# NATIONAL GREENHOUSE GAS INVENTORY REPORT OF THE CZECH REPUBLIC

*SUBMISSION UNDER THE UNFCCC AND UNDER THE KYOTO PROTOCOL*

*REPORTED INVENTORIES 1990-2015*

**Prague**

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Title: National Greenhouse Gas Inventory Report of the Czech Republic (reported inventories 1990- 2015)
Contact: Eva Krtkova
Organization: Czech Hydrometeorological Institute
Address: Na Sabatce 17, Praha 4 – Komorany, 143 06 Czech Republic
E-mail: eva.krtkova@chmi.cz
ISBN 978-80-87577-67-7

***Authors of individual chapters***

| | | | |
|---|---|---|---|
| Editors | | Eva Krtkova<br>Beata Ondrusova<br>Stanislav Roman | (CHMI)<br>(CHMI)<br>(CHMI) |
| Executive Summary | | Eva Krtkova | (CHMI) |
| Chapter 1 | Introduction and General Issues | Eva Krtkova | (CHMI) |
| Chapter 2 | Trend in Total Emissions | Eva Krtkova<br>Beata Ondrusova | (CHMI) |
| Chapter 3 | Energy<br>(CRF sector 1) | Vladimir Neuzil<br>Eva Krtkova<br>Leos Pelikan<br>Jiri Jedlicka<br>Miroslav Havranek | (KONEKO)<br>(CHMI)<br>(CDV)<br>(CDV)<br>(CUEC) |
| Chapter 4 | Industrial Processes and Product Use<br>(CRF sector 2) | Beata Ondrusova<br>Eva Krtkova | (CHMI)<br>(CHMI) |
| Chapter 5 | Agriculture<br>(CRF sector 3) | Zuzana Exnerova<br>Jana Beranova | (IFER)<br>(IFER) |
| Chapter 6 | LULUCF<br>(CRF sector 4) | Emil Cienciala | (IFER) |
| Chapter 7 | Waste<br>(CRF sector 5) | Miroslav Havranek<br>Denitsa Troeva Svobodova | (CUEC)<br>(CHMI) |
| Chapter 9 | Indirect $CO_2$ and Nitrous oxide emissions | Denitsa Troeva Svobodova<br>Rostislav Neveceral | (CHMI)<br>(CHMI) |
| Chapter 10 | Recalculations and Improvements | Eva Krtkova | (CHMI) |
| Chapter 11 | KP LULUCF | Emil Cienciala | (IFER) |
| Chapter 12 | Information on Accounting of Kyoto units | Martin Standera<br>Michal Danhelka<br>Eva Krtkova | (OTE)<br>(MoE)<br>(CHMI) |
| Chapter 13 | Information on Changes in National System | Eva Krtkova | (CHMI) |
| Chapter 14 | Information on Changes in National Registry | Martin Standera<br>Michal Danhelka | (OTE)<br>(MoE) |
| Chapter 15 | Information on Minimization of Adverse Impacts | Michal Danhelka | (MoE) |
| Annexes | | Eva Krtkova | (CHMI) |

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# Executive Summary

# ES 1 Background information on greenhouse gas (GHG) inventories and climate change

As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), the Czech Republic is required to prepare and regularly update national greenhouse gas (GHG) inventories. In addition, as a result of membership in the European Union, the Czech Republic must also fulfil its reporting requirements concerning GHG emissions and removals following from the Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 may 2013. This edition of National Inventory Report (NIR) deals with national greenhouse gas inventories for the period 1990 to 2015 with specific accent on the latest year 2015 while keeping track of already performed/planned changes according to the previous versions.

Inventories of emissions and removals of greenhouse gases were prepared in accord with the IPCC methodology: IPCC 2006 Guidelines, IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003). Application of this general methodology on country specific circumstances is described in category-specific chapters. When a method used to estimate emissions is improved or when some gaps are identified, a need to recalculate the whole time series may arise in order to maintain consistency. This means that data presented this year can be changed in the next submission.

The National Inventory Report is elaborated in accordance with the UNFCCC reporting guidelines (UNFCCC, 2013). However, Annex I Parties that are also Parties to the Kyoto Protocol are also required to report supplementary information required under Article 7.1 of the Kyoto Protocol that is specified by Decision 15/CPM.1. The information related to KP LULUCF is provided in Part 2 of this report.

The both parts of the National Inventory Report, together with the data output - Common Reporting Format (CRF) Tables, are submitted annually by 15$^{th}$ March to European Commission and by 15$^{th}$ April to UNFCCC.

The structure of this report follows new methodical handbook published by the Secretariat “Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention” (UNFCCC, 2013).

# ES 2 Summary of national emission and removal related trends

## ES 2.1 GHG inventory

In 2015, the most important GHG in the Czech Republic was $CO_2$ contributing 81.63% to total national GHG emissions and removals expressed in $CO_2$ eq., followed by $CH_4$ 10.77% and $N_2O$ 4.81%. PFCs, HFCs, $SF_6$ and $NF_3$ contributed for 2.79% to the overall GHG emissions in the country.

Tab. ES 1 provides data on GHG emissions in comparison of overall trend from 1990 to 2015. For overview of GHG emissions and removals by categories please see chapter ES 3.

**Tab. ES 1 GHG emission/removal overall trends**

| | Base year | 2015 | Base year | 2015 | trend |
|---|---|---|---|---|---|
| | [kt $CO_2$ eq.] | | % | | |
| $CO_2$ emissions without net $CO_2$ from LULUCF | 161649.59 | 103769.75 | 82.55 | 81.63 | -35.81 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 155024.01 | 97034.34 | 81.88 | 80.54 | -37.41 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 23450.87 | 13694.48 | 11.98 | 10.77 | -41.60 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 23568.21 | 13776.39 | 12.45 | 11.43 | -41.55 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 10642.52 | 6112.73 | 5.43 | 4.81 | -42.56 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 10663.05 | 6125.54 | 5.63 | 5.08 | -42.55 |
| F-gases | 84.10 | 3549.88 | 0.04 | 2.79 | |
| **Total (without LULUCF)** | **195827.08** | **127126.83** | | | **-35.08** |
| **Total (with LULUCF)** | **189339.37** | **120486.14** | | | **-36.36** |
| **Total (without LULUCF, with indirect)** | **197948.82** | **127925.53** | | | **-35.37** |
| **Total (with LULUCF, with indirect)** | **191461.11** | **121284.84** | | | **-36.65** |

Over the period 1990 - 2015 $CO_2$ emissions and removals decreased by 37.41%, $CH_4$ emissions decreased by 41.55% during the same period mainly due to lower emissions from 1 Energy, 3 Agriculture and 5 Waste; $N_2O$ emissions decreased by 42.55% over the same period due to emission reduction in 3 Agriculture and despite increase from the 1.A.3 Transport category. Emissions of HFCs and PFCs increased by orders of magnitude, whereas $SF_6$ emissions kept steady trend over the whole period.

# ES 3 Overview of source and sink category emission estimates and trends, including KP-LULUCF activities

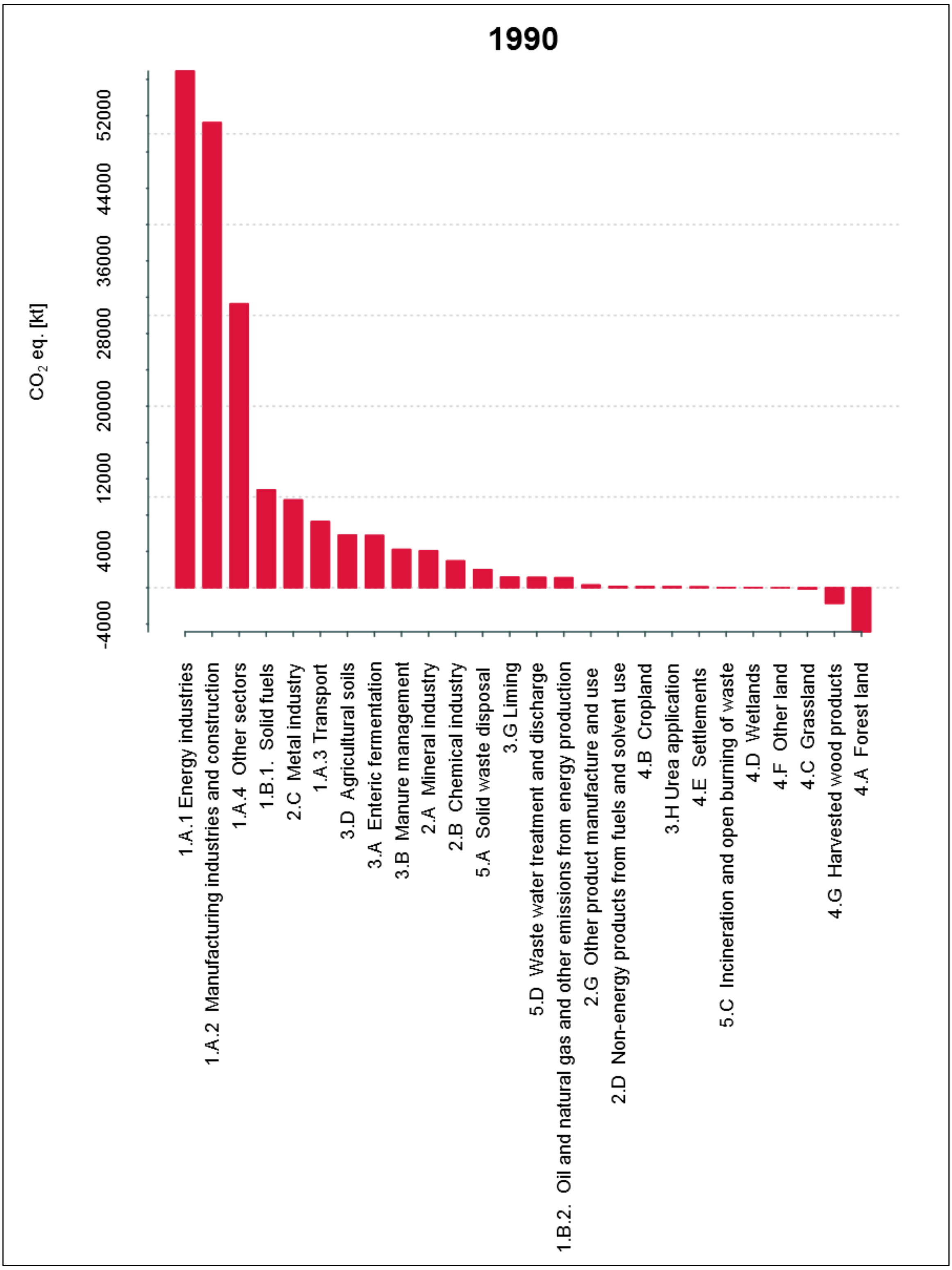



**Fig. ES 1 Sources and sinks of greenhouse gases in 1990 (kt $CO_2$ eq.)**

# ES 3.1 GHG inventory

**Tab. ES 2 Overview of GHG emission/removal trends by CRF categories**

| | Base year | 2015 | 2015 | 2015 | Trend |
|---|---|---|---|---|---|
| | kt $CO_2$ eq. | kt $CO_2$ eq. | Total share [%] | Sectoral share [%] | % |
| **1. Energy** | **158569.9** | **97973.6** | **81.32** | **100** | **-38.21** |
| A. Fuel combustion (sectoral approach) | 146708.4 | 93585.84 | 77.67 | 95.52 | -36.21 |
| 1. Energy industries | 56915.91 | 53628.86 | 44.51 | 54.74 | -5.78 |
| 2. Manufacturing industries and construction | 51234.04 | 9921.8 | 8.23 | 10.13 | -80.63 |
| 3. Transport | 7284.03 | 17747.55 | 14.73 | 18.11 | 143.65 |
| 4. Other sectors | 31274.42 | 11906.82 | 9.88 | 12.15 | -61.93 |
| 5. Other | NO | 380.81 | 0.32 | 0.39 | 100 |
| B. Fugitive emissions from fuels | 11861.51 | 4387.76 | 3.64 | 4.48 | -63.01 |
| 1. Solid fuels | 10779.39 | 3774.33 | 3.13 | 3.85 | -64.99 |
| 2. Oil and natural gas and other emissions from energy production | 1082.12 | 613.43 | 0.51 | 0.63 | -43.31 |
| C. $CO_2$ transport and storage | NO | NO | NO | NO | 0 |
| **2. Industrial Processes** | **17080.368** | **15413.84** | **12.79** | **100** | **-9.76** |
| A. Mineral industry | 4058.64 | 2533.91 | 2.10 | 16.44 | -37.57 |
| B. Chemical industry | 2944.23 | 2071.06 | 1.72 | 13.44 | -29.66 |
| C. Metal industry | 9661.62 | 6895.94 | 5.72 | 44.74 | -28.63 |
| D. Non-energy products from fuels and solvent use | 125.56 | 139.55 | 0.12 | 0.91 | 11.14 |
| E. Electronic industry | NO,NE | 18.97 | 0.02 | 0.12 | 100 |
| F. Product uses as ODS substitutes | NO | 3456.60 | 2.87 | 22.43 | 100 |
| G. Other product manufacture and use | 290.32 | 297.81 | 0.25 | 1.93 | 2.58 |
| H. Other | NO | NO | NO | NO | 0 |
| **3. Agriculture** | **17049.98** | **8482.99** | **7.04** | **100** | -50.25 |
| A. Enteric fermentation | 5754.89 | 2895.96 | 2.40 | 34.14 | -49.68 |
| B. Manure management | 4211.4 | 1779.28 | 1.48 | 20.97 | -57.75 |
| C. Rice cultivation | NO | NO | NO | NO | 0 |
| D. Agricultural soils | 5797.33 | 3457.76 | 2.87 | 40.76 | -40.36 |
| E. Prescribed burning of savannas | NO | NO | NO | NO | 0 |
| F. Field burning of agricultural residues | NO | NO | NO | NO | 0 |
| G. Liming | 1177.82 | 162.89 | 0.14 | 1.92 | -86.17 |
| H. Urea application | 108.53 | 187.1 | 0.16 | 2.21 | 72.39 |
| I. Other carbon-containing fertilizers | NO | NO | NO | NO | 0 |
| J. Other | NO | NO | NO | NO | 0 |
| **4. Land use, land-use change and forestry** | **-6487.71** | **-6640.69** | **-5.51** | **100** | **2.36** |
| A. Forest land | -4858.64 | -6052.84 | -5.02 | 91.15 | 24.58 |
| B. Cropland | 120.62 | 4.67 | 0.00 | -0.07 | -96.13 |
| C. Grassland | -145.34 | -550.34 | -0.46 | 8.29 | 278.67 |
| D. Wetlands | 21.51 | 25.18 | 0.02 | -0.38 | 17.09 |
| E. Settlements | 85.09 | 88.12 | 0.07 | -1.33 | 3.56 |
| F. Other land | 0 | 7.55 | NO | NO | |
| G. Harvested wood products | -1712.95 | -164.15 | -0.14 | 2.47 | -90.42 |
| H. Other | NO | NO | NO | NO | 0 |
| **5. Waste** | **3126.83** | **5256.41** | **4.36** | **100** | **68.11** |
| A. Solid waste disposal | 1979.27 | 3385.21 | 2.81 | 64.4 | 71.03 |
| B. Biological treatment of solid waste | NE,IE | 678.57 | 0.56 | 12.91 | 100 |
| C. Incineration and open burning of waste | 23.57 | 134.83 | 0.11 | 2.57 | 472.08 |
| D. Waste water treatment and discharge | 1123.99 | 1057.79 | 0.88 | 20.12 | -5.89 |
| E. Other | NO | NO | NO | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | **195827.08** | **127126.834** | **-** | **-** | **-35.08** |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | **189339.37** | **120486.141** | **100** | | **-36.36** |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | **197948.82** | **127925.53** | **-** | **-** | **-35.37** |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | **191461.11** | **121284.838** | **-** | **-** | **-36.65** |

In 2015, 97 973.60 kt $CO_2$ eq., that are 81.32% of national total emissions (including 4 Land Use, Land-Use Change and Forestry) arose from 1 Energy; 95.33% of these emissions arise from fuel combustion activities. The most important sub-category of 1 Energy with 54.74% of total sectoral emissions in 2015 is 1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction responses for 10.13% and 1.A.3 Transport for 18.11% of total sectoral emissions. From 1990 to 2015 emissions from 1 Energy decreased by 38.21%.

2 Industrial Processes is the second largest category with 12.79% of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2015 (15 413.84 kt $CO_2$ eq.); the largest sub-category is 2.C Metal Production with 44.74% of sectoral share. From 1990 to 2015 emissions from 2 Industrial Processes decreased by 9.76%.

3 Agriculture is the third largest category in the Czech Republic with 7.04% share of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2015 (8 482.99 kt $CO_2$ eq.); 34.14% of these emissions arose from 3.D Agricultural Soils. From 1990 to 2015 emissions from 3 Agriculture decreased by 50.25%.

4 Land Use, Land-Use Change and Forestry is the only category where removals exceed emissions. Net removals from this category increased from 1990 to 2015 by 2.36% to -6 640.69 kt $CO_2$ eq.

4.36% of the national total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2015 arose from 5 Waste. 64.4% share of GHG emissions arose from 5.A Solid waste disposal. Emissions from 5 Waste increased from 1990 to 2015 by 68.11% to 5 256.41 kt $CO_2$ eq.

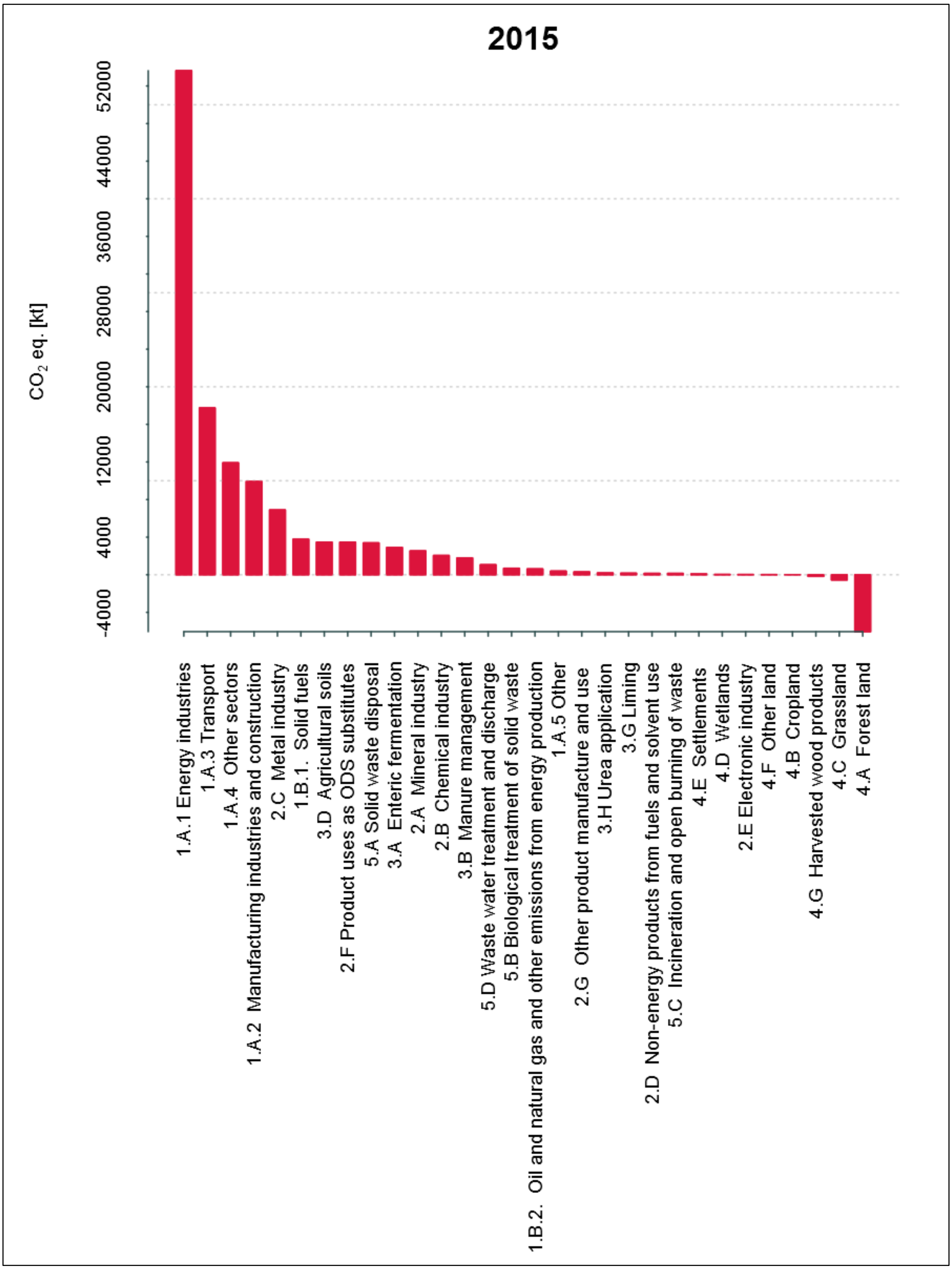



**Fig. ES 2 Sources and sinks of greenhouse gases in 2015 (kt $CO_2$ eq.)**

## ES 3.2 KP-LULUCF activities

Emission and removals estimates of GHGs for the KP LULUCF activities and HWP contribution for the years 2013-2015 are presented in Tables ES 3 to5.

**Tab. ES 3 Overview of KP-LULUCF article 3.3 activities**

| A. Article 3.3 activities | Unit | 2013 | 2014 | 2015 |
|---|---|---|---|---|
| *A.1. Afforestation and Reforestation* | | | | |
| $CO_2$ emissions/removals | Gg | -492.61 | -549.75 | -589.37 |
| $CH_4$ | Gg | NO | NO | NO |
| $N_2O$ | Gg | NO | NO | NO |
| Net $CO_2$ equivalent emissions/removals | Gg $CO_2$ eq. | -492.61 | -549.75 | -589.37 |
| *A.2. Deforestation* | | | | |
| $CO_2$ emissions/removals | Gg | 233.89 | 230.86 | 179.43 |
| $CH_4$ | Gg | NO | NO | NO |
| $N_2O$ | Gg | 0.00 | 0.00 | 0.00 |
| Net $CO_2$ equivalent emissions/removals | Gg $CO_2$ eq. | 234.27 | 231.19 | 179.73 |

**0.00 represents non-zero value lower than 0.005*

**Tab. ES 4 Overview of KP-LULUCF article 3.4 activities**

| B. Article 3.4 activities | Unit | 2013 | 2014 | 2015 |
|---|---|---|---|---|
| *B.1. Forest Management* | | | | |
| $CO_2$ emissions/removals | Gg | -6 341.43 | -6 264.90 | -4 998.51 |
| $CH_4$ | Gg | 2.59 | 2.89 | 3.22 |
| $N_2O$ | Gg | 0.02 | 0.02 | 0.02 |
| Net $CO_2$ equivalent emissions/removals | Gg $CO_2$ eq. | -6 271.32 | -6 186.73 | -4 911.41 |

**Tab. ES 5 Overview of KP-LULUCF estimates of HWP contribution**

| Harvested Wood Products | Unit | 2013 | 2014 | 2015 |
|---|---|---|---|---|
| *HWP contribution* | | | | |
| $CO_2$ emissions/removals | Gg | -133.95 | -94.13 | -164.15 |
| $CH_4$ | Gg | NO | NO | NO |
| $N_2O$ | Gg | NO | NO | NO |
| Net $CO_2$ equivalent emissions/removals | Gg $CO_2$ eq. | -133.95 | -94.13 | -164.15 |

# ES 4 Other information

## ES 4.1 Overview of emission estimates and trends of indirect GHGs and $SO_2$

Emission estimates of indirect GHGs and $SO_2$ for the period from 1990 to 2015 are presented in Tab. ES 6.

**Tab. ES 6 Indirect GHGs and $SO_2$ for 1990 to 2015 [kt]**

| | $NO_X$ | CO | NMVOC | $SO_X$ (as $SO_2$) |
|---|---|---|---|---|
| **1990** | 738.52 | 1068.64 | 300.70 | 1870.91 |
| **1991** | 723.47 | 1153.05 | 263.24 | 1767.49 |
| **1992** | 699.43 | 1158.34 | 248.04 | 1554.42 |
| **1993** | 684.06 | 1189.96 | 224.28 | 1466.04 |
| **1994** | 441.29 | 1070.96 | 247.01 | 1284.80 |
| **1995** | 418.85 | 927.55 | 207.24 | 1090.23 |
| **1996** | 437.65 | 960.42 | 257.10 | 931.11 |
| **1997** | 461.65 | 976.32 | 263.80 | 977.45 |
| **1998** | 408.22 | 802.19 | 258.61 | 438.27 |
| **1999** | 375.14 | 720.98 | 239.94 | 264.35 |
| **2000** | 339.10 | 808.29 | 255.39 | 224.54 |
| **2001** | 339.67 | 834.33 | 254.72 | 223.85 |
| **2002** | 329.32 | 807.52 | 243.56 | 219.98 |
| **2003** | 329.89 | 840.69 | 240.24 | 215.59 |
| **2004** | 327.61 | 814.84 | 230.65 | 211.54 |
| **2005** | 320.54 | 773.13 | 223.33 | 208.26 |
| **2006** | 313.44 | 761.35 | 218.30 | 203.29 |
| **2007** | 311.59 | 784.66 | 212.14 | 208.78 |
| **2008** | 294.00 | 711.36 | 200.04 | 168.71 |
| **2009** | 272.20 | 660.24 | 189.23 | 165.87 |
| **2010** | 262.03 | 692.76 | 185.43 | 160.39 |
| **2011** | 248.02 | 610.98 | 169.32 | 160.53 |
| **2012** | 234.62 | 611.99 | 163.98 | 154.82 |
| **2013** | 222.35 | 617.46 | 161.60 | 138.03 |
| **2014** | 211.59 | 558.10 | 152.21 | 127.08 |
| **2015** | 204.47 | 598.07 | 150.92 | 123.29 |
| Trend [%] | **-72.31%** | **-44.03%** | **-49.81%** | **-93.41%** |
| NEC | **286** | **-** | **220** | **265** |

*[1]NEC - National Emission Ceilings according to Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001*

Emissions of indirect greenhouse gases decreased from the period from 1990 to 2015: for $NO_X$ by 72.31%, for CO by 44.03%, for NMVOC by 49.81% and for $SO_2$ by 93.41%. The most important emission source for indirect greenhouse gases and $SO_2$ are fuel combustion activities, for details see chapter 9 in Part1: Annual inventory report.

# Part 1: Annual inventory submission

# 1 Introduction

## 1.1 Background information on GHG inventories and climate change

### 1.1.1 Climate change

Greenhouse gases (i.e. gases that contribute to the greenhouse effect) have always been present in the atmosphere, but in recent history the concentrations of a number of them are increasing as a result of human activity. Over the past century, the atmospheric concentrations of carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$) and halogenated hydrocarbons, i.e. greenhouse gases, have increased as a consequence of human activity. Greenhouse gases prevent the radiation of heat back into space and cause warming of the climate. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2014), the atmospheric concentrations of $CO_2$ have increased by 40%, primarily from fossil fuels emissions and secondarily from net land use change emissions. $CH_4$ concentrations increased by 150% and $N_2O$ concentrations have risen by 20%, compared with the pre-industrial era. Ground-level ozone also contributes to the greenhouse effect. The amount of ozone formed in the lower atmosphere has increased as a result of emissions of nitrogen oxides, hydrocarbons and carbon monoxide.

Relatively new, man-made greenhouse gases that are entering the atmosphere cause further intensification of the greenhouse effect. These include, in particular, a number of substances containing fluorine (F-gases), among them HFCs (hydrofluorocarbons). HFCs are used instead of ozone-layer-depleting CFCs (freons) in refrigerators and other applications, and their emissions are on rapid increase. Compared with carbon dioxide, all the other greenhouse gases occur at low ($CH_4$, $N_2O$) or very low concentrations (F-gases). On the other hand, these substances are more effective (per molecule) as greenhouse gases than carbon dioxide, which is the main greenhouse gas.

The threat of climate change is considered to be one of the most serious environmental problems faced by humankind. The globally averaged land and ocean surface temperature has risen by about 0.85 °C in the period 1880 to 2012 according to the IPCC 5AR. The increase of the average surface temperature of the Earth, together with the increase in the surface temperature of the oceans and the continents, will lead to changes in the hydrologic cycle and to significant changes in the atmospheric circulation, which drives rainfall, wind and temperature on a regional scale. This will increase the risk of extreme weather events, such as hurricanes, typhoons, tornadoes, severe storms, droughts and floods.

In consequence of scientific indications that human activities influence the climate and an increasing public awareness about local and global environmental issues during the middle of the 1980s, climate change became part of the political agenda. The *Intergovernmental Panel on Climate Change* (IPCC) was established in 1988 and, two years later, it concluded that anthropogenic climate change is a global threat and asked for an international agreement to deal with the problem. The *United Nations* started negotiations to create a *UN Framework Convention on Climate Change* (UNFCCC), which came into force in 1994. The long-term goal consisted in stabilizing the amount of greenhouse gases in the atmosphere at a level where harmful anthropogenic climate changes are prevented. Since UNFCCC came into force, the Framework Convention has evolved and a Conference of the Parties (COP) is held every year. The most important addition to the Convention was negotiated in 1997 in Kyoto, Japan. The *Kyoto Protocol* established binding obligations for the Annex I countries (including all EU member states and other industrialized countries). Altogether, the emissions of greenhouse gases by these countries should be at least 5% lower during 2008-2012 compared to the base year of 1990 (for fluorinated greenhouse gases, 1995 can be used as a base year). In 2001 the Czech Republic ratified the *Kyoto Protocol* and it came into force on February 16, 2005, even though it has not been ratified by the United States.

Under the *Kyoto Protocol,* the Czech Republic is committed to decrease its emissions of greenhouse gases in the first commitment period, i.e. from 2008 to 2012, by 8% compared to the base year of 1990 (the base year for F-gases is 1995). During the second commitment period (CP2) of Kyoto Protocol, the EU, its member states and Iceland should reduce average annual emissions during 2013 - 2020 by 20% compared to base year.

### 1.1.2 Greenhouse gas inventories

Annual monitoring of greenhouse gas emissions and removals is one of the obligations following from the *UN Framework Convention on Climate Change* and its *Kyoto Protocol*. In addition, as a result of membership in the European Union, the Czech Republic must also fulfil its reporting requirements concerning GHG emissions and removals following from Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC. This Decision also requires establishing a National Inventory System (NIS) pursuant to the *Kyoto Protocol* (Art. 5.1) from December 2005.

The *Czech Hydrometeorological Institute* (CHMI) was appointed in 1995 by the *Ministry of Environment* (MoE), which is the founder and supervisor of CHMI, to be the institution responsible for compiling GHG inventories. Thereafter, CHMI has been the official provider of Czech greenhouse gas emission data. The role of CHMI was improved following implementation of NIS in 2005, when CHMI was designated by MoE as the coordinating institution of the official national GHG inventory.

The inventory covers anthropogenic emissions of direct greenhouse gases $CO_2$, $CH_4$, $N_2O$, HFC, PFC, $SF_6$, $NF_3$ and indirect greenhouse gases $NO_X$, CO, NMVOC and $SO_2$. Indirect means that they do not contribute directly to the greenhouse effect, but that their presence in the atmosphere may influence the climate in various ways. As mentioned above, ozone ($O_3$) is also a greenhouse gas that is formed by the chemical reactions of its precursors: nitrogen oxides, hydrocarbons and/or carbon monoxide.

The obligations of the *Kyoto Protocol* have led to an increased need for international supervision of the emissions reported by the parties. The Kyoto Protocol therefore contains rules for how emissions should be estimated, reported and reviewed. Emissions of the direct greenhouse gases $CO_2$, $N_2O$, $CH_4$, HFCs, PFCs, $SF_6$ and $NF_3$ are calculated as $CO_2$ equivalents and added together to produce a total. Together with the direct greenhouse gases, also the emissions of $NO_X$, CO, NMVOC and $SO_2$ are reported to UNFCCC. These gases are not included in the obligations of the Kyoto Protocol. The emission estimates and removals are reported by gas and by source category and refer to 2014. Full time series of emissions and removals from 1990 to 2014 are included in the submission.

Inventories of emissions and removals of greenhouse gases were prepared according to the IPCC methodology: *2006 Guidelines for National Greenhouse Gas Inventories (IPCC, 2006)*; application of this general methodology under country-specific circumstances will be described in the sector-specific chapters. Since this submission the inventory was prepared using new updated methodology. Ale changes were conducted in the whole time-series. Details of specific changes are provided in specific chapters in this report. When a method used to estimate emissions is improved or when some gaps are identified, a need to recalculate the whole time series may arise in order to maintain consistency. This means that data presented this year can change in the next submission.

The 19. Conference of Parties agreed on Decision 24/CP.19 “Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention”, which establishing reporting requirements. This report attempts to follow this methodical handbook.

The current data submission (2016) for the EU contains all the data sets for 1990 - 2014 in the form of the official UNFCCC software called CRF Reporter. Since submission reported in 2015 the CRF Reporter was updated based on the new methodology in scope of different categorization and QWPs. The current version of CRF Reporter is web-based software, which is not considered fully reliable, especially concerning KP LULUCF tables. Additionally, current version of CRF Reporter is adding digits after decimal point during importing of tables, as well as it doesn’t show appropriate notation keys in sum categories. The Party would like to note, that all subcategories are filled up with data, or appropriate notation keys. Since official exported CRF tables are for few categories not calculated correctly, the NIR also contains additional Annex, where the corrected values are displayed.

This submission also contains relevant Annex regarding Dec. 529/2014 (Annex 6).

## 1.2 A description of the national inventory arrangements

### 1.2.1 Institutional, legal and procedural arrangements

The National Inventory System (NIS), as required by the *Kyoto Protocol* (Article 5.1) and by Regulation No. 525/2013/EC, has been in place since 2005. As approved by the *Ministry of Environment* (MoE), which is the single national entity with overall responsibility, the founder of CHMI and its superior institution.

The *Czech Hydrometeorological Institute* (CHMI), under the supervision of the *Ministry of the Environment*, is designated as the coordinating and managing organization responsible for the compilation of the national GHG inventory and reporting its results. The main tasks of CHMI consist in inventory management, general and cross-cutting issues, QA/QC, communication with the relevant UNFCCC and EU bodies, etc. Mrs. Eva Krtková is the responsible person at CHMI.

Sectoral inventories are prepared by sectoral experts from sector-solving institutions, which are coordinated and controlled by CHMI:

- KONEKO marketing Ltd. (KONEKO), Prague, is responsible for compilation of the inventory in sector 1. Energy, for stationary sources including fugitive emissions
- Transport Research Centre (CDV), Brno, is responsible for compilation of the inventory in sector 1. Energy, for mobile sources
- Czech Hydrometeorological Institute (CHMI), Prague, is responsible for compilation of the inventory in sector 2. Industrial Processes and Product Use
- Institute of Forest Ecosystem Research Ltd. (IFER), Jilove u Prahy, is responsible for compilation of the inventory in sectors 3. Agriculture and 4. Land Use, Land Use Change and Forestry
- Charles University Environment Centre (CUEC), Prague, is responsible for compilation of the inventory in sector 5. Waste.

Official submission of the national GHG Inventory is prepared by CHMI and approved by the *Ministry of Environment*. Moreover, the MoE secures contacts with other relevant governmental bodies, such as the *Czech Statistical Office*, the *Ministry of Industry and Trade* and the *Ministry of Agriculture*. In addition, the MoE provides financial resources for the NIS performance to the CHMI, which annually concludes contracts with sector-solving institutions.

More detailed information about NIS is given in the *Initial Report* (MoE, 2006) and in the 6th *National Communication* (MoE, 2014).

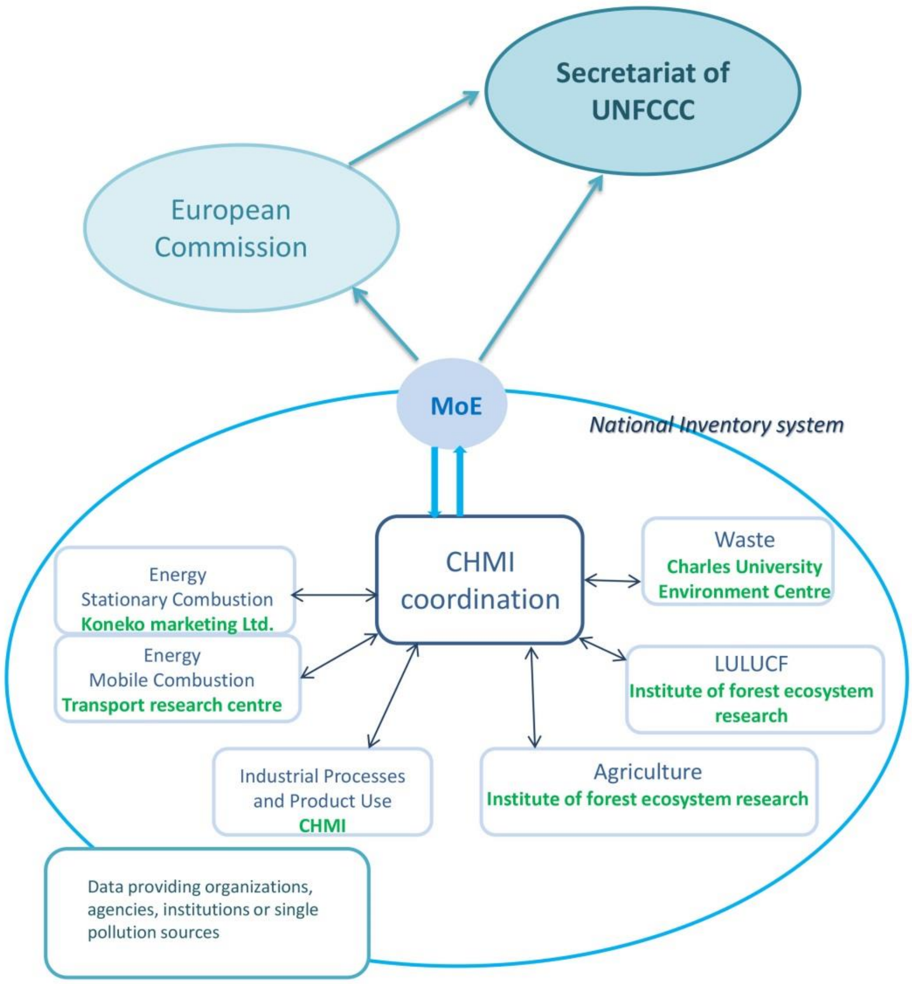



**Fig. 1-1 Institutional arrangements of National Inventory System in the Czech Republic**

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

UNFCCC, the *Kyoto Protocol* and the EU greenhouse gas monitoring mechanism require the Czech Republic to annually submit a *National Inventory Report* (NIR) and *Common Reporting Format* (CRF) tables. The annual submission contains emission estimates for the second but last year, so the 2015 submission contains estimates for the calendar year of 2014. The organisation of the preparation and reporting of the Czech greenhouse gas inventory and the duties of its institutions are detailed in the previous section (1.2.1).

The preparation of the inventory includes the following three stages:

- inventory planning
- inventory preparation
- inventory management.

During the first stage, specific responsibilities are defined and allocated: as mentioned before, CHMI coordinates the national GHG inventory, including the planning period. Within the inventory system, specific responsibilities, “sector-solving institutions”, are defined for the different source categories, as well as for all activities related to the preparation of the inventory, including QA/QC, data management and reporting.

During the second stage, the inventory preparation process, experts from sector-solving institutions collect activity data, emission factors and all the relevant information needed for final estimation of emissions. They also have specific responsibilities regarding the choice of methods, data processing and archiving. As part of the inventory plan, the NIS coordinator approves the methodological choice. Sector-solving institutions are also responsible for performing Quality Control (QC) activities that are incorporated in the QA/QC plan, (see Chapter 1.2.3). All data collected, together with emission estimates, are archived (see below) and documented for future reconstruction of the inventory.

In addition to the actual emission data, the background tables of the CRF are filled in by the sectoral experts, and finally QA/QC procedures, as defined in the QA/QC plan, are performed before the data are submitted to the UNFCCC.

For the inventory management, reliable data management to fulfil the data collecting and reporting requirements is necessary. As mentioned above, data are collected by the experts from the sector solving institutions and the reporting requirements increase rapidly and may change over time. The data and calculation spreadsheets are stored in a central network server at CHMI, which is regularly backed up to ensure data security. The inventory management includes a control system for all documents and data, for records and their archives, as well as documentation on QA/QC activities (see Chapter 1.2.3).

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

The QA/QC system is an integrated part of the national system. It ensures that the greenhouse gas inventories and reporting are of high quality and meet the criteria of timeliness, completeness, consistency, comparability, accuracy, transparency and improvement set for the annual inventories of greenhouse gases.

The objective of the national inventory system (NIS) is to produce high-quality GHG inventories. In the context of GHG inventories, high quality provides that both the structures of the national system (i.e. all institutional, legal and procedural arrangements) for estimating GHG emissions and removals and the inventory submissions (i.e. outputs, products) comply with the requirements, principles and elements rising from the UNFCCC, Kyoto Protocol, IPCC guidelines and EU GHG monitoring mechanism (Decision of the European Parliament and of the Council no. 525/2013/EC).Annex A5. 4 provides general form for QC procedures which is used in CR by each sectoral expert. Possible findings are examined and if possible corrected or included in Improvement plan for future submissions.

Annually the meetings with Slovak National Inventory team in order to discuss difficulties in processing GHG inventories in both teams are held. Several general issues were discussed, for instance improving the cooperation in the field of QA/QC. Further issues from Agriculture and IPPU were discussed. Similar, but trilateral meeting will be held in May 2017 in Bratislava, including Hungary as well.

#### *1.2.3.1 CHMI as a coordinating institution of QA/QC activities*

The NIS coordinator (NIS manager) and QA/QC manager from the Czech Hydrometeorological Institute (CHMI) control and facilitate the quality assurance and quality control (QA/QC) process and nominate QA/QC guarantors from all sector-solving institutions. NIS coordinator cooperates with the archive administrator on implementation and documentation of all the QA/QC procedures.

The Czech NIS team, which consists of involved experts from CHMI and experts from sector-solving institutions, cooperates in addressing QA/QC issues and in development and improvement of QA/QC plan. QA/QC issues are discussed regularly (about four times in a year) between CHMI experts and sectoral expert on bilateral meetings. At least once a year a joint meeting for all involved experts is organised by CHMI (by NIS coordinator). The work of the Czech inventory team is regularly checked (at least three times per year) by the Ministry of Environment (MoE) at supervisory days. There NIS coordinator provides MoE with information about all QA/QC activities and consults the possibilities for any further improvements. MoE also annually approves the QA/QC plan prepared by CHMI in cooperation with sector-solving institutions.

An electronic quality manual including e.g. guidelines, plans, templates and checklists has been developed by CHMI and is available to all participants of the national inventory system via the Internet (FTP box for NIS). All relevant documentations concerning QA/QC activities are achieved centrally at CHMI.

In addition to consideration of the special requirements of the guidelines concerning greenhouse gas inventories, the development of the inventory quality management system has followed the principles and requirements of the ISO 9001:2015 standard.

The CHMI ISO 9001:2015 working manual encompasses NIS segment, which is obligatory for relevant experts from CHMI and recommended also for experts from sector-solving institutions. NIS segment is developed in the form of flow-charts (diagrams) and consists of three sub-segments: (i) Planning and management of GHG inventories (ii) Preparation of sectoral inventory (iii) Compilation of data and text outputs.

In this way the NIS segment defines the rules for cooperation between CHMI as coordinating institution and the experts from sector-solving institutions. It involves the phase of inventory planning (including QA/QC procedures) and gives instructions for the inventory compilation and for preparation of data and text outputs (CRF Tables, NIR). All main principles mentioned above are incorporated also into the contracts between the CHMI and the sector-solving institutions.

**Tab. 1-1 CHMI staff for QA/QC coordination**

| Person | Activity |
|---|---|
| **Mr. Stanislav Roman, Mrs. Denitsa Svobodová** | Coordinator of all QA/QC activities carried out within NIS and QA/QC guarantor of “General and crosscutting issues” |
| **Ms. Eva Krtková** | NIS coordinator , inventory compiler and archive administrator |

### *1.2.3.2 Inventory process*

The annual inventory process describes at a general level how the inventory is produced by the national system. The quality of the output is ensured by the inventory experts in the course of compilation and reporting, which consist of four main stages: planning, preparation, evaluation and improvement (Fig. 1). The quality control and quality assurance elements are integrated into the production system of the inventory; each stage of the inventory includes the relevant QA/QC procedures.

A clear set of documents is produced on the different work phases of the inventory. The documentation ensures the transparency of the inventory: it enables external evaluation of the inventory and, where necessary, its replication.

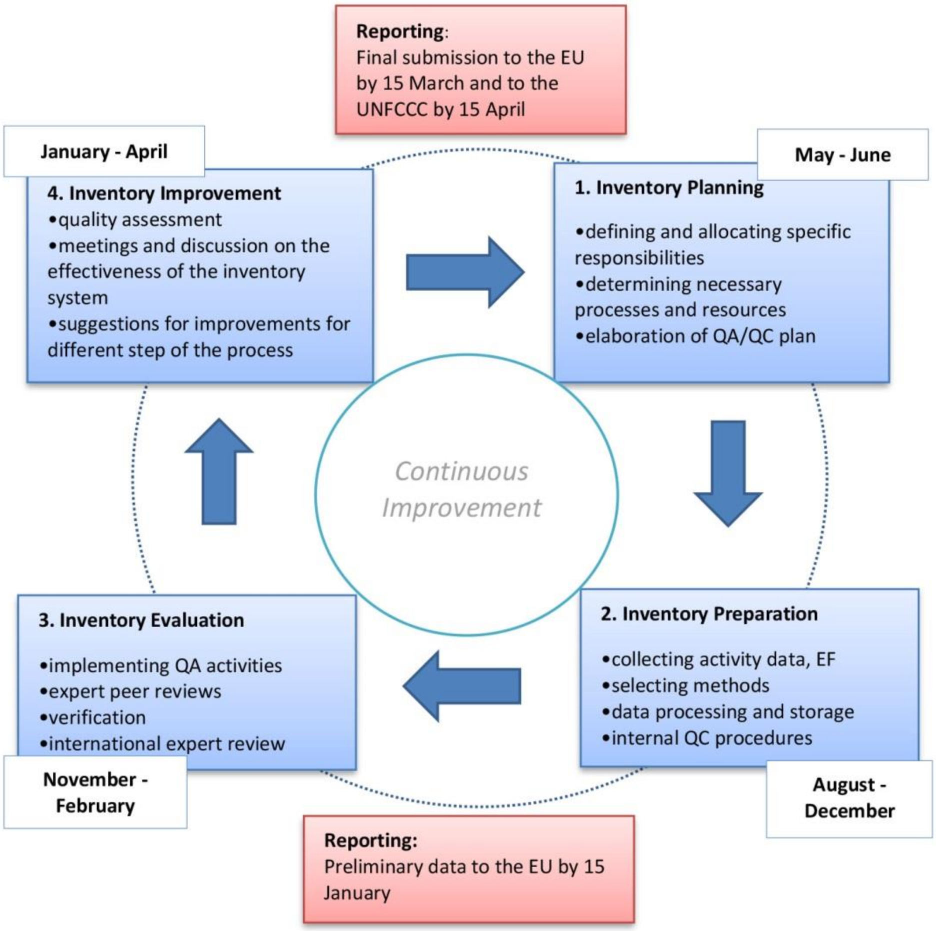



**Fig. 1-2 Timeschedule of submissions and QA/QC prodedures**

### *1.2.3.3 Procedures for data acquisition and communication with data suppliers*

In general, collection of activity data is based mainly on the official documents of the Czech Statistical Office (CzSO), which are published annually, where the Czech Statistical Yearbook is the most representative example. The Czech Statistical Yearbook is published usually in the late November, but some relevant data tables appear even earlier on the CzSO website. In order to improve the process of data acquisition from CzSO, CHMI and CzSO concluded the Memorandum of understanding (2009), which is focused mainly on prompt delivery of energy statistics data and on closer cooperation on compilation of GHG inventory in this sector.

However for industrial processes, due to the Czech Act on Statistics, production data are not generally available when there are less than 4 enterprises in the whole country. In such cases, inventory compilers have to rely either on specific statistical materials, edited by sectoral associations or, in some cases, the inventory experts have to carry out relevant inquiries. For example, data from chemical industry (including technology specific data) are obtained from contracted external co-operators of CHMI – the Institute of Chemical Technology (prof. B. Bernauer and Dr. M. Markvart). Similarly, relevant data concerning F-gases usage in enterprises are collected by Mr. V. Řeháček. Sector specific information concerning the data acquisition including the contact persons are given below, in the chapter "Sectoral specifications of QA/QC plan".

The deadline for all data acquisition is 15 November. However, CzSO in some cases carries out data corrections which are presented later. In such cases it is not possible to include corrected data into the output for EU, which is submitted by 15 January and must be considered as a preliminary output of the Czech national GHG inventory. However, practically all corrected data are incorporated into the final submission for UNFCCC by 15 April (which is also resubmitted to EU).

#### *1.2.3.4 QA/QC process*

#### *1.2.3.5 Inventory principles – the framework for quality*

The starting point for accomplishing a high-quality GHG inventory is consideration of the expectations and requirements directed at the inventory. The inventory principles defined in the UNFCCC and IPCC guidelines, that is, timeliness, completeness, consistency, comparability, accuracy, transparency and improvement, are dimensions of quality for the inventory and form the set of criteria for assessing the output produced by the national inventory system. In addition, the principle of continuous improvement is included.

#### *1.2.3.6 Quality objectives as an integral part of planning the QC and QA procedures*

The inventory planning stage includes the setting of quality objectives and elaboration of the QA/QC plan for the coming inventory preparation, compilation and reporting work. The setting of quality objectives is based on the inventory principles. Quality objectives are concrete expressions about the standard that is aimed at in the inventory preparation with regard to the inventory principles. The aim of objectives is to be appropriate and realistic while taking account of the available resources and other conditions in the operating environment. Where possible, quality objectives should be measurable.

The quality objectives regarding all calculation sectors for the 2015 inventory submissions are the following:

1) Continuous improvement
    - Treatment of review feedback is systematic
    - Improvements promised in the National Inventory Report (NIR) are introduced
    - Improvement of the inventory should be systematic. An improvement plan for a longer time horizon focused on gradual implementation of higher tiers for almost all key categories is being developed.
2) Transparency
    - Archiving of the inventory is systematic and complete
    - Internal documentation of calculations supports emission and removal estimates
    - CRF Tables and the National Inventory Report (NIR) include transparent and appropriate descriptions of emission and removal estimates and of their preparation.
3) Consistency
    - The time series are consistent
    - Data have been used in a consistent manner in the inventory.
4) Comparability
    - The methodologies and formats used in the inventory meet comparability requirements.
5) Completeness
    - The inventory covers all the emission sources, sinks and gases
6) Accuracy
    - The estimates are systematically neither greater nor less than the actual emissions or removals
    - The calculation is correct
    - Inventory uncertainties are estimated.

7) Timeliness
   - High-quality inventory reports reach their recipient (EU/UNFCCC) within the set time.

The quality objectives and the planned general QC and QA procedures regarding all the calculation sectors are recorded as the QA/QC plan. The QA/QC plan specifies the actions, the schedules for the actions and the responsibilities to attain the quality objectives and to provide confidence in the Czech national system's capability and implementation to perform and deliver high-quality inventories. The QA/QC plan is updated annually.

#### *1.2.3.7 Quality control procedures*

The QC procedures, which aim at attainment of the quality objectives, are performed by the experts during inventory calculation and compilation according to the QA/QC plan.

The QC procedures used in the Czech GHG inventory comply with the IPCC good practice guidance. General inventory QC checks (IPCC 2006 Guidelines, Table 6.1 and IPCC GPG LULUCF 2003, Table 5.5.1) include routine checks of the integrity, correctness and completeness of data, identification of errors and deficiencies and documentation and archiving of inventory data and quality control actions. In addition to general QC checks, category-specific QC checks including technical reviews of the source categories, activity data, emission factors and methods are applied on a case-by-case basis focusing on key categories and on categories where significant methodological and data revisions have taken place.

Once the experts have implemented the QC procedures, they complete the QA/QC form for each source/sink category, which provides a record of the procedures performed. Results of the completed QC checks are recorded in the internal documents for the calculation and archived in the expert organisations and at the CHMI (under responsibility of Ms. Eva Krtková). Key findings are summarised in the sector-specific chapters of the NIR.

<u>Specifically, QC procedures in the sectors are organised as described below:</u>

Each sector-solving institution – KONEKO, CDV, CHMI (Industrial processes), IFER and CUEC – will suggest to the NIS coordinator/manager (CHMI, Ms. Eva Krtková) their QA/QC guarantors, responsible for the compliance of all the QA/QC procedures in the given sector with the IPCC 2006 Guidelines and 2003 and also with the QA/QC plan.

At the basic level of control (Tier 1) individual steps should be controlled according to the Table 6.1 (IPCC 2006) and Table 5.5.1 (GPG 2003). The first step is carried out by the person responsible for the respective sub-sector (auto-control). Then follows the 2nd step carried out by the expert familiar with the topic. The reporting on the realized controls is documented in a special form prepared by CHMI. The completed form with all the records of the carried out checks is, in case of QC, Tier 1, submitted to the NIS coordinating institution – CHMI, together with data outputs: (i) XML file generated by the CRF Reporter, (ii) detailed calculation spreadsheet in MS Excel format, containing, in addition to all calculation steps also all activity data, emission factors and other parameters, as well as further supplementary data necessary for emission determination in the given category. All these files are then submitted to the central archive in CHMI. The records of the carried out QC checks, Tier 2, are submitted later (see the schedule below).

