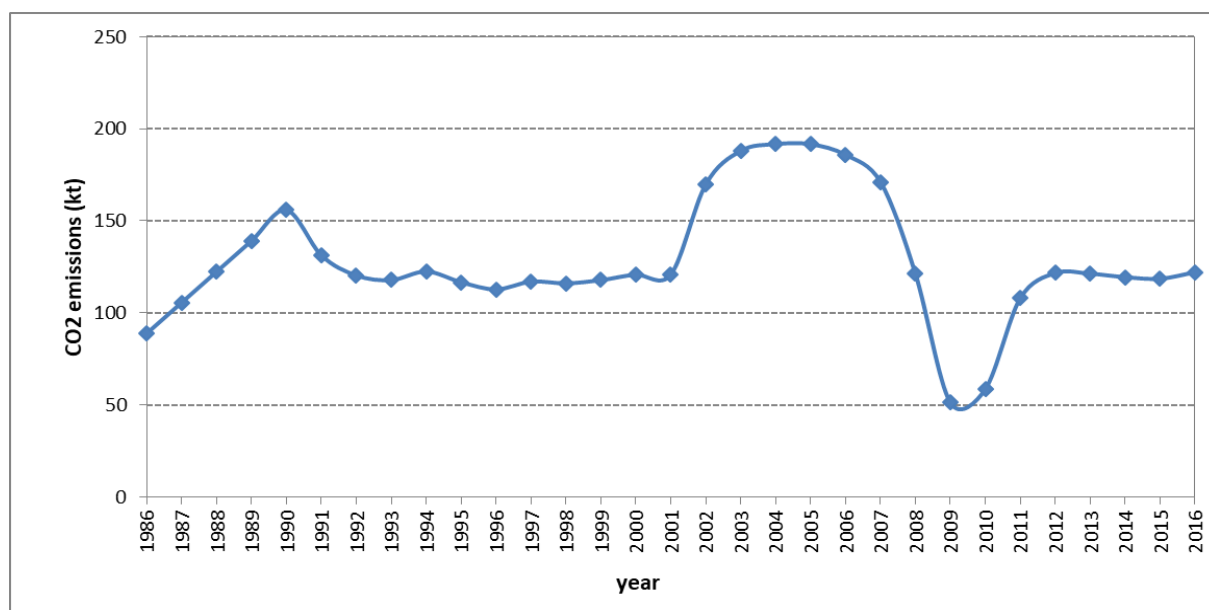


Figure 4.4.3: CO<sub>2</sub> emissions from aluminium production.

CO<sub>2</sub> emissions from primary aluminium production are most precisely estimated from the consumption of anodes. The consumption of anodes in 2016 amounted to 0.389 t/ton aluminium. The emission factor was 3.72 t CO<sub>2</sub>/ton anodes. The significant decline of CO<sub>2</sub> emissions in 2009 occurred due to lower aluminium production. In 2012, the production of aluminium increased considerably and CO<sub>2</sub> emissions reached pre-crises values. The same trend is observed for the following years as well (Figure 4.4.3).

In 2016, electrolysis unit C with point feeding prebaked anode Pechiney technology was in operation.

The 2006 IPCC methodology is used for the CO<sub>2</sub> emission calculation.

$$ECO_2 = (MP \cdot NAC \cdot (100 - S - Ash) / 100) \cdot 44 / 12$$

ECO<sub>2</sub> = CO<sub>2</sub> emissions from prebaked anode consumption (t CO<sub>2</sub>)

MP = aluminium production (t)

NAC = net prebaked anode consumption per tonne of aluminium (t C/t aluminium)

S = sulphur content in baked anodes (wt %)

Ash = ash content in baked anodes (wt %)

44/12 = CO<sub>2</sub> molecular mass/ carbon atomic mass ratio

To improve the transparency of CO<sub>2</sub> emission from aluminium production, this chapter comprises only emissions arising from consumption of anodes. CO<sub>2</sub> emissions from anode burn-off have been excluded from this chapter and they are now reported under CRF sector Other 2C7.

#### PFC emission

Data on emission calculations of tetrafluoromethane (CF<sub>4</sub>) and hexafluoroethane (C<sub>2</sub>F<sub>6</sub>) have been obtained directly from the aluminium producer. The technological changes and improved operating conditions in the aluminium production process are the reason for the decrease of CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> emission factors from 1995 to 2016. The CF<sub>4</sub> emission factor has decreased from the base year 1995 till now from 0.2 kg CF<sub>4</sub>/ton Al to 0.03 kg CF<sub>4</sub>/ton Al and C<sub>2</sub>F<sub>6</sub> emission factor from 0.02 kg C<sub>2</sub>F<sub>6</sub>/ton Al in the base year to 0.003 kg C<sub>2</sub>F<sub>6</sub>/ton Al in 2016.

In the scope of establishing a scheme for greenhouse gas emission allowance trading for the third trading period after 2012 thorough examination of data was performed. A higher method (Tier 3) was used for calculating of PFC emissions in electrolysis unit C for the period 2005 - 2016. Annually determined emission factors have been used for the emission calculation. The Pechiney overvoltage method has been used for the emissions calculation for both gases. All data has been obtained from producer's electronically recorded anode-effect inventory. The emissions of CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> in aluminium production are shown in Figure 4.4.4.

In 2016, electrolysis unit C with point feeding prebaked anode Pechiney technology has been in operation.

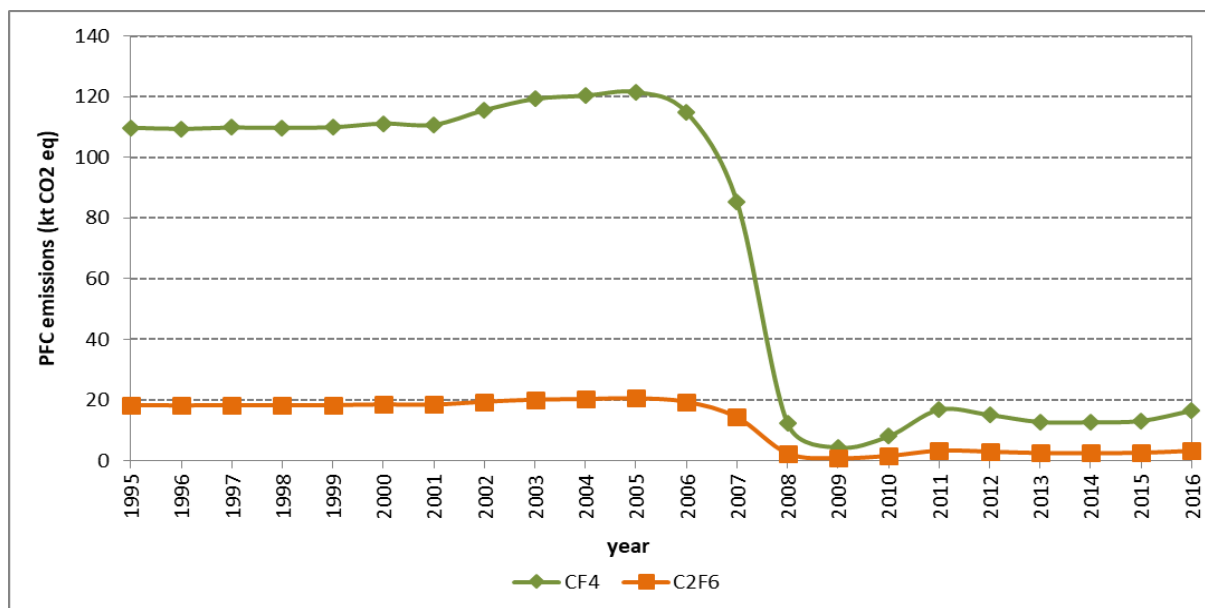


Figure 4.4.4: CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> emissions in aluminium production.

The 2006 IPCC methodology is used for CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> emission calculation.

$$ECF_4 = MP \cdot OVC \cdot AEO / CE$$

$$EC_2F_6 = E_{CF_4} \cdot F_{C_2F_6/CF_4}$$

ECF<sub>4</sub> = emissions of CF<sub>4</sub> from aluminium production (kg CF<sub>4</sub>)

EC<sub>2</sub>F<sub>6</sub> = emissions of C<sub>2</sub>F<sub>6</sub> from aluminium production (kg C<sub>2</sub>F<sub>6</sub>)

OVC = Overvoltage coefficient for CF<sub>4</sub> ((kg CF<sub>4</sub>/tonne Al)/mV)

AEO = anode effect overvoltage (mV)

CE = aluminium production process current efficiency expressed (%)

MP = aluminium production (t)

F<sub>C<sub>2</sub>F<sub>6</sub>/CF<sub>4</sub></sub> = weight fraction of C<sub>2</sub>F<sub>6</sub>/CF<sub>4</sub>, kg C<sub>2</sub>F<sub>6</sub>/kg CF<sub>4</sub>

The PFC emissions for the period 1995 – 2004 were calculated from the annual production of aluminium in each electrolysis unit and the corresponding emission factor are stated in Table 4.4.1.

Table 4.4.1: Technology used in the aluminium production and corresponding CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> emission factors.

Technology	Unit	Emission factors
Electrolysis unit A, Soderberg, HSS	kg CF <sub>4</sub> /t	0.61
	kg C <sub>2</sub> F <sub>6</sub> /t	0.061
Electrolysis unit B, Soderberg, HSS, until 1987	kg CF <sub>4</sub> /t	0.61
	kg C <sub>2</sub> F <sub>6</sub> /t	0.061
Electrolysis unit B, reconstruction to PB, 1988	kg CF <sub>4</sub> /t	0.40
	kg C <sub>2</sub> F <sub>6</sub> /t	0.04
Electrolysis unit C, Pechiney, PFPB, until 2004	kg CF <sub>4</sub> /t	0.022
	kg C <sub>2</sub> F <sub>6</sub> /t	0.003

PF - Point Feeding, PB - PreBaked anode, HSS - Horizontal Stud Soderberg

#### **4.4.3.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factors amounts to 10%.

#### **4.4.3.4 Category-specific QA/QC and verification**

The data obtained from the aluminium producer was thoroughly examined. Possible inconsistencies were consulted with producers expert team. We also visited the factory and observed a production operation and data acquiring in person.

#### **4.4.3.5 Category-specific recalculations**

No recalculations were performed since the last submission.

#### **4.4.3.6 Category-specific planned improvements**

No improvements are planned for the next submission.

#### **4.4.4 Lead Production (CRF 2.C.5)**

##### **4.4.4.1 Category description**

The category comprises primary and secondary lead production. In the direct primary smelting process, the sintering step is skipped, and the lead concentrates and other materials are entered directly into a furnace in which they are melted and oxidized. The secondary production of refined lead amounts to the processing of recycled lead to prepare it for reuse. The vast majority of this recycled lead comes from scrapped lead acid batteries. The CO<sub>2</sub> emissions from lead production are reported under Lead Production (CRF code: 2C5).

##### **4.4.4.2 Methodological issues**

CO<sub>2</sub> emissions have been estimated for the period 1986-2016. The CO<sub>2</sub> emissions have been calculated from the annual amount of lead produced. The data on the lead production for the period 1986-2016 was obtained from SORS. Primary production of lead existed in Slovenia in the period 1986-1988. After 1988 only secondary lead production has been taken place in the country. The 2006 IPCC emission factors have been used for the CO<sub>2</sub> emission calculations. These were 0.25 t CO<sub>2</sub>/t lead produced for primary production (1986-1988) and 0.2 t CO<sub>2</sub>/t lead produced for secondary lead production (1989-2016).

##### **4.4.4.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.  
The uncertainty of the activity data amounts to 10%.  
The uncertainty of the emission factors amounts to 10%.

##### **4.4.4.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

##### **4.4.4.5 Category-specific recalculations**

No recalculations were performed since the last submission.

##### **4.4.4.6 Category-specific planned improvements**

No improvements are planned for the next submission.

## **4.4.5 Zinc Production (CRF 2.C.6)**

### **4.4.5.1 Category description**

Zinc is produced from various primary and secondary raw materials. The primary processes use sulphidic and oxidic concentrates, while in secondary processes recycled oxidised and metallic products mostly from other metallurgical operations are employed. CO<sub>2</sub> emissions from zinc production are reported under Zinc Production (CRF code: 2C6).

### **4.4.5.2 Methodological issues**

CO<sub>2</sub> emissions have been estimated for the period 1986-2016. The CO<sub>2</sub> emissions have been calculated from the annual amount of zinc produced. The data on the zinc production for the period 1986-2016 was obtained from SORS. The 2006 IPCC emission factor of 1.72 t CO<sub>2</sub>/t zinc produced have been used for the CO<sub>2</sub> emission calculations.

### **4.4.5.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.  
The uncertainty of the activity data amounts to 10%.  
The uncertainty of the emission factors amounts to 10%.

### **4.4.5.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

### **4.4.5.5 Category-specific recalculations**

No recalculations were performed since the last submission.

### **4.4.5.6 Category-specific planned improvements**

No improvements are planned for the next submission.

## 4.4.6 Other – Anode burn-off (CRF 2.C.7)

### 4.4.6.1 Category description

This chapter comprises CO<sub>2</sub> emissions arising from anode burn-off in the process of anode production. Two sources of CO<sub>2</sub> emissions are associated with anode baking furnaces: combustion of volatile matter released during the baking operation and the combustion of baking furnace packing material. The emissions are reported under Other (CRF code: 2C7).

### 4.4.6.2 Methodological issues

CO<sub>2</sub> emissions from anode burn-off in anode baking process were excluded from the sector on aluminium production. They are reported separately in this chapter. Anodes are used in potline cells - pots for the production of aluminium. The CO<sub>2</sub> emissions generated in the process of green anodes baking arise from oxidation of volatile substances from a tar pitch and from burning-off the covering material (petroleum coke). The emission factor for anode burn-off is a plant specific. Data on the amount of anodes, operational parameters and emissions of CO<sub>2</sub> are provided by the producer expert service. The CO<sub>2</sub> implied emission factor for 2016 is 3.35 t CO<sub>2</sub>/t anode burn-off. Figure 4.4.5 shows CO<sub>2</sub> emissions arising from anode burn-off in the process of anode production.

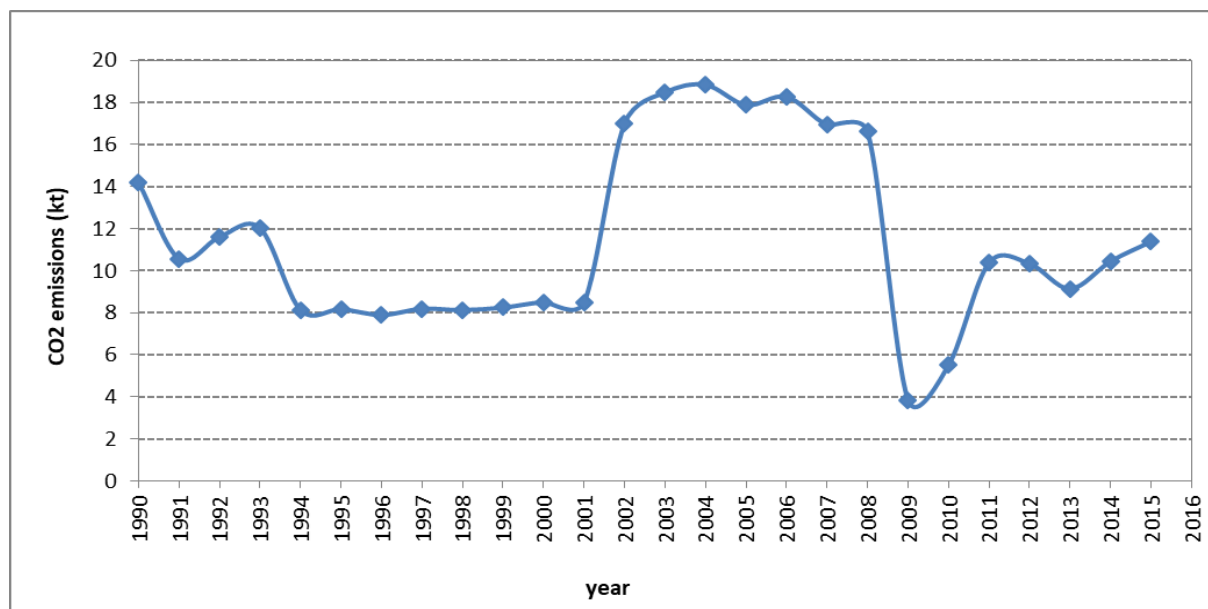


Figure 4.4.5: CO<sub>2</sub> emissions in the process of anode production.



#### **4.4.6.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factors amounts to 10%.

#### **4.4.6.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

#### **4.4.6.5 Category-specific recalculations**

No recalculations were performed since the last submission.

#### **4.4.6.6 Category-specific planned improvements**

No improvement is planned for the next submission.

## 4.5 NON-ENERGY PRODUCTS FROM FUELS AND SOLVENT USE (CRF 2.D)

### 4.5.1 Lubricant use (CRF 2.D.1)

#### 4.5.1.1 Category description

Lubricants are mostly used in industrial and transportation applications. The lubricants are produced either at refineries through separation from crude oil or at petrochemical facilities. They can be divided into motor and industrial oils and greases. The CO<sub>2</sub> emissions from lubricant use are reported under Lubricant Use (CRF code: 2D1).

#### 4.5.1.2 Methodological issues

CO<sub>2</sub> emissions have been estimated for the period 1986-2016. The 2006 IPCC methodology was used for emission calculation (Vol. 3 IPPU, Chapter 5: Non-Energy Products from Fuels and Solvent Use, Equation 5.2). As activity data is the difference between the total amount of lubricant consumption and lubricant used in two-stroke engines is used. The lubricant used in two-stroke engines was subtracted from the total consumption of lubricant. The data on the total lubricant use for the whole period was obtained from SORS. Tier 1 values for the carbon content of lubricant (20 t/TJ) and oxidised during use factor (0.2) were used for the emission calculation. COPERT 4 (version 11.4) model has been used as a source of lubricant used in two-stroke engines.

#### 4.5.1.3 Uncertainties and time-series consistency

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factors amounts to 10%.

#### 4.5.1.4 Category-specific QA/QC and verification

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

#### 4.5.1.5 Category-specific recalculations

Emissions of CO<sub>2</sub> have been recalculated for the period 1986-2015 due to new version of model COPERT 4 applied. COPERT 4, version 11.4 was used for emission calculation for the entire period. Updated data on vehicle fleet was used for emission calculation.

#### 4.5.1.6 Category-specific planned improvements

No improvements are planned for this category.

## 4.5.2 Paraffin wax use (CRF 2.D.2)

### 4.5.2.1 Category description

Paraffin waxes are used in applications such as: candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, surfactants (as used in detergents) and many others. Emissions from the use of waxes derive primarily when the waxes or derivatives of paraffin are combusted during use (e.g., candles). The paraffin waxes are separated from crude oil during the production of light (distillate) lubricating oils. The paraffin waxes are categorised by oil content and the amount of refinement. The CO<sub>2</sub> emissions from paraffin wax use are reported under Paraffin Wax Use (CRF code: 2D2).

### 4.5.2.2 Methodological issues

CO<sub>2</sub> emissions for the period 2000-2016 have been calculated from the consumption of paraffin wax. Data on the amount of paraffin wax used have been obtained from SORS. Default 2006 IPCC parameters have been used for the CO<sub>2</sub> emissions calculation. It can be assumed that 20% of paraffin waxes are used in a manner leading to emissions, mainly through the burning of candles, leading to a default ODU factor of 0.2. The carbon content in paraffin wax of 20.0 kg C/GJ has been used for the emission calculation.

CO<sub>2</sub> emissions for the period 1995 -1999 have been estimated in another way due to lack of data on paraffin wax consumption. The estimation of emissions was performed from Gross domestic product (GDP) data. The CO<sub>2</sub> emissions for 2000 were used as a reference year.

Estimated emission for 1995 was applied for the period 1986 -1994 due to a lack of data on paraffin wax consumption and information on BDP.

### 4.5.2.3 Uncertainties and time-series consistency

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factors amounts to 10%.

### 4.5.2.4 Category-specific QA/QC and verification

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

### 4.5.2.5 Category-specific recalculations

No recalculation was performed since the last submission.

### 4.5.2.6 Category-specific planned improvements

No improvements are planned for this category.

### 4.5.3 Other (CRF 2.D.3)

#### 4.5.3.1 Category description

This sector comprises emissions of non-methane volatile organic compounds (NMVOC) from road paving with asphalt, asphalt roofing and solvent use, and CO<sub>2</sub> emissions from use of urea-based additives in catalytic converters. The emissions from these sources are reported under category Other (CRF code: 2D3).

Asphalt paving consist of a mix of aggregate, sand, filler, bitumen and occasionally a number of additives. Asphalt road surfaces and pavements are composed of compacted aggregate and an asphalt binder. The asphalt binder may consist of heated asphalt cement (hot mix) or liquefied asphalts (cutback or emulsified). Hot Mix Asphalt is by far the most widely used, generally over 80%, and produces very few emissions. Cutback asphalts are liquefied by blending with petroleum solvents (diluent such as heavy residual oils, kerosene or naphtha solvents) and therefore show a relatively high level of emissions of NMVOC due to the evaporation of the diluent. Therefore most emissions from road paving will arise from the use of cutback asphalts. This section covers emissions from asphalt paving operations as well as subsequent releases from the paved surfaces.

The asphalt roofing industry produces saturated felt, roofing and siding shingles, roll roofing and sidings: asphalt shingles, smooth surfaced organic and asbestos felt roll roofing, mineral surfaced organic and asbestos felt roll roofing and sidings, asphalt saturated organic and asbestos felts, asphalt saturated and/or coated sheeting and asphalt compound. Most of these products are used in roofing and other building applications. Asphalt felt, roofing and shingle manufacture involves the saturation or coating of felt. Key steps in the total process include asphalt storage, asphalt blowing, felt saturation, coating and mineral surfacing. The direct greenhouse gas emissions from asphalt roofing products are negligible compared to NMVOC emissions.

The use of solvents manufactured using fossil fuels as feedstocks can lead to evaporative emissions of various NMVOCs, which are subsequently further oxidised in the atmosphere. Fossil fuels used as solvent are notably white spirit and kerosene. White spirit is used as an extraction solvent, as a cleaning solvent, as a degreasing solvent and as a solvent in aerosols, paints, wood preservatives, lacquers, varnishes and asphalt products. White spirit is the most widely used solvent in the paint industry.

Urea-based catalyst is used in Selective Catalytic Reduction (SCR). SCR is an advanced active emissions control technology system that injects a liquid-reductant agent through a special catalyst into the exhaust stream of a diesel engine. The reductant source is usually automotive-grade urea, which sets off a chemical reaction that converts nitrogen oxides into nitrogen, water and tiny amounts of carbon dioxide, which is then expelled through the vehicle tailpipe. CO<sub>2</sub> emissions from the use of urea-based additives in catalytic converters are non-combustive emissions. Urea consumption for catalytic converters in vehicles is directly related to the vehicle fuel consumption and technology.

### 4.5.3.2 Methodological issues

#### NMVOC emissions

EMEP/EEA air pollutant emission inventory guidebook, 2016 was applied for estimating NMVOC emissions from road paving with asphalt, asphalt roofing and solvent use. NMVOC emissions have been calculated for the period 1990-2016. Detailed information about the methodologies used is described in Informative Inventory Report for Slovenia, 2018 submitted under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP) and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants (NEC Directive).

<http://cdr.eionet.europa.eu/si/un/clrtap/iir/envwqjfaq/>

#### CO<sub>2</sub> emissions

This chapter comprises CO<sub>2</sub> emissions from the use of urea-based additives in catalytic converters in road transport. The CO<sub>2</sub> emissions have been calculated for the period 2009-2016. The CO<sub>2</sub> emissions have been estimated with COPERT 4 methodology. The methodology is fully incorporated in the computer software programme COPERT 4 (version 11.4) which facilitates its application. The actual calculations have been therefore performed by using this computer software. Urea consumption for catalytic converters in vehicles is directly related to the vehicle fuel consumption and technology. Vehicle fleet and fuel consumption used for the emission calculation is presented in the chapter, describing emissions from Road transport. The consumption factors and other data used for the emission calculation are default values offered by COPERT 4 programme.

### 4.5.3.3 Uncertainties and time-series consistency

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factors amounts to 10%.

### 4.5.3.4 Category-specific QA/QC and verification

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

### 4.5.3.5 Category-specific recalculations

Emissions of CO<sub>2</sub> have been recalculated for the period 1986-2015 due to new version of model COPERT 4 applied. COPERT 4, version 11.4 was used for emission calculation for the entire period. Updated data on vehicle fleet was used for emission calculation.

### 4.5.3.6 Category-specific planned improvements

No improvements are planned for this category.

## 4.6 Product uses as substitutes for ODS (CRF 2.F)

### 4.6.1 Category description

This category includes HFC emissions. The emission sources, the time period and the gases included in the GHG inventory are presented in the Table 4.6.1. The gases have been used in the pure form and most often in the following blends: R-402a, R-404a, R-407a, R-407c, R-410a, R-417a and R-507a. For the purpose of the GHG inventory all blends have been transformed to the pure F-gases using the Table 7.8 from 2006 IPCC GL, Vol3. As 1995 is the base year for HFC emissions no data have been collected for the years before.

**Table 4.6.1: Emission sources of F-gases with the time period.**

	period	gases
Refrigeration and AC equipment		
- domestic refrigeration	1995-2016	HFC-134a
- commercial refrigeration	1995-2016	HFC-32, HFC-125, HFC-134a, HFC-143a
- industrial refrigeration	1997-2016	HFC-32, HFC-125, HFC-134a, HFC-143a
- transport refrigeration	1995-2016	HFC-125, HFC-134a, HFC-143a
- stationary air conditioning	2000-2016	HFC-32, HFC-125, HFC-134a, HFC-143a
- mobile air conditioning	1995-2016	HFC-134a
Foam blowing		
- hard foam	1995-2016	HFC-134a
- soft foam	1995-1998	HFC-134a
Fire extinguishers	1997-2016	HFC-227ea
Aerosols and meter dose inhalers	2003-2016	HFC-134a

HFCs began to be used in Slovenia in 1993 as a substitute for CFCs, which are ozone-depleting substances. They asserted themselves in particular in those fields where no other, more appropriate alternatives (e.g. hydrocarbons, CO<sub>2</sub> etc.) were available.

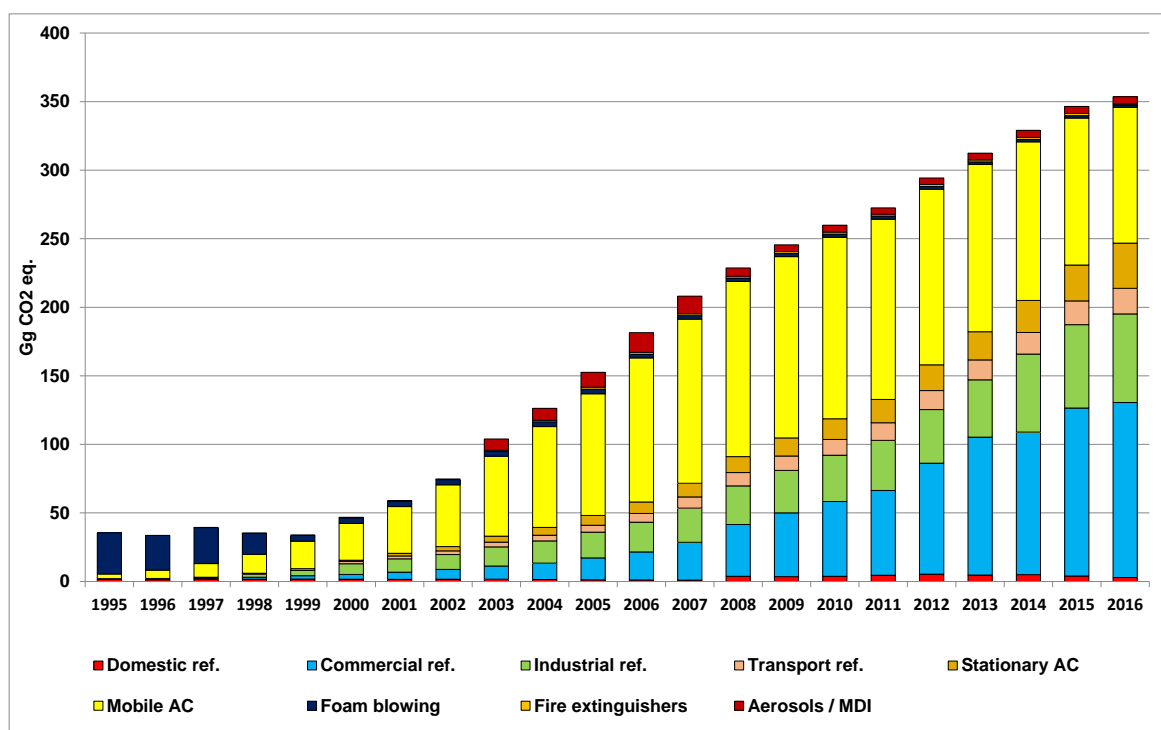
Slovenian chemical industry does not produce HFCs and therefore these substances are imported. Major users generally import them on their own, minor users buy them from distributors.

In the 1995 base year only HFC-134a was used, while also the other F-gases like R-125 and R-143a and HFC mixtures like R-402a, R-404a, R-407a, R-407c, R-410a, R-417a and R-507a have been used since 1998. In fire extinguishers R-227ea have been used since 1995.

The sources of HFC emissions are presented on the Figure 4.6.1 below. The first most important source of HFC emissions was Commercial refrigeration with contribution of 35%. Mobile Air-Conditioning is the second most important source. In 2015, nearly 31% of all HFC emissions arose from MAC. The production and sales of cars with air conditioning has risen sharply in recent years and despite the new EU directive from 2011 the use of refrigerant with lower GWP (R-1234yf) is still rather small.

The first data on HFC consumption was obtained by a research project carried out by the Chamber of Commerce and Industry of Slovenia in 1999 and covering the use of HFC for the period 1995-1997 potential emissions according to Tier 1a and 1b methods as well as actual emissions according to Tier 2 method have been calculated.

Since then we have started to collect data from the industry on use of HFC for first fillings of equipment for estimation of manufacturing emissions. To collect data necessary for the estimation of emissions from use, a new legislation has been adopted which requires the reporting on all devices with 3 kg of F-gases or more. In 2011 the database of these reports has been established; which includes information on the amount and type of F-gases, year of installation and purpose of the device (AC, industrial refrigeration...). These data have been used to estimate the amount of F-gases for stationary conditioning, industrial refrigeration and partly also for commercial refrigeration.



**Figure 4.6.1: HFC emissions from different sources.**

The second source of data are reports from service companies which are authorized to perform the 1<sup>st</sup> filling and to maintain the equipment which is filled with ODS and F-gases in the commercial sector and in the industry. In these reports, the total amount of each F-gas or blend, used for maintenance in one year, is available, but no disaggregation according to the type of maintained equipment was available until 2013 when for the first time data were collected and reported separately for four types of use (commercial, industrial, stationary AC, and fire protection).

There is one more source of data on F-gases in Slovenia. In 2008, Slovenia adopted a regulation on an environmental tax on the use of fluorinated greenhouse gases, which entered into force on 1 January 2009. This tax is calculated on the basis of pollution units

referring to CO<sub>2</sub> equivalents. When introducing the tax on the use of F-gases, the Slovenian government anticipated a transition period during which the tax burden has gradually increased until 2013, when the full price per pollution unit has been reached.

The level of the tax depends on the purpose of F-gases use: The first fill of pre-charged equipment and stationary equipment is taxed 5%, while F-gas quantities used for servicing and maintenance of equipment are taxed 100%.

First data on F-gas quantities used and tax revenues show a high increase of the use of F-gases. The problems of the scheme relate to the fact that taxes do not apply in neighbouring countries within the EU and outside of the EU and that it is possible for companies to buy F-gases there at lower prices. Furthermore, tax rebates for recovered F-gases for reclamation and destruction are not part of the scheme. For this reason the tax has been abolished in 2017.

## 4.6.2 Methodological issues

Actual emissions of HFC have been calculated using Tier 2a approach and the following equation (IPCC 2006 GL, Vol 3, chapter 7.1.2.1, eq. 7.4)

$$E_t = E_{\text{assembly}, t} + E_{\text{operation}, t} + E_{\text{disposal}, t}$$

where:

$$E_{\text{assembly}, t} = E_{\text{charge}, t} * (k/100)$$

$E_{\text{assembly}, t}$	=	Emissions during system manufacture/assembly in year t
$E_{\text{charge}, t}$	=	The amount of F-gas charged into new systems in year t
k	=	Production/assembly losses (%)

$$E_{\text{operation}, t} = E_{\text{stock}, t} * (x/100)$$

$E_{\text{operation}, t}$	=	Amount of F-gas emitted during system operation in year t
$E_{\text{stock}, t}$	=	Amount of F-gas stocked in existing systems in year t
x	=	Annual leakage rate (in per cent of total F-gas charge in the stock)

$$E_{\text{disposal}, t} = E_{\text{consumption} (t-n)} * (y/100)$$

$E_{\text{disposal}, t}$	=	Amount of F-gas emitted at disposal in year t
$E_{\text{consumption} (t-n)}$	=	Amount of F-gas used for production in year (t-n)
n	=	product lifetime (in years)
y	=	Share of F-gas in products to be disposed of in % of the amount used for their production



## 2.F.1 Refrigeration and Air Conditioning Equipment

The following chapters describe types of refrigeration and air-conditioning equipment considered in individual sub-categories, refrigerants used in the respective applications and method used for the calculation of emissions in Slovenia.

### Domestic refrigeration:

The use of HFC-134a as a refrigerant began towards the end of 1993 only to become partly replaced by isobutane already in 1995. Appliances with R-134a are produced exclusively for export to the USA and to other non European countries.

Since 1996, all household refrigerators produced in Slovenia for Slovenian market have been filled in with R-600 (isobutane). The amount of HFC-134a in imported refrigerators was estimated in the study (Chamber of commerce, 1999). Afterwards, the amount in new appliances decreased until 2006, when according to the information from experts there were no imported household refrigerators with HFC-134a. No other F-gases have been used.

The emission factors are presented in the Table 4.6.2. Product lifetime is considered to be 15 years and emissions from disposal have been calculated since 2008.

### Commercial and industrial refrigeration:

Only one plant in Slovenia had produced commercial and industrial refrigerators with HFC-134a until 2009, when it was closed.

The amount of refrigerant used was estimated in the study (Chamber of commerce, 1999) and we have used projections from this study to determine the amount for Standalone commercial appliances, while the amount in Medium and large commercial and Industrial refrigerators have been taken from the database. In addition to HFC-134a, the following blends have been used: R-402a, R-404a, R-407a, R-407c, and R-410a.

The emission factors are presented in the Table 4.6.2. Product lifetime is considered to be 12 years for small, 10 years for medium and large appliances, and 25 years for industrial refrigeration. The disposal emissions have been included in the inventory since 2007.

### Transport refrigeration

The amount of refrigerant used was estimated using the official database of registered vehicles. The number of trucks and trailers with the cooling unit has been divided into 3 groups according to the size: small – less than 3.5 t, medium – between 3.5 and 10 t, and large – more than 10 t. The amount of refrigerant in each type of vehicle has been taken from the 2006 IPCC Guidelines, Vol. 3, Table 7.9. For small trucks and trailers the lower value from the range (3 kg) has been used, for large the highest value 8 kg and for middle the average value 5.5 kg of refrigerant. The operation emissions have been calculated using emission factor of 30%. In Slovenia in the transport refrigerators only HFC 134a and HFC 404a have been used. No data are available on share of each F-gas for this reason we have assumed that half of the amount is R134a and half is R404a.

We also don't know how fast the ODS have been replaced with F-gases. For the inventory purpose we have assumed that no F-gases were in these vehicles in 1994.

For the 2017 submission, the GHG emission estimates have been improved using precise data on registered vehicles since 2005. According to the database on registered vehicles from 100 to 150 trucks and trailers with the cooling unit have been yearly deleted from the database in the recent period. According to our evidence, these vehicles have not been disposed in Slovenia but were sold abroad – mostly to the former Yugoslavian republic. In Slovenia there is no centre for decommissioning of spent trucks and buses.

#### Residential and commercial A/C and heat pump:

There is almost no production of air conditioners in Slovenia; their sale on Slovenian market is almost equal to their import. For a long time, only HCFC-22 was used. The import of air conditioners with HFC began in 2000.

The amount in A/C and heat pumps has been taken from the F-gases database. Although some AC equipment is already filled with refrigerants when imported, many of them are filled during installation. For this reason we have assumed that all amounts of F-gases have been filled in Slovenia. We have also included estimates on the amount of F-gases in small home AC appliances. In addition to HFC-134a, the following blends have been used: R-404a, R-407a, R-407c, R-410a, R-417a, and R-507a.

The emission factors are presented in the Table 4.6.2. Product lifetime is considered to be 15 years and emissions from disposal have not been calculated yet.

#### Mobile AC

Air conditioning systems in motor vehicles are filled with refrigerant at the moment of their installation into a vehicle. Car air conditioners are usually installed during vehicle assembly, although retrofitting is possible. HFC-134a began to be used in Slovenia in 1994, but some imported vehicles have been equipped with such air conditioners already since 1991. In the production of buses, HFC-134a began to be used in 1996.

There is one car producer in Slovenia and data on the amount filled in the new cars have been obtained from a personal contact with the producer.

Activity data for HFC stocks in MAC was annually estimated from the amount of HFC in new cars equipped with air-conditioning, the amount of HFC in operating systems and the amount of HFC in disposed cars. The data were obtained from the official database of registered vehicles. Product lifetime is considered to be 12 years

Product life factor (EF) was estimated in accordance with directive 2006/40/EC of the European parliament and of the council relating to emissions from air-conditioning systems in motor vehicles. The directive states that MAC value of 20% is appropriate for countries with no recovery and recycling program, and 10% for the countries with such program. Slovenia started to implement that directive in 2006. 20% for MAC system emission rate was

applied until 2006 due to the absence of such program. After implementation of the directive, gradually a recovery and recycling program have been introduced. We assumed 1 per cent lower emissions in 2006 and the same decrease for every year afterwards. The 13% for the year 2012 has been chosen according to that assumption. We assumed that a certain adaptation period is needed for the total implementation of recycling program. An annual decrease of 1 per cent in the EF is our conservative assumption, since we have been informed that mechanical workshops intensively carry out that recycling program. The directive is available on the link:

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:161:0012:0018:EN:PDF>

On Table 4.6.2 comparison of EFs and other parameters used by Slovenia (upper line) with the range from 2006 IPCC Guidelines is presented. The emission factors for all categories except mobile AC have been taken from a research made by The Chamber of commerce and industry of Slovenia in 1999. The experts have chosen the emission factors according to their own experiences and according to some suggestions from IPCC Guidelines.

**Table 4.6.2: HFC emissions, emission factors and other parameters used in refrigeration and air conditioning appliances for 2016 and comparison with EF 2006 Guideline (Table 7.9).**

	EF Production (%)	EF Use (%)	Lifetimes (years)	Recovery (%)	Charge (%)	HFC emissions (Gg CO <sub>2</sub> eq)
<b>Domestic refrigeration</b> Range from 2006 IPCC GL	1 0.2 - 1	0.5 0.1 - 0.5	15 12 - 20	70 0 - 70	85 0 - 80	2.8
<b>Commercial refrigeration</b> Stand alone Range from 2006 IPCC GL	3 0.5 - 3	8 1 - 15	12 10 - 15	70 0 - 70	40 0 - 80	127.7
Medium and large Range from 2006 IPCC GL	3 0.5 - 3	22.5 10 - 35	10 7 - 15	70 0 - 70	75 50 - 100	
<b>Industrial refrigeration</b> Range from 2006 IPCC GL	3 0.5 - 3	16 7 - 25	25 15 - 30	NO 0 - 90	NO 50 - 100	64.6
<b>Transport refrigeration</b> Range from 2006 IPCC GL	NO 0.1 - 1	30 15 - 50	NA 6 - 9	NO 0 - 70	NO 0 - 50	18.7
<b>Stationary Air Conditioning</b> Range from 2006 IPCC GL	0.6 0.2 - 1	1 - 10 1 - 10	15 10 - 20	NO 0 - 80	NO 0 - 80	33.0
<b>Mobile Air Conditioning</b> Range from 2006 IPCC GL	0.5 0.5	11.2 10 - 20	12 9 - 16	50 0 - 50	25 0 - 50	99.1

Recovery of F-refrigerants is mandatory under the EU F-gas Regulation No. 517/2014 and there are measures in place to increase recovery; however data on recovered amounts are not available by subcategories. For this reason we have used an approach which was agreed among EU members (default approach):

Recovery = amounts remaining in products at decommissioning – disposal emissions

## **2.F.2 Foam Blowing**

### Hard Foam

There is very few information about the use of F-gases in the past. For production of insulating foams for refrigerators only one plant had used HFC-134a until 1996, when it was replaced by cyclopentane. Emissions of HFC in the manufacturing of insulating foam for household refrigerating/freezing appliances amount to 3 to 5 %, for the calculations we have used an average value of 4%. Data about HFC in hard foam from the period 1993-1995 are available and default value of 4.5 % has been used to determine annual losses, as suggested from the 2006 IPCC GL, Vol. 3, Table 7.5.

Many plants have produced one-component PU foam but all products with HFC have been exported. Emissions during the production of polyurethane assembly foams amount to 1%. HFC performs the function of propellant and blowing agent. Part of HFC is emitted during application of the product, for instance during installation of windows or doors, within a year, but a part of HFC remains in the foam and is probably slowly released during the following 20-25 years. Considering the fact that this product is entirely destined for export, there are no emissions from application of the product on the domestic market and emissions arise in the importing countries.

Since 2007, the use of F-gases for PU OCF has been prohibited by the EU legislation. There is no other evidence that F-gases have been used for hard foam blowing in Slovenia. For production of PU, XPS and EPS hard foams, CO<sub>2</sub> and pentane have been used as blowing agents, while flammable hydrocarbons (propane, butane...) have been used for PU OCF.

### Soft Foam

In the production of soft foam the total amount of HFC is emitted during the production (EF is 100%) and therefore no emissions occur during their use and disposal. The only production of soft foam with HFC in Slovenia was the production of polyurethane (PU) shoe soles until 1998 and HFC-134a was used for this purpose.

### 2.F.3 Fire extinguishers

The evidence of F-gases used in fire extinguishers in our database is incomplete, because not all enterprises are aware of this reporting obligation. Generally used fire extinguishing agents include dust, CO<sub>2</sub>, or water. Halon systems were replaced by HFC.

Data about HFC used as a replacement for CFC was collected for the research made in 1999 (Chamber of Commerce, 1999). In this research it was assumed that 400 kg of HFC would be used per year. According to The operation plan of the Republic of Slovenia for management of Halon, 5800 kg of CFC still existed in fire extinguishers in 2002. According to the plan, the total amount was replaced with substitutes until the end of 2005. Due to the lack of detailed data we have assumed that all CFC was replaced with HFC, which is probably an overestimation. Since 2005, 100 kg of HFC is assumed to be used every year for new installations. In Slovenia, only use of HFC-227ea has been detected.

In calculating emissions of HFC, IPCC methodology and the therein-stated assumption that emissions amount to 35% of the quantities used in new stationary systems were applied. This assumption is derived from experience with the use of Halon systems and is supposed to be appropriate also for estimating HFC emissions. The EF from the 1<sup>st</sup> filling has decreased from 35% as it was estimated in 1997 to 2% in 2009 due to the rigorous legislation and high prices of F-gases and settled on 2% since then. We have used product emission factor of 5%.

For 2016 emissions data from service companies has been used. It is the first time for this sub-category. For this reason a sharp decline in IEF is observed from 2015 to 2016 from default 5% to observed 2.3%. When data for more year would be available, we will improve the EF used for the past.

### 2.F.4 Aerosols/Metered Dose inhalers

Slovenia began to use HFC-134a in the MDI in 2003 as replacement for the CFC. Due to the lack of country specific data we have used Austrian data about amount of HFC-134a in MDI divided by 4, which is the ratio between Austrian and Slovenian population (8 Mi and 2 Mi respectively). Austrian data have been chosen from a cluster of neighbouring countries because of the high quality of the Austrian inventory, which is complete and very transparent.

Since 2011, the national data on medical equipment with HFC-134a sold in Slovenia have been obtained. A comparison of emissions calculated from national data with those calculated from Austrian inventory for 2011 and 2012 shows that emissions from national data are slightly lower than emissions from the Austrian inventory. In 2011, the difference was -9.3% and in 2012 it was -4.8%. Due to the absence of national data we believe that using Austrian data for the period 2003 to 2010 is the best available method which gives reliable and conservative emission estimates.

### 4.6.3 Uncertainties and time-series consistency

The uncertainty estimates are based on an expert judgement and presented in the table 4.6.3 below.

**Table 4.6.3: Uncertainties in %.**

Category	AD	EF	Combined uncertainty
1. Refrigeration and Air Conditioning Equipment	50	50	70.7
2. Foam Blowing	10	50	51.0
3. Fire Extinguishers	50	50	70.7
4. Aerosols/MDI	100	0	100

### 4.6.4 Source-specific QA/QC and verification

After applying the standard QC procedure data, EFs and emissions have been undergoing the following QA/QC procedures:

- all EFs have been compared with the EFs from 2006 IPCC Guidance;
- values of stock have been compared with the data from neighbouring countries;
- emissions from every CRF category have been compared with the emissions from neighbouring countries

### 4.6.5 Category-specific recalculations

The emissions of F-gases have been recalculated for the year 2014 and 2015 due to the improved data on amount of HFC 134a in MDI.

### 4.6.6 Source-specific planned improvements

Slovenian F-gases database has not been completed yet. Every year, new devices are included and the amount of F-gases in stock is increasing. For this reason, data on stock will be updated regularly and, if needed, recalculation of emissions will be performed. This can be regarded as an ongoing process and will probably lead to an improvement of the inventory.

## 4.7 Other Product Manufacture and Use (CRF 2.G)

### 4.7.1 Electrical equipment (CRF 2.G.1)

#### 4.7.1.1 Category description

SF<sub>6</sub> is mostly used as an insulating agent and fire-extinguishing agent in electrical installations, in middle voltage and high voltage (110 kV and 400 kV) gas insulated switchgear and circuit breakers (HV equipment). SF<sub>6</sub> insulated switchgear and circuit breakers were first used in Slovenia in 1976. A general increasing trend can be observed, and particularly since 1993, the use of equipment with SF<sub>6</sub> as insulating gas has increased strongly (Table 4.7.1). This type of equipment is not produced in Slovenia and there is no export of SF<sub>6</sub> in equipment.

**Table 4.7.1: SF<sub>6</sub> emissions in high-voltage equipment.**

Emissions from	Units	1986	1990	1995	2000	2005	2010	2015	2016
manufacturing	kg	0.1	0.0	0.9	1.4	2.6	2.3	1.2	0.2
stock	kg	428.4	431.1	481.2	657.1	786.7	786.5	765.8	764.4
disposal	kg	-	-	-	-	-	-	0.3	0.2
<b>Total SF<sub>6</sub> emissions</b>	<b>kg</b>	<b>428.5</b>	<b>431.1</b>	<b>482.1</b>	<b>658.5</b>	<b>789.3</b>	<b>788.9</b>	<b>767.2</b>	<b>764.7</b>
<b>Total SF<sub>6</sub> emissions</b>	<b>Gg CO<sub>2</sub> eq</b>	<b>9.8</b>	<b>9.8</b>	<b>11.0</b>	<b>15.0</b>	<b>18.0</b>	<b>18.0</b>	<b>17.5</b>	<b>17.4</b>

#### 4.7.1.2 Methodological issues

Emissions have been calculated according to Tier 3 methodology from 2006 IPCC GL, where  $\text{Total Emissions} = \sum E_{\text{manufacturing},t} + \sum E_{\text{installation},t} + \sum E_{\text{use},t} + \sum E_{\text{recycling},t}$

Manufacturing emissions do not exist in Slovenia.

The equipment installation emissions have been estimated by subtracting the nameplate capacity of all new equipment filled from the actual amount of SF<sub>6</sub> used to fill new equipment.

The equipment use emissions are determined by the amount of SF<sub>6</sub> used to service equipment. SF<sub>6</sub> which has been recovered from equipment before servicing and returned after servicing is not included in the estimate.

The amount of SF<sub>6</sub> in the disposed equipment is determined by multiplying the nameplate capacity of disposed equipment by fraction of charge remaining at retirement. The default fraction for Europe has been taken from 2006 IPCC Guidance, Vol. 3, Ch. 8, from Table 8.2. for MV switchgear (0.93) or from Table 8.3. for HV switchgear (0.95). According to the expert judgement the SF<sub>6</sub> is fully recovered from the retiring equipment and it is their estimate that a leakage is less than 0.1%.

In 2006, a research covering all high-voltage equipment in Slovenia was done by The Milan Vidmar Electric Power Institute, Ljubljana. Estimation of SF<sub>6</sub> emissions for the period 1986-2005 was performed. All the activity data and emissions for 1996-2005 have been taken from this research while since 2009 they have been taken from the F-gases database (see chapter 4.6.1). Data for the period 2006-2008 have been interpolated.

#### **4.7.1.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 20%.

The uncertainty of the emission factor amounts to 10%.

#### **4.7.1.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

#### **4.7.1.5 Category-specific recalculations**

The emissions of SF<sub>6</sub> have been recalculated for the period 2011-2015 due to the use of updated values from the database.

#### **4.7.1.6 Source-specific planned improvements**

No improvements are planned for the next submission.

### **4.7.2 SF<sub>6</sub> and PFCs from other product use (CRF 2.G.2)**

#### **4.7.2.1 Category description**

In the period 1995-1997 the production of double-glazed sound-proof windows had occurred in Slovenia. All windows had been exported, thus no emissions from stock occurred. Since 1997 there has been no use of SF<sub>6</sub> for soundproof windows in Slovenia. According to the Regulation on certain fluorinated greenhouse gases, placing of double glazed windows filled with SF<sub>6</sub> on the market has also been prohibited in EU countries since 4 July 2007. (Regulation (EC) No 842/2006, Article 9 and Annex II.

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:161:0001:0011:EN:PDF>

#### **4.7.2.2 Methodological issues**

The amount of SF<sub>6</sub> in the sound-proof windows have been estimated by the research project carried out by the Chamber of Commerce and Industry of Slovenia in 1999. For the emissions calculation the EF of 10% has been used.



**4.7.2.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 20%.

The uncertainty of the emission factor amounts to 10%.

**4.7.2.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

**4.7.2.5 Category-specific recalculations**

No recalculations have been performed for this category.

**4.7.2.6 Source-specific planned improvements**

No improvements are planned for the next submission.

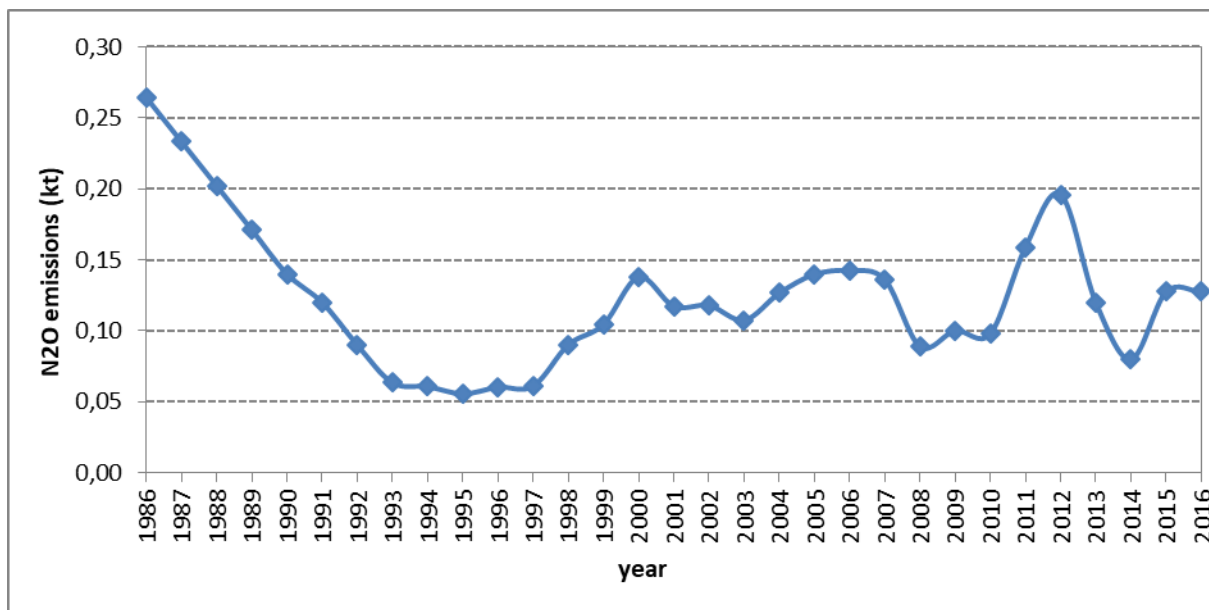
**4.7.3 N<sub>2</sub>O from Product Uses (CRF 2.G.3)****4.7.3.1 Category description**

Evaporative emissions of nitrous oxide (N<sub>2</sub>O) can arise from various types of product use. Medical applications and use as a propellant in aerosol products, primarily in food industry are likely to be dominant sources. All emissions from this category are reported under CRF code 2G3a: N<sub>2</sub>O from Medical Applications, since the largest application of N<sub>2</sub>O in Slovenia arising from the use in health service.

N<sub>2</sub>O emissions from CRF code 2G3b: Other are reported as IE. CRF code 2G3b covers the use of N<sub>2</sub>O as a propellant in aerosol products in food industry. The emissions from that category are included under CRF code 2G3a.

**4.7.3.2 Methodological issues**

N<sub>2</sub>O emissions have been estimated for the period 1986-2016. N<sub>2</sub>O emissions have been calculated from the amount of nitrous oxide used. Data on N<sub>2</sub>O consumption for the period 1999-2016 have been obtained from SORS. Activity data for the year 1986 and the period 1993-1998 have been provided in the scope of research project done by the Chamber of Commerce and Industry of Slovenia. Activity data for the period 1987-1992 was estimated by nearest-neighbour interpolation method. 2006 IPCC emission factor of 1.0 t N<sub>2</sub>O /t have been used for the emission calculations. Figure 4.7.1 shows N<sub>2</sub>O emissions arising product uses.



**Figure 4.7.1: N<sub>2</sub>O emissions from product uses.**

#### **4.7.3.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.

The uncertainty of the activity data amounts to 20%.

The uncertainty of the emission factor amounts to 10%.

#### **4.7.3.4 Category-specific QA/QC and verification**

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

#### **4.7.3.5 Category-specific recalculations**

Emissions of N<sub>2</sub>O have been recalculated for the year 2015 due to new activity data obtained.

#### **4.7.3.6 Category-specific planned improvements**

No improvements are planned for this category.

## 5 AGRICULTURE (CRF sector 3)

### 5.1 Overview of sector

In agricultural activities, emissions of GHGs are generated from a variety of different sources. This section includes the quantification of CH<sub>4</sub> emissions from livestock and manure management, N<sub>2</sub>O emissions from manure management (direct and indirect emissions) and from managed agricultural soils (direct and indirect emissions) as well as CO<sub>2</sub> emissions from limestone and urea application.

Burning crop residues is not practiced in Slovenia and is prohibited by a law since 2005, therefore emissions of greenhouse gases from this source have not been considered in this report. There are no ecosystems in Slovenia that are considered natural savannahs or rice fields; consequently, no greenhouse gas emissions exist for these subcategories.

Identification of the Key categories as well as methods and EFs used are in the table 5.1.1.

**Table 5.1.1: Methods, EFs used and key categories indications for the year 2016 in the Agriculture sector.**

	CO <sub>2</sub>			CH <sub>4</sub>			N <sub>2</sub> O		
	Method	EF	Key category	Method	EF	Key category	Method	EF	Key category
3.A Enteric Fermentation	NA	NA	NA	T1, T2	CS, D	L, T	NA	NA	NA
3.B Manure Management	NA	NA	NA	T1, T2	CS, D	L, T	T1, T2	CS, D	L, T
3.D.1 Direct Emissions	NA	NA	NA	NA	NA	NA	T1	D	L
3.D.2 Indirect Emissions	NA	NA	NA	NA	NA	NA	T1	D	L
3.G Liming	T1	D	-	NA	NA	NA	NA	NA	NA
3.H Urea application	T1	D	-	NA	NA	NA	NA	NA	NA

In Agriculture as the second most important sector, emissions in 2016 amounted to 1,777 Gg CO<sub>2</sub> eq, which represents 10.4% of all GHG emissions w/o LULUCF. Agriculture represents the main source of methane and N<sub>2</sub>O emissions, namely 56.4% of all methane emissions and 70.0% of all N<sub>2</sub>O emissions. In the agricultural sector in 2016, CH<sub>4</sub> emissions accounted for 68.1% and N<sub>2</sub>O emissions accounted for 30.8 % while CO<sub>2</sub> emissions represented only 1.2% of emissions in this sector. GHG emissions from agriculture show small oscillations for individual years, but the general trend is decreasing. In 2016, emissions were 11.8% below the base year emissions. The most important sub-sector represents emissions from enteric fermentation, which contributes 53.5% of all emissions from agriculture, followed by emissions from agricultural soils, with 25.1%; the rest is contributed by emissions of methane and N<sub>2</sub>O from animal manure (20.3%) while CO<sub>2</sub> emissions due to the liming and urea applications represent only 1.2% of emissions in this sector.

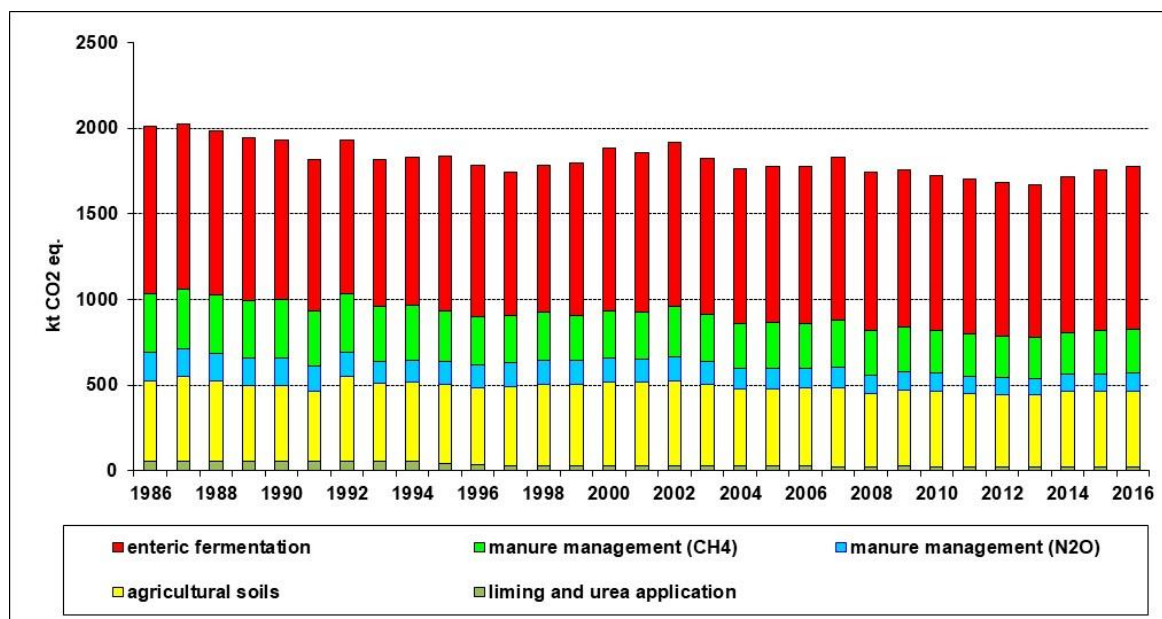


Figure 5.1.1: CH<sub>4</sub> and N<sub>2</sub>O emissions from agriculture activities in Gg CO<sub>2</sub> eq.

## 5.2 Enteric Fermentation (CRF 3.A)

### 5.2.1 Category description

CH<sub>4</sub> emissions from enteric fermentation in animals result from methane being produced as a by-product of microbial fermentation in the digestive system. This process occurs especially in the rumen of ruminant animals, but also in smaller quantities in monogastric animals (swine, horses, ...) where feedstuffs ferment in the large intestine. The estimates in this inventory comprise only emissions in farm animals. Emissions from wild animals and semi-domesticated game are not quantified and neither are emissions from humans or pet animals.

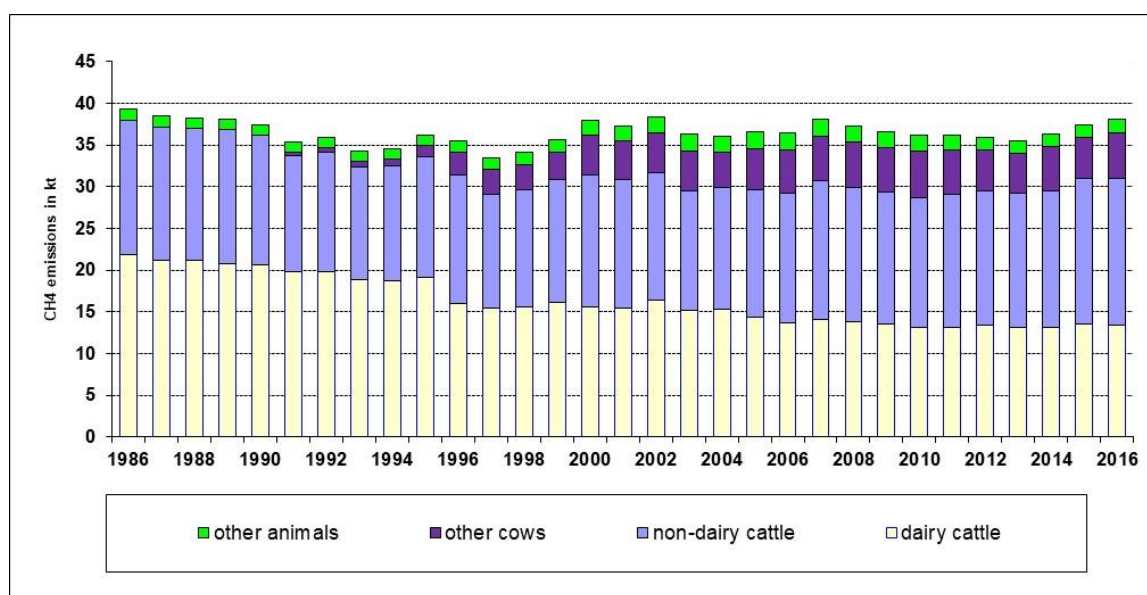


Figure 5.2.1: CH<sub>4</sub> emissions from enteric fermentation in Gg.

CH<sub>4</sub> emission from enteric fermentation is a key source, both by level and trend. Dairy cows and non-dairy cattle (including other cows) are significant sources: dairy cows represent 36.4% of total CH<sub>4</sub> emissions from enteric fermentation, other cows 13.2%, while non-dairy cattle represent about 46.3% of total CH<sub>4</sub> from enteric fermentation. Jointly, cattle are responsible for almost 96% of total CH<sub>4</sub> emissions from enteric fermentation (Figure 5.2.1).

The contribution of all other animals to methane emissions from enteric fermentation, e.g. sheep, swine, horses, and goats, listed here according to the importance of their contribution, is a little more than 4%. No methodology for calculating CH<sub>4</sub> emission from poultry is available in IPCC guidelines, for this reason emissions are not calculated and notation key NE is used.

### 5.2.2 Methodological issues

The methodology suggested by IPCC (2006) was used to assess the of CH<sub>4</sub> emissions from enteric fermentation.

The majority of activity data were obtained from the Statistical Office of the Republic of Slovenia (SORS). They are also available on the web page: <http://www.stat.si/eng/index.asp>

The agriculture statistics is on the SI-STAT data portal, under Environment and natural resources: <http://pxweb.stat.si/pxweb/Database/Environment/Environment.asp>

Some pieces of information, such as number of calves per cow and year, concentration of fat in milk for the period before the year 2000 and average daily gains in fattening cattle, were obtained from Central database CATTLE, managed by Agricultural Institute of Slovenia (reported by Božič et al., 2009 or calculated on request).