Sectoral QA/QC guarantor, in cooperation with the NIS coordinator, will assess the conditions for Tier 2 in the given sector (e.g. comparison with EU ETS data or with other independent sources). If everything is in order, the sectoral QA/QC guarantor organizes the QC check according to Tier 2.

CHMI, as the NIS coordinating institution, carries out mainly formal control of data outputs in the CRF Reporter, similar to the ”*Synthesis and Assessment*“ control carried out by the UNFCCC Secretariat. That means that CHMI controls the consistency of time series, and the possible IEF exceedance of the expected intervals (outliers), as well as the completeness and suitability of the use of notation keys and commentaries in CRF Reporter (mainly in case of NE and IE), etc. The calculation files with detailed results are controlled in CHMI only randomly.

In addition, the QC activities directed to the Member States submissions under the European Community GHG Monitoring Mechanism (e.g. completeness checks, consistency checks) produce valuable information on errors and deficiencies that is taken into account before Czech final annual inventory submission to the UNFCCC.

#### *1.2.3.1 Schedule for quality control procedures*

In addition to the UNFCCC provisions and obligatory documents the EU member states have to observe the relevant EU legislation, in this case the Decision of the European Parliament and of the Council No. 525/2013/EC concerning a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change. Article 7 of the decision sets that the member countries have to submit the results of the respective national inventories, incl. the accompanying text to the European Commission up to 15 January. The schedule of the inventory and the follow-up schedule of QA/QC procedures must respect this.

**Tab. 1-2_The schedule of QC activities – Tier 1 of the data output for EU (output deadline 15 January). The output for EU, after further controls (see below) and possible updates is used as the output for UNFCCC (deadline 15 April)**

| Time period | Activity | Responsible person |
|---|---|---|
| **15–20 November** | Final update of all detailed calculation sheets for the given category using the new data. Auto-control (1st step of QC procedure) carried out by the expert responsible for the given category. | Compiler of the category from the sector-solving institution |
| **21–25 November** | 2nd step of QC procedure carried out by the expert from the sector-solving institution familiar with the topic | Expert from the sector-solving institution familiar with the topic |
| **26-30 November** | Data from the calculation sheets are submitted to the sectoral module of the CRF Reporter and are controlled by the person responsible for the given category and by the expert from the sector-solving institution familiar with the topic. | Compiler of the category and the expert from the sector-solving institution familiar with the topic |
| **1–5 December** | Finalization of the QC control of the data output and completion of the control form for the given category | Sectoral QA/QC guarantor |
| **6–10 December** | Submission of all sectoral data outputs as well as records of the carried out QC procedures to CHMI | Main compiler of the sector-solving institution |
| **10–15 December** | Inventory compiler from CHMI (administrator of CRF Reporter) receives all data files and the records from the sector-solving institution for archiving, carries out the formal control of data in the CRF Reporter. If necessary, the sectoral QA/QC expert is contacted to remedy possible drawbacks. | Inventory compiler from CHMI (Eva Krtková) |
| **16–20 December** | Inventory compiler from CHMI (administrator of CRF Reporter) carries out the final control of data in the CRF Reporter and informs on the results the NIS coordinator who carries out independent control and informs MoE on the results. | NIS coordinator (manager) (Eva Krtková) |
| **up to 31 December** | CRF Tables submission to MoE for the approval | MoE and Sector coordinating group |

| | | |
|---|---|---|
| **Up to 15 January** | CRF Tables submitted to the European Commission within the reporting procedure pursuant to Article 7of the Decision No. 525/2013/EC | MoE |

The reporting pursuant to the Article 7 of the Decision No. 525/2013/EC includes also the text output containing several NIR elements. The text is created in the NIS coordinating institution (CHMI) and the control is carried out by the NIS coordinator. The text is submitted to MoE together with the CRF tables by 31 December.

The prepared output for the European Commission will contain only the QC procedures, Tier 1, realized by 31 December. The final submission for UNFCCC has the deadline by 15 April and thus the EU member states can carry out further controls (e.g. QC, Tier 2), and, if necessary, to further specify the results of their national inventories. The European Commission is informed about the final output for UNFCCC.

As mentioned above the sectoral QA/QC guarantor in cooperation with the NIS coordinator, will assess if the given sector meets the conditions for the application of the QC procedure, Tier 2. This assessment and discussion on the way of application will be carried out by 15 December. QC procedures, Tier 2, are then applied and controlled according to the similar schedule as presented in Table 1, however with the different deadline for the submission of the control results and the record of the carried out control to the coordinating institution, and namely by 15 February. If there are serious drawbacks, the competent representative of the sector-solving institution, together with the NIS coordinator, will consider the possibility of the correction of the data output for the given category prior to the final submission to UNFCCC (and simultaneously EU).

Similar procedure is applied in case of potential drawbacks detected within the control carried out by European Environmental Agency (EEA) on behalf of the European Commission. In this case the January data outputs will be corrected and included into the final submission for UNFCCC.

#### *1.2.3.2 Quality assurance procedures*

Quality assurance comprises a planned system of review procedures. The QA reviews are performed after the implementation of QC procedures to the finalised inventory. The inventory QA system comprises reviews and audits to assess the quality of the inventory and the inventory preparation and reporting process, to determine the conformity of the procedures taken and to identify areas where improvements could be made. While QC procedures are carried out annually and for all sectors, QA activities are expected to be performed by individual sectors and not so frequently. Each sector should be reviewed by the QA audit approx. once in three years as far as possible. Besides, QA activities should be focused mainly on key categories.

Peer reviews (QA – procedures) are sector or category-specific projects that are performed by external experts or expert groups. The reviewers should preferably be external experts who are independent of the inventory preparation. The objective of the peer review is to ensure that the inventory results, assumptions and methods are reasonable, as judged by those knowledgeable in the specific field. More detailed information about peer reviews will be given in the sector specific part of this QA/QC plan.

Peer reviews may also based on bilateral collaboration. For example, the Czech and Slovak GHG inventory teams have about once a year meetings to exchange information, experience and views relating to the preparation on the national GHG inventories. This collaboration also provides opportunities for bilateral peer reviews (QA audits). An example of such collaboration is the QA audit focused on General and crosscutting issues and on the Transport, which was carried out by Slovak GHG inventory experts in November 2009. The objectives of this QA review were (i) to judge suitability of General and crosscutting issues (including uncertainty) and to check whether the used national approach for road transport is in line with the IPCC methodology, and (ii) to recommend improvements in both cases. Similar bilateral QA reviews concentrated more on individual sectors are planned for future with the expected frequency a one QA audit for about a third of sectors per year. Further, in later year the cooperation was focused on different subsectors, i. e. Energy in total (2013), Agriculture and LULUCF (2015, 2016), IPPU (2016), uncertainties and other relevant issues.

The annual UNFCCC inventory reviews have similar and even more important impact on improving the quality of the national inventory. Therefore, the Czech team analyses very carefully the comments and recommendations of the international Expert Review Team (ERT) and strives to implement them as far as possible.

#### *1.2.3.3 Implementation of QA/QC procedures in cases of recalculations*

The QA/QC procedures described up to date are related particularly to standard situations, where the emission data from previous years remain unchanged and only emissions for the currently processed year are determined. The IPCC methodology requires that, in some cases, the emissions for previous years also be recalculated. These recalculations should be performed when an attempt is made to increase the accuracy by introducing a new methodology for the given category of sources or sinks, when more exact input data has been obtained or when consistent application of control procedures has revealed inadequacies in earlier emission determinations. In addition, recalculation should be performed in response to recommendations of the international inspection teams organized by the bodies of either the UN Framework Convention or the European Commission.

While new data are available roughly ten or eleven months after the end of the monitored year for standard emission determinations for the previous year, reasons for recalculation mostly arise well beforehand. If the methodology is changed during recalculation, the task becomes far more difficult than in standard determination of the previous year, as the new method must be thoroughly studied and tested. In addition, in order to maintain consistency of the time series, the recalculation is generally introduced for the entire time period, i.e. beginning with the reference year 1990. It is thus obvious that the danger of potential errors or omissions is greater in recalculation than in standard determination of the previous year using a well-tried methodology.

For these reasons, in recalculation, greater attention must be paid to QA/QC control mechanisms where, in addition to technical QC control (first step), it is necessary to employ more demanding control procedures (second step) and, where possible, also independent QA control by an expert not participating in the emission inventory in the given sector. While, for standardly performed QA/QC procedures, longer time validity is assumed, planning control procedures for recalculation must be tailored for the specific recalculation by the sector manager in cooperation with the NIS coordinator and QA/QC NIS guarantor.

Specific examples of recalculation are given in the sector-oriented chapters and in Chapter 10.

#### *1.2.3.4 Final approval of the inventory before submission*

Regarding the national GHG inventory submission to the UNFCCC (15 April.) the same procedure will be applied as for the corresponding reporting to the EC. The following approval procedure is within the authorization of the Ministry of the Environment of the Czech Republic. The procedure involves that the report is sent by the Ministry of the Environment, well ahead via email, to the relevant ministries in the Czech Republic (e.g. Ministry of Finance, Ministry of Transport, Ministry of Foreign Affairs, Ministry of Education, Youth and Sports, etc.), organizations (e.g. Czech Environmental Inspectorate, Czech Environmental Information Agency, non-governmental organizations, etc.), as well as to the unions of different producers (e.g. Czech-Moravian Confederation of Trade Unions, Confederation of Industry of the Czech Republic, Association of Chemical Industry of the Czech Republic, Union of Czech and Moravian Production Co-operatives, Czech Cement Association, etc.) before the official submission to the UNFCCC for their comments and observations. This is the so called proceeding of external comments. Thereafter, comments and observations must be resolved by the Climate Change Department of the Ministry of the Environment in consultation with CHMI. Such procedure is in accordance with the Provision no. 11/06 of the Ministry of the Environment, regarding the procedure for preparation and hand-over of reporting information

### *1.2.3.5 Sectoral specifications of QA/QC plan*

#### 1.2.3.5.1 Energy – stationary combustion

KONEKO, Ltd is a sector-solving institution for this category.

The plan of QA/QC procedures in the company KONEKO Ltd. is based on the internal system of quality control ensuing from the general part of the QA/QC plan for GHG inventory in the Czech Republic and is harmonized with the QA/QC system in the Transport research centre (CDV). As the fundamental/primary data sources for the processing of activity data are based on the energy balance of the Czech Republic the main emphasis is given to a close cooperation with the Czech statistical office (CzSO). This cooperation is based on the contract between CHMI, as the NIS coordinator, and CzSO. CzSO is a state institution established for statistical data processing in the Czech Republic, which has its own control mechanisms and procedures to ensure data quality.

Sectoral guarantor of QA/QC procedures, Vladimír Neužil (KONEKO manager):

- processes and updates the sectoral QA/QC plan
- organizes QC procedure (Tier 1)
- ensures QC procedure (Tier 2) and is responsible for its realization
- is responsible for the submission of all documents and data files for the storing in the coordinating institution
- suggests external experts for QA procedure
- is responsible for the compliance of all QA/QC procedures with the IPCC 2006 Guidelines and QA/QC plan.

Sectoral administrator, Monika Dvořáková:

- ensures data input in the CRF Reporter
- carries out auto-control (1st step of QC procedure, Tier 1)
- ensures and is responsible for the storing of documents

<u>The QC procedures at the Tier 1</u> are related with the processing, manipulation, documentation, storing and transmission of information. The first step of the control (auto-control) is carried out by the expert responsible for the sectoral approach (Vladimír Neužil), followed up by the control carried out by the QA/QC expert familiar with the topic (Monika Dvořáková). At this control level (Tier 1) individual steps are controlled according to the table 6.1 (IPCC 2006).

Data transmission to the CRF Reporter is carried out by the data administrator. After data transmission to the CRF Reporter the control of correct data transmission based on the summary values of activity data and emission data is carried out. If there are any discrepancies, the erroneous data are detected and corrected without delay.

<u>QC procedures at the Tier 2</u> are included upon the suggestion of the QA/QC sectoral guarantor after the consultation with the NIS coordinator. They are aimed mainly at the comparison with independent data sources that are not based on data processing from the CzSO energy balance. The relevant independent sources in the Czech Republic are represented by data published and verified within the EU Emission Trading Scheme (ETS) from the national system REZZO, used for the registration of ambient air

pollutants, and based mainly on data collection from individual plants. In addition to emission data the REZZO database includes also activity data, independent of CzSO data. The way how to optimally use the above data sources is determined on the basis of systematic research and is covered in the national inventory improvement plan.

Also external employees of KONEKO familiar with the assessed topic participate in the QC procedures (Tier 2). The cooperation is based on ad hoc contracts ensured by the QA/QC sectoral guarantor. As already mentioned above, also experts from CzSO, closely cooperating with CHMI and KONEKO, take part in the control procedures.

The QA procedures are planned in a way described in the general part of the QA/QC plan, i.e. approximately once in three years.

The QA/QC staff members for this category (Energy – stationary combustion) are given in the following table:

**Tab. 1-3 QA/QC staff members for Energy – stationary sources**

| Person | Activity |
|---|---|
| Mr. Vladimir Neužil | Sectoral QA/QC guarantor responsible for the compliance of all QA/QC procedures with the IPCC 2006 Guidelines and QA/QC plan |
| Ms. Monika Dvořáková | Emission calculation in stationary sources, auto-control (1st step of QC procedure, Tier 1) |
| Mr. Pavel Fott | Control carried out by a colleague familiar with the topic (2nd step of QC procedure, Tier 1) |
| Ms. Monika Dvořáková,<br>Mr. Vladimír Neužil | Control of the correct uploading of data from calculation sheets to the respective module of CRF Reporter |
| External KONEKO employees<br>(based on contract) | QC procedures, Tier 2 |
| External expert | QA procedure assurance |

#### 1.2.3.5.2 Energy – mobile sources

Transport research centre (CDV) is a sector-solving institution for this category.

The plan of QA/QC procedures in CDV is based on the inner quality control procedure system, which is harmonized with the QA/QC system of KONEKO company. Since the transport sector belongs to the energy sector, there is a close co-operation of CDV and KONEKO in the field of energy and fuel consumption data as well as specific energy data used (in MJ/ kg fuel). The KONEKO company, in close co-operation with CzSO, ensures that the transport research centre works with the most updated data about total energy and specific energy consumed.

Routine and consistent checks are performed to ensure data integrity, correctness, completeness and to identify and address errors. Documentation and archivation of all QC activities is carried out within CDV. QC activities include methods such as accuracy checks on data acquisition and calculations, and the use of approved standardised procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. QC activities also include technical reviews of categories, activity data, emission factors, other estimation parameters, and methods. QA and verification is guaranteed in CDV by comparing activity data with world and European databases.

The sectoral expert from CDV is responsible for coordinating the institutional and procedural arrangements for inventory activities, including data collection from CzSO, deciding on emission factors (default or CS) and estimation of emissions from mobile sources. The uncertainty assessment is carried out also by the sectoral export. The last step is documentation and archivation of data.

The responsibilities for completing the QA/QC procedures for mobile sources are divided between the sectoral guarantor, sectoral expert and external expert. The sectoral guarantor of QA/QC procedures for mobile sources (Mr. Roman Ličbínský) is responsible for the sectoral QA/QC plan and the compliance of all QA/QC procedures, provides for the QC procedure and is responsible for its implementation.

The sectoral expert from mobile sources (Mr. Leoš Pelikán) performs the emission calculations for the transport in emission model, provides for data import in the CRF table, provides for and is responsible for the storing of documents, carries out auto-control and control of data consistency, performs the uncertainty calculation, introduces improvements.

External expert (Mrs. Vilma Jandová) controls in detail timeliness, completeness, consistency, comparability and transparency.

The QA/QC staff members for this category (Energy – mobile sources) are given in the following table:

**Tab. 1-4 QA/QC staff members for Energy – mobile sources**

| Person | Activity |
|---|---|
| Mr. Roman Ličbínský<br>**(Head of the infrastructure and environment department)** | Sectoral QA/QC guarantor responsible for the compliance of all QA/QC procedures with the IPCC 2006 Guidelines and QA/QC plan. |
| Mr. Leoš Pelikán | Inventory compiler for transport sector. Calculations of emissions from traffic based on emission model, auto-control (1st step of QC procedure, Tier 1). Uploading data from the detailed emission calculation model to the CRF Reporter, control of the final “implied emission factors“, control of data consistency |
| Mrs. Vilma Jandová<br>**(Transport yearbook compiler)** | Control carried out by a colleague familiar with the topic (2nd step of QC procedure, Tier 1) |

### 1.2.3.5.3 Energy – fugitive emissions

KONEKO, Ltd is a sector-solving institution for this category.

The plan of QA/QC procedures in the KONEKO Ltd. is based on the internal system of quality control resulting from the general part of the QA/QC plan of the GHG inventory in the Czech Republic. As the basic data sources for activity data are taken from the Mining Yearbook and are supplemented and controlled by the data from the source part of the energy balance of the Czech Republic, the main emphasis is given to a close cooperation with the CzSO. This cooperation is ensured by the contract between CHMI as the NIS coordinator, and CzSO. CzSO is a state institution established for the processing of statistical data in the Czech Republic and as such it uses its own control mechanisms and procedures to ensure data quality.

Sectoral guarantor for QA/QC procedures, Vladimír Neužil (KONEKO manager)

- develops and updates the sectoral QA/QC plan
- organizes the QC procedure (Tier 1 and Tier 2) and is responsible for the compliance of all QA/QC procedures with the IPCC 2006 Guidelines and the QA/QC plan
- suggests external experts for QA procedures
- is responsible for the submission of all documents and calculation sheets for the storing in the coordinating institution

Sectoral administrator, Monika Dvořáková:

- ensures the uploading of data to CRF Reporter
- carries out auto-control (1st step of QC procedure, Tier 1)
- ensures and is responsible for the storing of documents

QC procedures at Tier 1 are related to the processing, manipulation, documentation, storing and transmission of information. The first step of the control (auto-control) is carried out by the expert responsible for the sectoral approach (Monika Dvořáková) and is followed by the control of the QA/QC colleague familiar with the topic (Vladimír Neužil). At this control level (Tier 1), the individual steps are controlled according to the table 6.1 (IPCC 2006).

Data transfer to the CRF Reporter is carried out by the data administrator. After data transmission to the CRF Reporter the control of correct transmission based on the summary values of activity data and emission data is carried out. If there are any discrepancies, the erroneous data are detected and corrected without delay.

The QC procedures at Tier 2 are included on the proposal of the sectoral QA/QC guarantor after the consultation with the NIS coordinator. They are aimed mainly at the comparison with independent data sources. The relevant independent sources in the Czech Republic are represented by data published in the Mining Yearbook, the source part of the energy balance of the Czech Republic, by the separate examinations in the gas industry plants and in the companies, mining the energy raw materials.

The QA procedures are planned as described in the general part of the QA/QC plan, i.e. approx. in three-year cycles.

The QA/QC staff members for this category (1.B Fugitive emissions) are given in the following table:

**Tab. 1-5 QA/QC staff members for Energy – fugitive emissions**

| Person | Activities |
|---|---|
| Mr. Vladimir Neužil | Sectoral QA/QC guarantor responsible for the compliance of all QA/QC procedures with the IPCC 2006 Guidelines and the QA/QC plan. |
| Ms. Monika Dvořáková | Calculations of fugitive emissions in coal mining, oil and gas industry, auto-control (1st step of QC procedure, Tier 1). |
| Mr. Vladimír Neužil | Control of an expert familiar with the topic (2nd step of QC procedure, Tier 1) and QC, Tier 2 |
| Ms. Monika Dvořáková | Control of the correct data input from calculation sheets to the respective module of CRF Reporter |
| External expert | Ensuring the QA procedure |

### 1.2.3.5.4 Industrial processes and product use

Czech Hydrometeorological Institute (CHMI) is a sector-solving institution for this category. The guarantor of the QA/QC procedures in this sector is Ms. Beáta Ondrušová.

The plan of QA/QC procedures is in compliance with NIS general QA/QC plan and is based on the overall CHMI ISO 9001:2015 quality standards, namely process No. 2462 “Sectoral GHG inventory – Industrial processes”. This process consists of two parts (a) 24621 “Data processing and emissions estimates” and (b) 24622 “Update of the National Inventory report”.

The QA/QC system is based on the inner quality control procedure system with inter-sectoral cooperation mainly with KONEKO on the field of non-energy use of fossil fuels in the sectors Chemical Industry and Iron and Steel and with Ministry of the Environment and Czech Accreditation Institute on the field of EU ETS data processing and verification.

The QA/QC system is based on the inner quality control procedure system with inter-sectoral cooperation: As for non-energy use of fossil fuels in 2.B and 2.C the relevant QA/QC procedures at the CHMI are performed in cooperation with KONEKO company. QA/QC procedures in the field of Chemical Industry are performed in co-operation with Dr. Markvart and Prof. Bernauer from the Institute of Chemical Technology (VSCHT), Prague. Besides, close cooperation with the Ministry of the Environment, as a competent authority for EU ETS, and with the Czech Accreditation Institute is developed for the usage of the EU ETS data for implementation of the QC Tier 2 procedures.

Activity data are supplied mostly by state statistical bodies (CzSO, Ministries etc.) which have their own control mechanisms to ensure quality of published data. In the case of EU ETS, the use of data is consulted with appropriate professional association (e.g. Czech Cement Association). In the case of F-gases, different sources of data are used (import/export statistics, direct questionnaire to all importers/exporters, MoE questionnaire on F-gases use) and compared.

The inner quality assurance and quality control procedure consists of the setting of responsible person for emission calculation and quality check. Summary of involved experts is given in the following table. In general, the responsibility is divided between the persons who implement the IPCC methodology and control the results, data consistency and documentation process.

The QA/QC staff members for this category (Industrial processes and solvent and other product use) are given in the following table:

**Tab. 1-6 QA/QC staff members for Industrial processes and solvent and other product use**

| Sector | Emission Estimate and the first step of QC procedure, Tier 1 (auto-control) | QC, Tier 1 (the second step of QC procedure) | QC, Tier 2 – verification |
|---|---|---|---|
| 2.A | Ms. Beáta Ondrušová | Ms. Eva Krtková | Mr. Gemrich – 2.A.1<br>Mr. Prokopec – 2.A.2 |
| 2.B, 2.C | Ms. Beáta Ondrušová, Ms. Eva Krtková | Ms. Eva Krtková | Prof. Bernauer and Dr. Markvart – 2.B<br>Ing. Toman – 2.C |
| 2.D | Ms. Beáta Ondrušová | Ms. Eva Krtková | Mr. Vladimír Neužil |
| 2.E, 2.F, 2.G | Mr. Vladimír Řeháček | Ms. Beáta Ondrušová | Prof. Bernauer – 2.G<br>Ing. Martin Beck |

### 1.2.3.5.5 Agriculture

The Institute of Forest Ecosystem Research (IFER) is a sector-solving institution for this category.

The sector specific QA/QC plan for Agriculture is an integral part of the general QA/QC plan. The agricultural greenhouse gas inventory is compiled by the experienced expert from the IFER, including performing auto-control. The sector specific QC was performed by another expert on agriculture (IFER) with help from the sectoral experts from the Czech University of Life Sciences (CULS). The Slovak agricultural experts (SHMI) also participate in discussions concerning inventory improvements.

The procedure of inventory compiling is initiated by IFER where all necessary data, obtained from the Czech Statistical Office (CzSO), are inserted into the excel spreadsheets. The excel files are then checked by other IFER experts. All differences are discussed and if necessary also corrected.

The Czech University of Life Sciences, Faculty of Agrobiology, Food and Natural Resources and the company AGROBIO are other institutes contributing with information used in the sector of agriculture. These data specifically concern cattle breeding. For calculation of CS EF for cattle (Tier 2) some specific parameters, not available from CzSO, are needed. The appropriate values in calculation spreadsheets are updated at IFER replacing the older ones. This work is archived by sector expert (IFER).

The final checked and verified data are transferred into the CRF Reporter. The CRF tables are sent to the NIS coordinator for the final checking and approval. All information used for the preparation of the inventory report is archived by the author and by the NIS coordinator.

The QA/QC staff members for this category (Agriculture) are given in the following table:

**Tab. 1-7 QA/QC staff members for Agriculture**

| Person | Activity |
|---|---|
| Mrs. Zuzana Exnerová (IFER) | Sector QA/QC guarantor<br>Emission estimation in Agriculture sector (1st step of QC procedure, auto-control)<br>Checking of CRF tables and time-series consistency |
| Mr. Emil Cienciala (IFER) | QC verification of other expert familiar with agricultural problem (2nd step of QC procedure) |
| Mrs. Jana Beranová (IFER) | Technical verification of emission factors and time series in the Agriculture sector |
| Mrs. Janka Szemesova (SHMI) | Consultation of QA/QC procedures and GHG estimation |

#### 1.2.3.5.6 LULUCF

Institute of Forest Ecosystem Research (IFER) is a sector-solving institution for this category.

The sector specific QA/QC plan for LULUCF is an integral part of the general QA/QC plan. The LULUCF greenhouse gas inventory (including KP reporting) is compiled by an experienced expert from the IFER, including auto-control procedure. The sector specific QC, Tier 1 was prepared by another LULUCF expert team with help from other sectoral experts.

The procedure of inventory compiling is initiated by IFER. IFER collects the required data from the Czech Statistical Office (CzSO), the Czech Office for Surveying, Mapping and Cadastre (COSMC) and the Forest Management Institute (FMI). The latter two institutes provide country specific information used for Tier 2 inventory calculation. COSMC provides the annually updated areas for all land-use categories. FMI reports the recent data on forests (harvest, increment, felling, etc.) that are used in the land-use categories involving forest land. The preparatory calculation is mostly performed in excel spreadsheets and in some instances in the specific software application prepared by IFER. All files are then checked by other IFER experts. All differences are discussed and if necessary, appropriate corrections are made. The appropriate values in calculation spreadsheets are updated at IFER replacing the older ones. This work is archived by an IFER expert.

The final data files including the checked and verified data are transferred into the CRF Reporter. The sectoral CRF files are sent to the NIS coordinator for the final checking and approval. All information used for the preparation of the inventory report is archived by the author and by the NIS coordinator.

The QA/QC staff members for this category (LULUCF) are given in the following table:

**Tab. 1-8 QA/QC staff members for LULUCF**

| Person | Activity |
|---|---|
| Mr. Emil Cienciala (IFER) | Sectoral QA/QC guarantor and expert with overall technical responsibility for the LULUCF inventory<br>Emission estimation in LULUCF sector, 1st step of QC procedure (auto-control)<br>Checking of CRF tables and time-series consistency |
| Mr. Ondřej Černý (IFER) | Emission estimation in LULUCF sector, 2nd step of QC procedure |
| Mrs. Jana Beranová (IFER) | Technical verification of emission factors and time series in the LULUCF sector |
| FMI | Selected data on forests |
| COSMC | Selected cadastral data |
| SHMI | Consultation of QA/QC procedures and GHG estimation |

#### 1.2.3.5.7 Waste

Charles University Environment Centre (CUEC) is a sector-solving institution for this sector.

The sectoral plan of QA/QC procedures is in compliance with the NIS general QA/QC plan. However CUEC is an academic institution and it uses also academic procedures used for quality assurance.

The inner quality assurance and quality control procedure consists of the setting of responsible persons for emission calculation – Mr. Miroslav Havránek and Mrs. Denitsa Svobodová, who is focusing on waste in more general terms. Mr. Havránek implements the IPCC methodology and Mrs. Svobodová controls the results and their consistency.

Activity data are supplied mostly by state statistical bodies (CzSO, Ministries, CENIA etc.) which have their own control mechanisms to ensure the quality of published data. It is beyond the scope of this sector review to list them all as they are used by the whole NIS.

CRF is regularly filled by Mr. Havránek, further the consistency between sector worksheets, CRF and NIR are controlled by the sectoral expert (Tier 1 auto-control) and a reviewer from NIS coordination team. Worksheets and all activity data are stored (so far indefinitely) by both NIS coordinator and CUEC. CUEC uses secure server which has backup copy. Backup is done regularly twice a week.

Cross-cutting issues from this sector are discussed regularly with the experts from the relevant sectors (Energy, Agriculture etc.).

Some findings from waste greenhouse gas inventories are published in scientific publications, in papers, articles or in various project reports which gives the additional layer of QA/QC for this particular sector.

The QA/QC staff members for this category (Waste) are given in the following table:

**Tab. 1-9 QA/QC staff members for Waste**

| Person | Activity |
|---|---|
| Mr. Miroslav Havránek | Sector guarantor of QA/QC implementation.<br>1st step of QC procedure, Tier 1 (auto-control) |
| Mrs. Denitsa Svobodová | 2nd step of QC procedure, Tier 1 and Tier 2 |

#### 1.2.3.5.8 Template for documentations of performed QC procedures

For the documentation of the QC procedures the uniform blank with the respective "c*heck-list*" is used. All used templates of the form are attached (see the Annex).

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

No significant changes were made in the Czech national inventory team and the main pillars of the national inventory system declared in the Czech Republic's Initial Report under the Kyoto Protocol are operational and running.

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

### 1.3.1 Activity data collection

Collection of activity data is based mainly on the official documents of the *Czech Statistical Office* (CzSO), which are published annually, where the *Czech Statistical Yearbook* is the most representative example. However for industrial processes, because of the *Czech Act on Statistics*, production data are not generally available when there are fewer than 4 enterprises in the whole country. In such cases, inventory compilers have to rely either on specific statistical materials edited by sectoral associations or, in some cases, inventory experts have to carry out the relevant inquiries. In a few cases, the Czech register of individual sources and emissions, called REZZO, is utilized as source of activity data.

Emission estimates from Sector 1.A Fuel Combustion Activities are based on the official Czech Energy Balance, compiled by the *Czech Statistical Office*. Data from the Czech Energy balance are processed both in the Reference Approach (TPES - primary sources data are used) and in the Sectoral Approach (data for fuel transformations and final consumptions). However, in the latter case, some additional data are required (e.g. data on transportation statistics).

Recently data from EU ETS system are used as well. For the purposes of Energy sector are these data used more for control purposes, more detailed information is given in relevant chapter for Energy sector. Furthermore, for the emission estimates in IPPU sectors are EU ETS data used in much higher extend. For some subcategories, e.g. Cement Production or Lime Production is these data used for the complete inventory; in the subcategories is EU ETS data used for improving emission factors and data. These improvements are listed in the Improvement Plan.

Furthermore across different sectors are used specific sectoral associations. In each chapter for subsectors are listed data providers for the specific subsectors.

### 1.3.2 Data processing and storage

Data Sector 1.A Fuel Combustion Activities are processed by the system of interconnected spreadsheets, compiled in MS Excel following "Worksheets" presented in IPCC 2006 Guidelines, Vol. 2. Workbook. The system is extended by incorporating sheets with modified energy balance: these sheets represent an input data system. This system was recently a bit modified to be more transparent.

Also, in the majority of other sectors, data are processed in a similar way - by using a system of joined spreadsheets taken from the *Workbook* and slightly modified in order to respect national circumstances. The following examples of such cases of processing can be mentioned: agriculture, waste, fugitive emissions. For LULUCF, a specific spreadsheet system is used, respecting the national methodology.

Originally, the calculation spreadsheets related to the individual sectors were stored only in the relevant sector-solving institutions. On the basis of recommendations from the "in-country review" in 2007, a simple system was developed for central archiving, based on storage of documents from institutions participating in the national system in electronic form in a central folder-structured FTP data box located at CHMI. During the subsequent "in-country review" in 2009, this system was evaluated as only partly satisfactory and consequently it was decided to further improve the archiving system using more sophisticated arrangements.

### *Archiving process scheme*

The NIS coordinator is responsible for the administration and functioning of the archive. The archiving system is administered in accordance with the provisions of the Kyoto Protocol and the IPPC methodical recommendations.

Material archived by the sector-solving organizations
- Input data in unmodified form
- Files for transformation of original data to calculation sheets (if used)
- Calculation sheets
- Outputs from CRF
- Outputs from QA/QC
- Other relevant documents

Material archived by the coordinator
- All administrative agenda with text outputs (contracts, orders, invoices)
- Important correspondence related to the operation and functioning of NIS
- Outputs from QA/QC
- Other relevant documents

***Structural arrangements of the NIS Archive***

The archiving system contains and connects 4 individual units.

1) The archive of the sector-solving organization
   - Functionality and administration are based on contracts with the sector-solving organizations
   - Administration is provided by the sectoral organizations
2) Central storage site for sharing material in the context of NIS
   - Storage site accessible at private ftp
   - Administered by the NIS coordinator
   - Contains working materials for current submissions intended for archiving
3) Central closed archive of the NIS Coordinator
   - Internal central archive, administered by the NIS coordinator
   - Contains all the officially archived materials
   - The content of the archive is stored in duplicate on special media designed for data archiving
   - The archive is located in the seat of the coordinator (CHMI – Prague Komořany)
   - Entries in the archive are always performed as of 30 June of the relevant year of submission and a detailed records of them is also archived.
   - Entries in the archive are also performed after the end of re-submissions or during any other unplanned intervention into the database or text part of already archived submissions.
   - Prior to archiving, data for archiving must be checked and authorized by the QA/QC guarantor of the relevant sectoral organization.
4) Central accessible archive
   - Mirror image of the central closed archive, available on the internet
   - Does not contain sensitive documents, but does contain a complete list of archived files
   - Available at http://portal.chmi.cz
   - Administered by the NIS coordinator
   - Updating corresponds to the entries in the Central closed archive, available a maximum of 3 working days after completion of archiving.

## 1.4 Brief general description of methodologies (including tiers used) and data sources used

The methods used in the Czech greenhouse gas inventory are consistent with the IPCC methodology, which has been prepared for the purpose of compilation of national inventories of anthropogenic GHG emissions and removals. The updated 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) are used for the inventory since this submission. For LULUCF sector IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003) was used as well.

Depending on the complexity of the calculation and types of emission factors used (generally recommended - *default*, country-specific, site-specific and technology-specific), the approaches described in the IPCC methodology consist of three tiers. Tier 1 is typically characterized by simpler calculations, based on the basic statistical data and on the use of generally recommended emission factors (*default*) of global or continental applicability, tabulated directly in above mentioned methodical manuals.

Tier 2 is based on sophisticated calculation and usually requires more detailed and less accessible statistical data. The emission factors (country-specific or technology-specific) are usually derived using calculations based on more complex studies and better knowledge of the source. Even in these cases, it is sometimes possible to find the necessary parameters for the calculation in IPCC manuals. Procedures in Tier 3 are usually considered to consist in procedures based on the results of direct measurements carried out under local conditions.

Methods of higher tiers should be applied mainly for key categories. Key categories (key source categories) are defined as categories that cumulatively contribute 90% or more to the overall uncertainty either in level or in trend. Apparently, procedures in higher tiers should be more accurate and should better reflect reality. However, they are more demanding in all respects, and especially they are more expensive. An overview of the methods and emission factors used by the Czech Republic for estimation of emissions of greenhouse gases is given in the CRF Table “Summary 3”.

Because of the above-described problems encountered in the application of the methods of higher tiers, these procedures have so far been introduced only for some key categories. For example, for combustion of fuels, country-specific factors are employed only for Brown/Hard Coal, Brown Coal + Lignite, Bituminous Coal, Coking Coal, Gas Works Gas, Refinery Gas, LPG and Natural Gas, while the default emission factors are employed for the rest of the other fuels. For Bituminous Coal, Brown Coal + Lignite and Brown Coal Briquettes are used country specific oxidation factors as well. Similarly, for Industrial Processes, only the Tier 1 method is used for the production of iron and steel. In contrast, the methods of higher tiers and/or country-specific factors are employed far more frequently for other key categories. Chapter 10 describes the “Improvement Plan”, which will also encompass gradual introduction of more sophisticated methods of higher tiers.

All direct GHG emissions can also be expressed in terms of total (or aggregated) values, which are calculated as a sum of the emissions of the individual gases multiplied by the Global Warming Potential values (GWP). GWP correspond to the factor by which the given gas is more effective in absorption of terrestrial radiation than $CO_2$ (1 for $CO_2$, 25 for $CH_4$ and 298 for $N_2O$). The total amount of F-gases is relatively small compared to $CO_2$, $CH_4$ and $N_2O$; nevertheless their GWP values are larger by 2-4 orders of magnitude. Consequently, total aggregated emissions to be reduced according to the *Kyoto Protocol* are expressed as the equivalent amount of $CO_2$ with the same radiation absorption effect as the sum of the individual gases.

On the other hand, in preparing this inventory, somewhat less attention was paid to emissions of the precursors $NO_X$, CO, NMVOC and $SO_2$, which are covered primarily by the *Convention on Long-Range Transboundary Air Pollution* (CLRTAP) and are not directly related to the Kyoto Protocol. Their inventories are compiled for the purposes of CLRTAP by NFR (*New Format of Reporting*) by another team at CHMI. Thus emissions of precursors in the GHG inventory (CRF) have been fully taken over and transferred from NFR to CRF. A detailed description of the methodology used to estimate emissions of *precursors* is provided in the *Czech Informative Inventory Report (IIR), Submission under the UNECE/CLRTAP Convention* (submitted annually by 15$^{th}$ February) and shortly in chapter 9 of the NIR.

In September of 2014, the Czech national greenhouse gas inventory was subject to "*centralised review*". The Czech national inventory team received annual inventory report in April 2015. Since the delay caused by not-fully functioning reporting software occurred in this submission, the recommendations were implemented in the submission to as high extend as possible. Other recommendations are part of the Improvement plan for the future improvement of specific categories.

Methodical aspects are described in a greater detail in sector-oriented Chapters 3 to 8 and in Chapter 10 "Recalculations and Improvements". Chapter 10 also deals with the reactions of the Czech team to the comments and recommendations of the recent international review organised by UNFCCC.

## 1.5 Brief description of key categories

The IPCC 2006 Guidelines (IPCC, 2006) provides two approaches of determining the key categories (key sources). Key categories by definition contribute to 90% percent of the overall uncertainty in a level (in emissions per year) or in a trend. Approach 2 follows from this definition, and requires thorough analysis of the uncertainty and use of sophisticated statistical procedures and evaluation of sources in terms of the appropriate characteristics.

**Tab. 1-10 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2015 evaluated with LULUCF (Approach 2)**

| IPCC Source Categories | GHG | Cumulative Total (LA, %) | Cumulative Total (TA, %) | KC type |
|---|---|---|---|---|
| **1.A Stationary Combustion - Solid Fuels** | $CO_2$ | 38.97 | 24.03 | LA, TA |
| **1.A Stationary Combustion - Liquid Fuels** | $CO_2$ | 40.85 | 78.45 | LA,TA |
| **1.A.3.b Transport - Road Transportation** | $CO_2$ | 52.46 | 46.10 | LA, TA |
| **1.A Stationary Combustion - Gaseous Fuels** | $CO_2$ | 62.33 | 58.46 | LA, TA |
| **2.C.1 Iron and Steel Production** | $CO_2$ | 67.41 | 98.67 | LA |
| **4.A.1 Forest Land remaining Forest Land** | $CO_2$ | 71.93 | 83.84 | LA, TA |
| **5.A Solid Waste Disposal on Land** | $CH_4$ | 75.27 | 89.16 | LA, TA |
| **2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.)** | HFC | 78.51 | 66.46 | LA, TA |
| **1.B.1.a Coal Mining and Handling** | $CH_4$ | 81.19 | 83.96 | LA, TA |
| **3.D.1 Agricultural Soils, Direct $N_2O$ emissions** | $N_2O$ | 83.77 | 89.05 | LA, TA |
| **3.A Enteric Fermentation** | $CH_4$ | 86.07 | 82.90 | LA, TA |
| **2.A.1 Cement Production** | $CO_2$ | 87.12 | 94.24 | LA |
| **3.D.2 Agricultural Soils, Indirect $N_2O$ emissions** | $N_2O$ | 88.02 | 93.52 | LA |
| **3.B Manure Management** | $N_2O$ | 88.89 | 89.77 | LA, TA |
| **1.B.2 Fugitive Emission from Oil, Natural Gas** | $CH_4$ | 89.59 | 93.29 | LA |
| **3.B Manure Management** | $CH_4$ | 90.25 | 89.77 | TA |
| **2.B.8 Petrochemical and carbon black production** | $CO_2$ | 90.91 | 95.92 | LA |
| **4.G Harvested wood products** | $CO_2$ | 98.23 | 81.41 | TA |
| **3.G Liming** | $CO_2$ | 98.40 | 84.36 | TA |
| **1.A Stationary Combustion - Solid Fuels** | $CH_4$ | 96.07 | 86.81 | TA |
| **5.B Biological treatment of solid waste** | $CH_4$ | 92.84 | 88.79 | TA |
| **2.B.2 Nitric Acid Production** | $N_2O$ | 96.51 | 90.50 | TA |

**Tab. 1-11 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2015 evaluated without LULUCF (Approach 2)**

| IPCC Source Categories | GHG | Cumulative Total (LA, %) | Cumulative Total (TA, %) | KC type |
|---|---|---|---|---|
| **1.A Stationary Combustion - Solid Fuels** | $CO_2$ | 41.44 | 23.59 | LA, TA |
| **1.A Stationary Combustion - Liquid Fuels** | $CO_2$ | 43.43 | 72.06 | LA, TA |
| **1.A.3.b Transport - Road Transportation** | $CO_2$ | 55.77 | 43.14 | LA, TA |
| **1.A Stationary Combustion - Gaseous Fuels** | $CO_2$ | 66.27 | 53.94 | LA, TA |
| **2.C.1 Iron and Steel Production** | $CO_2$ | 71.67 | 99.02 | LA |
| **5.A Solid Waste Disposal on Land** | $CH_4$ | 75.23 | 81.77 | LA, TA |
| **2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.)** | HFC | 78.67 | 61.08 | LA, TA |
| **1.B.1.a Coal Mining and Handling** | $CH_4$ | 81.52 | 77.19 | LA, TA |
| **3.D.1 Agricultural Soils, Direct $N_2O$ emissions** | $N_2O$ | 84.26 | 88.96 | LA,TA |
| **3.A Enteric Fermentation** | $CH_4$ | 86.71 | 83.23 | LA, TA |
| **2.A.1 Cement Production** | $CO_2$ | 87.82 | 94.80 | LA |
| **3.D.2 Agricultural Soils, Indirect $N_2O$ emissions** | $N_2O$ | 88.78 | 93.03 | LA |
| **3.B Manure Management** | $N_2O$ | 89.70 | 85.68 | LA, TA |
| **1.B.2 Fugitive Emission from Oil, Natural Gas** | $CH_4$ | 90.45 | 84.64 | LA |
| **3.G Liming** | $CO_2$ | 98.73 | 84.57 | TA |
| **1.A Stationary Combustion - Solid Fuels** | $CH_4$ | 96.90 | 86.85 | TA |
| **5.B Biological treatment of solid waste** | $CH_4$ | 93.90 | 88.61 | TA |
| **3.B Manure Management** | $CH_4$ | 91.15 | 89.65 | TA |
| **2.B.2 Nitric Acid Production** | $N_2O$ | 97.12 | 90.32 | TA |

**Tab. 1-12 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2015 evaluated with LULUCF (Approach 1)**

| IPCC Source Categories | GHG | Cumulative Total (LA, %) | Cumulative Total (TA, %) | KC type |
|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 41.92 | 23.09 | LA,TA |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 43.93 | 67.53 | LA, TA |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 56.57 | 44.33 | LA, TA |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 67.30 | 56.19 | LA, TA |
| 2.C.1 Iron and Steel Production | $CO_2$ | 72.41 | 97.57 | LA |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | 76.61 | 91.26 | LA, TA |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 79.28 | 72.40 | LA, TA |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 81.83 | 77.96 | LA, TA |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 84.35 | 84.95 | LA, TA |
| 3.A Enteric Fermentation | $CH_4$ | 86.50 | 86.20 | LA, TA |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 88.41 | 92.07 | LA, TA |
| 2.A.1 Cement Production | $CO_2$ | 89.57 | 94.96 | LA, TA |
| 3.B Manure Management | $N_2O$ | 90.32 | 87.11 | LA, TA |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 90.98 | 94.33 | LA, TA |
| 5.D Wastewater treatment and discharge | $CH_4$ | 91.62 | 96.20 | LA |
| 3.B Manure Management | $CH_4$ | 92.19 | 90.10 | LA, TA |
| 2.B.1 Ammonia Production | $CO_2$ | 92.74 | 99.29 | LA |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 93.28 | 95.72 | LA |
| 5.B Biological treatment of solid waste | $CH_4$ | 93.75 | 100.00 | LA |
| 2.A.2 Lime Production | $CO_2$ | 94.20 | 93.09 | LA, TA |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 94.65 | 95.38 | LA |
| 4.G Harvested wood products | $CO_2$ | 98.73 | 81.50 | TA |
| 3.G Liming | $CO_2$ | 98.85 | 88.06 | TA |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 97.50 | 88.91 | TA |
| 2.B.2 Nitric Acid Production | $N_2O$ | 96.33 | 89.54 | TA |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 95.86 | 91.89 | TA |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 95.10 | 92.70 | TA |
| 2.A.2 Lime Production | $CO_2$ | 94.20 | 93.09 | LA, TA |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 96.94 | 93.53 | TA |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 96.12 | 93.95 | TA |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 95.57 | 94.13 | TA |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 98.18 | 94.66 | TA |
| 1.A.3.c Transport - Railways | $CO_2$ | 97.13 | 94.90 | TA |

**Tab. 1-13 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2015 evaluated without LULUCF (Approach 1)**

| IPCC Source Categories | GHG | Cumulative Total (LA, %) | Cumulative Total (TA, %) | KC type |
|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 44.31 | 26.04 | LA,TA |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 46.43 | 71.56 | LA,TA |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 59.79 | 47.69 | LA,TA |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 71.13 | 59.60 | LA,TA |
| 2.C.1 Iron and Steel Production | $CO_2$ | 76.53 | 99.66 | LA |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 79.20 | 85.98 | LA,TA |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 82.01 | 76.77 | LA,TA |
| 3.A Enteric Fermentation | $CH_4$ | 84.29 | 87.38 | LA,TA |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 86.98 | 82.48 | LA,TA |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 89.00 | 91.82 | LA,TA |
| 2.A.1 Cement Production | $CO_2$ | 90.22 | 94.94 | LA,TA |
| 3.B Manure Management | $N_2O$ | 91.01 | 88.36 | LA,TA |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 91.58 | 96.99 | LA |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 92.28 | 94.65 | LA,TA |
| 3.B Manure Management | $CH_4$ | 92.88 | 90.87 | LA,TA |
| 5.D Wastewater treatment and discharge | $CH_4$ | 93.56 | 96.47 | LA |
| 2.B.1 Ammonia Production | $CO_2$ | 94.14 | 98.46 | LA |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 94.25 | 94.83 | LA,TA |
| 2.A.2 Lime Production | $CO_2$ | 94.73 | 93.53 | LA,TA |
| 3.G Liming | $CO_2$ | 98.94 | 89.37 | TA |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 98.81 | 90.26 | TA |
| 2.B.2 Nitric Acid Production | $N_2O$ | 97.60 | 91.54 | TA |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 96.96 | 92.46 | TA |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 96.46 | 93.10 | TA |

| | | | | |
|---|---|---|---|---|
| **1.A.5.b Mobile sources in Agriculture and Forestry** | $CO_2$ | 97.38 | 93.98 | TA |
| **1.A.3.b Transport - Road Transportation** | $N_2O$ | 95.98 | 94.41 | TA |

The procedure of the Approach 2 is based on the results of the uncertainty analysis. The key categories were considered to be those whose cumulative contribution is less than 90%. For trend assessment, a similar procedure is used; with the difference that here the decisive quantity is defined as the product of the relative contribution to the total emissions (determined in the previous case) and the absolute value of the relative deviation of the individual trends from the total trend.

For the right identification of key categories, also assessment without consideration of the LULUCF categories was employed. It is obvious from Tab. 1-10, Tab. 1-11 and 1-12 that no additional *key category* was identified when the LULUCF categories were not considered.

On the whole, 20 key categories were identified either by level assessment or by trend assessment. A summary of the assessed numbers concerning key categories is given in Tab. 1-12. Complete tables for key category analysis are presented in Annex 1 of this report.

**Tab. 1-14 Figures for key categories assessed**

| | Approach 1 | Approach 2 |
|---|---|---|
| **Key categories (KC) with LULUCF** | 33 | 22 |
| **KC identified by LA** | 21 | 17 |
| **KC identified by TA** | 26 | 17 |
| **KC identified by LA + TA concurrently** | 16 | 11 |
| **KC identified by only LA** | 6 | 5 |
| **KC identified by only TA** | 11 | 6 |
| | | |
| **Key Categories (KC) without LULUCF:** | 26 | 19 |
| **KC identified by LA** | 19 | 14 |
| **KC identified by TA** | 22 | 15 |
| **KC identified by LA + TA concurrently** | 15 | 10 |
| **KC identified by only LA** | 4 | 4 |
| **KC identified by only TA** | **7** | 5 |

## 1.6 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals

Uncertainty analysis characterizes the extent (i.e. possible interval) of results for the entire national inventory and for its individual components. Knowledge of the individual and overall uncertainties enables compilers of emission inventories better understanding of the inventory process, which encompasses collection of suitable input data and their evaluation. Uncertainty analysis also help in identifying those categories of emission sources and sinks that contribute most to the overall uncertainty and thus establish priorities for further improvement of the quality of the data.

A method of uncertainty determination based on the error propagation method (Tier 1), using calculation sheets obtained according to the prescribed methodology (IPCC, 2006), has been used in the Czech national inventory for a number of years. The accuracy of the calculation algorithm has been sufficiently verified but problems have been caused to date by the only roughly estimated input parameters (i.e. uncertainty in the activity data and emission factors for the individual categories).

Consequently, the existing procedure was recently reviewed and these input parameters were refined both on the basis of data published in the literature (IPCC methodical manuals, national inventory report, scientific literature) and also on the basis of qualified expert estimates. Experts from CHMI and all the contributing sectoral organizations participated in this work. The individual experts investigated the uncertainty parameters coming under their field of work and proposed new ones or defended the original ones in discussions. Details are described in the study (CHMI, 2012b). However, refinement of the input parameters did not substantially affect the resultant uncertainty values. For example, the resultant uncertainty in greenhouse gas emissions (including LULUCF) in the data for 2010 (reported in 2012) corresponded to a reduction of the value 3.79% to 3.43% and the resultant uncertainty in the trend decreased from 2.40% to 2.34%.

Uncertainty analysis of Tier 1, which is presented in this volume of NIR, employs the same source categorization as used in key categories assessment. Actual results of the uncertainty analysis for 2012 after above mentioned revision of the input parameters are given in Annex 2.

Further, uncertainty bases are yearly evaluated for LULUCF, Waste and 1.A.3 Transport, which are then used for the overall uncertainty analysis. Further investigation of uncertainty bases for other sectors will be carried out till the next submission.

Results of uncertainty assessment were obtained (i) for all sectors including LULUCF and (ii) for comparison also for all sectors without LULUCF. The estimated overall uncertainty in level assessment (case with LULUCF) reached 3.72%. The corresponding uncertainty in trend is 2.41%. For the case without LULUCF the estimated overall uncertainty in level assessment is 3.39% and 2.29% in trend.

The same source categories used in key sources assessment have also been used even in uncertainty analysis. In this way, the uncertainty analysis result was used later Approach 2 key source analysis. The uncertainty analysis is provided in Annex 2 tables.

## 1.7 General assessment of completeness

CRF Table 9 (Completeness) has been used to give information on the aspect of completeness. This part of the text includes additional information. All the categories of sources and sinks included in the IPCC Guidelines are covered. No additional sources and sinks specific to the Czech Republic have been identified. Both direct GHGs as well as precursor gases are covered by the Czech inventory. The geographic coverage is complete.

Additionally this year was used the ‘completeness’ function of new CRF Reporter. However, it was discovered, that this functionality doesn’t always give proper results, so additional form created by CHMI was used for the completeness checks. Example of this form is given in Annex 5.5 (for Waste sector). Specifically, there are some empty tables reported in this submission, since the CRF Reporter wasn’t able to import specific tables or display information filled in subcategories. This issue is occurring only for categories, which are not occurring in the Czech Republic.

### 1.7.1 Notation keys

The sources and sinks not considered in the inventory but included in the IPCC Guidelines are clearly indicated and the reasons for this exclusion are explained in Documentation box in CRF Reporter and in relevant chapter of NIR. In addition, the notation keys presented below are used to fill in the blanks in all the CRF Tables. Notation keys are used according to the UNFCCC guidelines on reporting and review (FCCC/CP/2002/8).

Allocations to categories may differ from Party to Party. The main reasons for different category allocations are different allocations in the national statistics, insufficient information on the national statistics, national methods, and the impossibility of disaggregating the reported emission values.

*IE (included elsewhere):*

“IE” is used for emissions by sources and removals by sinks of greenhouse gases that have been estimated but included elsewhere in the inventory instead of in the expected source/sink category. Where “IE” is used in the inventory, the CRF completeness table (Table 9) indicates where (in the inventory) these emissions or removals have been included. This deviation from the expected category is explained.

*NE (not estimated):*

“NE” is used for existing emissions by sources and removals by sinks of greenhouse gases that have not been estimated. Where “NE” is used in an inventory for emissions or removals, both the NIR and the CRF completeness table indicate why the emissions or removals have not been estimated. For emissions by sources and removals by sinks of greenhouse gases marked by “NE”, check-ups are in progress to establish if they actually are “NO” (not occurring). As part of the improvement programme of the inventory, it is planned that these source or sink categories will be either estimated or allocated to “NO”.

Overview of not estimated (NE) categories of sources and sinks and categories included elsewhere (IE) and the relevant explanations are given in CRF Table 9.