**Table 5.2.1: The correspondence between statistical and IPCC categories**

IPCC	SORS
Dairy cattle	Dairy cows over 2 years
Other cows (suckler-cows)	Other cows over 2 years
Non-dairy cattle	All other cattle
Non-dairy cattle	<p><b>YOUNG CATTLE – under 1 year</b>  calves for slaughter- young bulls  calves for slaughter - young heifers  calves for fattening - young bulls  calves for fattening - young heifers</p> <p><b>YOUNG CATTLE – 1 -2 years</b>  breeding heifers in calf  other breeding heifers  heifers for fattening  bulls, oxen</p> <p><b>CATTLE – over 2 years</b>  breeding heifers in calf  other breeding heifers  heifers for fattening  bulls for breeding  bulls and oxen for fattening</p>

In the category dairy cattle, only dairy cows have been included. Other cows (suckler cows) were treated differently due to the production of milk for calf. Non-dairy cattle consists of all other cattle groups. The correspondence between statistical and IPCC categories are evident from the table 5.2.1 above.

**Before 1997**, SORS collected data on the number of livestock by ownership and as of December 31. Data on livestock in agricultural enterprises were collected and reported in the Annual Report on Livestock Production, while data on livestock on family farms were collected in the Sample Survey on the Number of Livestock. Data on the number of livestock on family farms as of December 31, 1991 were estimated on the basis of the 1991 Census of Population, Households, Housing, and Agricultural Holdings. Some data on the number of livestock were taken from other administrative sources (Secretariat for Agriculture, Forestry and Food).

**In 1997**, SORS started collecting data on the number of livestock several times a year: data on the number of pigs were collected three times a year (April 1, August 1, and December 1), data on cattle twice a year (June 1 and December 1) and data on sheep and goats once a year (December 1). Data on family farms and agricultural enterprises were collected by

mail, separately for cattle, pigs, sheep, and goats. All agricultural enterprises were covered, but only those family farms that were selected in the sample. In 1997, the date of monitoring the number of animals changed: because of the harmonisation with EU standards, we no longer collect these data as of December 31, but as of December 1. Data on animal output up to 1997 are therefore not entirely comparable with data since 1997.

Since 2000, SORS has been collecting data on the number of livestock twice a year (June 1 and December 1) for cattle and pigs, and once a year (December 1) for sheep and goats, and poultry. To facilitate presentation of data on the structure of agricultural holdings, the number of animals is shown by where they are stabled and not by ownership as was the case until 2000. In the December 2002 survey, the data on the number of animals were collected with fieldwork and not by mail; this accounts for some differences between the individual periods.

In 2003, SORS published revised data on livestock numbers and production for the period 1991-2002. These data were published in Rapid Reports No. 256. The main purpose of this revision was the methodological harmonisation of data and methods of estimating data for the mentioned period. This methodology is harmonised with recommendations of the Statistical Office of the European Communities. Corrections refer to livestock number and production, while the data on total number of animals did not change. Not all published data were revised. Some remained the same. Explanations of corrections are therefore valid only for the revised data. Data were revised on the basis of the 2000 Census of Agriculture.

The explanations of corrections were divided into two parts: number of livestock and livestock production. Data on cattle, pigs, poultry, sheep and goats were mostly revised in the same way. Differences appear due to particularities of the individual species, the previous method of data collection for individual species of domestic animals and the quality of collected data.

In all monitored years, data on the total number of animals were obtained with statistical surveys and have not been corrected, but changes have been made to the year that the data refer to. Before 1997, each year data about animal population were collected on December 31 and in the past they were applied for the next year, but now SORS considers these data to be valid for the current year. Because SORS did this only for data from 1991 (the year Slovenia became an independent state), we have to change all data prior to 1991 in the same way by ourselves.

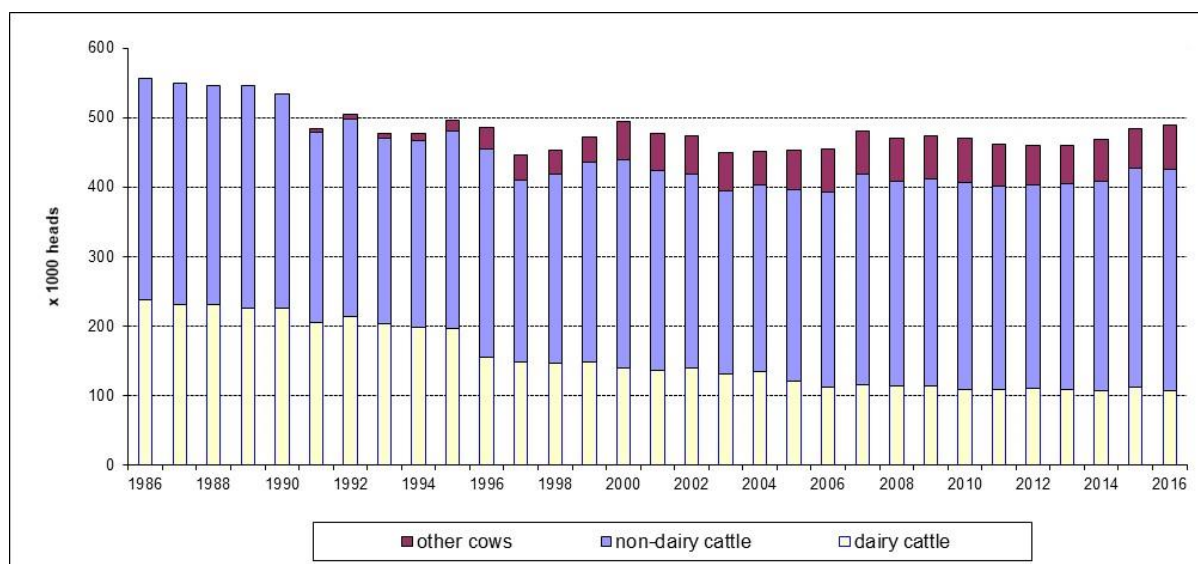
But discrepancies with FAO data still exist. In the FAO database, livestock numbers have been grouped in 12-month periods, ending on September 30 of the year stated in the tables. SORS collects data on animal population in December and reports them in the current year. In the FAO database, these data are applied for the next year. Considering this explanation, all data on animals in the FAO database and in our statistical database are the same. The only difference is in the number of poultry, where our entire poultry population is shown in the FAO database as chicken population.

2006 IPCC methodology provides two different methods for estimating the quantity of methane from enteric fermentation. A more detailed method (Tier 2) for calculating emissions is used for cattle because of the comparatively large population and considerable emission per head and the default methodology (Tier 1) is used for other animals.

### 5.2.2.1 Cattle (CRF 3.A.1)

#### Dairy cattle

The method for estimation of emissions due to enteric fermentation is based on data on dairy cow population (Figure 5.2.2) and their performance expressed in terms of milk production per year (Figure 5.2.3), milk composition, pregnancy rate and activity (grazing). IPCC (2006) methodology was used taking into account the local production practices.



**Figure 5.2.2: Number of cattle, dairy, non-dairy, and other cows in thousands.**

In the first step, net energy requirements for the maintenance ( $NE_m$ ), activity ( $NE_a$ ), milk production ( $NE_l$ ) and pregnancy ( $NE_p$ ) were estimated. Maintenance requirements were calculated on the basis of animal weight. It was supposed that animals producing more milk were heavier than those producing less milk. The relation  $W = 418.8 + 0.0313 \times M$  was used for the estimation of body weight ( $W$ , in kg).  $M$  in the equation is milk production in standard lactation (kg in 305 days). In case of grazing, additional energy required for animals to obtain their food was added up ( $NE_a$ , 17 % of maintenance requirements). Coefficient which was used to calculate the net energy required for maintenance was increased by 20% in case of cows in lactation (i.e.  $0.386 \text{ MJ d}^{-1} \text{ kg}^{-1}$ , IPCC, 2006). Requirements for milk production were estimated on the basis of milk production and milk fat content. Requirements for pregnancy were calculated on the basis of cow weight and constant (10 % of maintenance requirements) according to IPCC (2006). In order to express the requirements for pregnancy on a yearly basis (365 days) the obtained values were multiplied by the number of calves per cow and year.

In the second step, the gross energy intake was estimated on the basis of net energy requirements that were estimated during the first step. To do this, the information on the concentration of net energy for lactation in diets is needed. It is the most critical point of the whole procedure. Overestimation of the net energy concentration in the diet would result in underestimation of gross energy intake and vice versa. It may considerably affect the final result. The concentration of the net energy for lactation depends mainly on its concentration in the basal diet and on the proportion of concentrates in the diet. The latter depends largely



on daily milk production and intake capacity of a dairy cow. Therefore, it was decided to use country-specific data at this stage. Based on data from milk recording (the monitoring service performs monthly measurements of the milk yield of every individual cow) a total of 705.860 lactation curves were calculated for the period between January 1, 2000 and June 1, 2009. On the basis of the results, typical lactation curves for the range between 3500 and 12000 kg of milk in standard lactation were calculated for the intervals of 500 kg. Expected daily milk yields (for each individual day in lactation) were calculated for all these classes.

Based on daily milk yields and assumed concentrations of net energy for lactation in basal diet, the required proportions of concentrates in diets were estimated roughly. The equation for total mixed ratios presented by Spiekers (2004) was used. The rough estimates of the amount of concentrates in the diets enabled the use of more precise equation for prediction of dry matter intake (Gruber et al., 2006). Various parameters, such as breed, day of lactation, body weight, daily milk production in dependence on day of lactation, amount of concentrates, and concentration of net energy for lactation in the basal diet were used to predict dry matter intake for each individual day within each individual production class.

On the basis of forage quality in Slovenia it was estimated that with the increasing milk yield from 3500 to 8000 kg per standard lactation the concentration of net energy for lactation in the basal diet increased from 5.4 to 6.4 MJ per kg dry matter and remained on the same level at higher milk yields. It was also assumed that with increasing milk yields the concentrations of net energy for lactation in concentrates increased from 7.6 to 8.2 MJ per kg of dry matter. The concentration of net energy for lactation in the diet was calculated as a quotient between the animal requirements for maintenance, milk production and pregnancy on the one hand and potential dry matter intake on another. National feeding standards (Verbič and Babnik, 1999) were used to assess the requirements. The average concentration of net energy for lactation in the diet was obtained by averaging the daily values over the whole lactation and dry period. Information on the concentration of net energy for lactation was then transformed to organic matter digestibility (dOM) by the use of equation

$$dOM = 24.12 + \text{net energy for lactation} \times 7.9.$$

The equation was derived on the basis of wide range of forages, cereals and oil seed meals presented in DLG Feeding Tables (DLG, 1997). Energy digestibility (DE%) was estimated as

$$DE\% = dOM - 3.1.$$

The relation was obtained on the basis of equations presented by INRA (1989,) taking into account that diets are composed of grassland forages, maize silage and cereals. Finally, the gross energy intake (GE) was calculated as:

$$GE = \frac{\frac{NE_m + NE_a + NE_l + NE_p}{REM}}{\frac{DE\%}{100}}.$$

The ratio of net energy available for maintenance to digestible energy (REM) was calculated as suggested by IPCC (2006).

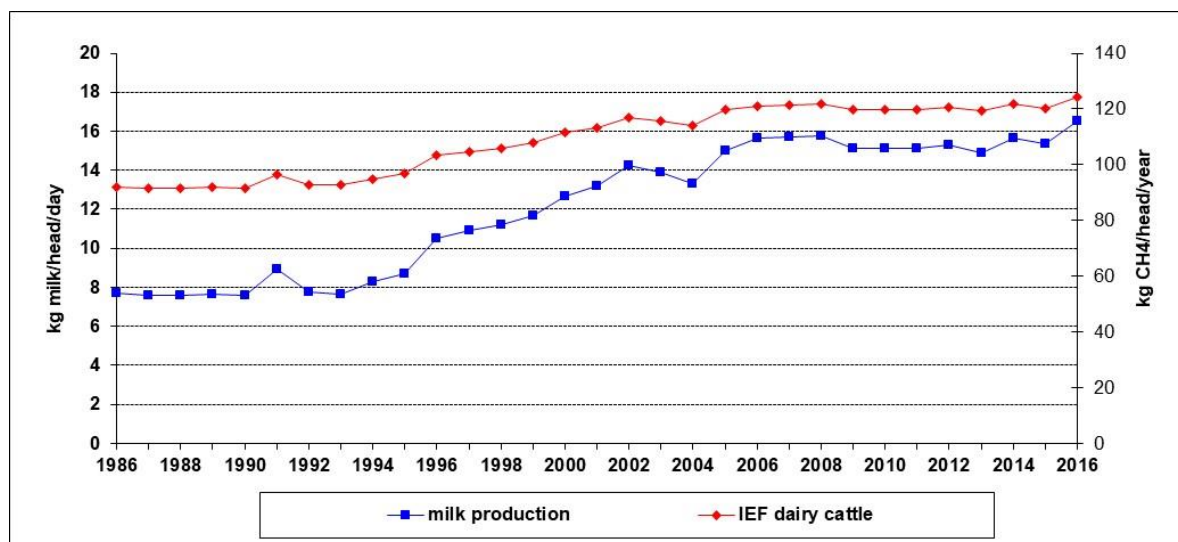
Emission factor was calculated from data on gross energy intake (GE) and methane conversion rate ( $Y_m$ ) according to IPCC (2006):

$$\text{Emissions (kg/animal/year)} = \text{GE (MJ/year)} \times Y_m \div 55.65 \text{ MJ/kg of methane}$$

For methane conversion rate ( $Y_m$ ) the value of 0.065 was used, as recommended by IPCC (2006). EFs and milk yield are presented on the table 5.2.2.

**Table 5.2.2: Milk yield and EFs for dairy cattle in kg/head/year.**

	1986	1987	1988	1989	1990	1991	1992	1993	1994
Milk yield	2818	2763	2770	2796	2774	3252	2836	2800	3015
EF	92.1	91.6	91.7	91.9	91.7	96.5	92.8	92.7	95.0
	1995	1996	1997	1998	1999	2000	2001	2002	2003
Milk yield	3168	3833	3975	4092	4252	4625	4807	5198	5063
EF	96.7	103.2	104.8	106.0	107.8	111.5	113.4	117.0	115.8
	2004	2005	2006	2007	2008	2009	2010	2011	2012
Milk yield	4855	5479	5709	5727	5763	5530	5519	5515	5592
EF	113.9	119.6	121.1	121.5	122.0	119.8	119.8	119.8	120.7
	2013	2014	2015	2016					
Milk yield	5435	5716	5598	6024					
EF	119.4	121.8	120.3	124.2					



**Figure 5.2.3: Milk production per cow in kg milk/head/day and IEF in kg CH4/head/year.**

Emission factor for methane released from enteric fermentation depends mainly on the level of milk production. By the increase of annual milk production from 3000 to 6000 kg of milk per cow, the emissions increase from about 95 to 124 kg of methane per year. Average milk production per cow was more than doubled during the period 1986 – 2016. The increase was mainly due to transition to open market economy and was accompanied by specialization of

dairy sector. The proportion of concentrates in the diets for dairy cows increased and dual purpose Simmental and Brown Swiss cows were in part replaced by cows of specialized Holstein-Frisian breed.

The increase in IEF for dairy cattle is due to the increase in the milk yield. In 2016, the CS EF was comparable (124.2 kg/head/year) to IPCC EF for dairy cattle for Western Europe (117 kg/head/year) and considerably higher than default EF for Eastern Europe (99 kg/head/year). Since agriculture sector in Slovenia is more similar to the systems in the countries from West Europe, the CS EF seems reasonable.

### **Other cows**

This category appeared after 1990. SORS differentiates between dairy cows and suckler-cows from the year 1996; the figure for the year 1995 is based on the number of premiums paid for suckler-cows and for the years 1991-1994 the numbers were estimated by an expert (Volk, personal communication). Data on pregnancy rate was obtained from Agricultural Institute of Slovenia (CATTLE database). For suckler-cows it was considered that the amount of emitted methane was equal to the amount attributed to dairy cows with 3000 kg of milk per lactation. Due to variation in pregnancy rate CS EF varied from 86.1 to 86.8 kg per cow per year (table 5.2.3).

### **Non-dairy cattle**

This group comprises young cattle (cattle for fattening, heifers) and sires (breeding bulls). Data on the number of heads of non-dairy cattle according to different categories are reported by the SORS.

The method for estimation of emissions due to enteric fermentation is based on data on population and their performance expressed in terms of growth rate, pregnancy rate and activity (grazing). IPCC (2006) methodology was used taking into account the local production practices.

#### Young cattle (cattle for fattening, heifers)

Since in younger animals the rumen does not function normally yet, calves up to the age of 3 months were not considered. In calculating methane emissions, only  $\frac{3}{4}$  of young bovine animals up to 1 year were considered.

In the first step, net energy requirements for the maintenance ( $NE_m$ ), activity ( $NE_a$ ), growth ( $NE_g$ ) and pregnancy ( $NE_p$ ) were estimated. Maintenance requirements were calculated on the basis of the average animal weight. For heifers it was supposed that the final weight is 90 % of the weight which characteristic for dairy cows (see 5.2.2.1). For the fattening cattle the final weight of 650 kg was supposed. Average weight was calculated on the basis of expected final weight and expected weight at the age of 3 months. In case of grazing, additional energy required for animals to obtain their food was added up ( $NE_a$ , 17 % of maintenance requirements). Coefficient which was used to calculate the net energy required for maintenance of heifers was  $0.322 \text{ MJ d}^{-1} \text{ kg}^{-1}$  (IPCC, 2006). It was increased by 15% in case of intact males (i.e.  $0.335 \text{ MJ d}^{-1} \text{ kg}^{-1}$ , IPCC, 2006). Requirements for growth were estimated on the basis of information on growth rate, average body weight and specific body

weight of adult female. For the heifers the growth rate was calculated by dividing the difference between final and birth weight by the expected age at first calving (in days). For fattening cattle no exact data on daily gains existed for the period before 2005. There was official information (Statistical Yearbook) on total weight gain (country level) and number of various cattle categories for the year 1986. It has been assumed that the weight gain of growing heifers from their sixth month of age to first mating amounts to 600 g per day, and of pregnant heifers to 500 g per day. The remaining weight gain (according to the Statistical Yearbook) has been equally distributed across other growing categories of cattle and thus the average daily weight gain for young bovine animals for fattening has been assessed as 740 g per day. Since 2005, more precise average daily gains for young bovine animals for fattening have been obtained. They were calculated on the basis of data on slaughter date and carcass weight from slaughter houses and on the basis of birth dates of individual animals which were recorded in the Central database CATTLE (Verbič and Jeretina, 2009, unpublished). Average daily gains between 1986 and 2005 were estimated by interpolation. For the period 2005-2015, average daily gains on a yearly basis were used for calculations. Requirements for growth were calculated according to equation given by IPCC (2006), taken into account a specific coefficient  $C = 0,8$  for females and  $C = 1,2$  for males. In heifers, the requirements for pregnancy were calculated on the basis of adult cow weight and a constant value of 10 % of its maintenance requirements (IPCC, 2006). In order to express the requirements for pregnancy on a yearly basis (365 days) the obtained values were multiplied by the factor (365/age at first calving).

In the second step, the gross energy intake was estimated on the basis of net energy requirements that were estimated during the first step. To transform net energy requirements into gross energy, the estimated energy digestibility was needed. Equations to predict the energy digestibility for individual categories were estimated on the basis of national feeding standards (Verbič and Babnik, 1999) and the expected feed intake was estimated according to Kirchgeßner et al. (2008). In the first step the required concentrations of the metabolisable energy were assessed. In the second step they were converted into organic matter digestibility (dOM) by the use of equation:

$$dOM = 13.95 + \text{concentration of metabolisable energy} \times 5.74.$$

The equation was derived on the basis of wide range of forages, cereals and oil seed meals presented in DLG Feeding Tables (DLG, 1997). Then it was converted into energy digestibility (DE%) using the same conversion factor as described for dairy cattle. The following equations for predicting average energy digestibility (DE%) were derived on the basis of the above mentioned procedure:

$$\begin{array}{ll} \text{Cattle for fattening} & DE\% = 57.2 + 13.72 \times \text{daily weight gain (g)} \\ \text{Breeding heifers} & DE\% = 54.9 + 16.28 \times \text{daily weight gain (g)} \end{array}$$

Finally, the gross energy intake (GE) was calculated as:

$$GE = \frac{\frac{NE_m + NE_a + NE_p}{REM} + \frac{NE_g}{REG}}{\frac{DE\%}{100}}$$

The ratio of net energy available for maintenance to digestible energy (REM) and the ratio of net energy available for growth to digestible energy (REG) were calculated as suggested by IPCC (2006).

Emission factor was calculated from data on gross energy intake (GE) and methane conversion rate ( $Y_m$ ) according to IPCC (2006):

$$\text{Emissions (kg/animal/year)} = \text{GE (MJ/year)} \times Y_m \div 55.65 \text{ MJ/kg of methane}$$

For methane conversion rate ( $Y_m$ ) the value of 0.065 was used, as recommended by IPCC (2006).

#### Breeding bulls

Emissions for breeding bulls were estimated by the use of same principles as for young cattle. The body weight of 700 kg and no daily gain were taken into account. It was estimated that energy digestibility of the diet has to be 60.6%. The value was derived on the basis of requirements and expected dry matter intake as summarized by Kirchgeßner et al. (2008).

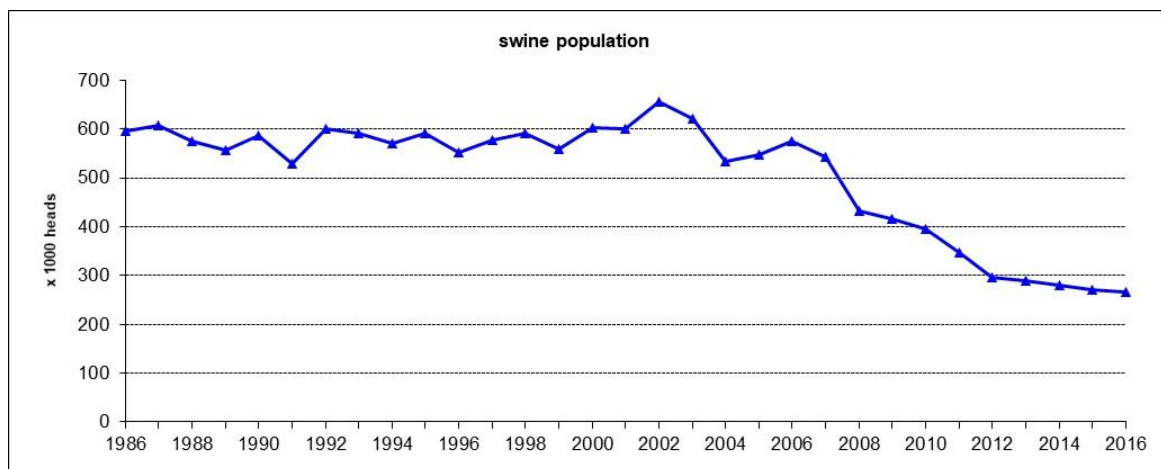
The country specific CH<sub>4</sub> EFs are presented on the table 5.2.3. All other data, which are not presented in the NIR, are available in the Annex 3 to the NIR and in the CRF tables.

**Table 5.2.3: EFs for non-dairy cattle and other cows in kg/head/year**

	1986	1987	1988	1989	1990	1991	1992	1993	1994
<b>Cattle for fattening</b>	57.2	57.3	57.4	57.6	57.7	57.8	58.0	58.1	58.3
<b>Heifers</b>	49.5	49.4	49.5	49.5	49.5	50.3	49.6	49.6	50.0
<b>Other cows</b>	NA	NA	NA	NA	NA	86.7	86.7	86.8	86.7
<b>Breeding bulls</b>	72.0	72.0	72.0	72.0	72.0	72.1	72.2	72.2	72.3
	1995	1996	1997	1998	1999	2000	2001	2002	2003
<b>Cattle for fattening</b>	58.4	58.6	58.7	58.9	59.0	59.2	59.3	59.4	59.6
<b>Heifers</b>	50.3	51.5	51.8	52.0	52.3	53.0	53.3	54.0	53.9
<b>Other cows</b>	86.7	86.7	86.7	86.6	86.6	86.7	86.7	86.7	86.6
<b>Breeding bulls</b>	72.3	72.4	72.5	72.5	72.6	72.7	72.7	72.7	72.7
	2004	2005	2006	2007	2008	2009	2010	2011	2012
<b>Cattle for fattening</b>	59.7	59.8	59.3	60.0	59.8	59.6	59.6	59.8	59.8
<b>Heifers</b>	53.6	54.6	55.1	55.1	55.2	54.9	54.8	54.9	54.9
<b>Other cows</b>	86.5	86.5	86.5	86.4	86.4	86.4	86.4	86.4	86.4
<b>Breeding bulls</b>	72.7	72.7	72.7	72.7	72.7	72.8	72.8	72.8	72.8
	2013	2014	2015	2016					
<b>Cattle for fattening</b>	59.7	58.6	59.7	59.7					
<b>Heifers</b>	54.7	55.2	54.9	55.6					
<b>Other cows</b>	86.3	86.2	86.2	86.1					
<b>Breeding bulls</b>	72.8	72.8	72.8	72.8					

### 5.2.2.2 Swine (CRF 3.A.3)

The number of swine (Figure 5.2.4) has been taken from the Statistical Yearbook.



**Figure 5.2.4: Number of swine in thousands.**

Methane emissions have been estimated by applying default emission factors according to IPCC (2006) methodology, i.e. 1.5 kg per year.

### 5.2.2.3 Sheep (CRF 3.A.2.) and Goats (CRF 3.A.4)

The SORS has changed its methodology of estimating the population of sheep and started to publish data on the number of goats (Statistical Information, No. 197, 1998). For breeding sheep, re-established data from 1992 to 1997 are available. The total number of sheep (Figure 5.2.5) has been estimated on the basis of data on breeding sheep for the period 1992 to 1997 by applying the interacting ratio between breeding sheep and all sheep in 1997. For the time prior to 1992, the numbers from old statistical yearbook have been taken. The number of goats (Figure 5.2.4) has been estimated in the same way as the number of sheep. As goats have not been counted before 1992, we consider the number of 8.000 heads as an estimate. The population data does not include lambs and young goats.

Considering the rather small number of sheep and goats, Tier 1 methodology and default EFs from the IPCC (2006) guidelines have been used for estimating methane emissions; 8 kg of methane annually per head for sheep and 5 kg of methane for goats.

### 5.2.2.4 Horses (CRF 3.A.4)

The number of horses (Figure 5.2.5) has been taken from the Statistical Yearbook. Methane emissions have been estimated by applying default emission factors according to IPCC (2006) methodology, i.e. 18 kg per year.

### 5.2.2.5 Rabbits (CRF 3.A.4)

The number of horses (Figure 5.2.5) has been taken from the Statistical Yearbook. Methane emissions have been estimated by applying emission factor used in the Italian GHG inventory, i.e. 0.08 kg per animal per year.

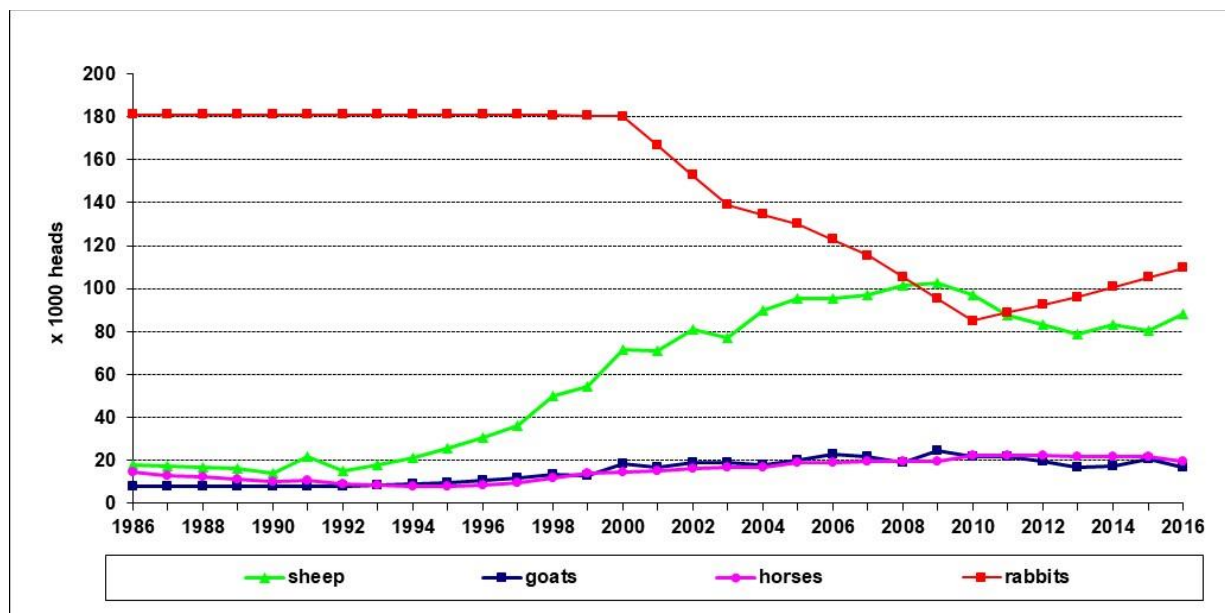


Figure 5.2.5: Number of sheep, goats, horses and rabbits in thousands.

### 5.2.3 Uncertainties and time-series consistency

Data on the number of livestock are not collected according to ownership of the livestock but according to who manages the livestock. The sample for the statistical survey on the number of livestock is selected according to the sampling methodology. Data collected using the sample is representative for the entire country. The sample is divided into four strata; each of them is determined regarding the size class of agricultural holding. The sample thus covers all large agricultural holdings, while other agricultural holdings are selected proportional to size class and represent a specific weight in their size class. Based on information from SORS, the uncertainty of activity data is 10%.

According to IPCC 2006 Guidelines, the uncertainty of the EFs when using default methodology is at least 30%, but could be as high as 50%. When Tier 2 methodology is used, the uncertainty is likely to be in the range of 20%. As most emissions in this category are estimated using Tier 2 methodology, uncertainty estimate of 20% have been used based on expert judgement.

The combined uncertainty, calculated according to IPCC 2006 Guideline, Tier 1 methodology, amounts to 22.36%.

## 5.2.4 Category-specific QA/QC and verification

For calculation of emissions from agriculture the new model has been made. The main purpose of this model is N balance and the harmonization of GHG and other pollutants reporting. Calculations in the model have been thoroughly vetted by experts in the KIS and in the SEA. Any errors that were found have been corrected.

Besides QA/QC procedures described above and in chapter 1.2.3 the following Tier 2 QA/QC procedures have been performed for the submission 2015:

- Enteric fermentation - CH<sub>4</sub> – Country specific CH<sub>4</sub> EF for cattle has been compared with IPCC default

## 5.2.5 Category-specific recalculations

Reviewers of the National Emission Inventory pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (NECD) suggested that emissions from rabbit production should be included into national inventory of atmospheric pollutants. With the intention to be consistent it was decided to report also methane emissions from enteric fermentation in rabbits. It was done for the entire reporting period.

New estimates for growth rate in fattening cattle were prepared for the entire reporting period. Growth rate is estimated on the basis of age and carcass weight of animals which are slaughtered in Slovenian slaughterhouses. To do it, the information on dressing percentage is needed. In previous submissions we used the figure derived from literature and some experiments. In 2017 breed specific equations for prediction of dressing percentage were developed. They are based on large number of animals (13.959) which were slaughtered during the period 2012-2015. The changes affect energy requirements and consequently methane emissions from digestive tract. The differences were of minor importance.

Statistical office released a new value for milk production in 2015. As a result, the methane emission from enteric fermentation slightly increased.

It was found, that by mistake, the emission factor which applies for adult goats, was applied also for kids. It happened for the period 1986-2013. Miscalculation was corrected.

## 5.2.6 Category-specific planned improvements

No further improvements are planned.



## 5.3 CH<sub>4</sub> Emissions from Manure Management (CRF 3.B)

### 5.3.1 Source category description

In storing solid and/or liquid manure, both methane and N<sub>2</sub>O are emitted. Emissions depend largely on the type of manure storage. Methane arises in significantly larger amounts when manure is managed as slurry, while N<sub>2</sub>O prevails in storage of solid manure.

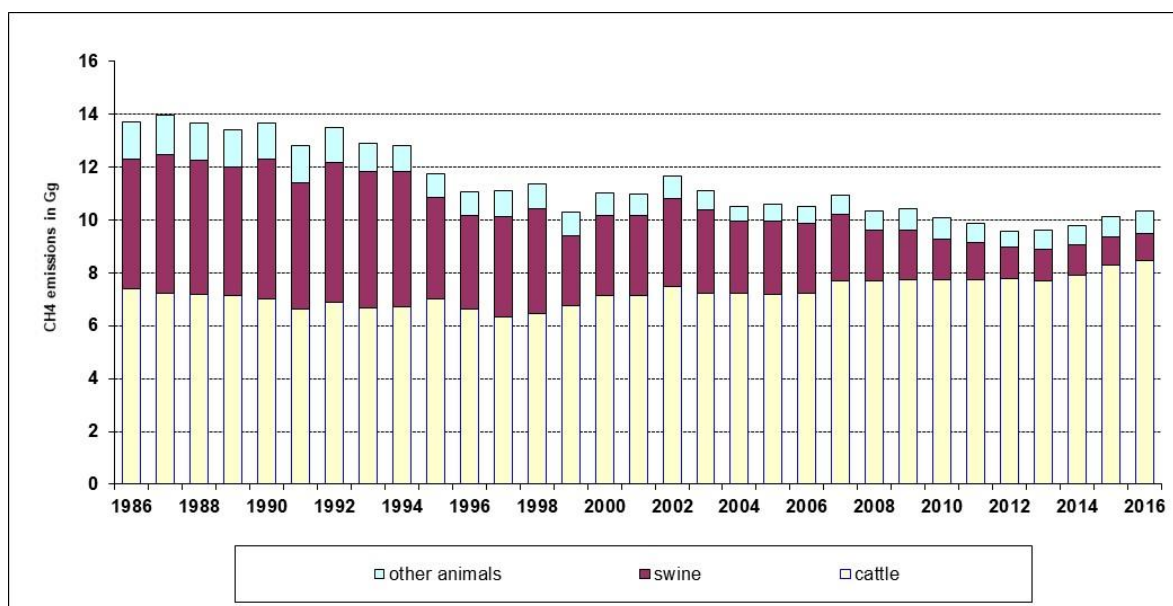


Figure 5.3.1: CH<sub>4</sub> emissions from manure management in Gg.

Significant quantities of methane are emitted during the decomposition of animal excreta. Under anaerobic conditions, methane-producing bacteria convert organic matter into methane. The quantities of produced methane are largely dependent on the type of manure management system and environment temperature. Storing manure in lagoons or as slurry produces significantly greater quantities of methane compared to grazing on pasture or solid manure storage.

To estimate the amount of methane produced during manure management (Figure 5.3.1), it is necessary to know the quantities of excreted volatile solids (VS), methane-producing capacity of manure ( $B_0$ , in m<sup>3</sup> per kg of VS), and the manure management system (MMS) which result in specific methane conversion factor (MCF). The climate in Slovenia is cool (average yearly temperature is below 12°C, Figure 5.3.2).

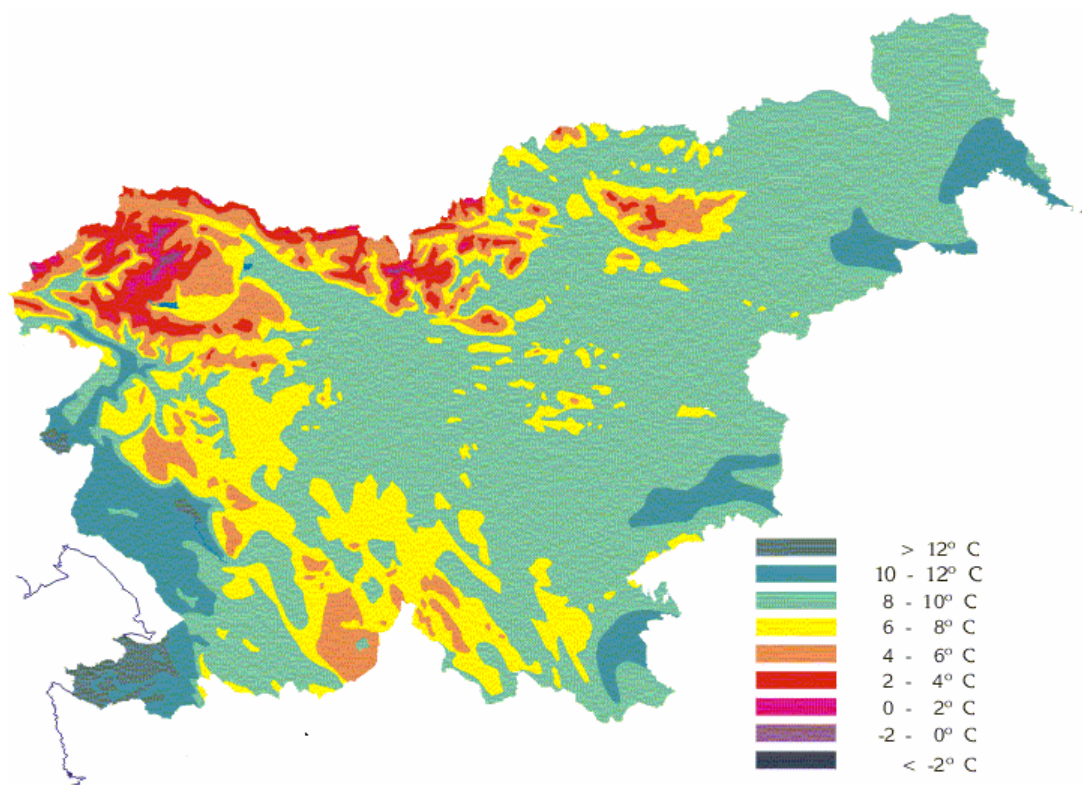


Figure 5.3.2: The average yearly temperature in Slovenia. (Sours: SEA)

[http://www.arso.gov.si/podro-cja/vreme\\_in\\_podnebje/napovedi\\_in\\_podatki/temperaturna\\_karta.html](http://www.arso.gov.si/podro-cja/vreme_in_podnebje/napovedi_in_podatki/temperaturna_karta.html)

## 5.3.2 Methodological issues

### 5.3.2.1 Cattle (CRF 3.B.1)

Annual quantities of volatile solids excreted via faeces were estimated by means of data gathered while estimating the extent of enteric fermentation. The equation that was laid down by IPCC (2006) was applied. In comparison to previous methodology (IPCC, 1996) the energy of urine was taken into account in addition to energy of faeces. It was expressed as fraction of GE (UE=0.04). It results in about 11 % higher emission factors than in previous reports (until 2014). Through estimated intake of gross energy, the amount of volatile solids is directly linked to the production intensity (to milk production or daily weight gain).

$$VS \text{ (kg/day)} = \left[ GE \times \left(1 - \frac{DE\%}{100}\right) + (UE \times GE) \right] \times \left[ \frac{1 - ASH}{18.45} \right]$$

In dairy cows the estimated amount of VS ranged between 1651 and 1905 kg per year and animal. For other cows, heifers and beef cattle the corresponding values were from 1517 to 1542, from 821 to 845 and from 820 to 876 kg per year and animal.

The annual emitted amount of methane ( $E_{M \text{ MANURE}}$ ) was estimated according to the equation:

$$E_{M \text{ MANURE}} = VS \text{ (kg/day)} \times 365 \text{ days/year} \times B_0 \text{ (m}^3\text{/kg VS)} \times 0.67 \text{ kg/m}^3 \times MCF$$

For methane producing capacity of manure ( $B_0$ ) the value of  $0.24 \text{ m}^3/\text{kg VS}$  was considered for dairy cows and the value  $0.17 \text{ m}^3/\text{kg VS}$  for other bovine animals (IPCC, 2006). The methane conversion factor MCF, which tells us what fraction of methane producing capacity of manure is actually used, was calculated on the basis of fractions of individual manure storage systems and partial manure conversion factors for the average temperature  $12^\circ\text{C}$ , which were found in appropriate tables (IPCC, 2006). Methane conversion factors 0.13, 0.20, 0.02, 0.20, 0.00 and 0.01 were used for liquid manure storage with natural crust cover, liquid manure storage below animal confinements, solid manure storage in heaps, solid manure in deep bedding systems, anaerobic digesters and grazing, respectively.

The fraction of individual manure management systems was estimated on the basis of the results of farm census data from 1991 and 2000. Since manure management systems were not reported in the census, data on size and structure of cattle-breeding farms were used for rough estimates. It was considered that all farms with less than 10 heads of bovine animals had solid manure storage systems, that 30% of farms with 10-19 head of animals practiced liquid manure storage and 70% of them solid manure storage, and that all farms with 20 cows or more had liquid manure storage systems. Linear regression was used to estimate the changes in manure management systems in the period 1990-2000. After 2000, data on farm size and structure were reported by the SORS for the years 2003, 2005, 2007, 2010 and 2013. For the years with missing values, the proportions of various manure storage systems were obtained by interpolation. For the years which exceed the available time series we used the last available estimate. In 2005, the estimates based on farm structure were tested using the information on manure management that was collected in the frame of milk recording service on a large number of dairy farms (Babnik and Verbič, 2007; about 70% of total dairy cows were covered). Based on farm structure, it was estimated that 55.6% of dairy cows were kept on liquid systems (if grazing is not taken into account). The corresponding value based on farm questionnaires was only slightly lower (53.2%). It proves that the estimates based on farm structure can be considered reliable. In 2010 data for the sample survey on agricultural production methods were collected for the first time along with the Agriculture Census (SORS). It gave considerably lower value for liquid systems (29.1%). The results are difficult to explain. Due to fact that there are no historical data on agricultural production methods it was decided to preserve the consistency of time series and to retain estimates based on farm structure. No new data on manure management methods were published by SORS recently. Therefore, we were not able to respect the recommendation of 2016 revision to include the latest SORS information on manure management systems into the calculation procedure.

Animals kept in liquid systems were further divided into animals kept in liquid manure storage with natural crust cover, animals kept in liquid manure storage below animal confinements and animals from which the excreta is treated in anaerobic digesters. Based on information on manure management that was collected in the frame of milk recording service on a large number of dairy farms in 2005 (Babnik and Verbič, 2007) it was estimated that the ratio between slurry stored in stores with natural crust and slurry stored below animal confinements is 0.46:0.54. Based on information from the same source the solid manure was divided into farmyard manure stored in heaps and deep bedding (0.90:0.10). The proportion of slurry treated in anaerobic digesters was estimated on the basis of data collected from biogas plants by the means of interview (data provided by Poje, unpublished). Based on

above mentioned data and data on total number of cattle it was estimated that during the period 2006-2010 the proportion of digested cattle manures increased from 0.03 to 0.36 %. Anaerobic digesters were not markedly spread thereafter and therefore the same value was used for the period 2011-2016.

The fraction of grazing bovine animals for 1990 has been estimated on the basis of data on grazing animals on mountain pastures and expert estimate on the scale of grazing on intensive grasslands (Verbič et al., 1999). In 2000, all grazing animals on mountain and other pastures were recorded. This census showed that in 2000, one way or another, 21% of animals were grazing. This data have been corrected with regard to the length of the grazing season, considering the fact that animals on mountain pastures will graze for 141 days on the average, and on other pastures for 210 days. As result, the corrected proportion of grazed animals for 2000 was estimated to be 0.117. The same procedure was used for the data obtained by sample survey on agricultural production methods in 2010. It showed that the corrected proportion of grazed animals increased to 0.126.

**Table 5.3.1: CH<sub>4</sub> EFs for cattle for manure management in kg/head/year.**

	1986	1987	1988	1989	1990	1991	1992	1993	1994
Dairy cows	21.1	21.0	21.0	21.0	21.0	21.9	21.7	22.0	22.6
Cattle for fattening	8.0	8.0	8.0	8.0	8.0	8.1	8.2	8.2	8.3
Heifers	7.8	7.8	7.8	7.8	7.8	8.0	8.0	8.1	8.3
Other cows	NA	NA	NA	NA	NA	14.9	15.1	15.3	15.5
Breeding bulls	12.7	12.7	12.7	12.7	12.7	12.9	13.0	13.2	13.4
	1995	1996	1997	1998	1999	2000	2001	2002	2003
Dairy cows	23.1	24.2	24.6	25.0	25.6	26.3	27.2	28.3	28.8
Cattle for fattening	8.4	8.5	8.6	8.7	8.8	8.8	9.0	9.2	9.4
Heifers	8.4	8.6	8.7	8.9	9.0	9.2	9.4	9.8	10.0
Other cows	15.6	15.8	16.0	16.1	16.3	16.5	16.9	17.3	17.7
Breeding bulls	13.6	13.7	13.9	14.1	14.3	14.4	14.8	15.2	15.5
	2004	2005	2006	2007	2008	2009	2010	2011	2012
Dairy cows	28.7	29.5	30.2	30.9	31.5	31.7	32.2	32.2	32.4
Cattle for fattening	9.5	9.5	9.7	9.9	10.1	10.3	10.5	10.5	10.5
Heifers	10.0	10.1	10.4	10.7	10.8	11.0	11.1	11.2	11.2
Other cows	17.8	17.8	18.2	18.6	18.9	19.2	19.5	19.5	19.6
Breeding bulls	15.6	15.7	16.0	16.4	16.7	16.9	17.2	17.2	17.3
	2013	2014	2015	2016					
Dairy cows	32.4	33.1	33.2	34.1					
Cattle for fattening	10.5	10.7	10.8	10.9					
Heifers	11.2	11.4	11.5	11.7					
Other cows	19.6	19.7	20.0	20.2					
Breeding bulls	17.3	17.6	17.8	18.0					

The estimate for 1990 was used for the period 1985-1990. For the period 1991-1999, the data on grazing were obtained by linear regression which was calculated on the basis of data for the years 1990 and 2000 and for the period 2001-2009 the estimates obtained by linear regression for the years 2000 and 2010. For the years up to 2016 extrapolated values based on 2000-2010 period were used. It has been estimated that the fraction of grazing animals and the fraction of liquid manure management systems have increased while the fraction of bovine animals in straw based systems has decreased

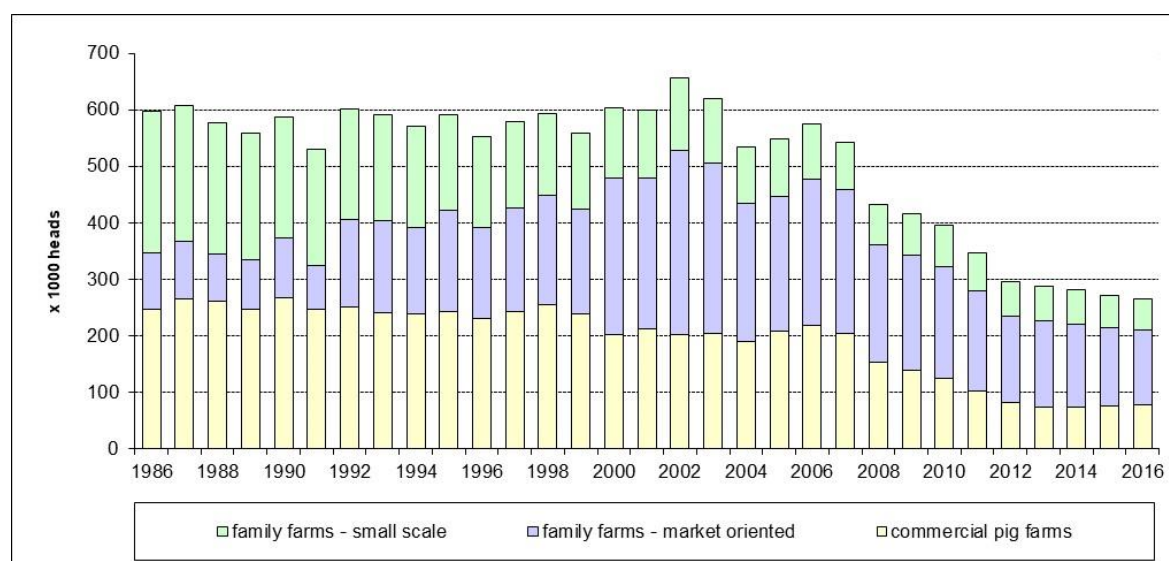
Data on the number of livestock were the same as those used for calculating methane emissions from enteric fermentation. Emission factors are presented in the table 5.3.1.

### 5.3.2.2 Swine (CRF 3.B.3)

#### Activity data

The population of swine (Figure 5.3.3) is divided into three segments:

- commercial (industrial) pig farms,
- market oriented family farms, and
- small scale (subsistence) family farms.



**Figure 5.3.3: Number of swine in thousands.**

Data published by the SORS allow a breakdown of the entire herd into commercial pig farms and family farms for the period 1986-2002. Family farms were further divided into market oriented and small scale farms. In 1986, the estimate of production for market oriented family farms was based on the data on acquisition of pigs from market oriented family farm production, which was published by the SORS. The number of swine in small scale family farm production has been estimated from the difference between the entire herd and market oriented production (commercial and market oriented family farms). For 2000, the number of pigs in the small scale family farm production has been estimated on the basis of the census of agricultural holdings. Pigs kept on farms with up to 10 pigs have been considered as small

scale family farm production, pigs on family farms which kept more than 10 pigs have been considered as market oriented family farm production. From 1986 to 2000, the fraction of pigs in small scale family farm production kept diminishing. In the period between 1986 and 2000, the proportion of small scale production was obtained by interpolation. After 2000, data on farm structure for the years 2003, 2005, 2007, 2010, 2013 and 2016 have been reported by the SORS. These data were used to estimate the number of pigs on small scale family farms. For the years with non-existing data on farm structure (2001, 2002, 2004, 2006, 2008, 2009, 2011, 2012, 2014, 2015) the numbers of pigs on small scale family farms were obtained by interpolating the values for neighbouring years. For the period after the year 2002 the number of pigs on commercial farms could not be obtained directly from the data reported by SORS. Therefore it was estimated using the data on farm structure for the years 2003, 2005, 2007, 2010, 2013 and 2016. The estimate is based on the number of pigs which are kept on farms with more than 399 pigs. The pigs belonging to this category (pigs kept on farms with more than 400 pigs) were allocated among commercial and market oriented family farms on the basis of their proportion in the year 2000. The pigs kept on farms with 10 to 399 pigs were entirely allocated to market oriented family farms.

An investigation on the extent of organic pig production was made in 2017 with the aim to find out if manure management practices on organic farms should be surveyed. It was found that in the period 2010-2016 only 0,6 to 1,4 % of total pigs were kept on organic farms. It was estimated that detailed information on manure management systems on these farms would not considerably contribute to improvement of data quality.

### **Emission factors**

Annual emissions of methane ( $E_{M \text{ MANURE}}$ ) have been estimated according to the IPCC method. Quantities of excreted volatile solids (VS) have been calculated using Western Europe default values of 0.46 kg of VS/day for breeding pigs and 0.30 kg of VS/day for fattening pigs (including piglets) (IPCC, 2006). For the methane-producing capacity of manure ( $B_0$ ), the value for swine (0.45 m<sup>3</sup>/kg VS; IPCC, 2006) has been applied. The average manure conversion factor (MCF) has been estimated with regard to the type of manure management system and partial manure conversion factors that had been laid down for various systems by IPCC (2006). Methane conversion factors 0.20, 0.02, 0.20, 0.70, and 0.00 were used for liquid manure storage, solid manure storage in heaps, solid manure in deep bedding systems, uncovered anaerobic lagoons and anaerobic digesters, respectively. The following estimates and assumptions have been taken into account.

#### Commercial Pig Farms

From 1985 to 1994 – using old-style separators on commercial farms, app. 20% of organic matter was separated from liquid manure. For this portion, the partial MCF for solid manure (0.02) has been taken into account. The remainder (80%) has been disaggregated into uncovered anaerobic lagoons (75%) and liquid manure (25%), taking into account a MCF 0.70 and 0.20, as suggested by IPCC (2006). The division into lagoons and liquid manure was founded on actual estimates of the extent of production on commercial farms, where the liquid portion of manure after separation was applied to fields and grassland. Considering the ratio between solid phase and liquid manure, which was either led into lagoons or used for fertilization, the average MCF = 0.464 has been calculated.

Years from 1995 to 1999 were a period of introducing new separators and the beginning of operation of an anaerobic digester in the Farm Ihan. Introducing new separators on commercial farms increased the estimated portion of separated solid phase to 40%. Since the construction of a new wastewater treatment plant in Farm Ihan, it has been considered that mechanic separation separated 80% of VS on that commercial farm, while the remainder (20%) was captured as biogas. For large commercial farms it is generally considered that the ratio between the liquid part, which flows off to lagoons, and the liquid part, which is used as fertilizer, is the same as prior to 1995 (3:1). The estimated average MCF for that period was 0.286. Due to new farm reconstructions leading to improved slurry separation and introduction of additional capacity of anaerobic digesters, the methane conversion factor MCF on big farms after 1999 had decreased to 0.150 until 2005 and further to 0.054 in 2015.

**Table 5.3.2: Distribution of various manure management systems in pig production in %.**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Slurry	28.1	25.0	34.5	36.0	35.5	35.1	34.1	36.6	37.4	40.1
Farmyard manure	35.5	37.5	32.3	31.5	31.1	28.7	29.1	26.6	24.6	24.5
Separation (solid fraction)	9.1	9.4	8.3	8.1	8.4	19.7	20.0	20.1	20.7	23.8
Anaerobic lagoons	27.4	28.1	24.9	24.4	25.1	14.8	15.0	15.1	15.5	06.4
Anaerobic digestion	0.0	0.0	0.0	0.0	0.0	1.6	1.7	1.7	1.7	5.1
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Slurry	50.3	49.4	53.6	52.5	50.7	48.8	48.6	49.0	48.9	49.9
Farmyard manure	22.1	21.3	20.9	20.1	19.9	19.7	18.4	17.1	18.2	19.2
Separation (solid fraction)	18.7	19.8	17.3	18.5	19.9	21.2	15.9	15.3	12.7	12.8
Anaerobic lagoons	5.0	5.3	4.6	5.0	5.3	5.7	4.3	4.1	3.4	3.4
Anaerobic digestion	4.0	4.2	3.7	4.0	4.3	4.6	12.9	14.4	16.9	14.7
	2010	2011	2012	2013	2014	2015	2016			
Slurry	54.1	54.7	55.4	56.0	55.3	54.5	53.8			
Farmyard manure	20.2	21.1	22.0	22.9	22.8	22.6	22.4			
Separation (solid fraction)	12.6	11.8	10.9	10.1	10.6	11.1	11.6			
Anaerobic lagoons	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
Anaerobic digestion	13.1	12.4	11.7	10.9	11.4	11.8	12.2			

#### Market oriented family farm production

For market oriented family farm production, it is considered that 95% of animal excreta are collected in the form of liquid manure and 5% in the form of solid manure. Based on the ratio between liquid manure and solid manure, the average manure conversion factor MCF = 0.191 was used for calculations until 2006. Since then, farm reconstructions occurred also on family farms and average MCF has decreased to 0.185 in 2016.

#### Small scale family farm production

For small scale family farm production, it is estimated that 95% of pigs are reared in solid manure storage systems and 5% in liquid manure systems. For this type of production the



average manure conversion factor MCF = 0.029 was calculated on the basis of IPCC (2006) guidelines.

Detailed information on manure management systems are given in Table 5.3.2.

In the Table 5.3.3 country specific IEFs for swine are presented. The decrease in IEF for swine is due to improved slurry separation and introduction of additional capacity of anaerobic digesters.

**Table 5.3.3: CH<sub>4</sub> EFs for manure management in pig production (in kg/head/year)**

	1986	1987	1988	1989	1990	1991	1992	1993	1994
CH <sub>4</sub> EFs	8.2	8.6	8.8	8.7	9.0	0.0	8.8	8.8	8.9
	1995	1996	1997	1998	1999	2000	2001	2002	2003
CH <sub>4</sub> EFs	6.4	6.4	6.6	6.7	4.7	5.0	5.0	5.1	5.1
	2004	2005	2006	2007	2008	2009	2010	2011	2012
CH <sub>4</sub> EFs	5.1	5.1	4.6	4.6	4.4	4.5	4.0	4.0	4.0
	2013	2014	2015	2016					
CH <sub>4</sub> EFs	4.1	4.1	4.1	4.1					

### 5.3.2.3 Poultry (CRF 3.B.4)

The number of poultry species (Figure 5.3.4) has been taken from the Statistical Yearbook. Emissions were calculated as a sum of emissions for broilers, layers, ducks, turkeys and geese. Methane produced during manure management was calculated by taking into account the quantities of excreted volatile solids (VS), methane-producing capacity of manure ( $B_0$ ), and methane conversion factors (MCF) for the specific manure management systems. For excretion of VS 0.02, 0.01, 0.07 and 0.02 kg per animal per day were used for layers, broilers, turkeys and ducks, respectively (IPCC, 2006). No value for geese is available. Therefore, an estimate of 0.05 kg per animal per day was obtained on the basis of value for ducks taken into account the difference in body mass weight. For methane producing capacity of manure ( $B_0$ ) the value of 0.39 m<sup>3</sup>/kg VS was considered for layers and the value 0.36 m<sup>3</sup>/kg VS for other poultry species (IPCC, 2006). For broilers, turkeys, geese and ducks exclusively floor system on bedding was assumed. For laying hens, combined floor system (1/4) and battery-cage systems (3/4) were assumed for 1990. Assumption was made on the basis of expert estimate. It was also assumed that in 50% the manure is removed daily and stored in tanks (liquid system) while in 50 % it is collected under the batteries (i.e. poultry manure without bedding). After introduction of dung drying system to certain farms a new estimates were obtained for 2002. Layers which were assumed to be kept in floor system, in system where manure is collected under the batteries and in dung drying system, were allocated to solid system. Layers which were assumed to be kept in system where the manure is removed daily and stored in tanks was allocated to liquid systems. Emission factor for poultry manure without litter (MCF=0.70) was used for manure which was allocated to liquid systems. For manure allocated to solid systems MCF for system with litter was used (MCF=0.015). It means that manure which is collected and dried under the batteries and manure from dung drying system were treated the same way as manure



with litter. IPCC (2006) reported no MCF's for dry manure without bedding. There is mentioned that MCF for aerobically treated manure are near zero and therefore for dry manure the use of MCF for manure with litter (0.015) seems more adequate than high MCF for manure without litter (0.70).

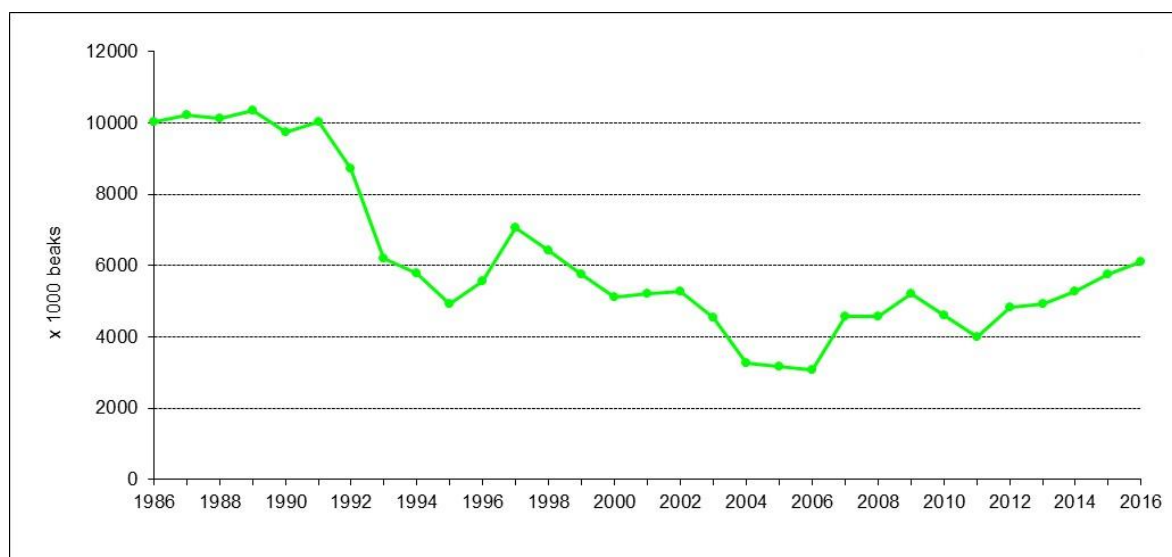


Figure 5.3.4: Number of poultry in thousands.

#### 5.3.2.4 Sheep (CRF 3.B.2), Goats, (CRF 3.B.4), and Horses (CRF 3.B.4)

For excretion of VS 0.4, 0.3 and 2.13 kg per animal per day were used for sheep, goats and horses. For methane producing capacity of manure ( $B_0$ ) the values of 0.19, 0.18 and 0.30  $m^3/kg$  VS were applied, respectively (IPCC, 2006). The proportions of grazing animals were estimated by the means of expert opinion. It was estimated that during the grazing season all sheep, 80% of goats and 50% of horses were grazed (expert estimate). Two hundred and fifty days of grazing season has been considered for sheep and 210 for goats and horses. As a result, the proportions of grazed animals were estimated to be 0.685, 0.460 and 0.288 for sheep, goats and horses, respectively. For the remaining period it has been considered that these animals were kept in straw based (solid) systems. Manure conversion factors of 0.02 and 0.01 were applied for housed and grazed animals, respectively.

#### 5.3.2.5 Rabbits (CRF 3.B.4)

For rabbits IPCC default emissions factor 0.08 kg/head/year was applied. It was considered that rabbits are not grazed and that only the solid manure system has been used.

### 5.3.3 Uncertainties and time-series consistency

Uncertainty of activity data amounts to 10% (Source: SORS, KIS)

The uncertainty estimate for EF in the IPCC 2006 Guidelines is 30% for default values and Tier 2 EFs have is not less than 20%. It is our experts' judgement that EFs for manure

management are less accurate than those for enteric fermentation. According to their judgement, we are using uncertainty of 30% for all EFs. Combined uncertainty amounts to 31.62%.

### 5.3.4 Category-specific QA/QC and verification

Besides QA/QC procedures described in the chapter 1.2.3 and 5.2.4, the following Tier 2 QA/QC procedures have been performed for the submission 2018:

- Manure management – CH<sub>4</sub> - Country specific CH<sub>4</sub> EFs for cattle and swine have been compared with IPCC default and with EFs used in other European countries with similar climate

During the 1. Phase of ESD review an error has been found. CH<sub>4</sub> emissions from other chicken have not been included in the inventory. For the final submission this error has corrected.

### 5.3.5 Category-specific recalculations

Reviewers of the National Emission Inventory pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (NECD) suggested that emissions from rabbit production should be included into national inventory of atmospheric pollutants. With the intention to be consistent it was decided to report also methane emissions from manure management in rabbits. It was done for the entire reporting period.

New estimates for growth rate in fattening cattle were prepared for the entire reporting period. The changes affect energy requirements and consequently methane emissions from manure management. The differences were of minor importance. The reasons for new estimates are given above (3.A. Enteric fermentation).

Statistical office released a new value for milk production in 2015. As a result, the methane emission from manure management slightly increased.

It was found, that by mistake, the emission factor which applies for adult goats, was applied also for kids. It happened for the period 1986-2013. Miscalculation was corrected.

Based on new farm structure data for 2016 estimates for manure management systems were corrected for years 2014 and 2015 (interpolation to last available data for 2013).

### 5.3.6 Category-specific planned improvements

No further improvements are planned.

## 5.4 N<sub>2</sub>O Emissions from Manure Management (CRF 3.B)

### 5.4.1 Source category description

This category considers N<sub>2</sub>O which is emitted, directly and indirectly, from treatment and storage of animal excreta before it is applied to agricultural land or used for other purposes. A considerable amount of N<sub>2</sub>O evolves during storage of animal waste. Animal excreta are also source of indirect N<sub>2</sub>O emissions. They are associated with volatilization of ammonia (NH<sub>3</sub>) and nitric oxide (NO<sub>x</sub>) from animal houses and manure stores. Volatilised N is deposited to soils and water surfaces where it causes indirect N<sub>2</sub>O emissions. They are also attributed to livestock production and reported within this category. Nitrous oxide emitted directly or indirectly from excreta of grazing animals is reported under category “N<sub>2</sub>O emissions from managed soils”.

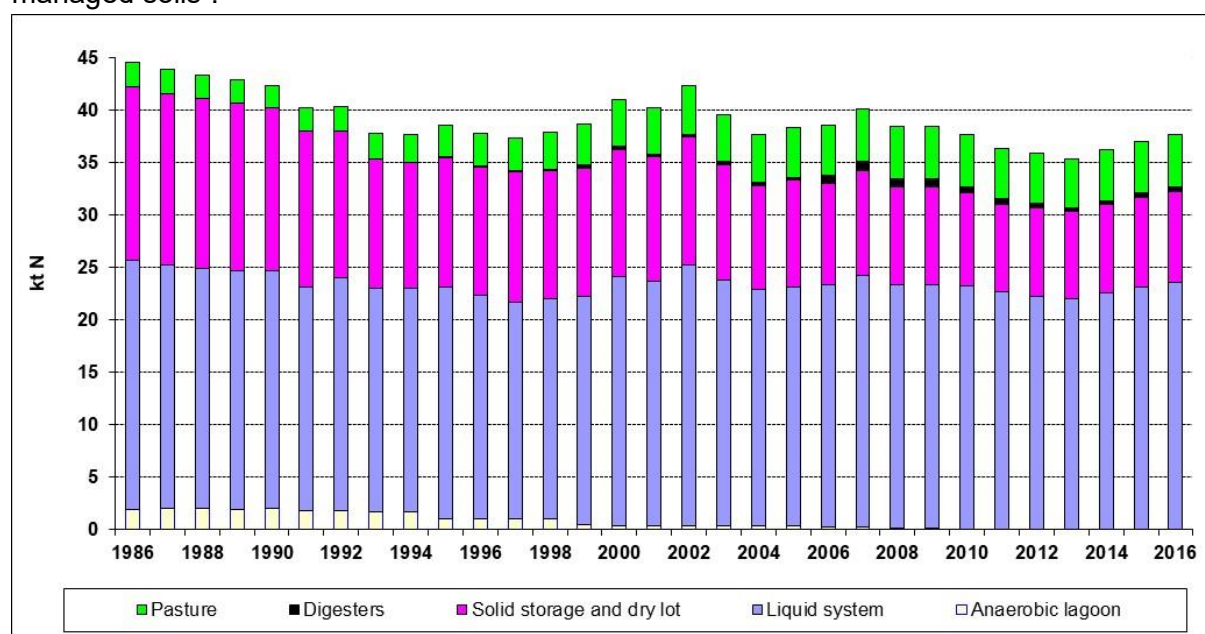


Figure 5.4.1: Nitrogen excretion per different MMS in kilotons.

### 5.4.2 Methodological issues

Mass balance approach which tracks nitrogen throughout the system was used to estimate N<sub>2</sub>O emissions. It was done by the means of detailed EMEP/CORINAIR (2013) methodology, which is also used for national NH<sub>3</sub> and NO<sub>x</sub> emission inventory. Based on suggestion by IPCC (2006) (Chapter 10, 10.56), we have decided to use National NH<sub>3</sub> emission inventory for the estimation of nitrogen volatilization from MMS also for reporting of GHG emissions. EMEP/EEA (2013) Tier 2 methodology ensures that there is consistency between EMEP and IPCC methodology (see EMEP/EEA, 2013, Chapter 3.B Manure management, p. 19).

The methodology is based on principles of total N and total ammonia nitrogen (TAN) fluxes through the manure management system. The model starts out with TAN excretions followed by emissions of NH<sub>3</sub>, N<sub>2</sub>O, NO and N<sub>2</sub> from animal housing and manure stores. It was taken

into account that only the nitrogen that was not lost from animal houses and manure stores is retained in animal manures. Therefore, emissions at each stage depend on the extent of emissions during the preceding stages. In case of slurry based systems mineralization of non-TAN N was taken into account and in the case of farmyard manure it was taken into account that a part of TAN is immobilised into organic matter. Ammonia losses that arise from the application of the manure to soil were also estimated within the same procedure. They were reported as a source of indirect N<sub>2</sub>O emissions under the category "N<sub>2</sub>O emissions from managed soils". In its final stage the procedure gives an information on the amount of total N returned to soil. It was used for assessment of N<sub>2</sub>O emissions due to nitrification and denitrification processes which results from the use of animal manure applied to soils. These emissions are reported under category "N<sub>2</sub>O emissions from managed soils".

EMEP/EEA methodology is based on total ammonia N flow (TAN) while IPCC (2006) is based on total N flow. Therefore, emission factors from one methodology can not be directly used in another. However, EMEP/EEA EF are based on IPCC factors and therefore we can consider them as comparable (see EMEP/EEA, 2013, Chapter 3.B Manure management, p. 54). In fact IPCC factors were converted by taking into account the proportion of TAN in manure entering storage.

#### 5.4.2.1 Direct N<sub>2</sub>O emissions from manure management

##### Activity data

The activity data were obtained from the Statistical Office of the Republic of Slovenia (SORS). They include the number of cattle, pigs, sheep, goats, horses and poultry as well as average milk production per cow. Details are described under the Chapter 5.2.2.

##### Emission factors

In the first step nitrogen excretion from farm animals was estimated. It was obtained by multiplying the number of farm animals and nitrogen excretion rates on the level of individual animal species and category. The nitrogen excretion rates, which were taken into account, are presented in Table 5.4.2. In dairy cows the nitrogen excretion has been linked to productivity, i.e. milk production (M). The equation proposed by Menzi et al. (1997) was used:

$$\text{N excretion (kg/year)} = 52.5 + 0.0105 \times M \text{ (kg/year)}$$

Nitrogen excretion rates for dairy cattle are presented in Table 5.4.1.

**Table 5.4.1: Nitrogen excretion rates for dairy cattle in kg/head/year.**

	1986	1987	1988	1989	1990	1991	1992	1993	1994
<b>Nex</b>	82.1	81.5	81.6	81.8	81.6	86.6	82,3	81.9	84.1
	1995	1996	1997	1998	1999	2000	2001	2002	2003
<b>Nex</b>	85.8	92.7	94.2	95.5	97.1	101.1	103.0	107.1	105.7
	2004	2005	2006	2007	2008	2009	2010	2011	2012
<b>Nex</b>	103.5	110.0	112.4	112.6	113.0	110.6	110.4	110.4	111.2
	2013	2014	2015	2016					
<b>Nex</b>	109.6	112.5	111.3	115.8					

**Table 5.4.2: Nitrogen excretion rates for the calculation of ammonia emissions from animal production**

Animal category	N excretion (kg/year)	Source
Cattle		
Dairy cows	81-118	Menzi et al. (1997) taken into account milk production
Suckling cows	78	Menzi et al. (1997) taken into account 2400 kg of milk per year
Calves, fattening cattle, heifers	35	Menzi et al. (1997)
Pigs		
Sows <sup>a</sup>	36	EMEP/CORINAIR (2002)
Fattening pigs	14	EMEP/CORINAIR (2002)
Small ruminants		
Sheep <sup>b</sup>	15.5	EMEP/CORINAIR (2016)
Goats <sup>c</sup>	15.5	EMEP/CORINAIR (2016)
Horses	47.5	EMEP/CORINAIR (2013)
Poultry		
Laying hens	0.71	Menzi et al. (1997)
Broilers	0.40	Menzi et al. (1997)
Turkeys	1.50	Döhler et al. (2002)
Geese	0.73	Döhler et al. (2002)
Ducks	0.60	Döhler et al. (2002)
Rabbits <sup>d</sup>	0.60	IPCC (2006)

<sup>a</sup> Sows and pregnant gilts; the value includes N excretion in piglets and boars

<sup>b</sup> Adult sheep (including breeding female sheep and other adult sheep, like rams and barren sheep); the excretion value includes N excretion in lambs

<sup>c</sup> Adult goats (including breeding female goats and other adult goats, like he goats and barren goats); the excretion value includes N excretion in kids

<sup>d</sup> The excretion value applies for does; the value includes excretion in other rabbit categories

### **Emissions from animal housing, manure stores and due to fertilization with animal manures in cattle production (CRF 3.B.1)**

Emission factors, which tell us how much of N from animal excreta is lost to the atmosphere in the form of various gasses, including N<sub>2</sub>O, depend on manure management systems. Total nitrogen excretion was allocated to four manure management systems (grazing, farmyard manure, slurry and anaerobic digesters). Nitrogen which is excreted in farmyard manure system was further divided in two fractions, farmyard manure (0.43) and liquid fraction (0.57). The latest corresponds to urine and effluent from storage of solid fraction. The same information as those used to estimate CH<sub>4</sub> emissions from manure management was used for allocation of nitrogen to various manure management systems (see Chapter 5.2.2.). Factors, along with some additional basic information on manure management systems in cattle production, are presented in Table 5.4.3.

Table 5.4.3 shows the emission factors and basic information on manure management systems for the calculation of NH<sub>3</sub>, N<sub>2</sub>O, NO and N<sub>2</sub> emissions in cattle production (Sources for emission factors: Menzi et al., 1997, EMEP/CORINAIR, 2013)

Table 5.4.3: Emission factors and basic information on manure management systems

		Tied housing system		Loose housing system
	Grazing	Farmyard* manure	Liquid* fraction (urine)	Slurry and anaerobic digesters
Proportion of TAN at the level of excretion (in kg/kg total N)*	0.60	0.30	0.70	0.60
<b>Basic information</b>				
Proportion of covered manure stores	/	0.00	0.90	0.50
Proportion of manure application in favourable weather conditions or immediate incorporation	/	0.20	0.20	0.20
Bedding material (kg per animal per year)	0	Cows: 730 kg Other cattle: 240 kg	0	0
N added in bedding (kg per animal per year)	0.00	Cows: 2,92 kg Other cattle: 0,96 kg	0.00	0.00
Mineralization of non-TAN N during storage (proportion of total non-TAN N)	/	0.00	0.00	0.10
Immobilization of TAN during storage (proportion of TAN)	/	0.0067	0.0000	0.0000
<b>Emission factors (kg NH<sub>3</sub>-N/kg TAN)</b>				
From animal houses or during grazing (proportion of excreted TAN)	Dairy cattle: 0.1 Other cattle: 0.06	0.190	0.200	0.200
Emissions from uncovered manure stores (proportion of TAN entering the stores)	/	0.270	0.200	0.200
Emissions from covered manure stores (proportion of TAN entering the stores)	/	/	0.040	0.040
Emissions due to manure application – basic coefficients (proportion of TAN leaving the stores)	/	0.790	0.550	0.550
Emissions due to manure application – coefficients for immediate manure incorporation or application in favourable weather conditions (proportion of TAN leaving the stores)	/	0.474	0.330	0.330
<b>Emission factors (kg N<sub>2</sub>O-N/kg TAN)</b>				
Emissions from manure stores (proportion of TAN entering the stores)	/	0.080	0.001	0.001
<b>Emission factors (kg NO-N/kg TAN)</b>				
Emissions from manure stores (proportion of TAN entering the stores)	/	0.0080	0.0001	0.0001
<b>Emission factors (kg N<sub>2</sub>-N/kg TAN)</b>				
Emissions from manure stores (proportion of TAN entering the stores)	/	0.300	0.003	0.003

\* in farmyard manure system it was taken into account that 0.43 of N was retained in solid and 0.57 in liquid fraction

### Emissions from animal housing, manure stores and due to fertilization with animal manures in pig production (CRF 3.B.3)

The estimated N excretion, which was estimated separately for breeding pigs and fattening pigs, was allocated to five manure management systems (slurry, farmyard manure, manure after slurry separation (solid), uncovered anaerobic lagoons and anaerobic digesters). The procedure which was used to estimate the distribution of entire herd into different manure management systems is described in chapter dealing with CH<sub>4</sub> emissions from manure management (Chapter 5.2.2.). Emission factors and some additional information, which is needed to estimate N losses throughout the manure management system, are presented in Table 5.4.4. Due the same emission factors, data for farmyard manure and solid fraction from slurry separation are presented within the same column.

**Table 5.4.4: Emission factors and basic information on manure management systems for the calculation of NH<sub>3</sub>, N<sub>2</sub>O, NO and N<sub>2</sub> emissions in pig production (Sources for emission factors: EMEP/CORINAIR, 2013, EPA, 2004)**

	Farmyard manure and solid*	Slurry	Anaerobic lagoon	Anaerobic fermenter
Proportion of TAN at the level of excretion (in kg/kg total N)*	0.70	0.70	0.70	0.70
<b>Basic information</b>				
Proportion of covered manure stores	0.00	0.50	0.00	1.00
Proportion of manure application in favourable weather conditions or immediate incorporation	0.20	0.20	/	0.20
Bedding material (kg per animal per year)	FP: 200 S: 600	0	0	0
N added in bedding (kg per animal per year)	FP: 0.8 S: 2.4	0	0	0
Mineralization of non-TAN N during storage (proportion of total non-TAN N)	0	0.1	1	0.1
Immobilization of TAN during storage (proportion of TAN)	0.0067	0.000	0.000	0.000
<b>Emission factors (kg NH<sub>3</sub>-N/kg N)</b>				
From animal houses (proportion of excreted TAN)	FP: 0.27 S: 0.25	FP: 0.28 S: 0.22	FP: 0.28 S: 0.22	FP: 0.28 S: 0.22
Emissions from uncovered manure stores (proportion of TAN entering the stores)	0.45	0.14	0.71	0.14
Emissions from covered manure stores (proportion of TAN entering the stores)	/	0.028	/	0.028
Emissions due to manure application – basic coefficients (proportion of TAN leaving the stores)	0.810	0.400	/	0.400
Emissions due to manure application – coefficients for immediate manure incorporation or application in favourable weather conditions (proportion of TAN leaving the stores)	0.486	0.240	/	0.240

<b>Emission factors (kg N<sub>2</sub>O-N/kg TAN)</b>				
Emissions from manure stores (proportion of TAN entering the stores)	FYM: 0.05 Solid: 0.08	0.00	0.00	0.00
<b>Emission factors (kg NO-N/kg TAN)</b>				
Emissions from manure stores (proportion of TAN entering the stores)	0.0080	0.0001	0.0001	0.0001
<b>Emission factors (kg N<sub>2</sub>-N/kg TAN)</b>				
Emissions from manure stores (proportion of TAN entering the stores)	0.300	0.003	0.290	0.003

\* solid fraction extracted from slurry during the separation process

Abbreviations: FP – Fattening pigs, S – Sows, FYM – farmyard manure

### Emissions from animal housing, manure stores and due to fertilization with animal manures in poultry production (CRF 3.B.4)

Emissions in poultry production were calculated as a sum of emissions for broilers, layers, ducks, turkeys and geese. For broilers, turkeys, geese and ducks exclusively floor system on bedding was assumed. For laying hens, excreta were distributed into the solid and liquid system as described in chapter dealing with CH<sub>4</sub> emissions from manure management (Chapter 5.2.2.). Layers which were assumed to be kept in floor system, in system where manure is collected under the batteries and in dung drying system were allocated to solid system. Layers, which were assumed to be kept in system where the manure is removed daily and stored in tanks, were allocated to liquid systems. Emission factors for poultry rearing are given in 5.4.5.

**Table 5.4.5: Emission factors for the calculation of NH<sub>3</sub>, N<sub>2</sub>O, NO and N<sub>2</sub> emissions in poultry production (Source for emission factors: EMEP/CORINAIR, 2013)**

	Laying hens - solid	Laying hens - liquid	Broilers	Ducks	Turkeys	Geese
Proportion of TAN at the level of excretion (in kg/kg total N)*	0.70	0.70	0.70	0.70	0.70	0.70
<b>Basic information</b>						
Proportion of manure application in favourable weather conditions or immediate incorporation	0.20	0.20	0.20	0.20	0.20	0.20
Bedding material (kg per animal per year)	0*	/	0*	0*	0*	0*
N added in bedding (kg per animal per year)	0*	/	0*	0*	0*	0*
Mineralization of non-TAN N during storage (proportion of total non-TAN N)	0.00	0.10	0.00	0.00	0.00	0.00



<b>Emission factors (kg NH<sub>3</sub>-N/kg N)</b>						
From animal houses (proportion of excreted TAN)	0.41	0.41	0.28	0.24	0.35	0.57
Emissions from manure stores (proportion of TAN entering the stores)	0.14	0.14	0.17	0.24	0.24	0.16
Emissions due to manure application – basic coefficients (proportion of TAN leaving the stores)	0.690	0.690	0.660	0.540	0.540	0.450
Emissions due to manure application – coefficients for immediate manure incorporation or application in favourable weather conditions (proportion of TAN leaving the stores)	0.414	0.414	0.396	0.324	0.324	0.270
<b>Emission factors (kg N<sub>2</sub>O-N/kg TAN)</b>						
Emissions from manure stores (proportion of TAN entering the stores)	0.040	0.000	0.030	0.030	0.030	0.030
<b>Emission factors (kg NO-N/kg TAN)</b>						
Emissions from manure stores (proportion of TAN entering the stores)	0.008	0.0001	0.008	0.008	0.008	0.008
<b>Emission factors (kg N<sub>2</sub>-N/kg TAN)</b>						
Emissions from manure stores (proportion of TAN entering the stores)	0.30	0.003	0.30	0.30	0.30	0.30

\* Sawdust; considered to contain no available N and to have no TAN immobilization potential

### **Emissions from animal housing, manure stores and due to fertilization with animal manures in small ruminants and horses and rabbits (CRF 3.B.2 and CRF 3.B.4)**

Nitrous oxide emissions in goats, sheep, horses and rabbits were estimated using the information presented in Table 5.4.6. Grazing and farmyard manure management system are typical for these species. The proportions of grazing animals were estimated by the means of expert opinion. The description and estimates are given in chapter dealing with CH<sub>4</sub> emissions (5.2.2.)

**Table 5.4.6: Emission factors and basic information on manure management systems for the calculation of NH<sub>3</sub>, N<sub>2</sub>O, NO and N<sub>2</sub> emissions in sheep, goats and horses (Source for emission factors: EMEP/CORINAIR, 2013)**

	Sheep	Goats	Horses	Rabbits
Proportion of TAN at the level of excretion (in kg/kg total N)*	0.50	0.50	0.60	0.50 <sup>a</sup>
<b>Basic information</b>				
Proportion of manure application in favourable weather conditions or immediate incorporation	0.20	0.20	0.20	0.20
Bedding material (kg per animal per year)	91	91	1460	3.65
N added in bedding (kg per animal per year)	0.365	0.365	5.84	0.015
Immobilization of TAN during storage (proportion of TAN)	0.0067	0.0067	0.0067	0.0067
<b>Emission factors (kg NH<sub>3</sub>-N/kg N)</b>				
From animal houses (proportion of excreted TAN)	0.22	0.22	0.22	0.22 <sup>a</sup>
During grazing (proportion of excreted TAN)	0.09	0.09	0.35	NA
Emissions from manure stores (proportion of TAN entering the stores)	0.280	0.280	0.350	0.28 <sup>a</sup>
Emissions due to manure application – basic coefficients (proportion of TAN leaving the stores)	0.090	0.090	0.090	0.090
Emissions due to manure application – coefficients for immediate manure incorporation or application in favourable weather conditions (proportion of TAN leaving the stores)	0.054	0.054	0.054	0.054
<b>Emission factors (kg N<sub>2</sub>O-N/kg TAN)</b>				
Emissions from manure stores (proportion of TAN entering the stores)	0.070	0.070	0.080	0.080 <sup>b</sup>
<b>Emission factors (kg NO-N/kg TAN)</b>				
Emissions from manure stores (proportion of TAN entering the stores)	0.008	0.008	0.008	0.008
<b>Emission factors (kg N<sub>2</sub>-N/kg TAN)</b>				
Emissions from manure stores (proportion of TAN entering the stores)	0.30	0.30	0.30	0.030

<sup>a</sup> There are no emission factors in EMEP/EEA emission inventory guidebook; values for sheep were used

<sup>b</sup> There are no emission factors in EMEP/EEA emission inventory guidebook; value for horses were used

#### 5.4.2.2 Indirect N<sub>2</sub>O emissions from manure management (CRF 3.B.5)

Indirect N<sub>2</sub>O emissions from manure management are associated with volatilization of ammonia (NH<sub>3</sub>) and nitric oxide (NO<sub>x</sub>). The amount of N which is lost in the form of above mentioned compounds was estimated simultaneously with direct N<sub>2</sub>O emissions using EMEP/CORINAIR (2013) methodology (Chapter 5.4.2.1). Emission factor 0.01 kg N<sub>2</sub>O-N per kg of volatilised N (NH<sub>3</sub>-N and NO<sub>x</sub>-N) was used, as suggested by IPCC (2006).

We have assumed that Indirect N<sub>2</sub>O emissions from manure management associated with leaching and run-off do not occur and notation key NO has been used. In Slovenia, storage of animal manures is regulated by a Decree on the protection of waters against pollution caused by nitrates from agricultural sources. The capacities of water tight stores are prescribed for liquid and solid manures, storage of farmyard manure in field heaps is prohibited. The implementation of decree is under inspection.

#### 5.4.3 Uncertainties and time-series consistency

Activity data consist of data on livestock populations, nitrogen excretion rates and MMS usage. The Nex has the larger contribution to the uncertainty of activity data. IPCC suggests that uncertainty range for default Nex is +/-50% but may be as low as 25%, if the country specific data about N intake and retention are available. In GHG inventory we are using other sources of Nex for cattle and swine which, we believe, better reflect the circumstances in Slovenia. It is expert judgment that overall uncertainty of AD in this category is 50%

Due to the use of IPCC default EF we have taken uncertainty estimates of 100% as suggested in the 2006 IPCC Guidelines.

Combined uncertainty amounts to 111.80%.

#### 5.4.4 Category-specific QA/QC

Besides QA/QC procedures described in the chapter 1.2.3 and 5.2.4, the following Tier 2 QA/QC procedures have been performed for the submission 2018:

- Manure management – N<sub>2</sub>O – Nex for cattle have been compared with IPCC default, and Nex for swine have been compared with values used by other countries

#### 5.4.5 Category-specific recalculations

Reviewers of the National Emission Inventory pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (NECD) suggested that emissions from rabbit production should be included into national inventory of atmospheric pollutants. With the intention to be consistent it was decided to report also nitrous oxide emissions from manure management in rabbits. It was done for the entire reporting period.

Statistical office released a new value for milk production in 2015. As a result, the estimated N excretion in dairy cows increased and consequently there was also an increase in nitrous oxide emissions from manure management.

Based on new farm structure data for 2016 estimates for manure management systems were corrected for years 2014 and 2015 (interpolation to last available data for 2013).

Reviewers of the NECD inventory recommended that N excretion rates, which were previously applied only to breeding female sheep and goats, should be applied also to other adult sheep/goat categories (barren animals, rams, he-goats). The recommendation was respected. As a result, the estimated N excretion in small ruminants increased and consequently there was also an increase in nitrous oxide emissions from manure management for the entire reporting period.

#### **5.4.6 Category-specific planned improvements**

No further improvements are planned for the next submission.

## 5.5 N<sub>2</sub>O Emissions from Agricultural Soils (CRF 3.D)

### 5.5.1 Overview of category

Two sources of N<sub>2</sub>O are distinguished in the IPCC methodology: direct N<sub>2</sub>O emissions from managed soils and indirect emissions from managed soils.

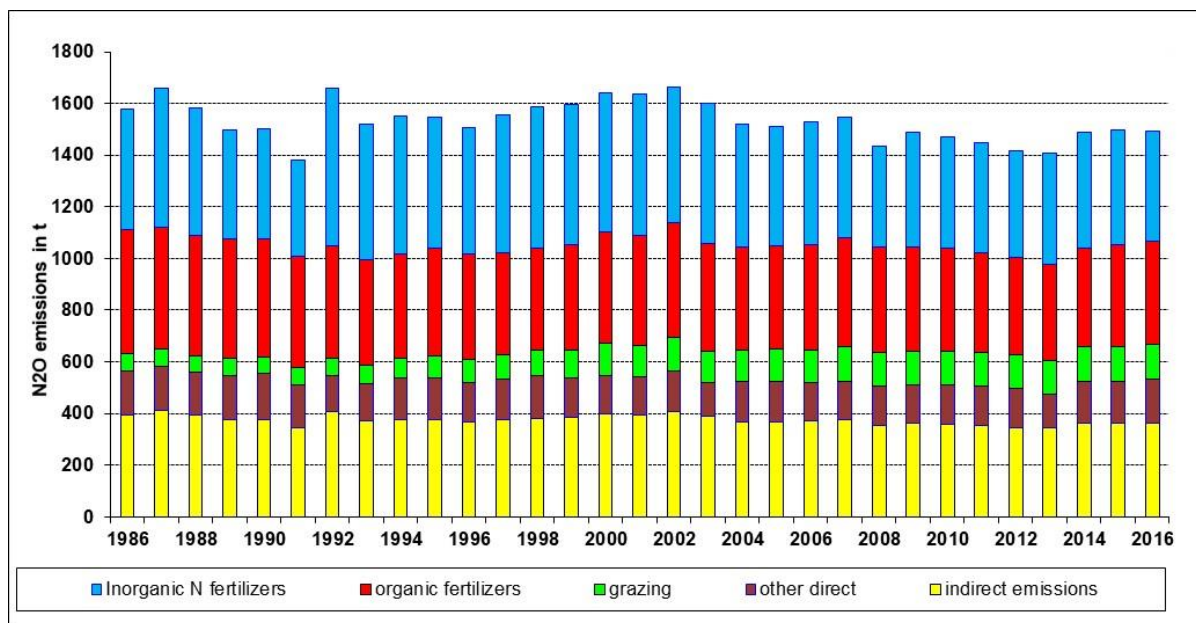


Figure 5.5.1: N<sub>2</sub>O emissions from agricultural soil in Gg.

### 5.5.2 Direct N<sub>2</sub>O Emissions from Managed Soils (CRF 3.D.a)

#### 5.5.2.1 Category description

Sources of nitrogen, causing direct emissions of nitrous oxide into the atmosphere, are the following (Figure 5.5.1):

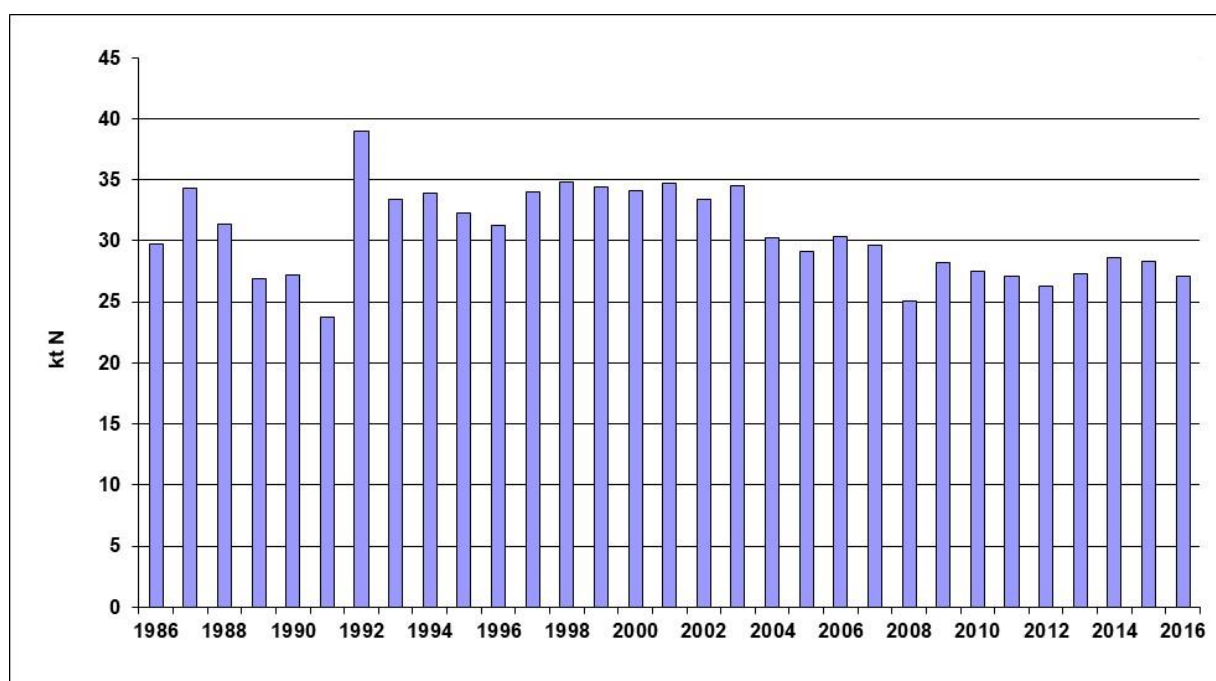
- mineral (inorganic) fertilizers;
- organic fertilizers, including animal manures and sewage sludge;
- urine and dung deposited by grazing animals;
- crop residues;
- mineralization of soil organic matter which is associated with land use change or management of mineral soils;
- management of organic soils.

### 5.5.2.2 Methodological issues

#### Inorganic N fertilizers (CRF 3.D.a.1)

This estimate is based on the amount of N in mineral fertilizers that are annually consumed in Slovenia. The consumption of nitrogen from mineral fertilizers on agricultural soil in Slovenia has been obtained from the Statistical Yearbook.

SORS collect data on fertilisers used in enterprises, companies and co-operatives involved in crop production. Likewise, they are taking into account the data on import, export, and production. The difference between all fertilizers sold in this country and the amount used by enterprises is the consumption of mineral fertilizers on family farms. Fertilizers that are not appropriate for agricultural production (mineral fertilizers for balcony flowers, lawns and similar) are not included.



**Figure 5.5.2: Amount of mineral fertilizers in kt N.**

From 1987-1991 on the Figure 5.5.2, use of fertilizers shows constant decrease and a sharp increase in 1992 – the amount of fertilizers used in 1992 is the highest in the whole reporting period. One of the reasons is reduction in industrial production, poor economic situation and war for independence in 1991. In 1992, Slovenia became independent and economic situation started to improve. It is very likely that farmers did not use all fertilizers in the year 1992, had just renewed their stocks. The consumption of N fertilizers per hectare of utilised agricultural area in was decreasing from 2001 to 2008. The decrease is, among others, attributable also to measures of Rural Development Programme which stimulates the expert based use of fertilizers. Consumption of N fertilizers decreased drastically in 2004 and in 2008. The main reasons for 2008 decrease was a considerable increase in mineral fertilizer price and consequently much lower use of fertilizers in agriculture.

The emission of nitrous oxide was calculated according to the Tier 1 method according to IPCC (2006) methodology. The emission factor 0.01 kg N<sub>2</sub>O-N per kg of consumed N was applied.

It has to be stressed that amounts of applied N were no longer adjusted for the amounts of  $\text{NH}_3$  and  $\text{NO}_x$  volatilization after application to soil, which was required by IPCC (1996) methodology.

### **Organic N fertilizers (CRF 3.D.a.2)**

#### **a. Animal manure applied to soils (CRF 3.D.a.2.a)**

The estimate is based on the amount of N in animal manures which is annually applied to agricultural area. The amount of N in the manure applied to soil has been calculated on the basis of methodology described in Chapter 5.4 ( $\text{N}_2\text{O}$  Emissions from Manure Management). To get the amount of nitrogen in animal manures, nitrogen excreted by grazing animals and nitrogen which was lost from animal houses and manure stores ( $\text{NH}_3$ ,  $\text{NO}_x$ ,  $\text{N}_2\text{O}$  and  $\text{N}_2$ ) were subtracted from the total amount of N excreted by farm animals. The emissions were estimated according to the Tier 1 method given by IPCC (2006). The emission factor of 0.01 kg  $\text{N}_2\text{O}$ -N per kg N i animal manure was used (IPCC, 2006). Similar as in case of mineral fertilizers, the N in animal manure were no longer adjusted for nitrogen which is lost after application to soil, as required by IPCC (1996) methodology.

#### **b. Sewage sludge applied to soils (CRF 3.D.a.2.b)**

Due to the very rigorous restrictions, fertilisation with sewage sludge in Slovenia is extremely low. Historical information on its use is also scarce. Data on sewage sludge deposited to agricultural area for years 1995 and 1998 were obtained from environmental reports. It was assumed that the amount of sewage sludge from waste water treatment plants during the period 1986- 1994 was equal to that in 1995 and that the same percent (30%) of sewage sludge have been deposited to agricultural area. Since 2000, data on sewage sludge applied to agricultural soils have been regularly obtained from the Slovenian reports prepared under the Sewage sludge directive. The data provider was the Environment Agency of the Republic of Slovenia. Values for 1996, 1997 and 1999 have been interpolated.

As data on N concentration in sewage sludge are not available in Slovenia, the value of 3.9 per cent N in dry matter has been taken from Austrian GHG inventory submission 2010. The emission factor of 0.01 kg  $\text{N}_2\text{O}$ -N per kg of N in sewage sludge (IPCC, 2006) was used to calculate the emissions. The amount of N in sewage sludge was not adjusted for nitrogen which was lost after application to soil.

#### **c. Other organic fertilizers applied to soils (CRF 3.D.a.2.c)**

It was estimated that fertilization with other organic fertilizers is not practiced in considerable quantities. Emissions were supposed to be zero.

### **Urine and dung deposited by grazing animals (CRF 3.D.a.3)**

The estimate is based on the amount of N deposited to soils by grazing animals. This amount has been calculated on the basis of methodology described in Chapter 5.4 ( $\text{N}_2\text{O}$  Emissions from Manure Management). The values were not corrected for ammonia N which was lost from the grazing areas. In line with IPCC (2006) methodology, emission factor 0.02 kg  $\text{N}_2\text{O}$ -N per kg of deposited N was used for cattle and 0.01 kg  $\text{N}_2\text{O}$ -N per kg of deposited N for sheep, goats and horses.

### Crop residues (CRF 3.D.a.4)

A considerable source of emissions of nitrous oxide into atmosphere is nitrogen from crop residue mineralization that remains or is returned to soil. The amount of crop residues were estimated on the basis of data on the production of individual field crops and fodder plants, including grassland forages.

**Table 5.5.1: Default factors for estimation of N added to soils from crop residues as applied in national inventory (Source: IPCC, 2006)**

Crop	Dry matter fraction of harvested crop	Above-ground residue dry matter (AG <sub>DM</sub> ) (t) AG <sub>DM</sub> = Crop (t, in DM) × slope + intercept		N conc. in above ground residues (N <sub>AG</sub> )	Ratio of below-ground residues to above-ground biomass (R <sub>BG-BIO</sub> )	N conc. in below-ground residues (N <sub>BG</sub> )
		Slope	Intercept			
Cereals						
Wheat	0.89	1.51	0.52	0.006	0.24	0.009
Rye	0.88	1.09	0.88	0.005	0.24 <sup>1</sup>	0.011
Barley	0.89	0.98	0.59	0.007	0.22	0.014
Oats	0.89	0.91	0.89	0.007	0.25	0.008
Maize for grains	0.87	1.03	0.61	0.006	0.22	0.007
Triticale	0.88 <sup>2</sup>	1.09 <sup>2</sup>	0.88 <sup>2</sup>	0.005 <sup>3</sup>	0.24 <sup>1</sup>	0.011 <sup>3</sup>
Buckwheat	0.88 <sup>2</sup>	1.09 <sup>2</sup>	0.88 <sup>2</sup>	0.006 <sup>1</sup>	0.24 <sup>1</sup>	0.009 <sup>1</sup>
Dried pulses						
Field peas	0.91	1.13	0.85	0.008	0.19	0.008
Kidney beans	0.91	1.13	0.85	0.008	0.19	0.008
Other dried pulses	0.91	1.13	0.85	0.008	0.19	0.008
Root crops						
Potatoes	0.22	0.10	1.06	0.019	0.20	0.014
Sugar beet	0.22	0.10	1.06	0.025 <sup>4</sup>	0.20	0.014
Fodder beet	0.22	0.10	1.06	0.025 <sup>4</sup>	0.20	0.014
Other fodder roots	0.22	0.10	1.06	0.025 <sup>4</sup>	0.20	0.014
Industrial crops						
Rapeseed	0.88 <sup>2</sup>	1.09 <sup>2</sup>	0.88 <sup>2</sup>	0.006 <sup>2</sup>	0.24 <sup>1</sup>	0.009 <sup>2</sup>
Sunflower seed	0.88 <sup>2</sup>	1.09 <sup>2</sup>	0.88 <sup>2</sup>	0.006 <sup>2</sup>	0.24 <sup>1</sup>	0.009 <sup>2</sup>
Soya bean	0.91	0.93	1.35	0.008	0.19	0.008
Fodder crops						
Green maize (silage)	Above-ground residue considered to be 0, below ground supposed to be the same as in maize for grain					
Other annual green fodder	0.20 <sup>4</sup>	0.30	0	0.015	0.54	0.012
Leguminous plants	0.88 <sup>4</sup>	0.30	0	0.025	0.80	0.016
Grasslands						
Temporary grassland	0.88 <sup>4</sup>	0.30	0	0.015	0.80	0.012
Permanent grassland	0.88 <sup>4</sup>	0.30	0	0.015	0.80	0.012

<sup>1</sup> Value for wheat; <sup>2</sup> Value for grains; <sup>3</sup> Value for rye; <sup>4</sup> National estimate.



The ratios between the edible (usable) crop part, which is reported by SORS, and part which remains on the fields were taken into account. Yields of the above-ground residue dry matter ( $AG_{DM}$ ) were estimated by the use of equations presented in Table 5.5.2 (equations according to IPCC, 2006). Yields of below-ground residues were calculated by taking into account the ratio of below-ground residues to above-ground biomass ( $R_{BG-BIO}$ ). Finally, the amount of N in crop residues was estimated by multiplying the total amount of above- and below-ground biomass (expressed on DM basis) and respective N concentrations in residues (Table 5.5.1).

For temporary grasses fraction of area which is renewed annually was considered to be 1/3. IPCC methodology envisages that crop residues that are used for other purposes have to be subtracted from the total amount of crop residue. No such correction has been applied for national inventory of  $N_2O$  emissions. In Slovenia crop residues from cereals are mainly used for bedding. In assessment of  $N_2O$  emissions from manure management N in bedding materials was not added to N excreted by farm animals. Therefore, it was not subtracted here. It has also been estimated that burning of crop residues is negligible.

To calculate emissions of nitrous oxide, the same emission factor as for other N sources (mineral and organic fertilizers, grazing, sewage sludge) (0.01 kg  $N_2O$ -N/kg N, IPCC, 2006) has been applied.

### **Mineralization/immobilization associated with loss/gain of soil organic matter (CRF 3.D.a.5)**

For estimation of indirect  $N_2O$  emissions from managed soils arising from N mineralization due to change of land use or management on mineral soils through leaching/runoff were estimated by applying Tier 2 method (equation 11.8) and default emission factors being available in Table 11.1 of IPCC 2006 Guidelines (0.01 kg  $N_2O$ -N/kg N, IPCC, 2006). Data on annual loss of soil organic carbon in tonnes of C have been taken from the LULUCF sector. Value for R (C:N ratio) was also IPCC default (15 for situations involving land-use change from FL and GL to CL and 10 for management changes on Cropland remain Cropland).

### **Cultivation of organic soils (CRF 3.D.a.6)**

Cultivation of soils with high contents of organic material (histosols) causes a release of a long-term bound N. Just like other N sources, mineralized N is considered to be available for  $N_2O$  formation. Nitrous oxide emissions were estimated on the basis of area of cultivated soils and default IPCC (2006) emission factor for temperate organic soils (8 kg  $N_2O$ -N per ha). The cultivated organic soil area has been obtained by covering two maps. Spatial information on the area of organic soils has been obtained from the Pedology map (1:25000) and information on land use has been obtained from the database of Ministry for Agriculture, Forestry and Food (Use of utilized agricultural area, 1:5000). Cultivated area was defined as a sum of two land categories, Fields and gardens (Code 1100) and Intensive orchards (Code 1221). Data for both categories exist from the year 1997 onwards. The data for the period 2000-2006 have been extrapolated on the basis of 2007-2013 series. For the period 1986-1999 the same values as for the year 2000 were used.

Detailed data about the area of cultivated organic soil and resulting N<sub>2</sub>O emissions are presented in Table 5.5.2.

**Table 5.5.2: Area of cultivated organic soil (in ha) and N<sub>2</sub>O emissions (in tons)**

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Area	2096	2096	2096	2096	2096	2096	2096	2096	2096	2096	2096
N <sub>2</sub> O	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2005	2006
Area	2096	2096	2096	2096	2116	2136	2156	2177	2197	2197	2217
N <sub>2</sub> O	26.3	26.3	26.3	26.3	26.6	26.9	27.1	27.4	27.6	27.6	27.9
	2007	2008	2009	2010	2011	2012	2012	2013	2014	2015	2016
Area	2254	2251	2266	2277	2343	2347	2347	2352	2497	2498	2498
N <sub>2</sub> O	28.3	28.3	28.5	28.6	29.5	29.5	29.5	29.6	31.4	31.4	31.4

### 5.5.3 Indirect N<sub>2</sub>O Emissions from Managed Soils (CRF 3.D.b)

#### 5.5.3.1 Category description

Indirect N<sub>2</sub>O emissions are caused by atmospheric deposition of volatilised N and by leaching/runoff of N compounds into waters. They are associated with volatilization of ammonia (NH<sub>3</sub>) and nitric oxide (NO<sub>x</sub>) from managed soils and with the leaching and runoff of nitrogen from agricultural soils into waters. Sources of nitrogen, causing indirect emissions of nitrous oxide into the atmosphere, are the following:

- mineral (inorganic) fertilizers;
- organic fertilizers, including animal manures and sewage sludge;
- urine and dung deposited by grazing animals;
- crop residues;
- mineralization of soil organic matter which is associated with land use change or management of mineral soils.

Emissions associated with volatilization of ammonia (NH<sub>3</sub>) and nitric oxide (NO<sub>x</sub>) from animal houses and manure stores are reported under the category "3B Manure management".

Indirect N<sub>2</sub>O emissions from managed soils are presented within 2 sub-categories:

- Atmospheric deposition
- Nitrogen leaching and run-off.

#### 5.5.3.2 Methodological issues

##### Atmospheric deposition (3Db1)

In fertilizing agricultural soils with nitrogen fertilizers, some N volatilises in form of ammonia and nitrogen oxides (NO<sub>x</sub>). This nitrogen is deposited by precipitation and particulate matter on agricultural soil, in natural terrestrial ecosystems and waters and thus indirectly contributes to emissions of N<sub>2</sub>O. Emissions are attributed to the place of origin of ammonia and NO<sub>x</sub>, not to the place where N is re-deposited, causing N<sub>2</sub>O emissions.

a. Mineral fertilizers applied to soils

Indirect emissions of nitrous oxide from mineral fertilizers depend to a large extent on the fraction of N that volatilises during fertilizing. Ammonia and NO<sub>x</sub> emissions due to use mineral fertilizers were assessed according to EMEP/CORINAIR (2016) methodology. Ammonia emissions were obtained by multiplying data on consumption of nitrogen from mineral fertilizers and emission factors for three main groups of fertilizers. Emission factors 0,008, 0,155 and 0,050 kg NH<sub>3</sub>-N per kg of N were used for calcium ammonium nitrate (CAN), urea and other mineral (NP and NPK) fertilizers respectively. For the year 2016 it was taken into account that low emission application techniques are used on 8,8 % of arable land. It was considered that 60% of urea is used on arable land and that urea incorporation reduces ammonia emissions by 50 %. The decision was made on the basis of the fact that investments in machinery which enables urea incorporation are supported by the Rural development programme. For the total amount of N in mineral fertilizers the same data as for direct N<sub>2</sub>O emissions were used. In addition, data for urea consumption for the period 1994-2015 were obtained from SORS (personal communication, data not officially published). For the period 1985-1993 the proportion of urea in total mineral-N fertilizer consumption was estimated by extrapolation based on 1994-2013 period. The allocation of the rest of mineral-N fertilizes between CAN and other (NP and NPK) fertilizers was done on the basis of expert judgement (50:50). NO<sub>x</sub> emissions were calculated by the use of an uniform emission factor, i.e. 0.040 kg NO per kg of N applied in form of synthetic fertilizers was used (EMEP/CORINAIR, 2016). For calculating indirect emissions of nitrous oxide, the emission factor of 0.01 kg N<sub>2</sub>O-N/kg NH<sub>3</sub> and NO<sub>x</sub>-N (IPCC, 2006) has been considered.

b. Animal manure applied to soils (CRF 3.D.a.2.a)

Numerous factors influence the fraction of volatilised N in form of ammonia and nitrogen oxides from agricultural soils. They include the losses of N from the preceding phase (animal houses and manure stores), as well as form of animal manure (farmyard manure or slurry) and the manner of application (splashing plate, incorporation, ...). In estimating N volatilization due to application of animal manures to agricultural soils, all these factors were taken into account. Estimates of NH<sub>3</sub> loses were done simultaneously with direct N<sub>2</sub>O emissions from manure management using EMEP/CORINAIR (2013) methodology (Chapter 5.4.2.1). For emissions of NO<sub>x</sub>, emission factor 0.040 kg NO per kg of nitrogen, which is applied to soil in form of animal manures, was used (EMEP/CORINAIR, 2016). In the second stage, emission factor 0.01 kg N<sub>2</sub>O-N per kg of volatilised N (NH<sub>3</sub>-N and NO<sub>x</sub>-N) was used to asses N<sub>2</sub>O emissions, as suggested by IPCC (2006).

c. Sewage sludge applied to soils

The same data on sewage sludge application to the agricultural soils have been used for estimation of indirect N<sub>2</sub>O emissions as for direct ones. The amount of nitrogen which is volatilised into air was assessed according to EMEP/CORINAIR (2013) methodology. There are no default emission factors for ammonia which is emitted due to application of sewage sludge. As a first approximation, emission factor for solid pig manure was used, as suggested by EMEP/CORINAIR (2013) (0.81 kg of ammonia nitrogen per kg of total ammonia nitrogen applied by sewage sludge). It was taken into account that 0.70 of total sewage sludge nitrogen is in the form of ammonia (data for solid pig manure; EMEP/CORINAIR, 2013). For emissions

of  $\text{NO}_x$ , emission factor 0.040 kg NO per kg of nitrogen, which is applied to soil in form sewage sludge, was used (EMEP/CORINAIR, 2016).

In the second stage, emission factor 0.01 kg  $\text{N}_2\text{O}$ -N per kg of volatilised N ( $\text{NH}_3$ -N and  $\text{NO}_x$ -N) was used to assess  $\text{N}_2\text{O}$  emissions, as suggested by IPCC (2006).

d. Urine and dung deposited by grazing animals

Estimates on the amount of  $\text{NH}_3$ -N which is volatilized from grazing areas due to N deposited by grazing animals were done simultaneously with direct  $\text{N}_2\text{O}$  emissions using EMEP/CORINAIR (2013) methodology (Chapter 5.4.2.1). For emissions of  $\text{NO}_x$ , emission factor 0.040 kg NO per kg of nitrogen, which is deposited to soil in by grazing animals, was used (EMEP/CORINAIR, 2016). In the second stage, emission factor 0.01 kg  $\text{N}_2\text{O}$ -N per kg of volatilised N ( $\text{NH}_3$ -N and  $\text{NO}_x$ -N) was used to assess  $\text{N}_2\text{O}$  emissions, as suggested by IPCC (2006).

## **Nitrogen leaching and run-off (CRF 3.D.b.2)**

The nitrogen that enters groundwater and watercourses, mainly in the form of nitrates, is there subjected to nitrification and denitrification. This gives rise to some nitrous oxide, which is diffused into the atmosphere. Denitrification takes place mostly in groundwater, riverine sediments, and estuarine sediments. Nitrogen, which enters watercourses, contributes to emissions of nitrous oxide also during the course of nitrification. Algae and aquatic plants assimilate nitrates into organic matter, which, during decomposition, releases ammonia that is quickly nitrified in rivers, giving rise to some nitrous oxide in the process.

a. Mineral fertilizers applied to soils

It has been considered that 30% of total N from mineral fertilizers are leached and run-off into the groundwater and watercourses. In calculating emissions of nitrous oxide, it has been considered that for every kg of leached/run-off nitrogen, 0.0075 kg of  $\text{N}_2\text{O}$ -N is emitted (IPCC, 2006).

b. Animal manure applied to soils

It has been considered that for every kg of N, which is applied to agricultural area, 0.3 kg of N is leached and run-off to watercourses and groundwater (IPCC, 2006). To get the amount of N applied to agricultural area, total amount of nitrogen excreted by housed farm animals has been corrected for the amount of  $\text{NH}_3$ -N,  $\text{N}_2\text{O}$ -N and  $\text{N}_2$  losses from animal houses and manure stores. The methodology of estimating annual quantities of N, which is applied to agricultural area, has already been described under Chapter 5.4.2.1. In calculating emissions of nitrous oxide, the same emission factor has been considered as in the case of nitrogen leaching/run-off due to mineral fertilizers (0.0075 kg  $\text{N}_2\text{O}$ -N/kg of leached/run-off N) (IPCC, 2006).

c. Sewage sludge applied to soils

Emissions of N<sub>2</sub>O which resulted from leaching and run-off of nitrogen applied by sewage sludge was estimated by the use of same methodology as for animal manures. It has been considered that 0.3 kg per kg of applied N was lost into waters. Nitrous oxide emissions were then obtained by default factor 0.0075 kg N<sub>2</sub>O-N per kg of leached/run-off N (IPCC, 2006).

d. Urine and dung deposited by grazing animals

Emissions of N<sub>2</sub>O which resulted from leaching and run-off of nitrogen deposited to agricultural soils by grazing animals were estimated on the basis of deposited N using the fraction of deposited N that is lost through leaching/run-off (0.3 kg per kg) and default emission factor 0.0075 kg N<sub>2</sub>O-N per kg of leached/run-off N (IPCC, 2006). The amount of nitrogen deposited to agricultural soils by grazing animals was estimated as described in chapter dealing with manure management (Chapter 5.4.2.1).

e. Crop residues

Emissions of N<sub>2</sub>O which arise from leaching and run-off of nitrogen as a result of crop residue mineralization were estimated by the use of same approach as for other N sources. The methodology for estimation of N in crop residues is given in chapter on Direct N<sub>2</sub>O Emissions from Managed Soils (5.5.2.). It has been taken into account that 0.3 kg of N per kg of released N from crop residues is lost into waters. Emission factor 0.0075 kg N<sub>2</sub>O-N per kg of leached/run-off N was used to calculate N<sub>2</sub>O emissions (IPCC, 2006).

f. Mineralization of soil organic matter which is associated with land use change or management of mineral soils

Emissions of N<sub>2</sub>O which arise from leaching and run-off of nitrogen as a result of mineralization of soil organic matter in mineral soils has been estimated as suggested by IPCC (2006). It has been taken into account that 0.3 kg of mineralized N is lost into waters. Emission factor 0.0075 kg N<sub>2</sub>O-N per kg of leached/run-off N was used to calculate emissions (IPCC, 2006).

**5.5.3.3 Uncertainties and time-series consistency**

Uncertainty estimates are based on expert judgement.

Uncertainty of activity data amounts to 50%.

Uncertainty of emission factor amounts to 100%.

Combined uncertainty amounts to 111.80%.

**5.5.3.4 Category-specific QA/QC and verification**

Besides QA/QC procedures described in the chapter 1.2.3 no additional QA/QC has been performed.

### 5.5.3.5 Category-specific recalculations

Difference between the latest and previous submissions results from difference in direct and indirect emissions due to application of animal manures. It is a consequence of new animal category which was introduced into inventory (rabbits) and a consequence of changes in nitrogen excretion in small ruminants. In the year 2015 a difference was also due to a new value for milk production which resulted in slightly higher estimates for nitrogen excretion in dairy cows.

Followed the recommendations of reviewers of NECD inventory EMEP/EEA 2013 ammonia emission factors for urea, CAN and other mineral fertilizers were replaced by EMEP/EEA 2016 factors. It resulted in new estimates of indirect nitrous oxide emissions due to volatilization of N compounds from the use of synthetic fertilizers for the entire reporting period.

Due to new estimates of loss/gain of soil organic matter for the entire reporting period there was a change in indirect nitrous oxide emissions which result from mineralization/immobilization of N compounds in soils.

### 5.5.3.6 Category-specific planned improvements

No improvements are planned for the next submission.

## 5.6 Liming (CRF 3.G)

### 5.6.1 Category description

Emissions due to liming of arable lands are not a key source of CO<sub>2</sub> emissions in Slovenia. Liming occurs on agricultural land, particularly on arable land to keep the soil pH near to neutral, while amount of lime applied on grassland is very limited or negligible. There are no data available on areas, where liming is being applied. This is also the reason why disaggregation of liming being applied to croplands and grasslands is currently impossible. There is no information to provide separate estimation on the amount of lime and dolomite application. Therefore, default emission factor for limestone was used in the emission estimation.

### 5.6.2 Methodological issues

There is no detailed data of limestone application in Slovenia. However, expert judgement for the period 1986 to 1994 assumed that 100,000 Mg per year of limestone was applied on agricultural land.

In Slovenia, in the period from 1973 to 1991 drainage systems had been built on approximately 72,000 hectares of land, what represent more than 10 % of used agricultural land at that time. On figure 5.6.1 the area of individual agricultural operations in different time periods is represented. The red columns indicate drainage and yellow columns indicate agromeliorations. The latter are agricultural operations, which improve the physical, chemical and biological

properties of the soil. Due to high soil acidity after reclamation from wetlands (pH is usually below 4.5) the liming is a necessary measure to improve soil fertility. The land reclamation had been the largest in the period 1986-1990 when on average around 6000 ha of land have been reclaimed from the wetlands each year. Liming was carried out with coarsely ground limestone in large quantities (even 15 t/ha). Approximately 80,000 to 90,000 tons of limestone have been used on reclaimed land each year and around 10,000 to 20,000 tonnes were used on other agricultural land.

In 1991 the construction of large drainage systems has been suspended with the adoption of a moratorium on the hydromeliorations. The reason for the adoption of the moratorium was mainly the increase of the ecological awareness, focus on the conservation of wetlands, which are among the most endangered and rare ecosystems in Europe and worldwide

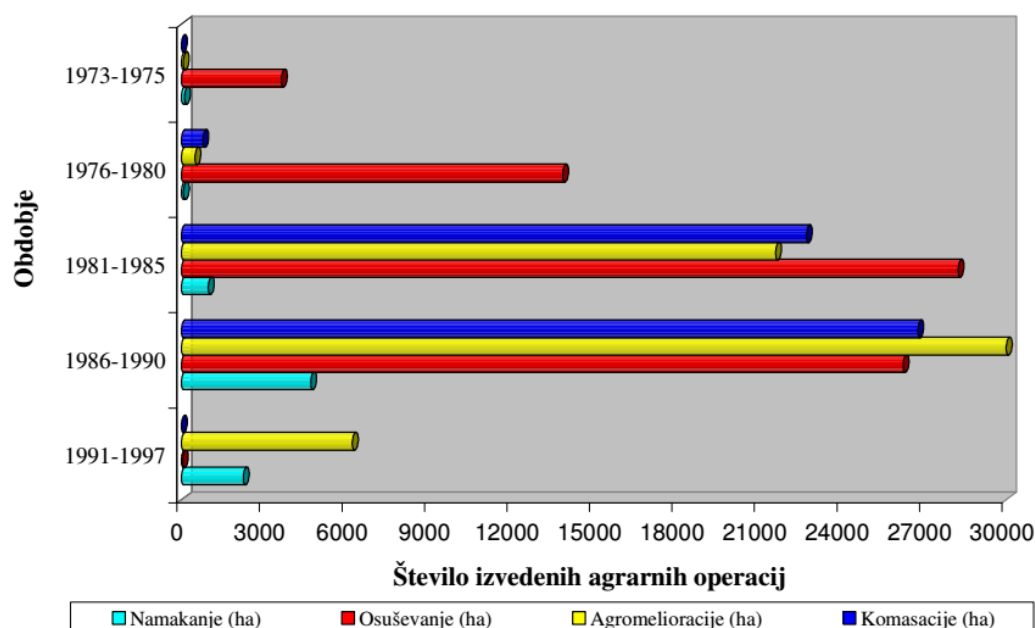


Figure 5.6.1: Area in hectares of different agricultural operations (irrigation-blue, drainage-red, agromelioration-yellow, land consolidation-blue), source: Miličič, 2007

Based on 2015 data that was obtained from the main lime producers in Slovenia and surrogate method, the estimates were provided for the period 1996-2015. Land use areas of agricultural holdings and GDP in agriculture were used as proxy data to apply the surrogate method (IPCC 2006).

Default emission factor ( $EF = 0.12$ ) for limestone was adopted from the 2006 IPCC Guidelines.

For calculations of emissions due to liming Tier 1 methodology and equation 11.12 of the 2006 IPCC Guidelines were used.

$$CO_2 - C \text{ Emissions} = (M_{\text{Limestone}} \bullet EF_{\text{Limestone}}) + (M_{\text{Dolomite}} \bullet EF_{\text{Dolomite}})$$

$CO_2 - C \text{ Emissions}$  – annual C emissions from lime application [ $t \text{ C yr}^{-1}$ ]

$M$  – annual amount of calcic limestone or dolomite [ $t \text{ yr}^{-1}$ ]

$EF$  – emission factor (default value 0.12)

### 5.6.3 Uncertainties and time-series consistency

The uncertainty estimates are based on an expert judgment.

The uncertainty of the activity data amounts to 25%.

The uncertainty of the emission factor amounts to 25%.

### 5.6.4 Category-specific QA/QC

No category-specific QA/QC were provided in this year's submission. However, general QA/QC, considering the figures check, correctness of the calculation used, data sources etc., were performed in the category, as it was subject to source specific recalculation.

### 5.6.5 Category-specific recalculations

Activity data, i.e. amounts of limestone for the period 1995 onwards were recalculated as follows; data on limestone production for the year 2015 (24,500 tons in total) were obtained from the major three limestone producers, which presumably produce over 90% of limestone in Slovenia. Since no other data on limestone are available, we obtain data on land use areas of agricultural holdings and GDP in agriculture. GDP per area unit, based on the newest data of Statistical Office of the Republic of Slovenia (2017 database), was then used to calculate the missing values considering the surrogate method.

### 5.6.6 Category-specific planned improvements

For future inventory reporting it is planned to establish an improved methodology for assessment of liming C emissions. Additional data, which will serve as proxy to complement the time series or to verify estimates will be gathered (e.g. sales records). In the future we plan to provide external independent review by the competent institution/expert to assure higher level of QA/QC reporting. In 2017, the Ministry of Agriculture, Forestry and Food prepared a questionnaire about grassland management, including the liming. Around 1,000 surveys were carried out through public tender, however the results have not been published. In 2018, the similar survey is planned for cropland, also taking into account the liming issues (amount, areas). The results will be used in the next annual submissions.



## **5.7 Urea application (CRF 3.H)**

### **5.7.1 Category description**

Adding urea to soils during fertilisation leads to a loss of CO<sub>2</sub>. This source category is included because the CO<sub>2</sub> removal from the atmosphere during urea manufacturing is estimated in the IPPU Sector.

### **5.7.2 Methodological issues**

Emissions have been calculated using Tier 1 approach and IPCC default EF of 0.20 for carbon emissions have been used. This is the absolute maximum emissions associated with urea fertilization.

Data on urea applied on the agriculture soils has been obtained from the SORS

### **5.7.3 Uncertainties and time-series consistency**

The uncertainty estimates are based on an expert judgement.

The uncertainty of activity data amounts to 10%.

The uncertainty of emission factor amounts to 20%.

### **5.7.4 Category-specific QA/QC and verification**

Besides QA/QC procedures described in the chapter 1.2.3 no additional QA/QC has been performed.

### **5.7.5 Category-specific recalculations**

No recalculations have been performed for this category.

### **5.7.6 Category-specific planned improvements**

No improvements are planned for the next submission.

## 6 LULUCF (CRF sector 4)

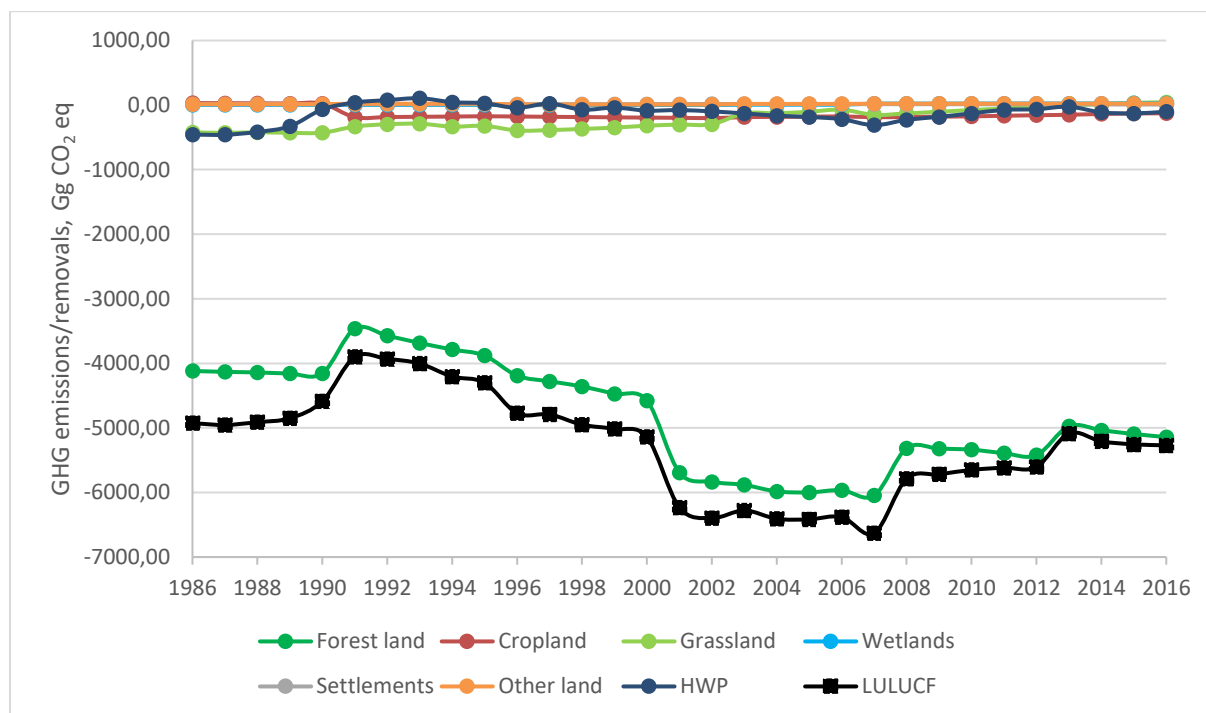
### 6.1 Overview of sector

The land use, land-use change, and forestry (LULUCF) sector deals with greenhouse gas (GHG) emissions and removals resulting from land use and land-use changes. According to 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006, hereinafter 2006 Guidelines) Slovenia classifies its national land into 6 land-use categories; Forest land, Cropland, Grassland, Wetlands, Settlements and Other land. GHG emission and removal estimates in this sector are calculated from carbon stock changes in the five carbon pools, namely aboveground biomass, belowground biomass, deadwood, litter and soil. The reporting also includes emissions associated with N<sub>2</sub>O emissions from drainage of soils, direct and indirect N<sub>2</sub>O emissions from N mineralization associated with loss of soil organic matter resulting from change of land use, and non-CO<sub>2</sub> emissions from biomass burning. In addition, GHG emissions and removals calculated from carbon stock changes in harvested wood products (HWP) are also reported. Direct N<sub>2</sub>O emissions from N fertilization and CO<sub>2</sub> emissions from liming agricultural soils are reported in the Agriculture sector.