# 2 Trends in greenhouse gas emissions

According to the Kyoto Protocol, Czech national GHG emissions have to decrease by 8% of base year emissions during the five-year commitment period from 2008 to 2012. The Czech Republic has already met its goal, however it is very difficult to separate influences of general decrease in industrial and agricultural production and increase in overall energy-emission efficiency.

For 2013 – 2020 is existing joint commitment of the EU, its MS and Iceland to reduce average annual emissions by 20% compared to base year. Czech Republic has already met this goal as well.

## 2.1 Description and interpretation of emission trends for aggregated GHG emissions

Tab. 2-1 presents a summary of GHG emissions excl. bunkers incl. indirect emissions for the period from 1990 to 2015. For $CO_2$, $CH_4$ and $N_2O$ the base year is 1990; for F-gases the base year is 1995.

**Tab. 2-1 GHG emissions from 1990-2015 excl. bunkers [kt $CO_2$ eq.]**

| | $CO_2$[1] | $CH_4$[3] | $N_2O$[3] | HFCs | PFCs | $NF_3$ | $SF_6$ | Total emissions | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | excl. LULUCF | incl. LULUCF |
| **1990** | 161649.59 | 23568.21 | 10663.05 | | NE | | 84.10 | 197948.82 | 191461.11 |
| **1991** | 146035.42 | 21973.73 | 9161.23 | | | | 83.94 | 179160.22 | 169551.36 |
| **1992** | 141549.39 | 20585.38 | 8298.15 | | | | 85.23 | 172382.80 | 162286.52 |
| **1993** | 135570.11 | 19677.99 | 7395.39 | | | | 86.40 | 164528.86 | 154836.15 |
| **1994** | 129159.53 | 18541.72 | 7242.92 | | | | 87.48 | 156649.89 | 149080.89 |
| **1995** | 129736.95 | 18135.00 | 7465.74 | 0.32 | 0.01 | NO | 88.47 | 157052.78 | 149006.34 |
| **1996** | 132201.92 | 17977.30 | 7289.86 | 38.02 | 0.68 | NO | 98.06 | 159170.91 | 150777.26 |
| **1997** | 128839.99 | 17571.27 | 7268.04 | 119.96 | 1.73 | NO | 95.83 | 155435.55 | 147958.95 |
| **1998** | 123647.03 | 16900.65 | 7137.39 | 173.54 | 1.66 | NO | 94.56 | 149360.65 | 141739.34 |
| **1999** | 115416.47 | 16184.56 | 7001.90 | 196.78 | 1.10 | NO | 95.53 | 140163.10 | 132258.04 |
| **2000** | 125788.18 | 15328.91 | 6845.16 | 272.92 | 4.69 | NO | 107.99 | 149380.15 | 140575.08 |
| **2001** | 125486.45 | 15072.59 | 6927.14 | 411.01 | 9.75 | NO | 98.41 | 148992.74 | 139859.53 |
| **2002** | 122537.80 | 14657.49 | 6638.76 | 534.27 | 16.39 | NO | 120.80 | 145430.10 | 136664.43 |
| **2003** | 126092.53 | 14674.61 | 6269.15 | 671.81 | 8.55 | NO | 144.19 | 148737.65 | 141471.41 |
| **2004** | 126838.97 | 14239.85 | 6726.99 | 771.03 | 12.81 | NO | 120.00 | 149560.41 | 141772.32 |
| **2005** | 124558.95 | 14613.64 | 6512.18 | 867.74 | 14.89 | NO | 111.18 | 147612.88 | 139478.29 |
| **2006** | 125889.26 | 14892.02 | 6307.82 | 1166.49 | 31.09 | NO | 108.28 | 149308.88 | 143339.59 |
| **2007** | 127402.86 | 14472.58 | 6296.50 | 1624.43 | 29.00 | NO | 93.41 | 150731.49 | 146971.94 |
| **2008** | 122315.94 | 14563.20 | 6408.78 | 1902.14 | 39.76 | NO | 93.29 | 146162.00 | 139251.38 |
| **2009** | 114684.10 | 14183.66 | 5975.22 | 2010.82 | 45.44 | NO | 96.06 | 137795.64 | 129863.57 |
| **2010** | 116159.34 | 14392.54 | 5765.04 | 2348.97 | 48.01 | NO | 80.23 | 139593.28 | 132393.21 |
| **2011** | 114037.62 | 14295.87 | 5948.31 | 2620.17 | 8.13 | NO | 85.39 | 137863.57 | 129474.60 |
| **2012** | 110621.25 | 14298.29 | 5861.44 | 2765.99 | 6.36 | 1.80 | 89.63 | 134465.77 | 125913.06 |
| **2013** | 107102.93 | 13731.61 | 5903.14 | 2989.02 | 4.55 | 3.82 | 92.35 | 130561.18 | 122640.95 |
| **2014** | 102799.18 | 13701.64 | 6093.78 | 3229.53 | 3.02 | 2.35 | 94.73 | 126616.31 | 118815.22 |
| **2015** | 103769.75 | 13776.39 | 6125.54 | 3455.08 | 1.96 | 2.29 | 90.55 | 127925.53 | 121284.84 |
| **%[2)]** | **-35.81** | **-41.55** | **-42.55** | | | | **7.67** | **-35.37** | **-36.65** |

*Note: Global warming potentials (GWPs) used (100 years time horizon): $CO_2$ = 1; $CH_4$ = 25; $N_2O$ = 298; $SF_6$ = 22 800; $NF_3$ = 17 200; HFCs and PFCs consist of different substances, therefore GWPs have to be calculated individually depending on substances*

*[1]GHG emissions excluding emissions/removals from LULUCF*

*[2] relative to base year*

*[3]incl. LULUCF*

GHG emissions and removals have significantly decreased in the period 1990 – 1995, mainly driven by the economy transition and pursuing major dropdown in heavy industry activities in the country. The fast decrease has stopped around 145 000 kt $CO_2$ eq. and continues fluctuating ever since (see Fig. 2-1). From 2010 to 2015 the total GHG emissions (incl. LULUCF) decreased by 8.39% or -11 108.37 $CO_2$ eq. resulting in total emissions of 121 284.84 kt $CO_2$ eq. The decrease was caused by $CO_2$, PFCs emissions and $SF_6$ emissions (decreased by 10.87%; 35.10%, 4.41%) despite increase in HFC emissions (raised by 6.98%) compared to previous year. The total GHG emissions and removals in 2015 were -36.65% below the base year level including LULUCF and -35,37%, when excluding LULUCF.

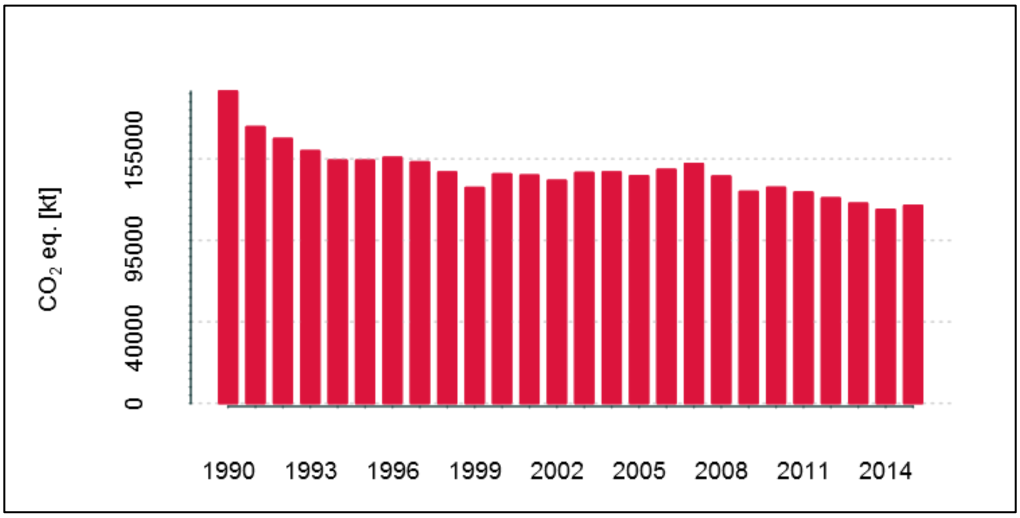



**Fig. 2-1 Total trend of GHG emissions, [kt $CO_2$ eq.]**

In 1989 then Czechoslovak economy was one of the centrally planned economies with high level of monopolization. All economic processes were controlled through central planning. For all practical purposes, there was no real market and this situation resulted in an ever deepening economic and technological lag which resulted in high energy and material inefficiency. Since 1989 to the present the economy transformed successfully to a developed market-driven economy. The transformation led to a decline in production, investment in environmental protection, energy efficiency, fuel switch and increasing use of renewable energy.

Greenhouse gases emission trend between 2007 and 2009 and supposedly up to present days passed through significant change driven mainly by economic recession. It is noteworthy that in 2015 some of the industrial and energy subsectors reached its lowest amounts of emitted GHGs according to the whole reported time-series.

## 2.2 Description and interpretation of emission trends by sector

### 2.2.1 Description and interpretation of emission trends by gas

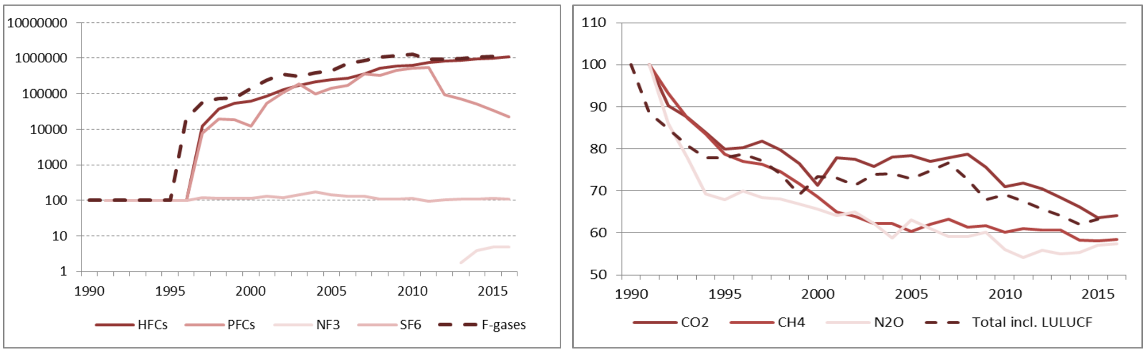



**Fig. 2-2 Trend in $CO_2$, $CH_4$ and $N_2O$ emissions 1990 - 2015 in index form (base year = 100%) and Trend in HFCs, PFCs (1995 – 2015) and $SF_6$ (1990 – 2015) actual emissions in index form (base year = 100%)**

The major greenhouse gas in the Czech Republic is $CO_2$, which represents 80.54% of total GHG emissions and removals in 2015, compared to 81.88% in the base year. It is followed by $CH_4$ (11.43% in 2015, 12.45% in the base year), $N_2O$ (5.08% in 2015, 5.63% in the base year) and F-gases (2.95% in 2015, 0.04% in the base year). The trend of individual GHG emissions relative to emissions in the respective base years is presented in Fig. 2-2.

***$CO_2$***

$CO_2$ emissions have been rapidly decreasing in early 90's, after 1994 the emissions have kept at average of 68% of the amount produced in 1990. Inter-annual decrease in $CO_2$ emissions (excl. LULUCF) from 2010 to 2015 by 10.67% results the total decrease of 35.81% from 1990 to 2015. Quoting in absolute figures, $CO_2$ emissions and removals decreased from 161 649.59 to 103 769.75 kt $CO_2$ in the period from 1990 to 2015, mainly due to lower emissions from the 1 Energy category (mainly 1.A.2 Manufacturing Industries & Construction, 1.A.4.a Commercial/Institutional and 1.A.4.b Residential).

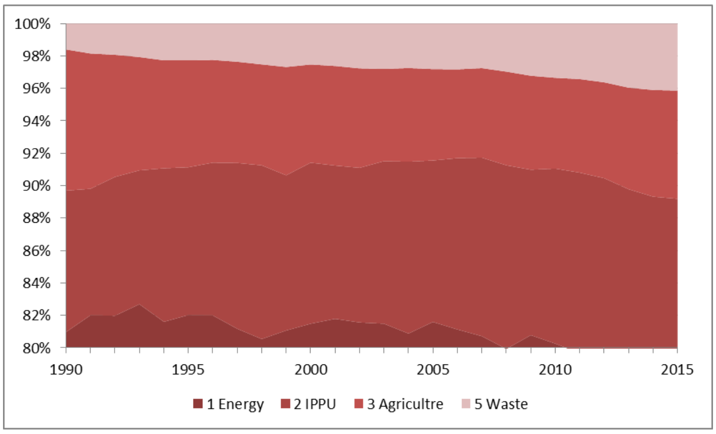



**Fig. 2-3 Percentual share of GHGs (Y-axis begins at 80% - part of $CO_2$ share is hidden)**

The main source of $CO_2$ emissions is fossil fuel combustion; within the 1.A Fuel Combustion category, 1.A.1 Energy Industry and 1.A.2 Manufacturing Industries & Construction sub-categories are the most important. $CO_2$ emissions increased remarkably between 1990 and 2015 from the 1.A.3 Transport category from 7 031.87 to 17 343.68 kt $CO_2$ eq.

***$CH_4$***

$CH_4$ emissions share decreased almost steadily during the period from 1990 to 2004, from 2004 methane fluctuated around 60% of its base year emissions. In 2015 $CH_4$ emissions were 41.60% below the base year level, mainly due to lower contribution of 1.B Fugitive Emissions from Fuels and emissions from 3 Agriculture and despite increase from the 5 Waste category. The main sources of $CH_4$ emissions are 1.B Fugitive Emissions from Fuels (solid fuel), 3 Agriculture (3.A Enteric Fermentation and 3.B Manure Management) and 5 Waste (5.A Solid Waste Disposal on Land and 5.B Wastewater Treatment and Discharge).

***$N_2O$***

$N_2O$ emissions strongly decreased from 1990 to 1994 by 32.11% over this period and then shows slow decreasing trend with inter-annual fluctuation. $N_2O$ emissions decreased between 1990 and 2015 from 10 642.52 to 6 112.73 kt $CO_2$ eq. In 2014 $N_2O$ emissions were 42.56% below the base year level, mainly due to lower emissions from 3 Agriculture and 2.B Chemical Industry and despite increase from the 1.A.3 Transport category.

The main source of $N_2O$ emission is category 3.D Agricultural Soils (others less important sources are 1.A Fossil Fuel Combustion and 2 Industrial Processes – 2.B Chemical Industry).

***HFCs***

HFCs actual emissions increased remarkably between 1995 and 2015 from 0.32 to 3 455.08 kt $CO_2$ eq. Emissions of HFCs have been rapidly increasing since the base year 1995. In 2015, HFCs emissions were more than 10 000-times higher than in the base year 1995.

The main sources of HFCs emissions are 2.F Product Uses as ODS substitutes (Refrigeration and Air Conditioning).

***PFCs***

PFCs actual emissions show very similar trend as HFCs emissions but on much lower scale. They increased between 1995 and 2015 from 0.01 to 1.96 kt $CO_2$ eq. In 2015, PFCs emissions are over 200 times higher than in the base year 1995. HFCs and PFCs have not been imported and used before 1995.

The main sources of PFCs emissions are Semiconductor Manufacture, Refrigeration and Air Conditioning equipment.

***$SF_6$***

$SF_6$ actual emissions in 1995 accounted for 88.47 kt $CO_2$ eq. Between 1995 and 2015 they inter-annually fluctuated with maximum of 144.19 kt $CO_2$ eq. in 2003 and minimum of 80.23 kt $CO_2$ eq. in 2010. In 2015 $SF_6$ reached amount of 90.55 kt, the level was 1.02% higher the base year (1995).

The main sources of $SF_6$ emissions is 2.G Other product manufacture and use.

***$NF_3$***

With the technological progress a new gas was included in the previous submission. $NF_3$ is a gas, used mainly for manufacturing of LCD displays, solar panels and etching semiconductors. Base year for this gas is 1995. In 2015 the emissions of $NF_3$ equalled to 2.29 kt $CO_2$ eq., which is 2.78% decrease, compared to year 2014.

### 2.2.2 Description and interpretation of emission trends by category

Fig. 2-4 presents a summary of GHG emissions by categories for the period from 1990 to 2015:

- Category 1 Energy
- Category 2 Industrial Processes and Product Use
- Category 3 Agriculture
- Category 4 LULUCF
- Category 5 Waste

The dominant category is the 1 Energy sector, which caused for 80.97% of total GHG emissions in 2015 (77.07% in 1990) excluding LULUCF, followed by the categories 2 Industrial Processes and Product Use and 3 Agriculture, which caused for 12.12% and 6.67% of total GHG emissions in 2015 (8.72% and 8.71% in 1990, resp.), 5 Waste category covered 4.13% and 4 LULUCF category removed 6 487.71 kt $CO_2$ eq. which represents share of 5.52% of all GHG emissions.

The trend of GHG emissions by categories is presented in Fig. 2-4 (indexed relative to the base year), see also the percentual share of individual sectors (Fig. 2-4).

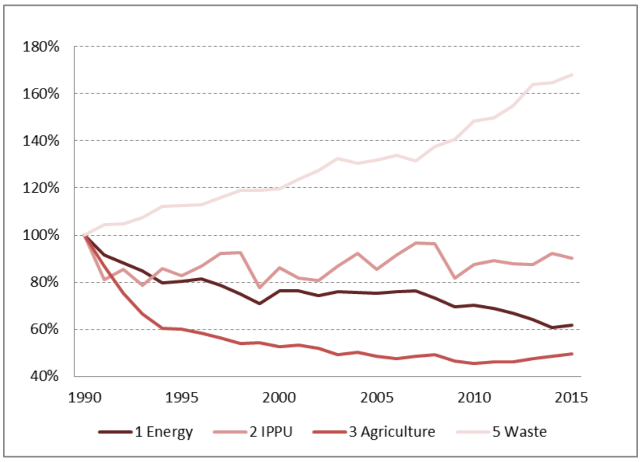



**Fig. 2-4 Emission trends in 1990-2015 by categories in index form (base year = 100)**

**Tab. 2-2 Summary of GHG emissions by category 1990-2015 [kt $CO_2$ eq.]**

| | 1 Energy | 2 IPPU | 3 Agriculture | 4 LULUCF | 5 Waste |
|---|---|---|---|---|---|
| **1990** | 158569.90 | 17080.37 | 17049.98 | -6487.71 | 3126.83 |
| **1991** | 145280.83 | 13822.62 | 14776.05 | -9608.86 | 3269.57 |
| **1992** | 139704.28 | 14587.97 | 12837.41 | -10096.28 | 3279.01 |
| **1993** | 134456.29 | 13429.78 | 11358.39 | -9692.70 | 3361.17 |
| **1994** | 126411.72 | 14667.86 | 10315.36 | -7569.01 | 3509.75 |
| **1995** | 127386.59 | 14157.41 | 10245.64 | -8046.44 | 3517.95 |
| **1996** | 129112.60 | 14834.19 | 9977.98 | -8393.65 | 3528.62 |
| **1997** | 124793.12 | 15727.31 | 9593.14 | -7476.59 | 3620.43 |
| **1998** | 119050.50 | 15833.77 | 9202.65 | -7621.31 | 3723.39 |
| **1999** | 112492.12 | 13282.45 | 9271.62 | -7905.05 | 3716.46 |
| **2000** | 120785.21 | 14720.47 | 8975.75 | -8805.07 | 3743.17 |
| **2001** | 120948.03 | 13979.55 | 9082.41 | -9133.21 | 3867.68 |
| **2002** | 117756.84 | 13767.46 | 8855.49 | -8765.67 | 3989.00 |
| **2003** | 120347.94 | 14815.57 | 8388.58 | -7266.25 | 4139.18 |
| **2004** | 120151.37 | 15745.25 | 8583.03 | -7788.08 | 4074.26 |
| **2005** | 119563.18 | 14591.83 | 8257.49 | -8134.59 | 4117.16 |
| **2006** | 120250.69 | 15663.66 | 8111.66 | -5969.29 | 4185.89 |
| **2007** | 120821.36 | 16482.26 | 8265.07 | -3759.54 | 4113.87 |
| **2008** | 116011.65 | 16438.62 | 8382.73 | -6910.63 | 4302.21 |
| **2009** | 110539.82 | 13964.07 | 7929.92 | -7932.08 | 4401.85 |
| **2010** | 111261.56 | 14965.30 | 7761.98 | -7200.07 | 4637.01 |
| **2011** | 109071.35 | 15257.84 | 7904.13 | -8388.97 | 4684.20 |
| **2012** | 105815.68 | 15012.07 | 7895.79 | -8552.72 | 4837.84 |
| **2013** | 101510.15 | 14982.78 | 8128.87 | -7920.23 | 5127.98 |
| **2014** | 96618.86 | 15787.85 | 8280.62 | -7801.09 | 5151.31 |
| **2015** | 97973.60 | 15413.84 | 8482.99 | -6640.69 | 5256.41 |
| **[1]%** | **1.40%** | **-2.37%** | **2.44%** | **-14.87%** | **2.04%** |
| **[2]%** | **-38.21%** | **-9.76%** | **-50.25%** | **2.36%** | **68.11%** |

*[1] Difference relative to previous year*

*[2] Difference relative to base year*

**Tab. 2-3 Overview of trends in categories and subcategories (kt $CO_2$ eq.)**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| **Total (net emissions)** | **189339.37** | **147261.15** | **139419.53** | **138395.08** | **131425.78** | **118037.53** | **120486.14** |
| **1. Energy** | **158569.90** | **127386.59** | **120785.21** | **119563.18** | **111261.56** | **96618.86** | **97973.60** |
| A. Fuel combustion (sectoral approach) | 146708.40 | 118081.58 | 113659.15 | 113154.06 | 105470.05 | 92105.06 | 93585.84 |
| 1. Energy industries | 56915.91 | 61850.19 | 62061.93 | 63165.64 | 61621.14 | 53533.77 | 53628.86 |
| 2. Manufacturing industries and construction | 51234.04 | 26177.60 | 23425.60 | 18844.61 | 12082.92 | 9703.89 | 9921.80 |
| 3. Transport | 7284.03 | 9354.55 | 11932.42 | 17106.65 | 17007.86 | 16966.80 | 17747.55 |
| 4. Other sectors | 31274.42 | 20699.24 | 16059.26 | 13763.70 | 14428.99 | 11581.60 | 11906.82 |
| 5. Other | NO | NO | 179.95 | 273.47 | 329.14 | 319.00 | 380.81 |
| B. Fugitive emissions from fuels | 11861.51 | 9305.01 | 7126.06 | 6409.12 | 5791.51 | 4513.80 | 4387.76 |
| 1. Solid fuels | 10779.39 | 8468.06 | 6249.66 | 5513.41 | 4894.36 | 3881.99 | 3774.33 |
| 2. Oil and natural gas and other emissions from energy production | 1082.12 | 836.95 | 876.40 | 895.71 | 897.15 | 631.81 | 613.43 |
| **2. Industrial Processes** | **17080.37** | **14157.41** | **14720.47** | **14591.83** | **14965.30** | **15787.85** | **15413.84** |
| A. Mineral industry | 4058.64 | 3002.08 | 3607.56 | 3314.59 | 3023.19 | 2538.66 | 2533.91 |
| B. Chemical industry | 2944.23 | 2808.20 | 2937.08 | 2837.88 | 2371.06 | 2372.84 | 2071.06 |
| C. Metal industry | 9661.62 | 7948.37 | 7435.43 | 7103.10 | 6752.62 | 7206.57 | 6895.94 |
| D. Non-energy products from fuels and solvent use | 125.56 | 103.75 | 148.60 | 136.23 | 117.72 | 116.64 | 139.55 |
| E. Electronic industry | NO,NE | NO,NE | 11.17 | 6.64 | 40.20 | 20.01 | 18.97 |
| F. Product uses as ODS substitutes | NO | 0.33 | 275.02 | 877.12 | 2356.78 | 3232.09 | 3456.60 |
| G. Other product manufacture and use | 290.32 | 294.69 | 305.63 | 316.27 | 303.73 | 301.04 | 297.81 |
| **3. Agriculture** | **17049.98** | **10245.64** | **8975.75** | **8257.49** | **7761.98** | **8280.62** | **8482.99** |
| A. Enteric fermentation | 5754.89 | 3588.22 | 3048.33 | 2848.41 | 2720.02 | 2817.27 | 2895.96 |
| B. Manure management | 4211.40 | 2796.78 | 2509.64 | 2178.08 | 1832.57 | 1753.38 | 1779.28 |
| D. Agricultural soils | 5797.33 | 3641.03 | 3257.89 | 3092.85 | 3036.67 | 3502.64 | 3457.76 |
| G. Liming | 1177.82 | 110.34 | 112.28 | 63.98 | 61.46 | 150.29 | 162.89 |
| H. Urea application | 108.53 | 109.27 | 47.61 | 74.17 | 111.27 | 57.03 | 187.10 |
| **4. Land use, land-use change and forestry** | **-6487.71** | **-8046.44** | **-8805.07** | **-8134.59** | **-7200.07** | **-7801.09** | **-6640.69** |
| A. Forest land | -4858.64 | -7116.58 | -7279.56 | -6407.45 | -5125.56 | -7318.76 | -6052.84 |
| B. Cropland | 120.62 | 127.91 | 89.27 | 49.02 | 30.67 | 17.14 | 4.67 |
| C. Grassland | -145.34 | -325.56 | -496.90 | -526.97 | -628.68 | -569.10 | -550.34 |
| D. Wetlands | 21.51 | 9.11 | 26.46 | 21.24 | 34.26 | 26.76 | 25.18 |
| E. Settlements | 85.09 | 90.72 | 132.24 | 164.42 | 128.58 | 127.60 | 88.12 |
| F. Other land | 0.00 | 0.00 | 0.00 | 10.27 | 7.21 | 8.55 | 7.55 |
| G. Harvested wood products | -1712.95 | -833.50 | -1277.79 | -1446.21 | -1647.68 | -94.41 | -164.15 |
| **5. Waste** | **3126.83** | **3517.95** | **3743.17** | **4117.16** | **4637.01** | **5151.31** | **5256.41** |
| A. Solid waste disposal | 1979.27 | 2404.98 | 2681.79 | 2867.18 | 3224.08 | 3330.79 | 3385.21 |
| B. Biological treatment of solid waste | NE,IE | NE,IE | NE,IE | 60.90 | 202.65 | 649.23 | 678.57 |
| C. Incineration and open burning of waste | 23.57 | 71.99 | 64.18 | 137.64 | 141.15 | 134.13 | 134.83 |
| D. Waste water treatment and discharge | 1123.99 | 1040.98 | 997.20 | 1051.44 | 1069.12 | 1037.16 | 1057.79 |
| Memo items: | | | | | | | |
| International bunkers | 528.22 | 562.83 | 593.83 | 978.94 | 965.41 | 882.76 | 895.14 |
| Aviation | 528.22 | 562.83 | 593.83 | 978.94 | 965.41 | 882.76 | 895.14 |
| $CO_2$ emissions from biomass | 6445.39 | 5787.22 | 6652.88 | 8667.39 | 12342.53 | 15726.25 | 16193.69 |
| Long-term storage of C in waste disposal sites | 15558.16 | 19620.02 | 24248.75 | 29472.04 | 35278.38 | 39196.76 | 40084.60 |
| Indirect $N_2O$ | 1307.45 | 629.48 | 499.88 | 475.63 | 391,22 | 318.85 | 308.79 |
| Indirect $CO_2$ | 2121.74 | 1745.19 | 1155.54 | 1083.21 | 967.43 | 777.69 | 798.70 |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | **195827.08** | **155307.59** | **148224.60** | **146529.67** | **138625.85** | **125838.63** | **127126.83** |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | **189339.37** | **147261.15** | **139419.53** | **138395.08** | **131425.78** | **118037.53** | **120486.14** |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | **197948.82** | **157052.78** | **149380.15** | **147612.88** | **139593.28** | **126616.31** | **127925.53** |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | **191461.11** | **149006.34** | **140575.08** | **139478.29** | **132393.21** | **118815.22** | **121284.84** |

***Energy (IPCC Category 1)***

The trend for GHG emissions from 1 Energy category shows decreasing trend of emissions. They strongly decreased from 1990 to 1994 and then fluctuated by 2002. After 2002 they stayed relatively stable by 2007. In the period 2002 – 2007 emissions kept around 120 000 kt $CO_2$ eq. Total decrease between 1990 and 2015 is 38.21%. Between 2014 to 2015 emissions from category 1 Energy slightly increased by 1.40%.

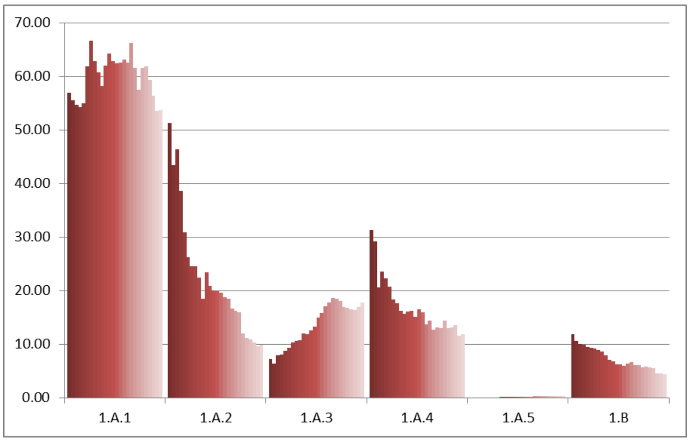



**Fig. 2-5 Trends in Energy by categories 1990-2015 (Tg $CO_2$ eq.)**

From the total 97 973.60kt $CO_2$ eq. in 2015 95.52% comes from 1.A Fuel Combustion, the rest are 1.B Fugitive Emissions from Fuels (mainly Solid Fuels). 1.B Fugitive Emissions from Fuels is the largest source for $CH_4$, which represented 30.62% of all $CH_4$ emissions in 2015. 37.22% of all $CH_4$ emissions in 2015 originated from Energy category.

$CO_2$ emissions from fossil fuels combustion (category 1.A Energy) are the main source in Czech Republic's inventory with a share of 88.52% in national $CO_2$ emissions (excl. LULUCF). $CO_2$ from category 1 Energy contributes for 73.62% to total GHG emissions, $CH_4$ for 6.60% and $N_2O$ for 13.49% in 2015.

***Industrial Processes and Product Use (IPCC Category 2)***

GHG emissions from the 2 Industrial Processes and Product Use category fluctuated with decreasing trend during the whole period 1990 to 2015. In early 90’s emissions decreased rather rapidly, then reached decade minimum in 1999 and subsequently decreased with total minimum in 2009 (global economic recession). Between 1990 and 2015 emissions from this category decreased by 9.76%. In 2015 emissions amounted for 15 413.84 kt $CO_2$ eq.

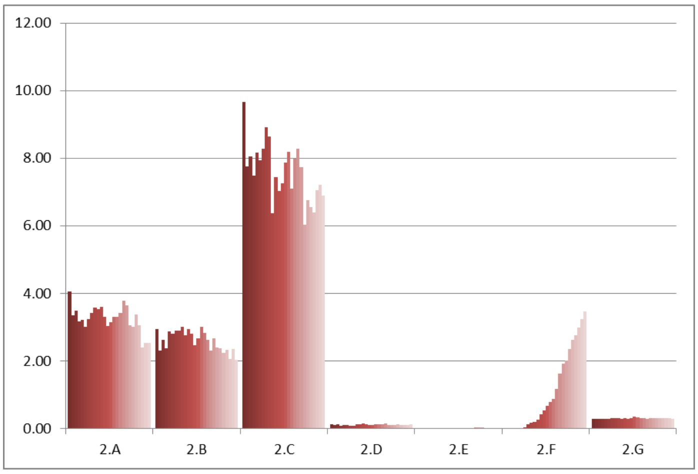



**Fig. 2-6 Trends in IPPU by categories 1990-2015**

The main categories in the 2 Industrial Processes and Product Use category are 2.C Metal Industry (44.74%), 2.F Product Uses as ODS substitutes (22.43%), 2.A Mineral Industry (16.44%) and 2.B Chemical Industry (13.44%) of the sectoral emissions in 2015 (Fig. 2-6).

The most important GHG of the 2 Industrial Processes and Product Use category was $CO_2$ with 72.89% of sectoral emissions, followed by F-gases (23.04%).

### *Agriculture (IPCC Category 3)*

GHG emissions from the category 3 Agriculture decreased relatively steadily over the period from 1990 to 2003 and then fluctuated. In 2010 emissions reached minimum level which is 54.48% below the base year level.

Agriculture amounted 8 482.99 kt $CO_2$ eq. in 2015 which corresponds to 6.67% of national total emissions (excluding LULUCF). The most important sub-category 3.D Agricultural Soils ($N_2O$ emissions) contributed by 40.76% to sectoral total in 2015, followed by the 3.A Enteric Fermentation ($CH_4$ emissions, 34.14%).

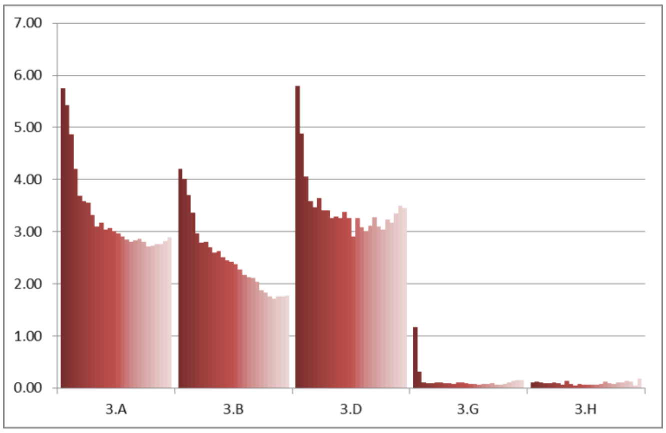



**Fig. 2-7 Trends in Agriculture by categories 1990-2015 (Tg $CO_2$ eq.)**

3 Agriculture is the largest source for $N_2O$ and second largest source for $CH_4$ emissions (73.05% of total emissions of $N_2O$ and 26.78% of total emissions of $CH_4$, excluding LULUCF). However it's emission trend steadily decreases over the whole observed period.

### *Land Use, Land-Use Change and Forestry (IPCC Category 4)*

GHG removals from the 4 Land Use, Land-Use Change and Forestry category vary through the whole time series with minimum of -10 096.28kt $CO_2$ eq. in 1992 and maximum -3 759.54 kt $CO_2$ eq. in 2007. In 2015 removals were by 2.36% above the base year level.

Emissions and removals amounted to -6 640.69 kt $CO_2$ eq. in 2015, which corresponds to 5.22% of total national emissions. Emissions and removals are calculated from all categories and in line with GPG for LULUCF; IPCC 2003 and IPCC 2006 Gl.

LULUCF category is the largest sink for $CO_2$. Net $CO_2$ removals from this category amounted to -6 735.41 kt $CO_2$ eq. in 2015. $CH_4$ emissions amounted to 81.91 kt $CO_2$ eq., $N_2O$ to 12.81 kt $CO_2$ eq. Trends of the sub-categories in LULUCF sector are presented in Fig. 2-8.

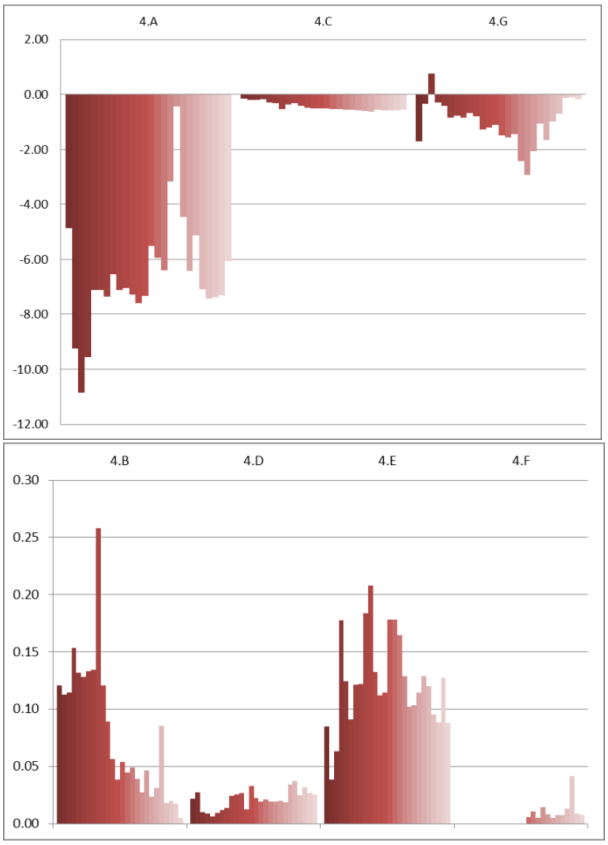



**Fig. 2-8 Trends in LULUCF by separate source and sink categories 1990 – 2015 (Tg $CO_2$ eq.)**

***Waste (IPCC Category 5)***

GHG emissions from category 5 Waste substantially increased during the whole period. In 2015 emissions amounted for 5 256.41 kt $CO_2$ eq., which is 68.11% above the base year level. The increase of emissions is mainly due to higher emissions of $CH_4$ from 5.A Solid Waste Disposal and due higher emissions in 5.C Incineration and open burning of waste. As a result of $CH_4$ recovery systems installed in 5.B Wastewater Treatment and Discharge total emissions from this category decreased by approx. 32% compared to the base year. The share of category 5 Waste in total emissions was 4.13% in 2015.

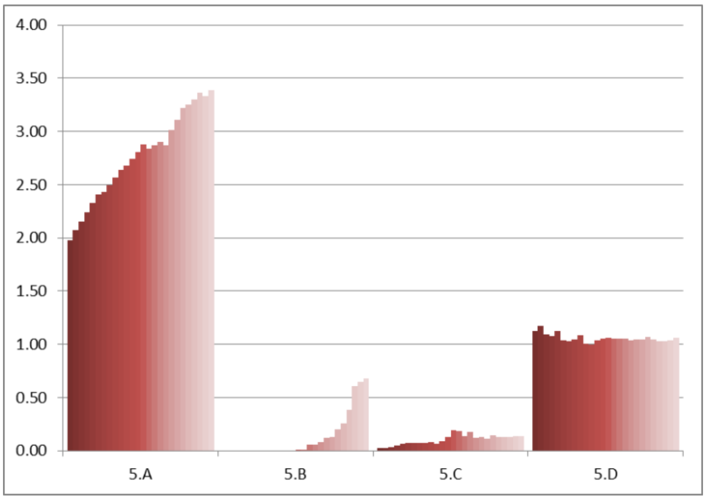



**Fig. 2-9 Trends in Waste by categories 1990-2015 (Tg $CO_2$ eq.)**

The main source is solid 5.A Solid Waste Disposal, which accounted for 69.37% of sectoral $CH_4$ emissions in 2015, followed by 5.D Wastewater Treatment and Discharge (17.64%) and 5.B Biological treatment of solid waste (12.99%). Trends of the separate sub-categories in Waste sector can be observed on Fig. 2-9.

92.83% of all emissions from Waste category are $CH_4$ emissions; $CO_2$ contributes by 2.52% and $N_2O$ by 4.65%.

### 2.2.3 Description and interpretation of emission trends of indirect greenhouse gases and $SO_2$

Description of trends of emissions of indirect greenhouse gases is provided in Chapter 9.

### 2.2.4 Description and interpretation of emission trends for KP-LULUCF inventory

Of the qualifying KP LULUCF activities, emission removals from Forest Management dominate for all years in the reported period from 2013 to 2015. There removals are enhanced by estimates for Afforestation/Reforestation activities and by the contribution from changes in carbon pools associated with Harvested Wood Products (HWP). On the contrary, Deforestation represents emissions for all years (Tab. 2-4).

**Tab. 2-4 Summary of GHG emissions and removals for KP LULUCF activities [kt $CO_2$ eq.]**

| Year | Article 3.3 activities | | Article 3.4 activities | | HWP |
|---|---|---|---|---|---|
| | Afforestation and Reforestation | Deforestation | Forest Management | Other Art. 3.4 activities | HWP contribution |
| **2013** | -491.6 | 234.3 | -6 405.3 | NA | -134.0 |
| **2014** | -549.8 | 231.2 | -6 280.9 | NA | -94.1 |
| **2015** | -589.4 | 179.7 | -5 075.6 | NA | -164.2 |
| **Total*** | -1 631.7 | 645.2 | -17 651.7 | NA | -392.2 |

**) Cumulative net emissions and removals for all years of the commitment period reported in the current submission*

# 3 Energy (CRF Sector 1)

## 3.1 Overview of sector

The energy sector in the Czech Republic is driven by the combustion of fossil fuels in stationary and mobile sources; however fugitive emissions are also important source of emissions. The two main categories are 1.A Fuel Combustion and 1.B Fugitive Emissions from Fuels.

Activity data are based on the energy balance of the Czech Republic prepared by the Czech Statistical Office (CzSO). Data from the energy balance form the basic framework for processing greenhouse gas emissions from combustion in stationary and mobile sources. Greenhouse gas emissions from stationary sources are calculated from the activity data and the emission factors.

Processing of the activity data is based on the total energy balance of the Czech Republic. The energy balance is prepared by CzSO, and is divided into issues for Solid Fuels, Liquid Fuels, Natural Gas, renewable energy sources and production of heat and electrical energy. Information on the energy balance forms the basis for preparing a database of activity data in the Reference and Sectoral Approaches. The Reference Approach is based on data from the source part of the energy balance; the Sectoral Approach involves processing of data on fuel consumption in a structure corresponding to the requirements of the IPCC categorization. In 2016 CzSO carried on extensive updates of activity data which are resulting in increased amount of recalculations appeared in this submission compared to the previous years.

Default emission factors from the IPCC methodology have been for key categories gradually substituted by country specific emission factors.

Inventories of $CO_2$, $CH_4$ and $N_2O$ emissions from subsector 1.A.3 Transport are performed using the CDV model for mobile sources. This model is fully harmonised with activity data from the official CzSO Energy balance mentioned above.

Fugitive emissions in sector 1.B are determined by calculation from activity data and country-specific or default emission factors. The activity data are obtained first of all from the official CzSO energy balance. The sector statistics and annual targeted surveys are used in special cases, when data missing or are insufficient.

### 3.1.1 Key categories in sector 1 Energy

Combustion processes included in category 1.A make a decisive contribution to total emissions of greenhouse gases. All $CO_2$, $CH_4$ and $N_2O$ emissions are derived from the combustion of fossil respectively biofuels and other fuels in stationary and mobile sources.

On the whole, 14 key sources have been identified in sector 1, the most important of which are the first 4 given Tab 3-1. This group of sources contributes 77.5% to total greenhouse gas emissions (without LULUCF).

It is apparent from the table that the first four categories are of fundamental importance for the level of greenhouse gas emissions in the Czech Republic and, of these, the combustion of Solid Fuels constitutes a decisive source. This consists primarily in the combustion of Solid Fuels for the production of electricity and supply of heat. Another important category consists in the combustion of Liquid Fuels in the transport sector and the combustion of Natural Gas has approximately the same importance. This corresponds mostly to the direct production of heat for buildings in the private and public sector and for households. Consequently, increased attention is paid to it.

The results of the inventory, including the activity data, are submitted in the standard CRF format. For direct greenhouse gases, the consumption of fuels and "implied" emission factors are also given. However, for stationary sources, the fuel consumption is given in the CRF format in aggregated structure, i.e. as Solid, Liquid and Gaseous Fuels according to IPCC definition. All the CRF Tables in sector 1.A were appropriately completed for the entire required time interval of 1990 to 2015.

In 1.B Fugitive Emissions from Fuels category, especially 1.B.1.a Coal Mining and Handling was evaluated as a key category (Tab. 3-1.) Category 1.B.2 also was identified as a key category by the latest assessment, but only in one from the four tests (LA). Moreover, identifiers placed this category just over the borderline between key and non-key categories.

**Tab. 3-1 Overview of key categories in 1 Energy (2015)**

| Category | Gas | KC A1 | KC A2 | KC A1 incl. LULUCF | KC A1 excl. LULUCF | KC A2 incl. LULUCF | KC A2 excl. LULUCF | % of total GHG incl. LULUCF | % of total GHG excl. LULUCF |
|---|---|---|---|---|---|---|---|---|---|
| **1.A Stationary Combustion - Solid Fuels** | $CO_2$ | LA,TA | LA, TA | yes | yes | yes | yes | 44.04 | 46.45 |
| **1.A Stationary Combustion - Liquid Fuels** | $CO_2$ | LA,TA | LA, TA | yes | yes | yes | yes | 2.11 | 2.22 |
| **1.A.3.b Transport - Road Transportation** | $CO_2$ | LA,TA | LA, TA | yes | yes | yes | yes | 13.28 | 14.00 |
| **1.A Stationary Combustion - Gaseous Fuels** | $CO_2$ | LA,TA | LA, TA | yes | yes | yes | yes | 11.27 | 11.89 |
| **1.B.1.a Coal Mining and Handling** | $CH_4$ | LA,TA | LA, TA | yes | yes | yes | yes | 2.80 | 2.95 |
| **1.B.2 Fugitive Emission from Oil, Natural Gas** | $CH_4$ | LA | LA | yes | no | yes | yes | 0.48 | 0.50 |
| **1.A Stationary Combustion - Solid Fuels** | $CH_4$ | TA | TA | yes | yes | yes | yes | 0.19 | 0.21 |
| **1.A Stationary Combustion - Other fuels - 1A2** | $CO_2$ | TA | | yes | yes | | | 0.30 | 0.32 |
| **1.A Stationary Combustion - Biomass** | $CH_4$ | TA | | yes | yes | | | 0.47 | 0.49 |
| **1.A.5.b Mobile sources in Agriculture and Forestry** | $CO_2$ | TA | | yes | yes | | | 0.21 | 0.22 |
| **1.A.3.b Transport - Road Transportation** | $N_2O$ | TA | | yes | yes | | | 0.27 | 0.29 |
| **1.A Stationary Combustion - Liquid Fuels** | $N_2O$ | TA | | yes | yes | | | 0.11 | 0.12 |
| **1.A Stationary Combustion - Other fuels - MSW** | $CO_2$ | TA | | yes | no | | | 0.17 | 0.18 |
| **1.A.3.c Transport - Railways** | $CO_2$ | TA | | yes | no | | | 0.21 | 0.22 |

*KC: key category*

### 3.1.2 Emissions Trends

$CO_2$ emissions from the 1.A sector decreased by 36.33% from 144 Mt $CO_2$ in 1990 to 92 Tg $CO_2$ in 2015. Furthermore $CO_2$ emissions from the 1.B sector decreased by 55.7% from 458 kt in 1990 to 194 kt in 2015, as well as $CH_4$ emissions from 1.B sectors decreased by 63.22% from 456 kt in 1990 to 168 kt in 2015. Fig. 3-1 indicates overall trend in $CO_2$ and $CH_4$ emissions in the whole time series for both sectors. Furthermore Tab. 3-2 provides data for trends in 1 Energy for each gas reported in sector.

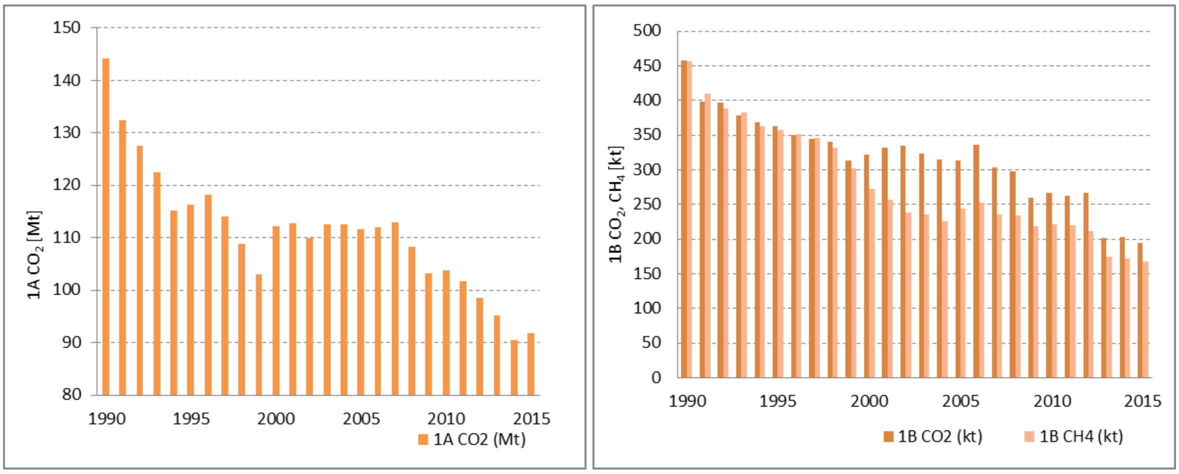



**Fig. 3-1 Trend total $CO_2$ (Sectoral Approach) in 1.A and trend of $CO_2$ and $CH_4$ from 1.B sector in period 1990 – 2015**

**Tab. 3-2 Emissions of greenhouse gases and their trend from 1990 – 2015 from IPCC Category 1 Energy**

| | $CO_2$ [kt] | $CH_4$ [kt] | $N_2O$ [kt] |
|---|---|---|---|
| **1990** | 144 726 | 520.9 | 2.752 |
| **1991** | 132 820 | 468.2 | 2.538 |
| **1992** | 127 970 | 439.1 | 2.544 |
| **1993** | 122 950 | 430.6 | 2.490 |
| **1994** | 115 488 | 407.3 | 2.485 |
| **1995** | 116 679 | 397.9 | 2.549 |
| **1996** | 118 482 | 392.9 | 2.712 |
| **1997** | 114 389 | 383.8 | 2.713 |
| **1998** | 109 145 | 363.6 | 2.739 |
| **1999** | 103 357 | 331.7 | 2.826 |
| **2000** | 112 532 | 302.4 | 2.328 |
| **2001** | 113 051 | 287.6 | 2.370 |
| **2002** | 110 313 | 269.0 | 2.409 |
| **2003** | 112 924 | 266.7 | 2.541 |
| **2004** | 112 959 | 256.4 | 2.627 |
| **2005** | 111 920 | 273.4 | 2.712 |
| **2006** | 112 335 | 283.6 | 2.768 |
| **2007** | 113 330 | 265.3 | 2.881 |
| **2008** | 108 553 | 264.4 | 2.850 |
| **2009** | 103 417 | 251.6 | 2.793 |
| **2010** | 104 043 | 256.0 | 2.743 |
| **2011** | 101 901 | 254.0 | 2.752 |
| **2012** | 98 833 | 246.9 | 2.717 |
| **2013** | 95 388 | 212.9 | 2.685 |
| **2014** | 90 622 | 207.9 | 2.684 |
| **2015** | 92 052 | 203.9 | 2.768 |
| **Trend 1990/2015** | **-36%** | **-61%** | **1%** |

### *3.1.2.1 Emission trends by subcategories*

The individual subsectors have different contributions to trends in emissions. Fig. 3-2 illustrates the trends in emissions on the example of $CO_2$ emissions and the share of $CO_2$ emissions in different subsectors in 2015.

The greatest increase in emissions was recorded in subsector 1.A.3 Transport between 1990 and 2007, when emissions increased by 160%. In absolute values, this corresponded to an increase from 7 Tg $CO_2$ in 1990 to 18.3 Tg in 2007. A slight decrease has been apparent since 2008, while between 2014 and 2015

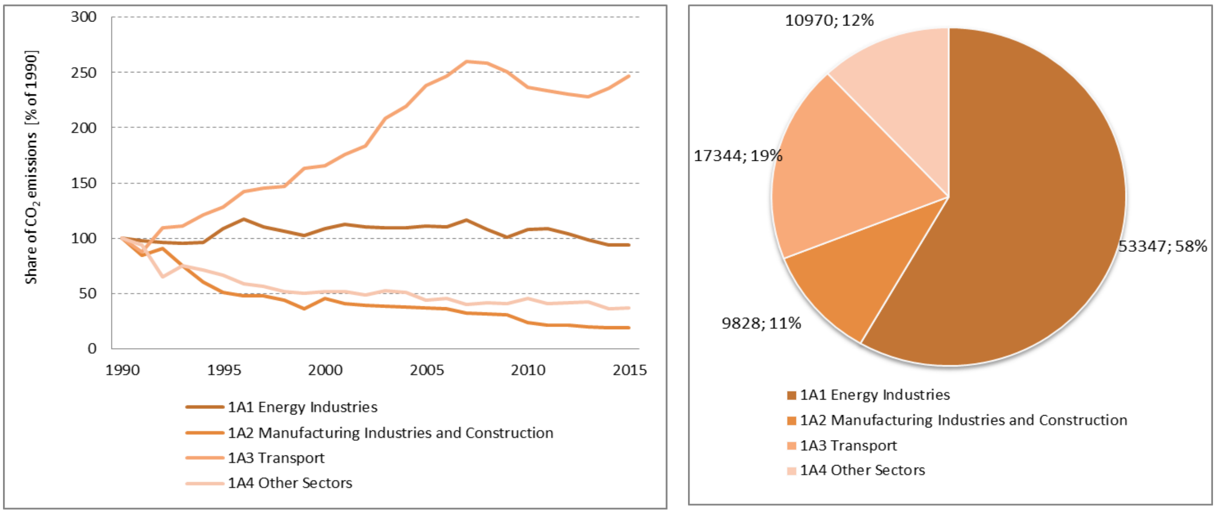



**Fig. 3-2 Share and development of $CO_2$ emissions from 1990 - 2015 in individual sub-sectors; share of $CO_2$ emissions in individual subsectors in 2015 [kt]**

is apparent slight increase by 0.7 Tg. Emissions from subsector 1.A.1 Energy Industries are almost constant with slight fluctuations over the entire period; the greatest reduction occurred in subsectors 1.A.2 and 1.A.4 from 50.9 and 29.7 Tg $CO_2$ in 1990 to 11 and 9.8 Tg $CO_2$ in 2015, respectively.

The fugitive emissions from Solid fuels also indicate substantial decrease in the whole time-series, i.e. 58.7% for $CO_2$ emission and 65.2% for $CH_4$ emissions. Fugitive $CH_4$ emissions from Oil and Natural Gas also indicate decrease for 43.7% in the time series. Fugitive $CO_2$ emissions from Oil and Natural Gas indicates increase, however these emissions are of minor importance in the whole submission.

The trends for different subcategories are also presented in Tab. 3-3.

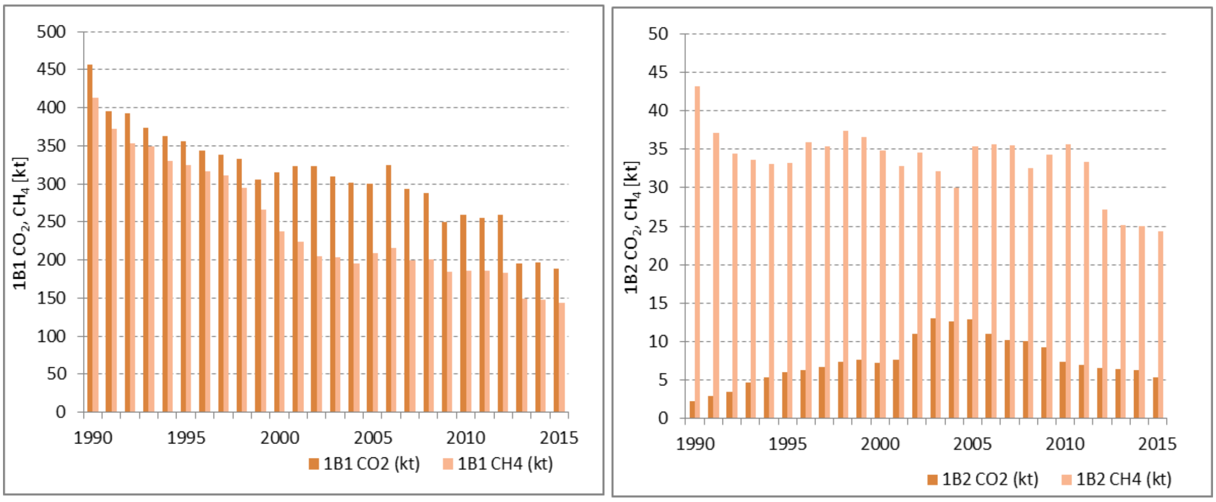



**Fig. 3-3 $CO_2$ and $CH_4$ trend from the sector Fugitive Emissions from Solid Fuels and from from the sector Fugitive Emissions from Oil and Natural Gas**

**Tab. 3-3 Total GHG emissions in [kt $CO_2$ equivalent] from 1990 – 2015 by sub categories of Energy**

| | 1 | 1.A | 1.A.1 | 1.A.2 | 1.A.3 | 1.A.4 | 1.A.5 | 1.B | 1.B.1 | 1.B.2 |
|---|---|---|---|---|---|---|---|---|---|---|
| **1990** | 158 570 | 146 708 | 56 916 | 51 234 | 7 284 | 31 274 | NO | 11 862 | 10 779 | 1 082 |
| **1991** | 145 281 | 134 652 | 55 540 | 43 482 | 6 390 | 29 240 | NO | 10 628 | 9 698 | 931 |
| **1992** | 139 704 | 129 614 | 54 705 | 46 354 | 7 973 | 20 582 | NO | 10 090 | 9 227 | 863 |
| **1993** | 134 456 | 124 523 | 54 321 | 38 583 | 8 076 | 23 543 | NO | 9 933 | 9 088 | 845 |
| **1994** | 126 412 | 116 968 | 54 969 | 30 860 | 8 812 | 22 327 | NO | 9 444 | 8 612 | 832 |
| **1995** | 127 387 | 118 082 | 61 850 | 26 178 | 9 355 | 20 699 | NO | 9 305 | 8 468 | 837 |
| **1996** | 129 113 | 119 958 | 66 578 | 24 625 | 10 366 | 18 390 | NO | 9 155 | 8 250 | 905 |
| **1997** | 124 793 | 115 802 | 62 867 | 24 608 | 10 602 | 17 725 | NO | 8 991 | 8 099 | 892 |
| **1998** | 119 051 | 110 414 | 60 726 | 22 509 | 10 747 | 16 259 | 173 | 8 636 | 7 696 | 940 |
| **1999** | 112 492 | 104 611 | 58 225 | 18 507 | 11 986 | 15 727 | 167 | 7 881 | 6 959 | 922 |
| **2000** | 120 785 | 113 659 | 62 062 | 23 426 | 11 932 | 16 059 | 180 | 7 126 | 6 250 | 876 |
| **2001** | 120 948 | 114 196 | 64 245 | 20 879 | 12 662 | 16 248 | 161 | 6 752 | 5 925 | 828 |
| **2002** | 117 757 | 111 452 | 62 800 | 19 999 | 13 244 | 15 168 | 242 | 6 305 | 5 431 | 873 |
| **2003** | 120 348 | 114 133 | 62 449 | 19 937 | 15 018 | 16 484 | 245 | 6 215 | 5 399 | 816 |
| **2004** | 120 151 | 114 204 | 62 568 | 19 569 | 15 773 | 16 020 | 273 | 5 947 | 5 186 | 762 |
| **2005** | 119 563 | 113 154 | 63 166 | 18 845 | 17 107 | 13 764 | 273 | 6 409 | 5 513 | 896 |
| **2006** | 120 251 | 113 615 | 62 615 | 18 543 | 17 765 | 14 433 | 259 | 6 635 | 5 735 | 900 |
| **2007** | 120 821 | 114 638 | 66 264 | 16 659 | 18 691 | 12 677 | 347 | 6 183 | 5 287 | 897 |
| **2008** | 116 012 | 109 875 | 61 533 | 16 197 | 18 564 | 13 204 | 377 | 6 136 | 5 312 | 825 |
| **2009** | 110 540 | 104 811 | 57 477 | 15 948 | 18 019 | 13 003 | 364 | 5 729 | 4 861 | 868 |
| **2010** | 111 262 | 105 470 | 61 621 | 12 083 | 17 008 | 14 429 | 329 | 5 792 | 4 894 | 897 |
| **2011** | 109 071 | 103 315 | 61 881 | 11 191 | 16 823 | 13 032 | 387 | 5 756 | 4 917 | 839 |
| **2012** | 105 816 | 100 276 | 59 304 | 10 893 | 16 552 | 13 211 | 316 | 5 540 | 4 856 | 684 |
| **2013** | 101 510 | 96 939 | 56 306 | 10 312 | 16 430 | 13 581 | 309 | 4 571 | 3 937 | 634 |
| **2014** | 96 619 | 92 105 | 53 534 | 9 704 | 16 967 | 11 582 | 319 | 4 514 | 3 882 | 632 |
| **2015** | 97 974 | 93 586 | 53 629 | 9 922 | 17 748 | 11 907 | 381 | 4 388 | 3 774 | 613 |
| **Total Trend 1990 - 2015** | **-38%** | **-36%** | **-5,8%** | **-81%** | **144%** | **-62%** | **121%**[1)] | **-63%** | **-65%** | **-43%** |

[1)] *Trend 1998-2015*

## 3.2 Fuel combustion activities (CRF 1.A)

### 3.2.1 Comparison of the sectoral approach with the reference approach

In addition to the Sectoral approach (SA), used commonly for determination of greenhouse gas emissions from sector 1.A, the IPCC methodology requires also to perform a Reference Approach (RA), whose main objective is to control the estimation of the $CO_2$ emissions in the Sectoral approach. The calculation does not require a lot of input activity data, since the reference approach requires only the basic values included in the source section of the national energy balance (primary sources) and some additional information. It provides information only on total $CO_2$ emissions without any further division into consumer sectors.

From 2015 submission onward, it is required to use the Reference Approach in line with IPCC 2006 Guidelines (IPCC, 2006). Main difference between the new reference approach in contrast with the old one, used until now (IPCC 1997), is that instead of the concept of “long-term stored carbon” (stored carbon), used for some non-energy fuels, now a new, broader concept is used - “excluded carbon”, which includes not only the stored carbon, but also carbon used and emitted as $CO_2$ in other sectors, not only in 1.A (most often in sector 2 IPPU). This means that from the total carbon, calculated on the base of apparent domestic consumption (Apparent consumption, AC) is deducted the “excluded carbon”. It is mainly the case of carbon contained in fossil fuels used: (i) as raw materials for further treatment in the industry (feedstocks), (ii) as reductants and (iii) as non-energy products.

Overview of materials, containing “excluded carbon” is given in Tab. 3-4.

**Tab. 3-4 Products used as feedstocks, reductants, and for non-energy products (IPCC, 2006)**

| | |
|---|---|
| **Feedstocks** | **Naphtha** |
| | **LPG (propane - butane)** |
| | **Oils used as feedstocks** |
| | **Refinery gas** |
| | **Natural gas** |
| | **Ethane** |
| **Reductants** | **Metallurgical coke and petroleum coke** |
| | **Coal and coal tar/pitch** |
| | **Natural gas** |
| **Non-energy products** | **Bitumen** |
| | **Lubricants** |
| | **Paraffin waxes** |
| | **White spirit** |

For fuels, which are used in other sectors, than Energy sector – 1.A (i.e. non-energy fuels: for example coke or naphtha), it is necessary to know, what quantity of certain material is used outside 1.A (e.g. like feedstock or reductant).

In the Czech national inventory above mentioned “excluded carbon” is considered for counting in case of the following substances:

- Naphtha
- Bitumen
- Paraffin waxes
- Oils, used for production of hydrogen by partial oxidation (further for ammonia)
- White spirit

In Tab. 3-5 and 3-6 are reported values, set by the reference approach for the years 1990, 1995, 2000, 2005, 2010, 2011, 2012, 2013, 2014 and 2015 and a comparison between the reference and sectoral approach for the same years. In Tab. 3-7 is summarized comparison for all time period. In majority of cases relative differences are less than 2%.

**Tab. 3-5 Activity data in energy units (TJ), used in reference and sectoral approach for basic groups of fossil fuels**

| Year | Type of fossil fuels | Apparent Consumption (PJ) | Carbon excluded (PJ) | Reference approach (PJ) | Sectoral approach (PJ) | (RA-SA)/SA (%) |
|---|---|---|---|---|---|---|
| **1990** | Liquid Fuels | 358.6 | 71.8 | 286.8 | 300.0 | -4.4 |
| | Solid Fuels | 1315.1 | 86.7 | 1228.4 | 1150.0 | 6.8 |
| | Gaseous Fuels | 219.9 | | 219.9 | 205.4 | 7.0 |
| | Other Fuels | | | | 0.3 | |
| | **Total** | **1893.5** | **158.5** | **1735.1** | **1655.7** | **4.8** |
| **1995** | Liquid Fuels | 321.3 | 97.0 | 224.3 | 240.0 | -6.5 |
| | Solid Fuels | 937.6 | 71.0 | 866.6 | 878.7 | -1.4 |
| | Gaseous Fuels | 274.7 | | 274.7 | 260.8 | 5.3 |
| | Other Fuels | | | | 0.7 | |
| | **Total** | **1533.7** | **168.0** | **1365.7** | **1380.2** | **-1.1** |
| **2000** | Liquid Fuels | 311.4 | 87.6 | 223.8 | 238.6 | -6.2 |
| | Solid Fuels | 901.8 | 66.3 | 835.5 | 810.1 | 3.1 |
| | Gaseous Fuels | 314.5 | | 314.5 | 305.1 | 3.1 |
| | Other Fuels | | | | 1.3 | |
| | **Total** | **1527.7** | **153.9** | **1373.8** | **1355.0** | **1.4** |
| **2005** | Liquid Fuels | 387.5 | 111.4 | 276.2 | 292.1 | -5.4 |
| | Solid Fuels | 847.1 | 75.5 | 771.6 | 754.7 | 2.2 |
| | Gaseous Fuels | 323.0 | | 323.0 | 318.9 | 1.3 |
| | Other Fuels | | | | 5.7 | |
| | **Total** | **1557.6** | **186.8** | **1370.8** | **1371.3** | **0.0** |
| **2010** | Liquid Fuels | 369.9 | 99.6 | 270.3 | 277.3 | -2.5 |
| | Solid Fuels | 781.0 | 71.5 | 709.5 | 687.1 | 3.3 |
| | Gaseous Fuels | 338.5 | 3.8 | 334.7 | 309.8 | 8.1 |
| | Other Fuels | | | | 5.9 | |
| | **Total** | **1489.4** | **174.9** | **1314.5** | **1280.1** | **2.7** |
| **2011** | Liquid Fuels | 358.0 | 92.6 | 265.4 | 272.1 | -2.5 |
| | Solid Fuels | 766.6 | 70.8 | 695.8 | 680.1 | 2.3 |
| | Gaseous Fuels | 285.7 | 4.0 | 281.7 | 282.5 | -0.3 |
| | Other Fuels | | | | 6.8 | |
| | **Total** | **1410.2** | **167.4** | **1242.8** | **1241.5** | **0.1** |
| **2012** | Liquid Fuels | 353.2 | 95.2 | 258.0 | 266.5 | -3.2 |
| | Solid Fuels | 721.3 | 71.0 | 650.3 | 656.6 | -1.0 |
| | Gaseous Fuels | 287.6 | 4.1 | 283.5 | 278.3 | 1.9 |
| | Other Fuels | | | | 5.8 | |
| | **Total** | **1362.0** | **170.2** | **1191.8** | **1207.2** | **-1.3** |
| **2013** | Liquid Fuels | 340.9 | 90.1 | 250.8 | 257.2 | -2.5 |
| | Solid Fuels | 716.4 | 73.7 | 642.7 | 629.1 | 2.2 |
| | Gaseous Fuels | 291.4 | 3.9 | 287.6 | 282.8 | 1.7 |
| | Other Fuels | | | | 4.7 | |
| | **Total** | **1348.7** | **167.7** | **1181.0** | **1173.7** | **0.6** |
| **2014** | Liquid Fuels | 362.3 | 100.6 | 261.7 | 269.5 | -2.9 |
| | Solid Fuels | 665.5 | 75.8 | 589.7 | 585.9 | 0.7 |
| | Gaseous Fuels | 259.4 | 4.0 | 255.4 | 250.4 | 2.0 |
| | Other Fuels | | | | 5.7 | |
| | **Total** | **1287.1** | **180.3** | **1106.8** | **1111.5** | **-0.4** |
| **2015** | Liquid Fuels | 354.8 | 81.9 | 272.9 | 281.3 | -3.0 |
| | Solid Fuels | 684.6 | 74.6 | 610.0 | 582.5 | 4.7 |
| | Gaseous Fuels | 272.0 | 4.0 | 268.0 | 263.3 | 1.8 |
| | Other Fuels | | | | 7.0 | |
| | **Total** | **1311.3** | **160.5** | **1150.9** | **1134.1** | **1.5** |

**Tab. 3-6 Results for $CO_2$ emissions (kt) according to reference approach and comparison with sectoral approach**

| Year | Type of fossil fuels | Apparent Consumption (kt $CO_2$) | Carbon excluded (kt $CO_2$) | RA (kt $CO_2$) | SA (kt $CO_2$) | (RA-SA)/SA (%) |
|---|---|---|---|---|---|---|
| **1990** | Liquid Fuels | 26 352 | 5 392 | 20 959 | 22 220 | -5.7 |
| | Solid Fuels | 127 096 | 9 280 | 117 816 | 110 823 | 6.3 |
| | Gaseous Fuels | 11 990 | 0 | 11 990 | 11 201 | 7.0 |
| | Other Fuels | | | | 24 | |
| | **Total** | **165 438** | **14 672** | **150 766** | **144 268** | **4.5** |
| **1995** | Liquid Fuels | 23 432 | 7 197 | 16 235 | 17 530 | -7.4 |
| | Solid Fuels | 90 470 | 7 600 | 82 870 | 84 384 | -1.8 |
| | Gaseous Fuels | 15 110 | 0 | 15 110 | 14 343 | 5.3 |
| | Other Fuels | | | | 60 | |
| | **Total** | **129 012** | **14 797** | **114 215** | **116 317** | **-1.8** |
| **2000** | Liquid Fuels | 22 801 | 6 481 | 16 320 | 17 296 | -5.6 |
| | Solid Fuels | 87 187 | 7 093 | 80 094 | 78 020 | 2.7 |
| | Gaseous Fuels | 17 297 | 0 | 17 297 | 16 777 | 3.1 |
| | Other Fuels | | | | 117 | |
| | **Total** | **127 286** | **13 574** | **113 711** | **112 210** | **1.3** |
| **2005** | Liquid Fuels | 28 359 | 8 282 | 20 077 | 21 108 | -4.9 |
| | Solid Fuels | 81 664 | 7 750 | 73 914 | 72 462 | 2.0 |
| | Gaseous Fuels | 17 765 | 0 | 17 765 | 17 535 | 1.3 |
| | Other Fuels | | | | 501 | |
| | **Total** | **127 788** | **16 032** | **111 756** | **111 606** | **0.1** |
| **2010** | Liquid Fuels | 27 104 | 7 394 | 19 710 | 20 018 | -1.5 |
| | Solid Fuels | 75 294 | 7 296 | 67 999 | 66 120 | 2.8 |
| | Gaseous Fuels | 18 717 | 210 | 18 507 | 17 127 | 8.1 |
| | Other Fuels | | | | 512 | |
| | **Total** | **121 116** | **14 900** | **106 216** | **103 777** | **2.4** |
| **2011** | Liquid Fuels | 26 201 | 6 883 | 19 317 | 19 661 | -1.7 |
| | Solid Fuels | 74 364 | 7 238 | 67 126 | 65 778 | 2.0 |
| | Gaseous Fuels | 15 786 | 220 | 15 565 | 15 610 | -0.3 |
| | Other Fuels | | | | 589 | |
| | **Total** | **116 350** | **14 342** | **102 009** | **101 638** | **0.4** |
| **2012** | Liquid Fuels | 25 876 | 7 072 | 18 804 | 19 243 | -2.3 |
| | Solid Fuels | 69 823 | 7 215 | 62 607 | 63 423 | -1.3 |
| | Gaseous Fuels | 15 876 | 225 | 15 651 | 15 363 | 1.9 |
| | Other Fuels | | | | 539 | |
| | **Total** | **111 574** | **14 512** | **97 062** | **98 568** | **-1.5** |
| **2013** | Liquid Fuels | 24 950 | 6 691 | 18 259 | 18 584 | -1.8 |
| | Solid Fuels | 68 895 | 7 487 | 61 408 | 60 550 | 1.4 |
| | Gaseous Fuels | 16 117 | 215 | 15 902 | 15 640 | 1.7 |
| | Other Fuels | | | | 413 | |
| | **Total** | **109 962** | **14 393** | **95 569** | **95 187** | **0.4** |
| **2014** | Liquid Fuels | 26 531 | 7 460 | 19 071 | 19 471 | -2.1 |
| | Solid Fuels | 64 494 | 7 632 | 56 863 | 56 588 | 0.5 |
| | Gaseous Fuels | 14 358 | 220 | 14 138 | 13 860 | 2.0 |
| | Other Fuels | | | | 500 | |
| | **Total** | **105 383** | **15 311** | **90 072** | **90 419** | **-0.4** |
| **2015** | Liquid Fuels | 26 066 | 6 134 | 19 932 | 20 335 | -2.0 |
| | Solid Fuels | 66 235 | 7 471 | 58 764 | 56 332 | 4.3 |
| | Gaseous Fuels | 15 059 | 223 | 14 836 | 14 585 | 1.7 |
| | Other Fuels | | | | 606 | |
| | **Total** | **107 360** | **13 828** | **93 532** | **91 858** | **1.8** |

**Tab. 3-7 Apparent consumption in energy units (PJ) used in reference and sectoral approach for all fossil fuels and corresponding results for $CO_2$ emissions (kt)**

| Year | Appar. cons. (PJ) | Carbon excluded (PJ) | Reference approach (PJ) | Sectoral approach (PJ) | (RA-SA)/SA (%) | Activity data (kt $CO_2$) | Carbon excluded (kt $CO_2$) | Reference approach (kt $CO_2$) | Sectoral approach (kt $CO_2$) | (RA-SA)/SA (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| **1990** | 1 893.5 | 158.5 | 1 735.1 | 1 655.7 | 4.8 | 165 438 | 14 672 | 150 766 | 144 268 | 4.5 |
| **1991** | 1 702.4 | 114.0 | 1 588.4 | 1 522.0 | 4.4 | 148 722 | 10 766 | 137 956 | 132 421 | 4.2 |
| **1992** | 1 639.7 | 120.2 | 1 519.5 | 1 486.4 | 2.2 | 140 845 | 11 327 | 129 518 | 127 574 | 1.5 |
| **1993** | 1 578.8 | 108.3 | 1 470.5 | 1 431.2 | 2.7 | 135 199 | 10 250 | 124 949 | 122 572 | 1.9 |
| **1994** | 1 510.4 | 130.6 | 1 379.8 | 1 353.9 | 1.9 | 128 422 | 12 125 | 116 297 | 115 121 | 1.0 |
| **1995** | 1 533.7 | 168.0 | 1 365.7 | 1 380.2 | -1.1 | 129 012 | 14 797 | 114 215 | 116 317 | -1.8 |
| **1996** | 1 575.8 | 174.0 | 1 401.8 | 1 418.8 | -1.2 | 130 975 | 15 311 | 115 664 | 118 132 | -2.1 |
| **1997** | 1 589.7 | 171.2 | 1 418.5 | 1 374.6 | 3.2 | 132 952 | 15 251 | 117 701 | 114 044 | 3.2 |
| **1998** | 1 538.5 | 167.2 | 1 371.3 | 1 326.7 | 3.4 | 127 464 | 14 935 | 112 529 | 108 805 | 3.4 |
| **1999** | 1 421.5 | 149.1 | 1 272.5 | 1 267.7 | 0.4 | 115 764 | 12 876 | 102 889 | 103 043 | -0.1 |
| **2000** | 1 527.7 | 153.9 | 1 373.8 | 1 355.0 | 1.4 | 127 286 | 13 574 | 113 711 | 112 210 | 1.3 |
| **2001** | 1 552.3 | 151.2 | 1 401.0 | 1 373.8 | 2.0 | 128 304 | 13 262 | 115 042 | 112 719 | 2.1 |
| **2002** | 1 535.2 | 158.9 | 1 376.3 | 1 343.8 | 2.4 | 126 666 | 14 023 | 112 642 | 109 979 | 2.4 |
| **2003** | 1 551.6 | 167.5 | 1 384.1 | 1 377.0 | 0.5 | 128 171 | 14 871 | 113 300 | 112 601 | 0.6 |
| **2004** | 1 520.1 | 195.7 | 1 324.4 | 1 382.7 | -4.2 | 124 505 | 17 064 | 107 441 | 112 644 | -4.6 |
| **2005** | 1 557.6 | 186.8 | 1 370.8 | 1 371.3 | 0.0 | 127 788 | 16 032 | 111 756 | 111 606 | 0.1 |
| **2006** | 1 585.3 | 196.8 | 1 388.4 | 1 373.5 | 1.1 | 130 371 | 17 090 | 113 281 | 111 999 | 1.1 |
| **2007** | 1 585.6 | 187.4 | 1 398.3 | 1 378.7 | 1.4 | 131 482 | 16 424 | 115 058 | 113 027 | 1.8 |
| **2008** | 1 525.0 | 192.4 | 1 332.7 | 1 328.7 | 0.3 | 125 215 | 16 524 | 108 691 | 108 255 | 0.4 |
| **2009** | 1 401.5 | 157.2 | 1 244.3 | 1 262.1 | -1.4 | 114 708 | 13 332 | 101 376 | 103 157 | -1.7 |
| **2010** | 1 489.4 | 174.9 | 1 314.5 | 1 280.1 | 2.7 | 121 116 | 14 900 | 106 216 | 103 777 | 2.4 |
| **2011** | 1 410.2 | 167.4 | 1 242.8 | 1 241.5 | 0.1 | 116 350 | 14 342 | 102 009 | 101 638 | 0.4 |
| **2012** | 1 362.0 | 170.2 | 1 191.8 | 1 207.2 | -1.3 | 111 574 | 14 512 | 97 062 | 98 568 | -1.5 |
| **2013** | 1 348.7 | 167.7 | 1 181.0 | 1 173.7 | 0.6 | 109 962 | 14 393 | 95 569 | 95 187 | 0.4 |
| **2014** | 1 287.1 | 180.3 | 1 106.8 | 1 111.5 | -0.4 | 105 383 | 15 311 | 90 072 | 90 419 | -0.4 |
| **2015** | 1 311.3 | 160.5 | 1 150.9 | 1 134.1 | 1.5 | 107 360 | 13 828 | 93 532 | 91 858 | 1.8 |

### 3.2.2 International bunker fuels

In the Czech Republic, this corresponds only to the storage of Kerosene Jet Fuel for international air transport since the Czech Republic does not have an ocean fleet.

Basic activity data are available in the CzSO energy balance (CzSO, 2016). Tab. 3-8 gives the amount of stored Kerosene Jet Fuel.

**Tab. 3-8 Kerosene Jet Fuel in international bunkers**

| Year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **[TJ/year]** | 7 325 | 6 020 | 6 967 | 5 792 | 7 208 | 7 805 | 5 866 | 6 759 | 7 991 | 7 520 | 8 234 | 8 750 | 7 556 |
| **Year** | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| **[TJ/year]** | 10 163 | 13 062 | 13 573 | 14 070 | 14 763 | 15 644 | 14 287 | 13 387 | 13 272 | 12 367 | 11 931 | 12 241 | 12 413 |

### 3.2.3 Feedstocks and non-energy use of fuels

New and since this year valid methodology (IPCC, 2006) clearly sets the borders between the sectors Energy and Industrial Processes and Product Use (IPPU). Compared to the previous methodology version (IPCC, 1997), emissions from non-energy use of fuels is reported mainly in sector 2 – IPPU. To prevent double counting or omission of resources it is necessary to carefully carry out a completeness check of $CO_2$ emissions in the sectors 1.A (Energy – combustion) and 2 – IPPU, for those kinds of fuels that are used for both energy and non-energy purposes.

Non-energy fuels are divided into three categories:

1) **Raw materials for the chemical industry (Feedstocks)**. These fossil fuels are used in particular in the production of organic compounds and to a lesser extent in the production of inorganic chemicals (e.g. ammonia) and their derivatives. For organic substances normally part of the carbon contained in the feedstock remains largely stored in these products. Typical examples of raw materials are the feedstocks for petrochemical industry (naphtha), natural gas, or different types of oils (e.g. the production of hydrogen for the subsequent production of ammonia by partial oxidation).
2) **Reductants**. Carbon is used as a reductant in metallurgy and inorganic technologies. Unlike the previous case, here when using fossil fuel as reductant only a very small amount of carbon remains long fixed in the products and the larger part of the carbon is being oxidized during the reduction process. Typical example of reductant is metallurgical coke.
3) **Non-energy products**. Non-energy products are materials, derived from fuels in refineries or coke plants, which unlike the previous two cases, are used directly for its conventional physical properties, specifically it is about lubricants (lubricating oils and petrolatum), diluents and solvents, bitumen (for covering roads and roofs) and paraffin. In category IPPU emissions of $CO_2$ and other GHG occur only to a limited extent (e.g. during the oxidation of lubricants and paraffin). Substantial emissions occur during their recovery and during disposal by incineration (in the sector and in Waste).

Emissions from feedstocks in chemical industry are reported in subsector 2.B, from reductants primarily in subsector 2.C and from non-energy products, used mainly for other purposes, than incineration (e.g. lubricating oils) in subsector 2.D.

The energy balance of the Czech Republic in accordance with the Regulation No 1099/2008 of the European Parliament and of the Council on energy statistics distinguishes various types of fuels in their use for energy and non-energy purposes. Below are listed the different kinds of fuels with a high proportion of non-energy use in the Czech Republic.

Some types of liquid fuels are designed mainly for non-energy use. This is primarily naphtha, for which CzSO indicates, since 2001, that virtually the entire amount is consumed for non-energy purposes by the chemical industry, mainly as petrochemicals (2.B). Less significant is the non-energy use of LPG. Since Naphtha is major feedstock, the emission from sector 2.B.8 Petrochemical and Carbon Black Production is reported in the CRF Table 1.A(d) as arising from this feedstock. LPG and Gas/Diesel oil is reported as IE, since these are used in variety of chemical production and the specific amount is not known.

Another important type of liquid fuels consumed for non-energy purposes of fuels is a group marked as Other Oils. Their most significant share is Other Petroleum Products, which finds application in the production of hydrogen by partial oxidation with steam for subsequent production of ammonia and further part of it is also used as a Solvent Use. In 2015, the consumption of Other Petroleum Products for non-energy purposes (particularly in sub-sectors 2.B, 2.D) was 18.4 PJ. $CO_2$ produced during ammonia production (2.B.1) is reported in Table 1.A(d) under Other Oil. The rest of the Other Oil used in non-energy use is processed for the Solvents. Following the IPCC 2006 Gls., from Solvent Use (2.D.3) there is no $CO_2$ produced.

Less important categories are White Spirit and Paraffin Wax, which are indeed only used for non-energy purposes in 2.D and naturally their consumption is small compared to Other Petroleum Products.

The liquid fuels, used specially for non-energy purposes, include also bitumen, whose consumption in 2015 was 21.9 TJ and lubricants with consumption in 2015 of 7.8 PJ. While in the case of using bitumen there are no emissions of $CO_2$ (Stored carbon), in the case of lubricants use, annually a part is oxidized to

$CO_2$ (Reported in 2.D.1) Consequently, $CO_2$ reported in Table1.A(d) under Lubricants is the $CO_2$ which is arising in 2.D.1.

Solid fuels for non-energy purposes are mainly used as reductants. These include coke (Coke Oven Coke), from which in 2015 were used 51.2 PJ in the production of iron and steel (2.C.1). Consequently, $CO_2$ reported in Table1.A(d) under Coke Oven Coke is the $CO_2$ which is arising in 2.C.1 from Metallurgical coke use. In the Other bituminous coal in 2015 were used 7.5 PJ as non-energy use. Other bituminous coal was used as reductant in 2.C.1 as well.

Natural gas (NG) is in many countries also used as a feedstock. In the Czech Republic it was not until recently, and since 2008 the CzSO indicates that approximately 1% of annual consumption of natural gas in the Czech Republic is used for non-energy purposes in the chemical industry. This non-energy use is reported under 2.B.10.

Fuels for non-energy use are not accounted for into the Sectoral approach in category 1.A. In the Reference approach NEU are deducted from the apparent consumption as excluded carbon (see. Sub-chapter "$CO_2$ reference approach and comparison with sectoral approach").

In Tab. 3-9 are listed calorific values of the energy balance calculation of CzSO and default emission factors, which were used in the reference approach.

**Tab. 3-9 Net calorific values and emission factors of feedstocks**

| Non-energy Fuels | NCV | EF |
|---|---|---|
| | [GJ/kt] | [t $CO_2$/TJ] |
| **LPG** | 45 945 | 65.86[1)] |
| **Naphtha** | 43 600 | 73.30 |
| **White Spirit** | 40 193 | 73.30 |
| **Lubricants** | 40 193 | 73.30 |
| **Bitumen** | 40 193 | 80.70 |
| **Paraffin Wax** | 40 193 | 73.30 |
| **Petroleum Coke** | 38 500 | 97.50 |
| **Other Petroleum Products** | 39 463 | 73.30 |
| **Refinery Gas** | 46 023 | 55.08[1)] |
| **Coke Oven Coke** | 28 775[2)] | 107.0 |

[1)] *country-specific value*
[2)] *used in blast furnaces*

### 3.2.4 Methodological issues

The chapter describes procedures, which are applied for emission estimates from combustion sources in general. Each chapter for specific subcategories then contains (if applicable) any specific procedures used for these specific sources.

The data for the whole time series was constructed on the basis of data from the CzSO Questionnaire (CzSO, 2016), where the data on fuel consumption are provided in various ways. Data are available for Solid and Liquid Fuels in mass units (kt p.a.), where the net caloric values of these fuels are also tabulated. The consumption of gaseous fuels derived from fossil fuels is given in TJ p.a. Natural Gas is given in thousand $m^3$ and the consumption in TJ is also tabulated; however, in this case it is calculated using the gross caloric value. The Energy balance in mass units (kt p.a.) for last reported year (2015) is given in Annex 4, Tables A4-1 – A4-7.

Since 2012 submission net calorific values for Liquid Fuels for the whole time series are available. These are now assumed to be correct (agreed by CzSO) and therefore used for conversion of activity data from natural units to energy units. Except of the official NCV provided by CzSO country specific NCVs are used, for Refinery Gas and LPG.

The principles of preparation of the emission inventory are further specified in detail for the individual phases of data preparation and processing and subsequent utilization of the results of calculations with subsequent data storage.

#### *3.2.4.1 Collection of activity data*

In collection of activity data, all the background data are stored at the workplace of the sector compiler, where possible in electronic form. These consist primarily in datasets obtained from CzSO as officially submitted data for drawing up the activity data. The dataset for the last reported year is given in Annex 4, Tables A4-1 – A4-7; similar datasets for the whole time series are stored in the archive of the sectoral expert.

If the data are taken from the Internet, the relevant passages (texts, tables) are stored in separate files with designation of the web site where they were obtained and the date of acquisition.

Data taken from printed documents are suitably cited, the written documents are stored in printed form at the workplace of the sector compiler and, where possible, the relevant passages (texts, tables) are scanned and stored in electronic form.

When the stage is completed, all the stored data are transferred to electronic media (CD, external HD, flash disks, etc.) and stored with the sector compiler; the most important working files that contain data sources, calculation procedures and the final results are submitted in electronic form for storage at the coordination workplace.

In case EU ETS data are used, the original forms are stored in archive of national inventory system coordinator, as well as officially at Ministry of Environment.

#### *3.2.4.2 Conversion of activity data to the CRF format*

The activity data are converted from the energy balance to the CRF structure in the EXCEL format. Each working file has a “Title page” as the first sheet. Using interconnected system of excel files was created computational model for emission estimates from the stationary sources in Energy sector.

The Title page shall contain particularly the following information:

- the name and description of the file
- the author of the file
- the date of creation of the file
- the dates of the latest up-dating, in order
- the source of the data employed
- description of transfer of specific data from the source files
- the means of aggregation of the data base employed in conversion
- explanations and comments.

Separate computational files for each kind of fuels are used, which are then interconnected with the final computational files, where are data transferred in the specific subcategories and the computation of emission estimates is carried out. The operational part of the files contains whole computational approach for estimation of $CO_2$, $CH_4$ and $N_2O$ emissions, which includes following steps:

- complete division of data about consumption of each kind of fuels from Energy balance provided by CzSO into the structure compatible with CRF Reporter (for purposes of Sectoral and Reference Approaches)

- complete set of NCV for specific kinds of fuels and emission and oxidation factors (if applicable)
- computation of emission estimates
- summation of activity data and emissions for each group of fuels (solid, liquid, gaseous etc.) into specific subcategories

Outputs form the computational model are datasets, which are possible to import into CRF Reporter. All computational sheets are managed in whole time-series and units of input and output values are recorded as well.

For current submission is added additional part of computational model, which enables comparison of data from previous submission with the data from current submission. This step is important especially because this year's submission was compiled using new updated methodology IPCC 2006 Guidelines (IPCC, 2006).

#### *3.2.4.3 Calculations of emissions*

Original activity data are provided in kilotons. It means that it is necessary to convert these values to energy units – terajoules. For this conversion are used calorific values listed in Annex 5.

Coke Oven Gas, Gas Works Gas and biofuels are given directly in terajoules in the CzSO Questionnaires (CzSO, 2016), however the data were calculated using the gross calorific values, so it is necessary to recalculate these values to net calorific values.

Natural Gas is provided in the statistic reporting in the CzSO Questionnaire (CzSO, 2016) in thousand $m^3$ and in TJ; however, the data in TJ is determined using the gross caloric value. Volume reported by CzSO in thousand $m^3$ is related to the „trade conditions", i.e. temperature 15°C and pressure 101.3 kPa.

CzSO uses for the conversion between gross and net calorific value coefficient NCV/GCV = 0.9. In 2014 was carried out research in order to develop methodology for determination of precise values of this coefficient. Details concerning the research and methodology of determination of the coefficient NCV/GCV is provided in Annex 5.

It was found (see Annex 5), that the ratio NCV/GCV for natural gas can be very preciously described by linear dependence

$$\frac{NCV}{GCV} = (0.001011 \cdot GCV) + 0.863274$$

where NCV and GCV are expressed in $MJ/m^3$ in the reference temperatures of 15 ˚C (i.e. trade conditions). However, improved values of the ratio NCV/GCV is not far from the IPCC default value 0.9. For example, to the NCV = 34.424 $MJ/m^3$ given in the Tab. 3-10 it corresponds the ratio NVC/GCV=0.9019 calculated from the equation above. This equation was used for calculation of NCV from GCV for all time period.

For calculation of $CO_2$ emissions are used emission factors, which are either provided in the IPCC 2006 Guidelines (IPCC, 2006), or which were determined as country-specific emission factors. Since $CO_2$ emission factors depend on quality of specific of fuel, the values of emission factors are listed in the specific chapters bellow. Default emission factors from the IPCC methodology have been for key categories gradually substituted by country specific emission factors. Moreover, in case of $CO_2$ emission factors from lignite (brown coal) and bituminous coal, the previous country-specific emission factors were in this submission refined by using up-to-date national data. Description of used country-specific emission factors including ways of their evaluations is provided in Annex 3.

$CH_4$ and $N_2O$ emissions from fuel combustion from stationary sources are not among the key categories. Thus contrary to $CO_2$ emission factors, for $CH_4$ and $N_2O$ emission factors are used always default values from IPCC 2006 Guidelines (IPCC, 2006). $CH_4$ and $N_2O$ emission factors are listed in the specific subchapters for specific subcategories.

General $CO_2$ emission factors and NCV are provided in Tab. 3- 10.

**Tab. 3-10 Net calorific values (NCV), $CO_2$ emission factors and oxidation factors used in the Czech GHG inventory – 2015**

| Fuel (IPCC 2006 Guidelines definitions) | NCV [TJ/kt] | $CO_2$ EF [a] [t $CO_2$/TJ] | Oxidation factor | $CO_2$ EF [b] [t $CO_2$/TJ] |
|---|---|---|---|---|
| Crude Oil | 42.400 | 73.30 | 1 | 73.30 |
| Gas/Diesel Oil | 42.600 | 74.10 | 1 | 74.10 |
| Residual Fuel Oil | 39.500 | 77.40 | 1 | 77.40 |
| LPG [d] | 45.945 | 65.86 | 1 | 65.86 |
| Naphtha | 43.600 | 73.30 | 1 | 73.30 |
| Bitumen | 40.193 | 80.70 | 1 | 80.70 |
| Lubricants | 40.193 | 73.30 | 1 | 73.30 |
| Petroleum Coke | 38.500 | 97.50 | 1 | 97.50 |
| Other Oil | 39.463 | 73.30 | 1 | 73.30 |
| Coking Coal [d] | 29.536 | 93.53 | 1 | 93.53 |
| Other Bituminous Coal [d] | 21.990 | 95.23 | 0.9707 | 92.44 |
| Lignite (Brown Coal) [d] | 11.979 | 100.79 | 0.9846 | 99.24 |
| Brown Coal Briquettes | 19.793 | 97.50 | 0.9846[d] | 96.00 |
| Coke Oven Coke | 28.750 | 107.00 | 1 | 107.00 |
| Coke Oven Gas (TJ/mill. $m^3$) | 16.064 [c] | 44.40 | 1 | 44.40 |
| Natural Gas (TJ/Gg) [d] | 48.756 | 55.42 | 1 | 55.42 |
| Natural Gas (TJ/mill. $m^3$) [d] | 34.575 | 55.42 | 1 | 55.42 |

*a) Emission factor without oxidation factor*
*b) Resulting emission factor with oxidation factor*
*c) TJ/mill. $m^3$, t= 15 °C, p = 101.3 kPa*
*d) Country specific values of $CO_2$ EFs and oxidation factors*

### 3.2.5 Uncertainties and time-series consistency

The emission inventory is based on 2 types of data accompanied by different levels of uncertainty:

- Activity data (consumption of individual kinds of fuels)
- Emission factors

Extensive research was carried out in 2012 to obtain new, more accurate values for the uncertainties (CHMI, 2012b). The results are given in chapter 1.6 and Annex 2 furthermore lists source of expert judgement provided for uncertainty analysis for each category.

***Activity data***

Information on fuel consumption is taken from CzSO (CzSO, 2016).

Uncertainties:

**1) on the part of CzSO in collecting and processing the primary data**

CzSO does not explicitly state the uncertainties in the published data. However, the uncertainty differs for the individual groups of data – statistical reports from the individual enterprises (economic units with more than 20 employees); consumption by the population is calculated on the basis of models and reports by suppliers of network energy (gas, electricity), production of the individual kinds of fuels (especially automotive fuels) and customs reports (imports, exports); the remainder is calculated so that the fuel consumption is balanced. Each step is accompanied by a different level of uncertainty. Overall the uncertainty in Natural Gas activity data should be lower than uncertainty of Solid Fuels activity data since the Natural Gas is measured more accurately in comparison to for instance coal.

Uncertainties also arise during data processing. CzSO obtains data in mass units – tons per year (1st level of uncertainty). The resultant balance is expressed in energy units – TJ p.a. Recalculation from mass units to energy units must be performed using the fuel calorific value. The determination of these values is accompanied by uncertainties following from the method employed (mostly laboratory expertise) (2nd level of uncertainty). The average fuel calorific value valid for all of the Czech Republic must be determined for each kind of fuel. Because the calorific value differs substantially in dependence on the mine location, it is necessary to determine the average calorific value on the basis of a weighted average – 3rd level of uncertainty.

**2) on the part of the sector compiler in interpretation of CzSO data**

The sector compiler introduced uncertainty into the processing that can be based on an elementary error in interpreting the data. However, because routine control procedures are employed and no fuel may be missing or calculated twice in the final balance, this uncertainty can be considered to be less than 1% (approx. 0.5%).

***Emission factors***

For calcualtions were applied

1) Default emission factors

The research carried out in 2012 focused also on the determining of uncertainties of emission factors (CHMI, 2012b). Results are provided in the Tab. 3-11. The uncertainty values for the default emission factors are based on the 2006 Guidelines (IPCC, 2006).

2) Country specific emission factors

The country-specific emission factors were determined on the basis of experimental data and this uncertainty can be estimated at approx. 2.5%.

**Tab. 3-11 Uncertainty data from Energy sector (stationary combustion) for uncertainty analysis**

| Gas | Source category | AD uncertainty [%] | EF uncertainty [%] | Origin of actual level of uncertainty |
|---|---|---|---|---|
| $CO_2$ | 1.A Stationary combustion – Solid Fuels | 4 | 3 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $CO_2$ | 1.A Stationary combustion – Gaseous Fuels | 3 | 2.5 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $CO_2$ | 1.A Stationary combustion– Liquid Fuels | 5 | 3 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $CO_2$ | 1.A Stationary combustion – Other Fuels – 1.A.2 | 10 | 15 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $CO_2$ | 1.A.3.e Other Transportation | 4 | 3 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $CO_2$ | 1.A.5.b Mobile sources in agriculture and forestry | 7 | 3 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $CH_4$ | 1.A Stationary combustion – Solid Fuels | 5 | 50 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $CH_4$ | 1.A Stationary combustion – Gaseous Fuels | 4 | 50 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $CH_4$ | 1.A Stationary combustion – Liquid Fuels | 5 | 50 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |

| | | | | |
|---|---|---|---|---|
| $CH_4$ | 1.A Stationary combustion – Biomass | 8 | 50 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $CH_4$ | 1.A.5.b Mobile sources in agriculture and forestry | 7 | 50 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $CH_4$ | 1.A.3.e Other Transportation | 4 | 50 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $N_2O$ | 1.A Stationary combustion – Solid Fuels | 5 | 60 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $N_2O$ | 1.A Stationary combustion – Gaseous Fuels | 4 | 60 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $N_2O$ | 1.A Stationary combustion – Liquid Fuels | 5 | 60 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $N_2O$ | 1.A Stationary combustion – Biomass | 8 | 60 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $N_2O$ | 1.A Stationary combustion – Other Fuels – 1.A.2 | 10 | 60 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $N_2O$ | 1.A.3.e Other Transportation | 4 | 60 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |
| $N_2O$ | 1.A.5.b Mobile sources in agriculture and forestry | 7 | 60 | E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines |

***Time - series consistency***

The time series consistency is regularly monitored by the sector compiler and evaluated as an instrument for revealing potential errors. As the sector compilers create the data time series from external CzSO data, they cannot affect the variation in the time series of activity data during processing.

However, feedback to the primary data processor does exist. If an anomaly is identified in the time series, CzSO is informed about this fact and is requested to provide an explanation.

So far, no means have been found for consistent and systematic verification of the consistency of time series at CzSO and for analysis of the causes of fluctuations. Rather than elementary errors, preliminary analysis indicates that the anomalies are caused solely by the methodology for ordering the statistical data in the energy balance structure. Assignment of the statistical data on fuel consumption to the individual energy balance chapters is performed by the valid methodology according to CZ-NACE (the former Czech equivalent was OKEC – Branch Classification of Economic Activities). The CZ-NACE code is assigned to economic entities on the basis of their Id.No. (Identification Numbers). This can result in substantial inter-annual changes in the individual subcategories.

**Example:**

*The decisive CZ-NACE code for entity A is that for chemical production. He operates a large boiler with a substantial fraction of fuel in the entire 1.A.2.c subsector. The energy production is split off to independent entity B, whose main activity is production and supply of heat. In the final analysis, the reported fuel consumption is shifted from 1.A.2.c to 1.A.1.a.*

In the Czech Republic, the 1990’s and beginning of the 20th century were a period when a route to rational utilization of means of production was sought and changes in the ownership structure of energy-production facilities were quite frequent. Consequently, consistency of the time series is interrupted in some subcategories. Justification for the exact causes of each such change lies outside the current capabilities of the sector compiler.

Changes in the consistency of time series of emission data must follow changes in activity data. If different anomalies occur, these anomalies are verified and any errors in the determination of the emission data are immediately eliminated.

***Other Fuels ( CRF 1.A.1.a) - Uncertainties and time-series consistency***

The time series comes from two data sources – time-series was reproduced by MIT and data about current incineration comes from ISOH (Information system of waste management). There are no country-specific uncertainties yet, as all the factors but activity data used in the equations are default IPCC factors.

### 3.2.6 QA/QC and verification

The general QA/QC plan was formulated since the last submission and is presented in the Chapter 1.2.3. The QA/QC procedures applied in the company KONEKO Ltd. are based on the QA/QC plan for GHG inventory in the Czech Republic and are harmonized with the QA/QC system of the CDV. As the basic data sources for the processing of activity data are based on the energy balance of the Czech Republic the main emphasis is given to close cooperation with the Czech statistical office (CzSO). This cooperation is based on the contract between CHMI, as the NIS coordination workplace, and CzSO. CzSO is a state institution established for statistical data processing in the Czech Republic, which has its own control and verification mechanisms and procedures to ensure data quality.

Sectoral guarantor and administrator of QA/QC procedures, Vladimir Neuzil (KONEKO manager):

- processes and updates the sectoral QA/QC plan
- organizes QC procedure
- ensures verification procedures and is responsible for its realization
- is responsible for the submission of all documents and data files for the storing in the coordinating institution suggests external experts for QA procedure
- ensures data input in the CRF Reporter
- carries out auto-control – control of input data and primary computations
- ensures and is responsible for the storing of documents

The QC procedures are related to the processing, manipulation, documentation, storing and transmission of information. The first step of the control is carried out by the expert responsible for the Sectoral Approach (Vladimir Neuzil), followed up by the control carried out by the QA/QC expert familiar with the topic (Pavel Fott, former NIS coordinator). At this control level individual steps are controlled according official QA/QC methodology (IPCC, 2006).

Data transmission to the CRF Reporter is accomplished by the data administrator. After data transmission to the CRF Reporter the control of correct data transmission based on the summary values of activity data and emission data is carried out. If there are any discrepancies, the erroneous data are detected and corrected.

Verification procedures are included upon the suggestion of the QA/QC sectoral guarantor after the consultation with the NIS coordinator. They are aimed mainly at the comparison with independent data sources that are not based on data processing from the CzSO energy balance. The relevant independent sources in the Czech Republic are represented by data published and verified within the EU Emission Trading Scheme (ETS), from the national system REZZO, used for the registration of ambient air pollutants, and based mainly on data collection from individual plants. In addition to emission data the REZZO database includes also activity data, independent of CzSO data. The way how to optimally use the above data sources has to be determined on the basis of systematic research and will be covered in the national inventory improvement plan.

External employees of KONEKO (Pavel Fott) familiar with the assessed topic participate in the QC procedures. The cooperation is based on ad hoc contracts ensured by the QA/QC sectoral guarantor. As already mentioned above, also experts from CzSO, closely cooperating with CHMI and KONEKO, take part in the control procedures.

The QA procedures are planned in a way described in the general part of the QA/QC plan, i.e. approximately once in three years. This year the QA was held by external expert of NIS team. Since this submission was processed using new updated methodology, the QA/QC procedures were applied on very detail this year.

Other QC procedures were performed using data indicators which should have the same course as the reported value. Where these data are available, details of this QC are given in the following figures.

### 3.2.7 Public electricity and heat production (CRF 1.A.1.a)

This category is divided into 3 sub categories:

- Electricity Generation (CRF 1.A.1.a.i)
- Combined Heat and Power Generation (1.A.1.a.ii)
- Heat Plants (1.A.1.a.iii)

Even though this division is used in the new methodology (IPCC, 2006), since so far no reliable data is available for this detailed classification, in this submission, the reported data is summarized in category CRF 1.A.1.a.i.

#### *3.2.7.1 Category description (CRF 1.A.1.a.i)*

The structure of fuels, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.A.1.a.i, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity** | **$CO_2$** | | | **$CH_4$** | | **$N_2O$** | |
| | **data** | **EF** | **OxF** | **Emission** | **EF** | **Emission** | **EF** | **Emission** |
| | **[TJ]** | **[t $CO_2$/TJ]** | **[-]** | **[kt]** | **[kg $CH_4$/TJ]** | **[kt]** | **[kg $N_2O$/TJ]** | **[kt]** |
| **Heating and Other Gasoil** | 85.2 | 74.1 | 1 | 6.3 | 3 | 0.00026 | 0.6 | 0.00005 |
| **Fuel Oil - Low Sulphur** | 829.5 | 77.4 | 1 | 64.2 | 3 | 0.00249 | 0.6 | 0.00050 |
| **Other Bituminous Coal** | 76 307.6 | 95.4*) | 0.9707*) | 7 065.7 | 1 | 0.07631 | 1.5 | 0.11446 |
| **Brown Coal + Lignite** | 370 913.7 | 100.8*) | 0.9846*) | 36 824.5 | 1 | 0.37091 | 1.5 | 0.55637 |
| **Coal Tars** | 25.0 | 80.7 | 1 | 2.0 | 1 | 0.00003 | 1.5 | 0.00004 |
| **Coke Oven Gas** | 4 937.2 | 44.4 | 1 | 219.2 | 1 | 0.00494 | 0.1 | 0.00049 |
| **Natural Gas** | 39 879.46 | 55.42*) | 1 | 2 210.1 | 1 | 0.03988 | 0.1 | 0.00399 |
| **Waste - fossil fraction** | 2 382.0 | 91.7 | 1 | 218.4 | 30 | 0.0715 | 4.0 | 0.00953 |
| **Waste - biomass fraction** | 3 573.0 | 100.0 | 1 | 357.3 | 30 | 0.1072 | 4.0 | 0.01429 |
| **Wood/Wood Waste** | 18 183.0 | 112.0 | 1 | 2 036.5 | 30 | 0.5455 | 4.0 | 0.07273 |
| **Gaseous Biomass** | 1 107.0 | 54.6 | 1 | 60.4 | 1 | 0.0011 | 0.1 | 0.00011 |
| **Total year 2015** | **518 222.6** | | | **49 064.8** | | **1.2201** | | **0.77256** |
| **Total year 2014** | 515 377.4 | | | 48 840.4 | | 1.1525 | | 0.76627 |
| **Index 2015/2014** | 1.01 | | | 1.00 | | 1.06 | | 1.01 |
| **Total year 1990** | 569 994.5 | | | 54 685.8 | | 0.6212 | | 0.81216 |
| **Index 2015/1990** | 0.91 | | | 0.90 | | 1.96 | | 0.95 |

*) *Country specific data*

The origin of the data, the emission factors used and the method of calculating the level of emissions for the individual gases are presented in detail in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Source of Activity data** | **Emission factors** | | | **Method used** | | |
| | | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **Heating and Other Gasoil** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Fuel Oil - Low Sulphur** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Other Bituminous Coal** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Brown Coal + Lignite** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Coal Tars** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Coke Oven Gas** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Waste - fossil fraction** | ISOH, MTI | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Waste - biomass fraction** | ISOH, MTI | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Wood/Wood Waste** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Gaseous Biomass** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

The fraction of $CO_2$ emissions from sector 1.A.1 equalled 58.1% in 2015 in the whole Energy sector (1.A) – combustion of fuels.

Under source category 1.A.1.a the energy balance includes district heating stations and electricity and heat production of public power stations.

This category encompasses all facilities that produce electric energy and heat supplies, where this production is their main activity and they supply their products to the public mains. Examples include the power plants of the ČEZ Inc. company, DALKIA Inc. power plants and heating plants, Energy United Inc. and a number of others in the individual regions and larger cities in the Czech Republic.