**Table 6.1.1: Methods, EFs used and key categories indications for the year 2016 in the LULUCF sector**

		CO <sub>2</sub>		
		Method	EF	Key category
A. Forest land	1. Forest land remaining Forest land	CS,D,T1,T2,T3	CS, D	L,T
	2. Land converted to Forest land	CS,D,T1,T2,T3	CS, D	L, T
B. Cropland	1. Cropland remaining Cropland	D,T1,T2	CS, D	L
	2. Land converted to Cropland	D,T1,T2	CS, D	T
C. Grassland	2. Land converted to Grassland	D,T1,T2	CS, D	T
D. Wetlands	2. Land converted to Wetlands	D,T1,T2	CS, D	-
E. Settlements	2. Land converted to Settlements	D,T2	CS,D	-
F. Other land	2. Land converted to other land	D,T2	CS,D	-
G. Harvested wood products		D, T1	D	L, T
		CH <sub>4</sub>		
		Method	EF	Key category
A. Forest land	1. Forest land remaining Forest land	D, T1	D	-
		N <sub>2</sub> O		
		Method	EF	Key category
A. Forest land	1. Forest land remaining Forest land	D, T1	D	-
B. Cropland	2. Land converted to Cropland	D,T1	D	-

The Land Use, Land-Use Change and Forestry (LULUCF) sector in 2016 as a whole acted as a CO<sub>2</sub> sink of -4,989.79 Gg CO<sub>2</sub> eq because total emissions arising from the sector were smaller than the total removals (Figure 6.1.1).



**Figure 6.1.1: Net emissions and removals in the LULUCF sector in 1986-2016 by land-use category, Gg CO<sub>2</sub> eq**

For this inventory, above- and belowground biomass are referred to collectively as “living biomass”, and deadwood and litter collectively as “dead organic matter”. Data acquisition and calculations are based on the 2006 Guidelines and are completed by country-specific methodologies.

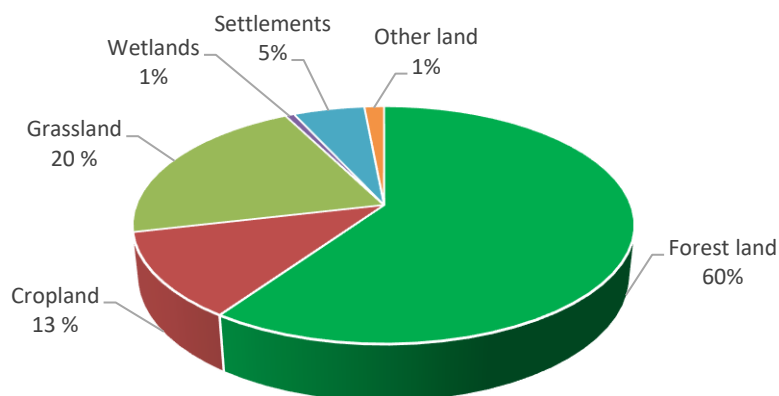
Country-specific emission factors and carbon stock values for forest lands and partially for cropland and grassland are derived from surveys and measurements and were used whenever possible. For other land use categories, IPCC default values or expert judgements are used.

Areas of all land uses in reporting year are presented in Table 6.1.2, while the structure of land use in Slovenia in the year 2016 in Figure 6.1.2.

**Table 6.1.2: Land use by categories in year 2016**

Category	Area, kha
Forest land	1206.25
Cropland	255.87
Grassland	399.30
Wetlands	14.68
Settlements	118.98
Other land	32.22
Sum	2027.30

Table 6.1.3 summarizes the CO<sub>2</sub> emissions and removals in consequence of carbon losses and gains for the period 1986-2016. The total net removals of CO<sub>2</sub> from LULUCF sector in the period 1986-2016 vary between -3,528 Gg (1991) and -6,269 Gg (2007). The main sink category in LULUCF in Slovenia is Forest land remaining Forest land.



**Figure 6.1.2: The shares of land uses in year 2016**

The emission trends showed that the highest change compared to the base year (1986) was in Wetlands and Cropland. Forest land and HWP (excluding the period 1991-95) are the sources of GHG removals. Grassland acted as a sink in the period 1986-2013, while at present it is source of emissions, as the result of decreasing trend of natural afforestation. Also the removals in Cropland have shown a decreasing trend of removals since 2002.

**Table 6.1.3: Emissions and removals from sector 4 LULUCF by top-level land categories and Harvested wood products in Gg CO<sub>2</sub> equivalent**

Year	4. Total	4.A FL	4.B CL	4.C GL	4.D WL	4.E SL	4.F OL	4.G HWP
GHG emissions/removals, Gg CO <sub>2</sub> equivalent								
Change to 1986 (%)	10	25	-508	-110	788	-27	56	-78
2016	-4990	-5140	-127	43	26	282	22	-102
2015	-4978	-5094	-130	34	26	288	21	-129
2014	-4920	-5036	-138	12	25	302	21	-113
2013	-4786	-4973	-150	-3	25	313	21	-25
2012	-5289	-5418	-157	-27	25	325	21	-64
2011	-5293	-5389	-165	-54	24	337	21	-75
2010	-5317	-5337	-175	-77	24	349	21	-129
2009	-5377	-5321	-179	-105	23	359	21	-183
2008	-5436	-5314	-184	-129	23	369	20	-228
2007	-6269	-6046	-188	-153	23	379	20	-311
2006	-5905	-5957	-176	-72	7	486	17	-219
2005	-5946	-5997	-180	-104	6	487	17	-185
2004	-5937	-5983	-183	-127	6	489	17	-164
2003	-5795	-5873	-187	-129	6	491	17	-129
2002	-6010	-5835	-202	-298	1	404	9	-98
2001	-5841	-5689	-197	-303	1	406	10	-78
2000	-4746	-4575	-194	-321	1	409	10	-85
1999	-4617	-4469	-190	-350	1	412	10	-40
1998	-4546	-4353	-185	-371	0	415	10	-71
1997	-4385	-4277	-181	-388	0	418	10	24
1996	-4363	-4189	-177	-395	0	421	10	-43
1995	-3926	-3880	-173	-323	2	389	20	28
1994	-3794	-3748	-178	-334	2	388	20	45
1993	-3580	-3633	-181	-290	2	386	20	106
1992	-3560	-3570	-185	-298	2	385	19	77
1991	-3528	-3461	-188	-333	2	384	19	40
1990	-4210	-4152	23	-429	3	388	14	-67
1989	-4475	-4156	25	-430	3	388	14	-329
1988	-4535	-4140	27	-422	3	388	14	-416
1987	-4565	-4118	29	-431	3	388	14	-460
1986	-4535	-4100	31	-423	3	388	14	-457

## 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 Land use and land-use change

In the NIR submissions until 2005 different vector layers of the Agricultural Land Use Map (ALUM) of Ministry of Agriculture and the Environment (MAE), now named as Ministry of Agriculture, Forestry and Food (MAFF) were used to present land use and land-use changes for Slovenia. The former approach of land representation included layers of the ALUM, which were used to detect land use changes using intersect tool of geospatial processing program. This approach enabled us acquiring good estimation of land use cover trends, as compared to the former auxiliary and less accurate data sources used to land use cover change in earlier reports. However, only one land-use change matrix was produced to estimate conversions among the six top-level categories, and other sub-categories accordingly. Applying a constant land-use changes over entire reporting period resulted in linear trends not only in areas, but also in emissions and removals. Moreover, several other difficulties were related to previous approach. Comparing two vector layers resulted in a non-realistic changes that do not occur in the nature. These changes were also a consequence of changes in methodology used to acquire data in the ALUM database that were subject to constant changes due to adaptation of the common agricultural policy (EU CAP).

Consistent land representation is one of the key importance and a baseline for objective estimation of GHG emissions and removals. Land-use change matrix, being produced by the above mentioned approach, was subject of issues that were highlighted continuously in the annual review reports by the ERT. That is why MAFF supported a targeted research project “Bases for improving the reporting methodology of greenhouse gas emissions in relation to land use, land use change and forestry” in the period 2014-2016, which was coordinated by Slovenian Forestry Institute. The project aimed at improving the land-use change matrices, activity data estimations, emission factors, land stratification for cropland, use of higher Tier levels etc. The main project results (area estimation and land use change matrices) were used in the NIR 2016 annual submission for the first time. Methodology is described more in detail in the sub-chapter 6.3.1.

The national land-use classes have seven main categories: agricultural land, forest, built-up areas and related surfaces, swamps and other marshy areas, dried open areas with special vegetation, open areas with little or no vegetation and on the end waters. According to 2006 Guidelines Slovenian land-use category the agricultural land is separated into two categories, namely Cropland and Grassland, and categories dried open areas with special vegetation, open areas with little or no vegetation are in the one class (Table 6.2.1).

Definitions of each category of land use from 2006 Guidelines for Slovenia are described below, while classification of national land-use classes of the ALUM according to six main categories from 2006 Guidelines are presented in the table 6.2.1.

### 6.2.2 Forest land

Forest land is defined as land spanning more than 0.25 hectares with trees higher than 5 meters and canopy cover more than 10 percent, or trees able to reach this threshold *in situ*. It includes abandoned agricultural land with natural afforestation of forest. All Forest land is considered managed.

### 6.2.3 Cropland

Cropland is defined as land suitable for agricultural production. Annual cropland includes arable land for annual crop production (cereals, potatoes, forage crops, vegetable crops, oilseed, ornamental plants, herbs, strawberries, hop fields...), agricultural fallow ground, and temporary meadows and greenhouses as well. Perennial cropland includes land for permanent crops, such as vineyards, extensive and intensive orchards, olive groves, nursery (for grapevines, fruit and forest trees), forest plantations and forest trees on agricultural land. All Cropland is assumed managed.

### 6.2.4 Grassland

Grassland is defined as agricultural land grown by grass and other herbs that are regularly cut or grazed. This land is not tilled nor fallow ground. Grassland include areas, which can be covered with some forest trees (less than 50 trees / ha), and alpine pastures. In this category there are swamp pastures and meadows on organic or mineral-organic soils, where the groundwater rises few times in the year. It includes also uncultivated agriculture land and all Grassland is assumed managed.

### 6.2.5 Wetlands

Wetlands are defined as land that are temporarily or permanently saturated by water. Wetlands include lands, such as fens, marshes, bogs and reeds and is not under agricultural use. Inland water bodies (major rivers, lakes and water reservoirs) are also part of Wetlands. Although there are small areas of raised bogs, all Wetlands are assumed managed.

### 6.2.6 Settlements

Settlements are defined as infrastructure components where buildings, roads, parking places, mines, stone pits and all other infrastructure are in human use. All Settlements are assumed managed.

### 6.2.7 Other land

Other land is defined as land covered with vegetation lower than 2 meters or land with vegetation cover less than 75 percent, which is not used in agriculture. There are inbuilt areas

with little or no vegetation as rocks, sands, sand banks (bigger than 5000 m<sup>2</sup>), waste and other opened areas. This is all land that is not classified in other land use definitions.

**Table 6.2.1: Categories from ALUM delivered in six main categories from 2006 Guidelines**

LULUCF category	LULUCF subcategory	National class ID	Category description
FOREST LAND	FL	2000	Forest
CROPLAND	CL_a	1100	Arable land
	CL_a	1160	Hop fields
	CL_a	1190	Green houses
	CL_w	1180	Other permanent crops on arable land
	CL_w	1211	Vineyards
	CL_w	1212	Nursery
	CL_w	1221	Intensive orchards
	CL_w	1222	Extensive orchards
	CL_w	1230	Olive groves
	CL_w	1240	Other permanent crops
	CL_w	1420	Forest plantation
GRASSLAND	GL_a	1300	Meadows and pastures*
	GL_a	1321	Swampy meadows and pastures
	GL_a	1330	Alpine meadows
	GL_a	1600	Uncultivated agriculture land
	GL_w	1410	Overgrown areas
	GL_w	1500	Mixed land use (arable land and forest, small areas)
	GL_w	1800	Forest trees on agricultural land
	WL	4100	Swamps
WETLANDS	WL	4210	Reeds
	WL	4220	Other marshy areas
	WL	7000	Waters (inland water bodies)
SETTLEMENTS	SL	3000	Built-up areas and related surfaces
OTHER LAND	OL	5000	Dried open areas with special vegetation
	OL	6000	Open areas with little or no vegetation

Note: In compliance with the Rules on the register of actual agricultural and forest land use (2006), the class Alpine meadows (1330) was removed from the Slovenian land-use classification in 2006. Therefore, those areas were included into other relevant classes (e.g. 1300, 5000).

## 6.3 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

### 6.3.1 Development of land-use change matrices

The targeted research project “Bases for improving the reporting methodology of greenhouse gas emissions in relation to land use, land use change and forestry” have given opportunity to



interpret land uses based on the national land classification for the three point in time, namely 2002, 2006 and 2012. Two land use change matrices were produced accordingly. Land use estimation was based on digital orthophoto images on a systematic 1 km x 1 km grid using a point sampling method. In total 20,253 grid points per sampling year were photointerpreted on a screen simultaneously. This means that theoretical location was sampled for three points at the same time. Other sources of spatial information, such as land cover from satellite images (Landsat), corresponding land-use maps of ALUM and LPIS and other maps were also used for verification of the problematic points (mostly related to agricultural lands).

For the period until 2002 data on land use from the Statistical Yearbook of the Statistical Office of the Republic of Slovenia have been used, as well as forest data of Slovenia Forest Service as no digital ortophotos are available for this period. To simulate land use conversions among the land-use subcategories for the period 1986-2002, two baselines were used. The first, being the transition rates that are available from the existing literature (Ferreira and Petek 2005, Kobler et al. 2005, Petek 2005, SORS 2005, Pišek 2012, Pirnat and Kobler 2014, Bole 2015) and the second being the transition trends that had been observed during the project in the matrices 2002-2006 and 2006-2012. Annual areas and land-use changes for the years 2013 2014 and 2015 were extrapolated based on the latest land-use change matrix 2006-2012.

**Table 6.3.1: Land use change matrix for the period 1986-1990 in hectares**

1986-1990	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	Total <sub>1986</sub>
FL	1016195	100	300	1000	500	100	600	100	1018895
CL_a		241952	900	4500	600		700		248652
CL_w		600	54957	700	700				56957
GL_a	100	1100	1800	317691	13800	300	5800		340591
GL_w	8000	2400	500	17300	193144		200		221544
WL					100	14415	200		14715
SL		800		5100			79502		85402
OL				2000	3000			35545	40545
Total <sub>1990</sub>	1024295	246952	58457	348291	211844	14815	87002	35645	2027300

**Table 6.3.2: Land use change matrix for the period 1990-1995 in hectares**

1990-1995	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	Total <sub>1990</sub>
FL	1019595	200	400	1800	1100	100	900	200	1024295
CL_a		231916	1000	10000	736		3300		246952
CL_w		300	51057	4000	3000		100		58457
GL_a	200	1100	1800	311791	27000	400	6000		348291
GL_w	82000	200	200	12000	117344		100		211844
WL					100	14415	300		14815
SL		600		5000			81402		87002
OL				500	1000			34145	35645
Total <sub>1995</sub>	1101795	234316	54457	345091	150280	14915	92102	34346	2027300

**Table 6.3.3: Land use change matrix for the period 1995-2002 in hectares**

<b>1995-2002</b>	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	Total <sub>1995</sub>
FL	1096095	100	500	1900	1100	100	2000		1101795
CL_a		214716	1800	13800	700		3300		234316
CL_w		300	49757	3200	600		600		54457
GL_a		3500	5100	291721	39410		5360		345091
GL_w	114255	334	394	4700	30396		200		150280
WL					300	13950	665		14915
SL		100		499			91025	478	92102
OL				330	2544			31472	34346
Total <sub>2002</sub>	1210350	219050	57550	316150	75050	14050	103150	31950	2027300

**Table 6.3.4: Land use change matrix for the period 2002-2006 in hectares**

<b>2002-2006</b>	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	Total <sub>2002</sub>
FL	1204650	100	300	1900	1100	100	2100	100	1210350
CL_a		211350	400	5600	300		1400		219050
CL_w		300	52850	3200	600		600		57550
GL_a	200	2600	2700	291150	17300		2200		316150
GL_w	1900	400	100	3800	68650		200		75050
WL					100	13750	200		14050
SL		100		500			102450	100	103150
OL				100				31850	31950
Total <sub>2006</sub>	1206750	214850	56350	306250	88050	13850	109150	32050	2027300

**Table 6.3.5: Land use change matrix for the period 2006-2012 in hectares**

<b>2006-2012</b>	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	Total <sub>2006</sub>
FL	1201650	100	300	1900	1100	400	1100	200	1206750
CL_a		205450	100	7500			1800		214850
CL_w		700	51050	4100	200		300		56350
GL_a		2400	1000	292050	8400	100	2300		306250
GL_w	4700	400	400	6700	75050		800		88050
WL						13850			13850
SL			100	200	100		108750		109150
OL	100							31950	32050
Total <sub>2012</sub>	1206450	209050	52950	312450	84850	14350	115050	32150	2027300

Although lots of changes have taken place in the nature during the period 2002-2012 the extent of conversions, resulting from the previous land-use change matrix, was not realistic for Slovenia. Majority of the converted areas, resulted from the former methodology, was in small land-use changes that occur due to the differences in polygons borders, which produce so called “sliver polygons”, when intersecting two layers. Furthermore, the weakness of vectorization process was a subjective delineation, by which various land-use types are

determined in the shape of polygons. The later were often interpreted incorrectly, in the past mostly due to poor quality of orthophotos and subjectivity of interpreters that produced unreal changes. Part of changes can be also attributed to rasterization process. All these issues have already been reviewed (Miličić and Udovč 2012, Nastran and Žižek Kulovec 2014). The survey of Nastran and Žižek Kulovec (2014) showed that the area of deforestation estimated by the previous methodology is approx. 10 times higher than the official value in Slovenia Forest Service annual reports.

Point sampling method allowed us to verify deforestation rates, and to discover the actual land-use conversions that do occur in the nature. It was found that deforestation rate is between 675 and 1425 ha per year. This is about 2-3 times higher compared to deforestation reported by the SFS in the annual reports. However, it should be emphasized that the estimates of the point sampling approach include conversions from forest land to wetlands and from forest land to other land. These types of deforestation is also considered human-induced because it occur on previous managed land. Therefore, results indicate that deforestation rate is around 900 ha per year, which is a bit more compared with the previous independent research (Nastran and Žižek Kulovec 2014). To be consistent with the KP reporting, the newest data on forest areas and deforestation were used for activity-based reporting within the 3.3 and 3.4 article of the KP.

Land-use areas for each land use were calculated using following equation:

$$Area_{LU, yearofinventory} = Area_{LU, previousinventoryyear} + Area_{landconvertedtoLU} \quad \text{(Equation 1)}$$

*Area<sub>LU, yearof inventory</sub>* - area of selected land use category in year of inventory [ha]  
*Area<sub>LU, previousinventoryyear</sub>* - area of selected land use category in previous year [ha]  
*Area<sub>landconvertedtoLU</sub>* - area of land converted to selected land use category [ha]

The standard error (in %) of an area estimate obtained in the targeted project (Mali et al. 2016) for years 2002, 2006 and 2012 are presented in the table below.

**Table 6.3.6: Standard error (%) of an area estimate for the land-use categories in years 2000, 2006 and 2012**

Land-use category	Standard error, %		
	2002	2006	2012
Forest land	0.6	0.6	0.6
Cropland annual	2.0	2.0	2.1
Cropland perennial	4.1	4.2	4.3
Grassland annual	1.6	1.7	1.6
Grassland perennial	3.6	3.3	3.4
Wetlands	8.5	8.5	8.4
Settlements	3.0	2.9	2.9
Other land	5.6	5.6	5.6

**Table 6.3.7: Areas per LULUCF land-use categories from 1986 to 2016 in kha**

Year	4. Total	4.A Forest Land	4.B. Cropland	4.C Grassland	4.D Wetlands	4.E Settlements	4.F Other Land
Area, kha							
2016	2027.30	1206.25	255.87	399.30	14.68	118.98	32.22
2015	2027.30	1206.30	257.40	398.80	14.60	117.87	32.20
2014	2027.30	1206.35	258.93	398.30	14.52	117.02	32.18
2013	2027.30	1206.40	260.47	397.80	14.43	116.03	32.17
2012	2027.30	1206.45	262.00	397.30	14.35	115.05	32.15
2011	2027.30	1206.50	263.53	396.80	14.27	114.07	32.13
2010	2027.30	1206.55	265.07	396.30	14.18	113.08	32.12
2009	2027.30	1206.60	266.60	395.80	14.10	112.10	32.10
2008	2027.30	1206.65	268.13	395.30	14.02	111.12	32.08
2007	2027.30	1206.70	269.67	394.80	13.93	110.13	32.07
2006	2027.30	1206.75	271.20	394.30	13.85	109.15	32.05
2005	2027.30	1207.65	272.55	393.53	13.90	107.65	32.03
2004	2027.30	1208.55	273.90	392.75	13.95	106.15	32.00
2003	2027.30	1209.45	275.25	391.98	14.00	104.65	31.98
2002	2027.30	1210.35	276.60	391.20	14.05	103.15	31.95
2001	2027.30	1194.84	278.34	406.08	14.17	101.57	32.29
2000	2027.30	1179.33	280.08	420.96	14.30	99.99	32.63
1999	2027.30	1163.83	281.82	435.84	14.42	98.42	32.98
1998	2027.30	1148.32	283.56	450.73	14.54	96.84	33.32
1997	2027.30	1132.81	285.29	465.61	14.67	95.26	33.66
1996	2027.30	1117.30	287.03	480.49	14.79	93.68	34.00
1995	2027.30	1101.79	288.77	495.37	14.91	92.10	34.35
1994	2027.30	1086.29	292.10	508.32	14.89	91.08	34.61
1993	2027.30	1070.79	295.43	521.28	14.87	90.06	34.87
1992	2027.30	1055.29	298.75	534.23	14.85	89.04	35.13
1991	2027.30	1039.79	302.08	547.18	14.83	88.02	35.39
1990	2027.30	1024.29	305.41	560.13	14.81	87.00	35.65
1989	2027.30	1022.94	305.46	560.63	14.79	86.60	36.87
1988	2027.30	1021.59	305.51	561.13	14.76	86.20	38.10
1987	2027.30	1020.24	305.56	561.63	14.74	85.80	39.32
1986	2027.30	1018.89	305.61	562.13	14.71	85.40	40.55

### 6.3.2 Carbon stocks in litter and soils

The existent databases in Slovenia were not established to be used for mineral soil carbon pool and litter pool assessment. For our assessment there are a total of 909 soil profiles (mineral soil) descriptions with analytical data. Soil database includes data about soil physical and chemical properties, but no data of soil bulk density, so pedotransfer functions were used.

#### LITTER

The separate estimate of carbon stock in O<sub>l</sub>, O<sub>f</sub> and O<sub>h</sub> sub horizon was provided, due to fact that each organic subhorizon were sampled within an area of 25 cm × 25 cm. separately. Volume of roots and coarse fragments (soil skeleton >2 mm) were subtracted from volume of soil sample. Carbon stock in litter was calculated according to following equation:

$$C_{pool} = \sum_{i=1}^k (\% C_{org,i} \cdot M_{105^{\circ}C,i} / 100) \quad \text{(Equation 2)}$$

*C<sub>pool</sub>* - carbon stock [Gg ha<sup>-1</sup>]  
*C<sub>org</sub>* - the organic carbon content and clay content (both in %)  
*M<sub>105°C,i</sub>* - quantity [Gg ha<sup>-1</sup>] of dry soil in sub horizon *i*  
*k* - number of soil horizon in soil profile

**Table 6.3.8: Average carbon stock in litter (from 8 × 8 km grid survey)**

Layer	Average carbon stock [t ha <sup>-1</sup> ]	n
O <sub>l</sub> horizon	1.44 ± 0.15	143
O <sub>fh</sub> horizon	8.85 ± 1.42	145
Litter (O <sub>l</sub> + O <sub>fh</sub> )	10.41 ± 1.50	143

#### SOILS

Carbon stock in mineral part of soil (SOM) was calculated from the following equation:

$$C_{pool} = \sum_{i=1}^k (\% C_{org,i} \cdot d_i \cdot \rho_i \cdot 100) \quad \text{(Equation 3)}$$

*C<sub>pool</sub>* - carbon stock [Gg ha<sup>-1</sup>]  
*D<sub>i</sub>* - thickness [m] of soil horizon *i*  
*ρ<sub>i</sub>* - soil bulk density [g cm<sup>-3</sup>]  
*k* - number of sub horizon in soil profile

Because no measurements of bulk density were available, the soil bulk density [g/cm<sup>3</sup>] was estimated from the following transfer function, equation 4.

$$\rho_i = \begin{cases} 1/(0,625 + 0,05 \cdot \%C_{org} + 0,0015 \cdot \%clay) \rightarrow \text{if } \%C_{org} \leq 5\% \\ 1,55 - 0,0814 \cdot \%C_{org} \rightarrow \text{if } 5\% < \%C_{org} \leq 15\% \\ 0,725 - 0,337 \cdot \log_{10} \%C_{org} \rightarrow \text{if } \%C_{org} \geq 15\% \end{cases} \quad \text{(Equation 4)}$$

$\rho_i$  - soil bulk density [g cm<sup>-3</sup>]  
 $C_{org}$  - the organic carbon content and clay content (both in %)

The top equation for mineral soils is based on data by Hoekstra and Poelman (1982), the bottom equation for peat(y) soils is derived from Van Wallenburg (1988) and the central equation is a linear interpolation (for clay=0) between the two (Reinds *et al.* 2001).

Average soil organic carbon stocks on agricultural land were estimated based on soil monitoring in recent years (Mali *et al.*, 2016; Mali *et al.*, 2017). Updated figures are presented in the Table 6.2.9. Note that wetlands and settlements were not subject of this monitoring.

**Table 6.3.9: Average carbon stock (SOC), depth 0-30 cm in mineral part of soil**

Land use	Average carbon stock [t ha <sup>-1</sup> ]	n
Cropland annual	80.08	52
Cropland perennial	83.71	35
Grassland annual	98.80	66
Grassland perennial	114.40	17
Wetlands	113.68	11
Settlements	49.40	/

On basis of data on green areas in urban land for municipality Ljubljana the expert judgment was provided that soil carbon stock in settlements equals to the half a value of soil carbon stock in the category Grassland annual.

**Table 6.3.10: Average carbon stock in mineral soils of forest land (from 8 × 8 km grid survey)**

Layer	Average carbon stock [t ha <sup>-1</sup> ]	n
M <sub>10</sub> horizon	35.25 ± 2.06	141
M <sub>40</sub> horizon	68.32 ± 6.22	136
Mineral soils	103.31 ± 7.90	136

## 6.4 Forest Land (4A)

### 6.4.1 Source category description

Forest land category includes CO<sub>2</sub> emissions from changes in carbon stock in living biomass (above and below ground biomass), in dead organic matter (dead wood and litter) and soils. Carbon stock changes are reported in Forest land remaining Forest land and in Land converted to Forest land. Also non-CO<sub>2</sub> emissions from biomass burning are reported.

Area of forest land in Slovenia in 2016 was 1,206.25 kha, which covered 59.5 % of the country. Most Slovenian forests are located within the area of beech, fir-beech and beech-oak sites (70 %), which have a relatively high production capacity. The share of growing stock of coniferous trees is 46.4 %, of deciduous trees 53.6 %. Main tree species are beech (*Fagus sylvatica*), spruce (*Picea abies*), fir (*Abies alba*), oak (*Quercus sp.*) and Scotch pine (*Pinus sylvestris*). These species represent 80.0 % of total growing stock (beech 31.0 %, spruce 33.9 %, fir 8.2 %, oak 5.8 %, pine 4.1 %).

Majority, 77.8 % of forests in Slovenia are private property, 22.2 % of forests are public (owned by the state or local communities) (Annual report on forests, SFS 2012). Larger and undivided forest estates of state-owned forests enable good professional management. Private forest estates are small, with an average area of only 3 ha and even these are further fragmented into several separate plots. For the great majority of these estates forests are not of economic interest. Private forest property is becoming even more fragmented as the number of forest owners is increasing. According to the latest data there are already 314,000 (with co-owners even 489,000) forest owners in Slovenia. The major fragmentation of forest property, the number of forest owners and co-owners, present a serious obstacle to professional work in private forests, to optimal timber production and utilization of forest potential (Slovenia Forest Service, 2011).

All forests in Slovenia are considered managed, because forest management plans are prepared for all forests, regardless ownership, conservation degree or natural conditions.

According to Forest Act (1993, Article 2);

(1) Forest is defined as land overgrown with forest trees in the form of stand or other forest plants which provides any of the functions of a forest. Forest according to this Act also includes overgrown land defined as forest land in the spatial element of the forest management plan.

(2) The forest infrastructure (e.g. forest road network) not allocated into separate lot is an integral part of the forest land.

(3) The following are not forest within the meaning of this act: individual forest trees, groups of forest trees up to an area of 0.05 hectares, non-autochthonous riverine and windbelt trees, avenues, parks, plantations of forest trees, pens for rearing game, and pastures overgrown with forest trees if used for pasturing, irrespective of how they are described in the land register.

(4) The provisions of this act and regulations issued on the basis hereof shall also apply to forest trees which grow outside forests insofar as they are specifically defined.

Table 6.4.1: Activity data for Forest land (1986 – 2016) in kha

Year	4.A. Total Forest Land	4.A.1. Forest Land remaining Forest Land	4.A.2. Land converted to Forest Land	4.A.2.1 Cropland converted to Forest Land	4.A.2.2 Grassland converted to Forest Land	4.A.2.3 Wetland converted to Forest Land	4.A.2.4 Settlements converted to Forest Land	4.A.2.5 Other Land converted to Forest Land
Area, kha								
2016	1206.25	1098.22	108.03	NO	107.87	NO	NO	0.17
2015	1206.30	1082.74	123.56	NO	123.41	NO	NO	0.15
2014	1206.35	1067.15	139.20	NO	139.06	NO	NO	0.13
2013	1206.40	1051.56	154.84	NO	154.72	NO	NO	0.12
2012	1206.45	1035.97	170.48	NO	170.38	NO	NO	0.10
2011	1206.50	1020.38	186.12	NO	186.03	NO	NO	0.08
2010	1206.55	1004.79	201.76	NO	201.69	NO	NO	0.07
2009	1206.60	1003.62	202.98	NO	202.93	NO	NO	0.05
2008	1206.65	1002.44	204.21	NO	204.17	NO	NO	0.03
2007	1206.70	1001.27	205.43	NO	205.41	NO	NO	0.02
2006	1206.75	1000.09	206.66	NO	206.66	NO	NO	NO
2005	1207.65	999.49	208.16	NO	208.16	NO	NO	NO
2004	1208.55	998.89	209.66	NO	209.66	NO	NO	NO
2003	1209.45	998.29	211.16	NO	211.16	NO	NO	NO
2002	1210.35	997.69	212.66	NO	212.66	NO	NO	NO
2001	1194.84	996.48	198.36	NO	198.36	NO	NO	NO
2000	1179.33	995.27	184.06	NO	184.06	NO	NO	NO
1999	1163.83	994.06	169.76	NO	169.76	NO	NO	NO
1998	1148.32	992.85	155.47	NO	155.47	NO	NO	NO
1997	1132.81	991.64	141.17	NO	141.17	NO	NO	NO
1996	1117.30	990.43	126.87	NO	126.87	NO	NO	NO
1995	1101.79	989.22	112.58	NO	112.58	NO	NO	NO
1994	1086.29	988.13	98.16	NO	98.16	NO	NO	NO
1993	1070.79	987.05	83.75	NO	83.75	NO	NO	NO
1992	1055.29	985.96	69.33	NO	69.33	NO	NO	NO
1991	1039.79	984.88	54.92	NO	54.92	NO	NO	NO
1990	1024.29	983.79	40.50	NO	40.50	NO	NO	NO
1989	1022.94	982.44	40.50	NO	40.50	NO	NO	NO
1988	1021.59	981.09	40.50	NO	40.50	NO	NO	NO
1987	1020.24	979.74	40.50	NO	40.50	NO	NO	NO
1986	1018.89	978.39	40.50	NO	40.50	NO	NO	NO



**Table 6.4.2: Emissions/removals from Forest land (1986 – 2016) in Gg CO<sub>2</sub>**

Year	4.A. Total Forest Land	4.A.1. Forest Land remaining Forest Land	4.A.2. Land converted to Forest Land	A.2. Land converted to Forest Land				
				4.A.2.1 Cropland converted to Forest Land	4.A.2.2 Grassland converted to Forest Land	4.A.2.3 Wetlands converted to Forest Land	4.A.2.4 Settlements converted to Forest Land	4.A.2.5 Other Land converted to Forest Land
GHG emissions/removals, Gg CO <sub>2</sub>								
2016	-5142.35	-4914.29	-228.07	NO	-224.55	NO	NO	-3.52
2015	-5094.43	-4845.21	-249.22	NO	-246.07	NO	NO	-3.14
2014	-5036.11	-4765.43	-270.68	NO	-267.92	NO	NO	-2.77
2013	-4973.49	-4681.34	-292.16	NO	-289.77	NO	NO	-2.39
2012	-5422.35	-5108.71	-313.64	NO	-311.62	NO	NO	-2.01
2011	-5390.38	-5055.66	-334.72	NO	-333.08	NO	NO	-1.64
2010	-5337.54	-4981.50	-356.05	NO	-354.54	NO	NO	-1.51
2009	-5321.84	-4967.98	-353.85	NO	-352.72	NO	NO	-1.13
2008	-5314.63	-4962.96	-351.66	NO	-350.91	NO	NO	-0.75
2007	-6047.15	-5697.68	-349.48	NO	-349.10	NO	NO	-0.38
2006	-5964.01	-5622.69	-341.32	NO	-341.32	NO	NO	NA,NO
2005	-5997.84	-5656.87	-340.97	NO	-340.97	NO	NO	NA,NO
2004	-5983.50	-5642.87	-340.62	NO	-340.62	NO	NO	NA,NO
2003	-5883.37	-5543.09	-340.28	NO	-340.28	NO	NO	NA,NO
2002	-5835.24	-5607.37	-227.87	NO	-227.87	NO	NO	NA,NO
2001	-5690.87	-5577.83	-113.04	NO	-113.04	NO	NO	NA,NO
2000	-4575.32	-4576.87	1.55	NO	1.55	NO	NO	NA,NO
1999	-4470.99	-4570.73	99.74	NO	99.74	NO	NO	NA,NO
1998	-4357.42	-4555.49	198.07	NO	198.07	NO	NO	NA,NO
1997	-4278.79	-4575.34	296.55	NO	296.55	NO	NO	NA,NO
1996	-4190.05	-4585.22	395.17	NO	395.17	NO	NO	NA,NO
1995	-3880.30	-4377.93	497.64	NO	497.64	NO	NO	NA,NO
1994	-3751.97	-4345.63	593.65	NO	593.65	NO	NO	NA,NO
1993	-3638.51	-4328.17	689.67	NO	689.67	NO	NO	NA,NO
1992	-3571.28	-4356.96	785.68	NO	785.68	NO	NO	NA,NO
1991	-3463.40	-4345.10	881.70	NO	881.70	NO	NO	NA,NO
1990	-4154.50	-4215.40	60.90	NO	60.90	NO	NO	NA,NO
1989	-4156.94	-4226.45	69.51	NO	69.51	NO	NO	NA,NO
1988	-4140.59	-4218.72	78.13	NO	78.13	NO	NO	NA,NO
1987	-4119.58	-4206.33	86.75	NO	86.75	NO	NO	NA,NO
1986	-4101.65	-4197.02	95.37	NO	95.37	NO	NO	NA,NO

The removals in category Forest land in the period 1986-2016 vary from -3,463.40 Gg CO<sub>2</sub> (1991) to -6,047.15 Gg CO<sub>2</sub> (2007).

Forest land remaining Forest land (CO<sub>2</sub>) and Land converted to Forest land (CO<sub>2</sub>) were identified as key source categories according to level and trend. Concerning the CH<sub>4</sub> or N<sub>2</sub>O emissions, Forest land remaining Forest land and Land converted to Forest land have not resulted as a key source.

#### **6.4.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation**

The information of forest area is based on two data sources. Data from Statistical Yearbook of the Statistical Office RS (SORS) was used to present forest area in the period 1986-2001. Until 1993 data on forest area were collected by forest and agro-forest enterprises that managed state-owned and private forests. Data of other forests and those that were subject of so called social property had been collected by the state bodies and local authorities. In the period 1993-2001 the main provider of forest data to the SORS was the Slovenia Forest Service (SFS). Data on forest area are provided by the SFS through renovation of forest management plans, covering the entire forest land. The basic information on forests by forest management units, districts and compartments and other administrative units can be view by the Forest data viewer (<http://prostor.zgs.gov.si/pregledovalnik/?locale=en>) of the SFS. The estimation of forest area for the period 2002-2012 was provided by the Slovenian Forestry Institute through targeted research project "Bases for improving the reporting methodology of greenhouse gas emissions in relation to land use, land use change and forestry". The approach used for representing areas of Forest land follows the principle of estimation of areas via proportions, where the total area of the inventory region is known (IPCC 2006). The methodology of data acquisition and of land-use changes from and to Forest land is described in the sub-chapter 6.3.1. The following maps and databases were used in the assessment of Forest land:

- Digital orthophotos of the Surveying and Mapping Authority RS,
- Land-use database of the Statistical Yearbook of the Statistical Office RS,
- Forest stand map of the Slovenia Forest Service,
- Agricultural Land Use Map of the Ministry of Agriculture, Forestry and Food,
- LiDAR data of the Surveying and Mapping Authority RS,
- Land cover map of Slovenia from Landsat satellite imagery (images for the period 1984-2014 collected by ZRC SAZU).

#### **6.4.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories**

The definition of forest follows the definition of the national law. According to Forest Act (2007), the forest definition was novelated. The Forest Act defines forest as land covered with forest trees in the form of stand, which is able to reach a minimum height of 5 m and a minimum area of 0.25 hectares (2,500 m<sup>2</sup>). Abandoned agricultural land spanning more than 0.25 ha, which has been abandoned for more than 20 years, with minimum tree height of 5 m and a canopy cover of at least 75 % is defined as forest.

Particular attention should be paid to change in methodology of data acquisition when distinguishing between forest and abandoned agricultural land, where spontaneous afforestation occurred. Forest land remaining Forest land includes only those lands that were as forest (national class 2000) designated by the Slovenia Forest Service. According to the

Slovenian classification of land use (Interpretation key 2013), which defines national classes, the following also fall within the forest definition; areas that are temporarily unstocked due to final cutting (regeneration) as part of a forest management practice or natural disasters (e.g. landslide, windthrow), forest plantations designated by the Slovenia Forest Service, forest clearing along the route of transmission lines, pipelines and ski lifts, forest road network, stands of dwarf pine, forest areas approved for grazing, pens in the forest for breeding game, areas covered by ferns designated by the SFS. All other lands are classified in other national classes (e.g. 1410 or 1500) as Land converted to Forest land.

## 6.4.4 Methodological issues

### 6.4.4.1 Forest land remaining Forest land

In the time period 1986-2016 the annual removals were between -4,197.02 Gg CO<sub>2</sub> (1986) and -5,697.68 Gg CO<sub>2</sub> (2007).

#### Carbon stock changes in living biomass

In accordance with the decision tree provided in the 2006 Guidelines, carbon stock changes in living biomass in Forest land remaining Forest land are estimated by Tier 3, Stock-Difference Method. The method requires biomass carbon stock inventories at two points in time. Biomass change is the difference between the biomass at two points in time, divided by the number of years between the inventories. Data from forest inventories of Slovenia Forest Service and Slovenian Forestry Institute, were used for our calculations.

For calculations the equation 2.5 from 2006 Guidelines was used:

$$\Delta C = \frac{(C_{t_2} - C_{t_1})}{t_2 - t_1} \quad \text{(Equation 5)}$$

$\Delta C$  – annual carbon stock change in living biomass [t C yr<sup>-1</sup>]  
 $C_t$  – carbon stock in living biomass at time  $t_1$  or  $t_2$  [t C]

The carbon stock in living biomass was calculated from the merchantable volume multiplied by wood density (WD), biomass expansion factor (BEF<sub>2j</sub>), root-to-shoot ratio (R) and carbon fraction of dry matter (CF). These parameters, except carbon fraction of dry matter, are determined separately for tree species.

$$C = (V_j * D_j * BEF_{2j}) * (1 + R_j) * CF \quad \text{(Equation 6)}$$

$V$  – merchantable growing stock volume  
 $D$  – basic wood density  
 $BEF_2$  – biomass expansion factor for conversion of merchantable volume to aboveground tree biomass  
 $R$  – root shoot ratio  
 $j$  – tree species

## Parameters

### Growing stock

Growing stock is volume over bark of all living trees more than 9.99 cm in diameter at breast height (1.3 m). Includes the stem from ground to a top diameter of 6.99 cm, and may also include branches to a minimum diameter of 6.99 cm.

To apply stock-difference method the Forest and Forest Ecosystem Condition Survey – FECS (Kušar et al., 2010) data from 2000, 2007 and 2012 were taken into account. The FECS, which can be understood as a national forest inventory, was performed on concentric permanent fixed plots of sampling grid with the density 4 km × 4 km (see detailed description in Annex 3). Growing stock in 2000 was 283.2 m<sup>3</sup>/ha (s.e. = 4.68 %), 2007 was 313.58 m<sup>3</sup>/ha (s.e. = 4.21 %) and 2012 was 333.74 (s.e. = 4.08 %).

The FECS increment data include all possible reasons for biomass increments and losses in the forest. That means that biomass increments due to abandonment of managed land or biomass losses due to traditional (non-commercial) fuel wood consumption, forest land conversion, forest fires and other damages are already considered in calculations based on the inventory data.

Since NIR 2015 submission emissions and removals have been estimated by different method than in previous annual submissions. Because FECS data prior to 1995 do not exist interpolation/extrapolation method over long period (up to 9 years) does not appear to be in line with the IPCC guidelines. That is why we have tried to use a better approach. We compared the FECS data on growing stock with data from forest management plans being prepared by Slovenia Forest Service.

For this reason the overlap method according to 2006 Guidelines was used. To estimate emissions/removals for the living biomass recalculation was performed according to equation 5.1 (IPCC 2006).

$y_0 = x_0 * \left( \frac{1}{(n - m + 1)} * \sum_{i=m}^n \frac{y_i}{x_i} \right)$	<b>(Equation 7)</b>
<p><i>y<sub>0</sub> – the recalculated estimate computed using the overlap method</i>  <i>x<sub>0</sub> – the estimate developed using the previously used method (SFS data series)</i>  <i>y<sub>i</sub>, x<sub>i</sub> – the estimates prepared using the new (FECS data provided by SFI) and previously used methods during the period of overlap, as denoted by years m through n</i></p>	

### Biomass expansion factor (BEF<sub>2</sub>) and Root-to-shoot ratio (R)

The default value given in the GPG2003 (Table 3A.1.10) has been adopted in calculations (BEF<sub>2</sub> = 1.15 for conifers and broadleaves) since it seems no updated values can be found in the 2006 Guidelines. Values were used from lower limits of the range (for temperate climatic zone), because they are more suitable for mature forests or those with high growing stock. Root-to-shoot ratio (R) values were adopted from 4.4 of the 2006 Guidelines. Mean

values (aboveground biomass > 150 t/ha) for conifers (0.20), for *Quercus* spp. (0.30) and for other broadleaves (0.24) were used.

### Basic wood density (D)

According to analyses of national data from previous researches done by Slovenian Forestry Institute (SFI) and Biotechnical Faculty, basic wood density is for *Fagus sylvatica* ( $D = 0.584 \text{ t/m}^3$ ) and *Abies alba* ( $D = 0.394 \text{ t/m}^3$ ). For other species the default values from Table 4.14 of the 2006 Guidelines were used.

### Carbon fraction of dry matter (CF)

The default value given in the Table 4.3 of the 2006 Guidelines has been adopted as the carbon fraction of dry matter ( $CF = 0.47 \text{ t C/t d.m.}$ ).

**Table 6.4.3: Parameters (WD, BEF<sub>2</sub>, R and CF) used for selected tree species**

Common name	D	BEF <sub>2</sub>	R	CF
	[t/m <sup>3</sup> ]	[dimensionless]	[dimensionless]	[t C/ t d.m.]
Spruce	0.400	1.15	0.20	0.47
Beech	0.584	1.15	0.24	0.47
Fir	0.394	1.15	0.20	0.47
Oak	0.580	1.15	0.30	0.47
Scotch Pine	0.420	1.15	0.20	0.47
Maple	0.520	1.15	0.24	0.47
Hornbeam	0.630	1.15	0.24	0.47
Chestnut	0.480	1.15	0.24	0.47
Black Pine	0.420	1.15	0.20	0.47
Hop Hornbeam	0.630	1.15	0.24	0.47

### Carbon stock changes in dead organic matter

In accordance with the decision tree provided in the 2006 Guidelines, carbon stock changes in dead organic matter in Forest land remaining Forest land are estimated by Tier 2, in accordance with equation 2.17.

$\Delta C_{FF_{DOM}} = \Delta C_{FF_{DW}} + \Delta C_{FF_{LT}} \quad \text{(Equation 8)}$ <p> <math>\Delta C_{FF_{DOM}}</math> – annual change in carbon stocks in dead organic matter [t C yr<sup>-1</sup>]  <math>\Delta C_{FF_{DW}}</math> – change in carbon stocks in dead wood [t C yr<sup>-1</sup>]  <math>\Delta C_{FF_{LT}}</math> – change in carbon stocks in litter [t C yr<sup>-1</sup>] </p>
--

Dead wood content is all non-living woody biomass not contained in the litter, either standing, lying on the ground.. According to definition from FECS 2007, dead wood in Slovenia includes:

- dead trees (DBH >10 cm);

- stumps (D >10 cm and H >20 cm);
- snags (D >10 cm and H >50 cm);
- coarse woody debris (D >10 cm and L >50 cm).

National data on the stock of dead wood are available from the FECS 2007 and 2012. So the dead wood biomass for the period prior to the year 2007 was extrapolated based on data of FECS 2007 and 2012. For calculations the equation 2.19 from 2006 Guidelines was used.

$$\Delta C_{FF}(DW) = \left[ A * \frac{(DW_{t2} - DW_{t1})}{T} \right] * CF \quad \text{(Equation 9)}$$

$\Delta C_{FF}(DW)$  – annual change in carbon stocks in dead wood [t yr<sup>-1</sup>]  
*A* – area of managed forest land remaining forest land [ha]  
*DW<sub>t2</sub>* – dead wood stock at time *t<sub>2</sub>* for managed forest remaining forest [t d. m.]  
*DW<sub>t1</sub>* – dead wood stock at time *t<sub>1</sub>* for managed forest remaining forest [t d. m.]  
*T* – time period between *t<sub>1</sub>* and *t<sub>2</sub>* [yr]  
*CF* – carbon fraction of dry matter [t d. m.]

According to FECS 2007 and 2012 the dead wood stock was 9.56 t d.m./ha (19.75 m<sup>3</sup>/ha) and 9.57 t d.m./ha (19.76 m<sup>3</sup>/ha). The share of dead wood was 5.9 % of growing stock in 2012. Although dead wood stock seems to be stable in the recent years, we did not take into account “not a source” approach, since it is difficult to judge the trend according to 5-year period only.

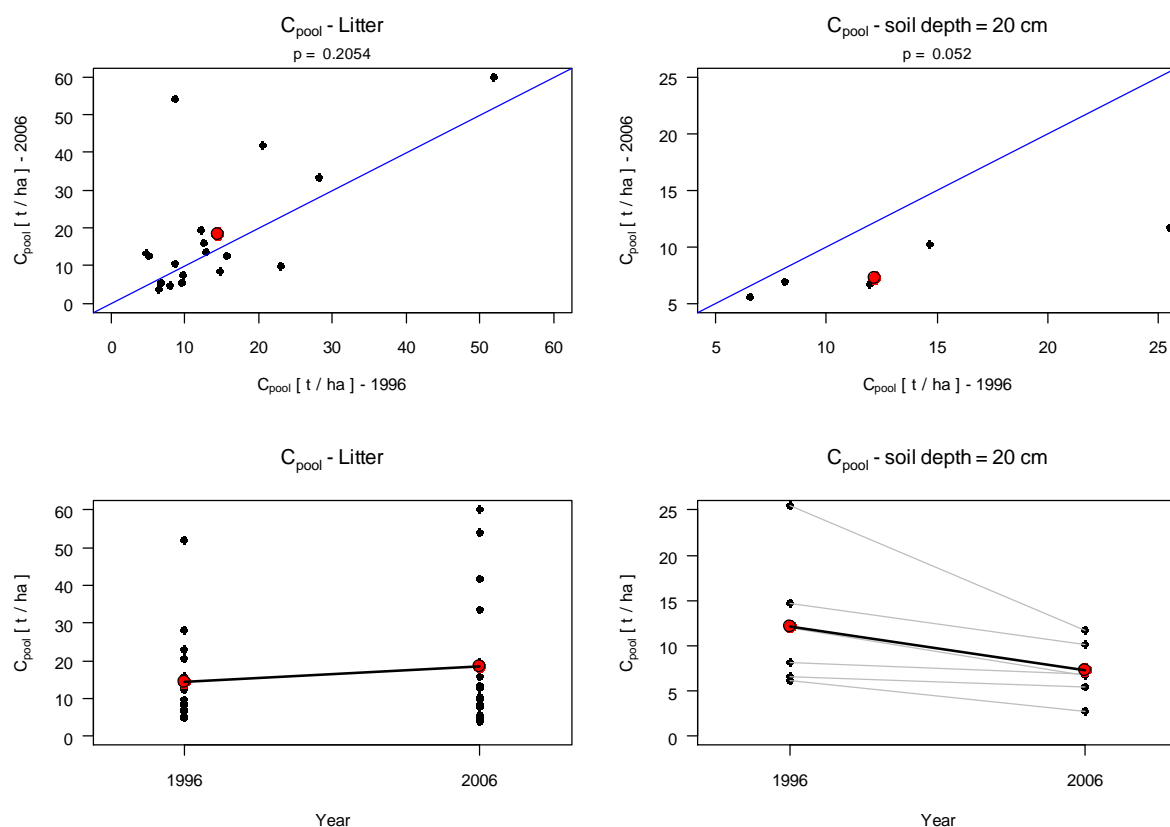
For carbon stock changes in litter it is assumed that the average transfer rate into the litter pool is equal to the transfer rate out of the litter pool, so the net change is zero. Results of our preliminary expertise for period 1996 – 2006 (Kobal M., Simoncic P., 2011), show relative stable carbon stocks in litter in Forest land remaining Forest land. Results are explained in “carbon stock changes in soils”. Furthermore, the data on carbon stock of dead wood also show the stable trend, at least for the period between the last two FECSS.

### **Carbon stock changes in soils**

For carbon stock changes in soils it is assumed that in Forest land remaining Forest land, the carbon stock in soil organic matter does not change, regardless of change in forest management, types, and disturbances regimes; in other words that the carbon stock in mineral soil remains constant so long as the land remains forest. Results of our preliminary expertise for period 1996 – 2006 (Kobal M., Simoncic P., 2011) show that carbon stocks in forest soils is relative stable. In the period of the last 20 year no large fluctuation in forest management regime has been occurring and no large disturbance event that could affect the soil carbon stock. Besides, soil as that depends along with the climate and bedrock factors largely on the source of carbon coming from dead wood and litter. Since those two pools are seemed to be stable, it is therefore assumed soil pool as stable.

### Changes in carbon stock in litter and soils in Forest land remaining Forest land in period 1996–2006

For year 1996, at each plot, three soil subsamples were taken for organic (Litter) and mineral layer (SOM). For mineral part of soil, samples were taken with soil auger ( $\varnothing = 7$  cm) at fixed depth (0–5, 5–10 and 10–20 cm) and for organic layer within  $25 \times 25$  cm square. Subsamples were taken 5 m apart from plot center,  $120^\circ$  clockwise and were combined for laboratory analysis (composite samples). Volume of roots and coarse fragments (soil skeleton  $>2$  mm) were subtracted from volume of soil sample. For year 2006, soil survey was made according to methodology for BioSoil demonstration project. Soil subsamples for organic and mineral layer were taken as in year 1996, with 5 replicates in each plot (center of a plot and celestial direction). Volume of roots and coarse fragments were subtracted from volume of soil sample. For evaluation of temporal changes paired t-test was performed.



**Figure 6.4.1: Carbon stock in forest soils and litter (1996-2006)**

The carbon stock changes in litter slightly increase from year 1996 to year 2006, when national forest soil surveys as a part of ICP Forest and BioSoil demonstration projects/surveys, were carried out. The differences for litter stock changes are not statistically significant ( $p = 0.205$ ). Carbon stock changes in mineral soils for the same period decrease, but the changes are not significant ( $p = 0.052$ ).

Preliminary results on limited number of sampling plots, show us relative stable carbon stocks in forest soils for observed period with insignificant differences between organic - litter layers and for mineral layer. If we take in account literature values for central European forests, in the

moment, we conclude that there are not significant changes in forest soils within periods e.g. 5-10 years if the land use is not changed (forest remaining forest; source: SFI project report 2011).

#### 6.4.4.2 Non-CO<sub>2</sub> greenhouse gas emission

##### N<sub>2</sub>O Emissions from N Fertilization and Drainage of Soils

Fertilization and drainage and rewetting of forests are not a common practices in Slovenia. Therefore, no emissions are reported in CRF Tables 4(I) and 4(II).

##### Emissions from Wildfires

As controlled burning is not allowed in Slovenia, all fires are assigned to “wildfires”. It is assumed that all fires affected productive forests. The area of wildfires in Slovenia is relatively small, less than half percent in the year 2003, which was the most problematic year in the following period. For calculations the Tier 2 (country level estimated of area burned) was used and estimation of GHGs directly released in fires. For calculations for emissions from wildfires the equation 2.27 (IPCC 2006) was applied.

$$L_{fire}[tGHG] = A * M_B * C_f * G_{ef} * 10^{-3} \quad \text{(Equation 10)}$$

*A* – area burnt [ha]  
*M<sub>B</sub>* – mass of fuel available for combustion [kg d.m. ha<sup>-1</sup>]  
*C<sub>f</sub>* – combustion factor (dimensionless)  
*G<sub>ef</sub>* – emission factor (g kg<sup>-1</sup> dry matter burnt)

For all GHG, the default emission factors were applied (IPCC 2006, Table 2.5). Values of emission factors of extra tropical forest were adopted.

**Table 6.4.4: Emission factors used from Table 2.5 (IPCC 2006)**

Gas		Emission factor (G <sub>ef</sub> )
		[g / kg d.m.]
CO <sub>2</sub>	carbon dioxide	1,569
CO	carbon oxide	107
CH <sub>4</sub>	methane	4.7
NO <sub>x</sub>	nitrogen oxide	3.0
N <sub>2</sub> O	nitrous oxide	0.26
NMHC	non methane hydrocarbons	10

Mass of available fuel (*M<sub>B</sub>*) was calculated from average growing stock in the part of country, where the majority of the wildfires occur (Karst region, see Slovenia forest fire risk map: [Forest fire risk map SFS](#)). The fraction of the biomass combusted (*C* = 0.45) was adopted from Table 2.6 (IPCC 2006). Inserting these values in equation 2.27 of the 2006 Guidelines, the GHG emissions shown in Table 6.3.4 were calculated.



According to national statistics about 70 % of wildfires in the forest occur in the Karst region. Database of forest fire is in the domain of Slovenia Forest Service (since 1994), which describes and records forest fire by information, such as location, type of fire, area burned, type of vegetation burned etc. Data are available for the forest management unit – OE Sežana: [Forest management plan OE Sežana](#), of which area is approximately the same as that of forest risk map. Average growing stocks from forest management plans of OE Sežana were applied. Data for the period until 2004 for Sežana forest management unit are aggregated and available only for decades (1980, 1990, 2000) because the duration of the inventory cycle is 10 years. We have searched for other data for this region but it seems it does not exist. Since 2004 data have been published each year and were used for estimation of mass of available fuel accordingly. Amount of dead dead organic matter is not taken into account in mass of available fuel as no country-specific data are available.

**Table 6.4.5: Productive forest land affected by wildfires and resulting GHG emissions 1986-2016**

Year	Area	CO <sub>2</sub>	CO	CH <sub>4</sub>	NO <sub>x</sub>	N <sub>2</sub> O	NM VOC
	ha	kt	kt	kt	kt	kt	kt
2016	237.41	16.13	1.100	0.048	0.031	0.003	0.103
2015	47.98	3.24	0.221	0.010	0.006	0.001	0.021
2014	13.03	0.89	0.061	0.003	0.002	0.000	0.006
2013	48.36	3.20	0.218	0.010	0.006	0.001	0.020
2012	606.53	38.33	2.614	0.115	0.073	0.006	0.244
2011	159.08	10.23	0.698	0.031	0.020	0.002	0.065
2010	52.06	3.35	0.229	0.010	0.006	0.001	0.021
2009	114.73	7.40	0.505	0.022	0.014	0.001	0.047
2008	46.69	2.97	0.202	0.009	0.006	0.000	0.019
2007	98.61	6.36	0.434	0.019	0.012	0.001	0.041
2006	1022.81	60.18	4.104	0.180	0.115	0.010	0.384
2005	142.23	8.12	0.554	0.024	0.016	0.001	0.052
2004	76.87	4.26	0.290	0.013	0.008	0.001	0.027
2003	1592.84	86.20	5.878	0.258	0.165	0.014	0.549
2002	77.47	4.09	0.279	0.012	0.008	0.001	0.026
2001	240.36	12.40	0.845	0.037	0.024	0.002	0.079
2000	124.14	6.24	0.426	0.019	0.012	0.001	0.040
1999	321.10	15.60	1.064	0.047	0.030	0.003	0.099
1998	725.10	34.05	2.322	0.102	0.065	0.006	0.217
1997	383.33	17.37	1.185	0.052	0.033	0.003	0.111
1996	243.75	10.65	0.726	0.032	0.020	0.002	0.068
1995	148.88	6.26	0.427	0.019	0.012	0.001	0.040
1994	835.47	33.76	2.302	0.101	0.065	0.006	0.215
1993	1196.92	46.40	3.164	0.139	0.089	0.008	0.296
1992	344.97	12.81	0.874	0.038	0.024	0.002	0.082
1991	559.51	19.86	1.354	0.059	0.038	0.003	0.127
1990	615.77	20.84	1.422	0.062	0.040	0.003	0.133
1989	120.00	3.98	0.271	0.012	0.008	0.001	0.025
1988	181.75	5.90	0.402	0.018	0.011	0.001	0.038
1987	393.00	12.47	0.850	0.037	0.024	0.002	0.079
1986	515.00	15.97	1.089	0.048	0.031	0.003	0.102

All data related to the burned areas are based on databases of Slovenia Forest Service (SFS). The areas are identified and geo-located. The annual data related to fires are annually published by SFS. All GHG emission from forest fires are reported under Forest land remaining Forest Land.

#### 6.4.4.3 Land converted to Forest land

Data for land-use change from other land use to Forest land are described in chapter 6.2.1 and chapter 6.3.2. For the calculation of the annual change in carbon stocks in other land converted to Forest land the Tier 2 (IPCC 2006) approach is used.

The average annual area converted from other land uses to forest land is between 0.53 and 16,3 kha according to land use change matrices (Table 6.3.1.-Table 6.3.5). As described in chapter 6.2.1 the land use change to forests appear only from grassland. Conversions to forest land are not direct human induced. The areas are under spontaneous afforestation (natural expansion) of forest. However, the SFS system of forest management differentiates forest lands covered by management plans according to production function and other ecological and social functions.

Definition of forest (Forests Act) related to management plans; land spanning more than 0.25 hectares with trees higher than 5 meters, or trees able to reach these thresholds *in situ*. It includes abandoned agricultural land (cropland, grassland) with natural expansion of forest (covered with trees 20-75 %). When land, being subject to natural expansion more than 20 years, exceeds the canopy cover of 75 %, it becomes Forest land.

#### **Carbon stock changes in living biomass**

The carbon stock change of living biomass has been calculated taking into account the increase and the decrease of carbon stock related to the areas in transition into Forest land. The annual increment of stem wood over bark on areas which converted to forests was estimated with 2.16 m<sup>3</sup>/ha (Wisdom Slovenia, 2006). For the calculation the equation 2.9 (following equation 2.10) from 2006 Guidelines was used. No distinction between intensively and extensively managed forests was made, because all land converted to forest land are managed extensively (naturally regenerated forests with minimum human intervention).

$\Delta C_{LF\ growth} = A * G_{total} * CF$ <p><i>A</i> – area of land converted to forest land [ha]  <i>G<sub>total</sub></i> – average annual increment rate in total biomass  in units of dry matter [t d.m. ha<sup>-1</sup> yr<sup>-1</sup>]  <i>CF</i> – carbon fraction of dry matter (default = 0.47 t C / t d.m.)</p>	<b>(Equation 11)</b>
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$$G_{total} = \Sigma(I_v * D * BEF_1 * (1 + R)) \quad \text{(Equation 12)}$$

$I_v$  – average annual net increment [ $m^3 \text{ ha}^{-1} \text{ yr}^{-1}$ ]

$D$  – basic wood density [ $t \text{ d.m. m}^{-3}$ ]

$BEF_1$  – biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment

$BEF_1$  values were used according to Table 3A.1.10 (IPCC 2003) for temperate climatic zone. Values from the upper limit of the range (representing young forests or forests with low growing stock) were taken:  $BEF_1 = 1.3$  for conifers and for broadleaves.

Average basic wood densities were used for conifers ( $D = 0.400 \text{ t d.m. m}^{-3}$ ) and for broadleaves ( $D = 0.580 \text{ t d.m. m}^{-3}$ ). Average annual increment ( $I_v$ ) on areas converted to forest land was  $2.16 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$  (Wisdom Slovenia, 2006, p. 57, class 1410).

Root-to-shoot ratio ( $R$ ) values were adopted from Table 4.4 (IPCC 2006). Mean values for conifers ( $R = 0.40$ ; aboveground biomass  $<50 \text{ t/ha}$ ) and for broadleaves ( $R = 0.46$ ; aboveground biomass  $<75 \text{ t/ha}$ ) were used.

**Table 6.4.6: Factors for calculation of  $\text{CO}_2$  accumulation in Land converted to Forest land**

	$I_v$	$D$	$R$	$BEF_1$
	[ $m^3 \text{ ha}^{-1} \text{ yr}^{-1}$ ]	[ $t \text{ d.m. m}^{-3}$ ]	[dimensionless]	[dimensionless]
Conifers	2.16	0.400	0.40	1.3
Broadleaves	2.16	0.580	0.46	1.3

### **Carbon stock changes in dead organic matter**

In the Tier 1 calculation, the average transfer rate into dead wood pool equals the transfer rate out of the dead wood pool. The net change is therefore equal to zero.

It is assumed (Tier 1, default) that the litter carbon stocks in non-forest lands converting to forests are stable. Slovenia does not experience significant changes in forest types or management regimes. The net effect of emission and removal factors is therefore equal to zero.

### **Carbon stock changes in soils**

For calculations of carbon stock changes in soils in land converted to forest land the Tier 2 method was applied, using equation 2.25 (IPCC 2006). As mentioned before no distinction between intensively and extensively managed forests was made, because all land converted to forest land are managed extensively (naturally regenerated forests with minimum human intervention).

$$\Delta C_{LF \text{ mineral}} = \frac{[(SOC_{ExtForest} - SOC_{non-forestland}) * A_{ExtForest}]}{T_{ExtForest}} \quad \text{(Equation 13)}$$

$\Delta C_{LF \text{ mineral}}$  – annual change in carbon stock in mineral soils [t C yr<sup>-1</sup>]  
 $SOC_{ExtForest}$  – stable soil organic carbon stocks of the new. extensively managed forest [t C ha<sup>-1</sup>]  
 $SOC_{non-forestland}$  – soil organic carbon stocks of the non-forest land prior to its conversion [t C ha<sup>-1</sup>]  
 $A_{ExtForest}$  – land area [ha]  
 $T_{ExtForest}$  – time [default 20 years]

$SOC_{ExtForest} = SOC_{ref} * f_{forest\ type} * f_{man\ intensity} * f_{dist\ regime}$

$SOC_{ref} = SOC_{40}$  – Slovenian national value for organic carbon stock in mineral soil for Forest land [t C ha<sup>-1</sup>]  
 $f_{forest\ type}$  – adjustment factor for a forest typoe different from the native forest vegetation  
 $f_{man\ intensity}$  – adjustment factor for the effect of management intensity  
 $f_{dist\ regime}$  – adjustment factor reflecting the effect on SOC of a disturbance regime different from the natural ones

Country specific value for  $SOC_{ref}$  ( $SOC_{40} = 103.31 \text{ t C ha}^{-1}$ ) was determined from national soil profiles data and it is presented in Table 6.3.10. Also values for soil organic stock of previous land uses -  $SOC_{non-forestland}$  are presented in Table 6.3.9 and used in calculations.