In 2015, the fraction of $CO_2$ emissions in subsector 1.A.1.a equalled 87.4% of total $CO_2$ emissions in sector 1.A.1 .

From the total installed capacity of electricity generation 19.99 GWe in 2015, 11.28 GWe are accounted for thermal power plants:

| | | |
|---|---|---|
| Nuclear | 4 290 | MWe |
| Hydro | 2 069 | MWe |
| Solar photovoltaic | 2 075 | MWe |
| Wind | 2 818 | MWe |
| Combustible fuels | 11 275 | MWe |
| **Total capacity** | **19 990** | **MWe** |

In the final energy balance of CzSO (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in section Transformation Sector under the items:

- Main Activity Producer Electricity Plants
- Main Activity Producer CHP Plants
- Main Activity Producer Heat Plants

The category includes consumption of all kinds of fuels in enterprises covered by the NACE Rev. 2:

35.11 Production of electricity

35.30 Steam and air conditioning supply (production, collection and distribution of steam and hot water for heating, power and other purposes)

The volume of production of electricity and heat and the structure of the sources are shown in the following overview.

| | |
|---|---|
| **Electricity production (GWh)** | **51 063** |
| Main activity producer electricity plants | 8 649 |
| Main activity producer CHP plants | 33 778 |
| Autoproducer electricity plants | 70 |
| Autoproducer CHP plants | 8 566 |
| **Heat production (TJ)** | **118 467** |
| Main activity producer CHP plants | 84 937 |
| Main activity producer heat plants | 17 195 |
| Autoproducer CHP plants | 9 595 |
| Autoproducer heat plants | 6 740 |

Fig. 3-4 presents an overview of development of $CO_2$ emissions in source category 1.A.1.a.

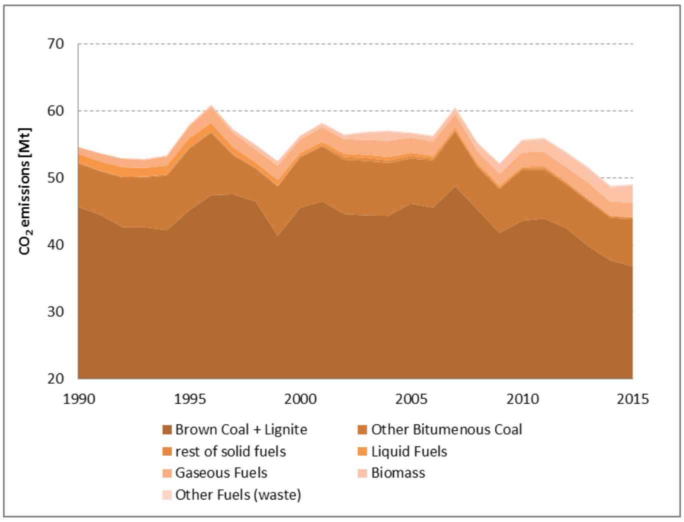



**Fig. 3-4 Development of $CO_2$ emissions in 1.A.1.a category**

$CO_2$ emissions indicate stable trend with only a few oscillations in the whole time series.

The trend in emissions is mainly shaped by the development and structures of the electricity generation installations involved, since these installations account for the majority of the pertinent emissions. As is clear from the figure, Solid Fuels are the main driving force for emissions in this source category. Brown Coal and Lignite are the most important, with average consumption of 446 PJ, corresponding to 43 981 kt $CO_2$/year on an average for the whole 1990 – 2015 period. The second largest consumption corresponds to Other Bituminous Coal, with an average consumption of 78 PJ, corresponding to 7 285 kt $CO_2$/year on an average for the whole 1990 – 2015 period. The remaining Solid Fuels do not correspond to any significant consumption in this category.

Since 2007, the country-specific emission factor for Brown Coal + Lignite has been equal to 27.50 t C/TJ; a country-specific emission factor equal to 26.02 t C/TJ for Other Bituminous Coal and Coking Coal has been used to calculate $CO_2$ emissions. In 2015 was conducted research in order to update these emission factors. The detailed description of the research is provided in Annex 3. As mentioned above, this means that approximately 95% of the emissions from fuels in this category were determined using country-specific emission factors, i.e. at the level of Tier 2.

Since last submission country specific oxidation factors for Other Bituminous Coal, Brown Coal and Lignite and Brown Coal Briquettes were applied. The detailed description of the research is given in Annex 3.

Liquid Fuels play a minor role in the electricity supply of the Czech Republic. They are used for auxiliary and supplementary firing in power stations – for instance stabilization of burners. Use of Liquid Fuels has decreased by more than half since 1990.

Natural Gas also plays a role in this source category. Use of NG does not exhibit a substantially oscillating trend. At the beginning of the period, it shows increasing trend, but later only minor changes were observed, which can be considered insignificant.

The item Other Fuels in Fig. 3-4 represents waste consumption for waste incineration.

#### *3.2.7.2 Methodological issues (CRF 1.A.1.a.i)*

The basic methodological approaches were presented in section 3.2.4. In the following text, only specific problems, which are characteristic for the described subsector, will be addressed. This is essentially a waste combustion in the municipal waste incinerators, which simultaneously produce electricity and supply heat - see chapter 3.2.7.2.1.

##### 3.2.7.2.1 Other Fuels (CRF 1.A.1.a.i): Waste Incineration for energy purposes

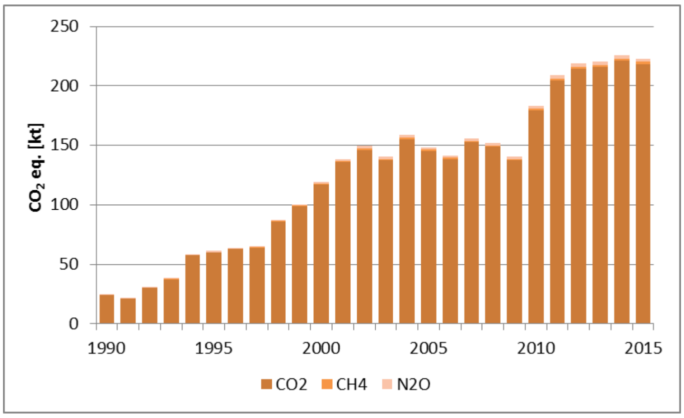



**Fig. 3-5 trend of GHG emissions from waste incineration for energy purposes**

This category consists of emissions caused by incineration of municipal solid waste for energy purposes. Originally this chapter was part of 5.C Waste Incineration but, based on the suggestion of ICR (in-country review), this chapter was shifted under the energy sector. This chapter is still prepared by CUEC (Charles University Environment Center) – the organization responsible for the Waste sector.

This category consists of emissions of $CO_2$ from incinerated fossil carbon in MSW and emissions of methane and $N_2O$ from incineration of MSW.

There are three municipal solid waste (MSW) incineration plants in the Czech Republic. One is located in Prague (ZEVO Malesice), one in Brno (SAKO) and the newest one in Liberec (Termizo).

**Tab. 3-12 Capacity of municipal waste incineration plants in the Czech Republic, 2015**

| Incinerator (city) | Capacity (kt) 2015 |
|---|---|
| TERMIZO (Liberec) | 96 |
| Pražské služby a.s. (Praha) | 310 |
| SAKO a.s. (Brno) | 224 |

*There are also 76 other facilities incinerating or co-incinerating industrial and hazardous waste, with a total capacity 600 kt of waste. This waste is reported under 5C.*

All the parameters and calculations are shown in the following Tab. 3-13.

#### *3.2.7.3 Uncertainties and time-series consistency (CRF 1.A.1.a.i)*

See chapter 3.2.5.

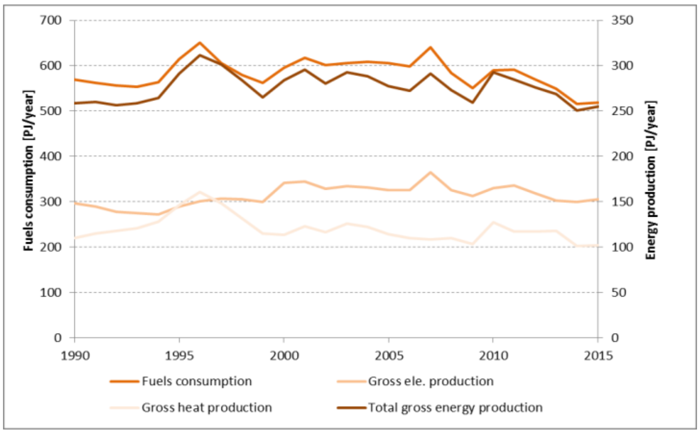



**Fig. 3-6 The ratio between the total consumption of fuels from the heat sources in the category 1.A1.a and overall energy production**

### *3.2.7.4 Category-specific QA/QC and verification (CRF 1.A.1.a.i)*

Fig. 3-6 shows the correlation of fuel consumption in category 1.A.1.a and total gross electricity and heat production. Total energy production should have a similar trend to total fuels consumption in category 1.A.1.a.

Throughout the whole time period it is possible to see a good correlation between the total fuel consumption and gross energy production. There are minor fluctuations, caused by variation of the ratio between the electricity and the amount of heat produced.

For additional information please see chapter 3.2.6.

#### 3.2.7.4.1 Other Fuels (CRF 1.A.1.a.i): Waste Incineration for energy purposes

Waste incineration is reported in the energy but in NIS it is still managed under waste sector and for this particular chapter all relevant QA/QC procedures are described in waste chapter.

### *3.2.7.5 Category-specific recalculations (CRF 1.A.1.a.i)*

Quite extensive recalculations were carried out in this submission due to different reasons. Following tables are describing the change caused by these recalculations.

**Recalculations based on changes in the official Energy balance of the Czech Republic provided by CzSO**

*Liquid fuels*

**Tab. 3-13 Recalculations caused by change in activity data for Liquid fuels in submission 2017**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| **Submission 2016** | TJ | 2 465.7 | 1 777.1 | 1 698.9 | 798.4 |
| **Submission 2017** | TJ | 2 350.4 | 3 003.6 | 1 738.5 | 995.5 |
| **Difference** | TJ | -115.4 | 1 226.5 | 39.6 | 197.1 |
| | % | -4.7 | 69.0 | 2.3 | 24.7 |
| **$CO_2$ emission** | | **2010** | **2011** | **2012** | **2013** |
| **Submission 2016** | kt | 190.4 | 137.5 | 131.4 | 61.4 |
| **Submission 2017** | kt | 181.5 | 232.5 | 134.4 | 76.6 |
| **Difference** | kt | -8.9 | 94.9 | 3.1 | 15.3 |
| | % | -4.7 | 69.0 | 2.3 | 24.9 |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** |
| **Submission 2016** | kt | 0.00740 | 0.00533 | 0.00510 | 0.00240 |
| **Submission 2017** | kt | 0.00705 | 0.00901 | 0.00522 | 0.00299 |
| **Difference** | kt | -0.00035 | 0.00368 | 0.00012 | 0.00059 |
| | % | -4.7 | 69.0 | 2.3 | 24.7 |
| **$N_2O$ emission** | | **2010** | **2011** | **2012** | **2013** |
| **Submission 2016** | kt | 0.00148 | 0.00107 | 0.00102 | 0.00048 |
| **Submission 2017** | kt | 0.00141 | 0.00180 | 0.00104 | 0.00060 |
| **Difference** | kt | -0.00007 | 0.00074 | 0.00002 | 0.00012 |
| | % | -4.7 | 69.0 | 2.3 | 24.7 |

*Solid fuels*

**Tab. 3-14 Recalculations caused by change in activity data for Solid fuels in submission 2017**

| Fuel consumption | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 499 481 | 530 029 | 525 934 | 505 295 | 479 193 | 453 163 |
| **Submission 2017** | TJ | 499 704 | 530 591 | 529 902 | 506 884 | 482 059 | 455 034 |
| **Difference** | TJ | 223.0 | 562.3 | 3 967.3 | 1 588.8 | 2 866.5 | 1 870.8 |
| | % | 0.04 | 0.1 | 0.8 | 0.3 | 0.6 | 0.4 |
| $CO_2$ emission | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 48 568 | 51 439 | 51 215 | 49 196 | 46 546 | 44 180 |
| **Submission 2017** | kt | 48 586 | 51 488 | 51 594 | 49 340 | 46 810 | 44 335 |
| **Difference** | kt | 18.0 | 48.8 | 378.7 | 143.3 | 264.7 | 155.3 |
| | % | 0.04 | 0.1 | 0.7 | 0.3 | 0.6 | 0.4 |
| $CH_4$ emission | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.4995 | 0.5300 | 0.5259 | 0.5053 | 0.4792 | 0.4532 |
| **Submission 2017** | kt | 0.4997 | 0.5306 | 0.5299 | 0.5069 | 0.4821 | 0.4550 |
| **Difference** | kt | 0.0002 | 0.0006 | 0.0040 | 0.0016 | 0.0029 | 0.0019 |
| | % | 0.04 | 0.1 | 0.8 | 0.3 | 0.6 | 0.4 |
| $N_2O$ emission*) | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.6947 | 0.7363 | 0.7286 | 0.7002 | 0.6635 | 0.6270 |
| **Submission 2017** | kt | 0.7446 | 0.7895 | 0.7861 | 0.7522 | 0.7148 | 0.6744 |
| **Difference** | kt | 0.0499 | 0.0532 | 0.0576 | 0.0521 | 0.0513 | 0.0473 |
| | % | 7.19 | 7.2 | 7.9 | 7.4 | 7.7 | 7.5 |

*) **combination of recalcualtions based on changes in activity data and change of emissions factor (UNFCCC review, September 2016)**

*Natural Gas*

**Tab. 3-15 Recalculations caused by change in activity data for Natural Gas in submission 2017**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 35 715.7 | 34 579.8 | 35 381.9 | 34 604.5 | 34 089.5 |
| **Submission 2017** | TJ | 39 331.2 | 38 510.8 | 39 551.5 | 44 016.4 | 36 756.5 |
| **Difference** | TJ | 3 615.5 | 3 931.0 | 4 169.6 | 9 411.9 | 2 667.0 |
| | % | 10.1 | 11.4 | 11.8 | 27.2 | 7.8 |
| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 1 974.6 | 1 910.9 | 1 953.1 | 1 913.7 | 1 887.0 |
| **Submission 2017** | kt | 2 174.5 | 2 128.1 | 2 183.3 | 2 434.2 | 2 034.6 |
| **Difference** | kt | 199.9 | 217.2 | 230.2 | 520.5 | 147.6 |
| | % | 10.1 | 11.4 | 11.8 | 27.2 | 7.8 |
| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0357 | 0.0346 | 0.0354 | 0.0346 | 0.0341 |
| **Submission 2017** | kt | 0.0393 | 0.0385 | 0.0396 | 0.0440 | 0.0368 |
| **Difference** | kt | 0.0036 | 0.0039 | 0.0042 | 0.0094 | 0.0027 |
| | % | 10.1 | 11.4 | 11.8 | 27.2 | 7.8 |
| $N_2O$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0036 | 0.0035 | 0.0035 | 0.0035 | 0.0034 |
| **Submission 2017** | kt | 0.0039 | 0.0039 | 0.0040 | 0.0044 | 0.0037 |
| **Difference** | kt | 0.0004 | 0.0004 | 0.0004 | 0.0009 | 0.0003 |
| | % | 10.1 | 11.4 | 11.8 | 27.2 | 7.8 |

**Recalculations based on ERT recommendation after UNFCCC review, September 2016 – change in $N_2O$ emission factor, original EF 1.4 to updated estimated 1.5 kg $N_2O$/TJ.**

This recalculation caused increase in $N_2O$ emission by 7.14%.

*Solid fuels*

**Tab. 3-16 Recalculations caused by change in $N_2O$ emission factor for solid fuels in submission 2017**

| $N_2O$ emission | | 1990 | 1995 | 2000 | 2005 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.745 | 0.782 | 0.761 | 0.764 | 0.695 | 0.736 | 0.729 | 0.700 | 0.664 | 0.627 |
| **Submission 2017** | kt | 0.798 | 0.838 | 0.816 | 0.818 | 0.745 | 0.790 | 0.786 | 0.752 | 0.715 | 0.674 |
| **Difference** | kt | 0.053 | 0.056 | 0.054 | 0.055 | 0.050 | 0.053 | 0.058 | 0.052 | 0.051 | 0.047 |
| | % | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.2 | 7.9 | 7.4 | 7.7 | 7.5 |

### Recalculations based on QA/QC procedures – Biomass

The recalculation of Biomass in 1.A.1.a.i was caused by two reasons: change of emission factor for the biogenic part of municipal waste combustion to 100 kg $CO_2$/TJ (original value 139.33 kg $CO_2$/TJ). Further, activity data starting 1994 was updated. Table 3-17 shows the comparison of original and updated values.

**Tab. 3-17 Recalculations caused by change in emission factors and activity data for Biomass in submission 2017**

| Fuel consumption | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 402 | 349 | 559 | 1 146 | 1 444 | 1 527 | 1 433 | 2 192 | 4 634 | 4 296 | 3 436 | 3 868 | 3 969 |
| **Submission 2017** | TJ | 402 | 349 | 559 | 1 147 | 1 447 | 1 854 | 2 627 | 4 538 | 6 003 | 5 627 | 4 677 | 5 106 | 5 189 |
| **Difference** | TJ | 0 | 0 | 0 | 1 | 3 | 327 | 1 194 | 2 346 | 1 369 | 1 331 | 1 241 | 1 238 | 1 220 |
| | % | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 21.4 | 83.3 | 107.0 | 29.5 | 31.0 | 36.1 | 32.0 | 30.7 |
| **Fuel consumption** | | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | |
| **Submission 2016** | TJ | 9 285 | 9 723 | 3319 | 3 429 | 3 810 | 4 813 | 6 999 | 8 195 | 8 896 | 14 183 | 18 703 | 19 480 | |
| **Submission 2017** | TJ | 9 794 | 12 516 | 5715 | 6 724 | 8 315 | 10 937 | 13 379 | 15 842 | 17 336 | 19 270 | 19 459 | 20 425 | |
| **Difference** | TJ | 509 | 2 793 | 2396 | 3 295 | 4 505 | 6 124 | 6 380 | 7 647 | 8 440 | 5 087 | 756 | 945 | |
| | % | 5.5 | 28.7 | 72.2 | 96.1 | 118.2 | 127.2 | 91.2 | 93.3 | 94.9 | 35.9 | 4.0 | 4.8 | |
| **$CO_2$ emission** | | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** |
| **Submission 2016** | kt | 55.8 | 48.6 | 76.1 | 141.9 | 186.6 | 197.7 | 188.5 | 246.5 | 549.1 | 521.6 | 438.7 | 492.2 | 509.4 |
| **Submission 2017** | kt | 40.3 | 35.0 | 56.7 | 118.0 | 150.0 | 195.9 | 281.9 | 468.2 | 637.9 | 593.9 | 490.2 | 533.6 | 542.0 |
| **Difference** | kt | -15.5 | -13.6 | -19.4 | -23.9 | -36.6 | -1.9 | 93.4 | 221.7 | 88.8 | 72.3 | 51.5 | 41.3 | 32.6 |
| | % | -27.7 | -28.0 | -25.5 | -16.8 | -19.6 | -0.9 | 49.5 | 89.9 | 16.2 | 13.9 | 11.7 | 8.4 | 6.4 |
| **$CO_2$ emission** | | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | |
| **Submission 2016** | kt | 1 126.3 | 1 139.8 | 418.5 | 435.2 | 443.7 | 545.3 | 797.4 | 944.2 | 1 074 | 1 659 | 2 156.9 | 2 249.0 | |
| **Submission 2017** | kt | 1 067.3 | 1 364.3 | 599.7 | 703.3 | 870.3 | 1 160 | 1 435.3 | 1 704.3 | 1 864 | 2 070 | 2 081.1 | 2 191.7 | |
| **Difference** | kt | -59.0 | 224.5 | 181.2 | 268.1 | 426.6 | 614.3 | 637.9 | 760.1 | 790 | 410.3 | -75.8 | -57.3 | |
| | % | -5.2 | 19.7 | 43.3 | 61.6 | 96.1 | 112.7 | 80.0 | 80.5 | 73.6 | 24.7 | -3.5 | -2.5 | |
| **$CH_4$ emission** | | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** |
| **Submission 2016** | kt | 0.0003 | 0.0001 | 0.0020 | 0.0145 | 0.0148 | 0.0165 | 0.0122 | 0.0205 | 0.0881 | 0.0720 | 0.0403 | 0.0436 | 0.0421 |
| **Submission 2017** | kt | 0.0121 | 0.0105 | 0.0168 | 0.0328 | 0.0430 | 0.0556 | 0.0788 | 0.1222 | 0.1712 | 0.1602 | 0.1349 | 0.1473 | 0.1504 |
| **Difference** | kt | 0.0118 | 0.0104 | 0.0148 | 0.0183 | 0.0282 | 0.0392 | 0.0666 | 0.1017 | 0.0830 | 0.0882 | 0.0946 | 0.1037 | 0.1083 |
| | % | 4243.5 | 10710.2 | 743.1 | 126.5 | 190.8 | 237.9 | 544.4 | 495.1 | 94.2 | 122.6 | 234.7 | 237.9 | 257.4 |
| **$CH_4$ emission** | | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | |
| **Submission 2016** | kt | 0.2098 | 0.2121 | 0.0224 | 0.0235 | 0.0238 | 0.0533 | 0.1244 | 0.1402 | 0.1477 | 0.2969 | 0.4269 | 0.4495 | |
| **Submission 2017** | kt | 0.2925 | 0.3720 | 0.1654 | 0.1903 | 0.2338 | 0.3099 | 0.3831 | 0.4577 | 0.5011 | 0.5545 | 0.5555 | 0.5862 | |
| **Difference** | kt | 0.0827 | 0.1599 | 0.1431 | 0.1668 | 0.2099 | 0.2566 | 0.2588 | 0.3176 | 0.3535 | 0.2577 | 0.1286 | 0.1367 | |
| | % | 39.4 | 75.4 | 639.7 | 709.6 | 880.7 | 481.8 | 208.1 | 226.6 | 239.4 | 86.8 | 30.1 | 30.4 | |
| **$N_2O$ emission** | | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** |
| **Submission 2016** | kt | 0.0020 | 0.0017 | 0.0027 | 0.0050 | 0.0067 | 0.0071 | 0.0068 | 0.0079 | 0.0191 | 0.0181 | 0.0154 | 0.0173 | 0.0179 |
| **Submission 2017** | kt | 0.0016 | 0.0014 | 0.0022 | 0.0044 | 0.0057 | 0.0074 | 0.0105 | 0.0163 | 0.0228 | 0.0214 | 0.0180 | 0.0196 | 0.0200 |
| **Difference** | kt | -0.0004 | -0.0003 | -0.0005 | -0.0006 | -0.0009 | 0.0003 | 0.0038 | 0.0083 | 0.0037 | 0.0032 | 0.0026 | 0.0024 | 0.0021 |
| | % | -19.6 | -19.9 | -18.1 | -12.2 | -13.9 | 4.6 | 55.5 | 105.0 | 19.6 | 17.8 | 17.0 | 13.8 | 11.9 |
| **$N_2O$ emission** | | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | |
| **Submission 2016** | kt | 0.0402 | 0.0405 | 0.0146 | 0.0149 | 0.0149 | 0.0184 | 0.0274 | 0.0327 | 0.0372 | 0.0578 | 0.0753 | 0.0787 | |
| **Submission 2017** | kt | 0.0390 | 0.0496 | 0.0221 | 0.0254 | 0.0312 | 0.0413 | 0.0511 | 0.0610 | 0.0668 | 0.0739 | 0.0740 | 0.0781 | |
| **Difference** | kt | -0.0012 | 0.0090 | 0.0074 | 0.0105 | 0.0162 | 0.0229 | 0.0237 | 0.0283 | 0.0296 | 0.0161 | -0.0013 | -0.0006 | |
| | % | -3.0 | 22.3 | 50.8 | 70.5 | 109.0 | 124.8 | 86.6 | 86.7 | 79.4 | 27.8 | -1.7 | -0.7 | |

### 3.2.7.5.1 Other Fuels (CRF 1.A.1.a.i): Waste Incineration for energy purposes

There are few reasons for this recalculation. After the recommendation from UNFCCC review in 2016 the emission factors were changed to 91.7 kg $CO_2$/TJ (original value 145.1 kg $CO_2$/TJ), 30 kg $CH_4$/TJ (original value 0.0208 kg $CH_4$/TJ), 4 kg $N_2O$/TJ (original value 5.208 kg $N_2O$/TJ).

**Tab. 3-18 Change in activity data for municipal waste combustion**

| Fuel consumption | | 2014 |
|---|---|---|
| Submission 2016 | TJ | 2 410 |
| Submission 2017 | TJ | 2 409 |
| Difference | TJ | -2 |
| | % | -0.1 |

**Tab. 3-19 Change in $CO_2$ emission after recalculation**

| $CO_2$ emission | | 1990 | 1995 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Submission 2016 | kt | 36.5 | 90.9 | 158.6 | 185.9 | 212.9 | 228.8 | 227.3 | 228.1 | 216.4 |
| Submission 2017 | kt | 24.0 | 59.8 | 98.5 | 117.0 | 135.8 | 146.2 | 137.5 | 155.2 | 145.2 |
| Difference | kt | -12.5 | -31.1 | -60.1 | -68.9 | -77.2 | -82.6 | -89.8 | -72.9 | -71.3 |
| | % | -34.2 | -34.2 | -37.9 | -37.1 | -36.2 | -36.1 | -39.5 | -32.0 | -32.9 |
| | | | | | | | | | | |
| $CO_2$ emission | | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Submission 2016 | kt | 218.4 | 218.3 | 209.8 | 200.9 | 260.3 | 326.5 | 339.9 | 342.5 | 349.8 |
| Submission 2017 | kt | 138.6 | 152.5 | 148.6 | 137.3 | 179.7 | 204.5 | 214.2 | 215.9 | 220.9 |
| Difference | kt | -79.8 | -65.8 | -61.1 | -63.5 | -80.5 | -122.0 | -125.7 | -126.6 | -128.9 |
| | % | -36.5 | -30.1 | -29.1 | -31.6 | -30.9 | -37.4 | -37.0 | -37.0 | -36.9 |

**Tab. 3-20 Change in $CH_4$ emission after recalculation**

| $CH_4$ emission | | 1990 | 1995 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Submission 2016 | kt | 5.2E-06 | 1.3E-05 | 2.3E-05 | 2.7E-05 | 3.1E-05 | 3.3E-05 | 3.3E-05 | 3.3E-05 | 3.1E-05 |
| Submission 2017 | kt | 0.0079 | 0.0196 | 0.0322 | 0.0383 | 0.0444 | 0.0478 | 0.0450 | 0.0508 | 0.0475 |
| Difference | kt | 0.0079 | 0.0196 | 0.0322 | 0.0383 | 0.0444 | 0.0478 | 0.0450 | 0.0507 | 0.0475 |
| | % | 149900 | 149900 | 141446 | 143337 | 145217 | 145571 | 137807 | 154965 | 152767 |
| | | | | | | | | | | |
| $CH_4$ emission | | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Submission 2016 | kt | 3.1E-05 | 3.1E-05 | 3.0E-05 | 2.9E-05 | 3.7E-05 | 4.7E-05 | 4.9E-05 | 4.9E-05 | 5.0E-05 |
| Submission 2017 | kt | 0.0454 | 0.0499 | 0.0486 | 0.0449 | 0.0588 | 0.0669 | 0.0701 | 0.0706 | 0.0723 |
| Difference | kt | 0.0453 | 0.0499 | 0.0486 | 0.0449 | 0.0588 | 0.0668 | 0.0700 | 0.0706 | 0.0722 |
| | % | 144542 | 159131 | 161380 | 155744 | 157288 | 142646 | 143527 | 143595 | 143810 |

**Tab. 3-21 Change in $N_2O$ emission after recalculation**

| $N_2O$ emission | | 1990 | 1995 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Submission 2016 | kt | 0.0013 | 0.0033 | 0.0057 | 0.0067 | 0.0076 | 0.0082 | 0.0082 | 0.0082 | 0.0078 |
| Submission 2017 | kt | 0.0010 | 0.0026 | 0.0043 | 0.0051 | 0.0059 | 0.0064 | 0.0060 | 0.0068 | 0.0063 |
| Difference | kt | -0.0003 | -0.0007 | -0.0014 | -0.0016 | -0.0017 | -0.0018 | -0.0022 | -0.0014 | -0.0014 |
| | % | -20.0 | -20.0 | -24.5 | -23.5 | -22.5 | -22.3 | -26.4 | -17.3 | -18.5 |
| | | | | | | | | | | |
| $N_2O$ emission | | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Submission 2016 | kt | 0.0078 | 0.0078 | 0.0075 | 0.0072 | 0.0093 | 0.0117 | 0.0122 | 0.0123 | 0.0126 |
| Submission 2017 | kt | 0.0060 | 0.0067 | 0.0065 | 0.0060 | 0.0078 | 0.0089 | 0.0093 | 0.0094 | 0.0096 |
| Difference | kt | -0.0018 | -0.0012 | -0.0010 | -0.0012 | -0.0015 | -0.0028 | -0.0029 | -0.0029 | -0.0029 |
| | % | -22.9 | -15.1 | -13.9 | -16.9 | -16.1 | -23.9 | -23.4 | -23.4 | -23.2 |

### *3.2.7.6 Category-specific planned improvements (CRF 1.A.1.a.i)*

The new methodology includes further subdivision of category 1.A.1.a into:

- 1.A.1.a.i - Electricity Generation
- 1.A.1.a.ii - Combined Heat and Power Generation
- 1.A.1.a.iii - Heat Plants

In the current submission, this detailed division was not applied and all activity data and GHG emissions are included in the category 1.A.1.a.i. Although the materials from CzSO contain information for the distribution of fuel consumption in each subsector, it will be required to verify their credibility and reliability from the point of the trends during the entire time series.

Therefore, for the next submission attention will be paid on the distribution of fuels in the specified subsectors in the detailed division.

Furthermore, attention will be focused on determining the country specific emission factors for other fuels, while considering the significance of the individual types of fuel.

## 3.2.8 Petroleum Refining (CRF 1.A.1.b)

### *3.2.8.1 Category description (CRF 1.A.1.b)*

The structure of fuels, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.A.1.b, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity** | **$CO_2$** | | | **$CH_4$** | | **$N_2O$** | |
| | **data** | **EF** | **OxF** | **Emission** | **EF** | **Emission** | **EF** | **Emission** |
| | **[TJ]** | **[t $CO_2$/TJ]** | | **[kt]** | **[kg $CH_4$/TJ]** | **[kt]** | **[kg $N_2O$ /TJ]** | **[kt]** |
| **Refinery Gas** | 6 489.2 | 55.1*) | 1 | 357.4 | 1 | 0.00649 | 0.1 | 0.00065 |
| **Other Oil** | 3 549.4 | 73.3 | 1 | 260.2 | 3 | 0.01065 | 0.6 | 0.00213 |
| **Natural Gas** | 3 843.5 | 55.4*) | 1 | 213.0 | 1 | 0.00384 | 0.1 | 0.00038 |
| **Total year 2015** | **13 882.2** | | | **830.6** | | **0.02098** | | **0.00316** |
| **Total year 2014** | 13 421.7 | | | 805.7 | | 0.02061 | | 0.00314 |
| **Index 2015/2014** | 1.03 | | | 1.03 | | 1.02 | | 1.01 |
| **Total year 1990** | 8 705.4 | | | 492.6 | | 0.01017 | | 0.00124 |
| **Index 2015/1990** | 1.59 | | | 1.69 | | 2.06 | | 2.56 |

The origin of the data, emission factors used and the method for calculating the emissions for each gas is shown in details in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Structure of Fuels | **Source of Activity data** | **Emission factors** | | | **Method used** | | |
| | | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **Refinery Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Other Oil** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |

This category includes all facilities that process raw petroleum imported into this country as their primary raw material. Domestic petroleum constitutes approximately 1.7% of the total amount in 2015. All fuels used in the internal refinery processes, internal consumption (reported by companies as “own use”) for production of electricity and heat and heat supplied to the public mains are included in emission calculations in this subcategory. This corresponds primarily to the Česká rafinérská Inc. company in the Czech Republic. Fugitive $CH_4$ emissions are included in category 1.B.2.a Fugitive Emissions from Fuels - Oil.

The fraction of $CO_2$ emissions in subsector 1.A.1.b in $CO_2$ emissions in sector 1.A.1 equalled 1.6% in 2015. It contributed 0.9% to $CO_2$ emissions in the whole Energy sector.

In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported under the item:

- Refinery Fuel
- Relevant NACE Rev. 2 code: 19.20 - Manufacture of refined petroleum products

Starting with this submission, the greenhouse gas emissions from combustion of refinery gas are estimated using country-specific emission factor. Detailed description of the research carried out in 2013 is provided in Annex 3 of this NIR. The default emission factors were used for the rest of the liquid fuels. A country-specific emission factor is used also for Natural Gas – see the outlines at the beginning of each subchapter.

Fig. 3-7 shows an overview of emissions trends in source category 1.A.1.b:

No consumption of Solid Fuels occurred in this category.

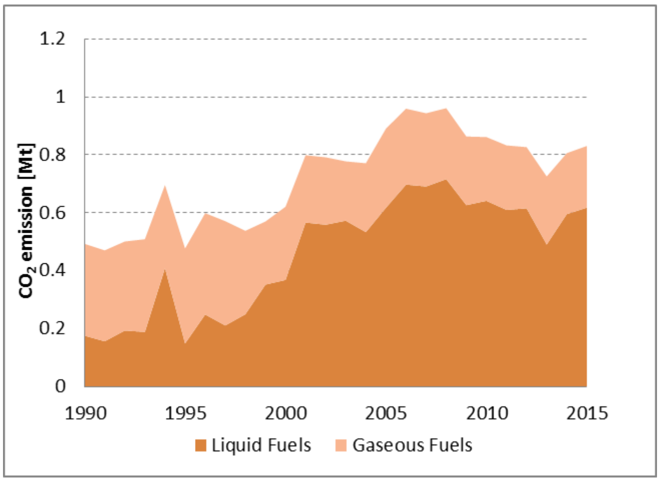



**Fig. 3-7 Development of $CO_2$ emissions in 1.A.1.b category**

Liquid Fuels are of the greatest importance and exhibit an increasing trend in the whole period. The fluctuations that have occurred over the years can be explained as resulting from differences in production quantities (see also Fig. 3-7). The maximum production equal to 716 kt $CO_2$ occurred in 2008, followed by a value of 697 kt $CO_2$ in 2006. Thereafter, production decreased to the resulting level of 595 kt $CO_2$ in 2014, resp. 618 kt $CO_2$ in 2015.

The second greatest role is played by Natural Gas, with emissions in the range between 205 kt $CO_2$ in 2003 and 360 kt $CO_2$ in 1997 and resulting with 213 kt $CO_2$ in 2015.

### *3.2.8.2 Methodological issues (CRF 1.A.1.b)*

Basic methodological approaches were presented in the section 3.2.4. In Chapter 3.2.8. no specific approaches were used for performing QA/QC in category 1.A.1.b.

### *3.2.8.3 Uncertainties and time-series consistency (CRF 1.A.1.b)*

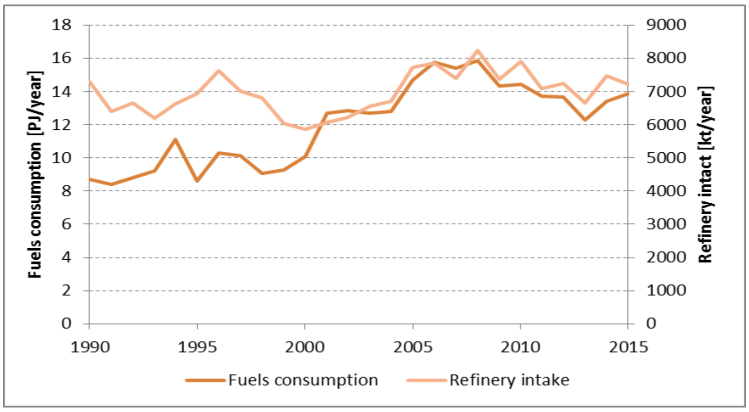



**Fig. 3-8 Comparison of fuel consumption in the sector 1.A.1.b and amount of crude oil processed**

See chapter 3.2.5.

### *3.2.8.4 Category-specific QA/QC and verification (CRF 1.A.1.b)*

Fig. 3-8 contains a comparison of fuel consumption in the sector 1.A.1.b with the total amount of crude oil processed in the Czech Republic in the separate years.

From the figure is apparent that since 2000 the relation between the amount of crude oil processed and the amount of fuel used are in line. In the period from 1990 to 2000, it is clear that the specific energy consumption for processing crude oil was lower than at present, and went through certain fluctuations. They were driven by the fact that, in this period the production capacity of both refineries were expanded (Litvinov and Kralupy nad Vltavou) towards deeper crude oil processing (especially using of cracking units since the end of the 90s).

The other QA/QC procedures were performed as described in chapter 3.2.6.

#### *3.2.8.5 Category-specific recalculations (CRF 1.A.1.b)*

After the recommendation of UNFCCC review the $N_2O$ emission factor for refinery gas was updated to 0.1 kt $N_2O$/TJ (original value 0.6 kg $N_2O$/TJ). Details of the change please see in the table.

**Tab. 3-22 Change in $N_2O$ emissions in 1.A.1.b in submission 2017**

| $N_2O$ emission | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.0017 | 0.0016 | 0.0019 | 0.0020 | 0.0035 | 0.0016 | 0.0024 | 0.0022 | 0.0023 |
| **Submission 2017** | kt | 0.0007 | 0.0005 | 0.0008 | 0.0005 | 0.0025 | 0.0004 | 0.0011 | 0.0006 | 0.0013 |
| **Difference** | kt | -0.0011 | -0.0011 | -0.0011 | -0.0015 | -0.0010 | -0.0012 | -0.0012 | -0.0015 | -0.0010 |
| | % | -62.3 | -69.3 | -59.7 | -77.2 | -27.5 | -74.1 | -52.7 | -70.2 | -43.2 |
| | | | | | | | | | | |
| $N_2O$ emission | | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
| **Submission 2016** | kt | 0.0032 | 0.0033 | 0.0051 | 0.0052 | 0.0054 | 0.0051 | 0.0058 | 0.0066 | 0.0065 |
| **Submission 2017** | kt | 0.0020 | 0.0021 | 0.0033 | 0.0030 | 0.0029 | 0.0025 | 0.0030 | 0.0034 | 0.0035 |
| **Difference** | kt | -0.0012 | -0.0012 | -0.0018 | -0.0022 | -0.0025 | -0.0026 | -0.0028 | -0.0032 | -0.0029 |
| | % | -38.5 | -36.9 | -35.3 | -42.3 | -46.9 | -50.2 | -48.4 | -48.1 | -45.4 |
| | | | | | | | | | | |
| $N_2O$ emission | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | | |
| **Submission 2016** | kt | 0.0068 | 0.0060 | 0.0063 | 0.0058 | 0.0059 | 0.0048 | 0.0058 | | |
| **Submission 2017** | kt | 0.0034 | 0.0030 | 0.0031 | 0.0029 | 0.0028 | 0.0021 | 0.0028 | | |
| **Difference** | kt | -0.0035 | -0.0031 | -0.0032 | -0.0029 | -0.0031 | -0.0027 | -0.0030 | | |
| | % | -50.4 | -50.8 | -51.3 | -50.6 | -53.0 | -56.3 | -52.2 | | |

After QA/QC activity data for Natural Gas in 2013 were updated.

**Tab. 3-23 Impact on emission estimates in 2013 after QA/QC for Natural Gas, 1.A.1.b**

| $CO_2$ emission | | 2013 |
|---|---|---|
| **Submission 2016** | kt | 211.3 |
| **Submission 2017** | kt | 234.8 |
| **Difference** | kt | 23.5 |
| | % | 11.1 |
| $CH_4$ emission | | 2013 |
| **Submission 2016** | kt | 0.00382 |
| **Submission 2017** | kt | 0.00425 |
| **Difference** | kt | 0.00042 |
| | % | 11.1 |
| $N_2O$ emission | | 2013 |
| **Submission 2016** | kt | 0.00038 |
| **Submission 2017** | kt | 0.00042 |
| **Difference** | kt | 0.00004 |
| | % | 11.1 |

#### *3.2.8.6 Category-specific planned improvements (CRF 1.A.1.b)*

Since the consumption of liquid fuels in 1994 shows a large difference (outlier) compared to 1993 and 1995 in further submissions, this data will be subjected to inspection. Specifically it is about the consumption of Other Oil as refinery fuel.

No further improvement in this subcategory are currently planned.

### 3.2.9 Manufacture of solid fuels and other energy industries (1.A.1.c)

This category is divided into two subcategories:

- Manufacture of Solid Fuels (1.A.1.c.i)
- Other Energy Industries (1.A.1.c.ii)

Given that this division is used in the new methodology (IPCC, 2006) and the fact that there are no precise data for more detailed classification, in this submission, the data is reported as a summary in category CRF 1.A.1.c.ii. Production of briquettes, which would fall under 1.A.1.c.i in the Czech Republic has been terminated and in terms of the share of the emissions, this production had, it was negligible and further accurate data on fuel consumption in this category are now hardly accessible.

#### *3.2.9.1 Category description (CRF 1.A.1.c.ii)*

The structure of fuels, their consumption, the emission factors and emissions of various greenhouse gases are shown in the following outline.

| 1.A.1.c, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity** | **$CO_2$** | | | **$CH_4$** | | **$N_2O$** | |
| | **data** | **EF** | **OxF** | **Emission** | **EF** | **Emission** | **EF** | **Emission** |
| | **[TJ]** | **[t $CO_2$/TJ]** | | **[kt]** | **[kg $CH_4$/TJ]** | **[kt]** | **[kg $N_2O$/TJ]** | **[kt]** |
| **Heating and Other Gasoil** | 681.6 | 74.1 | 1 | 50.5 | 3 | 0.0020 | 0.6 | 0.00041 |
| **Brown Coal + Lignite** | 38 993.3 | 100.8*) | 0.985*) | 3 871.3 | 1 | 0.0390 | 1.5 | 0.05849 |
| **Gas Works Gas** | 16 892.3 | 100.2*) | 1 | 1 692.1 | 1 | 0.0169 | 0.1 | 0.00169 |
| **Coke Oven Gas** | 6 400.9 | 44.4 | 1 | 284.2 | 1 | 0.0064 | 0.1 | 0.00064 |
| **Natural Gas** | 137.6 | 55.4*) | 1 | 7.6 | 1 | 0.0001 | 0.1 | 0.00001 |
| **Total year 2015** | **63 105.6** | | | **5 905.7** | | **0.0645** | | **0.06124** |
| **Total year 2014** | 62 127.6 | | | 5 801.7 | | 0.0635 | | 0.05849 |
| **Index 2015/2014** | 1.02 | | | 3.89 | | 1.02 | | 1.05 |
| **Total year 1990** | 28 984.6 | | | 1 516.4 | | 0.0335 | | 0.00824 |
| **Index 2015/1990** | 2.18 | | | 3.89 | | 1.93 | | 7.43 |

*) *Country specific data*

The table shows that while the index for 2015/1990 of fuel consumption is 2.18, the same index for $CO_2$ emissions is significantly higher. It is caused by the high proportion of coke oven gas in the fuel structure in 1990, which has a relatively low emission factor. Later, part of coke oven gas was reallocated to other subsectors (1.A.1.a and 1.A.2.a). Even more markedly the high proportion of coke oven gas, combined with relatively low emission factor, compared to other fuels, occurred in $N_2O$ emissions.

The origin of the data, the emission factors used and the method of calculating the level of emissions for each gas is presented in details in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Source of Activity data** | **Emission factors** | | | **Method used** | | |
| | | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **Heating and Other Gasoil** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Brown Coal + Lignite** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Gas Works Gas** | CzSO, CHMI | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Coke Oven Gas** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |

This category includes all facilities that process Solid Fuels from mining through coking processes to the production of secondary fuels, such as Brown-Coal Briquettes, Coke Oven Gas or Generator Gas. It also includes fuels for the production of electrical energy and heat for internal consumption (reported by companies as “own use”).

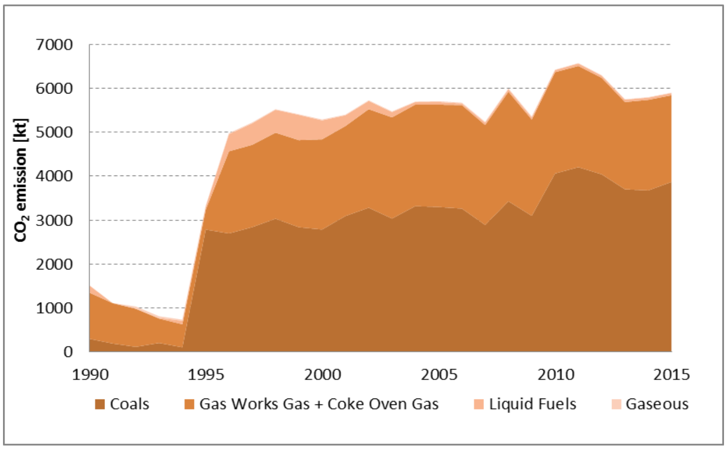



**Fig. 3-9 Development of $CO_2$ emissions in 1.A.1.c.ii category**

There are a number of companies in the Czech Republic that belong to this category. These are mainly companies performing underground and surface mining of coal and its subsequent processing, located in the vicinity of coal deposits. The category also includes Coke plants and the production of Generator Gas. Other energy industries, such as facilities for extraction of Natural Gas and Petroleum are of minor importance in the Czech Republic.

The fraction of $CO_2$ emissions in subsector 1.A.1.c in $CO_2$ emissions in sector 1.A.1 equalled 11% in 2015. It contributed only 6% to $CO_2$ emissions in the whole Energy sector 1.A.

In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in capture Energy Sector under the items:

- Coal Mines
- Oil and Gas Extraction
- Coke Ovens (Energy)
- Gas Works (Energy)
- Patent Fuel Plants (Energy)
- BKB Plants (Energy)
- Non-specified (Energy)

There are embodied the fuels of economic part according to NACE Rev. 2

- 05.10 Mining of Hard Coal
- 05.20 Mining of Lignite
- 06.10 Extraction of Crude Oil
- 06.20 Extraction of Natural Gas
- 19.10 Manufacture of Coke oven products (operation of Coke ovens, production of Coke and Semi-Coke, production of Coke Oven Gas)
- 19.20 Manufacture of refined petroleum products (this class also includes: manufacture of Peat Briquettes, manufacture of Hard-coal and Lignite fuel Briquettes)

Fig. 3-9 provides an overview of emission trends in source category 1.A.1.c. The figure clearly shows the increase in emissions in 1995 – 2012 period. The use of Coal predominated in the whole period followed by the consumption of Gas Works Gas and Coke Oven Gas. There is very low use of Liquid Fuels and Natural Gas in this category.

Sokolovská Uhelná Inc. makes the greatest contribution to the consumption of Solid fuels . The section for processing Brown Coal was established in 1950 and also produced Gas Works Gas and other chemical products. Formally, the existence of this combine ended in 1974 when this facility was moved under the Hnědouhelné doly a briketárny company. Together with this step was established Fuel combine Vřesová. The new combined-cycle power station started to operate in 1996 (http://www.suas.cz).

Between 1990 and 1995, production of Town Gas, which was distributed in the Czech Republic by Gas Work Vřesová, has been gradually phased out. On Fig. 3-9 can be seen a decline in production of Town Gas and the starting up of production of Gas Works Gas for the production of electricity and the supply heat. Pipelines used to distribute Town Gas at that time were converted for Natural Gas and took over the role for its long-distance transport and local distribution. Coke Oven Gas is produced in the Ostrava area where the Coke Plants are operating.

#### *3.2.9.2 Methodological issues (CRF 1.A.1.c.ii)*

The fuel consumption in the Vřesová Fuel combine plays a dominant role in fuel consumption in this category. This fuel is used for its own gasification process, as well as for production of technological steam, which enters into the process as a raw material. The produced high-pressure synthesis gas is then purified by acidic components ($CO_2$ and $H_2S$) and is used for power generation and supplied heat. From a methodological point of view, the whole combined production is divided into two parts – consumption of produced Gas Work Gas (and associated GHG emissions) for the production of electricity and heat and fuel consumption for technological purposes (input coal to produce technological steam). Not to neglect $CO_2$ emissions and other greenhouse gases, which are produced from the gasification of pressure gas, it was necessary to replace the consumption of Gas Work Gas in the model with coal, which enters into the process. The emission factor for lignite was used for the calculation of $CO_2$ and the value of total coal consumption in the technological part of the process was used as the activity data.

The amount of coal that was used for the production of technological steam is not directly accessible from the CzSO energy balance. Data from CHMI REZZO national emission database was used to determine the amount of coal. The quantity of coal for production of technological steam is given in Tab. 3-24.

**Tab. 3-24 Consumption of Lignite for production of technological steam in Fuel combine Vřesová 1995 – 2015**

| Year | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Lignite [kt/year]** | 1 439 | 1 596 | 1 536 | 1 571 | 1 588 | 1 651 | 1 715 | 1 746 | 1 856 | 1 931 | 2 064 |
| **Year** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | |
| **Lignite [kt/year]** | 2 003 | 2 088 | 2 107 | 1 938 | 2 044 | 2 094 | 2 117 | 1 994 | 1 951 | 2 013 | |

This amount of coal is in the data calculation of CzSO included in the total fuel consumption in the sector "Transformation - autoproducer heat plants". To avoid double counting of the quantity of coal, the amount was deducted from the other calculations in the model for fuels used in autoproducers.

No other specific approaches were used in this category.

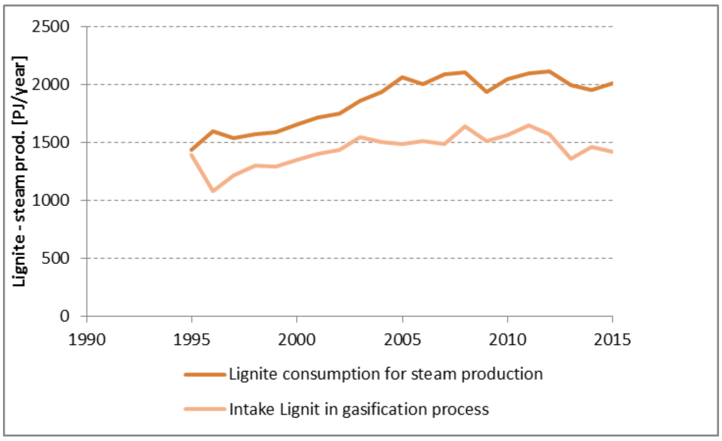



**Fig. 3-10 Comparison of lignite consumption for steam production and gasification**

#### *3.2.9.3 Uncertainties and time-series consistency (CRF 1.A.1.c.ii)*

See chapter 3.2.5.

#### *3.2.9.4 Category-specific QA/QC and verification (CRF 1.A.1.c.ii)*

Fig. 3-10 contains a comparison between consumption of lignite in sector 1.A.1.c (data from the REZZO national emission database) and the total amount of lignite, entering the transformation process (gasified coal) in the Czech Republic (data

CzSO) in the period 1995-2015.

Apart from the early years, when combined cycle was starting to reach his full power (1995 to 1998), the trends of the two curves are very similar. The minor fluctuations are caused by annual climatic influences, the technological steam is also used as a heating medium in the entire company and its consumption also depends on the average annual temperatures.

As a QA/QC procedure for this part of the calculations was utilized internal expertise of experts from the Department of emissions and sources at CHMI. Other procedures were performed as described in chapter 3.2.6.

### *3.2.9.5 Category-specific recalculations (CRF 1.A.1.c.ii)*

Quite extensive updates were provided in activity data by CzSO, which resulted in recalculation of this category.

**Tab. 3-25 Changes after recalculation in 1.A.1.c.ii for Liquid Fuels**

| Fuel consumption | | 2010 | $CO_2$ emission | | 2010 |
|---|---|---|---|---|---|
| **Submission 2016** | TJ | 724.2 | **Submission 2016** | kt | 53.7 |
| **Submission 2017** | TJ | 639.0 | **Submission 2017** | kt | 47.3 |
| **Difference** | TJ | -85.2 | **Difference** | kt | -6.3 |
| | % | -11.8 | | % | -11.8 |
| **$CH_4$ emission** | | **2010** | **$N_2O$ emission** | | **2010** |
| **Submission 2016** | kt | 0.00217 | **Submission 2016** | kt | 0.00043 |
| **Submission 2017** | kt | 0.00192 | **Submission 2017** | kt | 0.00038 |
| **Difference** | kt | -0.00026 | **Difference** | kt | -0.00005 |
| | % | -11.8 | | % | -11.8 |

**Tab. 3-26 Changes after recalculation in 1.A.1.c.ii for Solid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 74 617 | 73 860 | 70 422 | 66 513 | 57 261 |
| **Submission 2017** | TJ | 68 853 | 68 964 | 66 173 | 60 927 | 61 275 |
| **Difference** | TJ | -5 764.1 | -4 896.3 | -4 248.2 | -5 586.7 | 4 014.0 |
| | % | -7.72 | -6.6 | -6.0 | -8.4 | 7.0 |
| | | | | | | |
| **$CO_2$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 6 916 | 6 922 | 6 570 | 6 107 | 5 552 |
| **Submission 2017** | kt | 6 373 | 6 514 | 6 246 | 5 693 | 5 742 |
| **Difference** | kt | -543.4 | -408.7 | -324.0 | -414.0 | 189.8 |
| | % | -7.86 | -5.9 | -4.9 | -6.8 | 3.4 |
| | | | | | | |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.4995 | 0.5300 | 0.5259 | 0.5053 | 0.4792 |
| **Submission 2017** | kt | 0.4997 | 0.5306 | 0.5299 | 0.5069 | 0.4821 |
| **Difference** | kt | 0.0002 | 0.0006 | 0.0040 | 0.0016 | 0.0029 |
| | % | 0.04 | 0.1 | 0.8 | 0.3 | 0.6 |
| | | | | | | |
| **$N_2O$ emission *)** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.6947 | 0.7363 | 0.7286 | 0.7002 | 0.6635 |
| **Submission 2017** | kt | 0.7446 | 0.7895 | 0.7861 | 0.7522 | 0.7148 |
| **Difference** | kt | 0.0499 | 0.0532 | 0.0576 | 0.0521 | 0.0513 |
| | % | 7.19 | 7.2 | 7.9 | 7.4 | 7.7 |

**)combination of change in activity data and change in $N_2O$ emission factor (ERT recommendation 2016)*

**Tab. 3-27 Changes after recalculation in 1.A.1.c.ii for Natural Gas**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| Submission 2016 | TJ | 151.3 | 150.7 | 191.3 | 153.9 | 173.2 |
| Submission 2017 | TJ | 156.6 | 153.3 | 185.2 | 150.9 | 170.9 |
| Difference | TJ | 5.2 | 2.7 | -6.1 | -3.0 | -2.3 |
| | % | 3.46 | 1.8 | -3.2 | -2.0 | -1.3 |
| | | | | | | |
| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| Submission 2016 | kt | 8.366 | 8.326 | 10.558 | 8.510 | 9.587 |
| Submission 2017 | kt | 8.654 | 8.470 | 10.224 | 8.344 | 9.459 |
| Difference | kt | 0.287 | 0.144 | -0.334 | -0.166 | -0.128 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | -1.3 |
| | | | | | | |
| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| Submission 2016 | kt | 0.000151 | 0.000151 | 0.000191 | 0.000154 | 0.000173 |
| Submission 2017 | kt | 0.000157 | 0.000153 | 0.000185 | 0.000151 | 0.000171 |
| Difference | kt | 0.000005 | 0.000003 | -0.000006 | -0.000003 | -0.000002 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | -1.3 |
| | | | | | | |
| $N_2O$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| Submission 2016 | kt | 0.000015 | 0.000015 | 0.000019 | 0.000015 | 0.000017 |
| Submission 2017 | kt | 0.000016 | 0.000015 | 0.000019 | 0.000015 | 0.000017 |
| Difference | kt | 0.0000005 | 0.0000003 | -0.0000006 | -0.0000003 | -0.0000002 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | -1.3 |

Further, following the recommendation of ERT $N_2O$ emission factor was updated to 1.5 kg $N_2O$/TJ for solid fuels, which caused increase in $N_2O$ emissions by 7.14%. The whole impact is smaller, since in 1.A.1.c.ii is big share of Gas Works Gas, which $N_2O$ emission factor is 0.1 kg $N_2O$/TJ.

**Tab. 3-28 Changes after update of $N_2O$ emission factor in 1.A.1.c.ii**

| $N_2O$ emission | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Submission 2016 | kt | 0.0066 | 0.0048 | 0.0036 | 0.0042 | 0.0027 | 0.0409 | 0.0410 | 0.0427 | 0.0455 | 0.0430 |
| Submission 2017 | kt | 0.0069 | 0.0050 | 0.0037 | 0.0044 | 0.0028 | 0.0437 | 0.0437 | 0.0456 | 0.0486 | 0.0459 |
| Difference | kt | 0.0003 | 0.0002 | 0.0001 | 0.0002 | 0.0001 | 0.0028 | 0.0028 | 0.0029 | 0.0031 | 0.0029 |
| | % | 4.6 | 4.0 | 3.2 | 5.0 | 4.0 | 7.0 | 6.7 | 6.7 | 6.8 | 6.7 |
| | | | | | | | | | | | |
| $N_2O$ emission | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| Submission 2016 | kt | 0.0422 | 0.0465 | 0.0500 | 0.0465 | 0.0511 | 0.0509 | 0.0504 | 0.0446 | 0.0534 | 0.0498 |
| Submission 2017 | kt | 0.0450 | 0.0496 | 0.0533 | 0.0497 | 0.0546 | 0.0544 | 0.0538 | 0.0476 | 0.0570 | 0.0532 |
| Difference | kt | 0.0028 | 0.0031 | 0.0034 | 0.0031 | 0.0034 | 0.0034 | 0.0034 | 0.0030 | 0.0036 | 0.0034 |
| | % | 6.7 | 6.8 | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 | 6.8 |
| | | | | | | | | | | | |
| $N_2O$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 | | | | | |
| Submission 2016 | kt | 0.0691 | 0.0681 | 0.0643 | 0.0609 | 0.0537 | | | | | |
| Submission 2017 | kt | 0.0647 | 0.0664 | 0.0639 | 0.0586 | 0.0581 | | | | | |
| Difference | kt | -0.0043 | -0.0017 | -0.0004 | -0.0023 | 0.0044 | | | | | |
| | % | -6.3 | -2.4 | -0.6 | -3.8 | 8.2 | | | | | |

#### *3.2.9.6 Category-specific planned improvements (CRF 1.A.1.c.ii)*

Currently there are no planned improvements in this category.

## 3.2.10 Manufacturing industries and construction – Iron and Steel (1.A.2.a)

### 3.2.10.1 Category description (CRF 1.A.2.a)

The structure of fuels, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.A.2.a, 2015 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity data [TJ]** | **$CO_2$ EF [t $CO_2$/TJ]** | **OxF** | **Emission [kt]** | **$CH_4$ EF [kg $CH_4$/TJ]** | **Emission [kt]** | **$N_2O$ EF [kg $N_2O$/TJ]** | | **Emission [kt]** |
| **Anthracite** | 911.2 | 98.3 | 1 | 89.6 | 10 | 0.0091 | 1.5 | | 0.00137 |
| **Other Bituminous Coal** | 880.5 | 94.4*) | 0.9707*) | 80.6 | 10 | 0.0088 | 1.5 | | 0.00132 |
| **Brown Coal + Lignite** | 217.3 | 100.2*) | 0.9846*) | 21.4 | 10 | 0.0022 | 1.5 | | 0.00033 |
| **Coke** | 9 336.0 | 107.0 | 1 | 999.0 | 10 | 0.0934 | 1.5 | | 0.01400 |
| **Coke Oven Gas** | 5 385.4 | 44.4 | 1 | 239.1 | 1 | 0.0054 | 0.1 | | 0.00054 |
| **Natural Gas** | 8 988.34 | 55.4*) | 1 | 498.1 | 1 | 0.0090 | 0.1 | | 0.00090 |
| **Wood/Wood Waste** | 4.2 | 112.0 | 1 | 0.5 | 30 | 0.0001 | 4.0 | | 0.00002 |
| **Total year 2015** | **25 722.9** | | | **1 928.3** | | **0.1279** | | | **0.01847** |
| **Total year 2014** | 26 499.5 | | | 1 976.7 | | 0.1313 | | | 0.01893 |
| **Index 2015/2014** | 0.97 | | | 0.98 | | 0.97 | | | 0.98 |
| **Total year 1990** | 155 319.2 | | | 14 860.7 | | 1.3950 | | | 0.20941 |
| **Index 2015/1990** | 0.17 | | | 0.13 | | 0.09 | | | 0.09 |

*) *Country specific data*

The origin of the data, the emission factors used and the method of calculating the level of emissions for each gas is sown in details in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Source of Activity data** | **Emission factors** | | | **Method used** | | |
| | | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **Anthracite** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Other Bituminous Coal** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Brown Coal + Lignite** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Coke** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Coal Tars** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Coke Oven Gas** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Wood/Wood Waste** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

This category includes manufacturing in the area of pig iron (blast furnaces), rolling steel, casting iron, steel and alloys and is related only to ferrous metals. In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in section Industry Sector under the item: Iron and Steel. There are embodied the fuels of economic part according to NACE Rev. 2 Iron and steel: NACE Divisions 24.1 – 24.3 and 24.51, 24.52.

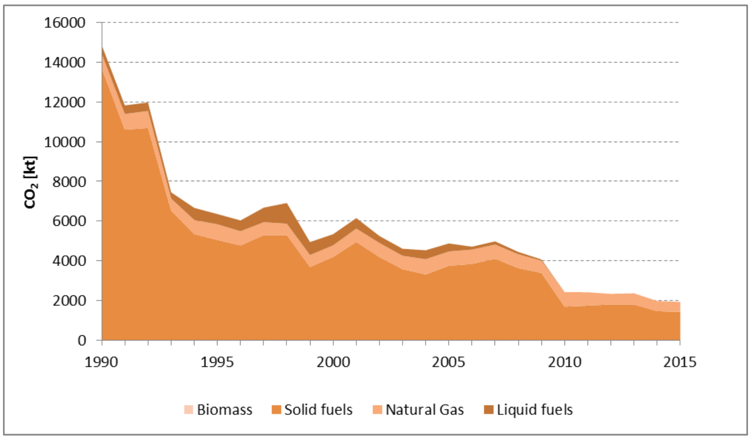



**Fig. 3-11 Development of $CO_2$ emissions in source category 1.A.2.a**

The fraction of $CO_2$ emissions in subsector 1.A.2.a in $CO_2$ emissions in sector 1.A.2 equalled 19.6% in 2015. It contributed only 2% to $CO_2$ emissions in the whole Energy sector.

Important facility belongs to this

category is ArcelorMittal Ostrava, a.s. and Třinecké železárny a.s. Both metallurgical plants include iron ore sinter production, blast furnaces, coke production, iron processing in oxygen converters for steel and casting of steel in electric furnaces and in tandem furnaces. Production of steel using Siemens-Martin process was stopped before 1990.

The following figure provides an overview of $CO_2$ emissions in the various sub-source categories in 1.A.2.a.

The graph in Fig. 3-11 shows apparent sharp decline in emissions in the early 90s, which was mainly due to the loss of markets, following the sharp political changes in the country. At the same time, an impact on the emissions was caused by the new legislation on air pollution and other environmental components. Gradual implementation and introduction of new, more stringent requirements for the protection of the environment is reflected in the decrease of emissions since about 1998. On the course of emissions after 2000 the competition of metallurgical plants in countries outside of Europe caused an impact. Minor fluctuations are caused by market demand and to a lesser extent, the necessary restructuring undertaken in individual companies.

Further, from Fig. 3-11 is clear that the main proportion of the $CO_2$ emissions is due to the use of fossil fuels, which are in this sector completely dominant.

### 3.2.10.2 Methodological issues (CRF 1.A.2.a)

All $CO_2$ emissions from metallurgical coke used in blast furnaces are reported under the Industrial processes sector (2.C.1) and estimated from the amount of carbon in the coke (see Chapter 4.4). Most of the blast furnace and converter gas is combusted in the two metallurgical plants (complexes) and only partly is used elsewhere. At present we are not able to identify exactly amount of these gases combusted outside metallurgical complexes. In order to prevent double-counting, we report all $CO_2$ emissions coming from metallurgical coke under 2.C.1. As a consequence of such approach we do not calculate any $CO_2$ emissions from blast furnace and converter gas.

### 3.2.10.3 Uncertainties and time-series consistency (CRF 1.A.2.a)

See chapter 3.2.5.

### 3.2.10.4 Category-specific QA/QC and verification (CRF 1.A.2.a)

As a basic indicators for verification of fuel consumption in the sector of production of pig iron and steel, it is necessary to consider the indicators of the overall production of agglomerates of iron ore and pig iron. This is due to their high energy intensity. Fig. 3-12 shows the relationship between fuel consumption and total production of sinter and iron in mill. tons.

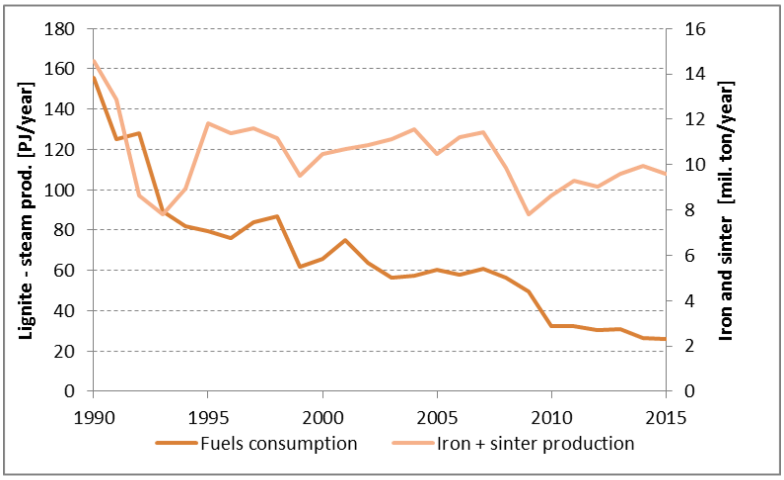



**Fig. 3-12 The trend in the manufacture of agglomerates of iron ore and iron, in comparison with the development of fuel consumption in the sector 1.A.2.a**

From the graph in Fig. 3-12 is clear that the fuel consumption decreases faster than the actual production. This is due to the gradual reduction of overall energy intensity throughout the metallurgical industry. This trend is particularly evident in the early 90s, when there was a major restructuring of production. This restructuring enabled, after the decline in 1990 and 1993, to return the volume of production almost to the level of 1990, but the decrease in total fuel consumption went further. Additional reductions in energy intensity are evident then until the end of the period.

Generally accepted methods of QA/QC are described in section 3.2.6.

### *3.2.10.5 Category-specific recalculations (CRF 1.A.2.a)*

Quite extensive updates were provided in activity data by CzSO, which resulted in recalculation of this category.

**Tab. 3-29 Changes after recalculation in 1.A.2.a for Liquid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| **Submission 2016** | TJ | 1 474 | 815 | 405 | 251 |
| **Submission 2017** | TJ | NO | NO | NO | NO |

**Tab. 3-30 Changes after recalculation in 1.A.2.a for Solid Fuels**

| Fuel consumption | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 37 685 | 23 911 | 29 397 | 23 147 | 24 716 | 21 289 |
| **Submission 2017** | TJ | 37 660 | 19 232 | 19 921 | 20 757 | 20 818 | 17 235 |
| **Difference** | TJ | -24.8 | -4 679.3 | -9 475.4 | -2 389.4 | -3 898.1 | -4 053.9 |
| | % | -0.07 | -19.6 | -32.2 | -10.3 | -15.8 | -19.0 |
| | | | | | | | |
| $CO_2$ emission | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 3 394.0 | 2 143.2 | 2 759.1 | 2 096.0 | 2 254.4 | 1 642.5 |
| **Submission 2017** | kt | 3 391.3 | 1 692.2 | 1 740.8 | 1 800.4 | 1 801.6 | 1 462.5 |
| **Difference** | kt | -2.7 | -450.9 | -1 018.3 | -295.6 | -452.8 | -179.9 |
| | % | -0.08 | -21.0 | -36.9 | -14.1 | -20.1 | -11.0 |
| | | | | | | | |
| $CH_4$ emission | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.3297 | 0.1930 | 0.2512 | 0.1907 | 0.2080 | 0.1253 |
| **Submission 2017** | kt | 0.3295 | 0.1474 | 0.1494 | 0.1556 | 0.1588 | 0.1213 |
| **Difference** | kt | -0.0002 | -0.0456 | -0.1018 | -0.0352 | -0.0491 | -0.0040 |
| | % | -0.08 | -23.6 | -40.5 | -18.4 | -23.6 | -3.2 |
| | | | | | | | |
| $N_2O$ emission*) | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0460 | 0.0268 | 0.0350 | 0.0265 | 0.0289 | 0.0172 |
| **Submission 2017** | kt | 0.0492 | 0.0219 | 0.0221 | 0.0230 | 0.0236 | 0.0179 |
| **Difference** | kt | 0.0032 | -0.0050 | -0.0128 | -0.0035 | -0.0054 | 0.0008 |
| | % | 6.98 | -18.5 | -36.7 | -13.1 | -18.6 | 4.4 |

**)combination of change in activity data and change in $N_2O$ emission factor (ERT recommendation 2016)*

**Tab. 3-31 Changes after recalculation in 1.A.2.a for Natural Gas**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 12 853 | 12 010 | 9 931 | 10 297 | 8 830 |
| **Submission 2017** | TJ | 13 294 | 12 217 | 9 617 | 10 096 | 9 241 |
| **Difference** | TJ | 441.5 | 207.5 | -314.2 | -201.0 | 410.8 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | 4.7 |
| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 710.6 | 663.7 | 548.2 | 569.5 | 488.8 |
| **Submission 2017** | kt | 735.2 | 675.4 | 530.8 | 558.3 | 511.5 |
| **Difference** | kt | 24.6 | 11.7 | -17.3 | -11.1 | 22.7 |
| | % | 3.46 | 1.8 | -3.2 | -2.0 | 4.7 |
| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0129 | 0.0120 | 0.0099 | 0.0103 | 0.0088 |
| **Submission 2017** | kt | 0.0133 | 0.0122 | 0.0096 | 0.0101 | 0.0092 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Difference** | kt | 0.0004 | 0.0002 | -0.0003 | -0.0002 | 0.0004 |
| | % | 3.46 | 1.8 | -3.2 | -2.0 | 4.7 |
| **$N_2O$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.00129 | 0.00120 | 0.00099 | 0.00103 | 0.00088 |
| **Submission 2017** | kt | 0.00133 | 0.00122 | 0.00096 | 0.00101 | 0.00092 |
| **Difference** | kt | 0.00004 | 0.00002 | -0.00003 | -0.00002 | 0.00004 |
| | % | 3.46 | 1.8 | -3.2 | -2.0 | 4.7 |

Further, following the recommendation of ERT $N_2O$ emission factor was updated to 1.5 kg $N_2O$/TJ for solid fuels, which caused increase in $_{N2O}$ emissions by 7.14%. The whole impact is smaller, since in 1.A.2.a is apparent share of coal gases, which $N_2O$ emission factor is 0.1 kg $N_2O$/TJ.

**Tab. 3-32 Changes after update of $N_2O$ emission factor in 1.A.2.a**

| **$N_2O$ emission** | | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.1911 | 0.1472 | 0.1495 | 0.0839 | 0.0683 | 0.0646 | 0.0594 | 0.0679 | 0.0707 | 0.0475 |
| **Submission 2017** | kt | 0.2048 | 0.1577 | 0.1602 | 0.0898 | 0.0730 | 0.0691 | 0.0635 | 0.0727 | 0.0757 | 0.0508 |
| **Difference** | kt | 0.0137 | 0.0105 | 0.0107 | 0.0059 | 0.0048 | 0.0045 | 0.0041 | 0.0047 | 0.0050 | 0.0033 |
| | % | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| **$N_2O$ emission** | | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| **Submission 2016** | kt | 0.0544 | 0.0640 | 0.0555 | 0.0459 | 0.0441 | 0.0502 | 0.0513 | 0.0563 | 0.0483 | 0.0460 |
| **Submission 2017** | kt | 0.0582 | 0.0685 | 0.0594 | 0.0491 | 0.0472 | 0.0538 | 0.0550 | 0.0603 | 0.0517 | 0.0492 |
| **Difference** | kt | 0.0038 | 0.0045 | 0.0039 | 0.0032 | 0.0031 | 0.0035 | 0.0036 | 0.0040 | 0.0034 | 0.0032 |
| | % | 7.0 | 7.0 | 7.1 | 7.0 | 7.0 | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 |
| **$N_2O$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** | | | | | |
| **Submission 2016** | kt | 0.0268 | 0.0350 | 0.0265 | 0.0289 | 0.0172 | | | | | |
| **Submission 2017** | kt | 0.0219 | 0.0221 | 0.0230 | 0.0236 | 0.0179 | | | | | |
| **Difference** | kt | -0.0050 | -0.0128 | -0.0035 | -0.0054 | 0.0008 | | | | | |
| | % | -18.5 | -36.7 | -13.1 | -18.6 | 4.4 | | | | | |

### *3.2.10.6 Category-specific planned improvements (CRF 1.A.2.a)*

We are planning to find data making possible to identify portions of both blast furnace and converter gases, which are combusted outside metallurgical complexes (see 3.2.10.2.).

## 3.2.11 Manufacturing industries and construction – Non-Ferrous Metals (1.A.2.b)

### *3.2.11.1 Category description (CRF 1.A.2.b)*

The structure of fuels, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| **1.A.2.b, 2015** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity** | **$CO_2$** | | | **$CH_4$** | | **$N_2O$** | |
| | **data** | **EF** | **OxF** | **Emission** | **EF** | **Emission** | **EF** | **Emission** |
| | **[TJ]** | **[t $CO_2$/TJ]** | | **[kt]** | **[kg $CH_4$/TJ]** | **[kt]** | **[kg $N_2O$ /TJ]** | **[kt]** |
| **Fuel Oil - Low Sulphur** | 14.4 | 77.4 | 1 | 1.1 | 3 | 0.00004 | 0.6 | 0.00001 |
| **Coke** | 114.6 | 107.0 | 1 | 12.3 | 10 | 0.00115 | 1.5 | 0.00017 |
| **Natural Gas** | 1669.6 | 55.4*) | 1 | 92.5 | 1 | 0.00167 | 0.1 | 0.00017 |
| **Wood/Wood Waste** | 2.8 | 112.0 | 1 | 0.3 | 30 | 0.00008 | 4.0 | 0.00001 |
| **Total year 2015** | **1 801.3** | | | **106.2** | | **0.00294** | | **0.00036** |
| **Total year 2014** | 1 617.3 | | | 95.7 | | 0.00273 | | 0.00033 |
| **Index 2015/2014** | 1.11 | | | 1.11 | | 1.08 | | 1.07 |
| **Total year 1990** | 1 476.3 | | | 102.0 | | 0.00572 | | 0.00081 |
| **Index 2015/1990** | 1.22 | | | 1.04 | | 0.51 | | 0.44 |

*) *Country specific data*

The origin of the data, the emission factors used and the method of calculating the level of emissions for the individual gases are shown in details in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Source of** | **Emission factors** | | | **Method used** | | |
| | **Activity data** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **Fuel Oil - Low Sulphur** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Coke** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Wood/Wood Waste** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

This category encompasses combustion processes in various areas of production of non-ferrous metals. In the Czech Republic, this corresponds mainly to foundry processes; primary production of nonferrous metals is not performed on an industrial scale in this country. In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

Non-Ferrous Metals

There are embodied the fuels of economic part according to NACE Rev. 2

Non-ferrous metals: NACE Divisions 24.4, 24.53, 24.54

Important facility belongs to this category is Kovohutě Příbram. The fraction of $CO_2$ emissions in subsector 1.A.2.b in $CO_2$ emissions in sector 1.A.2 equalled 1% in 2015. It contributed only 0.1% to $CO_2$ emissions in the whole Energy sector.

It can be said that this is one of the sectors that rank according to its emissions of greenhouse gases among the least important in the entire sector Fuel combustion.

The following figure (Fig. 3-13) provides an overview of $CO_2$ emissions in the various sub-source categories in 1.A.2.b.

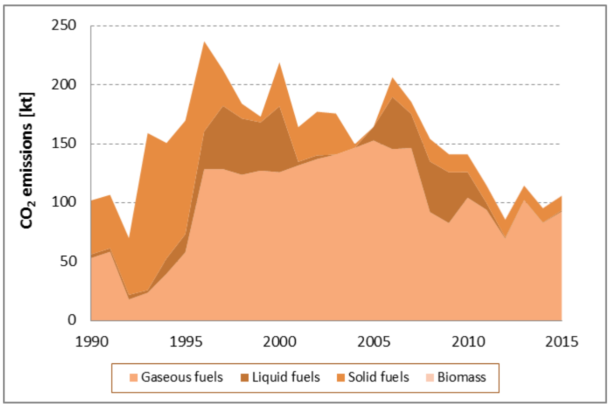



**Fig. 3-13 Development of $CO_2$ emissions in source category 1.A.2.b**

The trend of $CO_2$ emissions corresponds to the trend of consumption of individual types of fuels. After a decline in the early 90s, it is apparent a sharp increase in emissions, which was caused by the recovery in the industry. The recovery of the industry has happened in this sector, especially due to the increase in demand for parts, made of ferrous metals in the emerging automotive industry. Decrease in emissions at the end of the period was caused by the crisis between 2008 and 2012, as well as the reduction of the energy intensity of production. With this is also related a shift from fossil fuels in favour of natural gas. Furthermore, electrical energy is increasingly used for heating the melting furnaces, which has a positive impact on greenhouse gas emissions.

### *3.2.11.2 Methodological issues (CRF 1.A.2.b)*

In this subcategory, specific methodologies are not used - a description of the general procedures - see Section 3.2.4.

### *3.2.11.3 Uncertainties and time-series consistency (CRF 1.A.2.b)*

See chapter 3.2.5.

### *3.2.11.4 Category-specific QA/QC and verification (CRF 1.A.2.b)*

In this subcategory, specific methodologies are not used - a description of the general procedures - see Section 3.2.6.

### *3.2.11.5 Category-specific recalculations (CRF 1.A.2.b)*

Quite extensive updates were provided in activity data by CzSO, which resulted in recalculation of this category.

**Tab. 3-33 Changes after recalculation in 1.A.2.b for Liquid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 470.5 | 260.9 | 94.2 | 8.1 | 1.6 |
| **Submission 2017** | TJ | 280.5 | 74.1 | 12.3 | 2.6 | 4.2 |
| **Difference** | TJ | -190.0 | -186.8 | -81.9 | -5.5 | 2.5 |
| | % | -40.39 | -71.6 | -86.9 | -67.6 | 152.6 |
| | | | | | | |
| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 36.417 | 20.195 | 7.294 | 0.628 | 0.127 |
| **Submission 2017** | kt | 21.708 | 5.736 | 0.954 | 0.204 | 0.322 |
| **Difference** | kt | -14.709 | -14.459 | -6.340 | -0.425 | 0.194 |
| | % | -40.39 | -71.6 | -86.9 | -67.6 | 152.6 |
| | | | | | | |
| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.001412 | 0.000783 | 0.000283 | 0.000024 | 0.000005 |
| **Submission 2017** | kt | 0.000841 | 0.000222 | 0.000037 | 0.000008 | 0.000012 |
| **Difference** | kt | -0.000570 | -0.000560 | -0.000246 | -0.000016 | 0.000008 |
| | % | -40.39 | -71.6 | -86.9 | -67.6 | 152.6 |
| | | | | | | |
| $N_2O$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.000282 | 0.000157 | 0.000057 | 0.000005 | 0.000001 |
| **Submission 2017** | kt | 0.000168 | 0.000044 | 0.000007 | 0.000002 | 0.000002 |
| **Difference** | kt | -0.000114 | -0.000112 | -0.000049 | -0.000003 | 0.000002 |
| | % | -40.39 | -71.6 | -86.9 | -67.6 | 152.6 |

**Tab. 3-34 Changes after recalculation in 1.A.2.b for Solid Fuels**

| Fuel consumption | | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 143.3 | 167.9 | 168.2 | 142.4 | 142.7 |
| **Submission 2017** | TJ | 143.0 | 140.0 | 140.3 | 142.4 | 114.2 |
| **Difference** | TJ | -0.3 | -28.0 | -27.9 | 0.0 | -28.5 |
| | % | -0.23 | -16.7 | -16.6 | 0.02 | -20.0 |
| | | | | | | |
| $CO_2$ emission | | 2009 | 2010 | 2011 | 2012 | 2013 |
| **Submission 2016** | kt | 15.333 | 17.970 | 17.998 | 15.232 | 15.265 |
| **Submission 2017** | kt | 15.298 | 14.975 | 15.012 | 15.235 | 12.218 |
| **Difference** | kt | -0.035 | -2.995 | -2.986 | 0.003 | -3.047 |
| | % | -0.23 | -16.7 | -16.6 | 0.02 | -20.0 |
| | | | | | | |
| $CH_4$ emission | | 2009 | 2010 | 2011 | 2012 | 2013 |
| **Submission 2016** | kt | 0.0014 | 0.0017 | 0.0017 | 0.0014 | 0.0014 |
| **Submission 2017** | kt | 0.0014 | 0.0014 | 0.0014 | 0.0014 | 0.0011 |
| **Difference** | kt | -0.000003 | -0.000280 | -0.000279 | 0.000000 | -0.000285 |
| | % | -0.23 | -16.7 | -16.6 | 0.02 | -20.0 |

| $N_2O$ emission*) | | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| **Submission 2017** | kt | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| **Difference** | kt | 0.00001 | -0.00003 | -0.00003 | 0.00001 | -0.00003 |
| | % | 6.90 | -10.7 | -10.6 | 7.2 | -14.2 |

**)combination of change in activity data and change in $N_2O$ emission factor (ERT recommendation 2016)*

**Tab. 3-35 Changes after recalculation in 1.A.2.b for Natural Gas**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 1 823.7 | 1 672.9 | 1 299.0 | 1 883.1 | 1 516.7 |
| **Submission 2017** | TJ | 1 886.3 | 1 701.8 | 1 257.9 | 1 846.3 | 1 496.5 |
| **Difference** | TJ | 62.6 | 28.9 | -41.1 | -36.8 | -20.2 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | -1.3 |
| | | | | | | |
| **$CO_2$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 100.8 | 92.4 | 71.7 | 104.1 | 84.0 |
| **Submission 2017** | kt | 104.3 | 94.0 | 69.4 | 102.1 | 82.8 |
| **Difference** | kt | 3.5 | 1.6 | -2.3 | -2.0 | -1.1 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | -1.3 |
| | | | | | | |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.001824 | 0.001673 | 0.001299 | 0.001883 | 0.001517 |
| **Submission 2017** | kt | 0.001886 | 0.001702 | 0.001258 | 0.001846 | 0.001496 |
| **Difference** | kt | 0.000063 | 0.000029 | -0.000041 | -0.000037 | -0.000020 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | -1.3 |
| | | | | | | |
| **$N_2O$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.000182 | 0.000167 | 0.000130 | 0.000188 | 0.000152 |
| **Submission 2017** | kt | 0.000189 | 0.000170 | 0.000126 | 0.000185 | 0.000150 |
| **Difference** | kt | 0.000006 | 0.000003 | -0.000004 | -0.000004 | -0.000002 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | -1.3 |

Further, following the recommendation of ERT $N_2O$ emission factor was updated to 1.5 kg $N_2O$/TJ for solid fuels, which caused increase in $N_2O$ emissions by 7.14%. The whole impact is smaller, since in 1.A.2.a is apparent share of coal gases, which $N_2O$ emission factor is 0.1 kg $N_2O$/TJ.

**Tab. 3-36 Changes after update of $N_2O$ emission factor in 1.A.2.b**

| $N_2O$ emission | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.00065 | 0.00064 | 0.00068 | 0.00135 | 0.000774 | 0.000704 | 0.001071 | 0.000431 | 0.000176 |
| **Submission 2017** | kt | 0.00069 | 0.00069 | 0.00073 | 0.00144 | 0.000826 | 0.00075 | 0.001147 | 0.000461 | 0.000188 |
| **Difference** | kt | 0.00005 | 0.00005 | 0.00005 | 0.00009 | 0.00005 | 0.00005 | 0.00008 | 0.00003 | 0.00001 |
| | % | 7.1 | 7.1 | 7.1 | 6.9 | 6.7 | 6.6 | 7.1 | 7.1 | 7.1 |
| | | | | | | | | | | |
| **$N_2O$ emission** | | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** |
| **Submission 2016** | kt | 6.46E-05 | 0.00053 | 0.00041 | 0.00052 | 0.00048 | 3.97E-05 | NO | 0.00022 | 0.000136 |
| **Submission 2017** | kt | 6.92E-05 | 0.00056 | 0.00044 | 0.00055 | 0.00052 | 4.26E-05 | NO | 0.00024 | 0.00015 |
| **Difference** | kt | 4.61E-06 | 0.00004 | 0.00003 | 0.00004 | 0.00003 | 2.84E-06 | | 0.00002 | 0.00001 |
| | % | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | | 7.1 | 7.1 |
| | | | | | | | | | | |
| **$N_2O$ emission** | | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | | |
| **Submission 2016** | kt | 0.000253 | 0.000201 | 0.00024 | 0.00024 | 0.00020 | 0.00020 | 0.00016 | | |
| **Submission 2017** | kt | 0.00027 | 0.00021 | 0.00021 | 0.00021 | 0.000214 | 0.000171 | 0.000171 | | |
| **Difference** | kt | 0.00002 | 0.00001 | -0.00003 | -0.00003 | 0.00001 | -0.00003 | 0.00001 | | |
| | % | 7.1 | 6.9 | -10.7 | -10.6 | 7.2 | -14.2 | 7.1 | | |

#### *3.2.11.6 Category-specific planned improvements (CRF 1.A.2.b)*

Currently there are no planned improvements in this category.

### 3.2.12 Manufacturing industries and construction – Chemicals (1.A.2.c)

#### *3.2.12.1 Category description (CRF 1.A.2.c)*

The structure of fuels, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.A.2.c, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity** | **$CO_2$** | | | **$CH_4$** | | **$N_2O$** | |
| | **data** | **EF** | **OxF** | **Emission** | **EF** | **Emission** | **EF** | **Emission** |
| | **[TJ]** | **[t $CO_2$/TJ]** | | **[kt]** | **[kg $CH_4$/TJ]** | **[kt]** | **[kg $N_2O$/TJ]** | **[kt]** |
| **Fuel Oil - Low Sulphur** | 79.0 | 77.4 | 1 | 6.1 | 3 | 0.00024 | 0.6 | 0.00005 |
| **Other Oil** | 1538.1 | 73.3 | 1 | 112.7 | 3 | 0.00461 | 0.6 | 0.00092 |
| **Other Bituminous Coal** | 1289.3 | 94.4*) | 0.971*) | 118.1 | 10 | 0.01289 | 1.5 | 0.00193 |
| **Brown Coal + Lignite** | 6750.1 | 100.2*) | 0.985*) | 665.7 | 10 | 0.06750 | 1.5 | 0.01013 |
| **Natural Gas** | 12563.1 | 55.4*) | 1 | 696.2 | 1 | 0.01256 | 0.1 | 0.00126 |
| **Wood/Wood Waste** | 26.6 | 112.0 | 1 | 3.0 | 30 | 0.00080 | 4.0 | 0.00011 |
| **Total year 2015** | **22 246.1** | | | **1 601.9** | | **0.09860** | | **0.01439** |
| **Total year 2014** | 23 184.0 | | | 1 691.0 | | 0.10703 | | 0.01578 |
| **Index 2015/2014** | 0.96 | | | 0.95 | | 0.92 | | 0.91 |
| **Total year 1990** | 33 576.7 | | | 2 996.4 | | 0.26480 | | 0.03975 |
| **Index 2015/1990** | 0.66 | | | 0.53 | | 0.37 | | 0.36 |

*) *Country specific data*

The origin of the data, the emission factors used and the method of calculating the level of emissions for the individual gases are shown in details in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Source for** | **Emission factors** | | | **Method used** | | |
| | **Activity data** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **Fuel Oil - Low Sulphur** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Other Oil** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Other Bituminous Coal** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Brown Coal + Lignite** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Wood/Wood Waste** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

This subcategory includes all the processes in the organic and inorganic chemical industry and all related processes, incl. petrochemistry. The petrochemical plants are linked to two major refinery enterprises in Litvinov (Unipetrol RPA, sro) and in Kralupy (Synthos Kralupy as). Due to the historical linkage between the two units, it is very difficult to determine the fuel combusted in the refinery and petrochemical parts of the two plants separately. Furthermore, other major plants for processing organic chemistry products are in operation in the Czech Republic (DEZA a.s. Meziříčí – processing of coal tar, SYNTHESIA a.s. Pardubice - basic organic chemistry) and a number of factories for manufacturing of inorganic products (SPOLANA a.s. Neratovice, SPOLCHEMIE a.s. Ústí nad Labem, PRECHEZA a.s. Přerov and others). The largest plants are also equipped with energy resources, with a significant share of electricity and heat (autoproducers); this results in relatively high consumption of fossil fuels (see Fig 3-14). Heat is generated using abundant natural gas and, to a lesser extent, liquid fuels or, in some cases, electrical energy. In total, the national emission database recorded 1,000 production units that fall within sector 1.A.2.c.

In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

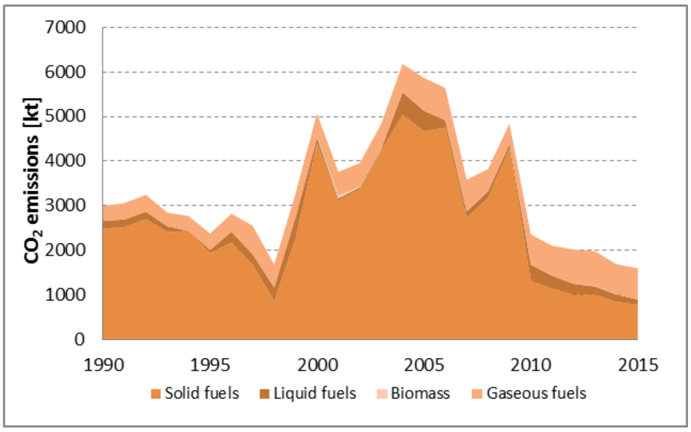



**Fig. 3-14 Development of $CO_2$ emissions in source category 1.A.2.c**

Chemical (including Petrochemical)

There are embodied the fuels of economic part according to NACE Rev. 2:

Chemicals: NACE Division 20

The fraction of $CO_2$ emissions in subsector 1.A.2.c in $CO_2$ emissions in sector 1.A.2 equalled 16.3% in 2015. It contributed 1.7% to $CO_2$ emissions in the whole Energy sector.

The following figure (Fig. 3-14) provides an overview of $CO_2$ emissions in the sub-category in 1.A.2.c.

The course of $CO_2$ emissions is not directly related to the volume of chemical production, since it is primarily emissions from burning fossil fuels to produce electricity and heat (autoproducers). For this reason, the development of emissions in time cannot be commented.

### *3.2.12.2 Methodological issues (CRF 1.A.2.c)*

Given that in the IPCC 2006 Gl. (IPCC, 2006)is used an updated approach to the allocation of feedstocks and non-energy use of fuels into IPPU. The new distribution of liquid fuels is to be considered as category specific methodological issue. This methodological approach is in the same time based on the new reallocation of fuel consumption for energy and non-energy use in the questionnaire from CzSO (2016). The reallocation of feedstocks and non-energy use of fuels in IPPU is in details described in chapter 3.2.3.

Other methodological approaches were applied as in the other subcategories, and their description is provided in chapter 3.2.4.

### *3.2.12.3 Uncertainties and time-series consistency (CRF 1.A.2.c)*

See chapter 3.2.5.

### *3.2.12.4 Category-specific QA/QC and verification (CRF 1.A.2.c)*

In this category, no specific QA/QC procedures were used. Given that the fuel consumption in this sector, reported directly, is not related to the production volume of chemicals, there cannot be used the relevant comparison with specific commodities.

Description of the QA/QC procedures is given in chapter 3.2.6.

### *3.2.12.5 Category-specific recalculations (CRF 1.A.2.c)*

Quite extensive updates were provided in activity data by CzSO, which resulted in recalculation of this category.

**Tab. 3-37 Changes after recalculation in 1.A.2.c for Liquid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 1 269.9 | 513.7 | 157.9 | 39.4 | 39.5 |
| **Submission 2017** | TJ | 4 933.8 | 3 930.5 | 3 384.4 | 2 410.0 | 2 314.4 |
| **Difference** | TJ | 3 663.9 | 3 416.8 | 3 226.5 | 2 370.6 | 2 274.9 |
| | % | 289 | 665 | 2044 | 6011 | 5759 |

| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 98.29 | 39.76 | 12.22 | 3.05 | 3.06 |
| **Submission 2017** | kt | 366.36 | 290.05 | 249.05 | 176.81 | 169.81 |
| **Difference** | kt | 268.08 | 250.29 | 236.82 | 173.76 | 166.75 |
| | % | 273 | 630 | 1938 | 5692 | 5454 |
| | | | | | | |
| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.00381 | 0.00154 | 0.00047 | 0.00012 | 0.00012 |
| **Submission 2017** | kt | 0.01480 | 0.01179 | 0.01015 | 0.00723 | 0.00694 |
| **Difference** | kt | 0.01099 | 0.01025 | 0.00968 | 0.00711 | 0.00682 |
| | % | 289 | 665 | 2044 | 6011 | 5759 |
| | | | | | | |
| $N_2O$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.00076 | 0.00031 | 0.00009 | 0.00002 | 0.00002 |
| **Submission 2017** | kt | 0.00296 | 0.00236 | 0.00203 | 0.00145 | 0.00139 |
| **Difference** | kt | 0.00220 | 0.00205 | 0.00194 | 0.00142 | 0.00136 |
| | % | 289 | 665 | 2044 | 6011 | 5759 |

**Tab. 3-38 Changes after recalculation in 1.A.2.c for Solid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 12 992 | 12 301 | 11 229 | 10 923 | 8 645 |
| **Submission 2017** | TJ | 13 526 | 11 707 | 10 283 | 10 477 | 8 683 |
| **Difference** | TJ | 534.4 | -594.1 | -945.9 | -445.2 | 38.2 |
| | % | 4.11 | -4.8 | -8.4 | -4.08 | 0.4 |
| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 1 255.0 | 1 191.0 | 1 085.8 | 1 050.8 | 840.7 |
| **Submission 2017** | kt | 1 316.2 | 1 146.5 | 1 003.7 | 1 018.5 | 844.5 |
| **Difference** | kt | 61.2 | -44.6 | -82.0 | -32.3 | 3.8 |
| | % | 4.88 | -3.7 | -7.6 | -3.08 | 0.4 |
| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.1299 | 0.1230 | 0.1123 | 0.1092 | 0.0864 |
| **Submission 2017** | kt | 0.1353 | 0.1171 | 0.1028 | 0.1048 | 0.0868 |
| **Difference** | kt | 0.0053 | -0.0059 | -0.0095 | -0.0045 | 0.0004 |
| | % | 4.11 | -4.8 | -8.4 | -4.08 | 0.4 |
| $N_2O$ emission *) | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0182 | 0.0172 | 0.0157 | 0.0153 | 0.0121 |
| **Submission 2017** | kt | 0.0203 | 0.0176 | 0.0154 | 0.0157 | 0.0130 |
| **Difference** | kt | 0.0021 | 0.0003 | -0.0003 | 0.0004 | 0.0009 |
| | % | 11.55 | 2.0 | -1.9 | 2.8 | 7.6 |

**)combination of change in activity data and change in $N_2O$ emission factor (ERT recommendation 2016)*

**Tab. 3-39 Changes after recalculation in 1.A.2.c for Natural Gas**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 11 539 | 11 421 | 13 965 | 13 164 | 13 415 |
| **Submission 2017** | TJ | 12 221 | 12 055 | 13 916 | 14 071 | 12 150 |
| **Difference** | TJ | 682.3 | 634.4 | -48.6 | 906.5 | -1 265.3 |
| | % | 5.91 | 5.6 | -0.3 | 6.9 | -9.4 |
| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 637.9 | 631.1 | 770.9 | 728.0 | 742.5 |
| **Submission 2017** | kt | 675.7 | 666.2 | 768.2 | 778.1 | 672.5 |
| **Difference** | kt | 37.7 | 35.1 | -2.7 | 50.1 | -70.0 |
| | % | 5.91 | 5.6 | -0.3 | 6.9 | -9.4 |
| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0115 | 0.0114 | 0.0140 | 0.0132 | 0.0134 |
| **Submission 2017** | kt | 0.0122 | 0.0121 | 0.0139 | 0.0141 | 0.0121 |
| **Difference** | kt | 0.0007 | 0.0006 | 0.0000 | 0.0009 | -0.0013 |
| | % | 5.91 | 5.6 | -0.3 | 6.9 | -9.4 |

| $N_2O$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.0012 | 0.0011 | 0.0014 | 0.0013 | 0.0013 |
| **Submission 2017** | kt | 0.0012 | 0.0012 | 0.0014 | 0.0014 | 0.0012 |
| **Difference** | kt | 0.0001 | 0.0001 | 0.0000 | 0.0001 | -0.0001 |
| | % | 5.91 | 5.6 | -0.3 | 6.9 | -9.4 |

Further, following the recommendation of ERT $N_2O$ emission factor was updated to 1.5 kg $N_2O$/TJ for solid fuels, which caused increase in $N_2O$ emissions by 7.14%.

**Tab. 3-40 Changes after update of $N_2O$ emission factor in 1.A.2.c**

| $N_2O$ emission | | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.0353 | 0.0255 | 0.0631 | 0.0670 | 0.0182 | 0.0172 | 0.0157 | 0.0153 | 0.0121 |
| **Submission 2017** | kt | 0.0378 | 0.0273 | 0.0676 | 0.0718 | 0.0203 | 0.0176 | 0.0154 | 0.0157 | 0.0130 |
| **Difference** | kt | 0.0025 | 0.0018 | 0.0045 | 0.0048 | 0.0021 | 0.0003 | -0.0003 | 0.0004 | 0.0009 |
| | % | 7.1 | 7.1 | 7.1 | 7.1 | 11.6 | 2.0 | -1.9 | 2.8 | 7.6 |

### *3.2.12.6 Category-specific planned improvements (CRF 1.A.2.c)*

Currently there are no planned improvements in this category.

## 3.2.13 Manufacturing industries and construction – Pulp, Paper and Print (1.A.2.d)

### *3.2.13.1 Category description (CRF 1.A.2.d)*

The structure of fuels, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.A.2.d, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity** | **$CO_2$** | | | **$CH_4$** | | **$N_2O$** | |
| | **data** | **EF** | **OxF** | **Emission** | **EF** | **Emission** | **EF** | **Emission** |
| | **[TJ]** | **[t $CO_2$/TJ]** | | **[kt]** | **[kg $CH_4$/TJ]** | **[kt]** | **[kg $N_2O$/TJ]** | **[kt]** |
| **LPG** | 45.9 | 65.9*) | 1 | 3.0 | 1 | 0.00005 | 0.1 | 0.000005 |
| **Heating and Other Gasoil** | 100.7 | 74.1 | 1 | 7.5 | 3 | 0.00030 | 0.6 | 0.00006 |
| **Fuel Oil - Low Sulphur** | 46.7 | 77.4 | 1 | 3.6 | 3 | 0.00014 | 0.6 | 0.00003 |
| **Brown Coal + Lignite** | 1398.9 | 100.2*) | 0.985*) | 138.0 | 10 | 0.01399 | 1.5 | 0.00210 |
| **Natural Gas** | 5045.4 | 55.4*) | 1 | 279.6 | 1 | 0.00505 | 0.1 | 0.00050 |
| **Wood/Wood Waste** | 17039.2 | 112.00 | 1 | 1 908.4 | 30 | 0.51118 | 4.0 | 0.06816 |
| **Gaseous Biomass** | 9373.4 | 54.6 | 1 | 511.8 | 1 | 0.00937 | 0.1 | 0.00094 |
| **Total year 2015** | **33 050.3** | | | **2 851.9** | | **0.54007** | | **0.07179** |
| **Total year 2014** | 31 917.0 | | | 2 817.1 | | 0.55273 | | 0.07352 |
| **Index 2015/2014** | 1.04 | | | 1.01 | | 0.98 | | 0.98 |
| **Total year 1990** | 25 900.8 | | | 2 285.3 | | 0.18784 | | 0.02890 |
| **Index 2015/1990** | 1.28 | | | 1.25 | | 2.88 | | 2.48 |

*) *Country specific data*

The origin of the data, the emission factors used and the method of calculating the level of emissions for the individual gases are shown in details in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Source of** | **Emission factors** | | | **Method used** | | |
| | **Activity data** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **LPG** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Heating and Other Gasoil** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Fuel Oil - Low Sulphur** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Brown Coal + Lignite** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Wood/Wood Waste** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Gaseous Biomass** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

This subcategory includes all manufacturing processes related to the production of paper, cardboard and print in printing plants. There are two primary paper production factories in the Czech Republic (JIP - Papírny Větřní, a. s., Mondi Štětí a.s.) with a high consumption of waste wood from production processes. The other plants select the kind of fuel on the basis of the same criteria as the rest of the processing industry.

In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

Paper, Pulp and Printing

There are embodied the fuels of economic part according to NACE Rev. 2

Pulp, paper and print: NACE Divisions 17 and 18

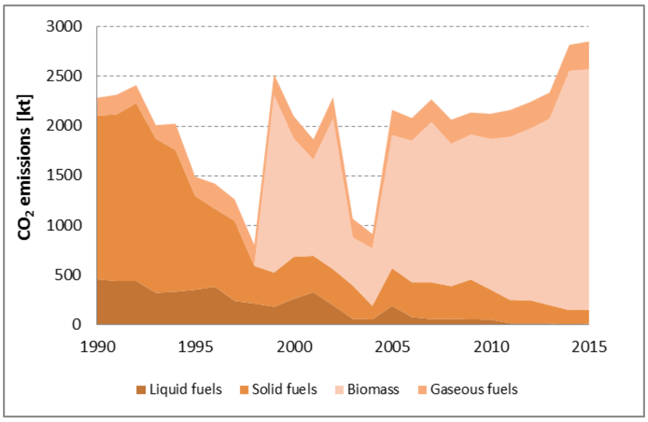



**Fig. 3-15 Development of $CO_2$ emissions in source category 1.A.2.d**

The fraction of $CO_2$ emissions in subsector 1.A.2.d in $CO_2$ emissions in sector 1.A.2 equalled 4% in 2015. It contributed 0.5% to $CO_2$ emissions in the whole Energy sector.

From the graph on Fig. 3-15 is clear that at the end of the 90s there was significant substitution, therefore used fossil fuels (primarily lignite) with wood and later biogas. Both biofuels represent waste products from the production of paper and pulp from the two largest plants in the Czech Republic. Following the decline in 2003 and 2004, the consumption of fuels after 2005 was relatively stable, while the share of biofuels further increased.

Biofuel consumption has a beneficial effect on the production of $CO_2$, which is included in the balance of greenhouse gases. In Fig. 3-15 is shown the development of $CO_2$ emissions from fossil fuels only in sector 1.A.2.d.

### *3.2.13.2 Methodological issues (CRF 1.A.2.d)*

No specific methodological approaches were applied in this subcategory, otherwise see chapter 3.2.6.

### *3.2.13.3 Uncertainties and time-series consistency (CRF 1.A.2.d)*

See chapter 3.2.5.

### *3.2.13.4 Category-specific QA/QC and verification (CRF 1.A.2.d)*

No specific methods for QA/QC in this category were used - otherwise see chapter 3.2.7.4.

### *3.2.13.5 Category-specific recalculations (CRF 1.A.2.d)*

Quite extensive updates were provided in activity data by CzSO, which resulted in recalculation of this category.

**Tab. 3-41 Changes after recalculation in 1.A.2.d for Liquid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 749.2 | 349.4 | 263.9 | 248.1 | 41.1 |
| **Submission 2017** | TJ | 700.1 | 217.0 | 202.1 | 205.1 | 43.7 |
| **Difference** | TJ | -49.1 | -132.4 | -61.7 | -43.0 | 2.5 |
| | % | -6.56 | -37.9 | -23.4 | -17.3 | 6.1 |
| **$CO_2$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 57.989 | 27.042 | 20.422 | 19.200 | 3.185 |
| **Submission 2017** | kt | 53.959 | 16.792 | 15.643 | 15.873 | 3.379 |
| **Difference** | kt | -4.029 | -10.250 | -4.779 | -3.326 | 0.194 |
| | % | -6.95 | -37.9 | -23.4 | -17.3 | 6.1 |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.002248 | 0.001048 | 0.000792 | 0.000744 | 0.000123 |
| **Submission 2017** | kt | 0.002061 | 0.000651 | 0.000606 | 0.000615 | 0.000131 |
| **Difference** | kt | -0.000187 | -0.000397 | -0.000185 | -0.000129 | 0.000008 |
| | % | -8.31 | -37.9 | -23.4 | -17.3 | 6.1 |
| **$N_2O$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.000450 | 0.000210 | 0.000158 | 0.000149 | 0.000025 |
| **Submission 2017** | kt | 0.000410 | 0.000130 | 0.000121 | 0.000123 | 0.000026 |
| **Difference** | kt | -0.000039 | -0.000079 | -0.000037 | -0.000026 | 0.000002 |
| | % | -8.75 | -37.9 | -23.4 | -17.3 | 6.1 |

**Tab. 3-42 Changes after recalculation in 1.A.2.d for Solid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 2 972.2 | 2 477.1 | 2 427.3 | 1 806.5 | 1 472.0 |
| **Submission 2017** | TJ | 3 109.4 | 2 385.9 | 2 414.3 | 1 881.2 | 1 480.4 |
| **Difference** | TJ | 137.2 | -91.1 | -13.0 | 74.7 | 8.4 |
| | % | 4.62 | -3.7 | -0.5 | 4.13 | 0.6 |
| | | | | | | |
| **$CO_2$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 288.76 | 242.61 | 234.01 | 175.40 | 145.56 |
| **Submission 2017** | kt | 302.30 | 234.06 | 233.55 | 183.31 | 146.40 |
| **Difference** | kt | 13.541 | -8.549 | -0.461 | 7.912 | 0.831 |
| | % | 4.69 | -3.5 | -0.2 | 4.51 | 0.6 |
| | | | | | | |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.0297 | 0.0248 | 0.0243 | 0.0181 | 0.0147 |
| **Submission 2017** | kt | 0.0311 | 0.0239 | 0.0241 | 0.0188 | 0.0148 |
| **Difference** | kt | 0.0014 | -0.0009 | -0.0001 | 0.0007 | 0.0001 |
| | % | 4.62 | -3.7 | -0.5 | 4.13 | 0.6 |
| | | | | | | |
| **$N_2O$ emission*)** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.0042 | 0.0035 | 0.0034 | 0.0025 | 0.0021 |
| **Submission 2017** | kt | 0.0047 | 0.0036 | 0.0036 | 0.0028 | 0.0022 |
| **Difference** | kt | 0.0005 | 0.0001 | 0.0002 | 0.0003 | 0.0002 |
| | % | 12.09 | 3.2 | 6.6 | 11.6 | 7.8 |

**)combination of change in activity data and change in $N_2O$ emission factor (ERT recommendation 2016)*

**Tab. 3-43 Changes after recalculation in 1.A.2.d for Natural Gas**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 4 407.8 | 4 802.9 | 4 987.3 | 4 861.6 | 4 774.3 |
| **Submission 2017** | TJ | 4 559.2 | 4 885.9 | 4 829.5 | 4 766.8 | 4 710.7 |
| **Difference** | TJ | 151.4 | 83.0 | -157.8 | -94.9 | -63.6 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | -1.3 |

| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 243.7 | 265.4 | 275.3 | 268.9 | 264.3 |
| **Submission 2017** | kt | 252.1 | 270.0 | 266.6 | 263.6 | 260.7 |
| **Difference** | kt | 8.4 | 4.6 | -8.7 | -5.2 | -3.5 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | -1.3 |
| | | | | | | |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.00441 | 0.00480 | 0.00499 | 0.00486 | 0.00477 |
| **Submission 2017** | kt | 0.00456 | 0.00489 | 0.00483 | 0.00477 | 0.00471 |
| **Difference** | kt | 0.00015 | 0.00008 | -0.00016 | -0.00009 | -0.00006 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | -1.3 |
| | | | | | | |
| **$N_2O$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.000441 | 0.000480 | 0.000499 | 0.000486 | 0.000477 |
| **Submission 2017** | kt | 0.000456 | 0.000489 | 0.000483 | 0.000477 | 0.000471 |
| **Difference** | kt | 0.000015 | 0.000008 | -0.000016 | -0.000009 | -0.000006 |
| | % | 3.44 | 1.7 | -3.2 | -2.0 | -1.3 |

Further, following the recommendation of ERT $N_2O$ emission factor was updated to 1.5 kg $N_2O$/TJ for solid fuels, which caused increase in $N_2O$ emissions by 7.14%.