## Organic soils

Activity data on organic soil are revised according to area data from Pedology map, which is consistent with areas in the Agriculture sector. Emissions from organic soil in Land converted to Forest land were not reported. For 70 % of national land-use classes, which have organic soils, the annual difference in land use changes is below 1 %, while in other 30 % classes the difference rarely exceeds 5 %. The difference is analysed by crosstabulation of vector layers and the result is in most cases due to methodology ("sliver" effect). Therefore, we believe that areas with organic soils are rather stable. Thus, no land-use conversions are assumed in Land converted to Forest land.

### 6.4.5 Uncertainties and time-series consistency

A process of using models to time-shift the forest estate forwards to represent future forest growth and forest managed, and backwards to improve historical estimates, is performed to minimize errors. As the estimation of carbon stocks is continuously being improved both past and future will be recalculated.

The FECS is based on a very comprehensive quality assurance system, which allows the exact identification of the right location of the grid and sample points guarantees the repeated measurement of the same trees. It also indicates at once implausible figures for individual

parameters during the measurements on site and any missing trees compared to the period before.

One of the goals of FECS 2012 was to obtain accurate and reliable data about the state of volume of wood growing stock (carbon stock) and dead wood stock as basis for KP/UNFCCC reporting for all Slovenian forests. Some of indicators from FECS 2007 and 2012 are in Table 6.4.7.

**Table 6.4.7: Indicators from FECS 2007 and 2012**

Parameter	FECS 2000	FECS 2007	FECS 2012
Growing stock	283.20 m <sup>3</sup> /ha (±4.68 %)	313.58 m <sup>3</sup> /ha (±4.21 %)	333.74 m <sup>3</sup> /ha (±4.08 %)
Dead wood	n.a.	19.75 m <sup>3</sup> /ha	19.76 m <sup>3</sup> /ha
Soil and litter	see chapter 6.3.2		

## 6.4.6 Source specific QA/QC and verification

The data based on forest statistics are produced by the Slovenian Forestry Institute (SFI). Data descriptions are available in Slovenian language.

QC measures related to national Forestry Inventory data were:

- A manual for FECS was prepared.
- Field instruments were calibrated and checked.
- All methods were tested in pilot inventory in 2006 (grid 16 x 16 km).
- In preparatory phase all field personnel was trained for:
  - correct use equipments.
  - correct measurements and classifications.
  - understanding of the guidelines and specific instructions.
- Verification measurements were carried out during field seasons - 4 teams from SFI were controlling the field measurements and work of Slovenian Forest Service teams.
- Field data was entered in database and checked for major discrepancies.
- All data used for our calculation is saved on our data server and are protected from unauthorized access.

All soil samples (from soil inventory on 8 km x 8 km) were delivered and stored in laboratory at SFI according to internal quality management system.

General QA/QC, taking into account the figures check, correctness of the calculation used, data sources etc., were performed in the category, as it was subject to source specific recalculation.

## 6.4.7 Source specific recalculations

Emissions was recalculated due to consideration of relatively high variation in EF for some periods recognized during the 2016 revision. As it was explained, jumps in emissions trends are results of the methodology. In recalculation, data from FECS 2000, 2007 and 2012 were

considered, which are in good correlation with SFS forest data, which have smoother trend. But rather than growing stock acquired from the SFS inventory, data on gain and loss were incorporated in the overlap method. Following the recommendation given by the ERT and in line with the IPCC 2006 guidelines update of EF from Table 2.5 was made, which result in recalculations. Moreover, new activity data on burnt area for the years 1986 and 1987 (Prelec, 1993) were obtained from the literature review.

#### **6.4.8 Source specific planned improvements**

For the next annual submission we plan to recalculate or estimate all uncertainty estimates related to activity data and/or emission factors for the category. In 2018 we assume the repetition of the national forest inventory (FECS), while forest soil monitoring has started in 2016.

Following the recommendation of the ERT the issue on increment data covered in the FECS was revised. It turns that all plots of the FECS inventory were taken into account in the calculation of increment (acumulation rate) for Forest land remaining Forest land, which is not correct. However, removals that occur on Land converted to Forest land are not double counted as different source of increment data (Wisdom Slovenia, 2006) is used in the calculation of carbon stock change. It is assumed that carbon stock in living biomass of Forest land remaining Forest land is underestimated. Those FECS plots that have not reached the age of 20 years will not be taken into account in the estimation of emissions and removals of the Forest land remaining Forest land category. The revised carbon stock will be also used when estimating the emissions occur on land converted from forest land in the next annual submission.

## 6.5 Cropland (4B)

### 6.5.1 Source category description

Cropland category includes CO<sub>2</sub> emissions from changes in carbon stock in living biomass and in soils. Carbon stock changes are reported in Cropland remaining cropland and in Land converted to cropland.

Cropland covered 12.6 % of country area in 2016. Cropland land use is separated in two subcategories: annual cropland (arable land, temporary meadows, hop fields, green houses) and perennial cropland (other permanent crops on arable land, vineyards, nursery, intensive orchards, extensive orchards, olive groves, other permanent crops, forest plantation).

Emissions and removals in category Cropland range from 31,13 Gg CO<sub>2</sub> (1986) to -201.53 Gg CO<sub>2</sub> (1991). Both categories Cropland remaining Cropland and Land converted to Cropland are key categories according to trend.

Table 6.5.1: Activity data for Cropland (1986 – 2016) in kha

Year	4.B. Total Cropland	4.B. Organic soil	4.B.1. Cropland remaining Cropland	4.B. 2. Land converted to Cropland	4.B.2.1 Forest Land converted to Cropland	4.B.2.2 Grassland converted to Cropland	4.B.2.3 Wetland converted to Cropland	4.B.2.4 Settlements converted to Cropland	4.B.2.5 Other Land converted to Cropland
Area, kha									
2016	255.87	2.50	233.14	22.73	1.58	20.80	NO	0.35	NO
2015	257.40	2.50	234.02	23.38	1.60	21.43	NO	0.35	NO
2014	258.93	2.50	235.44	23.49	1.65	21.39	NO	0.45	NO
2013	260.47	2.35	236.86	23.61	1.76	21.29	NO	0.56	NO
2012	262.00	2.35	238.27	23.73	1.76	21.31	NO	0.66	NO
2011	263.53	2.34	239.69	23.84	1.81	21.27	NO	0.76	NO
2010	265.07	2.28	241.11	23.96	1.87	21.23	NO	0.87	NO
2009	266.60	2.27	241.67	24.93	1.90	21.98	NO	1.05	NO
2008	268.13	2.25	242.24	25.89	1.93	22.73	NO	1.23	NO
2007	269.67	2.25	242.81	26.86	1.97	23.48	NO	1.42	NO
2006	271.20	2.22	243.37	27.83	2.00	24.23	NO	1.60	NO
2005	272.55	2.20	244.55	28.00	2.00	24.23	NO	1.78	NO
2004	273.90	2.18	245.72	28.18	2.00	24.23	NO	1.95	NO
2003	275.25	2.16	246.90	28.35	2.00	24.23	NO	2.13	NO
2002	276.60	2.14	248.07	28.53	2.00	24.23	NO	2.30	NO
2001	278.34	2.12	249.49	28.85	2.01	24.35	NO	2.49	NO
2000	280.08	2.10	250.91	29.16	2.03	24.46	NO	2.67	NO
1999	281.82	2.10	252.34	29.48	2.04	24.58	NO	2.86	NO
1998	283.56	2.10	253.76	29.80	2.06	24.70	NO	3.04	NO
1997	285.29	2.10	255.18	30.12	2.07	24.82	NO	3.23	NO
1996	287.03	2.10	256.60	30.43	2.09	24.93	NO	3.41	NO
1995	288.77	2.10	258.02	30.75	2.10	25.05	NO	3.60	NO
1994	292.10	2.10	260.50	31.60	2.08	25.84	NO	3.68	NO
1993	295.43	2.10	262.98	32.45	2.06	26.63	NO	3.76	NO
1992	298.75	2.10	265.45	33.30	2.04	27.42	NO	3.84	NO
1991	302.08	2.10	267.93	34.15	2.02	28.21	NO	3.92	NO
1990	305.41	2.10	270.41	35.00	2.00	29.00	NO	4.00	NO
1989	305.46	2.10	270.46	35.00	2.00	29.00	NO	4.00	NO
1988	305.51	2.10	270.51	35.00	2.00	29.00	NO	4.00	NO
1987	305.56	2.10	270.56	35.00	2.00	29.00	NO	4.00	NO
1986	305.61	2.10	270.61	35.00	2.00	29.00	NO	4.00	NO



Table 6.5.2: Emission from Cropland (1986 – 2016) in Gg CO<sub>2</sub>

Year	5.B. Total Cropland	5.B.1. Cropland remaining Cropland	5.B.2. Land converted to Cropland	5.B.2.1 Forest Land converted to Cropland	5.B.2.2 Grassland converted to Cropland	5.B.2.3 Wetland converted to Cropland	5.B.2.4 Settlements converted to Cropland	5.B.2.5 Other Land converted to Cropland
GHG emissions/removals, Gg CO <sub>2</sub>								
2016	-127.11	-180.22	53.11	27.14	27.29	NO	-1.32	NO
2015	-130.27	-180.24	49.98	26.75	24.66	NO	-1.43	NO
2014	-137.57	-184.96	47.39	26.40	23.26	NO	-2.27	NO
2013	-150.15	-194.83	44.67	25.97	21.82	NO	-3.12	NO
2012	-157.42	-199.65	42.23	25.68	20.51	NO	-3.96	NO
2011	-165.02	-204.59	39.58	25.30	19.12	NO	-4.84	NO
2010	-174.79	-211.78	37.00	24.92	17.76	NO	-5.68	NO
2009	-179.24	-215.24	36.01	24.50	18.58	NO	-7.08	NO
2008	-183.81	-218.75	34.94	24.09	19.36	NO	-8.51	NO
2007	-187.72	-221.64	33.92	23.68	20.17	NO	-9.94	NO
2006	-175.92	-226.56	50.63	37.22	24.59	NO	-11.18	NO
2005	-179.60	-231.00	51.39	36.66	27.16	NO	-12.43	NO
2004	-183.16	-235.32	52.16	36.09	29.74	NO	-13.67	NO
2003	-186.82	-239.74	52.92	35.52	32.31	NO	-14.92	NO
2002	-201.53	-244.40	42.87	29.40	29.70	NO	-16.23	NO
2001	-197.15	-241.68	44.53	28.93	33.15	NO	-17.55	NO
2000	-194.22	-240.44	46.22	28.46	36.63	NO	-18.87	NO
1999	-189.69	-237.69	48.00	28.11	40.08	NO	-20.19	NO
1998	-185.35	-235.13	49.78	27.72	43.53	NO	-21.47	NO
1997	-181.50	-233.03	51.53	27.34	46.98	NO	-22.79	NO
1996	-177.21	-230.48	53.27	26.95	50.43	NO	-24.11	NO
1995	-173.50	-228.02	54.52	38.68	40.63	NO	-24.79	NO
1994	-177.53	-233.15	55.61	38.15	42.84	NO	-25.38	NO
1993	-181.37	-238.07	56.71	37.62	45.01	NO	-25.93	NO
1992	-184.79	-242.55	57.76	37.05	47.22	NO	-26.52	NO
1991	-187.57	-246.43	58.85	36.52	49.40	NO	-27.07	NO
1990	22.73	-249.80	272.53	29.30	270.40	NO	-27.17	NO
1989	25.30	-246.80	272.10	28.87	270.40	NO	-27.17	NO
1988	27.34	-244.32	271.67	28.44	270.40	NO	-27.17	NO
1987	29.27	-241.96	271.24	28.01	270.40	NO	-27.17	NO
1986	31.13	-239.68	270.81	27.58	270.40	NO	-27.17	NO

## 6.5.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The information of cropland area is based on two data sources. Data from Statistical Yearbook of the Statistical Office RS (SORS) was used to present cropland area in the period 1986-2001. The estimation of cropland area for the period 2002-2012 was provided by the Slovenian Forestry Institute through targeted research project "Bases for improving the methodology of greenhouse gas emissions in relation to land use, land use change and forestry". The estimation of cropland area and annual land-use changes for the years 2013, 2014 and 2015 were extrapolated. The approach used for representing cropland areas follows the principle of estimation of areas via proportions, where the total area of the inventory region is known (IPCC 2006). The methodology of data acquisition as well as detection of land use changes from and to cropland is described in the sub-chapter 6.3.1. The following maps and databases were used in the assessment of cropland areas:

- Digital orthophotos of the Surveying and Mapping Authority RS,
- Land-use database of the Statistical Yearbook of the Statistical Office RS,
- Agricultural Land Use Map and LPIS database of the Ministry of Agriculture, Forestry and Food,
- Land cover map of Slovenia from Landsat satellite imagery (images for the period 1984-2014 collected by ZRC SAZU).

## 6.5.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The cropland is not defined specifically in terms of national legislation or land-use classification. However, the Agricultural Land Act (2011) defines agricultural land as land suitable for the agricultural production. The Act refers to the national land-use classes determined by Article 6 of the Rules on the register of actual agricultural and forest land use (2006). For the need of the GHG reporting the Cropland category includes the following land-use classes (Table 6.2.1); arable land, including fields and gardens, hop fields, green houses, other permanent crops on arable land, vineyards, nursery, intensive and extensive orchards, olive groves, other permanent crops and forest plantation.

## 6.5.4 Methodological issues

### 6.5.4.1 Cropland remaining Cropland

In time period from 1986 to 2016 the annual emissions were between -249.80 Gg CO<sub>2</sub> (1990) and -180.22 Gg CO<sub>2</sub> (2016).

### Carbon stock changes in living biomass

Annual Cropland remaining annual Cropland

According to 2006 Guidelines for annual crops, increase in biomass stocks in a single year is assumed equal to biomass losses from harvest and mortality in that same year – thus there is no net accumulation of biomass carbon stocks.

### Perennial Cropland remaining perennial Cropland

**Table 6.5.3: Areas of perennial cropland in reporting years, comparing with areas of perennial Cropland 30 years before (aggregated values)**

Year	Area of perennial cropland, ha	Year	Area of perennial cropland, ha
2016	37754	1985	27343
2015	37838	1984	27302
2014	38281	1983	27367
2013	38721	1982	27358
2012	39168	1981	27218
2011	39611	1980	27118
2010	40055	1979	26980
2009	40238	1978	26926
2008	40421	1977	26819
2007	40605	1976	26677
2006	40788	1975	26613
2005	41138	1974	26476
2004	41456	1973	26430
2003	41806	1972	26233
2002	42156	1971	26774
2001	41813	1970	26145
2000	41470	1969	26125
1999	41128	1968	25950
1998	40785	1967	25424
1997	40442	1966	25241
1996	40099	1965	24891
1995	39757	1964	24336
1994	40297	1963	23910
1993	40837	1962	23842
1992	41377	1961	24271
1991	41917	1960	23597
1990	42457	1959	23687
1989	42082	1958	23361
1988	41707	1957	22946
1987	41332	1956	22469
1986	40957		

The aggregated data for perennial Cropland (orchards and vineyards) are available from 1956 onwards from SORS (Statistical office of the Republic of Slovenia). For the calculation of

annual change in carbon stocks in living biomass of perennial Cropland remaining perennial Cropland Tier 1 (Gain-Loss) method was applied, described well in the Austrian NIR. According to this approach, annual change in biomass was calculated by the equation below:

$$\text{Annual change in biomass} = (\text{area of perennial Cropland remaining perennial Cropland} * \text{carbon accumulation rate}) - (\text{area of perennial Cropland before 30 years} * 0.033 * \text{biomass carbon stock at harvest})$$

After this approach it is assumed that areas of perennial Cropland other than orchards and vineyards are excluded since no data are available. Moreover, perennial Cropland areas lost by land use changes are excluded, as well.

For the annual carbon accumulation rate the default value of  $2.1 \text{ t C ha}^{-1} \text{ year}^{-1}$  was used according to Table 5.1 (IPCC 2006), whereas country-specific value of  $10.38 \text{ t C ha}^{-1}$  for above-ground biomass carbon stock at harvest in perennial Cropland. It is assumed that the country-specific value used is more appropriate to represent amount of living biomass carbon stock also in other perennial Cropland than default IPCC value ( $63 \text{ t C ha}^{-1}$ ). We have taken into account the 30 years rotation period for perennial Cropland according to the same table mentioned above. It is estimated that 3.33 % area per year of perennial Cropland is harvested.

### Perennial Cropland converted to annual Cropland

The average annual land-use change from perennial Cropland to annual Cropland in the time period from 1986 to 2012 was 85 ha.

For the calculation of annual change in carbon stocks in living biomass of perennial Cropland converted to annual Cropland the Tier 1/Tier 2 method was applied and equations 2.15 and 2.16 (IPCC 2006) were used.

$$\text{Annual change in biomass} = A * (\Delta C_{\text{conversion}} + \Delta C_G) \quad (\text{Equation 14})$$

$$\Delta C_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

$A$  – annual area of converted land

$C_{\text{after}}$  – carbon after conversion is 0

$C_{\text{before}}$  – IPCC default value for carbon stock in wood biomass before is  $10.38 \text{ t C ha}^{-1}$

$\Delta C_G$  – IPCC default value for annual crops carbon accumulation rate  $5.0 \text{ t C ha}^{-1}$

Value for the annual crops carbon accumulation rate ( $\Delta C_G = 5.0 \text{ t C ha}^{-1} \text{ yr}^{-1}$ ) was adopted from Table 5.9 (IPCC 2006) and country-specific value for carbon stock in wood biomass before conversion ( $C_{\text{before}} = 10.38 \text{ t C ha}^{-1}$ ). The values for temperate climate were chosen as this is default regime applicable to Slovenia (Europe).

### Annual Cropland converted to perennial Cropland

The average of annual land-use change from annual Cropland to perennial Cropland in the time period from 1986 to 2012 was 161 ha.

For the calculation of annual change in carbon stocks in living biomass of annual Cropland converted to perennial Cropland the Tier 1/Tier 2 method was applied and equations 2.15 and 2.16 (IPCC 2006) were used.

$$\text{Annual change in living biomass} = A * (\Delta C_{\text{conversion}} + \Delta C_G) \quad (\text{Equation 15})$$

$$\Delta C_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

$A$  – annual area of converted land

$C_{\text{after}}$  – carbon after conversion is 0

$C_{\text{before}}$  – IPCC default value for carbon stock in biomass before is  $5.0 \text{ t C ha}^{-1}$

$\Delta C_G$  – IPCC default value for perennial crops carbon accumulation rate  $2.1 \text{ t C ha}^{-1}$

Values for the perennial crops carbon accumulation rate ( $\Delta C_G = 2.1 \text{ t C ha}^{-1} \text{ yr}^{-1}$ ) was adopted from Table 5.1 (IPCC 2006) and value for carbon stock in annual crops biomass before conversion ( $C_{\text{before}} = 5.0 \text{ t C ha}^{-1}$ ) was adopted from Table 5.9 (IPCC 2006). The values for temperate climate were chosen as this is default regime applicable to Slovenia (Europe).

### **Carbon stock changes in dead organic matter**

The Tier 1 method of 2006 Guidelines assumes that the dead wood and litter stocks are not present in Cropland or are at equilibrium as in agroforestry systems and orchards. Thus, there is no need to estimate the carbon stock changes for these pools.

### **Carbon stock changes in soils**

#### **Mineral soils**

Emissions were estimated applying the Tier1/Tier 2 methodology and equation 2.25 (IPCC 2006) was used.

$$\Delta C_{CC\text{mineral}} = \frac{[SOC_0 - SOC_{0-T}] * A}{T} \quad (\text{Equation 16})$$

$\Delta C_{CC\text{mineral}}$  – annual change in carbon stock in mineral soils [ $\text{t C yr}^{-1}$ ]

$SOC_0$  – soil organic carbon stock in the inventory year [ $\text{t C ha}^{-1}$ ]

$SOC_{0-T}$  – soil organic carbon stock  $T$  years prior to the inventory [ $\text{t C ha}^{-1}$ ]

$T$  – time [default 20 years]

$A$  – land area [ha]

$$SOC = SOC_{CL}$$

$SOC_{CL}$  – country-specific value for organic carbon stock in mineral soil for Cropland

Slovenian national value for organic carbon stock in mineral soil for Cropland (annual Cropland:  $SOC_{CL\text{annual}} = 88.08 \text{ t C ha}^{-1}$ ; perennial Cropland:  $SOC_{CL\text{perennial}} = 83.71 \text{ t C ha}^{-1}$ ) are presented in Table 6.3.9.

## Organic soils

Total area of (cultivated) organic soils in Cropland category in year 2016 was 2,498.4 ha. The expert judgement is that areas of arable land on organic soils are relatively constant from 1995 onwards (Agricultural institute of Slovenia, 2006).

For calculations emissions from organic soil Tier 1/Tier 2 methodology and equation 2.26 from 2006 Guidelines was used:

$$\Delta C = \sum (A * EF) \quad \text{(Equation 17)}$$

*A* – land area of organic soils

*EF* – emission factor for climate type (10 t ha<sup>-1</sup>)

$$\Delta C = \sum (A * EF)$$

Default emission factor (EF = 10 t ha<sup>-1</sup> for warm temperate climatic temperature regime) from Table 5.6 (IPCC 2006) was adopted.

### 6.5.4.2 Land converted to Cropland

The average annual area in the period 1986-2012 converted from other land uses to Cropland is 1,251 ha; 640 ha to annual Cropland and 611 ha to perennial Cropland according to land-use change matrices. However, conversions from Forest land to Cropland and Grassland to Cropland appear. There are no conversions from Wetlands and Other land to Cropland, and also conversions from Settlements to Cropland rarely occur.

The average annual area converted from Forest land to Cropland is 392 ha (to annual Cropland: 23 ha; to perennial Cropland: 369 ha). The average annual area converted from Grassland to Cropland is 2,463 ha (to annual Cropland: 2,177 ha; to perennial Cropland: 286 ha).

#### Carbon stock changes in living biomass

For the calculations of the annual change in carbon stocks in living biomass on Land converted to Cropland the Tier1/Tier2 methodology and equations 2.15 and 2.16 (IPCC 2006) were used.

$$\text{Annual change in biomass} = A * (\Delta C_{\text{conversion}} + \Delta C_G) \quad \text{(Equation 18)}$$

$$\Delta C_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

*A* – annual area of converted land

$\Delta C_G$  – IPCC default value for carbon accumulation rate

accumulation rates: annual crops is 5.0 t C ha<sup>-1</sup>. perennial crops is 2.1 t C ha<sup>-1</sup>

*C<sub>after</sub>* – carbon after conversion is 0

*C<sub>before</sub>* – growing stock (Forest land), biomass carbon stocks (Grassland)

Values for the perennial crops carbon accumulation rate ( $\Delta C_G = 2.1 \text{ t C ha}^{-1}$ ) and for the annual crops accumulation rate ( $\Delta C_G = 5.0 \text{ t C ha}^{-1}$ ) were adopted from Table 5.1 (IPCC 2006). The growing stock in Forest land ( $C_{\text{before}}$ ) is represented in the subchapter 6.4.4.1. Value for biomass carbon stocks of Grassland ( $C_{\text{before}} = 13.5 \text{ t C ha}^{-1}$ , warm temperate - wet) was adopted from Table 6.4 (IPCC 2006).

### **Carbon stock changes in dead organic matter**

Carbon stock changes in dead organic matter were calculated for dead wood and litter pool in conversion from Forest land to Cropland. The following equation was used:

$$\Delta C_{LC_{DOM}} = \Delta C_{LC_{DW}} + \Delta C_{LC_{LT}} \quad \text{(Equation 19)}$$

$\Delta C_{LC_{DOM}}$  – annual change in carbon stocks in dead organic matter [ $\text{t C yr}^{-1}$ ]  
 $\Delta C_{LC_{DW}}$  – change in carbon stocks in dead wood [ $\text{t C yr}^{-1}$ ]  
 $\Delta C_{LC_{LT}}$  – change in carbon stocks in litter [ $\text{t C yr}^{-1}$ ]

For calculations of annual change in carbon stocks in dead wood the following equation was used:

$$\Delta C_{LC_{DW}} = \text{annual area of converted land} * \Delta C_{\text{conversion}} \quad \text{(Equation 20)}$$

$\Delta C_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$   
 $C_{\text{after}}$  – carbon after conversion is 0  
 $C_{\text{before}}$  – carbon stock in dead wood [ $\text{t C ha}^{-1}$ ]

Values for carbon stock in dead wood ( $C_{\text{before}}$ ) were calculated from FECS 2007 and FECS 2012 data.

For calculations of annual change in carbon stocks in litter the following equation was used:

$$\Delta C_{LC_{LT}} = \text{annual area of converted land} * \Delta C_{\text{conversion}} \quad \text{(Equation 21)}$$

$\Delta C_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$   
 $C_{\text{after}}$  – carbon after conversion is 0  
 $C_{\text{before}}$  – carbon stock in litter [ $\text{t C ha}^{-1}$ ]

Value for carbon stock in litter ( $C_{\text{before}} = 10.41 \text{ t C ha}^{-1}$ ) was used from Slovenian Forestry Institute research study (Kobal and Simoncic 2011).

**Carbon stock changes in soils****Mineral soils**

For calculations of emissions from soils in Land converted to Cropland Tier 2 methodology and equation 2.25 (IPCC 2006) were used.

$$\Delta C_{LCmineral} \frac{[SOC_0 - SOC_{0-T}]}{T} \quad \text{(Equation 22)}$$

$\Delta C_{LCmineral}$  – annual change in carbon stock in mineral soils [t C yr<sup>-1</sup>]  
 $SOC_0$  – soil organic carbon stock in the inventory year [t C ha<sup>-1</sup>]  
 $SOC_{0-T}$  – soil organic carbon stock T years prior to the inventory [t C ha<sup>-1</sup>]  
 $T$  – time [default 20 years]  
 $A$  – land area [ha]

$SOC = SOC_{CL}$   
 $SOC_{CL}$  – country-specific value for organic carbon stock in mineral soil for Cropland

Slovenian national value for organic carbon stock in mineral soil for Cropland (annual Cropland:  $SOC_{CLannual} = 88.08 \text{ t ha}^{-1}$ ; perennial Cropland:  $SOC_{CLperennial} = 83.71 \text{ t ha}^{-1}$ ) are presented in Table 6.2.8.

**Organic soils**

Activity data on organic soil are revised according to area data from Pedology map, which is consistent with areas in the Agriculture sector. Emissions from organic soil in Land converted to Cropland were not reported. For 70% of national land-use classes, which have organic soils, the annual difference in land use changes is below 1 %, while in other 30 % classes the difference rarely exceeds 5%. The difference is analysed by crosstabulation of vector layers and the result is in most cases due to methodology ("sliver" effect). Therefore, we believe that areas with organic soils are rather stable.

**N<sub>2</sub>O emissions from N mineralization/immobilization**

For calculations of N<sub>2</sub>O emissions associated with land conversion to Cropland Tier 1 methodology using equations 11.1 and 11.8 (IPCC 2006) and default emission factors from the table 11.1 were used. However, in NIR 2018 submission the direct N<sub>2</sub>O emissions as result of loss of soil C from soil organic matter due to land-use conversion to Cropland are estimated in Agriculture sector (CRF sector 3).

$$N_2O - N_{Direct} = N_2O_{Ninputs} - N \quad \text{(Equation 23)}$$

$$N_2O_{Ninputs} - N = EF_1 * F_{SOM}$$



$N_2O-N_{Direct}$  – annual direct  $N_2O-N$  emissions produced from managed soils ( $kg\ N_2O-N\ yr^{-1}$ )

$F_{SOM}$  – annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes to land use or management ( $kg\ N\ yr^{-1}$ )

$EF_1$  – IPCC default emission factor used to estimate direct  $N_2O$  emissions from managed soils [ $kg\ N_2O-N\ (kg\ N)^{-1}$ ]. The default value is  $0.01\ kg\ N_2O-N\ (kg\ N)^{-1}$

According to 2006 Guidelines conversion of  $N_2O-N$  emissions to  $N_2O$  emissions for reporting purposes is performed by using the following equation:  $N_2O = N_2O-N * 44/28$ .

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 was estimated using the following equation:

$$F_{SOM} = \sum_{LU} \left[ \left( \Delta C_{Mineral, LU} * \frac{1}{R} \right) * 1000 \right] \quad \text{(Equation 24)}$$

$F_{SOM}$  – annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes to land use or management ( $kg\ N\ yr^{-1}$ )

$\Delta C_{Mineral, LU}$  – average annual loss of soil carbon for each land-use type ( $t\ C$ )

$R$  – C:N ratio of soil organic matter. Default value for the C:N ratio is 15.

Values for annual carbon stock change in soils ( $\Delta C_{Mineral, LU}$ ) were taken from calculations of carbon stock changes in soils for Land converted to Cropland (Forest land and Grassland to Cropland). For emission factor ( $EF_1$ ), the default value ( $0.01\ kg\ N_2O-N/kg\ N$ ) was used.

### **Indirect $N_2O$ emissions from N leaching and run-off**

For estimation of indirect  $N_2O$  emissions from managed soils arising from N mineralization due to change of land use or management on mineral soils through leaching/runoff were estimated by applying Tier 1 method (equation 11.10) and default emission factors being available in Table 11.3 of GPG (IPCC 2006). However, these emissions are reported under Agriculture sector (CRF sector 3).

## **6.5.5 Uncertainties and time-series consistency**

Uncertainties can be analysed as uncertainty in activity data and uncertainty in variables such as emission factors, growth rates, effect of land management factors etc. It is the uncertainty in the IPCC default variables that dominates the overall uncertainty in the estimated provided by Slovenia.

The following uncertainties for 2015 were estimated. They are based on uncertainly values for IPCC default values taken from the IPCC-GPG (for the most sources these default values were used) and on expert judgement.

Variable	Uncertainty (95% CI)
Uncertainty in cropland remaining cropland	

Uncertainty in biomass accumulation rates		± 75 % (2006 Guidelines, Table 5.1)
Uncertainty from land converted to cropland		
Carbon stocks in previous land use	Grassland	± 75 % (2006 Guidelines, Table 5.9, 6.4)
	Forest land	See chapter 7.3

### 6.5.6 Category-specific QA/QC and verification

There were no category-specific QA/QC and verification in this annual submission. However, general QA/QC, taking into account the figures check, correctness of the calculation used, data sources etc., were performed in the category, as it was subject to source specific recalculation.

### 6.5.7 Category-specific recalculations

The carbon stock value in orchards and vineyards was reconsidered, which resulted in updated EF and recalculations. In consistence with the methodology provided in the 2006 Guidelines, gains occurred after 2 years onward were also estimated and reported in Land converted to perennial Cropland. In the NIR 2018 soil carbon stock values were updated, excluding forest land, based on data from soil monitoring, carried out on agricultural land (Mali et al., 2016, Mali et al., 2017).

### 6.5.8 Source-specific planned improvements

For the next annual submission we plan to recalculate emission factors for the category as inventory of above-ground biomass on agricultural land was implemented in 2017. There is another public tender planned in 2018, concerning soil monitoring on agricultural land, which will be base for futher improvements.

## 6.6 Grassland (4C)

### 6.6.1 Source category description

Grassland category includes CO<sub>2</sub> emissions from changes in carbon stock in living biomass and in soils. Carbon stock changes are reported in Grassland remaining Grassland and in Land converted to Grassland. Grassland covered 19.7 % of country total area in 2016.

Grassland land use includes: meadows and pastures, swampy meadows and pastures, alpine meadows, mixed land use (arable land and forest. small areas) and uncultivated agriculture land.

CO<sub>2</sub> emissions and removals in category Grassland range from -431.6 Gg CO<sub>2</sub> (1987) to 42.9 Gg CO<sub>2</sub> (2016). Land converted to Grassland (CO<sub>2</sub>) was identified as key source category according to the level and trend. Grassland remaining Grassland (CO<sub>2</sub>) was not identified as key source category.

**Table 6.6.1: Activity data for Grassland in 1986 – 2016 in kha**

Year	5.C. Total Grassland	5.C. Organic soil	5.C.1. Grassland remaining Grassland	5.C.2. Land converted to Grassland	5.C.2.1 Forest Land converted to Grassland	5.C.2.2 Cropland converted to Grassland	5.C.2.3 Wetlands converted to Grassland	5.C.2.4 Settlements converted to Grassland	5.C.2.5 Other Land converted to Grassland
Area, kha									
2016	399.30	0.95	339.33	59.97	10.57	45.05	0.36	1.43	2.56
2015	398.80	0.94	337.78	61.02	10.50	45.70	0.40	1.45	2.97
2014	398.30	0.99	334.35	63.95	10.58	47.28	0.42	2.40	3.27
2013	397.80	0.82	330.92	66.88	10.66	48.86	0.44	3.35	3.57
2012	397.30	0.83	327.49	69.81	10.74	50.44	0.46	4.30	3.87
2011	396.80	0.81	324.05	72.75	10.82	52.02	0.48	5.25	4.17
2010	396.30	0.88	320.62	75.68	10.90	53.60	0.50	6.20	4.47
2009	395.80	0.80	318.09	77.71	10.78	53.26	0.53	7.42	5.72
2008	395.30	0.82	315.56	79.74	10.65	52.92	0.55	8.65	6.97
2007	394.80	1.06	313.02	81.78	10.53	52.58	0.58	9.87	8.22
2006	394.30	1.14	310.49	83.81	10.40	52.24	0.60	11.10	9.47
2005	393.53	1.23	308.52	85.01	10.03	51.44	0.60	12.25	10.70
2004	392.75	1.27	306.54	86.21	9.65	50.64	0.60	13.40	11.92
2003	391.98	1.30	304.57	87.41	9.28	49.84	0.60	14.55	13.15
2002	391.20	1.34	302.59	88.61	8.90	49.04	0.60	15.70	14.37
2001	406.08	1.34	316.49	89.59	8.85	48.05	0.58	16.90	15.21
2000	420.96	1.33	330.39	90.57	8.79	47.06	0.56	18.11	16.05
1999	435.84	1.32	344.29	91.56	8.74	46.07	0.55	19.31	16.89
1998	450.73	1.32	358.19	92.54	8.69	45.08	0.53	20.51	17.73
1997	465.61	1.31	372.09	93.52	8.63	44.09	0.51	21.72	18.57
1996	480.49	1.33	385.99	94.50	8.58	43.10	0.49	22.92	19.41
1995	495.37	1.34	399.88	95.49	8.53	42.11	0.48	24.13	20.25
1994	508.32	1.35	413.73	94.59	8.32	40.19	0.48	24.40	21.20
1993	521.28	1.37	427.58	93.69	8.12	38.27	0.49	24.68	22.15
1992	534.23	1.38	441.43	92.79	7.91	36.34	0.49	24.95	23.10
1991	547.18	1.39	455.28	91.90	7.71	34.42	0.50	25.23	24.05
1990	560.13	1.41	469.13	91.00	7.50	32.50	0.50	25.50	25.00
1989	560.63	1.42	469.63	91.00	7.50	32.50	0.50	25.50	25.00
1988	561.13	1.43	470.13	91.00	7.50	32.50	0.50	25.50	25.00
1987	561.63	1.45	470.63	91.00	7.50	32.50	0.50	25.50	25.00
1986	562.13	1.46	471.13	91.00	7.50	32.50	0.50	25.50	25.00

Table 6.6.2: Emissions from Grassland (1986 – 2016) in Gg CO<sub>2</sub>

Year	4.C. Total Grassland	4.C.1. Grassland remaining Grassland	4.C.2. Land converted to Grassland	4.C.2.1 Forest Land converted to Grassland	4.C.2.2 Cropland converted to Grassland	4.C.2.3 Wetland converted to Grassland	4.C.2.4 Settlements converted to Grassland	4.C.2.5 Other Land converted to Grassland
GHG emissions/removals, Gg CO <sub>2</sub>								
2016	42.90	NA	42.90	192.43	-100.36	-0.95	-13.09	-35.13
2015	33.28	NA	33.28	190.62	-102.23	-1.06	-13.17	-40.88
2014	11.78	NA	11.78	188.59	-109.93	-1.14	-21.65	-44.10
2013	-4.09	NA	-4.09	187.17	-113.96	-1.17	-30.08	-46.05
2012	-27.98	NA	-27.98	184.88	-123.42	-1.25	-38.59	-49.60
2011	-54.46	NA	-54.46	182.10	-134.27	-1.28	-47.13	-53.87
2010	-77.87	NA	-77.87	179.65	-143.11	-1.32	-55.64	-57.46
2009	-105.12	NA	-105.12	177.71	-144.36	-1.39	-66.63	-70.45
2008	-130.00	NA	-130.00	175.95	-144.43	-1.47	-77.60	-82.45
2007	-153.77	NA	-153.77	174.20	-144.21	-1.54	-88.56	-93.66
2006	-72.47	NA	-72.47	266.33	-136.14	-0.04	-98.33	-104.28
2005	-104.78	NA	-104.78	262.62	-137.65	-0.04	-108.91	-120.80
2004	-127.52	NA	-127.52	259.73	-135.59	-0.04	-119.29	-132.33
2003	-129.04	NA	-129.04	258.20	-127.09	-0.04	-129.30	-130.81
2002	-298.75	NA	-298.75	139.27	-146.81	1.06	-140.98	-151.30
2001	-303.42	NA	-303.42	137.75	-141.72	1.10	-151.76	-148.79
2000	-320.85	NA	-320.85	135.83	-140.51	1.14	-162.66	-154.64
1999	-350.31	NA	-350.31	133.88	-142.56	1.17	-173.66	-169.14
1998	-370.87	NA	-370.87	132.20	-142.08	1.25	-184.58	-177.65
1997	-388.64	NA	-388.64	130.63	-140.84	1.28	-195.48	-184.24
1996	-395.61	NA	-395.61	129.31	-137.21	1.32	-206.31	-182.71
1995	-322.83	NA	-322.83	177.54	-106.30	-0.04	-200.85	-193.18
1994	-334.19	NA	-334.19	175.56	-100.17	-0.04	-203.78	-205.76
1993	-290.01	NA	-290.01	175.12	-82.17	-0.04	-202.46	-180.45
1992	-298.39	NA	-298.39	173.19	-75.61	-0.07	-205.25	-190.65
1991	-333.57	NA	-333.57	170.55	-74.36	-0.07	-209.94	-219.75
1990	-429.33	NA	-429.33	104.43	-101.79	0.22	-207.71	-224.48
1989	-430.74	NA	-430.74	103.02	-101.79	0.22	-207.71	-224.48
1988	-422.21	NA	-422.21	101.79	-100.83	0.22	-206.77	-216.61
1987	-431.59	NA	-431.59	100.23	-101.60	0.22	-207.52	-222.91
1986	-423.61	NA	-423.61	98.99	-100.61	-0.37	-206.59	-215.04

### 6.6.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The information of grassland area is based on two data sources. Data from Statistical Yearbook of the Statistical Office RS (SORS) was used to present grassland area in the period 1986-2001. The estimation of area of Grassland for the period 2002-2012 was provided by the Slovenian Forestry Institute through targeted research project "Bases for improving the reporting methodology of greenhouse gas emissions in relation to land use, land use change and forestry". The estimation of cropland area and annual land-use changes for the years 2013, 2014 and 2015 were extrapolated. The approach used for representing grassland areas follows the principle of estimation of areas via proportions, where the total area of the inventory region is known (IPCC 2006). The methodology of data acquisition as well as detection of land use changes from and to grassland is described in the sub-chapter 6.3.1. The following maps and databases were used in the assessment of grassland areas:

- Digital orthophotos of the Surveying and Mapping Authority RS,
- Land-use database of the Statistical Yearbook of the Statistical Office RS,
- Agricultural Land Use Map and LPIS database of the Ministry of Agriculture, Forestry and Food,
- Land cover map of Slovenia from Landsat satellite imagery (images for the period 1984-2014 collected by ZRC SAZU).

### 6.6.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The grassland is not defined specifically in terms of national legislation. However, the Agricultural Land Act (2011) defines agricultural land as land suitable for the agricultural production. The Act refers to the national land-use classes determined by Article 6 of the Rules on the register of actual agricultural and forest land use (2006). For the need of the GHG reporting the Grassland category includes the following land-use classes (Table 6.2.1); meadows and pastures, swampy meadows and pastures, uncultivated agriculture land, overgrown areas, mixed land use, and forest trees on agricultural land.

### 6.6.4 Methodological issues

#### 6.6.4.1 Grassland remaining grassland

##### **Carbon stock changes in living biomass**

The Tier 1 assumption is no change in living biomass carbon stocks. The rationale is that in Grassland where management practices are static, biomass carbon stock will be in an approximate steady-state where carbon accumulation through plant growth is roughly balanced by losses.

**Carbon stock changes in soils**

For calculations of carbon stock changes in soils in Grassland remaining Grassland, the equation 2.24 (IPCC 2006) was used.

$\Delta C_{GGsoils} = \Delta C_{GGmineral} - L_{GGorganic} + \Delta C_{inorganic}$ <p> <math>\Delta C_{GGsoils}</math> - annual change in carbon stocks in soil [ t C yr<sup>-1</sup>]  <math>\Delta C_{GGmineral}</math> - annual change in carbon stocks in mineral soils [ t C yr<sup>-1</sup>]  <math>L_{GGorganic}</math> - annual loss of carbon from drained organic soils [ t C yr<sup>-1</sup>]  <math>\Delta C_{GGinorganic}</math> - annual change in inorganic carbon stocks from soils [ t C yr<sup>-1</sup>] </p>	<b>(Equation 25)</b>
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**Mineral soils**

For calculations of annual carbon stock changes in mineral soils in Grassland remaining Grassland Tier 2 methodology and equation 2.25 (IPCC 2006) were used.

Due to the expert judgment it is assumed that there have been no change in grassland management in the default period of 20 years. Thus, it is assumed that carbon stock changes in mineral soil are zero.

**Organic soils**

Total area of organic soils in Grassland in year 2016 was 0.95 kha. Emissions from organic soil are not reported in the NIR 2018 submission. The reason is that the GPG2003 assumed that emissions from organic soil are caused by drainage and other management perturbations (e.g. pasture management practices). In contrast, it seems that according to 2006 Guidelines only drainage is assumed to pose emissions from organic soil ("managed" vs. "drained" grassland organic soil in Table 3.4.6 of the GPG2003 and in Table 6.3 of the 2006 Guidelines, respectively). Since the drainage of managed grassland organic soil is not a common practice in Slovenia, emissions are not reported here.

**6.6.4.2 Land converted to Grassland**

According to the results from the point sampling conversions from all categories to Grassland occur, although conversions from Wetlands are very rare. The average annual area converted from other land uses to Grassland is 3,804 ha. The average annual area converted from Forest land is 515 ha, from Settlements 438, from Wetlands 23 ha, and from Other land 364 ha.

**Carbon stock changes in living biomass**

For the calculations of the annual change in carbon stocks in living biomass on land converted to grassland the Tier 2 methodology and equations 2.15 and 2.16 (IPCC 2006) were used.

$$\text{Annual change in living biomass} = A * (\Delta C_{\text{conversion}} + \Delta C_G) \quad (\text{Equation 26})$$

$$\Delta C_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

$A$  – annual area of converted land

$\Delta C_G$  – default value for carbon accumulation rate (13.5 t d.m. ha<sup>-1</sup>)

$C_{\text{after}}$  – carbon after conversion is 0

$C_{\text{before}}$  – carbon stock (forest land), biomass carbon stocks (Cropland)

Values for the carbon accumulation rate ( $\Delta C_G = 13.5$  t d.m. ha<sup>-1</sup>; warm temperate - wet) were adopted from Table 6.4 (IPCC 2006). The carbon stock in Forest land ( $C_{\text{before}}$ ) is represented in subchapter 6.4.4.1. Value for biomass carbon stocks of Cropland ( $C_{\text{before}} = 10.38$  t C ha<sup>-1</sup>, temperate) was adopted from Table 5.1 (IPCC 2006).

**Carbon stock changes in dead organic matter**

Carbon stock changes in dead organic matter were calculated for dead wood and litter pool in conversion from Forest land to Grassland. The following equation was used:

$$\Delta C_{LG_{DOM}} = \Delta C_{LG_{DW}} + \Delta C_{LG_{LT}} \quad (\text{Equation 27})$$

$\Delta C_{LG_{DOM}}$  – annual change in carbon stocks in dead organic matter [t C yr<sup>-1</sup>]

$\Delta C_{LG_{DW}}$  – change in carbon stocks in dead wood [t C yr<sup>-1</sup>]

$\Delta C_{LG_{LT}}$  – change in carbon stocks in litter [t C yr<sup>-1</sup>]

For calculations of annual change in carbon stocks in dead wood the following equation was used:

$$\Delta C_{LG_{DW}} = \text{annual area of converted land} * \Delta C_{\text{conversion}} \quad (\text{Equation 28})$$

$$\Delta C_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

$C_{\text{after}}$  – carbon after conversion is 0

$C_{\text{before}}$  – carbon stock in dead wood [t C ha<sup>-1</sup>]

Values for carbon stock in dead wood ( $C_{\text{before}}$ ) were calculated from FECS 2007 and 2012.

For calculations of annual change in carbon stocks in litter the following equation was used:



$$\Delta C_{LG_{LT}} = \text{annual area of converted land} * \Delta C_{\text{conversion}}$$

Equation 29

$$\Delta C_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

$C_{\text{after}}$  – carbon after conversion is 0

$C_{\text{before}}$  – carbon stock in litter [ $\text{t C ha}^{-1}$ ]

Value for carbon stock in litter ( $C_{\text{before}} = 10.41 \text{ t C ha}^{-1}$ ) was used from Slovenian Forestry Institute Research study (Kobal and Simoncic 2011).

### **Carbon stock changes in soils**

For calculations of emissions from soils in land converted to grassland Tier 2 methodology and equation 2.25 (IPCC 2006) were used.

$$\Delta C_{LG_{\text{mineral}}} = \frac{[SOC_0 - SOC_{0-T}] * A}{T}$$

(Equation 30)

$\Delta C_{LG_{\text{mineral}}}$  – annual change in carbon stock in mineral soils [ $\text{t C yr}^{-1}$ ]

$SOC_0$  – soil organic carbon stock in the inventory year [ $\text{t C ha}^{-1}$ ]

$SOC_{0-T}$  – soil organic carbon stock  $T$  years prior to the inventory [ $\text{t C ha}^{-1}$ ]

$T$  – time [default 20 years]

$A$  – land area [ha]

$$SOC = SOC_{GL}$$

$SOC_{GL}$  – country-specific value for organic carbon stock in mineral soil

Slovenian national value for organic carbon stock in mineral soil for grassland (grassland annual:  $SOC_{GL_{\text{annual}}} = 98.8 \text{ t C ha}^{-1}$ ; grassland perennial:  $SOC_{GL_{\text{perennial}}} = 114.4 \text{ t C ha}^{-1}$ ) are presented in Table 6.2.8.

### **Organic soil**

Activity data on organic soil were reviewed according to area data from Pedology map, which are consistent with those in Agricultural sector. However, emissions from organic soil were not estimated. For explanation, please see subchapter 6.5.4.1.

### **N<sub>2</sub>O emissions from N mineralization/immobilization**

For calculations of N<sub>2</sub>O emissions associated with land conversion to Grassland Tier 1 methodology using equations 11.1 and 11.8 and default emission factors from the table 11.1 (IPCC 2006) were used. Direct N<sub>2</sub>O emissions are estimated due to conversions in land use from Forest land, Cropland and Wetlands to Grassland.

**Indirect N<sub>2</sub>O emission from N leaching and run-off**

For estimation of indirect N<sub>2</sub>O emissions from N mineralization due to change of land use in mineral soils through leaching/runoff were estimated by applying Tier 1 method (equation 11.10) and default emission factors from Table 11.3 of GPG (IPCC 2006). Indirect N<sub>2</sub>O emissions are estimated due to conversions in land use from Forest land, Cropland and Wetlands to Grassland.

**6.6.5 Uncertainties and time-series consistency**

The following uncertainties for 2012 were estimated. They are based on uncertainly values for IPCC default values taken from the IPCC-GPG (for the most sources these default values were used) and on expert judgement.

Variable		Uncertainty (95% CI)
Uncertainty in grassland remaining grassland		
Uncertainty in biomass accumulation rates		± 75 % (2006 Guidelines, Table 5.1)
Uncertainty from land converted to grassland		
Carbon stocks in previous land use	Cropland	± 75 % (2006 Guidelines, Table 5.9)
	Forest land	

**6.6.6 Category-specific QA/QC and verification**

No specific QA/QC and verification was used for Grassland in NIR 2018 submission. However, general QA/QC, taking into account the figures check, correctness of the calculation used, data sources etc., were performed in the category, as it was subject to source specific recalculation.

**6.6.7 Category-specific recalculations**

Emissions were recalculated due to inclusion of new data on biomass growth obtained from SORS as well as biomass growth after conversion to perennial grassland, which improved EFs. In the NIR 2018 soil carbon stock values were updated, excluding forest land, based on data from soil monitoring, carried out on agricultural land (Mali et al., 2016, Mali et al., 2017).

**6.6.8 Source-specific planned improvements**

For the next annual submission we plan to recalculate emission factors for the category as inventory of above-ground biomass on agricultural land was implemented in 2017. There is another public tender planned in 2018, concerning soil monitoring on agricultural land, which will be base for futher improvements.

## 6.7 Wetlands (4D)

### 6.7.1 Source category description

Wetlands are defined according to the 2006 Guidelines as land that is covered or saturated by water for all or part of the year and that does not fall into the Forest land, Cropland, Grassland or Settlements categories. Emissions in Wetlands remaining Wetlands are not estimated, conversions from other land uses to Wetlands, except from Forest land and Grassland, do not occur in Slovenia.

Wetlands covered 0.7 % of country area in 2016. Wetlands include: swamps, reeds, other marshy areas and waters (inland water bodies). Emissions from Wetlands were between 0.26 Gg CO<sub>2</sub> (1998) and 25.99 Gg CO<sub>2</sub>. In the years 1996 and 1997 Wetlands acted as a small net sink of emissions.

Table 6.7.1: Activity data of Wetlands 1986 – 2016 in kha

Year	4.D Total wetlands	4.D.1 Wetlands remaining wetlands	Land converted to wetlands					
			4.D.2 Land converted to wetlands	4.D.2.1 Forest converted to wetlands	4.D.2.2 Cropland converted to wetlands	4.D.2.3 Grassland converted to wetlands	4.D.2.4 Settlements converted to wetlands	4.D.2.5 Other land converted to wetlands
			Area, kha					
2016	14.68	13.66	1.02	0.85	NO	0.17	NO	NO
2015	14.60	13.65	0.95	0.80	NO	0.15	NO	NO
2014	14.52	13.55	0.97	0.75	NO	0.21	NO	NO
2013	14.43	13.45	0.98	0.71	NO	0.28	NO	NO
2012	14.35	13.35	1.00	0.66	NO	0.34	NO	NO
2011	14.27	13.25	1.02	0.61	NO	0.40	NO	NO
2010	14.18	13.15	1.03	0.57	NO	0.47	NO	NO
2009	14.10	13.05	1.05	0.53	NO	0.53	NO	NO
2008	14.02	12.95	1.07	0.48	NO	0.58	NO	NO
2007	13.93	12.85	1.08	0.44	NO	0.64	NO	NO
2006	13.85	12.75	1.10	0.40	NO	0.70	NO	NO
2005	13.90	12.73	1.18	0.40	NO	0.78	NO	NO
2004	13.95	12.70	1.25	0.40	NO	0.85	NO	NO
2003	14.00	12.68	1.33	0.40	NO	0.93	NO	NO
2002	14.05	12.65	1.40	0.40	NO	1.00	NO	NO
2001	14.17	12.69	1.49	0.41	NO	1.08	NO	NO
2000	14.30	12.73	1.57	0.42	NO	1.15	NO	NO
1999	14.42	12.76	1.66	0.43	NO	1.23	NO	NO
1998	14.54	12.80	1.74	0.44	NO	1.30	NO	NO
1997	14.67	12.84	1.83	0.45	NO	1.38	NO	NO
1996	14.79	12.88	1.91	0.46	NO	1.45	NO	NO
1995	14.91	12.91	2.00	0.48	NO	1.53	NO	NO
1994	14.89	12.89	2.00	0.48	NO	1.52	NO	NO
1993	14.87	12.87	2.00	0.49	NO	1.52	NO	NO
1992	14.85	12.85	2.00	0.49	NO	1.51	NO	NO
1991	14.83	12.83	2.00	0.50	NO	1.51	NO	NO
1990	14.81	12.81	2.00	0.50	NO	1.50	NO	NO
1989	14.79	12.79	2.00	0.50	NO	1.50	NO	NO
1988	14.76	12.76	2.00	0.50	NO	1.50	NO	NO
1987	14.74	12.74	2.00	0.50	NO	1.50	NO	NO
1986	14.71	12.71	2.00	0.50	NO	1.50	NO	NO

Table 6.7.2: Emission from Wetlands (1986 – 2016) in Gg CO<sub>2</sub>

Year	4.D Total wetlands	4.D.1 Wetlands remaining wetlands	Land converted to wetlands					
			4.D.2 Land converted to wetlands	4.D.2.1 Forest converted to wetlands	4.D.2.2 Cropland converted to wetlands	4.D.2.3 Grassland converted to wetlands	4.D.2.4 Settlements converted to wetlands	4.D.2.5 Other land converted to wetlands
			GHG emissions/removals, Gg CO <sub>2</sub>					
2016	25.99	NO. NE	25.99	26.19	NO	-0.20	NO	NO
2015	25.90	NO. NE	25.90	26.05	NO	-0.15	NO	NO
2014	25.49	NO. NE	25.49	25.82	NO	-0.32	NO	NO
2013	25.09	NO. NE	25.09	25.59	NO	-0.50	NO	NO
2012	24.69	NO. NE	24.69	25.36	NO	-0.67	NO	NO
2011	24.28	NO. NE	24.28	25.12	NO	-0.84	NO	NO
2010	23.86	NO. NE	23.86	24.88	NO	-1.02	NO	NO
2009	23.45	NO. NE	23.45	24.63	NO	-1.17	NO	NO
2008	23.04	NO. NE	23.04	24.38	NO	-1.33	NO	NO
2007	22.63	NO. NE	22.63	24.12	NO	-1.49	NO	NO
2006	6.55	NO. NE	6.55	8.46	NO	-1.91	NO	NO
2005	6.20	NO. NE	6.20	8.32	NO	-2.11	NO	NO
2004	5.86	NO. NE	5.86	8.17	NO	-2.32	NO	NO
2003	5.51	NO. NE	5.51	8.03	NO	-2.52	NO	NO
2002	1.46	NO. NE	1.46	4.18	NO	-2.73	NO	NO
2001	1.15	NO. NE	1.15	4.08	NO	-2.93	NO	NO
2000	0.85	NO. NE	0.85	3.98	NO	-3.14	NO	NO
1999	0.55	NO. NE	0.55	3.90	NO	-3.34	NO	NO
1998	0.26	NO. NE	0.26	3.81	NO	-3.55	NO	NO
1997	-0.03	NO. NE	-0.03	3.72	NO	-3.75	NO	NO
1996	-0.32	NO. NE	-0.32	3.64	NO	-3.96	NO	NO
1995	2.41	NO. NE	2.41	5.33	NO	-2.92	NO	NO
1994	2.32	NO. NE	2.32	5.23	NO	-2.91	NO	NO
1993	2.24	NO. NE	2.24	5.14	NO	-2.89	NO	NO
1992	2.16	NO. NE	2.16	5.04	NO	-2.88	NO	NO
1991	2.07	NO. NE	2.07	4.94	NO	-2.87	NO	NO
1990	3.36	NO. NE	3.36	6.29	NO	-2.93	NO	NO
1989	3.25	NO. NE	3.25	6.18	NO	-2.93	NO	NO
1988	3.14	NO. NE	3.14	6.07	NO	-2.93	NO	NO
1987	3.03	NO. NE	3.03	5.97	NO	-2.93	NO	NO
1986	2.93	NO. NE	2.93	5.86	NO	-2.93	NO	NO

### **6.7.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation**

The information of wetlands area is based on multiple data sources. Data from Statistical Yearbook of the Statistical Office RS (SORS) was used to present wetlands area in the period 1986-2001. Besides, data on area of Wetlands until 2001 were complemented by the information from the land cover map (based on Landsat TM, ETM – EURIMAGE, Eurostat/CESD), being available for the years 1993, 1997 and 2001 and officially published (SORS 2005). The estimation of wetlands area for the period 2002-2012 was provided by the Slovenian Forestry Institute through targeted research project “Bases for improving the reporting methodology of greenhouse gas emissions in relation to land use, land use change and forestry”. The estimation of cropland area and annual land-use changes for the years 2013, 2014 and 2015 were extrapolated. The approach used for representing areas of Wetlands follows the principle of estimation of areas via proportions, where the total area of the inventory region is known (IPCC 2006). The methodology of data acquisition as well as detection of land use changes from and to wetlands is described in the sub-chapter 6.3.1. The following maps and databases were used in the assessment of wetlands areas:

- Digital orthophotos of the Surveying and Mapping Authority RS,
- Agricultural Land Use Map of the Ministry of Agriculture, Forestry and Food,
- Land cover map of Slovenia from Landsat satellite imagery (images for the period 1984-2014 collected by ZRC SAZU).

### **6.7.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories**

The wetlands are not defined specifically in terms of national legislation. However, the Rules on delineation of surface water bodies (2005) defines that detached surface water bodies are determined for large streams, natural lakes, sea and brackish water, artificial channels, water reservoirs on rivers and artificial lakes. For the need of the GHG reporting the Wetlands category includes the following land-use classes (Table 6.2.1); swamps, reeds, other marshy areas, and waters (inland water bodies). In line with the land-use classification (Identification key 2013) waters (class 7000) includes running and standing waters, channels, temporarily dry riverbeds, sandy beaches and dunes, gravel areas along or in the streams, river islands covered with vegetation, running waters in the forest (if recognizable from the map), capture and reservoirs, and fishponds.

### **6.7.4 Methodological issues**

#### **6.7.4.1 Wetlands remaining wetlands**

Slovenia has not reported emissions from Flooded land remaining Flooded land due to lack of data. As Ljubljana marsh, which is the largest Slovene and southernmost European wetland (area of cca. 160 km<sup>2</sup>), is subject to regular floods and drainage regime (e.g. clearing of the

drainage channels) emissions do occur in this wetland area. However, at present there is lack of sufficient data available to apply the Wetlands Supplement.

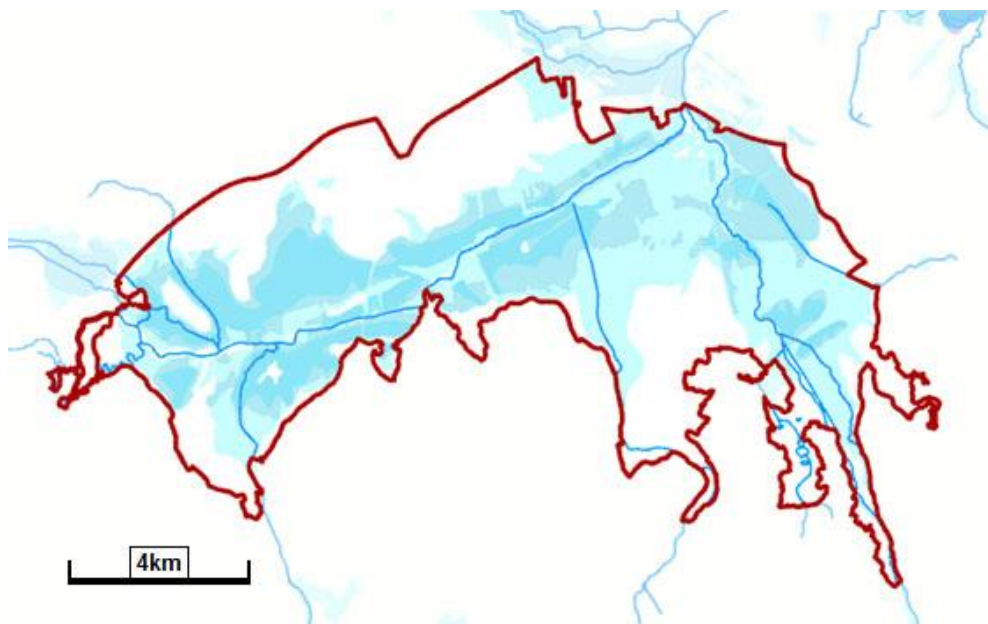


Figure 6.7.1 : Ljubljana Marsh and the Ljubljanica river basin with floodwater area (shaded)

#### 6.7.4.2 Land converted to wetlands

According to the results from the point sampling there are no conversions from other land uses to Wetlands, excluding those from Forest land. Due to necessary assurance for Slovenian land area consistency through whole time series, also conversion from Settlements (one example in the period 2002-2006) was taken into account.

##### **Carbon stock changes in living biomass**

For the estimation of the annual change in carbon stocks of living biomass in Land converted to Wetlands the equation 7.10 of the 2006 Guidelines was applied:

$$\Delta C_{LWfloodLB} = \left[ \sum_i A_i * (B_{After} - B_{Before}) \right] * CF \quad \text{Equation 31}$$

*A<sub>i</sub>* – area of land converted annually to Flooded land from original land use (from Forest land and from Grassland) (ha yr<sup>-1</sup>)  
*B<sub>After</sub>* – biomass immediately following conversion to Flooded land, tonnes d. m. ha<sup>-1</sup> (default = 0)  
*B<sub>Before</sub>* – biomass in land immediately before conversion to Flooded land, tonnes d.m. ha<sup>-1</sup>  
*CF* – carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)<sup>-1</sup>

**Carbon stock changes in soils**

For calculations of emissions from soils in land converted to grassland Tier 2 methodology and equation 2.25 (IPCC 2006) were used.

$\Delta C_{LG\text{ mineral}} = \frac{[SOC_0 - SOC_{0-T}] * A}{T}$ <p><i>ΔC<sub>LGmineral</sub> – annual change in carbon stock in mineral soils [t C yr<sup>-1</sup>]</i>  <i>SOC<sub>0</sub> – soil organic carbon stock in the inventory year [t C ha<sup>-1</sup>]</i>  <i>SOC<sub>0-T</sub> – soil organic carbon stock T years prior to the inventory [t C ha<sup>-1</sup>]</i>  <i>T – time [default 20 years]</i>  <i>A – land area [ha]</i></p> <p><math>SOC = SOC_{WL}</math></p> <p><i>SOC<sub>WL</sub> – country-specific value for organic carbon stock in mineral soil</i></p>	<b>(Equation 32)</b>
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Slovenian national value for organic carbon stock in mineral soil for Wetlands: SOC<sub>WL</sub> = 113.68 t ha<sup>-1</sup> is presented in Table 6.2.8.

**6.7.5 Uncertainties and time-series consistency**

The uncertainty estimates are not reported here.

**6.7.6 Category-specific QA/QC and verification**

No specific QA/QC and verification was used for Wetlands. However, general QA/QC, taking into account the figures check, correctness of the calculation used, data sources etc., were performed in the category, as it was subject to source specific recalculation.

**6.7.7 Category-specific recalculations**

The main recalculations in the Wetlands category, namely Land converted to Wetlands in the NIR 2018 submission were provided due to updated soil emission factors.

**6.7.8 Source-specific planned improvements**

Methodology of the Wetlands Supplement has already been considered. In the future, a special analysis will be provided on what area of Ljubljana Marsh a drainage is being maintained. A Tier 1 methodology is assumed to be applied to estimate the emissions and removals in this category. In 2018 soil monitoring on wetlands is planned, which will improve emission factors in next annual submissions.



## 6.8 Settlements (4E)

### 6.8.1 Source category description

Settlements covered 5.9 % of country area in 2016. Settlements include: built-areas and related surfaces.

This land use category is described (IPCC 2006) as including all developed land, i.e. residential, transportation, commercial, and production (commercial, manufacturing) infrastructure of any size, unless it is already included under other land-use categories. Settlements includes land along streets, in residential (rural and urban) and commercial lawns, in public and private gardens, in golf courses and athletic fields, and in parks, provided such land is functionally or administratively associated with particular cities, villages or other settlement types and is not accounted for in another land-use category.

CO<sub>2</sub> emissions in category Settlements in the period 1986-2016 vary in the range from 453.0 (2003) to 256.35 Gg CO<sub>2</sub> (2016).

Land converted to Settlements (CO<sub>2</sub>) was identified as key source category according to the level and trend.

Table 6.8.1: Activity data of Settlements (1986-2016) in kha

Year	4.E Total settlement	4.E.1. Settlements remaining settlements	Land converted to settlements					
			4.E.2 Land converted to settlement	4.E.2.1 Forest converted to settlement	4.E.2.2 Cropland converted to settlement	4.E.2.3 Grassland converted to settlement	4.E.2.4 Wetland converted to settlement	4.E.2.5 Other lands converted to settlement
Area, kha								
2016	118.98	91.39	27.59	5.65	8.84	12.33	0.77	NO
2015	117.87	89.73	28.14	5.75	9.05	12.48	0.86	NO
2014	117.02	87.65	29.36	5.75	9.38	13.31	0.92	NO
2013	116.03	85.58	30.45	5.74	9.71	14.02	0.98	NO
2012	115.05	83.51	31.54	5.74	10.04	14.72	1.04	NO
2011	114.07	81.43	32.63	5.74	10.37	15.42	1.10	NO
2010	113.08	79.36	33.72	5.73	10.70	16.13	1.16	NO
2009	112.10	77.55	34.55	5.70	10.53	17.11	1.21	NO
2008	111.12	75.74	35.37	5.67	10.35	18.09	1.26	NO
2007	110.13	73.93	36.20	5.63	10.18	19.08	1.31	NO
2006	109.15	72.13	37.02	5.60	10.00	20.06	1.36	NO
2005	107.65	70.43	37.22	5.23	9.68	20.96	1.36	NO
2004	106.15	68.73	37.42	4.85	9.35	21.86	1.36	NO
2003	104.65	67.03	37.62	4.48	9.03	22.76	1.36	NO
2002	103.15	65.33	37.82	4.10	8.70	23.66	1.36	NO
2001	101.57	63.60	37.97	3.96	8.32	24.37	1.32	NO
2000	99.99	61.88	38.11	3.83	7.94	25.07	1.27	NO
1999	98.42	60.16	38.25	3.69	7.55	25.78	1.23	NO
1998	96.84	58.44	38.40	3.56	7.17	26.48	1.18	NO
1997	95.26	56.72	38.54	3.42	6.79	27.19	1.14	NO
1996	93.68	55.00	38.68	3.29	6.41	27.89	1.09	NO
1995	92.10	53.28	38.83	3.15	6.03	28.60	1.05	NO
1994	91.08	52.52	38.56	3.12	5.52	28.88	1.04	NO
1993	90.06	51.77	38.30	3.09	5.02	29.16	1.03	NO
1992	89.04	51.01	38.03	3.06	4.51	29.44	1.02	NO
1991	88.02	50.26	37.77	3.03	4.01	29.72	1.01	NO
1990	87.00	49.50	37.50	3.00	3.50	30.00	1.00	NO
1989	86.60	49.10	37.50	3.00	3.50	30.00	1.00	NO
1988	86.20	48.70	37.50	3.00	3.50	30.00	1.00	NO
1987	85.80	48.30	37.50	3.00	3.50	30.00	1.00	NO
1986	85.40	47.90	37.50	3.00	3.50	30.00	1.00	NO

**Table 6.8.2: Emissions from Settlements (1986 – 2016) in Gg CO<sub>2</sub>**

Year	4.E Total settlement	4.E.1. Settlements remaining settlements	Land converted to settlements					
			4.E.2 Land converted to settlement	4.E.2.1 Forest converted to settlement	4.E.2.2 Cropland converted to settlement	4.E.2.3 Grassland converted to settlement	4.E.2.4 Wetland converted to settlement	4.E.2.5 Other lands converted to settlement
			GHG emissions/removals, Gg CO <sub>2</sub>					
2016	256.35	-107.87	364.22	130.35	60.69	164.10	9.07	NO
2015	261.69	-105.90	367.59	130.54	62.13	164.72	10.19	NO
2014	273.99	-103.46	377.44	129.69	64.50	172.36	10.90	NO
2013	284.70	-101.01	385.71	128.83	66.86	178.41	11.60	NO
2012	295.41	-98.56	393.97	127.98	69.23	184.45	12.31	NO
2011	306.03	-96.11	402.15	127.04	71.59	190.50	13.02	NO
2010	316.65	-93.67	410.32	126.10	73.95	196.54	13.73	NO
2009	325.60	-91.53	417.13	124.86	72.75	205.21	14.31	NO
2008	334.55	-89.40	423.95	123.62	71.55	213.88	14.90	NO
2007	343.51	-87.26	430.77	122.38	70.35	222.54	15.49	NO
2006	449.33	-85.13	534.46	243.36	71.55	203.47	16.08	NO
2005	450.62	-83.12	533.74	236.67	69.36	211.62	16.08	NO
2004	451.91	-81.12	533.02	229.99	67.18	219.77	16.08	NO
2003	453.20	-79.11	532.31	223.31	64.99	227.92	16.08	NO
2002	365.33	-77.10	442.43	136.37	60.20	229.78	16.08	NO
2001	367.69	-75.07	442.76	133.42	57.56	236.23	15.55	NO
2000	370.06	-73.04	443.10	130.48	54.92	242.68	15.02	NO
1999	372.71	-71.01	443.72	127.82	52.27	249.14	14.49	NO
1998	375.37	-68.98	444.34	125.16	49.63	255.59	13.96	NO
1997	378.02	-66.95	444.96	122.50	46.99	262.04	13.43	NO
1996	380.66	-64.91	445.58	119.83	44.35	268.49	12.90	NO
1995	347.53	-62.88	410.41	85.33	38.59	274.11	12.37	NO
1994	346.26	-61.99	408.25	84.24	35.03	276.73	12.26	NO
1993	345.00	-61.10	406.10	83.14	31.46	279.36	12.14	NO
1992	343.73	-60.21	403.94	82.05	27.89	281.98	12.02	NO
1991	342.47	-59.32	401.78	80.95	24.33	284.60	11.90	NO
1990	347.16	-58.43	405.58	71.49	23.60	298.71	11.78	NO
1989	346.98	-57.95	404.94	70.84	23.60	298.71	11.78	NO
1988	346.81	-57.48	404.29	70.20	23.60	298.71	11.78	NO
1987	346.63	-57.01	403.64	69.55	23.60	298.71	11.78	NO
1986	346.46	-56.54	403.00	68.90	23.60	298.71	11.78	NO

## 6.8.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The information of settlements area is based on two data sources. Data from Statistical Yearbook of the Statistical Office RS (SORS) was used to present settlements area in the period 1986-2001. The estimation of settlements area for the period 2002-2012 was provided by the Slovenian Forestry Institute through targeted research project "Bases for improving the reporting methodology of greenhouse gas emissions in relation to land use, land use change and forestry". The estimation of cropland area and annual land-use changes for the years 2013, 2014, 2015 and 2016 were extrapolated. The approach used for representing settlements areas follows the principle of estimation of areas via proportions, where the total area of the inventory region is known (IPCC 2006). The methodology of data acquisition as well as detection of land use changes from and to settlements is described in the sub-chapter 6.3.1. The following maps and databases were used in the assessment of settlements areas:

- Digital orthophotos of the Surveying and Mapping Authority RS,
- Agricultural Land Use Map of the Ministry of Agriculture, Forestry and Food,
- Land cover map of Slovenia from Landsat satellite imagery (images for the period 1984-2014 collected by ZRC SAZU).

## 6.8.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The settlements is not defined specifically in terms of national legislation. However, the Rules on recording land use data in the land cadaster (1982) specified land use related to man-made objects and properties, such as residential and industry buildings, outbuildings, garage, functional objects, monuments, roads, railways, market squares, parking places, waste dumps, open warehouses etc. For the need of the GHG reporting the Settlements category includes the land-use class 3000 (Table 6.2.1), i.e. built-up areas and related surfaces. According to Interpretation key (2013) the latter includes all lands associated with buildings, roads, settlements, houses, parking places, mines and quarries and other infrastructure related to human activities.

## 6.8.4 Methodological issues

### 6.8.4.1 Settlements remaining Settlements

#### **Carbon stock changes in living biomass**

The 2006 Guidelines defined methods for biomass, dead organic matter and soil carbon stock change assessment in Settlements remaining Settlements. The new acquired data enable us to estimate the emissions in the living biomass, using a Tier 1 approach. Equation 8.2 of the 2006 Guidelines was used to estimate annual biomass increment based on total crown cover area.

**Carbon stock changes in dead organic matter**

In line with 2006 Guidelines the Tier 1 default assumes all carbon contained in dead wood and litter is lost during conversion and does not take account of any subsequent accumulation. Therefore, changes in carbon stocks of DOM are assumed zero.

**Carbon stock changes in soils**

It is assumed in the Tier 1 method that inputs equal outputs so that settlement soil C stocks do not change in 6.7.4.1 Settlements remaining Settlements.

**6.8.4.2 Land converted to Settlements**

The average annual area converted from other land uses to Settlements is 1,666 ha. The average annual area converted from Forest land to Settlements is 258 ha. The average annual area converted from Cropland to Settlements is 465 ha, from Grassland to Settlements is 891 ha, and from Wetlands 52 ha.

According to the results from the point sampling there are no conversions from Other land to Settlements.

**Carbon stock changes in living biomass**

The fundamental equation for estimating changes in carbon stocks associated with land-use conversions is the same as applied for other areas of land-use conversion (Land converted to Forest land, Cropland or Grassland). The default assumption for Tier 2 estimate is that all living biomass present before conversion to Settlement will be lost in the same year as the conversion takes place, and that carbon stocks following conversion are equal to zero. For calculations of emissions from other land uses converted to Settlements Tier 2 methodology and equations 2.15 and 2.16 (IPCC 2006) were used.

$$\text{Annual change in biomass} = A * (\Delta C_{\text{conversion}} + \Delta C_G) \quad (\text{Equation 33})$$

$$\Delta C_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

*A* – annual area of converted land

$\Delta C_G$  – default value for carbon accumulation rate

*C<sub>after</sub>* – carbon after conversion is 0

*C<sub>before</sub>* – biomass stock on land type before the conversion

**Carbon stock changes in dead organic matter**

In line with 2006 Guidelines the Tier 1 default assumes all carbon contained in dead wood and litter is lost during conversion and does not take account of any subsequent accumulation. Therefore, changes in carbon stocks of DOM are assumed zero.

**Carbon stock changes in soils**

For calculations of emissions from soils in land converted to Settlements Tier 2 methodology and equation 2.25 (IPCC 2006) were used.

$\Delta C_{LSmineral} = \frac{[SOC_0 - SOC_{0-T}] * A}{T}$ <p> <math>\Delta C_{LSmineral}</math> – annual change in carbon stock in mineral soils [t C yr<sup>-1</sup>]  <math>SOC_0</math> – soil organic carbon stock in the inventory year [t C ha<sup>-1</sup>]  <math>SOC_{0-T}</math> – soil organic carbon stock T years prior to the inventory [t C ha<sup>-1</sup>]  <math>T</math> – time [default 20 years]  <math>A</math> – land area [ha] </p> <p> <math>SOC = SOC_{SL}</math> </p> <p> <math>SOC_{SL}</math> – country-specific value for organic carbon stock in mineral soil (see Table 6.2.8.) </p>	<b>(Equation 34)</b>
---	----------------------

**N<sub>2</sub>O emissions from N mineralization/immobilization**

For calculations of N<sub>2</sub>O emissions associated with land conversion to Settlements Tier 1 methodology using equations 11.1 and 11.8 and default emission factors from the table 11.1 (IPCC 2006) were used. Direct N<sub>2</sub>O emissions are estimated due to conversions in land use from Forest land, Cropland, Grassland and Wetlands to Settlements.

**Indirect N<sub>2</sub>O emission from N leaching and run-off**

For estimation of indirect N<sub>2</sub>O emissions from N mineralization due to change of land use in mineral soils through leaching/runoff were estimated by applying Tier 1 method (equation 11.10) and default emission factors from Table 11.3 of GPG (IPCC 2006). Indirect N<sub>2</sub>O emissions are estimated due to conversions in land use from Forest land, Cropland, Grassland and Wetlands to Settlements.

**6.8.5 Uncertainties and time-series consistency**

The uncertainty estimates are not reported here.

**6.8.6 Category-specific QA/QC and verification**

No specific QA/QC and verification was used for Settlements. However, general QA/QC, taking into account the figures check, correctness of the calculation used, data sources etc., were performed in the category, as it was subject to source specific recalculation.

### **6.8.7 Category-specific recalculations**

The main recalculations in the Settlements, namely Land converted to Settlements were provided due to updated emission factors.

### **6.8.8 Category-specific planned improvements**

In 2018 soil and aboveground biomass monitoring is planned within a public tender, and based on new data collected and results obtained, the emission factors will be improved in the next annual submission.

## **6.9 Other land (4F)**

### **6.9.1 Source category description**

According to 2006 Guidelines Other land is defined as category which includes bare soil, rock, ice and all unmanaged land areas which do not fall into any of the other five categories. This land use category is included to allow the total of identified areas to match the national area.

Other land covered 1.6 % of country area in 2016. Other land includes: open areas with little or no vegetation and dried open areas with special vegetation.

CO<sub>2</sub> emissions in category Other land range from 8.90 Gg CO<sub>2</sub> (2002) to 20.98 Gg CO<sub>2</sub> (2016).



Table 6.9.1: Activity data of other land (1986-2016) in kha

Year	4.F Other land	4.F.1. Other land remaining other land	Land converted to other land					
			4.F.2. Land converted to other land	4.F.2.1 Forest Land converted to other land	4.F.2.2 Cropland converted to other land	4.F.2.3 Grassland converted to other land	4.F.2.4 Wetlands converted to other land	4.F.2.5 Settlements converted to other land
Area, kha								
2016	32.22	31.27	0.94	0.43	NO	NO	NO	0.51
2015	32.20	31.22	0.98	0.40	NO	NO	NO	0.58
2014	32.18	31.20	0.98	0.41	NO	NO	NO	0.58
2013	32.17	31.18	0.99	0.41	NO	NO	NO	0.58
2012	32.15	31.15	1.00	0.42	NO	NO	NO	0.58
2011	32.13	31.13	1.00	0.43	NO	NO	NO	0.58
2010	32.12	31.11	1.01	0.43	NO	NO	NO	0.58
2009	32.10	31.10	1.00	0.43	NO	NO	NO	0.58
2008	32.08	31.09	0.99	0.42	NO	NO	NO	0.58
2007	32.07	31.08	0.99	0.41	NO	NO	NO	0.58
2006	32.05	31.07	0.98	0.40	NO	NO	NO	0.58
2005	32.03	31.07	0.95	0.40	NO	NO	NO	0.55
2004	32.00	31.07	0.93	0.40	NO	NO	NO	0.53
2003	31.98	31.07	0.90	0.40	NO	NO	NO	0.50
2002	31.95	31.07	0.88	0.40	NO	NO	NO	0.48
2001	32.29	31.46	0.83	0.43	NO	NO	NO	0.41
2000	32.63	31.84	0.79	0.45	NO	NO	NO	0.34
1999	32.98	32.23	0.75	0.48	NO	NO	NO	0.27
1998	33.32	32.61	0.70	0.50	NO	NO	NO	0.20
1997	33.66	33.00	0.66	0.53	NO	NO	NO	0.14
1996	34.00	33.39	0.62	0.55	NO	NO	NO	0.07
1995	34.35	33.77	0.58	0.58	NO	NO	NO	NO
1994	34.61	34.05	0.56	0.56	NO	NO	NO	NO
1993	34.87	34.32	0.55	0.55	NO	NO	NO	NO
1992	35.13	34.60	0.53	0.53	NO	NO	NO	NO
1991	35.39	34.87	0.52	0.52	NO	NO	NO	NO
1990	35.65	35.15	0.50	0.50	NO	NO	NO	NO
1989	36.87	36.37	0.50	0.50	NO	NO	NO	NO
1988	38.10	37.60	0.50	0.50	NO	NO	NO	NO
1987	39.32	38.82	0.50	0.50	NO	NO	NO	NO
1986	40.55	40.05	0.50	0.50	NO	NO	NO	NO

**Table 6.9.2: Emissions from other land (1986–2016) in Gg CO<sub>2</sub>**

Year	4.F Other land	4.F.1. Other land remaining other land	Land converted to other land					
			4.F.2. Land converted to other land	4.F.2.1 Forest Land converted to other land	4.F.2.2 Cropland converted to other land	4.F.2.3 Grassland converted to other land	4.F.2.4 Wetlands converted to other land	4.F.2.5 Settlements converted to other land
GHG emissions/removals, Gg CO <sub>2</sub>								
2016	20.98	NA	20.98	19.48	NO	NO	NO	1.50
2015	20.62	NA	20.62	18.90	NO	NO	NO	1.72
2014	20.56	NA	20.56	18.84	NO	NO	NO	1.72
2013	20.50	NA	20.50	18.77	NO	NO	NO	1.72
2012	20.43	NA	20.43	18.71	NO	NO	NO	1.72
2011	20.35	NA	20.35	18.63	NO	NO	NO	1.72
2010	20.27	NA	20.27	18.55	NO	NO	NO	1.72
2009	20.00	NA	20.00	18.28	NO	NO	NO	1.72
2008	19.73	NA	19.73	18.00	NO	NO	NO	1.72
2007	19.46	NA	19.46	17.73	NO	NO	NO	1.72
2006	16.94	NA	16.94	14.36	NO	NO	NO	2.57
2005	16.72	NA	16.72	14.22	NO	NO	NO	2.50
2004	16.51	NA	16.51	14.08	NO	NO	NO	2.43
2003	16.29	NA	16.29	13.94	NO	NO	NO	2.35
2002	8.90	NA	8.90	5.14	NO	NO	NO	3.76
2001	9.00	NA	9.00	5.46	NO	NO	NO	3.54
2000	9.14	NA	9.14	5.79	NO	NO	NO	3.35
1999	9.24	NA	9.24	6.11	NO	NO	NO	3.13
1998	9.38	NA	9.38	6.43	NO	NO	NO	2.95
1997	9.48	NA	9.48	6.75	NO	NO	NO	2.73
1996	9.62	NA	9.62	7.07	NO	NO	NO	2.55
1995	19.86	NA	19.86	19.86	NO	NO	NO	NO, NA
1994	19.49	NA	19.49	19.49	NO	NO	NO	NO, NA
1993	19.12	NA	19.12	19.12	NO	NO	NO	NO, NA
1992	18.75	NA	18.75	18.75	NO	NO	NO	NO, NA
1991	18.38	NA	18.38	18.38	NO	NO	NO	NO, NA
1990	13.67	NA	13.67	13.67	NO	NO	NO	NO, NA
1989	13.56	NA	13.56	13.56	NO	NO	NO	NO, NA
1988	13.45	NA	13.45	13.45	NO	NO	NO	NO, NA
1987	13.34	NA	13.34	13.34	NO	NO	NO	NO, NA
1986	13.24	NA	13.24	13.24	NO	NO	NO	NO, NA

## **6.9.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation**

The information of other land area is based on two data sources. Data from Statistical Yearbook of the Statistical Office RS (SORS) was used to present other land area in the period 1986-2001. The estimation of other land area for the period 2002-2012 was provided by the Slovenian Forestry Institute through targeted research project "Bases for improving the reporting methodology of greenhouse gas emissions in relation to land use, land use change and forestry". The estimation of cropland area and annual land-use changes for the years 2013, 2014 and 2015 were extrapolated. The approach used for representing other land areas follows the principle of estimation of areas via proportions, where the total area of the inventory region is known (IPCC 2006). The methodology of data acquisition as well as detection of land use changes from and to other land is described in the sub-chapter 6.3.1. The following maps and databases were used in the assessment of other land areas:

- Digital orthophotos of the Surveying and Mapping Authority RS,
- Agricultural Land Use Map of the Ministry of Agriculture, Forestry and Food,
- Land cover map of Slovenia from Landsat satellite imagery (images for the period 1984-2014 collected by ZRC SAZU).

## **6.9.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories**

The other land is not defined specifically in terms of national legislation. This category includes all land areas that do not fall into any of the other five top-level land-use categories which is in line with the 2006 Guidelines. For the need of the GHG reporting the Other Land category includes the following land-use classes (Table 6.2.1); dried open areas with special vegetation and open areas with little or no vegetation.

## **6.9.4 Methodological issues**

### **6.9.4.1 Other land remaining Other land**

Consistent with the IPCC Guidelines, change in carbon stocks and non-CO<sub>2</sub> emissions and removals would not need to be assessed for the category of "Other land remaining Other land" assuming that it is typically managed. At present, no guidance can be given for "Other land" that is managed. "Other land" is included, however, for checking overall consistency of land area and tracking conversions to and from other land.

### **6.9.4.2 Land converted to Other land**

According to the results from the point sampling there are only conversions from Forest land and from Settlements to Other land.

For calculations of emissions from other land uses converted to Other land Tier 2 methodology and equations 2.15 and 2.16 and 2.25 (IPCC 2006) were used.

#### **6.9.5 Uncertainties and time-series consistency**

The uncertainty estimates are not reported here.

#### **6.9.6 Category-specific QA/QC and verification**

No specific QA/QC and verification was used for Other land. However, general QA/QC, taking into account the figures check, correctness of the calculation used, data sources etc., were performed in the category, as it was subject to source specific recalculation.

#### **6.9.7 Category-specific recalculations**

The main recalculations in the Other land category in the NIR 2018 submission were provided due to updated emissions factors.

#### **6.9.8 Category-specific planned improvements**

No category-specific improvement are planned in the near future.

## 6.10 Harvested wood products (4G)

### 6.10.1 Source category description

### 6.10.2 Source category description

Harvested wood products (HWP) includes all wood material that leaves harvest sites. Typically, HWP are represented by sawnwood, veneer sheets, particle board, fibreboard, wood pulp, mechanical wood pulp, chemical wood pulp, paper and paperboard, and \*wood products in solid waste disposal sites (SWDS).

\*Note: not included in the calculation of HWP removals in LULUCF sector

### 6.10.3 Methodological issues

The GHG removals for HWP were calculated taking into account primary product groups and conversion factors as specified in Table 6.10.1. Data sources are industrial reports, official statistical data and national studies.

Time series are starting from year 1900 using all existing sources of information (historical records, official statistics, independent studies). E.g.: for fibreboard production, annual data starting from year 1946 are used (one of the first companies producing fibreboards in Europe).

The product group "Plywood" was not considered in our calculations as these products originate from sawnwood and veneer and as such would cause a double counting of carbon inflow. Carbon input from domestic pulpwood in paper and paperboard production was estimated using data for production of wood pulp (mechanical and chemical pulp).

Revised FOD ("first order decay") method was used according to 2006 Guidelines and Pingoud and Wagner (2006). The calculation of net emissions follows recommended method as outlined in IPCC 2006 (Equation 12.1). The estimation uses the product categories, half-lives and methodologies as suggested in paragraph 27, page 31 of FCCC/KP/AWG/2010/CRP.4/Rev.4:

- Sawnwood: 35 years,
- WBP (Particle boards, Fibreboards, Veneer): 25 years,
- Paper and Paperboard: 2 years.

**Table 6.10.1: Conversion factors and primary product groups used in calculation**

Classification	Description of commodity	Air dry density	C conv. factor	C conv. factor	Source
UNECE		[g/cm <sup>3</sup> ]	[Gg C/1000 tonnes]	[Gg C/1000m <sup>3</sup> ]	
5.	Sawnwood	-	-	0,23	IPCC (2003, national estimate based on composition of coniferous and broadleaved sawn wood)
6.1	Veneer sheets	-	-	0,295	IPCC (2003)
6.3	Particle board	0,65	0,425	0,28	National estimate based on IPCC and data from producers of particle boards in Slovenia
6.4.	Fibreboard	0,81 – 1,00	0,425	0,344 - 0,425	National estimate based on IPCC and data from producers of fibreboards in Slovenia
7	Wood pulp	1,00*	0,45	-	UNECE, IPCC (2003, 2006)
7.1	Mechanical wood pulp	1,00*	0,45	-	UNECE, IPCC (2003, 2006)
7.3	Chemical wood pulp	1,00*	0,45	-	UNECE, IPCC (2003, 2006)

\*“air dried metric ton” is assumed to be 10% mcw (pulp and paper moisture content is reflected on a “wet basis” (mcw) - one air-dried metric ton of pulp is assumed to be 900 kg of oven dry fibre and 100 kg of contained water (UNECE)

### Method for calculation of Carbon Inflow

Carbon Inflow to HWP pool is calculated according to equations 35 and 36.

$$Inflow\ HWP = \sum_i^n (F_{DPPAi} \times HWP_i)$$

(Equation 35)

Where:

$HWP_i$  – primary product  $i$  (sawnwood, veneer, particle boards, fibreboards, wood pulp)

$F_{DPPAi}$  – factor for selected primary product groups defining the share of domestic INDRW input compared to all wood consumption in the production (total wood consumption covers roundwood, woodchip, wood particles and wood residues)

$$F_{DPPAi} = \frac{Domestic\ INDRW\ Consumption_i}{WOOD\ Consumption_i}$$

(Equation 36)

HWP are calculated separately for sawnwood, veneer, particle board, fibreboard and virgin pulp with time series starting from year 1900 using all existing sources of information (historical records, official statistics independent studies). The domestic share of roundwood is calculated separately for product group sawnwood and veneer and product group consisting of WBP and product group virgin pulp.

As the production process of sawnwood and veneer use logs as input material and to be as close to real roundwood flows from domestic sources the FDPPA is the same for both products. However, the calculation for sawnwood uses HL 35 y and calculation for veneer uses HL 25 y. Product groups: sawnwood, WBP and paper and paperboard are calculated and reported separately.

## Factors and data sources for primary product groups

### 1. $F_{DPPAi}$ for sawn wood and veneer ( $F_{SW+V}$ )

$$F_{SW+V} = \frac{\text{Production LOGS} - \text{Export LOGS}}{\text{Production LOGS} + \text{Import LOGS} - \text{Export LOGS}} \quad (\text{Equation 37})$$

Data sources for calculation of amounts of domestic round wood accounted in product group sawn wood and veneer are based on data from Statistical Office of the Republic of Slovenia (SORS), industrial reports and independent national studies. Due to changes in statistical data collection amounts of produced sawn wood in period 1996-2009 are calculated using conversion factors and mass balance of logs consumption.

### 2. $F_{DPPAi}$ for particle boards and fibreboards ( $F_{WBP}$ )

$$F_{WBP} = \frac{\text{Domestic INDRW Consumption}_{WBP}}{\text{WOOD Consumption}_{WBP}} \quad (\text{Equation 38})$$

Data sources for calculation of  $F_{WBP}$  until 2009 are official data and industry reports. From 2010 onwards, data were obtained directly from producers and included in calculations (data from companies: production, input material, type of input material (roundwood, wood residues), quantities from import and from domestic sources). Due to small number of companies to obtain realistic figures and confidential data of national statistics covering industry we suppose our direct full coverage of production is, despite time-consuming process, precise and unbiased.

### 3. $F_{DPPAi}$ for wood pulp ( $F_{WP}$ )

$$F_{WP} = \frac{\text{Domestic INDRW Consumption}_{WP}}{\text{WOOD Consumption}_{WP}} \quad (\text{Equation 39})$$

Data sources for calculation of  $F_{WP}$  are based on industry reports for years before 1990, interpolation for missing years and direct full data coverage obtained from domestic producers (production, input material, type of input material: roundwood, wood residues quantities of input

material originating from import and from domestic sources, percentage of pulp in production process) was used for the period 2004-2016.

#### 6.10.4 Uncertainties and time-series consistency

The uncertainty estimates are not reported here.

#### 6.10.5 Category-specific QA/QC and verification

The method that had been applied in the Submission of information on forest management reference levels by Slovenia (FMRL Submission) and updated for this reporting is based on Equation 12.1 from the 2006 Guidelines. Some country specific methods are also described in the FMRL Submission (MAFF, SFI, SFS 2011).

General QA/QC, taking into account the figures check, correctness of the calculation used, data sources etc., were performed in the category, as it was subject to source specific recalculation.

**Table 6.10.2: Comparison between C Inflow and C in domestic INDRW (1.000 t C)**

	2005	2006	2007	2008	2009	Average
Domestic INDRW*	292	382	329	324	299	325
Inflow - model	242	251	275	251	237	251
Share HWP Inflow/Dom. INDRW	0.83	0.66	0.83	0.77	0.79	0.77

\*Carbon in consumption of domestic INDRW is calculated separately for coniferous and broadleaved INDRW using basic densities 0.40 t/m<sup>3</sup> and 0.58 t/m<sup>3</sup>, respectively.

Estimates of carbon Inflow are consistent with consumption of domestic industrial round wood. The difference present losses which occur during processing to selected primary products.

#### 6.10.6 Category-specific recalculations

No recalculations have occurred in this category.

#### 6.10.7 Category-specific improvements

Due to complexity of our current system and some difficulties related to reporting requirements we are in the process of revision of our system. Comparison and sensitivity tests will be done accordingly. The revised methods and new datasets will be provided in next submissions.



## 7 WASTE (CRF sector 5)

### 7.1 Overview of sector

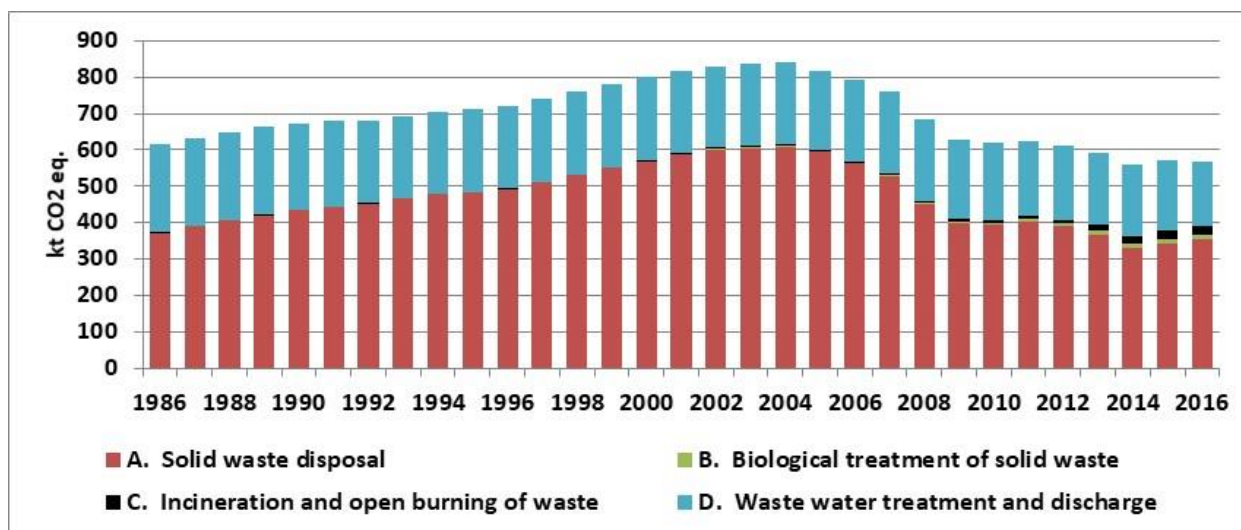
In this chapter the following sources are presented:

- Solid waste disposal (5.A),
- Biological treatment of solid waste – composting (CRF 5.B),
- Incineration of waste (CRF 5.C), and
- Wastewater treatment and discharge (CRF 5.D).

**Table 7.1.1: Methods, EFs used and key categories indications for the year 2016 in the Waste sector.**

	CO <sub>2</sub>			CH <sub>4</sub>			N <sub>2</sub> O		
	Method	EF	Key category	Method	EF	Key category	Method	EF	Key category
Solid waste disposal	NA	NA	NA	T2	CS, D	L	NA	NA	NA
Composting	NA	NA	NO	T1	D	-	T1	D	-
Incineration	T2	D	-	T2	D	-	T2	D	-
Wastewaters	NA	NA	NO	T1	CS, D	L	T1	D	-

In this sector methane emissions from Solid waste disposal sites and from Waste water treatment are the key categories according to the level assessment (Table 7.1.1).



**Figure 7.1.1: Emissions from solid waste disposal on land and from wastewater handling in Gg CO<sub>2</sub> eq. Emissions from waste incineration are very small and therefore not visible in this figure.**

In 2015, emissions from the Waste sector amounted to 565.9 Gg CO<sub>2</sub> eq, or 3.2 per cent of the total GHG emissions. Since 1986 emissions decreased by 7.8 per cent. The key driver for the decline of emissions is the decrease of biodegradable part of the municipal waste deposited on the SWDS and gas recovery on the SWD sites and in the wastewater treatment plants.

Within the sector 62.8 per cent of the emissions were from solid waste disposal on land, followed by 30.8 per cent from wastewater handling, 4.2 per cent from waste incineration while remaining 2.3 per cent of emissions were from composting (Figure 7.1.1).

Methane emissions from the Waste sector are the second largest source of methane and represents 23.3% of all methane emissions in Slovenia in 2016. The fraction of methane emissions in this sector amounts to 88.3%, while the remaining part represents N<sub>2</sub>O (7.6%), and CO<sub>2</sub> emissions (4.2%).

Almost 5.5 million tonnes of waste were generated in Slovenia in 2016 what is 6% more than in 2015. Most of the waste was construction and demolition waste (39%), followed by municipal waste (18%), waste from thermal processes (16%), waste from wood processing and from metal processing (10%), waste from waste management facilities (7%), while other type of waste represents 9%. Waste streams are presented on the Figure 7.1.2.

Waste stream, Slovenia, 2016

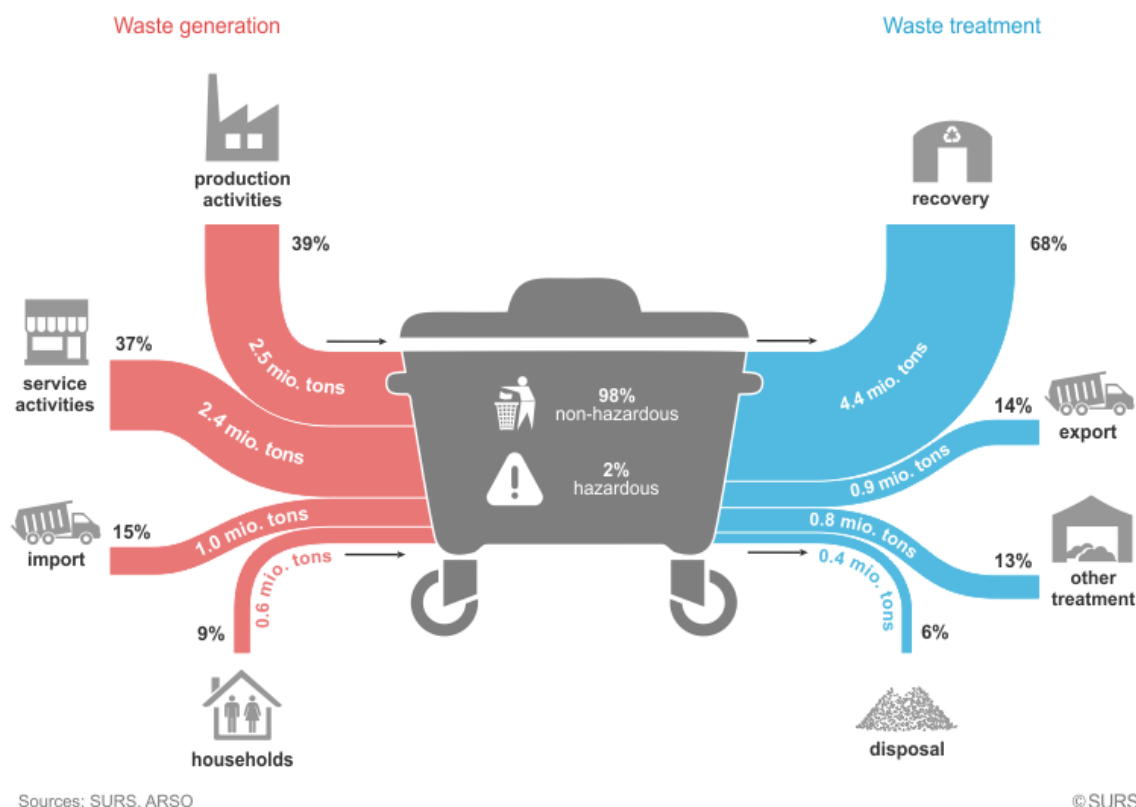


Figure 7.1.2: Waste stream in Slovenia in 2016  
(Source: <http://www.stat.si/StatWeb/en/News/Index/7099> )

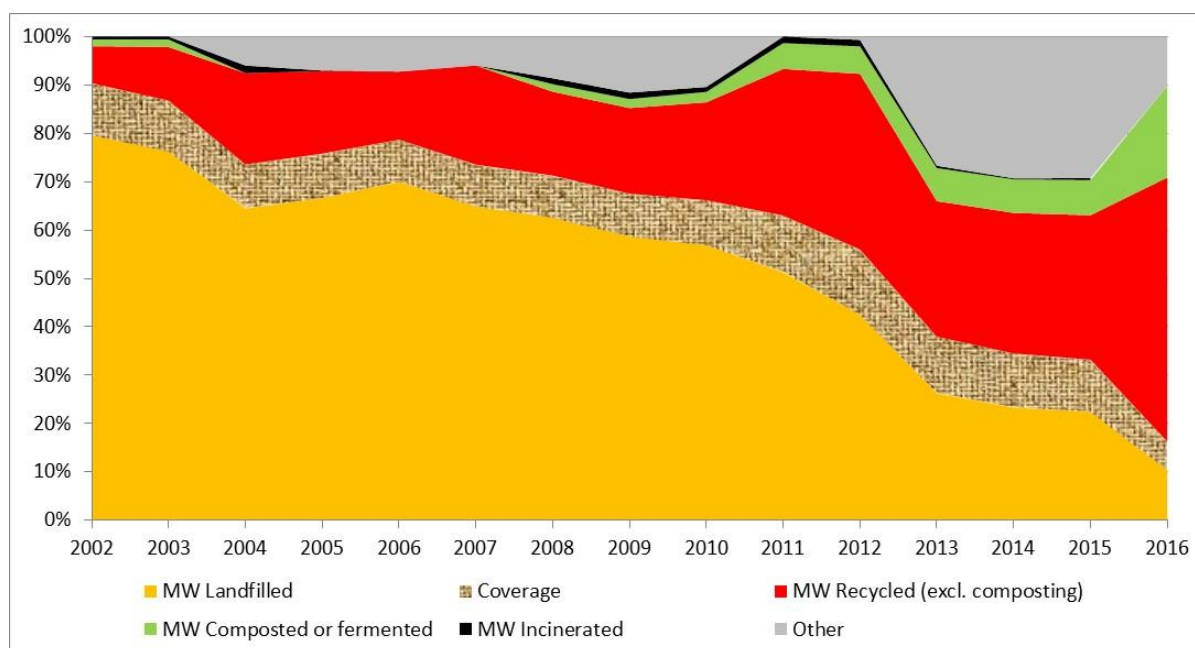
In this report “**municipal waste**” is defined as waste generated by households and other waste similar to household waste generated by the manufacturing, trade, service and other industries and the public sector. These types of waste are reported under code 20 according to the List of Waste.

In 2016 a person in Slovenia generated on average 476 kg of municipal waste or 1.3 kg of municipal waste per day. The amount of municipal waste increased by 4.0% compared to 2015 however only 8.1% of generated municipal waste was landfilled and as much as 67% of municipal waste generated, was separately collected in 2016.

The waste regulations have introduced a 5-stage waste hierarchy, according to which the top priority is given to the prevention of waste generation, followed by preparing for reuse, recycling, other recovery procedures (e.g. energy recovery), whereas waste disposal (e.g. landfilling, incineration without energy recovery) is deemed to be the least preferred option.

The volume of separately collected fractions of municipal waste has been increasing in recent years. The system of door-to-door separate collection of waste facilitates further processing of separately collected waste (recycling and recovery). In this way we contribute to the conservation of natural resources and to a decrease in the negative environmental impacts of waste deposited in landfills (e.g. CH<sub>4</sub> emissions and other landfill gasses and leachate waters, the impact on groundwater).

With the introduction of the separate collection of municipal waste and statutory requirements regarding the processing of mixed residual waste prior to disposal, the amount of deposited municipal waste in relation to generated waste has been declining. In 2002, 90% of generated municipal waste was deposited (713 thousand tonnes), compared to 22.4% in 2016 (209 thousand tonnes); see Figure 7.1.3.



**Figure 7.1.3: Handling of municipal waste, collected by public waste removal services (data from SORS)**

Waste management pays particular attention to packaging waste, not so much because of the generated quantities and risk potential, but primarily because of its enormous volume, short life cycle and substantial portion of organic matter. Up to 2004, the majority of Slovenian packaging waste ended up in landfills. With the introduction of regulations providing for the

payment of an environmental tax on packaging, the separate collection of packaging waste, the establishment of a system for processing packaging waste, and by focusing on achieving the objectives set for the recovery and recycling of packaging waste, packaging waste management has seen substantial improvement.

### Relevant legislation

List of relevant Slovenian laws transposing the EU Landfill Directive:

- Decree on the landfill of waste (No. 32/2006), which came into force in March 2006 and was amended twice, in 2007 (No. 98/2007) and 2008 (No. 62/2008), with the Decree amending the Decree on the landfill of waste;
- Decree on the management of waste (No. 34/2008), which amended previous Rules on the management of waste;
- on the basis of EU Landfill Directive and National environmental action, Programme on waste management Slovenia also issued an Operational Programme regarding waste management for the time period 2009-2013 and new Operational Programme for the time period from 2013 until 2020

The Decree on the landfill of waste is the main act in which the EU Landfill Directive was transposed. Thus in 2006, when Decree on the landfill of waste cancelled the mentioned Rules on the landfill of waste, Slovenia fully complied with the requirements of the Landfill Directive.

On the political level Slovenia started with the activities on the field of waste management in 1996, when also strategic orientations for waste management were prepared. On this basis National environmental action Programme was adopted in 2006 and set the enforcement of modern forms of waste management as priority objective. A period of systematic regulation in the field of waste management followed, with the adoption of implementing acts on the basis of EPA.

However, in 1998 Rules on the management of waste a new regulation period in waste management has already started. The National environmental action Programme formed the basis for the Operational Programme for waste disposal and its goal was the reduction of deposited biodegradable waste for the period 2009-2013; it was adopted by the government in 2008. However, the Rules on the landfill of waste adopted in 2000 had already comprised provisions regarding reduction of biodegradable waste and these were also included in the Decree on the treatment of biodegradable waste, which was adopted in 2008 and repealed the mentioned Rules.

The Operational Programme from 2008 was project oriented, focusing on goals:

- at least 65% or more of the produced municipal waste should be redirected in other type of treatment and at least 42% of them should be reused;
- all kitchen waste should be extracted and biologically processed;
- the remainder of waste should be processed in a way that the content of organic carbon will not exceed 5%;
- in the structure of the whole deposited waste 47% of the deposited biodegradable waste should be reduced to 16% until 2013 or 2015 that means in average 5% per year.

Measures for achieving the listed goals are also a part of the Operational Programme:

- the existing landfills should be closed down, if the adjustment to the existing provisions were too expensive or technically difficult to manage;
- reconstruction and enlargement of the existing landfills, which will be operating until the end of 2008;
- construction of a new infrastructure for treatment, recovery and disposal of waste for regional centres for waste management and national centres for thermal treatment.

Decree on the landfill of waste also includes annex 4. It specifies the volume of biodegradable substance in municipal waste, which can be deposited in all landfills in the territory of Slovenia per year. It also sets that the amount of deposited biodegradable waste should be decreased:

- by 10% in years 2008-2009,
- by 5% in years 2009 – 2010, 2011– 2012 and 2013 – 2015 in accordance with the 1995 amount.

A new strategic document, Operational Programme from 2013 adopted in this area provides the certain measures for achieving the following targets by 2020:

- increasing the recycling rate of municipal waste to 61–64%;
- increasing the incineration rate to approximately 25%; and
- decreasing the disposal of municipal waste in landfills to 11–15%.

In December 2015, the European Commission presented an ambitious package of measures aimed at achieving a transition to a circular and thus more competitive economy with a more sustainable use of resources. The package also includes amended legislative proposals on waste with ambitious targets: the EU's common goal by 2030 is 65% of municipal waste recycling, 75% of packaging waste recycling, and a binding target of reducing the amount of waste that ends up at landfills to a maximum of 10% of municipal waste.

In 2016, Slovenia adopted the Waste Management Plan as well as the Waste Prevention Programme, which serve as a basis for achieving ambitious objectives by 2030.

Main measures, which already in the past contributed to reducing the quantities of deposited biodegradable waste, are waste separation at source and mechanical biological treatment of mixed municipal waste. In most municipalities, door-to-door collection systems are used for waste packaging, bio-waste, and paper.

Since 2016, the mechanical biological treatment of mixed municipal waste prior to disposal in municipal waste management centres has been mandatory. That is why facilities for mechanical and biological treatment of mixed municipal waste in Slovenia had to be upgraded in order to meet the country's needs.

In addition to the separate collection of waste and the mechanical biological treatment of mixed waste, the following measures of the waste management programme will contribute to further reduction of the quantity of deposited biodegradable waste:

- raising tax for the landfilling of waste and other changes to the environmental tax for the final establishment of the waste hierarchy (prevention, preparation for reuse, recycling, other recovery operations, waste disposal);

- improving the collection and management system for waste packaging by promoting packaging reuse systems;
- introduction of payment for a public service according to the “Pay as you throw” system in order to encourage users to reduce waste generation;
- harmonisation of the prescribed limit values for compost used in agriculture, with limit values in other EU countries in order to promote the use of compost for agricultural purposes.

**The Waste Prevention Programme**, adopted in 2016, addresses eight content sets, namely, waste prevention in enterprises, households and the public sector, and the following waste streams: construction waste, light plastic waste bags, bulk waste, food waste, textile and clothing waste. The main objective of the programme is to reduce the volume of waste and to minimise its negative effect on the environment. By reducing the need to produce new materials and products, the measure indirectly influences the reduction of GHG emissions. Special instruments were prepared for each set. The programme includes 34 instruments. The instruments that appear for most of the content sets, are awareness-raising, information and educational activities, while other instruments include: green public procurement, recording of generated waste in the public sector, increasing the number of companies involved in environmental management systems, launching identification and implementation programmes for potential waste prevention in companies, introduction of techniques and technologies that extend the life of buildings, etc.

The only emissions from the biological treatment are emissions from **composting**. In 2016 emissions from this source (CH<sub>4</sub> and N<sub>2</sub>O) amounted only 12.8 kt CO<sub>2</sub> eq.

**Waste incineration** is not important source of GHG emissions. The large amount of waste is incinerated in one small thermal power plant and in the industry (mostly cement plants) and corresponding emissions are reported in the energy sector. Emissions from the remaining incinerated waste are reported in the Waste sector. They arise mostly from incineration of clinical and hazardous wastes. Emissions from this source in 2016 were 23.6 Gg CO<sub>2</sub> eq.

**Waste-water** is treated in municipal or common waste-water treatment plants classified by level of treatment as specified in regulations. As a rule, primary treatment is defined as the mechanical or chemical elimination of a smaller quantity of organic loading and some suspended substances. Secondary treatment is a process of biological purification. It removes a large amount of organic substances and nutrients (20%-30%). Tertiary treatment eliminates organic matter and a large amount of nutrients (nitrogen, phosphors).

According to the 2016 data approximately 63% of population in Slovenia are connected to waste-water treatment plants, 90 of them are large (more than 2000 population equivalents) and 260 are medium. Nearly 37% of the population still uses septic tanks, of these, less than one per cent is comprised of small municipal waste-water treatment plants (of less than 50 population equivalents).

## 7.2 Solid Waste Disposal Sites (CRF 5.A)

### 7.2.1 Category description

Methane is emitted during anaerobic fermentation of degradable organic substances in solid waste disposal sites in processes, which may last several decades. If waste were not disposed of on solid waste disposal sites, the degradation would take place in aerobic conditions without methane formation. Methane emissions from waste disposal are thus of anthropogenic origin and, consequently, a constituent part of national GHG inventories in accordance with IPCC methodology.

### 7.2.2 Methodological issues

The IPCC methodology for estimating CH<sub>4</sub> emissions from SWDS is based on the First Order Decay (FOD) method. This method assumes that the degradable organic component (degradable organic carbon, DOC) in waste decays slowly throughout a few decades, during which CH<sub>4</sub> and CO<sub>2</sub> are formed. If conditions are constant, the rate of CH<sub>4</sub> production depends solely on the amount of carbon remaining in the waste. As a result the emissions of CH<sub>4</sub> from waste deposited in a disposal site are the highest in the first few years after deposition, then gradually decline as the degradable carbon in the waste is consumed by the bacteria responsible for the decay. Transformation of degradable material in the SWDS to CH<sub>4</sub> and CO<sub>2</sub> is by a chain of reactions and parallel reactions.

A full model is likely to be very complex and vary with the conditions in the SWDS. However, according to the IPCC 2006 Guidelines the overall decomposition process can be approximated by first order kinetics which is used in the IPCC model.

For Slovenian inventory the Tier 2 method and IPCC model has been used for calculation of GHG emissions with combination of default parameters and country specific data.

The CH<sub>4</sub> emissions from solid waste disposal for a single year can be estimated using the equation below. Part of the CH<sub>4</sub> generated is oxidised in the cover of the SWDS, or can be recovered for energy or flaring.

$$\text{CH}_4 \text{ emitted} = \left[ \sum_x \text{CH}_4 \text{ generated}_{x,T} - R_T \right] * (1 - \text{OX}_T)$$

where:

T = inventory year

X = waste category or type/material

R<sub>T</sub> = CH<sub>4</sub> recovered (Gg/yr) in year T

OX<sub>T</sub> = oxidation factor (fraction) in year T

The CH<sub>4</sub> generation potential (L<sub>0</sub>) of the waste that is disposed in a certain year will decrease gradually throughout the following decades. In this process, the release of CH<sub>4</sub> from this specific amount of waste decreases gradually. The FOD model is built on an exponential factor that describes the fraction of degradable material which each year is degraded into CH<sub>4</sub> and CO<sub>2</sub>.

One key input in the model is the amount of degradable organic matter (DOC<sub>m</sub>) in waste disposed into SWDS. This is estimated based on the information on disposal of different waste categories (municipal solid waste (MSW), sludge, industrial and other waste) and the different waste types/material (food, paper, wood, textiles, etc.) included in these categories.

The equations for estimating the CH<sub>4</sub> generation are given below. As the mathematics are the same for estimating the CH<sub>4</sub> emissions from all waste categories/waste types/materials, no indexing referring to the different categories/waste materials/types is used in the equations below.

$$L_0 = \text{DDOCm} \cdot F \cdot 16/12$$

and

$$\text{DDOCm} = W \cdot \text{DOC} \cdot \text{DOC}_F \cdot \text{MCF}$$

where:

L<sub>0</sub> = methane generation potential, Gg CH<sub>4</sub>

F = fraction by volume of CH<sub>4</sub> in landfill gas (volume fraction)

16/12 = conversion from C to CH<sub>4</sub> (molecular weight ratio)

DDOCm = mass of decomposable DOC deposited, Gg

W = mass of waste deposited, Gg

DOC = degradable organic carbon in the year of deposition (fraction, Gg C/Gg waste)

DOC<sub>F</sub> = fraction of DOC that can decompose (fraction)

MCF = CH<sub>4</sub> correction factor for aerobic decomposition in the year of deposition (fraction)

With a first order reaction, the amount of product is always proportional to the amount of reactive material. This means that the year in which the waste material was deposited in the SWDS is irrelevant to the amount of CH<sub>4</sub> generated each year. It is only the total mass of decomposing material currently in the site that matters.

This also means that when we know the amount of decomposing material in the SWDS at the start of the year, every year can be regarded as year number 1 in the estimation method, and the basic first order calculations can be done by these two simple equations, with the decay reaction beginning on the 1st of January the year after deposition.

$$\text{DDOCma}_T = \text{DDOCmd}_T + (\text{DDOCma}_{T-1} \cdot e^{-k})$$

and

$$\text{DDOCm decomp}_T = \text{DDOCma}_{T-1} \cdot (1 - e^{-k})$$



where:

T = inventory year

DDOCma<sub>T</sub>= DDOCm accumulated in the SWDS at the end of year T, Gg

DDOCma<sub>T-1</sub>= DDOCm accumulated in the SWDS at the end of year (T-1), Gg

DDOCmd<sub>T</sub>= DDOCm deposited into the SWDS in year T, Gg

DDOCm decomp<sub>T</sub>= DDOCm decomposed in the SWDS in year T, Gg

k reaction constant,  $k = \ln(2)/t_{1/2}$  (y<sup>-1</sup>)

t<sub>1/2</sub>= half-life time (y)

The simple FOD spreadsheet model (IPCC Waste Model) has been developed on the basis of equations shown above. The spreadsheet keeps a running total of the amount of decomposable DOC in the disposal site, taking account of the amount deposited each year and the amount remaining from previous years. This is used to calculate the amount of DOC decomposing to CH<sub>4</sub> and CO<sub>2</sub> each year.

The IPCC Waste Model provides two options for the estimation of the emissions from MSW, that can be chosen depending on the available activity data. We have used the first option which is based on waste composition data. This option is better in cases when rapid changes in waste composition occur what is a case in Slovenia in the recent period.

### **Activity data and parameters**

#### **The amount of waste in the period 1964 – 1994**

There are no data on the amount of waste prior to 1995. The first regulated municipal solid waste disposal site, the Ljubljana Barje SWDS, started its operation in 1964. An estimate for the period 1964 - 1994 was performed based on the presumption that in 1964, 50% of population was included in municipal waste collection system and that this percentage slightly increased and reached 60% in 1977 and 76% in 1995.

The composition of waste was deemed same all time. We are fully aware that this is a rough estimate, but since methane emissions from that period exert a significantly smaller impact on emissions in the reported period, this error is not considerable. Data is presented in the table 7.2.1.

We have also assumed that in that period the amount of waste per person was 470 kg/year or 1.29 kg/day. This amount is in the middle if we compare it with the country specific values from Eastern and Western European countries, presented in the Table 2.1 in The 2006 IPCC guidelines, Vol. 5. This value is intentionally higher from values in the neighbouring countries, because also biodegradable industrial waste was deposited on municipal SWDS. Since 1995 we have used actual data on the amount of waste.

**Table 7.2.1: Quantities of landfilled waste in the period 1964 - 1994.**

year	Urban population	Coverage in %	Waste generation (disposal) rate in kg/per./y.	Deposit waste (t) = Generated
1964	815,277	50.0	470	383,180
1965	825,207	50.0	470	387,847
1966	851,499	51.0	470	400,205
1967	862,379	51.0	470	405,318
1968	885,928	52.0	470	416,386
1969	891,291	52.0	470	418,907
1970	915,052	53.0	470	430,074
1971	921,194	53.0	470	432,961
1972	945,813	54.0	470	444,532
1973	953,708	54.0	470	448,243
1974	980,359	55.0	470	460,768
1975	1,026,013	57.0	470	482,226
1976	1,073,373	59.0	470	504,485
1977	1,103,615	60.0	470	518,699
1978	1,134,129	60.9	470	533,040
1979	1,162,846	61.8	470	546,537
1980	1,191,424	62.7	470	559,969
1981	1,218,658	63.6	470	572,769
1982	1,240,476	64.4	470	583,024
1983	1,262,961	65.3	470	593,592
1984	1,286,567	66.2	470	604,686
1985	1,324,204	67.1	470	622,376
1986	1,346,888	68.0	470	633,037
1987	1,370,518	68.9	470	644,144
1988	1,395,547	69.8	470	655,907
1989	1,412,912	70.7	470	664,069
1990	1,429,744	71.6	470	671,980
1991	1,450,170	72.4	470	681,580
1992	1,463,610	73.3	470	687,897
1993	1,477,485	74.2	470	694,418
1994	1,493,847	75.1	470	702,108

**The amount of waste in the period 1995 – 2000**

According to the data provided by SURS (data submitted to EUROSTAT), over 1 million tons of municipal waste were produced in that period. It is inferred that this amount, due to the unclear definition of municipal waste, included industrial waste as well. The calculation of quantities in the table 7.2.2 takes into account the assumption that all collected municipal waste was landfilled (which is quite accurate for Slovenian circumstances).

**Table 7.2.2: Quantities of landfilled waste in the period 1995 - 2000.**

year	Urban population	Coverage in %	Waste generation rate in kg/per./y.	Deposited waste (t) = Generated
1995	1,510,504	76.0	468	707,000
1996	1,561,674	78.4	464	725,000
1997	1,606,565	80.9	462	743,000
1998	1,651,310	83.3	461	761,000
1999	1,702,019	85.7	458	780,000
2000	1,749,847	87.9	457	800,000

The amount of waste in the period 2001 - 2015

The initial parameters for calculating methane emissions are the total annual amount of municipal waste and the fraction of landfilled municipal waste. In calculating, we have used data by the Slovenian Environment Agency, which collects data on the formation and handling all types of waste in Slovenia on a regular basis. The data are collected by means of forms which are set down by the law and must be filled in once a year (for the preceding year) by the reporting agent. In addition the quantities of collected mixed waste and separate fractions of municipal waste from households, reporting agents also provide data on quantities of collected mixed and separate fractions of municipal waste and related waste which is produced in economic and service activities. On the basis of these data, the SORS generates its annual reports on waste handling. Results from these reports are presented in the table 7.2.3.

**Table 7.2.3: Quantities of landfilled waste in the period 2001 - 2016.**

year	Urban population	Coverage in %	Waste generation rate in kg/per./y.	Generated Waste (t)	Deposited waste (t)
2001	1,795,222	90.1	457	820,000	820,000
2002	1,854,535	92.3	462	850,740	821,436
2003	1,874,203	92.5	476	879,829	820,132
2004	1,873,992	93.0	448	832,827	727,464
2005	1,881,047	94.0	454	844,949	752,546
2006	1,881,713	93.6	461	865,620	840,338
2007	1,884,055	93.0	472	885,595	811,674
2008	1,886,601	93.0	491	922,829	822,722
2009	1,889,147	93.0	481	912,981	750,743
2010	1,905,813	93.0	453	863,877	623,224
2011	2,052,496	100	352	721,844	504,997
2012	2,056,262	100	362	744,010	388,365
2013	2,059,114	100	414	853,388	274,724
2014	2,061,623	100	433	891,708	256,647
2015	2,063,077	100	451	929,460	260,820
2016	2,064,341	100	467	963,066	113,280

Despite the fact that the data on the amount of waste in the period 1995-2000 were provided by the SORS and obtained from Slovenian Environmental Agency for 2001-2015, the time consistency is ensured. In both sets data are gathered from all SWDS in Slovenia. The only difference is that questioners are now send from and returned to SEA, which means that SEA has the right to individual data. Before, according to Statistical law, SEA got only aggregated data and no control of individual SWDS were possible. All data gathered by SEA are sent to SORS where they are processed and published.

The coverage has increased from 50% in 1984 to 94% in 2005 and since 2011 a 100% coverage is assumed. Urban population and generated and deposited waste are presented from table 7.2.1 to table 7.2.3 and corresponding biodegradable part of waste is presented on the table 7.2.4.

**Table 7.2.4: Quantities of landfilled waste in the period 1964 - 2016.**

Year	Deposited waste (t)	Biodegradable waste (t)	Year	Deposited waste (t)	Biodegradable waste (t)
1964	383,180	180,095	1991	681,580	361,237
1965	387,847	182,288	1992	687,897	392,101
1966	400,205	188,096	1993	694,418	402,762
1967	405,318	190,499	1994	702,108	414,244
1968	416,386	195,702	1995	707,000	445,410
1969	418,907	196,886	1996	725,000	456,750
1970	430,074	202,135	1997	743,000	468,090
1971	432,961	203,492	1998	761,000	479,430
1972	444,532	208,930	1999	780,000	491,400
1973	448,243	210,674	2000	800,000	504,000
1974	460,768	216,561	2001	820,000	483,800
1975	482,226	226,646	2002	821,436	460,004
1976	504,485	237,108	2003	820,132	418,267
1977	518,699	243,789	2004	727,464	341,908
1978	533,040	250,529	2005	752,546	331,120
1979	546,537	256,873	2006	840,338	347,900
1980	559,969	263,185	2007	811,674	294,747
1981	572,769	269,202	2008	822,722	281,624
1982	583,024	274,021	2009	750,743	267,324
1983	593,592	278,988	2010	623,224	187,146
1984	604,686	284,203	2011	504,997	138,037
1985	622,376	292,517	2012	388,365	113,367
1986	633,037	297,528	2013	274,724	81,870
1987	644,144	302,747	2014	256,647	87,025
1988	655,907	308,276	2015	260,820	85,583
1989	664,069	338,675	2016	113,280	5,182
1990	671,980	349,430			

Methane correction factor (MCF) accounts for the effect of management practices on CH<sub>4</sub> generation. Unmanaged disposal sites present lower methane-generating potential, because a larger fraction of waste decomposes aerobically in the top layers of the unmanaged SWDS. The IPCC guidelines describe a managed SWDS as a site with one off the following:

- cover material
- mechanical compacting
- levelling of waste

For calculation implied MCF the following default MCF from 2006 IPCC Guidelines, Vol. 5 from Table 3.1 have been used:

- 0.6 for uncategorised SWDS and
- 1 for managed SWDS

In 1964, the Ljubljana-Barje SWDS started to operate as our first managed solid waste disposal site. Other existing solid waste disposal sites were unmanaged at that time. According to our estimate, roughly a half of the waste was collected at managed SWDS (Ljubljana – Barje) and a half at unmanaged SWDS. As the depth of the unmanaged SWDS at that time is unknown, we considered them as non-categorised and assumed a MCF of 0.6 for them, while assuming a MCF of 1 for managed SWDS. For the entire period 1964-1976, emissions have been calculated with an average value of MCF, i.e. 0.8.

1977 presented an accelerated rate of controlled placement of waste, which resulted in disposing of three quarters of waste on managed solid waste disposal sites in that year; we have therefore assumed a MCF of 0.90. After that year, all other solid waste disposal sites progressively introduced managing practices and since 1986 all other SWDS in Slovenia may be classified as managed SWDS. Accordingly, MCF increased linearly in the period from 1977 to 1986 MCF, and it has been equal to 1 since 1986.

Following the recommendation from the 2013 review report the table 7.2.5 have been added to clearly represent how MCF has been determined.

**Table 7.2.5: Calculation of MCF.**

Year	Unmanaged SWDS	Managed SWDS	calculation	Implied MCF
1964 - 1976	50 %	50 %	$(0.6 * 50 + 1 * 50) / 100$	0.8
1977	25 %	75 %	$(0.6 * 25 + 1 * 75) / 100$	0.9
1978 - 1985	Linear interpolation from 25 % to 0 %	Linear interpolation from 75 to 100 %	Linear interpolation	Linear interpolation
Since 1986	0 %	100 %	$1 * 100 / 100$	1

### Composition of waste

The following data on composition of waste have been estimated:

A = fraction of waste that is paper and textiles

B = fraction of waste that is garden waste, park waste or other non-food organic putrescibles

C = fraction of waste that is food waste

D = fraction of waste that is wood or straw

The fractions used for GHG emission calculations are presented in the table 7.2.6.

For mixed waste, which represents the major part of municipal and similar types of waste, we have assumed the composition or fractions A, B, C in D, as stated in the Operational programme of waste disposal to be the same for the entire period 1986 to 1988: A:12%, B:5%, C:25%, D:5%. Later this number has been changed to A: 15%, B: 8%, C: 32%, D: 8% for 1995 (the base year for the Operational programme) and for the values in between the expert estimates have been used.