**Tab. 3-44 Changes after update of $N_2O$ emission factor in 1.A.2.d**

| $N_2O$ emission | | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.0233 | 0.0134 | 0.0061 | 0.0054 | 0.0042 | 0.0035 | 0.0034 | 0.0025 | 0.0021 |
| **Submission 2017** | kt | 0.0250 | 0.0144 | 0.0065 | 0.0058 | 0.0047 | 0.0036 | 0.0036 | 0.0028 | 0.0022 |
| **Difference** | kt | 0.0017 | 0.0010 | 0.0004 | 0.0004 | 0.0005 | 0.0001 | 0.0002 | 0.0003 | 0.0002 |
| | % | 7.1 | 7.1 | 7.1 | 7.1 | 12.1 | 3.2 | 6.6 | 11.6 | 7.8 |

#### *3.2.13.6 Category-specific planned improvements (CRF 1.A.2.d)*

Currently there are no planned improvements in this category.

### 3.2.14 Manufacturing industries and construction – Food Processing, Beverages and Tobacco (1.A.2.e)

#### *3.2.14.1 Category description (CRF 1.A.2.e)*

The structure of fuels, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.A.2.e, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity** | **$CO_2$** | | | **$CH_4$** | | **$N_2O$** | |
| | **data** | **EF** | **OxF** | **Emission** | **EF** | **Emission** | **EF** | **Emission** |
| | **[TJ]** | **[t $CO_2$/TJ]** | | **[kt]** | **[kg $CH_4$/TJ]** | **[kt]** | **[kg $N_2O$/TJ]** | **[kt]** |
| **LPG** | 91.9 | 65.9 | 1 | 6.05 | 1 | 0.00009 | 0.1 | 0.00001 |
| **Heating and Other Gasoil** | 50.3 | 74.1 | 1 | 3.73 | 3 | 0.00015 | 0.6 | 0.00003 |
| **Fuel Oil - Low Sulphur** | 79.0 | 77.4 | 1 | 6.11 | 3 | 0.00024 | 0.6 | 0.00005 |
| **Other Oil** | 78.9 | 73.3 | 1 | 5.78 | 3 | 0.00024 | 0.6 | 0.00005 |
| **Other Bituminous Coal** | 754.7 | 94.4*) | 0.971*) | 69.13 | 10 | 0.00755 | 1.5 | 0.00113 |
| **Brown Coal + Lignite** | 1 235.9 | 100.2*) | 0.985*) | 121.90 | 10 | 0.01236 | 1.5 | 0.00185 |
| **Coke** | 257.7 | 107.0 | 1 | 27.58 | 10 | 0.00258 | 1.5 | 0.00039 |
| **Natural Gas** | 13 962.5 | 55.4*) | 1 | 773.81 | 1 | 0.01396 | 0.1 | 0.00140 |
| **Wood/Wood Waste** | 633.0 | 112.0 | 1 | 70.90 | 30 | 0.01899 | 4.0 | 0.00253 |
| **Gaseous Biomass** | 9 110.6 | 54.6 | 1 | 497.44 | 1 | 0.00911 | 0.1 | 0.00091 |
| **Total year 2015** | **26 254.6** | | | **1 582.42** | | **0.06526** | | **0.00835** |
| **Total year 2014** | 26 787.6 | | | 1 570.30 | | 0.04964 | | 0.00615 |

| | | | | |
|---|---|---|---|---|
| **Index 2015/2014** | 0.98 | 1.01 | 1.31 | 1.36 |
| **Total year 1990** | 37 616.5 | 2 988.18 | 0.21342 | 0.03226 |
| **Index 2015/1990** | 0.70 | 0.53 | 0.31 | 0.26 |

*) *Country specific data*

The origin of the data, the emission factors used and the method of calculating the level of emissions for the individual gases are shown in details in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Source of Activity data** | **Emission factors** | | | **Method used** | | |
| | | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **LPG** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Heating and Other Gasoil** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Fuel Oil - Low Sulphur** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Other Oil** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Other Bituminous Coal** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Brown Coal + Lignite** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Coke** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Wood/Wood Waste** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Gaseous Biomass** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

This subcategory includes all manufacturing processes related to the production of foodstuffs, beverages and foodstuff preparations. The subcategory also includes fuel consumption in the tobacco industry. The nature of the production processes permits the use of a relatively high fraction of biofuels, especially towards the end of the period.

In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

Food, Beverages and Tobacco

There are embodied the fuels of economic part according to NACE Rev. 2

Food processing, beverages and tobacco: NACE Divisions 10, 11 and 12

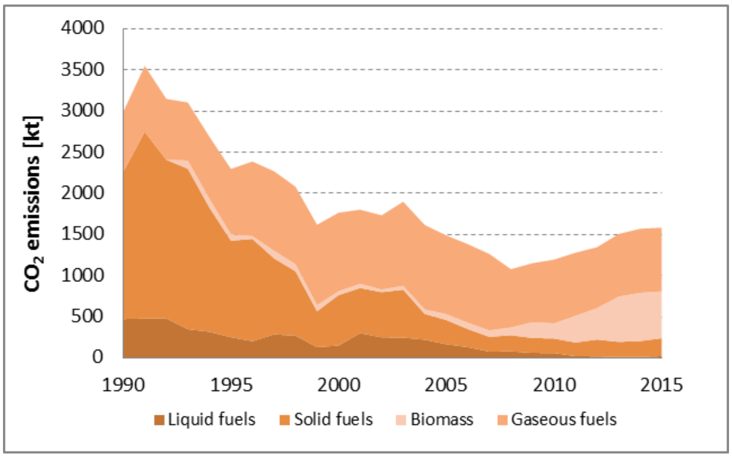



**Fig. 3-16 Development of $CO_2$ emissions from fossil fuels combustion in source category 1.A.2.e**

The fraction of $CO_2$ emissions in subsector 1.A.2.e in $CO_2$ emissions in sector 1.A.2 equalled 10% in 2015. It contributed 1.1% to $CO_2$ emissions in the whole Energy sector.

The following figure provides an overview of fuels consumption in the sub-category in 1.A.2.e.

It is obvious from the graph in Fig. 3-16 that natural gas is the dominant fuel over the entire time series with quite balanced consumption. The high share of fossil fuels at the beginning of the period reduced continuously and with replacement of fossil fuels by solid and gaseous biofuels towards the end of this period. The overall amount of fuel consumed decreased until 2008. Since 2008 there has been an increase in fuel consumption, which is covered by increasing consumption of biofuels, in response to the development of the financial crisis in the period at the end of the first decade of the 21st century.

Biofuel consumption has a beneficial effect on the production of $CO_2$, which is included in the balance of greenhouse gases. Fig. 3-16 shows the development of $CO_2$ emissions from fossil fuels only in sector 1.A.2.e.

### 3.2.14.2 Methodological issues (CRF 1.A.2.e)

No specific methodological approaches were applied in this subcategory, otherwise see chapter 3.2.6.

### 3.2.14.3 Uncertainties and time-series consistency (CRF 1.A.2.e)

See chapter 3.2.5.

### 3.2.14.4 Category-specific QA/QC and verification (CRF 1.A.2.e)

No specific methods for QA/QC in this category were used - otherwise see chapter 3.2.7.4.

### 3.2.14.5 Category-specific recalculations (CRF 1.A.2.e)

Quite extensive updates were provided in activity data by CzSO, which resulted in recalculation of this category.

**Tab. 3-45 Changes after recalculation in 1.A.2.e for Liquid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| **Submission 2016** | TJ | 723.8 | 643.4 | 250.4 | 168.2 |
| **Submission 2017** | TJ | 783.0 | 287.7 | 250.4 | 128.7 |
| **Difference** | TJ | 59.2 | -355.7 | | -39.4 |
| | % | 8.18 | -55.3 | | -23.5 |
| | | | | | |
| **$CO_2$ emission** | | **2010** | **2011** | **2012** | **2013** |
| **Submission 2016** | kt | 55.188 | 48.958 | 18.4 | 12.180 |
| **Submission 2017** | kt | 59.542 | 21.427 | 18.4 | 9.128 |
| **Difference** | kt | 4.353 | -27.531 | | -3.053 |
| | % | 7.89 | -56.2 | | -25.1 |
| | | | | | |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** |
| **Submission 2016** | kt | 0.00208 | 0.00184 | 0.00066 | 0.00041 |
| **Submission 2017** | kt | 0.00222 | 0.00077 | 0.00066 | 0.00029 |
| **Difference** | kt | 0.00014 | -0.00107 | | -0.00012 |
| | % | 6.64 | -58.1 | | -28.7 |
| | | | | | |
| **$N_2O$ emission** | | **2010** | **2011** | **2012** | **2013** |
| **Submission 2016** | kt | 0.00041 | 0.00036 | 0.00013 | 0.00008 |
| **Submission 2017** | kt | 0.00044 | 0.00015 | 0.00013 | 0.00005 |
| **Difference** | kt | 0.00003 | -0.00021 | | -0.00002 |
| | % | 6.24 | -58.8 | | -30.4 |

**Tab. 3-46 Changes after recalculation in 1.A.2.e for Solid Fuels**

| Fuel consumption | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 1 859.8 | 1 843.7 | 1 961.6 | 2 147.1 | 2 062.2 | 1 971.7 |
| **Submission 2017** | TJ | 1 859.4 | 1 808.3 | 1 705.1 | 2 100.9 | 1 909.7 | 1 977.9 |
| **Difference** | TJ | -0.4 | -35.4 | -256.6 | -46.2 | -152.4 | 6.2 |
| | % | -0.02 | -1.9 | -13.1 | -2.15 | -7.4 | 0.3 |
| | | | | | | | |
| **$CO_2$ emission** | | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 181.312 | 179.515 | 190.805 | 209.059 | 201.034 | 192.100 |
| **Submission 2017** | kt | 181.271 | 176.127 | 166.253 | 206.016 | 186.715 | 192.718 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Difference** | kt | -0.041 | -3.388 | -24.552 | -3.043 | -14.319 | 0.618 |
| | % | -0.02 | -1.9 | -12.9 | -1.46 | -7.1 | 0.3 |
| | | | | | | | |
| **$CH_4$ emission** | | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.0186 | 0.0184 | 0.0196 | 0.0215 | 0.0206 | 0.0197 |
| **Submission 2017** | kt | 0.0186 | 0.0181 | 0.0171 | 0.0210 | 0.0191 | 0.0198 |
| **Difference** | kt | 0.0000 | -0.0004 | -0.0026 | -0.0005 | -0.0015 | 0.0001 |
| | % | -0.02 | -1.9 | -13.1 | -2.15 | -7.4 | 0.3 |
| | | | | | | | |
| **$N_2O$ emission *)** | | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.0026 | 0.0026 | 0.0027 | 0.0030 | 0.0029 | 0.0028 |
| **Submission 2017** | kt | 0.0028 | 0.0027 | 0.0026 | 0.0032 | 0.0029 | 0.0030 |
| **Difference** | kt | 0.00019 | 0.00013 | -0.00019 | 0.00015 | -0.00002 | 0.00021 |
| | % | 7.1 | 5.1 | -6.9 | 4.8 | -0.8 | 7.5 |

**)combination of change in activity data and change in $N_2O$ emission factor (ERT recommendation 2016)*

**Tab. 3-47 Changes after recalculation in 1.A.2.e for Natural Gas**

| **Fuel consumption** | | **2010** | **2011** | **2012** | **2013** | **2014** |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 13 541.6 | 13 628.2 | 13 522.9 | 14 016.9 | 14 277.8 |
| **Submission 2017** | TJ | 14 006.8 | 13 863.7 | 13 410.0 | 13 743.4 | 14 087.6 |
| **Difference** | TJ | 465.2 | 235.5 | -112.9 | -273.6 | -190.2 |
| | % | 3.4 | 1.7 | -0.8 | -2.0 | -1.3 |
| | | | | | | |
| **$CO_2$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 748.7 | 753.1 | 746.5 | 775.2 | 790.3 |
| **Submission 2017** | kt | 774.4 | 766.1 | 740.2 | 760.0 | 779.8 |
| **Difference** | kt | 25.7 | 13.0 | -6.2 | -15.1 | -10.5 |
| | % | 3.4 | 1.7 | -0.8 | -2.0 | -1.3 |
| | | | | | | |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.0135 | 0.0136 | 0.0135 | 0.0140 | 0.0143 |
| **Submission 2017** | kt | 0.0140 | 0.0139 | 0.0134 | 0.0137 | 0.0141 |
| **Difference** | kt | 0.0005 | 0.0002 | -0.0001 | -0.0003 | -0.0002 |
| | % | 3.4 | 1.7 | -0.8 | -2.0 | -1.3 |
| | | | | | | |
| **$N_2O$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.00135 | 0.00136 | 0.00135 | 0.00140 | 0.00143 |
| **Submission 2017** | kt | 0.00140 | 0.00139 | 0.00134 | 0.00137 | 0.00141 |
| **Difference** | kt | 0.00005 | 0.00002 | -0.00001 | -0.00003 | -0.00002 |
| | % | 3.4 | 1.7 | -0.8 | -2.0 | -1.3 |

Further, following the recommendation of ERT $N_2O$ emission factor was updated to 1.5 kg $N_2O$/TJ for solid fuels, which caused increase in $N_2O$ emissions by 7.14%.

**Tab. 3-48 Changes after update of $N_2O$ emission factor in 1.A.2.e**

| **$N_2O$ emission** | | **1990** | **1995** | **2000** | **2005** | **2010** | **2011** | **2012** | **2013** | **2014** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.02545 | 0.015643 | 0.008783 | 0.004174 | 0.002581 | 0.002746 | 0.003006 | 0.002887 | 0.00276 |
| **Submission 2017** | kt | 0.02727 | 0.016755 | 0.00941 | 0.004472 | 0.002713 | 0.002558 | 0.003151 | 0.002865 | 0.002967 |
| **Difference** | kt | 0.00182 | 0.00111 | 0.00063 | 0.00030 | 0.00013 | -0.00019 | 0.00015 | -0.00002 | 0.00021 |
| | % | 7.1 | 7.1 | 7.1 | 7.1 | 5.1 | -6.9 | 4.8 | -0.8 | 7.5 |

### *3.2.14.6 Category-specific planned improvements (CRF 1.A.2.e)*

Currently there are no planned improvements in this category.

## 3.2.15 Manufacturing industries and construction – Non-metallic Minerals (1.A.2.f)

### 3.2.15.1 Category description (CRF 1.A.2.f)

The structure of fuels, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline

| 1.A.2.f, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Structure of Fuels | Activity | $CO_2$ | | | $CH_4$ | | $N_2O$ | |
| | data | EF | OxF | Emission | EF | Emission | EF | Emission |
| | [TJ] | [t $CO_2$/TJ] | | [kt] | [kg $CH_4$/TJ] | [kt] | [kg $N_2O$/TJ] | [kt] |
| LPG | 91.9 | 65.86 | 1 | 6.05 | 1 | 0.00009 | 0.1 | 0.00001 |
| Heating and Other Gasoil | 92.9 | 74.10 | 1 | 6.89 | 3 | 0.00028 | 0.6 | 0.00006 |
| Fuel Oil - Low Sulphur | 46.7 | 77.40 | 1 | 3.61 | 3 | 0.00014 | 0.6 | 0.00003 |
| Fuel Oil - High Sulphur | 158.0 | 77.40 | 1 | 12.23 | 3 | 0.00047 | 0.6 | 0.00009 |
| Other Oil | 197.2 | 73.30 | 1 | 14.45 | 3 | 0.00059 | 0.6 | 0.00012 |
| Other Bituminous Coal | 4 874.1 | 94.36*) | 0.971*) | 446.44 | 10 | 0.04874 | 1.5 | 0.00731 |
| Brown Coal + Lignite | 190.1 | 100.17*) | 0.985*) | 18.75 | 10 | 0.00190 | 1.5 | 0.00029 |
| Coke | 830.5 | 107.00 | 1 | 88.86 | 10 | 0.00831 | 1.5 | 0.00125 |
| Coal Tars | 828.0 | 80.70 | 1 | 66.82 | 10 | 0.00828 | 1.5 | 0.00124 |
| Cove Oven Gas | 64.9 | 44.40 | 1 | 2.88 | 1 | 0.00006 | 0.1 | 0.00001 |
| Natural Gas | 23 396.2 | 55.42*) | 1 | 1296.62 | 1 | 0.02340 | 0.1 | 0.00234 |
| Other fuels - liquid | 1 016.7 | 79.33*) | 1 | 80.65 | 30 | 0.03050 | 4.0 | 0.00407 |
| Other fuels - solid | 3 576.0 | 85.72*) | 1 | 306.54 | 30 | 0.10728 | 4.0 | 0.01430 |
| Wood/Wood Waste | 83.8 | 112.00 | 1 | 9.39 | 30 | 0.00252 | 4.0 | 0.00034 |
| **Total year 2015** | **35 447.1** | | | **2360.20** | | **0.23256** | | **0.03144** |
| Total year 2014 | 33 313.6 | | | 2227.45 | | 0.19726 | | 0.02687 |
| Index 2015/2014 | 1.06 | | | 1.06 | | 1.18 | | 1.17 |
| Total year 1990 | 59 962.4 | | | 4 527.12 | | 0.29373 | | 0.04487 |
| Index 2015/1990 | 0.59 | | | 0.52 | | 0.79 | | 0.70 |

*) *Country specific data*

The origin of the data, the emission factors used and the method of calculating the level of emissions for the individual gases are shown in details in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Structure of Fuels | Source of Activity data | Emission factors | | | Method used | | |
| | | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| LPG | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| Heating and Other Gasoil | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| Fuel Oil - Low Sulphur | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| Fuel Oil - High Sulphur | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| Other Oil | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| Other Bituminous Coal | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| Brown Coal + Lignite | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| Coke | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| Coal Tars | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| Coke Oven Gas | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| Natural Gas | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| Other fuels - liquid | ETS, REZZO**) | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| Other fuels - solid | ETS, REZZO**) | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| Wood/Wood Waste | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

**) *REZZO - national emissions database; Data was verified by the Czech Union of manufacturers of cement and lime*

Category 1.A.2.f now comprises all industrial processes for the treatment of non-minerals raw materials and products such as cement, lime, burnt building materials and refractory materials, ceramics, glass etc. Category 1.A.2.f was established by dividing the original category into 2 groups, i.e. in 1.A.2.g are included remained sources of greenhouse gases from the category "Manufacturing industries and construction."

The category is characterized by high energy intensity, and for it is also typical consumption "Other fuels", that are burned at the cement works furnaces. The cement kilns in the Czech Republic are the only one facilities (except the industrial waste incinerators reported in sector 5 Waste), in which it is allowed incinerating waste, respectively an alternative fuels made from waste.

In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:
Non-Metallic Minerals

There are embodied the fuels of economic part according to NACE Rev. 2:

NACE Divisions 23

23 Manufacture of other non-metallic mineral products
23.1 Manufacture of glass and glass products
23.2 Manufacture of refractory products
23.4 Manufacture of other porcelain and ceramic products
23.5 Manufacture of cement, lime and plaster

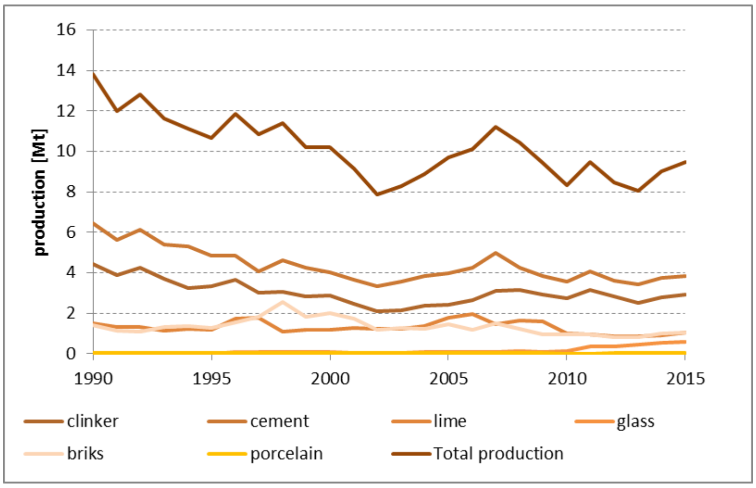


**Fig. 3-17 Production of the most important mineral products**

The fraction of $CO_2$ emissions in subsector 1.A.2.f in $CO_2$ emissions in sector 1.A.2 equalled 22.6% in 2015. It contributed 2.5% to $CO_2$ emissions in the whole Energy sector.

Between the most important businesses are included mainly cement (a total of 5 facilities), which are operated in the northern, central and eastern Bohemia and Central Moravia and lime (a total of 3 facilities) in southern and eastern Bohemia and North Moravia.

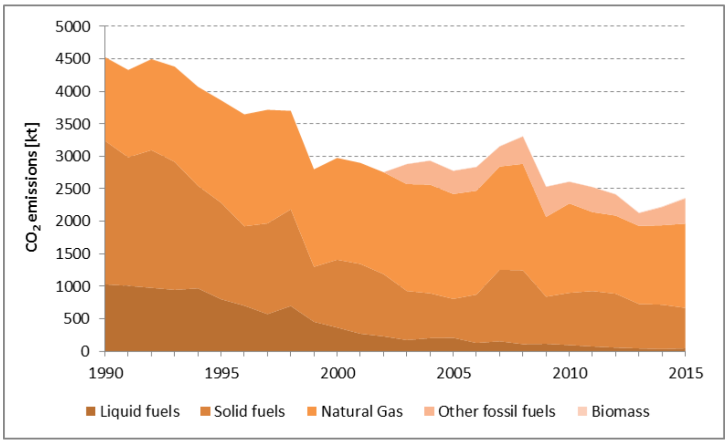


**Fig. 3-18 Development of $CO_2$ emissions in source category 1.A.2.f**

Total production of the most important mineral products is shown in the graph on Fig. 3-17.

Fig. 3-18 provides an overview of fuels consumption and $CO_2$ emissions in the sub-category in 1.A.2.f.

The graph shows the evolution of $CO_2$ emissions, that has the same pattern as the fuel consumption. The high consumption of fossil fuel at the beginning of the period decreased gradually, and it is evident that the most important fuel in this sector is natural gas. The high consumption of fossil fuels gradually was declining and liquid fuels, from 2002 gradually were replaced by alternative fuels (Other fuels). The increase in fuel consumption between 2005 and 2008, was interrupted by the crisis development of the economy and after some recovery in 2010-2011, followed by another decline.

### *3.2.15.2 Methodological issues (CRF 1.A.2.f)*

The category of Non-Metallic Minerals reports consumption of alternative fuels (Other fuels). The compilation consumption balance and the determination of the emission factors are different from the procedures used for other fuels, as described in section 3.2.4. The basic source of information is the ETS database, where the emission factors for different types of alternative fuels are available. At the same time, data from the REZZO national emission database are used, where data are available on the consumption of alternative fuels in the whole time series since 2003. The resulting processed data on consumption of alternative fuels is further corrected according to the data on the server of the Union of cement and lime manufacturers (www.svcement.cz). Alternative fuel consumption is shown in Tab. 3-49.

**Tab. 3-49 Consumption of alternative fuels in sector 1.A.2.f**

| [TJ/year] | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Solid fuels** | 2 424 | 3 200 | 3 517 | 3 398 | 3 726 | 5 037 | 5 537 | 3 224 | 3 885 | 3 055 | 1 137 | 3 234 | 3 576 |
| **Liquid fuels** | 1 266 | 1 156 | 589 | 1 014 | 240 | 557 | 682 | 708 | 661 | 394 | 1 181 | 18 | 1 017 |
| **Total** | 3 690 | 4 356 | 4 105 | 4 412 | 3 966 | 5 594 | 6 219 | 3 932 | 4 546 | 3 449 | 2 318 | 3 252 | 4 593 |

Emission factors for calculating $CO_2$ emissions vary according to composition of the individual types of fuel (solid, liquid fuels). As a solid alternative fuels are used variety of sorted waste, used tires, animal meal, etc. Among the alternative liquid fuels are included mainly used oils, waste petroleum products, or even rendered fats. The resulting emission factor corresponds to the relative representation of individual types of fuels. In Tab. 3-50 is shown an overview of emission factors used for solid and liquid alternative fuels in different years.

**Tab. 3-50 $CO_2$ emission factors used in the consumption of alternative fuels in sector 1.A.2.f**

| [t $CO_2$/TJ] | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Solid fuels** | 87.5 | 87.5 | 88.5 | 84.5 | 78.3 | 75.7 | 75.7 | 85.2 | 85.8 | 96.2 | 92.8 | 86.0 | 85.7 |
| **Liquid fuels** | 75.4 | 75.8 | 75.1 | 76.2 | 73.0 | 71.9 | 64.6 | 81.2 | 77.4 | 77.4 | 77.8 | 72.6 | 79.3 |

For the calculation of $CH_4$ and $N_2O$ emissions were used default emission factors in line with the IPCC methodology 2006, for the entire time series 2003-2014 (Tab. 3-51).

**Tab. 3-51 Emission factors for $CH_4$ and $N_2O$ emissions used in the consumption of alternative fuels sector 1.A.2.f**

| EF [kg/TJ] | $CH_4$ | $N_2O$ |
|---|---|---|
| **Solid fuels** | 30 | 4 |
| **Liquid fuels** | 30 | 4 |

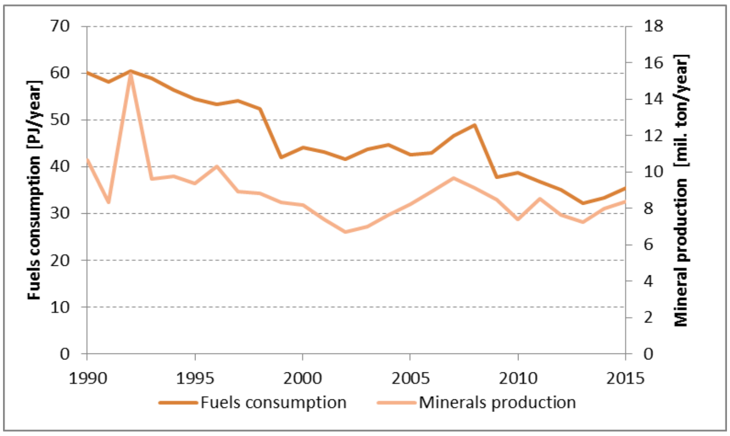



**Fig. 3-19 Trends in production of mineral products compared with the development of fuel consumption in the sector 1.A.2.f**

### *3.2.15.3 Uncertainties and time-series consistency (CRF 1.A.2.f)*

See chapter 3.2.5.

### *3.2.15.4 Category-specific QA/QC and verification (CRF 1.A.2.f)*

As a basic indicator for verification of fuel consumption in the sector of production of pig iron and steel, should be regarded indicators of the overall production of basic goods such as cement, lime, clay tiles and roof tiling or glass and fine ceramics. This is a relatively large mass flows, which also exhibit high energy demands (Fig. 3-19). Comparison of total production and total fuel consumption in the sub sector 1.A.2.f is shown in Fig. 3-19.

The basic trend flow of production of mineral products in total corresponds well with the total fuel consumption. Given that this is a rough comparison, it might be that the minor variations are caused by different specific energy intensities of the individual kinds of mineral products.

Other QA/QC procedures are set out in section 3.2.6.

### *3.2.15.5 Category-specific recalculations (CRF 1.A.2.f)*

Quite extensive updates were provided in activity data by CzSO, which resulted in recalculation of this category.

**Tab. 3-52 Changes after recalculation in 1.A.2.f for Liquid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 1 269.4 | 891.3 | 630.4 | 539.5 | 444.6 |
| **Submission 2017** | TJ | 1 271.6 | 972.5 | 729.4 | 565.3 | 447.2 |
| **Difference** | TJ | 2.2 | 81.2 | 99.1 | 25.8 | 2.5 |
| | % | 0.18 | 9.1 | 15.7 | 4.8 | 0.6 |
| **$CO_2$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 94.967 | 66.496 | 46.961 | 40.400 | 33.067 |
| **Submission 2017** | kt | 94.911 | 72.781 | 54.629 | 42.399 | 33.261 |
| **Difference** | kt | -0.055 | 6.285 | 7.667 | 1.999 | 0.194 |
| | % | -0.06 | 9.5 | 16.3 | 4.9 | 0.6 |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.003716 | 0.002582 | 0.001799 | 0.001526 | 0.001242 |
| **Submission 2017** | kt | 0.003684 | 0.002826 | 0.002096 | 0.001604 | 0.001250 |
| **Difference** | kt | -0.000033 | 0.000244 | 0.000297 | 0.000077 | 0.000008 |
| | % | -0.88 | 9.4 | 16.5 | 5.1 | 0.6 |
| **$N_2O$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.000739 | 0.000512 | 0.000355 | 0.000301 | 0.000244 |
| **Submission 2017** | kt | 0.000730 | 0.000561 | 0.000415 | 0.000316 | 0.000245 |
| **Difference** | kt | -0.000009 | 0.000049 | 0.000059 | 0.000015 | 0.000002 |
| | % | -1.15 | 9.5 | 16.7 | 5.2 | 0.6 |

**Tab. 3-53 Changes after recalculation in 1.A.2.f for Solid Fuels**

| Fuel consumption | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 7 734 | 8 771 | 11 094 | 10 230 | 8 817 | 7 380 |
| **Submission 2017** | TJ | 7 731 | 8 535 | 9 228 | 9 000 | 7 488 | 7 437 |
| **Difference** | TJ | -2.3 | -235.4 | -1 865.7 | -1 230.1 | -1 328.6 | 56.6 |
| | % | -0.03 | -2.7 | -16.8 | -12.02 | -15.1 | 0.8 |
| **$CO_2$ emission** | | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 724.8 | 826.8 | 1 027.5 | 947.1 | 807.1 | 677.7 |
| **Submission 2017** | kt | 724.6 | 803.7 | 853.4 | 829.3 | 683.9 | 682.3 |
| **Difference** | kt | -0.2 | -23.0 | -174.0 | -117.8 | -123.2 | 4.6 |
| | % | -0.03 | -2.8 | -16.9 | -12.4 | -15.3 | 0.7 |
| **$CH_4$ emission** | | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.0768 | 0.0873 | 0.1105 | 0.1019 | 0.0878 | 0.0732 |
| **Submission 2017** | kt | 0.0768 | 0.0849 | 0.0918 | 0.0894 | 0.0743 | 0.0738 |
| **Difference** | kt | -0.00002 | -0.0024 | -0.0187 | -0.0124 | -0.0135 | 0.0006 |
| | % | -0.03 | -2.7 | -16.9 | -12.2 | -15.3 | 0.8 |
| **$N_2O$ emission *)** | | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.0108 | 0.0122 | 0.0155 | 0.0143 | 0.0123 | 0.0103 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Submission 2017** | kt | 0.0115 | 0.0127 | 0.0138 | 0.0134 | 0.0111 | 0.0111 |
| **Difference** | kt | 0.0008 | 0.0005 | -0.0017 | -0.0008 | -0.0011 | 0.0008 |
| | % | 7.11 | 4.2 | -11.0 | -5.9 | -9.3 | 8.0 |

**)combination of change in activity data and change in $N_2O$ emission factor (ERT recommendation 2016)*

**Tab. 3-54 Changes after recalculation in 1.A.2.f for Natural Gas**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 24 058 | 21 612 | 22 364 | 22 160 | 22 391 |
| **Submission 2017** | TJ | 24 884 | 21 985 | 21 788 | 21 727 | 22 092 |
| **Difference** | TJ | 826.4 | 373.4 | -575.8 | -432.5 | -298.3 |
| | % | 3.44 | 1.7 | -2.6 | -2.0 | -1.3 |
| **$CO_2$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 1 330.1 | 1 194.3 | 1 234.5 | 1 225.5 | 1 239.4 |
| **Submission 2017** | kt | 1 375.8 | 1 214.9 | 1 202.7 | 1 201.6 | 1 222.9 |
| **Difference** | kt | 45.7 | 20.6 | -31.8 | -23.9 | -16.5 |
| | % | 3.44 | 1.7 | -2.6 | -2.0 | -1.3 |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.0241 | 0.0216 | 0.0224 | 0.0222 | 0.0224 |
| **Submission 2017** | kt | 0.0249 | 0.0220 | 0.0218 | 0.0217 | 0.0221 |
| **Difference** | kt | 0.0008 | 0.0004 | -0.0006 | -0.0004 | -0.0003 |
| | % | 3.44 | 1.7 | -2.6 | -2.0 | -1.3 |
| **$N_2O$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.00241 | 0.00216 | 0.00224 | 0.00222 | 0.00224 |
| **Submission 2017** | kt | 0.00249 | 0.00220 | 0.00218 | 0.00217 | 0.00221 |
| **Difference** | kt | 0.00008 | 0.00004 | -0.00006 | -0.00004 | -0.00003 |
| | % | 3.44 | 1.7 | -2.6 | -2.0 | -1.3 |

Further, following the recommendation of ERT $N_2O$ emission factor was updated to 1.5 kg $N_2O$/TJ for solid fuels, which caused increase in $N_2O$ emissions by 7.14%.

**Tab. 3-55 Changes after update of $N_2O$ emission factor in 1.A.2.f**

| $N_2O$ emission | | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.0322 | 0.0192 | 0.0151 | 0.0087 | 0.0122 | 0.0155 | 0.0143 | 0.0123 | 0.0103 |
| **Submission 2017** | kt | 0.0345 | 0.0205 | 0.0162 | 0.0094 | 0.0127 | 0.0138 | 0.0134 | 0.0111 | 0.0111 |
| **Difference** | kt | 0.0023 | 0.0014 | 0.0011 | 0.0006 | 0.0005 | -0.0017 | -0.0008 | -0.0011 | 0.0008 |
| | % | 7.1 | 7.1 | 7.1 | 7.1 | 4.2 | -11.0 | -5.9 | -9.3 | 8.0 |

Additional QA/QC procedures were also carried out and as a result emission factors for liquid and solid part of other fossil fuels were updated. Updated EF for liquid other fossil fuels is 72.57 t $CO_2$/TJ, for solid fossil fuels 86.03 t $CO_2$/TJ for 2014.

**Tab. 3-56 Change of CO2 from Other fossil fuels for 2014**

| $CO_2$ emission | | 2014 |
|---|---|---|
| **Submission 2016** | kt | 301.6 |
| **Submission 2017** | kt | 279.5 |
| **Difference** | kt | -22.1 |
| | % | -7.32 |

After a recommendation of ERT $CH_4$ and $N_2O$ emission factors for Other fossil fuels were also changed. For $CH_4$ updated emission factors is 30 kg $CH_4$/TJ for both liquid and solid other fossil fuels. For $N_2O$ updated emission factors is 4 kg $N_2O$/TJ for both liquid and solid other fossil fuels.

**Tab. 3-57 Change of $CH_4$ from Other fossil fuels**

| $CH_4$ emission | | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.028 | 0.035 | 0.037 | 0.037 | 0.038 | 0.052 | 0.057 | 0.034 | 0.041 | 0.032 | 0.015 | 0.032 |
| **Submission 2017** | kt | 0.111 | 0.131 | 0.123 | 0.132 | 0.119 | 0.168 | 0.187 | 0.118 | 0.136 | 0.103 | 0.070 | 0.098 |
| **Difference** | kt | 0.083 | 0.095 | 0.086 | 0.095 | 0.081 | 0.116 | 0.129 | 0.084 | 0.096 | 0.072 | 0.055 | 0.065 |
| | % | 295 | 268 | 233 | 258 | 213 | 222 | 225 | 243 | 234 | 226 | 366 | 201 |

**Tab. 3-58 Change of $N_2O$ from Other fossil fuels**

| $N_2O$ emission | | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.004 | 0.005 | 0.005 | 0.005 | 0.005 | 0.007 | 0.008 | 0.005 | 0.006 | 0.005 | 0.002 | 0.005 |
| **Submission 2017** | kt | 0.015 | 0.017 | 0.016 | 0.018 | 0.016 | 0.022 | 0.025 | 0.016 | 0.018 | 0.014 | 0.009 | 0.013 |
| **Difference** | kt | 0.011 | 0.012 | 0.011 | 0.012 | 0.011 | 0.015 | 0.017 | 0.011 | 0.012 | 0.009 | 0.007 | 0.008 |
| | % | 255 | 237 | 211 | 229 | 196 | 203 | 205 | 218 | 212 | 206 | 303 | 187 |

### *3.2.15.6 Category-specific planned improvements (CRF 1.A.2.f)*

Currently there are no planned improvements in this category.

## 3.2.16 Manufacturing industries and construction – Other (1.A.2.g)

### *3.2.16.1 Category description (CRF 1.A.2.g)*

The structure of fuels, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.A.2.g, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity** | **$CO_2$** | | | **$CH_4$** | | **$N_2O$** | |
| | **data** | **EF** | **OxF** | **Emission** | **EF** | **Emission** | **EF** | **Emission** |
| | **[TJ]** | **[t $CO_2$/TJ]** | | **[kt]** | **[kg $CH_4$/TJ]** | **[kt]** | **[kg $N_2O$/TJ]** | **[kt]** |
| **LPG** | 735.1 | 65.86 | 1 | 48.41 | 1 | 0.00074 | 0.1 | 0.00007 |
| **Heating and Other Gasoil** | 309.8 | 74.10 | 1 | 22.96 | 3 | 0.00093 | 0.6 | 0.00019 |
| **Fuel Oil - Low Sulphur** | 247.8 | 77.40 | 1 | 19.18 | 3 | 0.00074 | 0.6 | 0.00015 |
| **Fuel Oil - High Sulphur** | 79.0 | 77.40 | 1 | 6.11 | 3 | 0.00024 | 0.6 | 0.00005 |
| **Other Oil** | 6 862.2 | 73.30 | 1 | 503.00 | 3 | 0.02059 | 0.6 | 0.00412 |
| **Anthracite** | 345.1 | 98.30 | 1 | 33.92 | 10 | 0.00345 | 1.5 | 0.00052 |
| **Brown Coal + Lignite** | 747.0 | 100.17*) | 0.985*) | 73.67 | 10 | 0.00747 | 1.5 | 0.00112 |
| **Coke** | 229.1 | 107.00 | 1 | 24.51 | 10 | 0.00229 | 1.5 | 0.00034 |
| **Cove Oven Gas** | 32.0 | 44.40 | 1 | 1.42 | 1 | 0.00003 | 0.1 | 0.00000 |
| **Natural Gas** | 30 055.8 | 55.42*) | 1 | 1665.70 | 1 | 0.03006 | 0.1 | 0.00301 |
| **Wood/Wood Waste** | 9 923.4 | 112.00 | 1 | 1111.42 | 30 | 0.29770 | 4.0 | 0.03969 |
| **Gaseous Biomass** | 438.0 | 54.60 | 1 | 23.92 | 1 | 0.00044 | 0.1 | 0.00004 |
| **Total year 2015** | **50 004.3** | | | **3 534.22** | | **0.36467** | | **0.04930** |
| **Total year 2014** | 46 300.7 | | | 3 253.57 | | 0.32708 | | 0.04412 |
| **Index 2015/2014** | 1.08 | | | 1.09 | | 1.11 | | 1.12 |
| **Total year 1990** | 301 656.3 | | | 24 730.77 | | 1.97324 | | 0.29944 |
| **Index 2015/1990** | 0.17 | | | 0.14 | | 0.18 | | 0.16 |

*) *Country specific data*

The origin of the data, the emission factors used and the method of calculating the level of emissions for the individual gases are shown in details in the following outline.

| | 2015 | | | | | | |
|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Source of Activity data** | **Emission factors** | | | **Method used** | | |
| | | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **LPG** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Heating and Other Gasoil** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Fuel Oil - Low Sulphur** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Fuel Oil - High Sulphur** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Other Oil** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Other Bituminous Coal** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Brown Coal + Lignite** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Coke** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Coke Oven Gas** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Wood/Wood Waste** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Gaseous Biomass** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

This subcategory includes the remaining enterprises in the processing industry not included in subcategories 1.A.2.a to 1.A.2.f. This is an energy-demanding branch with fuel consumption, such as the textile and leather industry, wood processing and subsequent production processes, the entire machine industry, incl. production of means of transport and the construction industry.

In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

- Transport Equipment
- Machinery
- Mining (excluding fuels) and Quarrying
- Wood and Wood Products
- Construction
- Textiles and Leather
- Non-specified (Industry)

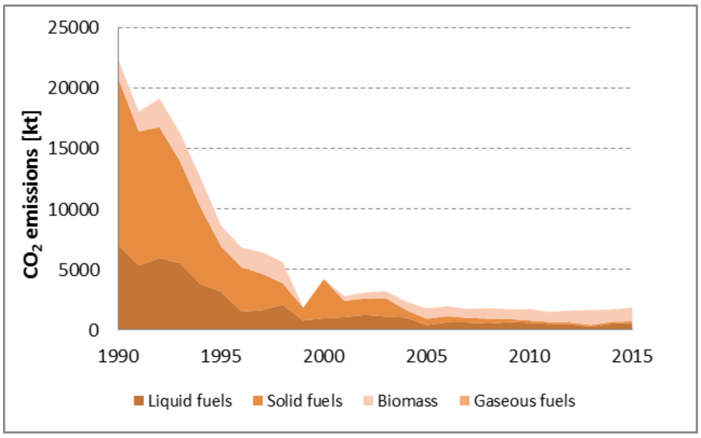



**Fig. 3-20 Development of $CO_2$ emissions in source category 1.A.2.g**

There are embodied the fuels of economic part according to NACE Rev. 2 Other: NACE Divisions 05 – 09, 13 – 16, 21 – 22, 25 – 33 and 41 – 43.

The fraction of $CO_2$ emissions in subsector 1.A.2.f in $CO_2$ emissions in sector 1.A.2 equalled 24.4% in 2015. It contributed 2.6% to $CO_2$ emissions in the whole Energy sector. Overall emissions have exhibited a decrease since 1990. At the beginning of the period, solid Fuels were of major importance, but this has constantly decreased until 2015. Liquid fuels have also constantly decreased in importance since 1990. Natural Gas is also important fuel in this category.

The graph in Fig. 3-20 shows that the beginning of the period was characterised by highly energy-intensive types of industrial processes in this category. Social changes occurring in the Czech Republic in the early 90s resulted in energy-saving measures being introduced by newly privatized enterprises. Together, these influences led to an end to inefficient production and suppression of consumption, particularly of fossil fuels, which were the dominant fuels at the beginning of the period and virtually disappeared by 2005, when they were replaced by biomass. At the same time, the importance of liquid fuels decreased. All this was reflected very significantly by a decline in the $CO_2$ emissions (and other greenhouse gases). This is the category with the largest relative decrease in $CO_2$ emissions from 1990 to 2015 (90% decrease).

### 3.2.16.2 Methodological issues (CRF 1.A.2.g)

Sector specific methodological approaches were not used, the general approaches are given in chapter 3.2.4.

### 3.2.16.3 Uncertainties and time-series consistency (CRF 1.A.2.g)

See chapter 3.2.5.

### 3.2.16.4 Category-specific QA/QC and verification (CRF 1.A.2.g)

See chapter 3.2.6.

### 3.2.16.5 Category-specific recalculations (CRF 1.A.2.g)

Quite extensive updates were provided in activity data by CzSO, which resulted in recalculation of this category.

**Tab. 3-59 Changes after recalculation in 1.A.2.g for Liquid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 10 045 | 10 237 | 10 307 | 7 202 | 9 757 |
| **Submission 2017** | TJ | 8 212 | 7 002 | 6 531 | 3 724 | 7 510 |
| **Difference** | TJ | -1 833 | -3 234 | -3 775 | -3 478 | -2 246 |
| | % | -18.2 | -31.6 | -36.6 | -48.3 | -23.0 |
| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 741.4 | 756.9 | 753.7 | 522.1 | 713.4 |
| **Submission 2017** | kt | 613.5 | 520.6 | 481.8 | 275.4 | 545.3 |
| **Difference** | kt | -127.9 | -236.3 | -271.9 | -246.6 | -168.1 |
| | % | -17.2 | -31.2 | -36.1 | -47.2 | -23.6 |
| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0297 | 0.0303 | 0.0288 | 0.0187 | 0.0277 |
| **Submission 2017** | kt | 0.0240 | 0.0205 | 0.0188 | 0.0104 | 0.0202 |
| **Difference** | kt | -0.0057 | -0.0097 | -0.0100 | -0.0082 | -0.0075 |
| | % | -19.1 | -32.1 | -34.9 | -44.1 | -27.0 |
| $N_2O$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0059 | 0.0060 | 0.0057 | 0.0036 | 0.0055 |
| **Submission 2017** | kt | 0.0048 | 0.0041 | 0.0037 | 0.0021 | 0.0039 |
| **Difference** | kt | -0.0011 | -0.0019 | -0.0019 | -0.0015 | -0.0015 |
| | % | -19.3 | -32.2 | -34.4 | -42.8 | -28.0 |

**Tab. 3-60 Changes after recalculation in 1.A.2.g for Solid Fuels**

| Fuel consumption | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 2 773.9 | 2 071.9 | 1 664.5 | 1 565.9 | 1 685.8 | 1 418.3 |
| **Submission 2017** | TJ | 2 773.4 | 2 165.2 | 1 546.8 | 1 483.3 | 1 461.9 | 1 435.9 |
| **Difference** | TJ | -0.5 | 93.3 | -117.7 | -82.6 | -223.8 | 17.6 |
| | % | -0.02 | 4.5 | -7.1 | -5.28 | -13.3 | 1.2 |
| $CO_2$ emission | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 249.97 | 188.23 | 157.91 | 146.92 | 162.67 | 140.19 |
| **Submission 2017** | kt | 249.93 | 191.66 | 146.16 | 144.45 | 143.77 | 141.93 |
| **Difference** | kt | -0.05 | 3.43 | -11.75 | -2.47 | -18.91 | 1.74 |
| | % | -0.02 | 1.8 | -7.4 | -1.68 | -11.6 | 1.2 |
| $CH_4$ emission | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0239 | 0.0182 | 0.0155 | 0.0144 | 0.0160 | 0.0139 |
| **Submission 2017** | kt | 0.0239 | 0.0181 | 0.0143 | 0.0143 | 0.0143 | 0.0140 |
| **Difference** | kt | 0.0000 | 0.0000 | -0.0012 | -0.0001 | -0.0017 | 0.0002 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | % | -0.02 | -0.2 | -7.9 | -0.40 | -10.8 | 1.3 |
| $N_2O$ emission*) | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0033 | 0.0025 | 0.0022 | 0.0020 | 0.0022 | 0.0019 |
| **Submission 2017** | kt | 0.0036 | 0.0027 | 0.0021 | 0.0021 | 0.0021 | 0.0021 |
| **Difference** | kt | 0.00023 | 0.00017 | -0.00003 | 0.00014 | -0.00010 | 0.00016 |
| | % | 7.03 | 6.7 | -1.3 | 6.9 | -4.4 | 8.5 |

**)combination of change in activity data and change in $N_2O$ emission factor (ERT recommendation 2016)*

**Tab. 3-61 Changes after recalculation in 1.A.2.g for Natural Gas**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 35 611.7 | 32 054.4 | 31 303.8 | 33 824.9 | 29 384.5 |
| **Submission 2017** | TJ | 36 835.1 | 32 608.3 | 33 520.6 | 32 799.5 | 28 146.5 |
| **Difference** | TJ | 1 223.3 | 553.9 | 2 216.8 | -1 025.5 | -1 238.0 |
| | % | 3.4 | 1.7 | 7.1 | -3.0 | -4.2 |
| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 1 968.9 | 1 771.3 | 1 728.0 | 1 870.6 | 1 626.5 |
| **Submission 2017** | kt | 2 036.5 | 1 801.9 | 1 850.3 | 1 813.9 | 1 558.0 |
| **Difference** | kt | 67.6 | 30.6 | 122.4 | -56.7 | -68.5 |
| | % | 3.4 | 1.7 | 7.1 | -3.0 | -4.2 |
| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0356 | 0.0321 | 0.0313 | 0.0338 | 0.0294 |
| **Submission 2017** | kt | 0.0368 | 0.0326 | 0.0335 | 0.0328 | 0.0281 |
| **Difference** | kt | 0.0012 | 0.0006 | 0.0022 | -0.0010 | -0.0012 |
| | % | 3.4 | 1.7 | 7.1 | -3.0 | -4.2 |
| $N_2O$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0036 | 0.0032 | 0.0031 | 0.0034 | 0.0029 |
| **Submission 2017** | kt | 0.0037 | 0.0033 | 0.0034 | 0.0033 | 0.0028 |
| **Difference** | kt | 0.0001 | 0.0001 | 0.0002 | -0.0001 | -0.0001 |
| | % | 3.4 | 1.7 | 7.1 | -3.0 | -4.2 |

Further, following the recommendation of ERT $N_2O$ emission factor was updated to 1.5 kg $N_2O$/TJ for solid fuels, which caused increase in $N_2O$ emissions by 7.14%. Overall change is however smaller than 7.14%, since there is share of coal gases in this category, which have emission factor 0.1 kg $N_2O$/TJ.

**Tab. 3-62 Changes after update of $N_2O$ emission factor in 1.A.2.g**

| $N_2O$ emission | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.171 | 0.133 | 0.123 | 0.117 | 0.087 | 0.051 | 0.052 | 0.043 | 0.025 | 0.015 |
| **Submission 2017** | kt | 0.183 | 0.143 | 0.132 | 0.126 | 0.093 | 0.055 | 0.056 | 0.046 | 0.027 | 0.016 |
| **Difference** | kt | 0.012 | 0.009 | 0.009 | 0.008 | 0.006 | 0.004 | 0.004 | 0.003 | 0.002 | 0.001 |
| | % | 7.0 | 7.0 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 |
| $N_2O$ emission | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| **Submission 2016** | kt | 0.0464 | 0.0192 | 0.0193 | 0.0216 | 0.0084 | 0.0072 | 0.0068 | 0.0051 | 0.0054 | 0.0033 |
| **Submission 2017** | kt | 0.0497 | 0.0206 | 0.0206 | 0.0231 | 0.0090 | 0.0077 | 0.0073 | 0.0055 | 0.0058 | 0.0036 |
| **Difference** | kt | 0.0033 | 0.0014 | 0.0014 | 0.0015 | 0.0006 | 0.0005 | 0.0005 | 0.0004 | 0.0004 | 0.0002 |
| | % | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 7.0 |
| $N_2O$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 | | | | | |
| **Submission 2016** | kt | 0.0025 | 0.0022 | 0.0020 | 0.0022 | 0.0019 | | | | | |
| **Submission 2017** | kt | 0.0027 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | | | | | |
| **Difference** | kt | 0.0002 | 0.0000 | 0.0001 | -0.0001 | 0.0002 | | | | | |
| | % | 6.7 | -1.3 | 6.9 | -4.4 | 8.5 | | | | | |

#### *3.2.16.6 Category-specific planned improvements (CRF 1.A.2.g)*

Currently there are no planned improvements in this category.

### 3.2.17 Transport (1.A.3)

The categories of means of transport for calculations of greenhouse gas emissions have not changed since 2008. The criteria for inclusion of a certain means of transport in a particular category consist in the kind of transport, the fuel employed and the type of emission standard that the particular vehicle must meet (in a road transport). The categories of vehicles are not as detailed for a non-road transport.

The categories of mobile sources are as follows:

***Domestic Aviation (CRF 1.A.3.a)***

- airplanes fuelled by aviation gasoline
- airplanes fuelled by jet kerosene

***Road Transportation (CRF 1.A.3.b)***

- motorcycles,
- passenger and light duty gasoline vehicles conventional,
- passenger and light duty gasoline vehicles with EURO 1-6 limits,
- passenger and light duty diesel vehicles conventional,
- passenger and light duty diesel vehicles with EURO 1-6 limits,
- passenger cars and light duty vehicles using LPG, Compressed Natural Gas (CNG) and biofuels (separately),
- heavy duty diesel vehicles and buses, conventional,
- heavy duty diesel vehicles and buses with EURO I-VI limits,
- heavy duty vehicles and buses using CNG and biofuels (separately).