**Table 7.2.6: Fractions of degradable waste in deposited waste.**

year	A paper textiles	B garden waste	C food waste	D wood straw	Degradable waste in %
1964-1986	12.0	5.0	25.0	5.0	47.0
1987	12.0	5.0	25.0	5.0	48.0
1988	12.0	5.0	25.0	5.0	49.0
1989	13.0	6.0	26.0	6.0	50.0
1990	13.0	6.0	27.0	6.0	51.0
1991	13.0	6.0	28.0	6.0	52.0
1992	14.0	7.0	29.0	7.0	53.0
1993	14.0	7.0	30.0	7.0	54.0
1994	14.0	7.0	31.0	7.0	55.0
1995	15.0	8.0	32.0	8.0	63.0
1996	15.0	8.0	32.0	8.0	63.0
1997	15.0	8.0	32.0	8.0	63.0
1998	16.0	8.0	31.0	8.0	63.0
1999	16.0	8.0	31.0	8.0	63.0
2000	17.0	8.0	30.0	8.0	63.0
2001	17.0	6.0	28.0	8.0	59.0
2002	18.0	4.0	26.0	8.0	56.0
2003	18.0	2.0	23.0	8.0	51.0
2004	19.0	0.0	21.0	7.0	47.0
2005	20.4	0.0	16.5	7.1	44.0
2006	20.8	0.0	14.2	6.4	41.4
2007	16.7	0.0	10.7	8.9	36.3
2008	15.9	0.0	11.0	7.3	34.2
2009	11.4	0.0	15.6	8.6	35.6
2010	12.6	0.0	11.8	5.6	30.0
2011	12.2	0.0	9.9	5.3	27.3
2012	13.0	0.0	11.3	4.9	29.2
2013	13.3	0.0	11.4	5.1	29.8
2014	14.9	0.0	13.7	5.3	33.9
2015	14.4	0.0	13.0	5.4	32.8
2016	3.0	0.0	0.0	1.5	4.5

**Table 7.2.7: Amounts of different wastes deposited on municipal SWDS and results for screening analyzes for mixed MSW (code from LoW 20 03 01) for the period 2008 to 2016.**

year	All waste deposited on the SWDS (t)	Municipal solid waste – MSW (t)	Mixed fraction of MSW – code 20 03 01 (t)	A paper textiles %	C food waste %	D wood straw %
2008	822,722	684,719	616,588	20.2	13.5	9.2
2009	750,743	627,686	524,734	14.8	14.4	11.1
2010	623,224	557,901	516,502	14.0	13.8	5.6
2011	504,997	419,228	380,414	19.9	16.6	5.2
2012	388,365	314,952	290,284	18.9	17.2	4.5
2013	274,724	224,001	203,945	18.9	17.2	4.5
2014	256,647	207,676	188,387	17.9	17.7	3.8
2015	260,820	208,618	188,638	17.9	17.7	3,8
2016	113,280	54,893	40,117	NO	NO	NO

The List of Waste (LoW) is a list of hazardous and non-hazardous waste listed in the Annex 4 of the Decree on Waste (OJ RS, No 103/2011) and is available on the web site below:

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2000D0532:20020101:EN:PDF>

Waste is classified into groups according to the origin. In addition to the name, each waste has a six-digit classification number.

**Table 7.2.8: Disaggregation of different types of biodegradable waste according to composition.**

Main code	Type of wastes	Additional code	A paper and textile	C food	D wood
02 01	wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing	01, 02, 03, 99		100%	
02 01	wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing	07			100%
02 02	wastes from the preparation and processing of meat, fish and other foods	01, 02, 03, 99		100%	
02 03	wastes from fruit, vegetables, cereals, edible oils, cocoa, coffee, tea...	01, 02, 03, 04, 99		100%	
02 04	wastes from sugar processing	99		100%	
02 05	wastes from the dairy products industry	01, 99		100%	
02 06	wastes from the baking and confectionery industry	01, 02		100%	
02 07	wastes from the production of alcoholic and non-alcoholic beverages	01, 02, 04			
03 01	wastes from wood processing and the production of panels and furniture	01, 05, 99			100%
03 03	wastes from pulp, paper and cardboard production and processing	01			100%
03 03	wastes from pulp, paper and cardboard production and processing	07, 10, 99	100%		
04 02	wastes from the textile industry	09, 10, 21, 22, 99	50%		
15 01	packaging	01	100%		
15 01	packaging	03			100%
15 01	packaging	09	100%		
15 02	other	03	50%		
17 02	wood, glass and plastic	01			100%
17 09	Mixed construction waste	04			20%
19 08	wastes from waste water treatment plants	01, 02	10%		5%
19 12	wastes from the mechanical treatment of waste	01	100%		
19 12	wastes from the mechanical treatment of waste	07			100%
19 12	wastes from the mechanical treatment of waste	08	50%		
19 12	wastes from the mechanical treatment of waste	12	10%		5%
20 01	separately collected fractions	08, 25		100%	
20 01	separately collected fractions	10, 11	50%		
20 01	separately collected fractions	38			100%
20 02	garden and park wastes	01			100%
20 03	other municipal wastes - mixed municipal wastes	01, 99	Table 7.2.7	Table 7.2.7	Table 7.2.7
20 03	other municipal wastes	03	20%	10%	5%
20 03	Bulky waste	07			35%

In 2005 and partly in 2006, new screening analyses of mixed municipal waste were performed. The results were as followed: 22.1% A, 17.5% C and 7.5% D, or, together, 47% of all degradable wastes. Considering all waste disposed of in SWDS and fraction of degradable waste in other types of disposed wastes, we have estimated the following composition of waste for 2005: A: 20.4%, C: 16.5% and D: 7.1%. The fraction of waste “garden waste or park waste” is zero because legislation prohibits deposition of such type of waste on SWDS.

In the period 2008-2015 the screening analyses have been done for mixed part of municipal solid waste for every landfill many times per year and results are presented in the table 7.2.7. For other types of wastes the disaggregation on table 7.2.8 has been used. The composition of waste and the composition of its biodegradable part are taken from the yearly reports on deposited waste on MSW disposal sites.

Since 2016, the mechanical biological treatment (MBT) of mixed municipal waste prior to disposal in municipal waste management centres has been mandatory. That is why all facilities for mechanical and biological treatment of mixed municipal waste in Slovenia had to be upgraded in order to meet the country's needs. The treated municipal waste has to fulfill the following restrictions before they are allowed to be disposed on the SWDS.

- heating value: does not exceed 6,000 kJ / kg of dry matter,
- TOC: does not exceed 18% by weight of dry MB treated municipal waste and
- AT4: does not exceed 10 mg O<sub>2</sub> /g dry matter of biodegradable waste.

For such a treated waste it is assumed that no biodegradable component is included any more. In 2016 deposited wastes with a biodegradable component are presented in the table 7.2.9.

**Table 7.2.9: Composition of deposited biodegradable waste in 2016.**

Main code	Type of wastes	Additional code	A paper and textile	D wood
04 02	Wastes from the textile industry - other	99	50%	
15 02	absorbents, filter materials, wiping cloths and protective clothing	03	50%	
17 02	Construction and demolition waste - wood	01		100%
19 08	wastes from waste water treatment plants	01, 02	10%	5%
19 12	wastes from the mechanical treatment of waste - other	12	10%	5%

Fraction of degradable organic carbon that can decompose (DOC<sub>i</sub>) is an estimate of the fraction of carbon that is ultimately degraded and converted into landfill gas, and reflects the fact that some organic carbon does not degrade, or degrades very slowly, when deposited in SWDS. The recommended IPCC default value of 0.5 has been used.

Fraction of CH<sub>4</sub> in generated landfill gas (F) reflects the fact that biogas mainly consists of CH<sub>4</sub> and CO<sub>2</sub> (usually considered half of each gas). We apply 0.5 as the most commonly used value in our estimates.

Oxidation factor (OX) reflects the portion of CH<sub>4</sub> from SWDS that is oxidised in the soil or other material covering the waste. The amount of CH<sub>4</sub> that oxidises turns primarily to CO<sub>2</sub>. If OX is zero, no oxidation takes place, and if OX is 1, then 100% of CH<sub>4</sub> is oxidised. We assumed that, in our case, OX was very close to zero until 2008, when we start using 0.1.



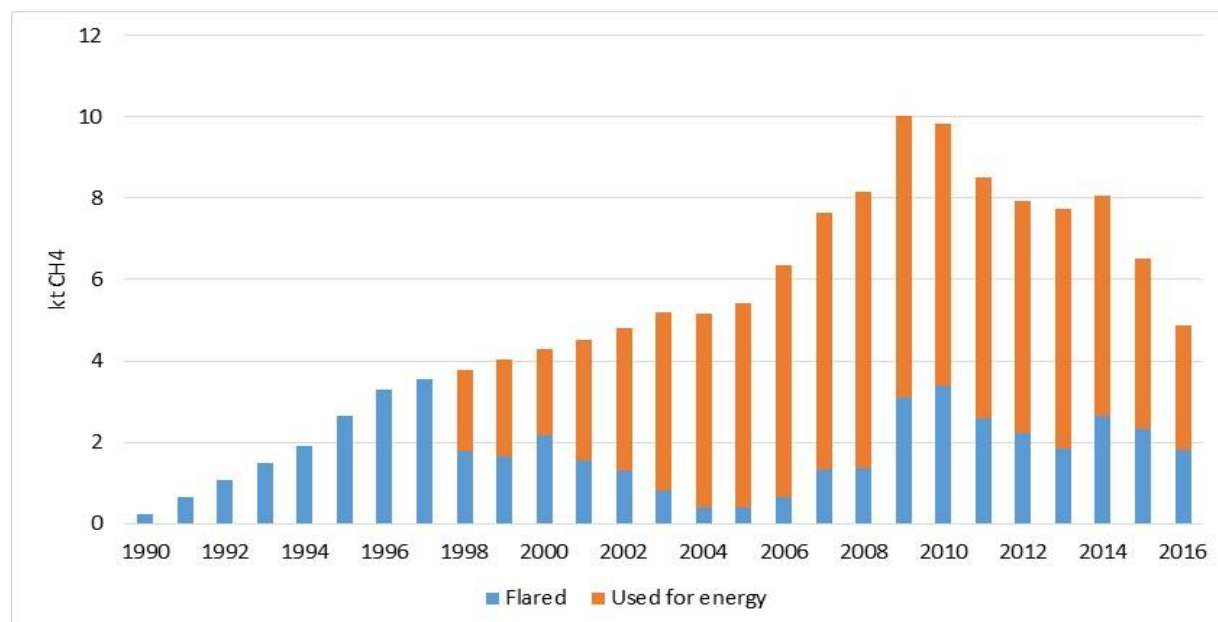
The oxidation value of 0.1 is justified for well-managed landfills which are covered with soil or other material. In the past very few SWDSs in Slovenia, although they were managed, use the cover material. In 2006 Slovenia started to implement EU legislation and until 2008 all SWDSs became well managed (are covered with soil or other material). It is very hard to estimate the oxidation factor before 2008 but according to the 2006 IPCC GL, use of 0.1 is appropriate since 2008 only.

The half-life value,  $t_{1/2}$  is the time taken for the  $\text{DOC}_m$  in waste to decay to the half its initial mass. In the FOD model the reaction constant  $k$  has been used. The relationship between  $k$  and  $t_{1/2}$  is:  $k = \ln(2)/t_{1/2}$ . The half-life is affected by a wide variety of factors; the most important are the composition of waste and climatic conditions. In the Slovenian inventory the IPCC default values for temperate and wet climatic conditions from the 2006 IPCC GL, Vol.5, Table 3.3 have been used (Table 7.2.10).

**Table 7.2.10: IPCC default methane generation rate ( $k$ ) values and DOC used in the IPCC waste model.**

Type of Waste		IPCC Range	IPCC default	Half-life (years)	DOC
Slowly degrading waste	A. paper, textiles	0.05-0.07	0.06	11.6	0.4
	D. wood, straw	0.02-0.04	0.03	23.1	0.43
Moderately degrading waste	B. garden, park	0.06-0.10	0.10	6.9	0.2
Rapidly degrading waste	C. food	0.1-0.2	0.185	3.7	0.15

$\text{CH}_4$  recovery (R) is the amount of  $\text{CH}_4$  generated at SWDS that is recovered and combusted (e.g. flared or used for energy). The amount of methane that is recovered and flared or oxidised in gas engines is subtracted from the annual methane emissions.



**Figure 7.2.1: Methane recovery in tons.**

Data on the quantities of recovered methane from 2000 on were provided by the Waste Sector (SEA) and for previous years directly by the disposal sites. Since there are no data on the amount of recovered methane for 2001, an interpolated value was used in calculation.

**Table 7.2.11: Recovery of methane, generated at SWDS**

	Unit	1998	1999	2000	2001	2002	2003	2004	2005
Recovery	t CH <sub>4</sub>	3,794	4,036	4,278	4,520	4,820	5,210	5,165	5,422
Recovery	TJ	191	203	216	228	243	263	260	273
used for electricity	TJ	102	120	107	149	178	221	241	253
Difference - flared	TJ	89	83	109	79	65	42	19	20
flared	t CH <sub>4</sub>	1,770	1,655	2,155	1,564	1,288	825	383	402

	Unit	2006	2007	2008	2009	2010	2011	2012	2013
Recovery	t CH <sub>4</sub>	6,366	7,633	8,165	1,0011	9,816	8,513	7,938	7,728
Recovery	TJ	321	385	411	505	495	429	400	389
used for electricity	TJ	288	317	343	349	324	298	287	297
Difference - flared	TJ	33	68	68	156	171	131	113	92
flared	t CH <sub>4</sub>	651	1,344	1,359	3,087	3,396	2,601	2,243	1,835

	Unit	2014	2015	2016	2017	2018	2019	2020
Recovery	t CH <sub>4</sub>	8,054	6,517	4,860				
Recovery	TJ	406	328	245				
used for electricity	TJ	272	210	153				
Difference - flared	TJ	134	118	92				
flared	t CH <sub>4</sub>	2,660	2,341	1,824				

Energy use of methane after 1998 is reported in Energy sector in 1.A.1.a Public electricity and heat production, and the remaining amount is assumed to be flared. Before 1998, all methane recovered on SWDS was flared. Emissions from flaring are not included in the inventory. A detailed data on methane recovery are presented in the Figure 7.2.1 and Table 7.2.11.

According to the Slovenian landfill regulation all landfill operators were obliged to build landfill gas capture facilities by the end of 2005. If the captured landfill gas can not be used for energy purposes, it must be incinerated in the area of the landfill or prevented from emitting into the air using other methods equivalent to gas incineration.

In some cases the amount of methane in the generated landfill gas is too low to support energy recovery or even flaring. In these cases a passive landfill gas bio-filter vents could be used. In Slovenia in many closed SWDS this method of methane emission reduction is used. The number of closed sites is increasing in recent years due to the increasingly stringent environmental standards that must be met by operated landfills. The amount of methane oxidized in bio-filter system is not available, however we are assuming that it was not negligible in the recent year.

Emissions estimates according to the first order decay method are presented in the Figure 7.2.2. The contribution to the generated methane emissions from each type of biodegradable waste is presented with the chart diagram while the red line represents final emissions taking into consideration also the recovery. The first order decay method takes into account also the

contribution of waste disposed of in the past; therefore the reduction of quantity of disposed of biodegradable waste is shown only after a certain time delay.

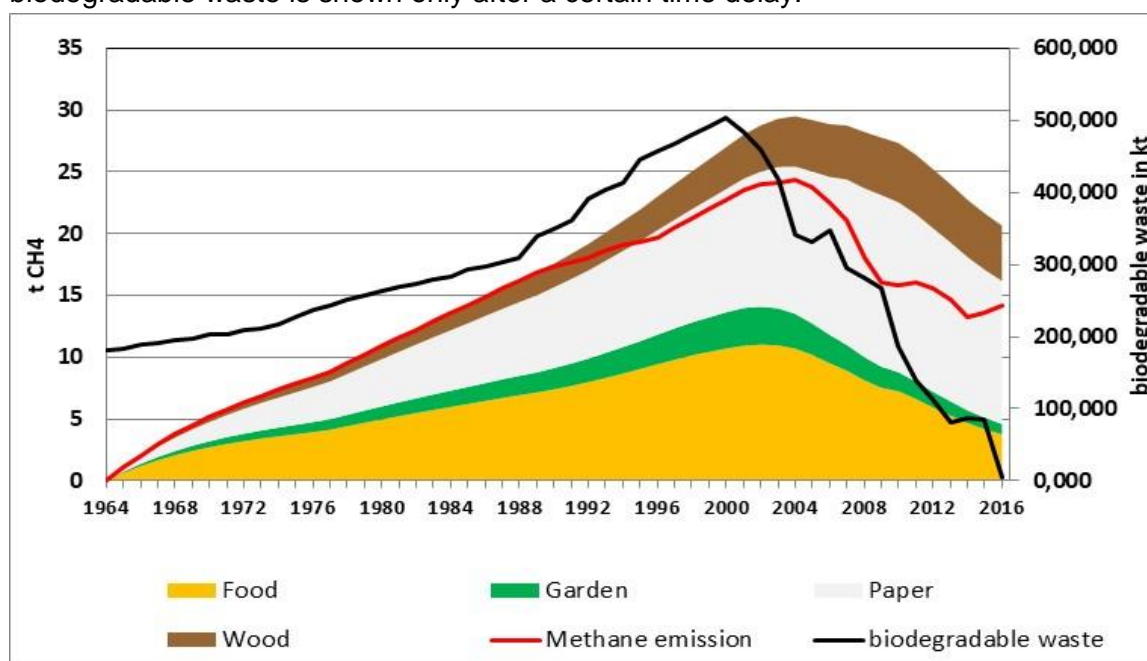


Figure 7.2.2: Methane emissions from SWDS in t CH<sub>4</sub>.

### 7.2.3 Uncertainty and time series consistency

The uncertainty estimates are based on an expert judgement taking into account uncertainty ranges suggested in the 2006 IPCC GL.

The uncertainty of the activity data amounts to 30%.

The uncertainty of the emission factor amounts to 40%.

### 7.2.4 Category-specific QA/QC and verification

Besides general QC checks, source specific checks have been performed for 2014 submission and the following procedures have been done:

- Comparison of CS values on MSW generated and waste composition with IPCC default values;
- Comparison of CH<sub>4</sub> emissions calculated with the IPCC waste model with the results from the old FOD method (from IPCC GPG);
- Comparison of the recovery data gathered for tax purposes with SORS data.

### 7.2.5 Category-specific recalculations

No recalculations have occurred in this category.

### 7.2.6 Category-specific planned improvements

For the next submission we are planning to estimate methane recovered in the bio-filtered system.

## 7.3 Biological Treatment of Solid Waste (CRF 5.B)

### 7.3.1 Category description

Composting is an aerobic process and a large fraction of the degradable organic carbon (DOC) in the waste is converted into CO<sub>2</sub>. Composting can also produce emissions of N<sub>2</sub>O and CH<sub>4</sub>.

### 7.3.2 Methodological issues

The activity data on composting waste have been obtained from SORS for all years since 2002. No data prior 2002 is available. A household composting is not included in these data.

Emission factors have been taken from 2006 IPCC GL, Vol. 5 Table 4.1 for wet weight: 4 g CH<sub>4</sub> / kg waste and 0.24 g N<sub>2</sub>O / kg waste.

### 7.3.3 Uncertainty and time series consistency

The uncertainty estimates are based on an expert judgement taking into account uncertainty ranges suggested in the 2006 IPCC GL.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factor amounts to 20%.

### 7.3.4 Category-specific QA/QC and verification

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

### 7.3.5 Category-specific recalculations

No recalculation have been performed.

### 7.3.6 Category-specific planned improvements

No improvements are planned for the next submission.

## 7.4 Waste incineration (CRF 5.C)

### 7.4.1 Category description

The purpose of waste incineration until 2008 in Slovenia was to remove waste which was not allowed to be deposited on the SWDS, the amount of incinerated waste was small and emissions from this source were less than 5 Gg CO<sub>2</sub> eq. In 2009 the only Slovenian waste incineration thermal plant started to work. Since then incinerated amount of hazardous and clinical waste increased and corresponding emissions in 2016 were 23.6 Gg CO<sub>2</sub> eq.

### 7.4.2 Methodological issues

The amount of waste incinerated in Slovenia have been obtained from SEA. The data as presented in the Table 7.4.1 are available for individual plants from yearly reports for the period 2000-2016 for every category from waste classification. For the time before this period, only total amount of clinical and hazardous waste is available.

**Table 7.4.1: Amount of waste incinerated in Slovenia in the period 1986 – 2016.**

Year	biogenic	municipal solid waste	clinical waste	hazardous waste
1986 – 1993	0	0	0	815
1994	0	0	132	456
1995	0	0	0	268
1996	0	0	0	389
1997	0	0	214	73
1998	10	0	205	335
1999	0	0	85	1,031
2000	0	0	109	1,261
2001	0	0	280	1,190
2002	260	0	441	946
2003	235	0	534	1,382
2004	110	15	138	1,366
2005	291	2	113	1,325
2006	345	4	108	1,616
2007	676	9	160	1,987
2008	533	33	148	2,091
2009	630	19	193	2,585
2010	31	21	671	2,836
2011	251	9	660	2,860
2012	221	11	578	7,714
2013	132	10	524	6,883
2014	29	10	267	8,235
2015	41	12	195	11,110
2016	71	1	299	8,993

Incinerated waste was divided to biogenic and non-biogenic part and non-biogenic part was further disaggregated in three types of waste (hazardous, clinical and municipal). CO<sub>2</sub> emissions from biogenic waste are not included in the national total amount of emissions.

CO<sub>2</sub> emission factors are presented in the table 7.4.3 and have been calculated using Equation 5.1 from 2006 IPCC Guideline as follows:

$$EF = dm * CF * FCF * OX * 44/12$$

EF – CO<sub>2</sub> emission factor in t/t

dm – dry matter content in % of wet weight;

TCC – total carbon content in % of dry weight,

FCF – fossil carbon fraction in % of TCC

OX – oxidation factor

44/12 - conversion factor from C to CO<sub>2</sub>

The exemption was CO<sub>2</sub> EF for fossil liquid waste for which Equation 5.3 have been used.

$$EF = CF * FCF * OX * 44/12$$

Parameters used for calculation of CO<sub>2</sub> EF are IPCC default and are presented on the Table 7.4.2. Source is IPCC 2006 Guidelines, Vol 5, Table 2.4., 2.5, 2.6 and 5.2.

The CH<sub>4</sub> EFs have been taken from the Table 5.3 for semi-continuous incineration while N<sub>2</sub>O EFs are from Table 5.5 and 5.6.

**Table 7.4.2: Parameters used for the calculation of CO<sub>2</sub> EF.**

	Unit	Wood and paper	MSW	Clinical waste	Fossil liquid waste	Other industrial
dm (%)	%	85	90	35	NA	50
TCC	%	50	3	60	80	50
FCF	%	0	100	40	100	90
OF	%	100	100	100	100	100

Source for CH<sub>4</sub> EF is IPCC 2006 Guidelines, Vol 5, Table 5.3. According to the information on combustion technique in two most important incineration plants EF for the semi-continuous incineration have been used.

Source for N<sub>2</sub>O EF is IPCC 2006 Guidelines, Vol 5, Table 5.5 and 5.6.

**Table 7.4.3: Emission factors used in the period 1986 - 2016.**

	Unit	Wood and paper	MSW	Clinical waste	Fossil liquid waste	Other industrial
CO <sub>2</sub>	t / t waste	0	99	308	2933	825
CH <sub>4</sub>	g/ t waste	6	6	6	6	6
N <sub>2</sub> O	g/ t waste	10	50	100	9.8	100

According to the data for 2014 and 2015 around three quarters (77%) of hazardous waste is liquid. The same assumption has been used for all years before. Since 2016 the actual yearly data has been used. CO<sub>2</sub> and N<sub>2</sub>O emission factors for hazardous waste, which is different for the liquid and for other industrial waste are presented in the Table 7.4.4.

**Table 7.4.4: CO<sub>2</sub> and N<sub>2</sub>O emission factors used for hazardous waste in 2016.**

	Unit	Until 2015	2016
liquid	%	77	84.4
CO <sub>2</sub>	t / t waste	2.448	2.604
N <sub>2</sub> O	g/ t waste	30.5	23.9

### 7.4.3 Uncertainty and time series consistency

The uncertainty estimates are based on an expert judgement taking into account uncertainty ranges suggested in the 2006 IPCC GL.

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factor amounts to 10%.

### 7.4.4 Category-specific QA/QC and verification

This category has been checked by the general QC procedures described in the Chapter 1.2.3.

### 7.4.5 Category-specific recalculations

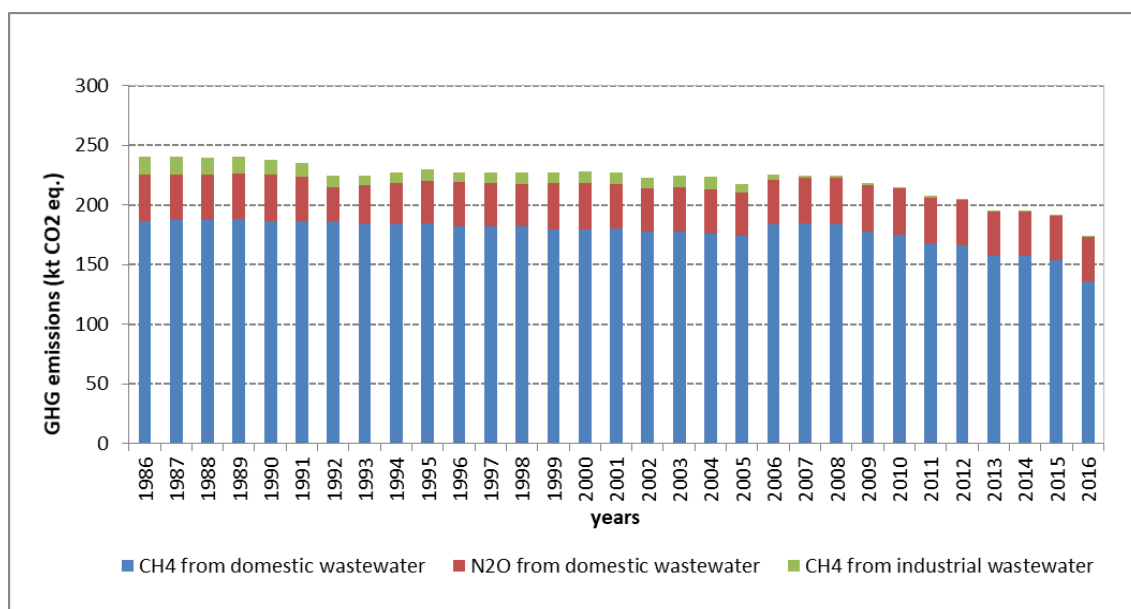
No recalculation have been performed.

### 7.4.6 Category-specific planned improvements

No improvements are planned for the next submission.

## 7.5 Emissions from Wastewater Treatment and Discharge (CRF 5.D)

### 7.5.1 Category description



**Figure 7.5.1: Emissions of methane and nitrous oxide from wastewater treatment.**

Wastewater could be a source of methane ( $\text{CH}_4$ ) when treated or disposed anaerobically. It can also be a source of nitrous oxide ( $\text{N}_2\text{O}$ ) emissions. Carbon dioxide ( $\text{CO}_2$ ) emissions from wastewater are not considered in the IPCC Guidelines because these are of biogenic origin and should not be included in national total emissions. Wastewater originates from a variety of domestic and industrial sources and may be treated on site (uncollected), sewerage to a centralized plant (collected) or disposed untreated nearby or via an outfall. IPCC methodology requires separate handling of domestic and industrial wastewater. Domestic wastewater is defined as wastewater from household water use, while industrial wastewater is from industrial practices only.

Wastewater as well as its sludge components can produce  $\text{CH}_4$  if it degrades anaerobically. The extent of  $\text{CH}_4$  production depends primarily on the quantity of degradable organic material in the wastewater, the temperature, and the type of treatment system. With increases in temperature, the rate of  $\text{CH}_4$  production increases. This is especially important in uncontrolled systems and in warm climates. Below  $15^\circ\text{C}$ , significant  $\text{CH}_4$  production is unlikely because methanogens are not active.

$\text{N}_2\text{O}$  is associated with the degradation of nitrogen components in the wastewater (urea, nitrate, protein). Domestic wastewater includes human sewage mixed with other household wastewater, which can include effluent from shower drains, sink drains, washing machines.  $\text{N}_2\text{O}$  emissions can occur as direct emissions from treatment plants or from indirect emissions from wastewater after disposal effluent into waterways (rivers, lakes, sea). Direct emissions



from nitrification and denitrification at wastewater treatment plants are much smaller than those from effluent.

Calculations of CH<sub>4</sub> and N<sub>2</sub>O emissions from domestic and industrial wastewater treatment and discharge were performed in accordance with 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Figure 7.5.1 and Table 7.5.1 show CH<sub>4</sub> and N<sub>2</sub>O emissions from domestic and industrial wastewater treatment for the period 1986-2016. Emissions in Figure 7.5.1 are expressed in kt CO<sub>2</sub> equivalent. Conversion factors of 25 for CH<sub>4</sub> and 298 for N<sub>2</sub>O were used in the calculations. Referring to the fourth IPCC assessment report, 1 g CH<sub>4</sub> and 1 g N<sub>2</sub>O have the greenhouse effect of 25 and 298 g CO<sub>2</sub>, respectively.

**Table 7.5.1: Methane and nitrous oxide emissions from wastewater treatment.**

Year	Domestic wastewater	Domestic wastewater	Industrial wastewater	Domestic wastewater	Domestic wastewater	Industrial wastewater
	CH <sub>4</sub> emissions (kt)	N <sub>2</sub> O emissions (kt)	CH <sub>4</sub> emissions (kt)	CH <sub>4</sub> emissions (kt CO <sub>2</sub> eq.)	N <sub>2</sub> O emissions (kt CO <sub>2</sub> eq.)	CH <sub>4</sub> Emissions (kt CO <sub>2</sub> eq.)
1986	7.47	0.13	0.58	186.7	38.9	14.5
1987	7.49	0.13	0.58	187.3	38.2	14.5
1988	7.51	0.13	0.57	187.7	37.8	14.3
1989	7.52	0.13	0.57	188.0	37.8	14.2
1990	7.44	0.13	0.51	186.0	39.4	12.8
1991	7.45	0.12	0.47	186.2	37.0	11.6
1992	7.45	0.09	0.39	186.3	28.2	9.8
1993	7.35	0.11	0.32	183.9	32.4	8.1
1994	7.36	0.11	0.36	184.1	34.0	9.0
1995	7.37	0.12	0.39	184.3	35.9	9.7
1996	7.27	0.13	0.33	181.8	37.3	8.1
1997	7.27	0.12	0.36	181.9	36.6	8.9
1998	7.27	0.12	0.39	181.8	35.7	9.7
1999	7.18	0.13	0.36	179.5	38.7	9.1
2000	7.19	0.13	0.38	179.7	38.3	9.6
2001	7.20	0.13	0.40	179.9	37.5	10.1
2002	7.09	0.12	0.36	177.2	37.0	8.9
2003	7.09	0.13	0.37	177.3	37.6	9.3
2004	7.04	0.13	0.43	176.0	37.3	10.7
2005	6.95	0.12	0.27	173.7	36.9	6.8
2006	7.34	0.12	0.19	183.5	37.1	4.6
2007	7.40	0.13	0.08	185.0	37.4	2.1
2008	7.36	0.13	0.07	184.1	38.8	1.7
2009	7.10	0.13	0.07	177.5	39.2	1.6
2010	6.99	0.13	0.06	174.8	38.7	1.5
2011	6.70	0.13	0.06	167.6	38.2	1.5
2012	6.64	0.13	0.04	165.9	38.0	1.0
2013	6.30	0.13	0.03	157.5	37.3	0.8
2014	6.3	0.1	0.0	156.9	37.3	0.9
2015	6.14	0.13	0.04	153.6	37.3	0.9
2016	5.43	0.13	0.04	135.8	37.4	1.0

## 7.5.2 Methodological issues

### Domestic Wastewater

#### CH<sub>4</sub> EMISSIONS

Modified IPCC 2006 methodology has been used in calculating the emission of methane from domestic wastewater treatment and discharge. Emissions of CH<sub>4</sub> from domestic waste water were calculated per individual discharge pathway separately. Sum up CH<sub>4</sub> emissions of all pathways results was performed subsequently.

As the first step, it is necessary to determine total amount of organically degradable material in the wastewater (TOW) for each pathway. TOW is the activity data for this source category. It is expressed in terms of biochemical oxygen demand (kg BOD/year). The equation for calculation of TOW is:

$$TOW_j = P * BOD * I * 0.001 * 365 * T_j$$

TOW<sub>j</sub> - total organics in wastewater for each discharge pathway, j (kg BOD/year)

P - country population (number of person)

BOD - country-specific per capita BOD (g/person/day)

0.001 - conversion from grams BOD to kg BOD

I - correction factor for additional industrial BOD discharged into sewers

T<sub>j</sub> - share of population included into each discharge pathway, j (fraction)

Secondly, the emission factors for each domestic wastewater treatment and discharge pathways have to be estimated. The emission factor is a function of the maximum CH<sub>4</sub> producing potential (B<sub>0</sub>) and the methane correction factor (MCF) for the wastewater treatment and discharge system. The B<sub>0</sub> is the maximum amount of CH<sub>4</sub> that can be produced from a given quantity of organics in the wastewater. The MCF indicates the extent to which the CH<sub>4</sub> producing capacity (B<sub>0</sub>) is realised in each type of treatment and discharge pathway and system. MCF is an indication of the degree to which the system is anaerobic. Emission factor is expressed in kg CH<sub>4</sub>/kg of degradable organic component:

$$EF_j = B_0 * MCF_j$$

EF<sub>j</sub> - emission factor (kg CH<sub>4</sub>/kg BOD)

j - each treatment and discharge pathway

B<sub>0</sub> - maximum CH<sub>4</sub> producing capacity (kg CH<sub>4</sub>/kg BOD)

MCF<sub>j</sub> - methane correction factor for each discharge pathway, j (fraction)

In the third step, emission for each domestic wastewater treatment and discharge pathways have to be estimated.

$$CH_4Emissions\_j = ((TOW_j - S_j) * EF_j) - R_j$$

CH <sub>4</sub> Emissions <sub>j</sub>	- CH <sub>4</sub> emissions for each discharge pathway (kg CH <sub>4</sub> /year)
TOW <sub>j</sub>	- total organics in wastewater for each discharge pathway, j (kg BOD/year)
S <sub>j</sub>	- organic component removed as sludge for each discharge pathway (kg BOD/year)
R <sub>j</sub>	- amount of CH <sub>4</sub> recovered for each discharge pathway (kg CH <sub>4</sub> /year)

In the end, the total national emission of methane from domestic wastewater is estimated. Individual emission estimates for each discharge pathway are sum up.

The equation for calculation of annual CH<sub>4</sub> emissions is as follows:

$$CH_4Emissions = \sum_j CH_4Emissions\_j$$

CH <sub>4</sub> Emissions	- total annual CH <sub>4</sub> emissions in the country (kg CH <sub>4</sub> /year)
CH <sub>4</sub> Emissions <sub>j</sub>	- CH <sub>4</sub> emissions for each discharge pathway (kg CH <sub>4</sub> /year)

CH<sub>4</sub> emissions from domestic wastewater treatment and discharge for the period 1986 - 2016 are shown in Figure 7.5.2. Emissions were increased in 2006 due bigger share of septic tanks.

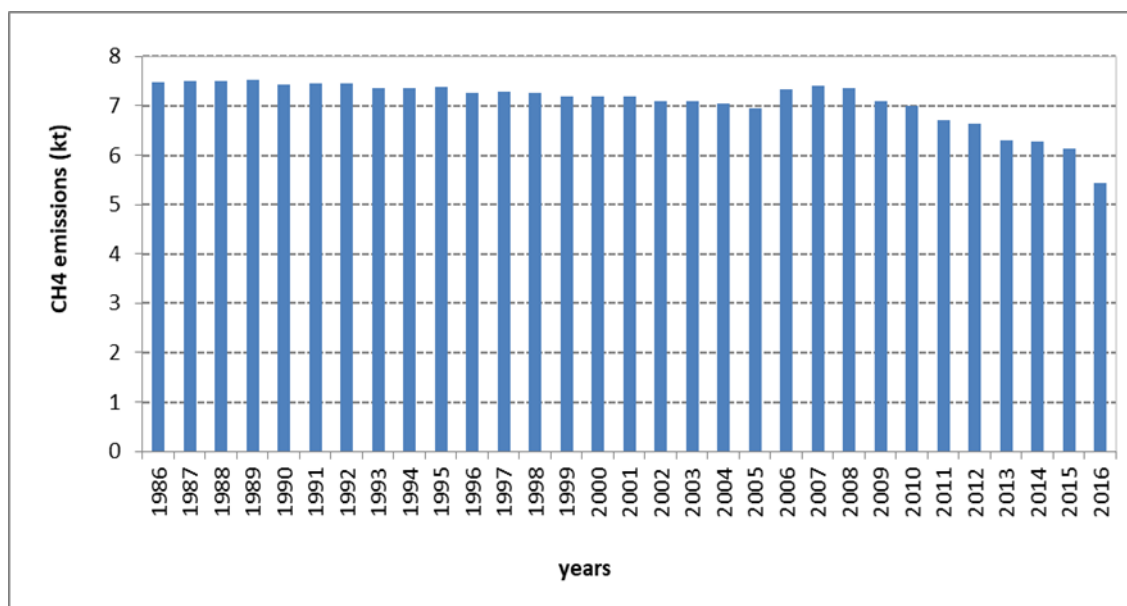


Figure 7.5.2: CH<sub>4</sub> emissions from domestic wastewater treatment.

The total organically degradable material in domestic wastewater (total organic product - TOW) is presented in Table 7.5.2.

**Table 7.5.2: Total organically degradable material (TOW) in domestic wastewater**

Year	Total organics in domestic wastewater (kt BOD)	Year	Total organics in domestic wastewater (kt BOD)	Year	Total organics in domestic wastewater (kt BOD)	Year	Total organics in domestic wastewater (kt BOD)
1986	46.78	1994	47.39	2002	48.04	2010	50.68
1987	47.03	1995	47.48	2003	48.14	2011	51.09
1988	47.15	1996	47.47	2004	48.91	2012	51.26
1989	47.21	1997	47.49	2005	49.22	2013	51.47
1990	47.36	1998	47.41	2006	49.15	2014	51.55
1991	47.40	1999	47.68	2007	49.63	2015	51.71
1992	47.36	2000	47.80	2008	49.82	2016	52.40
1993	47.33	2001	47.95	2009	50.48		

### Wastewater treatment and discharge pathways

Dispersed settlements and a large number of communities with less than 2000 inhabitants exert a strong influence on the extent and structure of municipal infrastructure as well as on the organisation of municipal activities. Domestic wastewater has been treated in centralized aerobic wastewater plants, septic tanks and latrines.

In 2016, about 63% of population was connected to centralized aerobic wastewater treatment plants (secondary and tertiary treatment). 37% of population use septic tanks and only 0.1% use latrines. Number of inhabitants included into various types of domestic wastewater treatment is shown in Table 7.5.3.

Data on inhabitants included into various types of domestic wastewater treatment is obtained from the Statistical Office of the Republic of Slovenia (SORS) and the database on municipal wastewater treatment plants collected by the Slovenian Environment Agency (SEA).

5.D.1 Domestic Wastewater CRF subcategory comprises emissions from all types of wastewater treatment, waste water sewered to centralized plants (collected) and treated on site (uncollected).

### Degradable organic component indicator (BOD):

For domestic wastewater, biochemical oxygen demand (BOD) is the recommended parameter used to measure the degradable organic component of the wastewater. The BOD concentration indicates only the amount of carbon that is aerobically biodegradable. The IPCC default as well as national legislation value of 60 g BOD/person/day or 21900 kg BOD/1000 person/year was used for emission calculations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.14, Table 6.4).

### Correction factor for additional industrial BOD discharged into sewers (I):

The factor expresses the BOD from industries and establishments (restaurants, butchers or grocery stores) that is co-discharged with domestic wastewater. The IPCC default value of 1.25 was used only for sewered, collected waste water (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.14). For septic tanks and latrines value of I is 1 was used for emission calculations.

**Table 7.5.3: Number of inhabitants included into various types of domestic wastewater treatment.**

Year	Number of inhabitants (in 1000)				
	Primary treatment	Secondary and tertiary treatment	Septic tanks	Latrines	Country population
1986	307	295	900	483	1985
1987	311	303	902	478	1994
1988	315	311	904	467	1996
1989	319	319	905	453	1996
1990	323	327	907	443	2000
1991	327	335	909	428	1999
1992	331	343	911	409	1994
1993	335	351	913	390	1989
1994	339	359	915	377	1989
1995	343	367	916	364	1990
1996	347	375	918	347	1987
1997	351	383	920	331	1985
1998	355	391	922	310	1978
1999	359	399	924	306	1988
2000	363	407	925	294	1990
2001	367	415	927	284	1994
2002	371	423	929	271	1995
2003	375	431	931	259	1996
2004	383	560	934	120	1998
2005	359	618	946	80	2003
2006	52	884	1014	60	2010
2007	51	910	1025	41	2026
2008	25	946	1041	20	2032
2009	8	1024	997	18	2047
2010	8	1047	979	16	2050
2011	9	1101	931	14	2055
2012	9	1117	920	12	2059
2013	9	1147	894	10	2061
2014	9	1155	890	8	2063
2015	0	1189	869	6	2064
2016	0	1307	755	4	2066

Maximum methane producing capacity ( $B_0$ ):

The methane producing potential ( $B_0$ ) is the maximum amount of  $CH_4$  that can be produced from a given quantity of organics (as expressed in BOD) in the wastewater. The  $CH_4$  producing

potential varies according to the composition of the wastewater and its degradability, but the IPCC Guidelines provide only one default value of  $B_0$ . The IPCC default of 0.6 kg  $\text{CH}_4$ /kg BOD was used for emission calculations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.12, Table 6.2).

#### Methane conversion factor (MCF):

The calculated amount of generated methane depends on the methane conversion factor, which tells us which fraction is actually transformed into methane. The MCF indicates the extent to which the  $\text{CH}_4$  producing capacity ( $B_0$ ) is realised in each type of treatment and discharge pathway. Thus, it is an indication of the degree to which the system is anaerobic. MCF is 0 for completely aerobic systems and 1 for completely anaerobic systems.

For septic tanks MCF value of 0.5 was used. Latrines are mostly used by only one or two elder people in rural area and dry climate. MCF value of 0.1 was used for latrines. Centralized aerobic treatment plants are well managed, but some  $\text{CH}_4$  can be emitted from settling basins and other pockets. Share of well managed aerobic treatment plants was estimated from information on implementation of the Urban Waste Water Treatment Directive. In 2016 about 93 % of the waste water is treated at aerobic treatment plants that are well managed, remaining 7 % is treated at not well managed plants.

The default MCF value of 0 for well managed and 0.3 for not well managed aerobic treatment plant were used for emission calculation (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.13, Table 6.3).

#### Organic component removed as sludge (S)

For sludge removal from the wastewater default IPCC value of zero was used for emission calculations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.9).

#### Methane recovery (R)

For amount of methane recovered default IPCC value of zero was used for emission calculations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.9).

## **N<sub>2</sub>O EMISSIONS**

Calculations of indirect nitrous oxide emissions from wastewater treatment effluent that is discharged into aquatic environments were performed according to IPCC methodology. Direct emissions from nitrification and denitrification at wastewater treatment plants were not calculated due to inexistence of advanced centralized wastewater treatment plants with controlled nitrification and denitrification steps.

As the first step, it is necessary to determine total amount of nitrogen in the wastewater effluent ( $N_{\text{EFFLUENT}}$ ). The equation for calculation of  $N_{\text{EFFLUENT}}$  is:

$$N_{\text{EFFLUENT}} = (P * \text{Protein} * F_{\text{NPR}} * F_{\text{NON-CON}} * F_{\text{IND-COM}}) - N_{\text{SLUDGE}}$$

$N_{\text{EFFLUENT}}$	- total annual amount of nitrogen in the wastewater effluent (kg N/year)
P	- human population
Protein	- annual per capita protein consumption (kg/person/year)
$F_{\text{NPR}}$	- fraction of nitrogen in protein
$F_{\text{NON-CON}}$	- factor for non-consumed protein added to the wastewater
$F_{\text{IND-COM}}$	- factor for industrial and commercial co-discharged protein into the sewer system
$N_{\text{SLUDGE}}$	- nitrogen removed with sludge (kg N/year)

Finally, emissions of  $\text{N}_2\text{O}$  from wastewater effluent are calculated as follows:

$$\text{N}_2\text{O emissions} = N_{\text{EFFLUENT}} * EF_{\text{EFFLUENT}} * 44/28$$

$\text{N}_2\text{O}$ emissions	- $\text{N}_2\text{O}$ emissions in inventory year (kg $\text{N}_2\text{O}$ /year)
$N_{\text{EFFLUENT}}$	- nitrogen in the effluent discharged to aquatic environments (kg N/year)
$EF_{\text{EFFLUENT}}$	- emission factor for $\text{N}_2\text{O}$ emissions from discharged to wastewater (kg $\text{N}_2\text{O}$ -N/kg N)
44/28	- the conversion of kg $\text{N}_2\text{O}$ -N into kg $\text{N}_2\text{O}$ .

$\text{N}_2\text{O}$  emissions from wastewater effluent for the period 1986 - 2016 are shown in Figure 7.5.3. Emissions have been relatively constant over two decades due to constant protein consumption. Drop of emissions in 1992 could be observed due to poor economic situation and Slovenian war for independence. Due to a very high global warming potential of  $\text{N}_2\text{O}$ , relatively low amounts of  $\text{N}_2\text{O}$  formation can substantially contribute to GHGs emissions. Referring to the fourth IPCC assessment report, 1 g  $\text{N}_2\text{O}$  has the greenhouse effect of 298 g  $\text{CO}_2$ .



Figure 7.5.3:  $\text{N}_2\text{O}$  emissions from wastewater effluent.

Emission factor for N<sub>2</sub>O emissions from discharged to wastewater (EF<sub>EFFLUENT</sub>)

The IPCC default value of 0.005 kg N<sub>2</sub>O-N/kg N was used for emission calculations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.25).

Human population (P)

Annual number of country population has been obtained from SORS.

Protein consumption (Protein)

Average consumption of protein per inhabitant in every individual year has been obtained from United Nations Food and Agriculture Organization (FAO). The publication of protein consumption data on the FAO's statistical database (FAOSTAT) has a time lag of four years. The last available consumption rate is applied to the years with missing data as well. Since the consumption protein data has not been available for the years 2014, 2015 and 2016 value for the year 2013 has been applied for the following years as well. We have also checked other potential sources of required data, but no other institution collects up-to-date data on protein consumption. Data on population and annual protein intake are presented in Table 7.5.4.

Fraction of nitrogen in protein (F<sub>NPR</sub>)

0.16 kg N/kg protein as an IPCC default fraction of nitrogen in protein was used for emission calculations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.25).

**Table 7.5.4: Population and protein consumption in the period 1986-2016**

Year	Population	Protein consumption (kg/person/year)	Year	Population	Protein consumption (kg/person/year)
1986	1985486	38.0	2002	1995033	36.0
1987	1994066	37.2	2003	1996433	36.5
1988	1996325	36.8	2004	1997590	36.2
1989	1996377	36.8	2005	2003358	35.8
1990	1999945	38.2	2006	2010377	35.8
1991	1998912	35.9	2007	2025866	35.9
1992	1994084	27.4	2008	2032362	37.1
1993	1989408	31.6	2009	2046976	37.2
1994	1989477	33.2	2010	2050189	36.7
1995	1990266	35.0	2011	2055496	36.1
1996	1986989	36.5	2012	2058821	35.9
1997	1984923	35.8	2013	2061085	35.1
1998	1978334	35.0	2014	2062874	35.1
1999	1987755	37.8	2015	2064188	35.1
2000	1990094	37.4	2016	2065895	35.1
2001	1994026	36.5			

Non-consumed protein added to the wastewater (F<sub>NON-CON</sub>)

Additional 'non-consumed' protein discharged to wastewater pathways has to be taken into account for N<sub>2</sub>O emission calculation. Food (waste) that is not consumed may be washed down the drain and also, bath and laundry water can be expected to contribute to nitrogen loadings. Since in Slovenia there is no garbage disposals the IPCC default factor of 1.1 was used for



emission calculations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, Table 6.11, pg. 6.27).

Industrial and commercial co-discharged protein into the sewer system ( $F_{IND-COM}$ )

Wastewater from industrial or commercial sources that is discharged into the sewer may contain protein. The IPCC default for this fraction is 1.25 and it was used for  $N_2O$  emission calculation (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.25).

Nitrogen removed with sludge ( $N_{SLUDGE}$ )

For sludge removal default IPCC value of zero was used for emission calculations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.25).

## **Industrial Wastewater**

### **CH<sub>4</sub> EMISSIONS**

IPCC methodology has been used in calculating the emission of methane from industrial wastewater handling. This chapter includes CH<sub>4</sub> emissions from on-site industrial wastewater treatment. Assessment of CH<sub>4</sub> production potential from industrial wastewater streams is based on the concentration of degradable organic matter in the wastewater, the volume of wastewater, and the propensity of the industrial sector to treat their wastewater in anaerobic systems. Only industrial wastewater with significant carbon loading that is treated under intended or unintended anaerobic conditions will produce CH<sub>4</sub>.

As the first step, it is necessary to determine total amount of organically degradable material in the wastewater (TOW). It is expressed in terms of chemical oxygen demand (kg COD/year). The equation for calculation of TOW for particular industrial sectors is:

$$TOW_i = Q * COD_i$$

TOW - total organically degradable material in the wastewater for industry i (kg COD/year)

Q - quantity of wastewater

COD<sub>i</sub> - degradable organics concentration in wastewater (kg COD/m<sup>3</sup>)

i - industrial sector

Secondly, the emission factors for each industrial wastewater treatment and discharge pathways for each industrial sector have to be estimated.

$$EF_j = B_0 * MCF_j$$

EF<sub>j</sub> - emission factor (kg CH<sub>4</sub>/kg COD)

j - each treatment and discharge pathway or system

B<sub>0</sub> - maximum CH<sub>4</sub> producing capacity (kg CH<sub>4</sub>/kg COD)

MCF<sub>j</sub> - methane correction factor (fraction)

In the end, the total emission of methane from industrial wastewater is estimated. The equation for calculation of annual CH<sub>4</sub> emissions is as follows:

$$CH_4 \text{ emissions} = \sum_i \left( (TOW_i - S_i) * EF_i \right) - R_i$$

CH <sub>4</sub> emissions	- CH <sub>4</sub> emissions (kg CH <sub>4</sub> /year)
TOW	- total organically degradable material in the wastewater for industry i (kg COD/year)
S <sub>i</sub>	- organic component removed as sludge for industry i (kg COD/year)
EF <sub>i</sub>	- emission factor for industry i
R <sub>i</sub>	- amount of CH <sub>4</sub> recovered (kg CH <sub>4</sub> /year)
i	- industrial sector

CH<sub>4</sub> emissions from industrial wastewater treatment for the period 1986 - 2016 are shown in Figure 7.5.4. Drop of emissions in 1992 could be observed due to poor economic situation and weaker industrial production as a consequence of Slovenian war for independence. Decrease of emissions from 2005 onwards was mainly due to decline in paper and pulp production. Lower emissions are also due to pre-treatment of wastewater in some large industrial facilities before releasing it into the centralized treatment plant to avoid high discharge fees and to meet regulatory standards.

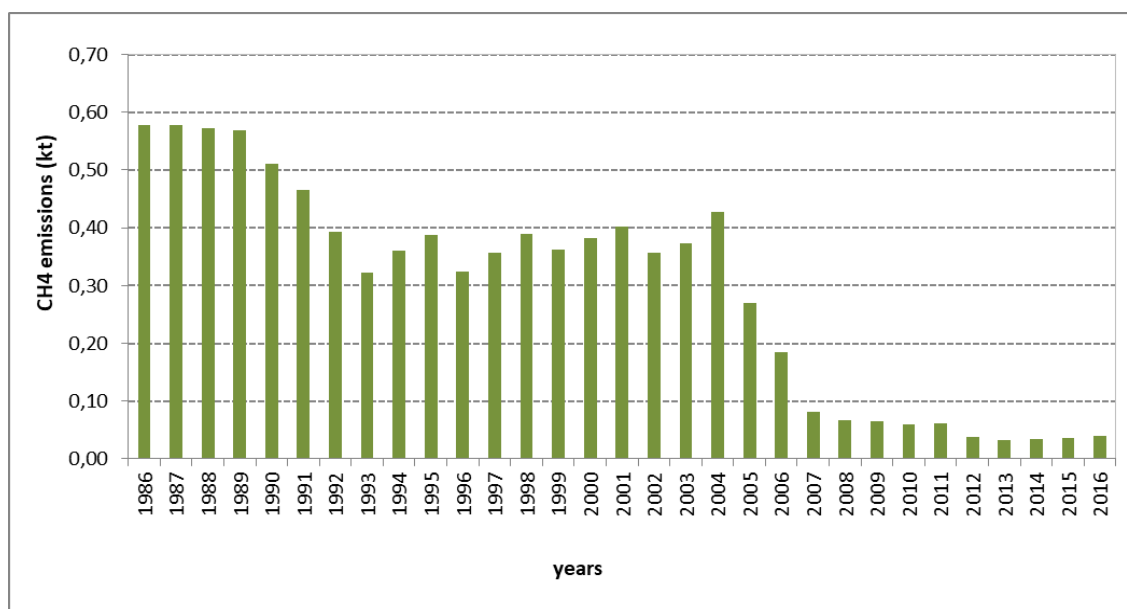


Figure 7.5.4: CH<sub>4</sub> emissions from industrial wastewater treatment.

The total organically degradable material in industrial wastewater (total organic product - TOW) is presented in Table 7.5.5.

**Table 7.5.5: Total organically degradable material (TOW) in industrial wastewater**

Year	Total organics in waste water (kt COD)	Year	Total organics in waste water (kt COD)	Year	Total organics in waste water (kt COD)	Year	Total organics in waste water (kt COD)
1986	24.87	1994	19.21	2002	29.68	2010	7.64
1987	24.87	1995	20.62	2003	31.08	2011	7.89
1988	24.58	1996	19.70	2004	35.60	2012	7.04
1989	24.44	1997	21.63	2005	27.70	2013	6.03
1990	24.29	1998	23.55	2006	18.99	2014	6.29
1991	22.15	1999	25.48	2007	8.42	2015	6.73
1992	18.71	2000	26.88	2008	8.54	2016	7.14
1993	17.19	2001	28.28	2009	8.36		

#### Industrial sectors and ways of wastewater treatment

Emissions of methane from industrial wastewater are calculated for the chosen industrial sectors with a large output of wastewater and high content of degradable organic components. In Slovenia, these are in particular pharmaceutical industry followed by production of soft drinks and alcohol beverage, meat processing, the pulp and paper industry and milk production while minor quantities of organically degradable organic components are produced also by some other sectors. Industrial wastewater is mainly treated in aerobic treatment plants. Some large industrial facilities apply pre-treatment of wastewater before releasing it into the centralized treatment plant to avoid high discharge fees and to meet regulatory standards.

#### Quantity of wastewater (Q)

Data on amount of wastewater output for individual industries for the period 1986-2016 are presented in Table 7.5.6.

Annual amount of wastewater output for an individual industry for the period 2004-2016 were obtained from database of annual reports on operational monitoring of industrial effluents collected by Slovenian Environment Agency. Since actual monitored volumes of wastewater are not available before the year 2004, estimation of volumes of wastewater for the years 1986-2003 was performed. We estimated volumes of wastewater for the period 1986-2003 in such way that we multiplied the ratio between data of actual volumes and data of production units for individual industries for the year 2004 with data on annual production of individual industry for the period 1986-2003. We decided to choose ratios for the year 2004, since this year most closely represents situation in previous years.

**Table 7.5.6: Wastewater output with regard to various industries.**

Year	Production of pulp and paper	Production of leather	Production of soft drinks and alcohol beverage	Production of food	Production of milk	Production of meat	Production of pharmaceutical products
	Wastewater output (m <sup>3</sup> )						
1986	18612812	960966	1993330	513066	992776	854301	
1987	18560824	948137	1993276	479440	1008278	908295	
1988	18199349	935331	1993223	445821	1023777	962289	
1989	17992579	922503	1993164	412196	1039279	1016283	
1990	17785835	909674	1993106	378570	1054778	1070278	
1991	15813639	778661	1897174	369069	1034204	1059647	
1992	13167759	736567	1773698	245566	921828	764296	
1993	12056736	686178	1812219	272168	767155	650592	
1994	13879156	678212	1906083	296905	835621	634050	
1995	15431625	459865	1879191	304715	911369	574572	
1996	14369458	529332	1881993	300437	885387	662932	
1997	16266638	496348	1941510	282961	926754	663706	
1998	18163843	463364	2001042	265483	968119	664480	
1999	20061023	430379	2060559	248007	1009486	665255	
2000	21397736	397395	2120086	230529	1050850	666029	
2001	22734450	364411	2179603	213054	1092218	666803	
2002	24071163	331427	2239130	195578	1133582	667578	
2003	25407851	298442	2298652	178100	1174950	668352	
2004	27672000	274700	1970685	136139	1133979	662367	1577989
2005	26947000	233185	1362038	178404	1230059	1420996	1368549
2006	21112000	238400	2074000	164120	986677	1143262	1544907
2007	12231000	281863	1771724	185040	984528	1393753	1487780
2008	16508000	228651	1572889	191920	981910	1334951	1523185
2009	15881919	11617	1533764	223853	901292	1162973	1765726
2010	13596494	9224	1737723	167710	865144	1268351	1633612
2011	12514742	22597	1785722	213732	871805	1161579	1560375
2012	12773572	39893	1543121	297757	820968	1119638	1465488
2013	10408933	44994	1458113	343150	835151	1074228	1528190
2014	11206175	47428	1268376	320628	838646	1144594	1578317
2015	11456759	40083	1166600	301864	750391	1307631	1684019
2016	11491537	35961	1058938	232644	805551	1724137	1747853

**Industrial degradable organic component indicator (COD<sub>i</sub>)**

The principal factor in determining the CH<sub>4</sub> generation potential of wastewater is the amount of degradable organic material in the wastewater. Common parameter used to measure the organic component of the industrial wastewater is Chemical Oxygen Demand (COD). Under the same conditions, wastewater with higher COD will generally yield more CH<sub>4</sub> than wastewater with lower COD concentrations. The COD measures the total material available for chemical oxidation (both biodegradable and non-biodegradable). Concentration of organic component in the wastewater (COD) for an individual industry for the period 2004-2016 were obtained from database of annual reports on operational monitoring of industrial effluents collected by Slovenian Environment Agency. COD values for the period 1986-2003 were adopted from 2004 data due to unavailability of precise data for earlier years.

Maximum methane producing capacity ( $B_0$ )

The default IPCC value of 0.25 kg CH<sub>4</sub>/kg COD was used for all types of industries (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.12, Table 6.2).

Methane conversion factor (MCF):

Industrial wastewater is mostly treated in well managed aerobic treatment plants, but some CH<sub>4</sub> can be emitted from settling basins and other pockets. Share of well managed aerobic treatment plants was estimated from information on implementation of the Urban Waste Water Treatment Directive. In 2016 about 93 % of the waste water is treated at aerobic treatment plants that are well managed, remaining 7 % is treated at not well managed plants.

The default MCF value of 0 for well managed and 0.3 for not well managed aerobic treatment plant were used for emission calculation (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.21, Table 6.8).

Organic component removed as sludge (S)

For sludge removal from the wastewater default IPCC value of zero was used for emission calculations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.9).

Methane recovery (R)

For amount of methane recovered default IPCC value of zero was used for emission calculations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, pg. 6.9).

### **7.5.3 Category-specific QA/QC and verification**

According to ERT recommendations transparent explanations of methodology, activity data and parameters for CH<sub>4</sub> and N<sub>2</sub>O emission calculations from domestic and industrial wastewater treatment were provided. Changes in methodology and parameters used were performed according to 2006 IPCC Guidelines for National Greenhouse Gas Inventories and conclusions of the capacity building webinar of 2017 ESD Review.

According to 2017 ESD Review modification of the application of equations 6.1-6.3 in the 2006 IPCC guidelines (Volume 5, chapter 6) was performed. Exact application of those equations seems to provide false results. Emissions of CH<sub>4</sub> from domestic waste water were calculated per individual discharge pathway separately: first multiply ((TOW-S) and EF) for each pathway. Sum of all pathways results was performed subsequently.

Since updated methodology has been applied all activity data and other parameters have been thoroughly checked as well. We have checked activity data used for CH<sub>4</sub> and N<sub>2</sub>O emission calculation for domestic waste water. SORS and FAOSTAT periodically report updated data. When updated data are published, we use them for emissions calculation. For data on protein consumption we have compared data published by Food and Agriculture Organization of the United Nations and World Health Organisation. We have also checked activity data used for CH<sub>4</sub> emission calculation for industrial waste water. We have made a comparison of emissions derived from actual volumes of wastewater and emissions calculated from production units for

individual industry. The peer review of waste water was conducted in 2011 and no important errors have been found.

### **7.5.4 Uncertainty and time-series consistency**

The uncertainty estimates are based on an expert judgement.

CH<sub>4</sub> from domestic waters:

The uncertainty of the activity data amounts to 10%.

The uncertainty of the emission factor amounts to 100%.

N<sub>2</sub>O from domestic waters:

The uncertainty of the activity data amounts to 15%.

The uncertainty of the emission factor amounts to 250%.

CH<sub>4</sub> from industrial waters:

The uncertainty of the activity data amounts to 25%.

The uncertainty of the emission factor amounts to 100%.

### **7.5.5 Source-specific recalculations**

#### 5.D.1 Domestic Wastewater

Emissions of CH<sub>4</sub> have been recalculated for the period 1986-2015 due to modification in methodology used. New methane conversion factor was used for centralized aerobic treatment plants due to new data obtained on share of well managed and not well managed treatment plants. Updated values on number of inhabitants included into various types of domestic wastewater treatment was obtained and used for emission calculations.

Emissions of N<sub>2</sub>O have been recalculated for the period 1986-2015 due to new value on non-consumed protein discharged to wastewater pathways applied. Since there was no garbage disposal in our country, value of 1.1 instead of 1.4 was used for emission calculation.

#### 5.D.2 Industrial Wastewater

Emissions of CH<sub>4</sub> have been recalculated for the period 1986-2015 due to new methane conversion factor used for centralized aerobic treatment plants.

### **7.5.6 Future improvements**

No improvement is planned for next submission.

## **8 OTHER**

No emissions have been reported in this sector.

## **9 INDIRECT CO<sub>2</sub> AND N<sub>2</sub>O EMISSIONS**

No emissions have been reported in this chapter.

## 10 RECALCULATIONS AND IMPROVEMENTS

### 10.1 Explanations and justification for recalculations, and implication for emission level

In this submission almost all off recalculations are due to the recommendations from the NEC review of other pollutants which was held in the June 2017. The impact of the recalculations on the total GHG emissions is presented in the Table 10.1.1.

**Table 10.1.1: The total changes in kt CO<sub>2</sub> eq. due to the recalculation with a respect to the previous submission.**

	1986	1990	1995	2000	2005	2010	2015
1. Energy	-6.0	-5.6	-35	-56.7	16.5	-13.1	3.4
2. IPPU	0.0	0.0	0.0	0.0	0.0	0.1	-36.7
3. Agriculture	9.4	10.2	8.1	7.6	5.7	2.7	10.6
4. LULUCF	264.2	244.4	793.8	1,370.0	1,544.3	1,482.5	650.3
6. Waste	20.9	28.5	34.9	31.3	29.4	71.8	51.2
Total w/o LULUCF	24.3	33.2	8.1	-17.8	51.6	61.5	28.5
Total with LULUCF	288.5	277.5	801.9	1,352.2	1,595.9	1,544.0	678.9
Total in % w/o LULUCF	0.1	0.2	0.0	-0.1	0.3	0.3	0.2
Total in % with LULUCF	1.8	1.9	5.4	9.4	10.9	10.8	5.7

#### 10.1.1 Energy

The impact of the recalculations on emissions in Energy sector is presented in the Table 10.1.2.

**Table 10.1.2: Changes due to the recalculation with a respect to the previous submission in Energy sector in kt CO<sub>2</sub> eq.**

Energy	1986	1990	1995	2000	2005	2010	2015
A. Fuel Combustion	-6.0	-5.6	-35	-56.7	16.5	-13.1	3.4
1. Energy Industries							
2. Manufacturing Ind.							
3. Transport	-6.0	-5.7	-32.0	-49.7	-12.3	-10.8	3.4
4. Other Sectors		0.1	-3.0	-6.9	28.8	-2.3	
5. Other							
B. Fugitive Emissions							
1. Solid Fuels							
2. Oil and Natural Gas							
Total of Energy in kt CO <sub>2</sub> eq	-6.0	-5.6	-35	-56.7	16.5	-13.1	3.4
Total of Energy in %	-0.04	-0.04	-0.23	-0.37	0.10	-0.08	0.03



1.A.3.b Road Transportation, CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O

Emissions of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O have been recalculated for the period 1986-2015 due to new version of model COPERT 4 applied. The latest version of COPERT 4, that is version 11.4 was used for emission calculation for the entire period. Updated activity data on vehicle fleet was introduced in the model and used for emission calculation.

1.A.3.c Railways, CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O

Emissions of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O have been recalculated for the period 2005-2015 due to inclusion of more precise data on fuel oil used in the railways. In the same time since 2005 a very small amount of brown coal used in one old steam driven locomotive was included in the inventory and GHG emissions have been recalculated accordingly.

1.A.4.b Fuel combustion: Other sectors, CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O

Activity data on biomass used in the commercial and residential sector have been improved and GHG emissions for the period 1990 - 2014 have been recalculated. Since 2008 the updated values from SORS have been used while for the period 1990-2007 we have decided that interpolation is a better option.

## 10.1.2 Industrial processes and product use

The impact of recalculations on emissions in this sector is presented in the Table 10.1.3 below.

**Table 10.1.3: Changes due to recalculation with respect to the previous submission in the Industrial processes and product use sector in kt CO<sub>2</sub> eq.**

Industrial Proc. and Prod. Use	1986	1990	1995	2000	2005	2010	2015
A. Mineral Products							
B. Chemical Industry							
C. Metal Production							
D. Non-energy products	0.01	0.01	0.03	0.05	0.04	0.10	0.98
F. ODS substitutes							0.30
G. Other products						0.04	-37.93
Total IPPU in kt CO <sub>2</sub> eq.	0.01	0.01	0.03	0.05	0.04	0.15	-36.66
Total of IPPU in %	0.001	0.001	0.003	0.004	0.002	0.015	-3.228

2.D.1 Lubricant Use

Emissions of CO<sub>2</sub> have been recalculated for the period 1986-2015 due to new version of model COPERT 4 applied. COPERT 4, version 11.4 was used for emission calculation for the entire period. Updated data on vehicle fleet was used for emission calculation.

2.D.3 Other (Urea based catalyst)

Emissions of CO<sub>2</sub> have been recalculated for the period 1986-2015 due to new version of model COPERT 4 applied. COPERT 4, version 11.4 was used for emission calculation for the entire period. Updated data on vehicle fleet was used for emission calculation.

2.F.1 Product uses as ODS substitutes / Refrigeration and AC

The emissions of F-gases have been recalculated for the year 2014 and 2015 due to the improved data on amount of HFC 134a in MDI.

2.G.1 Other product manufacture and use / Electrical equipment

The emissions of SF<sub>6</sub> have been recalculated for the period 2011-2015 due to the use of updated values from the database.

2.G.3.a Medical Applications

Emissions of N<sub>2</sub>O have been recalculated for the year 2015 due to new activity data obtained.

**10.1.3 Agriculture**

The impact of recalculations on the emissions in this sector is presented in the Table 10.1.4.

**Table 10.1.4: Changes due to the recalculation with a respect to the previous submission in the Agricultural sector in kt CO<sub>2</sub> eq.**

3. Agriculture	1986	1990	1995	2000	2005	2010	2015
A. Enteric Fermentation	-1.0	-0.3	1.4	2.0	2.3	1.7	3.1
B. Manure Management	4.5	4.4	4.4	4.2	3.5	2.7	7.3
D. Agricultural Soils	5.9	6.0	2.5	1.5	-0.1	-1.6	0.2
G. Liming		-0.2	-0.2	-0.1	-0.1	-0.1	
H. Urea application							
Total in Agriculture in kt CO <sub>2</sub> eq.	9.4	10.2	8.1	7.6	5.7	2.7	10.6
Total of Agriculture in %	0.5	0.5	0.4	0.4	0.3	0.2	0.6

3.A Enteric Fermentation

Reviewers of the National Emission Inventory pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (NECD) suggested that emissions from rabbit production should be included into national inventory of atmospheric pollutants. With the intention to be consistent it was decided to report also methane emissions from enteric fermentation in rabbits. It was done for the entire reporting period.

New estimates for growth rate in fattening cattle were prepared for the entire reporting period. Growth rate is estimated on the basis of age and carcass weight of animals which are

slaughtered in Slovenian slaughterhouses. To do it, the information on dressing percentage is needed. In previous submissions we used the figure derived from literature and some experiments. In 2017 breed specific equations for prediction of dressing percentage were developed. They are based on large number of animals (13.959) which were slaughtered during the period 2012-2015. The changes affect energy requirements and consequently methane emissions from digestive tract. The differences were of minor importance.

Statistical office released a new value for milk production in 2015. As a result, the methane emission from enteric fermentation slightly increased.

It was found, that by mistake, the emission factor which applies for adult goats, was applied also for kids. It happened for the period 1986-2013. Miscalculation was corrected.

### 3.B Manure management, CH<sub>4</sub>

Reviewers of the National Emission Inventory pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (NECD) suggested that emissions from rabbit production should be included into national inventory of atmospheric pollutants. With the intention to be consistent it was decided to report also methane emissions from manure management in rabbits. It was done for the entire reporting period.

New estimates for growth rate in fattening cattle were prepared for the entire reporting period. The changes affect energy requirements and consequently methane emissions from manure management. The differences were of minor importance. The reasons for new estimates are given above (3.A. Enteric fermentation).

Statistical office released a new value for milk production in 2015. As a result, the methane emission from manure management slightly increased.

It was found, that by mistake, the emission factor which applies for adult goats, was applied also for kids. It happened for the period 1986-2013. Miscalculation was corrected.

Based on new farm structure data for 2016 estimates for manure management systems were corrected for years 2014 and 2015 (interpolation to last available data for 2013).

### 3.B Manure management, N<sub>2</sub>O

Reviewers of the National Emission Inventory pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (NECD) suggested that emissions from rabbit production should be included into national inventory of atmospheric pollutants. With the intention to be consistent it was decided to report also nitrous oxide emissions from manure management in rabbits. It was done for the entire reporting period.

Statistical office released a new value for milk production in 2015. As a result, the estimated N excretion in dairy cows increased and consequently there was also an increase in nitrous oxide emissions from manure management.

Based on new farm structure data for 2016 estimates for manure management systems were corrected for years 2014 and 2015 (interpolation to last available data for 2013).

Reviewers of the NECD inventory recommended that N excretion rates, which were previously applied only to breeding female sheep and goats, should be applied also to other adult sheep/goat categories (barren animals, rams, he-goats). The recommendation was respected. As a result, the estimated N excretion in small ruminants increased and consequently there was also an increase in nitrous oxide emissions from manure management for the entire reporting period.

### 3.D Agricultural soils

Difference between the latest and previous submissions results from difference in direct and indirect emissions due to application of animal manures. It is a consequence of new animal category which was introduced into inventory (rabbits) and a consequence of changes in nitrogen excretion in small ruminants. In the year 2015 a difference was also due to a new value for milk production which resulted in slightly higher estimates for nitrogen excretion in dairy cows.

Followed the recommendations of reviewers of NECD inventory EMEP/EEA 2013 ammonia emission factors for urea, CAN and other mineral fertilizers were replaced by EMEP/EEA 2016 factors. It resulted in new estimates of indirect nitrous oxide emissions due to volatilization of N compounds from the use of synthetic fertilizers for the entire reporting period.

Due to new estimates of loss/gain of soil organic matter for the entire reporting period there was a change in indirect nitrous oxide emissions which result from mineralization/immobilization of N compounds in soils.

### 2.G Liming

Activity data, i.e. amounts of limestone for the period 1995 onwards were recalculated as follows; data on limestone production for the year 2015 (24,500 tons in total) were obtained from the major three limestone producers, which presumably produce over 90% of limestone in Slovenia. Since no other data on limestone are available, we obtain data on land use areas of agricultural holdings and GDP in agriculture. GDP per area unit, based on the newest data of Statistical Office of the Republic of Slovenia (2017 database), was then used to calculate the missing values considering the surrogate method

### 10.1.4 LULUCF

The impact of recalculations on the emissions in the LULUCF sector is presented in the Table 10.1.5.

**Table 10.1.5: Changes due to the recalculation with a respect to the previous submission in LULUCF sector in kt CO<sub>2</sub> eq.**

5. LULUCF	1986	1990	1995	2000	2005	2010	2015
A. Forest Land	350.0	332.0	928.3	1,520.9	1,720.2	1,667.2	809.3
B. Cropland	107.1	107.1	84.3	65.0	45.9	25.0	26.5
C. Grassland	-156.9	-156.9	-172.6	-160.2	-150.8	-132.2	-94.9
D. Wetlands	2.5	2.5	2.6	1.9	1.3	0.8	0.3
E. Settlements	-38.5	-40.3	-48.4	-57.7	-72.1	-78.3	-90.9
F. Other Land	0.05	0.05	-0.03	0.40	0.33	0.61	0.37
G. HWP							
Total in LULUCF in kt CO <sub>2</sub> eq	264.2	244.4	793.8	1,370.0	1,544.3	1,482.5	650.3
Total of LULUCF in %	-5.8	-5.8	-20.2	-28.9	-26.0	-27.9	-13.1

#### Forest Land, CO<sub>2</sub>

Small recalculations were provided due to new available data on loss in living biomass in the period 2013-2015 obtained from Slovenia Forest Service (FF subcategory). However, large recalculations were made due to inclusion of new emissions factors for agricultural soil, which affected the figures in the whole period 1986-2015 (LF subcategory).

We have searched for additional data on deadwood stocks for the years prior to 2007 following the recommendations from the 2016 review. There are no other deadwood estimation in the country for the period 1986-2007. SFI estimated deadwood in the previous form of the forest inventory for the year 2000, however we believe the estimate is largely underestimated as only volume of dead lying and dead standing tree was taken into account, but not the stumps, snags and CWD. Thus, we consider conservative approach is better than flawed estimate, which would result in questionable removals.

#### Cropland, CO<sub>2</sub>

Recalculations were made due to inclusion of new emissions factors for agricultural soil, which affected the figures in the whole period 1986-2015. Information on updated soil carbon stocks will be included in the NIR 2018.

#### Grassland, CO<sub>2</sub>

Recalculations were made due to inclusion of new emissions factors for agricultural soil, which affected the figures in the whole period 1986-2015. Information on updated soil carbon stocks will be included in the NIR 2018.

Wetlands, CO<sub>2</sub>

Recalculations were made due to inclusion of new emissions factors for agricultural soil, which affected the figures in the whole period 1986-2015. Information on updated soil carbon stocks will be included in the NIR 2018.

Settlements, CO<sub>2</sub>

Recalculations were made due to inclusion of new emissions factors for agricultural soil, which affected the figures in the whole period 1986-2015. Information on updated soil carbon stocks will be included in the NIR 2018. Considering the recommendations from the 2016 review, the methodology used for biomass was reconsidered. Because country-specific value seems not to be in line with the assumption with the AGP trend, we used a default removal factor for tree biomass (CRW) from the IPCC guidelines, which caused recalculations in the period 1986-2015.

4. F Other land, CO<sub>2</sub>

Recalculations were made due to inclusion of new emissions factors for agricultural soil, which affected the figures in the whole period 1986-2015. Information on updated soil carbon stocks will be included in the NIR 2018.

4 (III) Direct N<sub>2</sub>O emissions from N mineralization / immobilization

Recalculations were made due to use of updated default emission factor, additional estimation for N mineralization due to changes in land use (other than land converted to cropland) considering the 2016 recommendations and besides, due to new emission factors for agricultural soil.

4 (IV) Nitrogen leaching and run-off, N<sub>2</sub>O

Indirect N<sub>2</sub>O emissions from leaching/run-off in relation to N mineralization were estimated as recommended by the 2016 review.

4 (V) Biomass burning, CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O

Updated default emission factors from Table 2.5 of the 2006 IPCC guidelines for extra tropical forest were used as recommended by the 2016 review. In addition, after survey of older forestry literature we found activity data on area burnt in 1986, 1987, 1993 and 1994. Based on these data we estimated CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O emissions.

## 10.1.5 Waste

The impact of the recalculations on emissions in the Waste sector is presented in the Table 10.1.6.

**Table 10.1.6: Changes due to the recalculation with a respect to the previous submission in Waste sector in kt CO<sub>2</sub> eq.**

6. Waste	1986	1990	1995	2000	2005	2010	2015
A. Solid waste disposal							
B. Biological treatment							
C. Incineration							
D. Waste water treatment	20.9	28.5	34.9	31.3	29.4	71.8	51.2
Total in Waste in kt CO <sub>2</sub> eq	20.9	28.5	34.9	31.3	29.4	71.8	51.2
Total of Waste in %	3.4	4.2	4.9	3.9	3.6	11.6	9.0

### 5.D.1 Domestic Wastewater

Emissions of CH<sub>4</sub> have been recalculated for the period 1986-2015 due to modification in methodology used. New methane conversion factor was used for centralized aerobic treatment plants due to new data obtained on share of well managed and not well managed treatment plants. Updated values on number of inhabitants included into various types of domestic wastewater treatment was obtained and used for emission calculations.

Emissions of N<sub>2</sub>O have been recalculated for the period 1986-2015 due to new value on non-consumed protein discharged to wastewater pathways applied. Since there was no garbage disposal in our country, value of 1.1 instead of 1.4 was used for emission calculation.

### 5.D.2 Industrial Wastewater

Emissions of CH<sub>4</sub> have been recalculated for the period 1986-2015 due to new methane conversion factor used for centralized aerobic treatment plants.

## 10.1.6 KP- LULUCF

4(KP-II)3 N<sub>2</sub>O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils

Emissions were estimated and reported in the relevant CRF table.

## 10.2 Response to the Review Process

Slovenian GHG inventory report for 2017 was not included in the UNFCCC review in 2017. It will be reviewed in 2018 in the conjunction with the 2018 submission. The majority of the recommendation from 2016 review was implemented already in the submission 2017 and a few more in the submission 2018 as indicated on the table 10.2.1.

In 2017 Slovenian GHG inventory was included in the ESD review. Because performed checks during first step of review did not identify any significant issues, Slovenia was not subject of second step of the annual ESD review and the review report has no recommendations.



Table 10.2.1: A response to the recommendations from the UNFCCC review process.

CRF category / issue	Review recommendation	Review report, paragraph	status of the implementation	Chapter in the NIR or comment
<b>ENERGY</b>				
1.A. Fuel combustion - CO <sub>2</sub>	Obtain the missing composition data for natural gas and recalculate the emissions.	UNFCCC 2016 - E.15	Not implemented	Data is not available
1.A. Fuel combustion - CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O	Report on action do to resolve the problem with the constant NCVs for liquid fuels.	UNFCCC 2016 - E.14	Not implemented	We have notify SORS on this problem by mail and again on joint SEA and SORS meeting on 31.3.2017. Since then, we didn't received any information.
1.A.3.b Road transport - CO <sub>2</sub> and 1.A.4 Other sectors - CO <sub>2</sub>	Explore different options for obtaining information on the content of C and NCV for liquid fuels and develop CS EFs.	UNFCCC 2014, para 31 and UNFCCC 2016 - E.8, E.11	Not implemented	Data is not available – this issue is part of EU capacity building webinar but is not yet resolved
1.A.4.C - Agriculture/Forestry/Fishing - CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O	Update the coefficient for the estimation of fuel consumption (7.1 t/1000 hectares) for agricultural activities since 2000	UNFCCC 2014, para 33 UNFCCC 2016 - E.12	Not implemented	In the improvement plan
1.B.2.b Fugitive emissions - CO <sub>2</sub> , CH <sub>4</sub>	Determine how the natural gas produced within the country is used and/or processed to better understand all emission pathways associated with this gas production and document the results of this investigation in the NIR.	UNFCCC 2016 - E.16	Implemented	NIR, April 2017, Ch. 3.3.2.1
1.B.2.b Fugitive emissions - General	Correct Table 3.3.13 in the next submission of the NIR and improve its QA/QC procedures to avoid such mistakes in future submissions.	UNFCCC 2016 - E.17	Implemented	NIR, April 2017, Table 3.3.13

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INDUSTRIAL PROCESSES AND PRODUCT USE				
2.A.4 Other process uses of carbonates - CO <sub>2</sub>	Include in the NIR in its next submission data on soda ash imports, soda ash exports and soda ash used in glass production in order to enhance transparency.	UNFCCC 2016 - I.7	Not implemented	In the improvement plan
2.A.4 Other process uses of carbonates - CO <sub>2</sub>	Estimates the emission levels for 1990 - 1994 using a robust extrapolation method relevant to the country's circumstances, taking into account factors like the peaking of the country's construction industry in 2006 and the 2008 economic crisis, and include the estimates in its next annual submission.	UNFCCC 2016 - I.8	Not implemented	In the improvement plan
2.G.1 - Electrical Equipment - SF <sub>6</sub>	Update the information in the NIR regarding emissions from disposal of electrical equipment and strengthen the QC process for monitoring the conformity of the NIR and the CRF tables	UNFCCC 2016 - I.6	Implemented	NIR, April 2017, Ch. 4.7.
2.F and 2.G _ General	Correct all errors in the NIR - numeration of chapters, references to the Table 4.7.1	UNFCCC 2016 - I.9, I.10	Implemented	NIR, April 2017, Ch. 4.6, 4.7
AGRICULTURE				
3. Agriculture - General	Correct all errors in the NIR and improve transparency (agriculture para 1, 2, 5, 7, 8)	UNFCCC 2016 - A.5, A.10, A.12	Implemented	NIR, April 2017, Ch. 5

3.B.3 Swine - General	Conduct an investigation and update the AWMS matrix for swine because the practice of organic farming may include deep litter manure management system or pasture and paddock. Present a quantitative analysis to demonstrate the significance of omitting this category.	UNFCCC 2016 – A.4	Implemented	NIR, April 2017, Ch. 5.3.2.1
3.A Enteric fermentation – CH <sub>4</sub>	Include animal performance data in the NIR	UNFCCC 2016 – A.6	Implemented	NIR, April 2017, Annex 3
3.B - Manure management – CH <sub>4</sub> and N <sub>2</sub> O	Report digesters separately from other liquid system.	UNFCCC 2016 – A.8	Implemented	CRF, Table 3.B.1
3.B Manure management – CH <sub>4</sub> and N <sub>2</sub> O	Make all effort to include the latest information obtained by SORS on manure management systems applied on cattle farms and taking in the consideration housing technology types (e.g. loose housing or tie stall housing) used in cattle farms when developing/updating the AWMS matrix.	UNFCCC 2016 - A.1, A.2, A.7	Not implemented	No new data on manure management methods were published by SORS recently.
3.B - Manure management - N <sub>2</sub> O	Provide additional information on nitrogen excretion rate and demonstrate that those parameters are appropriate in the specific national circumstances and more accurate than the default data provided in the 2006 IPCC Guidelines.	UNFCCC 2016 - A.3, A.11	Implemented	NIR, April 2017, Ch. 5.4.2
3.B - Manure management - N <sub>2</sub> O	Provide an explanation on the exclusion of indirect N <sub>2</sub> O emissions from manure management systems in its next submission.	UNFCCC 2016 - A.14	Implemented	NIR, April 2017, Ch. 5.4.2.2

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3.G Liming - CO2	Justify the AD used to estimate emissions from lime application to agricultural soils and recalculate emissions from the period 1992-2014.	UNFCCC 2016 - A.15 (SP)	Implemented	NIR, April 2017, Ch. 5.6
LULUCF				
4.A.1 Forest land remaining FL – CO2	Search for additional data on deadwood stocks collected from observations for some of the years prior to and after 2007 in order to improve the estimates based on interpolation/extrapolation.	UNFCCC 2016 – L.5	Implemented	NIR, April 2018, Ch. 6.4.4.1
4.B.2 - Land Converted To Cropland – CO2	Determine and use country-specific data on changes in carbon stocks from one year of grassland growth using annual data on grassland stock from SORS.	UNFCCC 2016 – L.7	Implemented	NIR, April 2017, Ch. 6.5.4.2.
4.C.2 – Land converted to grassland – CO2	Determine and use country-specific data on changes in carbon stocks from one year of grassland growth.	UNFCCC 2016 – L.8	Implemented	NIR, April 2018, Ch. 6.6.4.2
4. LULUCF – general – CO2	Provide additional information explaining land use changes is considered not occurred on organic soil area in Slovenia.	UNFCCC 2016 – L.10	Implemented	NIR, April 2017, Ch. 6.3.4.3, 6.4.4.2,
4. LULUCF – general – CO2	Improve uncertainty estimates for AD and EFs.	UNFCCC 2016 – L.11	Partly implemented	NIR, April 2017, Ch. 6.3.1 NIR, April 2018, Ch. 6.5.4.2, 6.6.4.2

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4.A.1 Forest land remaining FL – CO2	Improve estimation of net removals in forestland and eliminate trend gaps caused by methodological reasons as much as possible.	UNFCCC 2016 – L.12	Implemented	NIR, April 2017, Ch. 6.3.4.1
4.A.1 Forest land remaining FL – CO2	Revise the explanation of the scope of increment data covered in FECS and confirm the estimation of forestland remaining forestland is not double counted in removals occur on land converted to forestland and in emissions occur on land converted from forestland.	UNFCCC 2016 – L.13	Implemented	NIR, April 2017, Ch. 6.4.8
4.A.2.5 Other land converted to FL – CO2	Update the explanation of land converted to forest land in the NIR	UNFCCC 2016 – L.14	Implemented	NIR, April 2017, Ch. 6.3.4.3
4.B.1 Cropland remaining cropland – CO2	Reconsider the carbon stock value in orchard and vineyard which used for estimation of land conversion from perennial cropland as appropriate	UNFCCC 2016 – L.15	Implemented	NIR, April 2017, Ch. 6.4.4.1
4.B.2 Land converted to cropland – CO2	Provide information on assumption of amount of living biomass carbon stock in other perennial cropland, which implicitly used for estimation of land conversion from perennial cropland.	UNFCCC 2016 – L.16	Implemented	NIR, April 2017, Ch. 6.5.4.1

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4.B.2 Land converted to cropland – CO2	Improve completeness and eliminating double counting as far as possible in the estimation of carbon stock change of living biomass in perennial cropland.	UNFCCC 2016 – L.17	Implemented	NIR, April 2017, Ch. 6.4.4.1, CRF Table 4.B.1
4.C Grassland – CO2	Improve methodologies of woody grassland including removal factor applied to biomass growth after conversion to woody grassland and biomass carbon stock of woody grassland used to estimations of land use conversion.	UNFCCC 2016 – L.18	Implemented	NIR, April 2017, Ch. 6.5.4.2
4.D Wetlands – CO2	Update the explanation of Section 6.6.4.1 in the NIR which referring peat lands and use flooded land sub-category instead of other wetlands sub-category in the CRF Table 4D for reporting.	UNFCCC 2016 – L.19	Implemented	NIR, April 2017, Ch. 6.7.4.1, CRF Table 4.D
4.D Wetlands – CO2	Use the Wetlands Supplement in preparing its annual inventories for Slovenia in future annual submissions	UNFCCC 2016 – L.20	Not implemented	In the improvement plan
4.E Settlements – CO2	Provide information on methodology used in living biomass in settlements remaining settlements in the NIR, take further consideration whether carbon stock in settlements area is increasing or expected to be maturing in the future and examine application of actual growing period (AGP) if considered necessary.	UNFCCC 2016 – L.21	Implemented	NIR, April 2018, Ch. 6.8.4.1
4.E Settlements – CO2	Provide all necessary information on explaining methodologies applied to dead organic matter and soil in settlements in the NIR.	UNFCCC 2016 – L.22	Implemented	NIR, April 2017, Ch. 6.8.4.1

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4.F Other land – CO <sub>2</sub>	Provide in the NIR all necessary information to explain the methodologies and assumption applied for land converted to other land.	UNFCCC 2016 – L.23	Implemented	NIR, April 2018, Ch. 6.9.4.2
4 (III) Direct N <sub>2</sub> O emissions from N mineralization / immobilization	Use the default emission factor of EF1 0.01 [kgN <sub>2</sub> O-N/kgN] provided in the 2006 IPCC Guideline, if there is no specific reason that the old EF1 is considered more appropriate.	UNFCCC 2016 – L.24	Implemented	NIR, April 2017, Ch. 6.4.4.2, 6.5.4.2, 6.7.4.2
4 (III) Direct N <sub>2</sub> O emissions from N mineralization / immobilization	Estimate direct N <sub>2</sub> O emissions from N mineralisation occurred in any land uses other than land converted to cropland.	UNFCCC 2016 – L.25	Implemented	NIR, April 2017, Ch. 6.4.4.2, 6.5.4.2, 6.7.4.2
4 (IV).2 Nitrogen leaching and run-off	Estimate indirect N <sub>2</sub> O emissions from leaching/runoff in relation to N mineralisation and provide appropriate information on its methodology applied in its NIR.	UNFCCC 2016 – L.26	Implemented	NIR, April 2017, Ch. 6.4.4.2, 6.5.4.2, 6.7.4.2
4 (V) Biomass burning – CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O	Use the default emission factors of "extra tropical forest" in Table 2.5, Chapter 2, Volume 4 of the 2006 IPCC Guideline for the estimation of biomass burning, if Tier.1 is applied	UNFCCC 2016 - L.27	Implemented	NIR, April 2017, Ch. 6.3.4.2
4 (V) Biomass burning – CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O	Examine whether forest wildfires occurred in Slovenia considered affected to dead organic pool and add dead organic pool into MB if appropriate.	UNFCCC 2016 – L.28	Implemented	NIR, April 2017, Ch. 6.3.4.2
4 (V) Biomass burning – CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O	Make efforts to estimate emissions for the missing years (1986, 1987, 1993, and 1994)	UNFCCC 2016 – L.29	Implemented	NIR, April 2018, Ch. 6.4.4.2, CRF, Table 4(V)

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4.G Harvested wood products – CO <sub>2</sub>	Fully revise Section 6.9 in the NIR in its next submission based on the latest methodologies applied and provide all necessary information on activity data, parameters and equations applied.	UNFCCC 2016 – L.30	Implemented	NIR, April 2017, Ch. 6.9
4.G Harvested wood products – CO <sub>2</sub>	The ERT recommends that Slovenia report the proper half-live in the CRF Table 4.Gs1.	UNFCCC 2016 – L.31	Implemented	CRF, Table 4.Gs1
4.G Harvested wood products – CO <sub>2</sub>	Report estimation result of wood based panel separately in the CRF Table 4.Gs1 in order to increase transparency.	UNFCCC 2016 – L.32	Implemented	CRF, Table 4.Gs1
4.G Harvested wood products – CO <sub>2</sub>	Provide adequate information on data and method used to construct time series in the years historical data are not available especially years before 1946	UNFCCC 2016 – L.33	Implemented	NIR, April 2017, Ch. 6.9
<b>WASTE</b>				
5.A Solid waste disposal on land - CH <sub>4</sub>	Enhance the transparency of the sector overview, especially regarding the categorization to different treatment and management practices	UNFCCC 2016 - W.8	Implemented	NIR April 2018, Ch. 7.1
5.A.1 Managed waste disposal sites - CH <sub>4</sub>	Recalculate the population data and waste generation rate used for the period 1964-1994 to ensure consistency with actual data for the period 1995-2014	UNFCCC 2016 - W.9	Not implemented	The data used are the best we have.
5.A.1 Managed waste disposal sites - CH <sub>4</sub>	Use the 2006 IPCC Guidelines as a reference from which to source the correct MCF values and that it recalculate the CH <sub>4</sub> emissions if necessary.	UNFCCC 2016 - W.11	NA	No recalculations are needed because MCF are the same.



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5.A.1 Managed waste disposal sites - CH <sub>4</sub>	Include the details of the improvement in the screening and results of the AD in the NIR, and include an explanation for the impact of the recalculation on the category emissions and the total emissions that have resulted from the recalculation.	UNFCCC 2016 - W.12	Implemented	NIR April 2018, Ch. 7.2.2
5.B.1 Composting - CH <sub>4</sub> , N <sub>2</sub> O	Undertake a survey to estimate the average amount of waste composted in homes and include the emission estimates to improve completeness	UNFCCC 2016 - W.13	Not implemented	We don't agree with this recommendation, because EFs in IPCC GL 2006 are not appropriate for home composting and no methodology for home composting is provided in the GL.
5.D.1 Domestic wastewater - indirect N <sub>2</sub> O	Indirect N <sub>2</sub> O emissions from this category are not estimated or reported. Report these emissions or provide in its NIR quantitative estimates of these emissions for this category.	UNFCCC 2016 - W.14	NA	This recommendation is not relevant, because indirect N <sub>2</sub> O emissions are reported in this submission and was reported also in the submission 2016, which was subject to the UNFCCC review.
KP- LULUCF				
KP-LULUCF - General	Update the chapter 11 of the NIR entirely in line with the elements specified in Annex II to Decision 2/CMP.8, including update of description about the methodologies and the underlying assumptions used.	UNFCCC 2016 – KL.2	Implemented	NIR, April 2017, Ch. 11
KP-LULUCF - General	Complete the CRF Tables, including filling the information on NIR-3, providing proper notation key in cells relating to natural disturbance provision and carbon equivalent forest provision in accounting table and providing forest management cap value in accounting table.	UNFCCC 2016 – KL.3	Implemented	CRF, Table NIR-3, Accounting

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KP-LULUCF – General	Provide additional information on using a single national boundary does not lead to increase uncertainty nor reduce heterogeneity of forest status in Slovenia.	UNFCCC 2016 – KL.4	Implemented	NIR, April 2017, Ch. 11.2.3
KP-LULUCF – Deforestation – CO2	Implement further consideration on whether the natural disturbance area of forest land in Slovenia satisfies the guidance of non-direct human induced deforestation taking into account the relevant guidance in the 2013 KP supplement, revise deforestation area where applicable, and provide additional information on the result of this consideration in the NIR.	UNFCCC 2016 – KL.5	Implemented	NIR, April 2017, Ch. 11.4.4
KP-LULUCF – Deforestation – CO2	Ensure consistent deforestation emissions between the NIR and the CRF tables.	UNFCCC 2016 – KL.6	Implemented	NIR, April 2018, Ch. 11.4, CRF 4(KP) KP. A.2 Deforestation
KP-LULUCF – FM – CO2	Include the information about conversion of natural forest to the planted forest in the NIR and correct the notation key in CRF table NIR 2-1.	UNFCCC 2016 – KL.7	Implemented	NIR, April 2018, Ch. 11.5.5, CRF, Table NIR 2-1.
KP-LULUCF – FM – CO2	Provide in the NIR information on the technical correction and methodological consistency relating to the FMRL in accordance with the reporting requirements specified in decision 2/CMP.8, annex II, paragraph 5(e) and (f).	UNFCCC 2016 – KL.8	Partly implemented	NIR, April 2018, Ch. 11.5.6 and 11.5.7

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KP-LULUCF – HWP – CO <sub>2</sub>	Create a new section in chapter 11 of the NIR and include all the necessary information on the reporting of HWP in accordance with decision 2/CMP.8, annex II, paragraph 2(g)(i–vii).	UNFCCC 2016 – KL.9	Implemented	NIR, April 2017, Ch. 11.3.1.1.5, NIR, April 2018, Ch. 11.3.1.1.5
KP-LULUCF – HWP – CO <sub>2</sub>	Exclude HWP already accounted as emissions during the first commitment period from the HWP estimation under KP-LULUCF.	UNFCCC 2016 – KL.10	Not implemented yet	In the improvement plan
KP-LULUCF – HWP – CO <sub>2</sub>	Estimate the volume of HWP resulting from deforestation on the basis of instantaneous oxidation under KP-LULUCF.	UNFCCC 2016 – KL.11	Not implemented yet	In the improvement plan
KP-LULUCF – HWP – CO <sub>2</sub>	Report appropriate data in CRF table 4(KP-I).	UNFCCC 2016 – KL.12	Partly implemented	CRF, Table 4(KP-I)B.1
KP-LULUCF – N <sub>2</sub> O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils – N <sub>2</sub> O	Estimate this source of emissions and report these emissions under deforestation.	UNFCCC 2016 – KL.13	Implemented	CRF, Table 4(KP-II)3

## PART II: SUPPLEMENTARI INFORMATION UNDER ARTICLE 7, PARAGRAPH 1

### 11 KP-LULUCF

#### 11.1 General information

Slovenia provides supplementary information under Article 7 of the Kyoto Protocol for the LULUCF sector. The information is prepared and reported in line with the requirements as specified in Decision 16/CMP.1, 2/CMP.8, 6/CMP.9 and the Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC 2014).

Slovenia reports and accounts emissions and removals from Deforestation (D) under Article 3.3. and emissions and removals from Forest Management (FM) under Article 3.4. No emissions and removals from Afforestation and Reforestation (AR) are reported under Article 3.3. as these activities are not considered human-induced.

Emissions from Article 3.3 activity (D) in 2016 were 447.03 Gg CO<sub>2</sub> eq. The area subjected to D was 27.98 kha at the end of 2016. Removals from Article 3.4 activity (FM) in 2016 were - 5,013.14 Gg CO<sub>2</sub> eq. The area subjected to FM was 1,098.22 kha at the end of 2016.

##### 11.1.1 Definition of forest and any other criteria

Forest is defined as land spanning more than 0.25 hectares with trees higher than 2 meters and canopy cover more than 30 percent, or trees able to reach these threshold in situ. It includes abandoned agricultural land on area more than 0.25 ha, which have been abandoned for more than 20 years, with minimal tree height 5.0 m and have a tree crown cover between up to 75 % are defined as forests. The selected values are listed in the CRF table NIR1 under the KP LULUCF and in table below.

**Table 11.1.1: Elected values for forest parameters.**

Parameter	Range	Selected value
Minimum land area	0.05 – 1 ha	0.25 ha
Minimum crown cover	10 – 30 %	30 %
Minimum tree height	2 – 5 m	2 m

Activity data of forest land between KP and UNFCCC reporting are consistent, as a new approach using point sampling method (1 km x 1 km grid) has been used to acquire activity data since 2016 annual submission. Activity data of forest land and deforestation from forest management plans being provided annually by Slovenia Forest Service, as well as data of

forest areas from the official land-use map (ALUM) are expected to be used for verification in the future.

All land converted to forest land occurs through process of spontaneous afforestation of abandoned agricultural lands. There was no human planting or seedling of forests in the specified time period. According to national policy it is also unlikely that this will occur in the future.

The selected threshold values are consistent with those values used in the reporting to the FAO and FRA forest definition. Differences of definitions are not relevant for final estimation of CO<sub>2</sub> sinks under Articles 3.3 and 3.4.

### **11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol**

In accordance with Paragraph 6 of the Annex to Decision 16/CMP.1 Slovenia has decided to elect the activity Forest Management (FM) under Article 3.4 of the Kyoto Protocol, for inclusion in the accounting for the first commitment period. Therefore, the accounting of FM become mandatory in the second commitment period.

For the accounting of LULUCF-activities under Article 3.4 during the second commitment period, Slovenia has not elected any other voluntary activity.

### **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 information about the areas for activities under Articles 3.3. and 3.4. is based on the same methodology as that for the UNFCCC reporting. The methodology was developed in the targeted project “Bases for improving the reporting methodology of greenhouse gas emissions in relation to land use, land use change and forestry”. By applying the same source of activity data in the KP and UNFCCC reporting overall consistency was improved. For D area all conversions from Forest land to other land uses taken into account. Forest land remaining Forest land area was used to define FM. The activity Forest management (FM) is assumed occurring on all land fulfilling the forest definition (see subchapters 6.2.2 and 6.4.3). Areas of spontaneous afforestation was added to category Other. Reforestation does not occur in Slovenia.

### **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**

Slovenia has elected to report Forest Management under Article 3.4 activities. Therefore there is no need to build up a hierarchy between forest management and other Article 3.4 activities.

To ensure that the reported Forest Management activities have occurred on forest land, the total land area was classified into six land-use categories as for the UNFCCC reporting, and each land area was classified only under one land-use category. Besides, the definition of forest has remained the same irrespective of the data source.

## **11.2 Land-related information**

### **11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3**

The spatial assessment unit to determine the area of units of land under Article 3.3 is 0.25 ha, which is the same as the minimum area of the forest. The spatial assessment unit under Article 3.3 is the same as for the UNFCCC reporting.

### **11.2.2 Methodology used to develop the land transition matrix**

The methodology used to develop the land transition matrix under KP is the same as for the UNFCCC reporting. The methodology is based on the point sampling on the 1 km x 1km grid (20,253 sampling plots) set over the whole territory of Slovenia (see description in the subchapter 7.2.1.). Thus, annual and total areas under Articles 3.3 and 3.4 for Deforestation (D) and Forest Management (FM) are consistent with the data used for developing the land-use matrix under the UNFCCC reporting. Areas of spontaneous afforestation were added from Other to FM when those areas meet the definition of forest.

### **11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations**

Forestry spatial information system, managed by SFS, is based on stand level inventory for forest management purposes. There are 14 forest management regions, which are further divided into 136 management units. For both management levels forest management plans are prepared for the period of 10 years. Smallest spatial unit for forest management is compartment (2 – 5 ha). All data are georeferenced and can be aggregated to higher levels. Therefore, according to 2006 Guidelines Slovenia uses Reporting Method 1 with national border as geographical boundary to identify the geographical location. As Slovenia is considered relatively small, the use of one geographic area is assumed not to lead to increase uncertainty nor reduce heterogeneity of forest status, which is in line with the good practice of the KP Supplement (p. 2.16, IPCC 2014).

Due to strict environmental legislation at all conversions from forest, a permit from SFS is needed. Therefore, all areas converted from forests are documented in forestry spatial information system database and included in annual reports (Annual reports on forests). Slovenian legislation forbids clear cutting as forest management practices. Deforestation activities according to SFS occur due to urbanization, infrastructure, agriculture, mining, power industry and other reasons, but in recent years mostly for agricultural purposes. Although SFS records all deforestation activities, there is lack of data on specific purposes within each of the

category abovementioned. Areas of spontaneous expansion of forest are annually documented in forestry spatial information system database for 1/10 of forest management units (10 years period cycle for whole country) and added to FM area and included in annual reports.

## **11.3 Activity-specific information**

### **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**

##### **11.3.1.1.1 *Carbon pools***

Methodological principles used for estimatons of carbon stock changes and greenhouse gas emissions/removals under Kyoto Protocol were the same as for estimations under UNFCCC reporting. Calculations were made in accordance with IPCC 2006 Guidelines and with the IPCC 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.

Under Article 3.3 activities (D) estimation of carbon stock changes in living biomass (above and belowground biomass), dead organic matter (dead wood, litter) and soils were made. Also calculations for N<sub>2</sub>O emission from disturbance associated with conversion from Forest land to Cropland, to Grassland and to Settlements were taken into account.

Main methodological approach for calculations of carbon stock change estimates during the commitment period was by determining the carbon stocks in all pools prior to and after deforestation event. Biomass carbon stock after deforestation was assumed to be equal to zero. More detailed description of calculations for conversion of forest to other land uses were made in accordance to chapters 7.4.2.2, 7.5.2.2 and 7.7.2.2.

Under Article 3.4 activities (FM) estimation of carbon stock changes in living biomass (above and belowground biomass), dead organic matter (dead wood, litter) and soils were made. Also calculations for N<sub>2</sub>O emission from biomass burning were taken into account.

##### **Carbon stock changes in living biomass**

In accordance with the decision tree provided in the 2006 Guidelines, carbon stock changes in living biomass in Forest land remaining Forest land are estimated by Tier 3, stock change method. The method requires biomass carbon stock inventories at two points in time. Biomass change is the difference between the biomass at two points in time, divided by the number of years between the inventories. Data from forest inventory at national level (FECS), carried out in years 2007 and 2012, were used for our calculations.

#### Carbon stock changes in dead organic matter

In accordance with the decision tree provided in the 2006 Guidelines, carbon stock changes in dead organic matter in Forest land remaining Forest land are estimated by Tier 2.

For carbon stock changes in litter “a pool is not a source” approach was used. In the latter, it is assumed that the average transfer rate into the litter pool is equal to the transfer rate out of the litter pool, so the net change is zero. Results of our preliminary expertise for period 1996 – 2006 (Kobal M., Simoncic P., 2011), show relative stable carbon stocks in litter in Forest land remaining forest land. For additional explanation, please see chapters 7.3.2.1 and 7.3.4 under the Convention.

#### Carbon stock changes in soils

In accordance with GPG2003, for carbon stock changes in soils “a pool is not a source” approach was applied. Under the latter, it is assumed that when forest remains forest, the carbon stock in soil organic matter does not change, regardless of change in forest management, types, and disturbances regimes; in other words that the carbon stock in mineral soil remains constant so long as the land remains forest. Results of our preliminary expertise for period 1996 – 2006 (Kobal M., Simoncic P., 2011), show relative stable carbon stocks in forest soils. In the last 20-year period no large fluctuation in forest management regime has been occurring. However, forests were hardly damaged by ice storm in 2014. Carbon stock monitoring of forest soil has started in 2016 in the region of Postojna, where disturbance was the worst. Preliminary results at 30 sites show that carbon in litter and soil organic carbon increased, but the results are not published yet. Soil monitoring will continue in 2018. Soil as that depends along with the climate and bedrock factors largely on the source of carbon coming from dead wood and litter. Since those two pools are seem to be stable, it is therefore assumed soil pool as stable. For additional explanation, please see chapters 7.3.2.1 and 7.3.4 under the Convention.

#### Emissions from Wildfires

As controlled burning is not allowed in Slovenia, all fires are assigned to “wildfires”. It is assumed that all fires affected productive forests. The area of wildfires in Slovenia is very small, less than half percent in the year 2003, which was the most problematic year in the following period. For calculations the Tier 2 (country level estimated of area burned) was used and estimation of GHGs directly released in fires. Data on wildfires, such as frequency, type of fires and burnt forest area, are collected annually by Slovenia Forest Service.

More detailed explanation about calculations is described in chapter 7.3.2 (7.3.2.1 Forest land remaining forest land and 7.3.2.2 Non-CO<sub>2</sub> greenhouse gas emission).

#### **11.3.1.1.2 Other emissions**

Emissions of N<sub>2</sub>O and CH<sub>4</sub> are estimated in the same way as under the UNFCCC. Estimations of N<sub>2</sub>O and CH<sub>4</sub> emissions due to biomass burning were made using default emission factors from table 2.5 for N<sub>2</sub>O and Equation 2.27 according to 2006 Guidelines default methodology (see chapter 7.3.2.2). The reporting of N<sub>2</sub>O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions in mineral soils are reported for D (see chapter 6.5.4.2).



#### **11.3.1.1.3 Pools reported under Article 3.3 and elected activities under Article 3.4 of the KP**

Slovenia reports and accounts for all carbon pools (aboveground biomass, belowground biomass, litter, dead wood and soil organic carbon) as well as for all non-carbon pool emissions.

#### **11.3.1.1.4 Natural disturbances**

Slovenia does not intend to use the provision to exclude emissions caused by natural disturbances during the second commitment period of the Kyoto Protocol.

#### **11.3.1.1.5 Harvested wood products**

The methodology used for accounting for net emissions from the HWP pool is equal to the method used for the reporting of HWP under the UNFCCC with the exception that HWP from deforestation is excluded.

Data sets cover production figures from year 1900-2015 for: Roundwood separately for logs and pulpwood, sawnwood, veneer, particle board, fibreboard, pulp production. Time series start from year 1900 using all existing sources of information (historical records, official statistics and independent industry reports and other studies). Imported wood is not accounted. Equations 35 and 36 provide information how imported wood is excluded. Emissions occurring during the second commitment period from the HWP removed from forests before the start of the second commitment period were also accounted for. Additionally, equations 37, 38 and 39 define how imported wood is excluded for different product categories (see chapter 0). Calculation model excludes all wood residues (instant oxidation), excludes double counting issues (plywood could be a product where double counting exists as plywood subcategories use products already reported in other product groups: e.g. CN 44129490 use sawnwood as input material) and excludes use of recovered paper (it is difficult to trace origin of recovered paper which is dominant input material in paper and paperboard production and could severely overestimate real HWP contribution originating from domestic harvest).

Initial stock figures and data for each HWP type are provided in this year submission.

HWP resulting from deforestation has been accounted based on instantaneous oxidation. Datasets regarding areas of deforestation and harvested volume were used for determining factor  $f_{FM}$  according to IPCC 2013 KP Supplement. CO<sub>2</sub> emissions from SWDS and energy purposes are accounted based on instantaneous oxidation and are excluded from calculations.

#### **11.3.1.2 Justification when omitting any carbon pool or GHG emissions and removals from activities under Article 3.3 and elected activities Article 3.4**

For calculations of carbon stock changes in litter and soils “a pool is not a source” approach was used. According to this approach the net emissions/removals from litter and soils is balanced and therefore equal to zero. Results of our preliminary expertise for period 1996 – 2006 (Kobal and Simoncic 2011), show relative stable carbon stocks in litter in forest land remaining forest land. Estimates under FM for carbon stock changes in litter and soils were therefore not reported. See also the comments being provided in the 7.3.2.1 section (Convention part).

#### **11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out**

Slovenia has not factored out effects from elevated carbon dioxide concentrations, indirect nitrogen deposition or the dynamic effects of age structure resulting from activities prior to 1 January 1990. However, such effects are however balanced in terms of accounting for Forest Management, since they are included in the FMRL and in the reported figures.

#### **11.3.1.4 Changes in data and methods since the previous submission (recalculations)**

Considering ERT revision report and recommendations data and methodologies were internally revised and recalculations were made.

#### **11.3.1.5 Uncertainty estimates**

The uncertainties for Article 3.4 have not been estimated separately for lands under FM. It was assumed that uncertainty estimates for Forest land remaining Forest land apply also for lands under FM (Section 7.3.3). The uncertainties for Article 3.3 activities have not been estimated separately.

#### **11.3.1.6 Information on other methodological issues**

Slovenia has decided to account for the emissions and removals under Article 3, paragraphs 3 and 4 at the end of the commitment period. Slovenia will further develop the methods for area estimation as well the methods to estimate emissions and removals of greenhouse gases and their uncertainties.

National forest inventory (FECS) provides data about growing stock, dead organic matter and soils (in forest land). The argument for applying FECS data is that it is the only large scale sample plot based monitoring system in Slovenia that covers all forest land and gives reliable estimates for the living biomass and dead organic matter. It is also a system, which can produce the input data for the soil model.

In 2012 the repetition of the national forest inventory, so called Forest and Forest Ecosystem Condition Survey (FECS 2012) was carried out for the third time. The methodology stayed the same from the one from 2000, although some improvements were made to ensure consistency over time when reporting the GHG emissions/removals for the first commitment period. A detailed protocol was established for the FECS 2012 (see Annex 3).

**11.3.1.7 For the purpose of accounting as required in paragraph 18 of the annex to draft decision -/CMP. 1 (Land use, land-use change and forestry) attached to decision 11/CP.7, an indication of the year of the onset of an activity, if after 2008.**

Forest management (FM) area increases during the first commitment period, as well in the beginning of the second commitment period due to inclusion of new forest area by natural (spontaneous) afforestation of abandoned agricultural land. The land of natural afforestation is added to FM only when the land meets exact definition of forest area under FM.

According to requirement of paragraph 6(d) of Annex to decision 15/CMP.1, Slovenia declares that new FM area is not accounted (estimated as removals) in previous years during the first and in the second commitment period. Therefore, new area of FM is estimated by its removals and accounted under FM only the years since the area has been recognized as forest.

## **11.4 Article 3.3**

### **11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced**

All data for areas under Articles 3.3 in the period 1986-2014 were adopted from the targeted project "Bases for improving the methodology of greenhouse gas emissions in relation to land use, land use change and forestry" to improve consistency among the UNFCCC and KP reporting. However, data of Slovenia Forest Service will serve as additional data source to verify deforestation acquired by the point sampling. Deforestation that results in conversions from Forest land to Wetlands and from Forest land to Other land was not accounted for D under Article 3.3 reporting, since it was proved not to be human-induced, but impact of natural erosion.

Deforestation in Slovenia, which is human-induced, have to be permitted by legal entities. Forest Act (Section 2, paragraph 1) states: "A permit for a spatial intervention in accordance with regulations on regional planning shall be necessary for interventions in forests or a forest land. The Forest Service must give its agreement to the permit for a spatial intervention (clearing a forest)." Human-induced Afforestation/Reforestation (AR) do not occur in Slovenia, because all land converted to forest land occurs through process of natural afforestation of abandoned agricultural lands. There was no human planting or seedling of forests in the specified time period. According to national policy it is also unlikely that this will occur in the second commitment period.

#### **11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation**

Extensive forest disturbances have been rare in Slovenia. If a large forest area is mainly or totally damaged, the legislation on prevention of insect and fungus disturbances binds owners to remove the rest of the damaged trees. After that, the reestablishment work should be started immediately if possible. That areas remain registrated as forest land in forestry spatial information system database.

#### **11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested**

All areas converted from forests are documented in forestry spatial information system database and are included in annual reports. Therefore, there are no forest areas without forest cover, which are not yet classified as deforested.

#### **11.4.4 Emissions and removals from Deforestation**

Deforestation in the second commitment period is a net source of emissions. The latter amounted to 447.03 Gg CO<sub>2</sub> equivalent in 2016.

Area of deforestation under KP is the same as sum of areas of Forest land converted to other land uses reported under Convention. Reconstructed land-use change matrices assume objective areas on deforestation, although trends are not completely in line with the annual estimates of Slovenia Forest Service. All deforested areas are spatially located (geo-referenced) and are documented in annual report of Slovenia Forest Service, which is entitled by legislation to approve all conversions from forest (deforestation). In their annual reports, they include also illegally deforested areas.

### **11.5 Article 3.4**

#### **11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since January 1990 and are human-induced**

All data for areas under Articles 3.4 in the period 1986-2016 were adopted based on the methodology of targeted project "Bases for improving the methodology of greenhouse gas emissions in relation to land use, land use change and forestry" to improve consistency among the UNFCCC and KP reporting. All selected forest areas (for KP reporting) were at 1 January 1990 under FM activities, because Slovenia includes all these forests in forest management plans.

### **11.5.2 Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year**

Slovenia has not elected Cropland Management, Grazing Land Management or Revegetation nor B.5. Wetland drainage and rewetting under Article 3.4.

### **11.5.3 Information relating to Forest Management**

All forests in Slovenia are considered managed, because forest management plans are prepared for all forests, regardless ownership, conservation degree or natural conditions.

Slovenian forests are part of sustainable and multipurpose management with the principles of environmental protection and natural values. Our main concerns are: permanent and optimal functioning of forest as ecosystems and implementation of all of their functions (productive, ecological and social) on a permanent basis.

### **11.5.4 Emissions and removals from Forest Management**

Forest management (FM) was a net sink in the beginning of the second commitment period. The removals from carbon stock changes were -5,013.14 Gg CO<sub>2</sub> equivalent in 2016.

According to paragraph 9(c) of Annex to decision 15/CMP.1, Slovenia declares that FM removals are not accounted for under activities under Article 3.3 (Deforestation for Slovenia case).

### **11.5.5 Information on how all emissions arising from the conversion of natural forests to planted forests are accounted for**

Regarding the natural forests such forests do not exist in Slovenia. The national legislation in Slovenia does not define the term “natural forests” either the IPCC. Moreover, all forests are considered managed in Slovenia, thus all forests are reported.

### **11.5.6 Information that demonstrates methodological consistency between the reference level and reporting for forest management during the second commitment period**

Slovenia reported a FMRL of -3.171 Mt CO<sub>2</sub> eq per year (including HWP) in 2011 as requested by the Cancún decisions. The reported value is average of the projected FM data series for the period 2013-2020, taking account of policies implemented before the end of 2009. In the construction of the forest management reference level, the elements contained in footnote 1 of paragraph 4 of the decision ([-/CMP.6]) on LULUCF were taken into account.

The emissions from harvested wood products (HWP) until the second commitment period have

been calculated using a revised FOD ("first order decay") method according to IPCC GL (2006) and Pingoud and Wagner (2006). The calculation of net emissions follows recommended method as outlined in IPCC 2006, Vol.4, Ch. 12 (Equation 12.1). The estimation uses the product categories, half-lives and methodologies as suggested in paragraph 27, page 31 of FCCC/KP/AWG/2010/CRP.4/Rev.4.

Since there has been methodological and data changes for Forest Management, Slovenia will make technical corrections for the FMRL at the end of the second commitment period according to requirements of decisions 2/CMP.7 and 2/CMP.8 and in line with the 2013 Revised Supplementary Methods and GPG arising from the Kyoto Protocol.

### **11.5.7 Technical corrections**

Technical corrections for the FMRL will be provided in the next submission. Information on technical corrections and methodological consistency will be reported as part of the annual greenhouse gas inventory and inventory report, in accordance with relevant decisions under Articles 5 and 7 of the Kyoto Protocol, and reviewed as part of the review of the annual greenhouse gas inventory review in accordance with relevant decisions under Article 8 of the Kyoto Protocol.

## **11.6 Other information**

### **11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4**

Key category analysis for KP-LULUCF was performed according to section 5.4 of the IPCC good practice guidance for LULUCF (IPCC 2006). The key categories, also reported in CRF table NIR.3, are CO<sub>2</sub> emissions from deforestation (conversion to grassland). CO<sub>2</sub> removals due to forest management is also a key category.

## **11.7 Information relating to Article 6**

There are no Article 6 activities concerning the LULUCF sector in Slovenia.

## **11.8 Legal entities authorized to participate in mechanisms under Article 6, 12 and 17 of the Kyoto Protocol**

In order to reduce GHG emissions installation operators may use up to 15.761 % of their issued allowances in the period 2008-2012. They can surrender emission reduction units (ERU) from the projects of joint investment (JI) and certified emission reductions (CER) from the projects of clean development mechanism (CDM).

There is no project under Article 6, 12 or 17 of the Kyoto Protocol in Slovenia.

## 12 INFORMATION ON ACCOUNTING OF KYOTO UNITS

### 12.1 Background information

Annex I Parties are required to report their national registries' holdings and transactions of Kyoto units and inform about related issues as specified in Decision 15/CMP.1 Section E. The following chapters serve this purpose.

### 12.2 Summary of information reported in the SEF tables, discrepancies and notifications

**Table 12.2.1: SEF, discrepancies and notifications**

Reporting Item	Description
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	The Standard Electronic Format report for 2017 generated on 7 March 2018 (RREG_SI_2017_2_1.xlsx) contains the information required in paragraph 11 of the annex to decision 15/CMP.1. The content of the SEF report is part of this submission.
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	No discrepant transactions occurred in 2017.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2017.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2017.
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2017.
15/CMP.1 annex I.E paragraph 17 Actions and changes to address discrepancies	No actions were taken or changes made to address discrepancies for the period under review.

### 12.3 Publicly Accessible Information

The public has access via the national registry website (<http://www.arso.gov.si/>), by the selection "Register emisijskih kuponov" (<http://www.arso.gov.si/podnebne%20spremembe/Register%20emisijskih%20kuponov/>).

Information on registry account types and account holders, information regarding Article 6 projects, information on transactions and the list of account holders authorised to hold Kyoto units in their accounts (Table 12.1.1) are available on the same website under “Javno dostopna poročila”/UNFCCC reports.

**Table 12.3.1: Publicly Accessible Information**

Annual Submission Item	Report
15/CMP.1 annex I.E  Publicly accessible information	Public available information could be accessed via registry website, URL: <a href="http://www.arso.gov.si/">http://www.arso.gov.si/</a> by the selection of “Register emisijskih kuponov”, under title »Javno dostopna poročila” - UNFCCC reports: <a href="http://www.arso.gov.si/podnebne%20spremembe/Register%20emisijskih%20kuponov/Javno%20dostopna%20porocila%20dila/">http://www.arso.gov.si/podnebne%20spremembe/Register%20emisijskih%20kuponov/Javno%20dostopna%20porocila%20dila/</a> In accordance with the requirements of Annex E to decision 13/CMP.1, all required information for a Party is provided.

## 12.4 Calculation of the 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. For the purposes of the joint fulfilment, the commitment period reserve applies to the EU, its Member States and Iceland individually.

The national commitment period reserve is calculated in accordance with paragraph 6 of the Annex to decision 11/CMP.1 as 90% of the proposed assigned amount or 100% of eight times its most recently reviewed inventory, whichever is the lowest. The Slovenian commitment period reserve is calculated either as:

99,425,782 t CO<sub>2</sub> equivalent \* 0.9 = 89,483,204 t CO<sub>2</sub> equivalent                      or

16,582,314 t CO<sub>2</sub> equivalent (emission level 2014) \* 8 = 132,658,495 t CO<sub>2</sub> equivalent

Slovenia has interpreted the ‘most recently reviewed inventory’ as the year 2014, which has been reviewed in September 2016. The Slovenian commitment period reserve is therefore 89,483,204 t CO<sub>2</sub> equivalent.



**Table 12.4.1: Slovenia's emission level and commitment period reserve**

Assigned amount for the second commitment period (t CO <sub>2</sub> eq)	90 % of assigned amount (t CO <sub>2</sub> eq)	100% of most recently reviewed inventory multiplied by 8 (t CO <sub>2</sub> eq)	Commitment period reserve (t CO <sub>2</sub> eq)	Article 3.7
99,425,782	89,483,204	132,658,495	89,483,204	Does not apply

## 12.5 KP-LULUCF Accounting

Slovenia has chosen to account for emissions and removals from the LULUCF for the entire commitment period at the end of the commitment period.

## 13 Changes to National System

No changes have been made since the previous submission.

## 14 Information on changes in the national registry

The following changes to the national registry of Slovenia have therefore occurred in 2017.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	No change in the name or contact information of the registry administrator occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	The version of the EUCR released after 8.0.7 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No changes regarding security occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. 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.

There is no new Annex H to attach. Annex H testing is planned later in 2018 when version 8.1 is available.

## **15 Information on Minimization of Adverse Impacts in Accordance with Article 3, Paragraph 14**

Under Article 3.1 of the Kyoto Protocol and UNFCCC Decision 31/CMP.1, Annex I Parties shall report on how they are striving to implement the commitments, together minimizing adverse social, environmental and economic impacts on developing country Parties. And according to the BR reporting guidelines (2/CP.17) Annex I party is encouraged to provide, to the extent possible, information on the assessment of the economic and social consequences of response measures.

Annex I countries, including Slovenia, implement measures in the framework of the Kyoto Protocol, aimed at substantially reducing greenhouse gas emissions and contributing to climate change mitigation. The implementation of increasingly stringent environmental legislation and other measures aimed at fulfilling this obligation might be associated with a range of side effects. It is not excluded that potentially associated adverse economic effects could affect some developing and least developed countries having less capacity for adequate remedial response measures. The magnitude of these potential impacts is conditioned by the selection of the policy measures, their stringency, the size of the economy implementing the measures, as well as the characteristics of the possibly affected developing countries.

As a Member State of the European Union, Slovenia, designs and implements most of its policies in the framework of EU directives, regulations, decisions and recommendations. To ensure that all relevant possible impacts are taken into account, the EU has established processes that assess the economic and social consequences of climate policy measures. For the development of new policy initiatives through legislative proposals by the European Commission, an impact assessment system have been established in which all proposals are examined before any legislation is passed. It is based on an integrated approach which analyses both benefits and costs, and addresses all significant economic, social and environmental impacts of possible new initiatives.

When adopting national measure Slovenia is mindful of the principle that its policies and measures to reduce greenhouse gas emissions are designed in a way to have no, or minimum, adverse impacts on developing countries, particularly on the least developed ones. One of the examples in this regard is the possibility of carbon leakage which would entail higher greenhouse gas emissions in countries which have lower environmental standards. Slovenia is promoting the implementation of measures that ensure that carbon leakage would not take place. As regards fiscal policy instruments, no significant impact on third countries is expected from the already implemented fiscal policies and therefore no specific policies to offset any negative effects have been considered. Negative effects are also potentially linked with the increased promotion of biofuels, as increased demand and subsequent production of biofuels may be linked to rising commodity prices and potentially induced land use change, however taking into account the low quantities of biofuels in use in Slovenia, we do not expect any

negative effects neither on forests destruction nor contribution to the rising world prices of agricultural commodities.

In recent years, Slovenia has been increasing its climate finances. In 2016, Slovenia contributed EUR 3 million for climate finance or assistance in developing countries, which represents an increase of 26% as compared to 2015. In 2016, Slovenia has for the first time also added resources from the “Slovenian climate change fund” (around EUR 1 million per year), where resources are gathered from the sale of allowances from the EU-ETS greenhouse gas emissions trading scheme. Slovenia estimates its climate assistance to be an amount of EUR 3.5 million in 2017. Slovenia will strive to obtain the amount of EUR 3.5 million for climate assistance by 2020.

In the draft Development Assistance Programme for developing countries, which also includes climate finance, Slovenia plans to increase the annual contribution from the Climate fund by 2030 in order for the total climate finance to reach between EUR 6 and EUR 7 million in 2030. The current share of climate finance in 2016 amounts to around 15% of the total ODA, and by 2030, it would be expected to increase at least to 30%, which is twice the increase in the share of climate finance, both in absolute amount and in the share of all ODA resources. In the field of climate finance, Slovenia will also follow joint decisions and guidelines, both at EU and UNFCCC level agreements.

# ABBREVIATIONS

4AR	IPCC - Forth Assessment Report
AD	Activity data
CH <sub>4</sub>	Methane
CKD	Cement kiln dust
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CNG	Compressed natural gas
CO	Carbon monoxide
COP	Conference of the Parties (to the United Nations Framework Convention on Climate Change)
COPERT	model and methodology for determination of emissions from road transport
CORINAIR	CORe INventory AIR emissions
CO <sub>2</sub>	Carbon dioxide
CO <sub>2</sub> eq.	CO <sub>2</sub> equivalent
CRF	Common Reporting Format
EEA	European Environment Agency
EF	Emission factor
EMEP	European Monitoring and Evaluation Programme
ETC-ACC	European Topic Centre on Air and Climate Change
ETS	Emission Trading Scheme
EU	European Union
FAO	The Food and Agriculture Organization of the United Nations
F-Gases	Hydrofluorocarbons (HFC), Perfluorocarbons (PFC) and Sulphur hexafluoride (SF <sub>6</sub> )
FOD	First order decay method for calculating CH <sub>4</sub> emissions from waste
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gases
GWP	Global warming potential
HFC	Hydrofluorocarbons
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control
ISEE	Slovenian Information System for GHG Emission Inventories
JQ	Joint Questionnaire
LPG	Liquid Petroleum gas
LULUCF	Land Use, Land Use Change and Forestry
MAC	Mobile Air Conditioning
MKGP	Ministry of Agriculture, Forestry and Food
MMR	Monitoring Mechanism Regulation ( <a href="#">525/2013</a> )
MOP	Ministry of the Environment and Spatial Planning
NCV	Net caloric value
NECD	Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants

NH <sub>3</sub>	Ammonium hydroxide
NIR	National Inventory Report
NMVOC	Non Methane Volatile Organic Compounds
NO <sub>x</sub>	Nitrogen oxides
N <sub>2</sub> O	Nitrous oxide
OECD	Organisation for Economic Co-operation and Development
PFC	Perfluorocarbons
QA/QC	Quality assurance / Quality control
RA	Reference approach
RS	Republic of Slovenia
SAR	IPCC - Second Assessment Report
SEA	Slovenian Environment Agency
SF <sub>6</sub>	Sulphur hexafluoride
SWDS	Solid waste disposal sites
LEG	Statistical Yearbook of Energy Economics
SO <sub>2</sub>	Sulphur dioxide
SORS	Statistical Office of the Republic of Slovenia
TE–TOL	Ljubljana heat and power plant
TEŠ	Šoštanj thermo-power plant
TET	Trbovlje thermo-power plant
TEB	Brestanica thermo-power plant
UNFCCC	UN Framework Convention for Climate Change

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