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

- diesel locomotives

***Domestic Navigation (CRF 1.A.3.d)***

- ships with diesel engines

***Other Transportation(CRF 1.A.3.e)***

The consumption of Natural Gas to power compressors for transit gas pipelines is included in this subcategory under mobile combustion sources but it is actually a stationary combustion source. This consumption is reported in the IEA – CzSO (CzSO, 2015) Questionnaire in the Transport Sector section under the item:

- Pipeline Transport

There are embodied the fuels of economic part according to NACE Rev. 2 Pipeline Transport: NACE Divisions 35.22, 49.50.

### 3.2.17.1 Methodological issues

The methodology in the Czech Republic operates with emission factors in [$g.kg^{-1}$] of fuel not in [$g.TJ^{-1}$] of energy, because the country-specific measured data for every greenhouse gas or pollutant in the internal database are in listed this unit. The emission factors are listed in [$g.kg^{-1}$] of fuel mainly because the consumption of each fuel is monitored in units of weight. The emission data calculated for the CRF Reporter are not affected by a calorific value (which is variable in different years) of a particular fuel but the fuel consumption for the CRF Reporter must be converted from weight to energy units (using the calorific value). Thus, the trend in IEF depends partially on the trend in calorific values and, in this case, mostly on the emission factors of different vehicle technologies (based on the EURO emission standard). The emission factors of individual transport categories are always given for the current submission year. All the calorific values used for calculations in a given transport sector are presented in Chapter 3 (Energy).

***Activity data***

The activity data for mobile sources are based on the official energy balance of the Czech Republic and are provided by the Czech Statistical Office (CzSO). The most important figures for the next data processing are the annual amounts of fuels sold, calculated in units of weight, since emission factor values are expressed in [$g.kg^{-1}$] of fuel in the CDV database. The parameters necessary for a distribution of sold fuels are: the transport mode, the fuel type, the weight of the vehicle and the effectivity of its catalytic system. The appropriate distribution is necessary for assigning to the relevant emission factor. Sector 1.A.3.b Road Transportation is based on the IPCC 2006 Gl. and split into the five following subsectors:

- 1.A.3.b.i Cars
- 1.A.3.b.ii Light Duty Trucks
- 1.A.3.b.iii Heavy Duty Trucks and Buses
- 1.A.3.b.iv Motorcycles
- 1.A.3.b.v Other

The activity data and greenhouse gas emission estimates of subsector 1.A.3.b.ii Light Duty Trucks in this submission are included in subsector 1.A.3.b.i Cars, because differentiation between these two subsectors was not available when the emission model was created. In some years a great many passenger cars are registered in the Central Vehicle Register as light duty vehicles, because of the fixed partition between a passenger cabin and a trunk space according to an earlier definition in the Czech legislation. The distribution of these mixed data into two subsectors is included in the current Improvement plan.

The data required for the fuel distribution are provided by the Ministry of Transport of the Czech Republic (transport yearbooks), The Czech Hydrometeorological Institute (research), The Czech Air Navigation Services (yearbooks) and traffic surveys (Traffic census) and CDV´s research activities. Some activity data for categories of road transport are monitored separately. Primarily data about CNG vehicles, which have been experiencing a boom in recent years, are collected from two public website sources. The first of these is a Czech source administrated by the Czech Gas Association and the second is the Natural & Bio Gas Vehicle Association Europe. The most important source of information on the distribution of the dynamic structure (emission standards) of the vehicle fleet on the roads in the Czech Republic is particularly the research of CDV, a large number of traffic surveys, the traffic census every five years and also the aggregate outcomes of studies prepared in 2001 (Pisa et al., 2001), 2005 (Pisa et al., 2006) and 2010 (Pisa et al., 2010) for the Road and Motorway Directorate of the Czech Republic.

The total consumption of kerosene in the Czech Republic is divided into five categories (Domestic Aviation, International Bunkers, Army, Industry and Commercial and Public Services). The kerosene consumption as well as relevant emissions from the categories of Army, Industry, and Commercial and

Public Services are not reported in the CRF Reporter in Transport sector 1.A.3 (or International Bunkers 1.D.1), but in sectors 1.A.5.b.i, 1.A.2.f and 1.A.4.a, respectively. The other two categories (Domestic Aviation 1.A.3.a and Aviation Bunkers 1.D.1.a) were divided on the basis of expert judgment over the whole time period where the main criteria were passenger transport (At the present time, this includes the only regular domestic line between the airports in Prague and Ostrava) and transport of goods (MoT, 2000; MoT, 2006; MoT, 2011; MoT, 2015,). Regular domestic flights (14 TJ) using kerosene represent a very small percentage in the Czech Republic compared to international flights (12 413 TJ). In the Domestic Aviation category, the IEA data (1472 TJ) also include kerosene consumption in the categories of Army (13 kilotons of jet kerosene frontloading is included in 2014), Industry, and Commercial and Public Services which are not used for aviation or transport. The following table (on the recommendation of ERT) shows the distribution of kerosene consumption in the CRF Reporter in comparison with IEA data. As can be seen from this table, the total sums of kerosene (CRF vs. IEA) are identical or nearly identical in most cases.

**Tab. 3-63 Distribution of the Jet Kerosene consumption in CRF Reporter and IEA data in 1990-2015 [TJ]**

| Year | CRF Reporter | | | | | | IEA data | | |
|---|---|---|---|---|---|---|---|---|---|
| | Domestic Aviation (1.A.3.a) | Internat. Aviation (1.D.1.a) | Army (1.A.5.b.i) | Industry (1.A.2.f) | Commercial and Public Services (1.A.4.a) | Total CRF | Internat. Aviation | Domestic Aviation | Total IEA |
| **1990** | 19 | 7 325 | 0 | 0 | 0 | 7 344 | 7 344 | 0 | 7 344 |
| **1991** | 20 | 6 020 | 0 | 0 | 0 | 6 040 | 6 040 | 0 | 6 040 |
| **1992** | 29 | 6 967 | 0 | 0 | 0 | 6 996 | 6 996 | 0 | 6 996 |
| **1993** | 31 | 5 792 | 0 | 0 | 0 | 5 823 | 5 823 | 0 | 5 823 |
| **1994** | 49 | 7 208 | 0 | 0 | 0 | 7 257 | 7 257 | 0 | 7 257 |
| **1995** | 15 | 7 805 | 0 | 0 | 0 | 7 820 | 7 820 | 0 | 7 820 |
| **1996** | 41 | 5 866 | 0 | 0 | 0 | 5 907 | 5 603 | 304 | 5 907 |
| **1997** | 54 | 6 759 | 0 | 0 | 0 | 6 812 | 5 217 | 1 595 | 6 812 |
| **1998** | 50 | 7 991 | 0 | 0 | 0 | 8 041 | 4 902 | 3 139 | 8 041 |
| **1999** | 48 | 7 520 | 0 | 0 | 0 | 7 568 | 5 633 | 1 935 | 7 568 |
| **2000** | 22 | 8 234 | 0 | 0 | 0 | 8 256 | 6 665 | 1 591 | 8 256 |
| **2001** | 24 | 8 750 | 0 | 0 | 0 | 8 774 | 6 762 | 2 012 | 8 774 |
| **2002** | 19 | 7 556 | 770 | 0 | 0 | 8 346 | 6 976 | 1 370 | 8 346 |
| **2003** | 24 | 10 163 | 556 | 0 | 0 | 10 743 | 8 432 | 2 311 | 10 743 |
| **2004** | 35 | 13 062 | 685 | 0 | 0 | 13 782 | 12 070 | 1 712 | 13 782 |
| **2005** | 37 | 13 573 | 728 | 0 | 0 | 14 338 | 13 182 | 1 156 | 14 338 |
| **2006** | 46 | 14 070 | 563 | 0 | 0 | 14 679 | 14 073 | 606 | 14 679 |
| **2007** | 46 | 14 763 | 823 | 87 | 217 | 15 936 | 14 462 | 1 472 | 15 934 |
| **2008** | 31 | 15 644 | 823 | 87 | 173 | 16 758 | 14 895 | 1 862 | 16 757 |
| **2009** | 45 | 14 287 | 909 | 87 | 173 | 15 501 | 14 246 | 1 256 | 15 501 |
| **2010** | 36 | 13 387 | 650 | 87 | 130 | 14 290 | 13 120 | 1 169 | 14 289 |
| **2011** | 22 | 13 272 | 1 256 | 87 | 173 | 14 810 | 12 990 | 1 819 | 14 809 |
| **2012** | 17 | 12 367 | 520 | 87 | 130 | 13 121 | 12 297 | 823 | 13 120 |
| **2013** | 19 | 11 931 | 563 | 43 | 43 | 12 599 | 11 864 | 736 | 12 600 |
| **2014** | 12 | 12 241 | 606 | 0 | 0 | 12 859 | 12 254 | 693 | 12 974 |
| **2015** | 14 | 12 413 | 563 | 43 | 173 | 13 206 | 12 341 | 1472 | 13 813 |

### *Emission factors*

Based on the ERT recommendation, tables of emission factors for all greenhouse gases were added. The first table shows the situation in road transportation in detail and is divided according to the vehicle category, the fuel type and the EURO standard. The second table contains information about the emission factors of non-road transportation, in particular of railways, a water-borne navigation and civil aviation. Aviation is divided into two modes (LTO and CRUISE). The emission factors are derived from the internal database of the Transport Research Centre (CDV), which contains the default emission factors taken from the IPCC and EIG databases ($CO_2$ and $N_2O$), and also those with country-specific character

($CH_4$). The calculated emission factor of the biomass was taken as the weighted average for gasoline and diesel oil, taking into account the real vehicle fleet on the roads (recommended by ERT). The calculation of the biomass emission factors of other greenhouse gases also takes into account the amount of renewable components in fuels. The CDV´s methodology employs emission factors only in [$g.kg^{-1}$] of fuel because the country-specific measured data are listed in this unit.

**Tab. 3-64 Emission factors of $CO_2$, $N_2O$ and $CH_4$ from road transport in 2015 in [$g.kg^{-1}$] of fuel**

| Vehicle type | Fuel type | European emission standard | EF $CO_2$ [$g.kg^{-1}$] | EF $N_2O$ [$g.kg^{-1}$] | EF $CH_4$ [$g.kg^{-1}$] |
|---|---|---|---|---|---|
| **Motorcycles** | Gasoline | PRE-EURO and higher | 3 083 | 0.06 | 4.10 |
| **Motorcycles** | Bioethanol | PRE-EURO and higher | 1 912 | 0.02 | 0.08 |
| **PC+LDT** | Gasoline | PRE-EURO | 3 083 | 0.2 | 0.90 |
| **PC+LDT** | Gasoline | EURO I and EURO II | 3 083 | 0.2 | 0.40 |
| **PC+LDT** | Gasoline | EURO III and higher | 3 083 | 0.2 | 0.10 |
| **PC+LDT** | Diesel Oil | PRE-EURO | 3 182 | 0.10 | 0.08 |
| **PC+LDT** | Diesel Oil | EURO I and EURO II | 3 182 | 0.20 | 0.08 |
| **PC+LDT** | Diesel Oil | EURO III and higher | 3 182 | 0.25 | 0.08 |
| **PC+LDT** | LPG | PRE-EURO and higher | 3 028 | 0.01 | 1.02 |
| **PC+LDT** | CNG | PRE-EURO and higher | 2 697 | 0.15 | 4.54 |
| **PC+LDT** | Bioethanol | PRE-EURO and higher | 1 912 | 0.02 | 0.08 |
| **PC+LDT** | FAME | PRE-EURO and higher | 2 620 | 0.02 | 0.06 |
| **HDT** | Diesel Oil | PRE-EURO | 3 182 | 0.10 | 0.60 |
| **HDT** | Diesel Oil | EURO I and EURO II | 3 182 | 0.20 | 0.20 |
| **HDT** | Diesel Oil | EURO III and higher | 3 182 | 0.25 | 0.15 |
| **HDT** | CNG | PRE-EURO and higher | 2 697 | 0.15 | 4.54 |
| **HDT** | FAME | PRE-EURO and higher | 2 620 | 0.02 | 0.06 |
| **Bus** | Diesel Oil | EURO II and older | 3 182 | 0.18 | 0.60 |
| **Bus** | Diesel Oil | EURO III and higher | 3 182 | 0.10 | 0.15 |
| **Bus** | CNG | PRE-EURO and higher | 2 697 | 0.15 | 4.54 |
| **Bus** | FAME | PRE-EURO and higher | 2 620 | 0.02 | 0.06 |

**Tab. 3-65 Emission factors of $CO_2$, $N_2O$ and $CH_4$ from non-road transport in 2015 in [$g.kg^{-1}$] of fuel**

| Transport type | Fuel type | EF $CO_2$ [$g.kg^{-1}$] | EF $N_2O$ [$g.kg^{-1}$] | EF $CH_4$ [$g.kg^{-1}$] |
|---|---|---|---|---|
| **Railways** | Diesel Oil | 3 182 | 1.23 | 0.18 |
| **Water-borne navigation** | Diesel Oil | 3 182 | 0.09 | 0.30 |
| **Civil Aviation - LTO** | Aviation Gasoline | 3 065 | 0.09 | 0.02 |
| **Civil Aviation - Cruise** | Aviation Gasoline | 3 065 | 0.09 | 0.02 |
| **Civil Aviation - LTO** | Kerosene | 3 096 | 0.09 | 0.02 |
| **Civil Aviation - Cruise** | Kerosene | 3 096 | 0.09 | 0.02 |

### *$CO_2$ emissions*

Carbon dioxide emissions were calculated on the basis of the total consumption of the individual automotive fuels used in transport (i.e. gasoline, diesel oil, LPG, CNG, biofuels and aviation fuels) and on the basis of the emission factors for the weight of $CO_2$ corresponding to 1 kg of burned fuel. Consumption of different types of fuel by road, railway and water transport was determined on the basis of cooperation with CzSO. The consumption of fuels in road transport was further divided into the following categories of means of transport on the basis of statistics on transport output:

- gasoline-fuelled passenger vehicles;
- diesel vehicles for passenger and light freight transport;
- diesel vehicles for heavy freight transport and buses;
- passenger and light vehicles fuelled by LPG, CNG and biofuels (separately);
- heavy trucks and buses fuelled by CNG and biofuels (separately).

The gradually increasing contrilbution of transport to total $CO_2$ emissions in the Czech Republic became evident during the 1990's and this trend continued until 2007. Individual road and freight transport make the greatest contribution to energy consumption in transport. The amount of sold fuels is monitored annually and constitutes the main input data for calculations of energy consumption.

In 2008, for the first time, a decrease was recorded in the emissions of carbon dioxide from transport, which started a downward trend that continued until 2014 (Jedlicka et al, 2014). The reduction in carbon dioxide emissions is primarily a result of the reduction in the consumption of gasoline and diesel oil, which is interpreted as being a consequence of the global economic crisis. The downward trend in the fuel consumption is evaluated very favourably from the viewpoint of greenhouse gases.

A continuous downward trend in the gasoline consumption dates back to 2007. However, the persistent downward trend may no longer be a consequence of the economic crisis. A slight increase in diesel oil consumption was recorded in 2014. This phenomenon indicates a return to predictions of further development in the consumption of conventional fuels. The increase of fuel consumption in 2014 and 2015 may have been affected by the progress of the national economy and the increased transportation of goods and materials connected with acceleration of the economy after the crisis. The greenhouse gas emission balance reflects not only the scenario of the consumption of alternative fuels, but also the scenario of trends in the transport infrastructure, the further construction of the throughway network in different variants, urban bypasses, further construction of railway corridors, etc.

The consumption of gasoline fluctuated around 2 mil. tons from 2002 to 2009, but has started to decline significantly since 2010. It even reached a value of 1455 kilotons in 2014. This decline is caused especially by the downward trend in the average fuel consumption by modern passenger cars. In 2015, the gasoline consumption reached 1565 kilotons (this increase was caused by the restored economical growth connected with more intense transport of goods and persons). Since 2008, the consumption of gasoline has also included the consumption of bioethanol, which has been added to all gasoline in the amount of 2% since January 1, 2008. The share of bioethanol as a renewable resource in gasoline reached a value 4.1% in 2010 and the share of fatty acid methyl esters (FAME) as a renewable resource in diesel oil reached a value 6% in 2010; both values are expected to remain unchanged in the coming years. The share of biofuels in fuels is also increasing (6.8% in 2010 and 8.5% in 2015). These facts (the reduction in consumption and increasing share of bio-components) have a favourable impact on $CO_2$ emissions.

Mobile sources used for purposes other than transport (gasoline-powered lawn mowers, chain saws, construction machinery, etc.) make a smaller contribution to the increasing consumption of gasoline and diesel oil.

In relation to $CO_2$ emissions from air transport, it can be stated that domestic transport makes a very small contribution to these emissions (about 1%), as it is limited mainly to flights between the three largest cities in the Czech Republic, Prague, Brno and Ostrava. Similar to road transport and consumption of aircraft fuel, this is not monitored centrally by the Czech Statistical Office. Aircraft are fuelled mainly by jet kerosene while the consumption of gasoline and $CO_2$ emissions from aviation gasoline are limited to small aircrafts used in agriculture and in sports and recreational activities.

- The total consumption by army and domestic transport (estimated on the basis of the number of flights, distances between destinations and a specific consumption of fuels per unit distance in the LTO regime and the cruise itself) were subtracted from the total kerosene consumption. The remaining kerosene consumption is related to international air transport.

**Tab. 3-66 $CO_2$ emissions calculation from mobile sources in 1990 – 2015 [kt $CO_2$]**

| Year | Aviation (without Bunkers) | Road Transportation | Railways | Water-borne navigation | Other Transport Pipeline transport | Other Mobile Agric. and others | Total |
|---|---|---|---|---|---|---|---|
| | 1.A.3.a | 1.A.3.b | 1.A.3.c | 1.A.3.d | 1.A.3.e | 1.A.4.c.ii + 1.A.5.b | 1.A.3 + 1.A.4.c.ii + 1.A.5 |
| **1990** | 139.4 | 6 177 | 654 | 56.6 | 5.4 | 1 655 | 8 687 |
| **1991** | 38.2 | 5 478 | 582 | 56.2 | 9.2 | 1 439 | 7 603 |
| **1992** | 38.9 | 7 108 | 494 | 54.8 | 13.1 | 1 335 | 9 044 |
| **1993** | 23.7 | 7 299 | 415 | 54.3 | 17.0 | 1 290 | 9 099 |
| **1994** | 21.9 | 8 079 | 335 | 53.5 | 20.8 | 1 299 | 9 809 |
| **1995** | 13.4 | 8 584 | 334 | 55.2 | 36.0 | 1 191 | 10 214 |
| **1996** | 15.2 | 9 504 | 329 | 45.9 | 87.6 | 1 139 | 11 121 |
| **1997** | 10.0 | 9 654 | 283 | 38.5 | 75.2 | 1 188 | 11 249 |
| **1998** | 9.7 | 9 862 | 356 | 37.8 | 58.2 | 1 401 | 11 725 |
| **1999** | 12.6 | 11 083 | 332 | 22.1 | 62.2 | 1 377 | 12 889 |
| **2000** | 10.8 | 11 237 | 329 | 15.8 | 58.0 | 1 380 | 13 031 |
| **2001** | 7.8 | 11 975 | 301 | 24.9 | 59.3 | 1 319 | 13 687 |
| **2002** | 10.6 | 12 561 | 292 | 12.4 | 61.5 | 1 290 | 14 228 |
| **2003** | 10.9 | 14 309 | 286 | 12.4 | 58.1 | 1 237 | 15 913 |
| **2004** | 11.7 | 15 047 | 282 | 18.6 | 56.0 | 1 301 | 16 716 |
| **2005** | 8.8 | 16 344 | 285 | 15.5 | 68.5 | 1 284 | 18 006 |
| **2006** | 9.4 | 16 964 | 304 | 19.0 | 73.4 | 1 259 | 18 629 |
| **2007** | 9.4 | 17 831 | 301 | 15.8 | 119.0 | 1 336 | 19 612 |
| **2008** | 8.3 | 17 647 | 334 | 12.7 | 146.1 | 1 406 | 19 554 |
| **2009** | 9.3 | 17 136 | 303 | 15.9 | 151.6 | 1 381 | 18 997 |
| **2010** | 8.7 | 16 159 | 293 | 12.8 | 151.6 | 1 336 | 17 961 |
| **2011** | 4.6 | 15 977 | 287 | 9.6 | 145.5 | 1 400 | 17 824 |
| **2012** | 7.4 | 15 787 | 277 | 15.9 | 89.3 | 1 340 | 17 517 |
| **2013** | 7.5 | 15 680 | 271 | 6.4 | 92.3 | 1 334 | 17 391 |
| **2014** | 7.0 | 16 206 | 274 | 9.6 | 83.7 | 1 350 | 17 930 |
| **2015** | 10.2 | 16 986 | 264 | 12.7 | 71.0 | 1 393 | 18 737 |

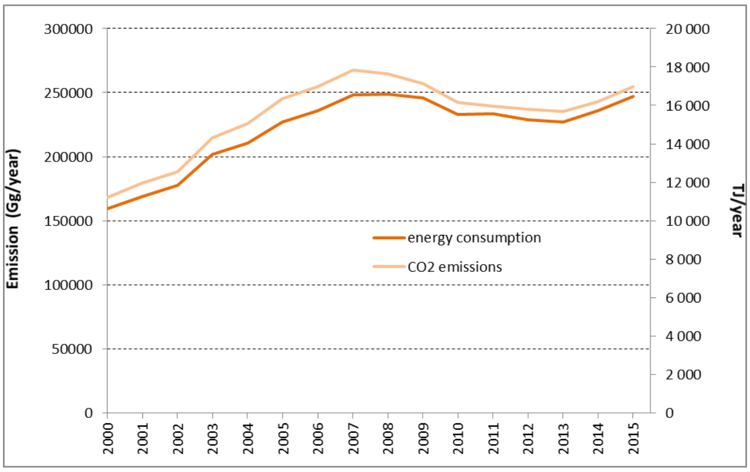



**Fig. 3-21 Comparison of energy consumption and $CO_2$ emissions from road transport**

According to Fig. 3-22 the emissions of $CO_2$ from road transportation follow the trend in energy consumption. There are no disproportions. $CO_2$ emissions are dependent on the ratio between the energy consumption of a particular type of fuel. EF is calculated on the basis of the slightly variable calorific value of a particular fuel and these values are given for each year (by CzSO).

### *$CH_4$ emissions*

For road transportation, the method of methane emission calculation corresponds to the Tier 2 level, because different road vehicles produce different amounts of methane. It can be stated that methane emissions from road transportation show the same differences as total hydrocarbons. Mobile emission sources were divided into several categories according to the type of fuel, the transport mode and the emission limit that a particular vehicle must meet. This division is more detailed because there are more significant differences in methane production by individual vehicles. These categories are described in detail at the beginning of this chapter.

The total consumption of gasoline, diesel oil, LPG, CNG and biofuels has been taken from CzSO statistical surveys. The next step consisted in separation of these fuel consumptions by the vehicle categories mentioned above and then according to their transport outputs acquired in the last National Traffic Census, which is updated once in a five year period in the Czech Republic; the last one was in 2010. The emission factors were the IPCC default values and, from 2004, the country-specific values as the CDV became part of the emission inventory team.

The Czech Republic has been very successful in stabilizing and decreasing methane emissions derived from transport-related greenhouse gas emissions. The annual trends in these emissions are constantly decreasing and are very similar to other hydrocarbon emissions, which are limited in accordance with UNECE regulations. New vehicles must fulfill substantially higher EURO standards for hydrocarbons than older vehicles (currently the EURO 6 standard for passenger cars and EURO VI for heavy duty vehicles and buses). The greatest problems are associated with the slow renewal of the freight transport fleet. There has been a slight decrease in the number of older trucks in this country and these older vehicles are frequently used in the construction and food industries (Adamec et al., 2005a). A slight increase of $CH_4$ emissions was observed in 2014 and 2015. This was caused mainly by the accquisition of a large number of CNG buses (supported from national funds) and overall growth of the economy and transport of goods and persons.

Methane emissions from mobile sources are now calculated using methane emission factors taken from the internal database, containing both data from Czech emission measurements (mostly obtained from the Motor Vehicle Research Institute - TÜV UVMV) and internationally accepted values from the IPCC methodology, European Environmental Agency - Emission Inventory Guidebook, CORINAIR, etc. The resultant emission factors were calculated using the weighted averages of all the data classified according to transport vehicle categories. The following categories were included: conventional gasoline-fuelled passenger cars, gasoline-fuelled passenger cars fulfilling EURO limits, diesel-fuelled passenger cars, light-duty vehicles, heavy-duty vehicles, diesel locomotives, diesel-fuelled watercraft, aircraft fuelled by aviation gasoline and kerosene-fuelled aircraft (Adamec et al., 2005b).

**Tab. 3-67 $CH_4$ emissions calculation from mobile sources [Mg] of $CH_4$ in 1990 – 2015**

| | Aviation (without Bunkers) | Road Transportat ion | Railways | Water-borne navigation | Other Transport Pipeline transport | Other Mobile Agric. and others | Total |
|---|---|---|---|---|---|---|---|
| | 1.A.3.a | 1.A.3.b | 1.A.3.c | 1.A.3.d | 1.A.3.e | 1.A.4.c.ii + 1.A.5.b | 1.A.3 + 1.A.4.c.ii + 1.A.5 |
| **1990** | 0.996 | 1 500 | 37 | 5.35 | 0.10 | 0.13 | 1 544 |
| **1991** | 0.273 | 1 354 | 33 | 5.31 | 0.17 | 0.12 | 1 393 |
| **1992** | 0.278 | 1 757 | 28 | 5.18 | 0.24 | 0.11 | 1 791 |
| **1993** | 0.169 | 1 683 | 23 | 5.13 | 0.31 | 0.10 | 1 712 |
| **1994** | 0.156 | 1 814 | 19 | 5.05 | 0.38 | 0.10 | 1 839 |
| **1995** | 0.095 | 1 826 | 19 | 5.22 | 0.66 | 0.09 | 1 851 |
| **1996** | 0.108 | 1 924 | 18 | 4.34 | 1.59 | 0.08 | 1 948 |
| **1997** | 0.071 | 1 851 | 16 | 3.64 | 1.37 | 0.09 | 1 872 |
| **1998** | 0.069 | 1 771 | 20 | 3.57 | 1.06 | 0.10 | 1 796 |
| **1999** | 0.090 | 1 834 | 19 | 2.09 | 1.13 | 0.10 | 1 856 |
| **2000** | 0.077 | 1 703 | 18 | 1.49 | 1.05 | 0.13 | 1 724 |
| **2001** | 0.056 | 1 701 | 17 | 2.35 | 1.08 | 0.13 | 1 722 |
| **2002** | 0.075 | 1 647 | 16 | 1.17 | 1.12 | 0.13 | 1 665 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2003** | 0.077 | 1 703 | 16 | 1.17 | 1.06 | 0.11 | 1 721 |
| **2004** | 0.083 | 1 612 | 16 | 1.76 | 1.02 | 0.11 | 1 631 |
| **2005** | 0.062 | 1 556 | 16 | 1.46 | 1.25 | 0.11 | 1 575 |
| **2006** | 0.067 | 1 473 | 17 | 1.80 | 1.33 | 0.10 | 1 493 |
| **2007** | 0.067 | 1 448 | 17 | 1.50 | 2.16 | 0.11 | 1 469 |
| **2008** | 0.059 | 1 338 | 19 | 1.20 | 2.65 | 0.11 | 1 361 |
| **2009** | 0.066 | 1 209 | 17 | 1.50 | 2.75 | 0.11 | 1 230 |
| **2010** | 0.062 | 1 061 | 16 | 1.21 | 2.74 | 0.11 | 1 081 |
| **2011** | 0.033 | 995 | 16 | 0.90 | 2.63 | 0.12 | 1 015 |
| **2012** | 0.052 | 945 | 16 | 1.50 | 1.62 | 0.11 | 964 |
| **2013** | 0.054 | 925 | 15 | 0.60 | 1.67 | 0.10 | 942 |
| **2014** | 0.050 | 957 | 15 | 0.90 | 1.51 | 0.11 | 975 |
| **2015** | 0.073 | 1012 | 15 | 1.20 | 1.42 | 0.12 | 1 030 |

Figure 3-22 shows the opposite trend in emission production of $CH_4$ and energy consumption in road transportation. The continuous decrease started in 2000 when the EURO 3 standard was implemented. Starting in that year, there was a separate limit value for THC. The decrease in the following years was intensified by toughening of the THC limits in 2005 by the EURO 4 standard. Another cause of the downward trend is the increasing ratio of diesel passenger cars within the car fleet over the past few years, which produce less $CH_4$. This trend changed in 2014 when $CH_4$ emissions began to increase due to the purchase of a large number of CNG buses by cities and regions of the Czech Republic with high air pollution.

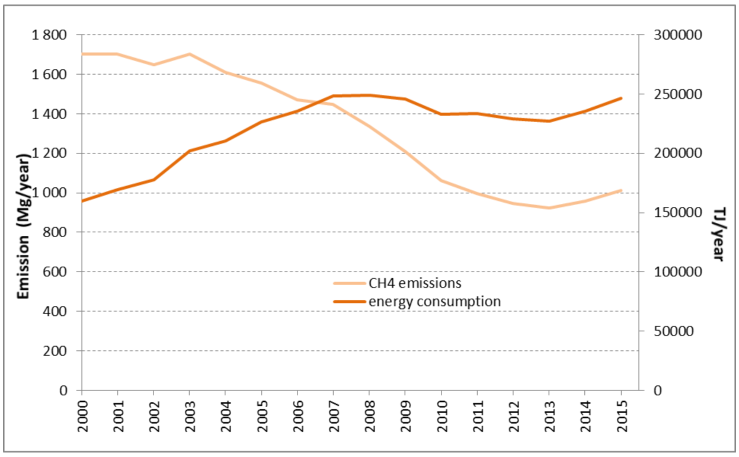



**Fig. 3-22 Comparison of energy consumption and $CH_4$ emissions from road transport**

### *$N_2O$ emissions*

Nitrous oxide emissions decreased in 2008, similar to carbon dioxide emissions, as a consequence of reduced consumption of gasoline and diesel oil. New vehicles exhibit higher emissions compared to older models because they are equipped with 3-way catalytic converters which reduce only $NO_X$ emissions but not $N_2O$ emissions. However, this effect is suppressed in new vehicles as a consequence of the lower fuel consumption. Between 2008 and 2013, the $N_2O$ emissions decreased similar to carbon dioxide emissions. Nitrous oxide emissions increased slightly in 2014 and 2015. This fact is caused by the higher consumption of diesel oil, which is influenced by growth of the national economy and by an increase in the transportation of goods and material. Another factor is the higher consumption of CNG connected with purchasing of CNG buses, supported from national funds.

Road transport was identified as a key source of $N_2O$ emissions over the past 5 years, as the share of vehicles with high $N_2O$ emissions has been increasing in this period. Consequently, $N_2O$ emissions from mobile sources represent a somewhat more important contribution than $CH_4$ emissions. In calculation of $N_2O$ emissions from mobile sources, the most important source according to the IPCC methodology seems to be passenger automobile transport, especially gasoline-fuelled passenger cars with catalysts. The vehicle categories for the nitrous oxide calculation are the same as for methane (see above).

Because of large differences between national $N_2O$ measurement results and the values recommended in the IPCC methodology, a special verification including a statistical evaluation has been performed. The resultant values of the $N_2O$ emission factors from mobile sources approach the recommended IPCC values. The $N_2O$ emissions factors of vehicles with diesel motors and of vehicles with gasoline motors without catalysts are not very high and were taken from the methodical instructions in the standard manner (IPCC default values). The situation is more complex for vehicles with gasoline motors equipped with three-way catalysts. The IPCC methodology (IPCC, 2006) gives three pairs of emission factors for passenger cars with catalysts (for new and deactivated catalysts). The value for a deactivated catalyst is approximately three times higher than for a new catalyst. The pair of values recommended on the basis of Canadian research was selected because of a lack of domestic data; in addition, American and French coefficients are presented in the *IPCC Reference Manual*, Box 3 (IPCC, 1997). The arithmetic mean of the values of new and long-used catalysts was taken as the final emission factor for passenger cars with catalysts.

A partial increase in $N_2O$ emissions can be expected in this category in connection with the growing proportion of vehicles equipped with three-way catalysts. The approach described above was recently revised and modified by CDV, which has been a member of the Czech national GHG inventory team since 2005. CDV has been providing the official Czech inventory with transport data since 2004. The CDV approach is based on combination of measurements performed for some cars typically used in the Czech Republic with widely used EFs values taken from the literature (Dufek, 2005).

In relation to the reports on $N_2O$ emissions, the situation in the Czech Republic is rather complicated, as the values in some of the measurements performed here in the past were substantially different from internationally recognized emission factors. Consequently, control measurements of the $N_2O$ emissions of the commonest cars were performed in the Czech passenger vehicle fleet (Skoda Felicia, Fabia and Octavia) during 2004 – 2006. These corrections brought the results closer to those obtained by using the IPPC emission factors when compared to the older data and thus led to more adequate harmonization of the results of the nitrous oxide emission inventory per energy unit with those obtained in other countries. The locally measured data of $N_2O$ emissions in exhaust gases were verified by assigning the weighting criteria for each measurement; the most important of these criteria were the number of measurements, the method of analysis, the type of vehicle and the proportion of these vehicles in the Czech vehicle fleet (Dufek, 2005 and Jedlicka et al., 2005).

Nitrous oxide emission factors were obtained using a similar method to that employed for methane, by a statistical evaluation of weighted averages of the emission factors for each category of vehicles, employing the interactive database. This database now encompasses the results of the Czech measurements performed in 2004 and 2005 (Adamec et al., 2005b). Emissions of $N_2O$ are given in Tab. 3-24.

EFs described higher were used untill the year 1999. In next years the CS EFs, based on the recomandation of the ESD review in June 2016, have been replaced by EFs from IPCC Guidelines 2006. More in the Chapter 10 (Recalculations and Improvements).

**Tab. 3-68 $N_2O$ emissions calculation from mobile sources in 1990 – 2015 [Mg $N_2O$]**

| | Aviation (without Bunkers) | Road Transportation | Railways | Water-borne navigation | Other Transport Pipeline transport | Other Mobile Agric. and others | Total |
|---|---|---|---|---|---|---|---|
| | **1.A.3.a** | **1.A.3.b** | **1.A.3.c** | **1.A.3.d** | **1.A.3.e** | **1.A.4.c.ii + 1.A.5.b** | **1.A.3 + 1.A.4.c.ii + 1.A.5** |
| **1990** | 3.98 | 459 | 252 | 1.53 | 0.010 | 0.059 | 717 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1991** | 1.09 | 418 | 225 | 1.52 | 0.017 | 0.053 | 646 |
| **1992** | 1.11 | 543 | 191 | 1.48 | 0.024 | 0.050 | 737 |
| **1993** | 0.68 | 589 | 160 | 1.47 | 0.031 | 0.050 | 751 |
| **1994** | 0.63 | 728 | 129 | 1.44 | 0.038 | 0.053 | 859 |
| **1995** | 0.38 | 828 | 129 | 1.49 | 0.066 | 0.047 | 959 |
| **1996** | 0.43 | 996 | 127 | 1.24 | 0.159 | 0.047 | 1125 |
| **1997** | 0.28 | 1070 | 109 | 1.04 | 0.137 | 0.051 | 1181 |
| **1998** | 0.28 | 1132 | 138 | 1.02 | 0.106 | 0.064 | 1271 |
| **1999** | 0.36 | 1305 | 128 | 0.60 | 0.113 | 0.065 | 1434 |
| **2000** | 0.31 | 674 | 127 | 0.43 | 0.105 | 0.070 | 802 |
| **2001** | 0.22 | 727 | 116 | 0.67 | 0.108 | 0.073 | 844 |
| **2002** | 0.30 | 773 | 113 | 0.34 | 0.112 | 0.080 | 887 |
| **2003** | 0.31 | 893 | 110 | 0.34 | 0.106 | 0.079 | 1004 |
| **2004** | 0.33 | 952 | 109 | 0.50 | 0.102 | 0.089 | 1062 |
| **2005** | 0.25 | 1049 | 110 | 0.42 | 0.125 | 0.094 | 1160 |
| **2006** | 0.27 | 1081 | 117 | 0.51 | 0.133 | 0.091 | 1199 |
| **2007** | 0.27 | 1151 | 116 | 0.43 | 0.216 | 0.100 | 1268 |
| **2008** | 0.24 | 1152 | 129 | 0.34 | 0.265 | 0.106 | 1282 |
| **2009** | 0.27 | 1131 | 117 | 0.43 | 0.275 | 0.105 | 1249 |
| **2010** | 0.25 | 1078 | 113 | 0.34 | 0.274 | 0.100 | 1192 |
| **2011** | 0.13 | 1079 | 111 | 0.26 | 0.263 | 0.109 | 1191 |
| **2012** | 0.21 | 1071 | 107 | 0.43 | 0.162 | 0.102 | 1179 |
| **2013** | 0.21 | 1069 | 104 | 0.17 | 0.167 | 0.101 | 1174 |
| **2014** | 0.20 | 1108 | 106 | 0.26 | 0.151 | 0.104 | 1215 |
| **2015** | 0.29 | 1166 | 102 | 0.30 | 0.142 | 0.109 | 1269 |

Fig. 3-23 shows a greater increase in $N_2O$ emissions for road transport until 2005 compared to the energy consumption trend. This phenomenon is caused by replacing older catalyst technologies with high production of $N_2O$ by new ones with higher EURO standards, which are more effective. The implementation of the EURO V standard for trucks in 2008 and EURO 5 standard in 2009 for passenger cars introduced tougher limits for $NO_x$. Consequently and because of the impact of last economic crisis (decrease in transport of goods) a decrease in $N_2O$ emissions was observed in the following years, which is more intense than the decrease in energy consumption.

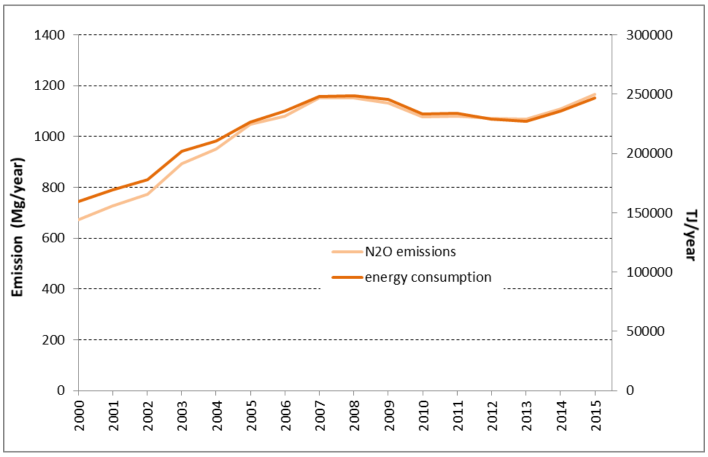



**Fig. 3-23 Comparison of energy consumption and $N_2O$ emissions from road transport**

***Other Transportation (CRF1.A.3.e )***

Country specific $CO_2$ emission factor is used in this category. For detailed information please see Annex 3.

Default emission factors are used for $CH_4$ and $N_2O$ in the entire time series.

### 3.2.17.2 Uncertainties and time-series consistency

The uncertainty in road transport was calculated according to the EMEP/EEA air pollutant emission inventory guidebook 2016. The uncertainty given here has been evaluated in reported categories to compare the years 1990 and 2015.

**Tab. 3-69 Uncertainty data from Energy sector (mobile combustion) for uncertainty analysis**

| IPCC Source Category | Gas | Base year emissions (1990) | Year t emissions (2015) | Activity data uncertainty | Emission factor uncertainty | Combined uncertainty |
|---|---|---|---|---|---|---|
| | | kt | kt | % | % | % |
| **1A3aii Civil Aviation-Aviation Gasoline** | $CO_2$ | 138.1 | 9.2 | 4.0 | 3.9 | 5.6 |
| **1A3aii Civil Aviation-Jet Kerosene** | $CO_2$ | 1.4 | 1.0 | 4.0 | 3.2 | 5.1 |
| **1A3bi PC+LDV-Gasoline** | $CO_2$ | 3468.7 | 4478.6 | 3.0 | 4.0 | 5.0 |
| **1A3bi PC+LDV-Diesel Oil** | $CO_2$ | 1548.9 | 5300.2 | 3.0 | 1.5 | 3.3 |
| **1A3bi PC+LDV-LPG** | $CO_2$ | 0.0 | 296.7 | 3.0 | 3.2 | 4.4 |
| **1A3bi PC+LDV Gaseous Fuels** | $CO_2$ | 0.0 | 57.9 | 3.0 | 3.2 | 4.4 |
| **1A3bi PC+LDV Biomass** | $CO_2$ | 0.0 | 489.0 | 3.0 | 2.5 | 3.9 |
| **1A3biii HDV-Diesel Oil** | $CO_2$ | 7344.6 | 6788.6 | 3.0 | 1.5 | 3.3 |
| **1A3biii HDV-Gaseous Fuels** | $CO_2$ | 0.0 | 25.7 | 3.0 | 3.2 | 4.4 |
| **1A3biii HDV-Biomass** | $CO_2$ | 0.0 | 388.4 | 3.0 | 1.5 | 3.3 |
| **1A3biv Motorcycles-Gasoline** | $CO_2$ | 18.4 | 37.9 | 3.0 | 4.0 | 5.0 |
| **1A3biv Motorcycles-Biomass** | $CO_2$ | 0.0 | 1.6 | 3.0 | 4.0 | 5.0 |
| **1A3c Railways-Diesel Oil** | $CO_2$ | 653.9 | 264.1 | 5.0 | 1.5 | 5.2 |
| **1A3dii National navigation-Diesel Oil** | $CO_2$ | 56.6 | 12.7 | 5.0 | 1.5 | 5.2 |
| **1D1a International Aviation-Jet Kerosene** | $CO_2$ | 523.7 | 887.5 | 4.0 | 3.2 | 5.1 |
| **1A3aii Civil Aviation-Aviation Gasoline** | $CH_4$ | 0.0 | 0.0 | 4.0 | 78.5 | 78.7 |
| **1A3aii Civil Aviation-Jet Kerosene** | $CH_4$ | 0.0 | 0.0 | 4.0 | 78.5 | 78.6 |
| **1A3bi PC+LDV-Gasoline** | $CH_4$ | 26.0 | 5.6 | 3.0 | 157.5 | 157.5 |
| **1A3bi PC+LDV-DieselOil** | $CH_4$ | 1.0 | 3.5 | 3.0 | 101.3 | 101.3 |
| **1A3bi PC+LDV-LPG** | $CH_4$ | 0.0 | 2.5 | 3.0 | 809.8 | 809.8 |
| **1A3bi PC+LDV Gaseous Fuels** | $CH_4$ | 0.0 | 2.4 | 3.0 | 809.8 | 809.8 |
| **1A3bi PC+LDV Biomass** | $CH_4$ | 0.0 | 0.4 | 3.0 | 123.2 | 123.2 |
| **1A3biii HDV-Diesel Oil** | $CH_4$ | 35.0 | 8.4 | 3.0 | 157.5 | 157.5 |
| **1A3biii HDV-Gaseous Fuels** | $CH_4$ | 0.0 | 1.1 | 3.0 | 809.8 | 809.8 |
| **1A3biii HDV-Biomass** | $CH_4$ | 0.0 | 0.2 | 3.0 | 101.3 | 101.3 |
| **1A3biv Motorcycles-Gasoline** | $CH_4$ | 0.6 | 1.3 | 3.0 | 151.7 | 151.7 |
| **1A3biv Motorcycles-Biomass** | $CH_4$ | 0.0 | 0.0 | 3.0 | 151.7 | 151.7 |
| **1A3c Railways-Diesel Oil** | $CH_4$ | 0.9 | 0.4 | 5.0 | 157.5 | 157.5 |
| **1A3dii National navigation-Diesel Oil** | $CH_4$ | 0.1 | 0.0 | 5.0 | 157.5 | 157.5 |
| **1D1a International Aviation-Jet Kerosene** | $CH_4$ | 0.1 | 0.2 | 4.0 | 78.5 | 78.6 |
| **1A3aii Civil Aviation-Aviation Gasoline** | $N_2O$ | 1.2 | 0.0 | 4.0 | 110.0 | 110.1 |
| **1A3aii Civil Aviation-Jet Kerosene** | $N_2O$ | 0.0 | 0.0 | 4.0 | 110.0 | 110.1 |
| **1A3bi PC+LDV-Gasoline** | $N_2O$ | 106.7 | 7.5 | 3.0 | 133.8 | 133.8 |
| **1A3bi PC+LDV-DieselOil** | $N_2O$ | 14.7 | 10.2 | 3.0 | 137.2 | 137.2 |
| **1A3bi PC+LDV-LPG** | $N_2O$ | 0.0 | 0.0 | 3.0 | 1266.7 | 1266.7 |
| **1A3bi PC+LDV Gaseous Fuels** | $N_2O$ | 0.0 | 0.1 | 3.0 | 1266.7 | 1266.7 |
| **1A3bi PC+LDV Biomass** | $N_2O$ | 0.0 | 0.1 | 3.0 | 135.8 | 135.9 |
| **1A3biii HDV-DieselOil** | $N_2O$ | 84.3 | 132.7 | 3.0 | 137.2 | 137.2 |
| **1A3biii HDV-Gaseous Fuels** | $N_2O$ | 0.0 | 0.4 | 3.0 | 1266.7 | 1266.7 |
| **1A3biii HDV-Biomass** | $N_2O$ | 0.0 | 1.0 | 3.0 | 97.9 | 97.9 |
| **1A3biv Motorcycles-Gasoline** | $N_2O$ | 0.1 | 0.2 | 3.0 | 156.9 | 156.9 |
| **1A3biv Motorcycles-Biomass** | $N_2O$ | 0.0 | 0.0 | 3.0 | 156.9 | 156.9 |
| **1A3c Railways-Diesel Oil** | $N_2O$ | 75.2 | 30.4 | 5.0 | 137.2 | 137.3 |
| **1A3dii National navigation-Diesel Oil** | $N_2O$ | 0.5 | 0.1 | 5.0 | 137.2 | 137.3 |
| **1D1a InternationalAviation-Jet Kerosene** | $N_2O$ | 4.4 | 7.5 | 4.0 | 110.0 | 110.1 |

### 3.2.17.3 Source-specific QA/QC and verification

QC carried out in the Transport Research Centre (CDV) is based on routine and consistent checks to ensure data integrity, correctness and completeness and to identify and address errors. All QC activities were documented and archived. QC activities include methods such as accuracy checks on data acquisition and calculations, and the use of approved standardised procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. QC activities also include technical reviews of categories, activity data, emission factors, other estimated parameters and methods. QA and verification of activity data are guaranteed at CDV by comparing the activity data with world and European databases and third person checks.

An inventory compiler is responsible for coordinating the institutional and procedural arrangements of inventory activities. These cover data collection from CzSO, deciding on usage of emission factors (according to CS or EIG) and estimation of emissions from mobile sources. Uncertainty assessment is also carried out by the inventory compiler. The last step is the documentation and archiving of data. The inventory compiler designates responsibilities for implementation of QA/QC procedures among persons not directly involved in the compilation of the inventory and among organizations.

A QA/QC plan is a fundamental element of the QA/QC and verification system. The plan of QA/QC procedures at CDV is based on the inner quality control procedure system, which is harmonised with the QA/QC system of the Czech Hydrometeorological Institute (CHMI). Since the transport sector belongs to the energy sector, CDV and CHMI cooperate closely in the fields of energy and fuel consumption data, as well as specific energy data used in calculations in units of [$MJ.kg^{-1}$] of fuel. In close cooperation with CzSO, CHMI ensures that the Transport Research Centre works with the most updated data about consumed total energy and specific energy.

#### a. QA/QC activities

QC Activities:

- Checking criteria for the selection of activity data, emission factors and other estimated parameters are documented.
- Checking that emissions and removals are calculated correctly.
- Checking that parameters and units are correctly recorded and that appropriate conversion factors are used.
- Checking the integrity of database files.
- Checking for consistency in data between categories.
- Checking that the movement of inventory data among processing steps is correct.
- Checking that uncertainties in emissions and removals are estimated and calculated correctly.
- Checking time series consistency.

QA Activities:

- Checking completeness (confirming that estimates are reported for all categories, all years, all subcategories and confirm that entire category of mobile sources is being covered).
- Trend checks (checking value of implied emission factors and unusual, unexplained trends noticed for activity data or other parameters across the time series)
- Checking of internal documentation and archiving.

#### b. Responsibilities in CDV

The sectoral guarantor of QA/QC procedures for mobile sources:

- is responsible for the sectoral QA/QC plan and the compliance of all QA/QC procedures,
- provides plan for the QC procedure and is responsible for its implementation.
- Inventory compiler of inventory from mobile sources:

- performs the emission calculations from transport in the emission model,
- provides for data import in the NFR table,
- is responsible for the storing of documents,
- carries out auto-control and control of data consistency,
- performs the uncertainty calculation,
- introduces improvements.

The third person check (compiler of the Transport yearbook of the Czech Republic)

- detailed control of timeliness, completeness, consistency, comparability and transparency.

The sectoral guarantor of QA/QC procedures for Agricultural and Forestry non-road mobile sources:

- Martin Dedina (Research Institute of Agricultural Technology)

### c. QA/QC procedure in CDV

During every submission, at the beginning of summer, the inventory compiler first receives preliminary activity data from CzSO and makes the first calculations, which are compared with the previous years to reveal a trend in the data from the previous years. If there are some discrepancies, the activity data are consulted with CzSO and inaccuracies are corrected. During the autumn, CzSO provides the final activity data. Then the final calculations are made. QC is also performed by the inventory compiler and then by the person responsible for compilation of the Transport yearbook in CDV and the sectoral guarantor of QA/QC. Every error is described, documented and saved. The next quality control is performed by an expert at CHMI. The last step in QC is European reviews. QA is performed on activity data by comparing it with databases like Eurostat and IEA. The main discrepancies are consulted with CzSO and explained during reviews. Emission estimates are prepared for submission by 5 February and sent to an inventory coordinator. The Stage 1 review questions are processed during the second half of March. The Stage 2 review questions are processed during May and June.

### *3.2.17.4 Recalculations and improvements*

Based on the updated activity data obtained from CzSO concerning LPG consumption in 1.A.3.b.i. Cars , the recalculation was performed. For details see the tables below.

**Tab. 3-70 Comparison of Activity data for 1.A.3.b.i. Cars LPG, provided by CzSO**

| | Activity data (TJ) | | |
|---|---|---|---|
| | **Original activity data** | **Updated activity data** | **Difference** |
| **1990** | NO | NO | NO |
| **1991** | NO | NO | NO |
| **1992** | NO | NO | NO |
| **1993** | 200.0 | 200.0 | 0.0 |
| **1994** | 375.7 | 375.7 | 0.0 |
| **1995** | 551.3 | 551.3 | 0.0 |
| **1996** | 551.3 | 551.3 | 0.0 |
| **1997** | 1539.2 | 1148.6 | -390.54 |
| **1998** | 2527.0 | 2527.0 | 0.00 |
| **1999** | 2940.5 | 2940.5 | 0.00 |
| **2000** | 2848.6 | 2848.6 | 0.00 |
| **2001** | 2894.6 | 2894.6 | 0.00 |
| **2002** | 2940.5 | 2940.5 | 0.00 |
| **2003** | 2986.5 | 2986.5 | 0.00 |
| **2004** | 3124.3 | 3124.3 | 0.00 |
| **2005** | 3216.2 | 3216.2 | 0.00 |
| **2006** | 3308.1 | 3308.1 | 0.00 |
| **2007** | 3537.8 | 3537.8 | 0.00 |
| **2008** | 3583.7 | 3675.6 | 91.89 |

| | | | |
|---|---|---|---|
| **2009** | 3675.6 | 3400.0 | -275.67 |
| **2010** | 3491.9 | 3537.8 | 45.95 |
| **2011** | 3400.0 | 3583.7 | 183.78 |
| **2012** | 3262.1 | 3951.3 | 689.18 |
| **2013** | 3170.2 | 4089.1 | 918.91 |
| **2014** | 3445.9 | 4502.7 | 1056.75 |

**Tab. 3-71 Comparison of original and updated emission estimates for 1.A.3.b.i. Cars, LPG**

| | $CO_2$ (kt) | | | $CH_4$ (t) | | | $N_2O$ (t) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Original estimate data** | **Upated estimate data** | **Difference** | **Original estimate data** | **Updated estimate data** | **Difference** | **Original estimate data** | **Updated estimate data** | **Difference** |
| **1990** | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **1991** | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **1992** | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **1993** | 13.18 | 13.18 | 0.00 | 4.44 | 4.44 | 0.00 | 0.04 | 0.04 | 0.00 |
| **1994** | 24.76 | 24.76 | 0.00 | 8.34 | 8.34 | 0.00 | 0.08 | 0.08 | 0.00 |
| **1995** | 36.34 | 36.34 | 0.00 | 12.24 | 12.24 | 0.00 | 0.11 | 0.11 | 0.00 |
| **1996** | 36.34 | 36.34 | 0.00 | 12.24 | 12.24 | 0.00 | 0.11 | 0.11 | 0.00 |
| **1997** | 101.44 | 75.70 | -25.74 | 34.17 | 25.50 | -8.67 | 0.31 | 0.23 | -0.08 |
| **1998** | 166.54 | 166.54 | 0.00 | 56.10 | 56.10 | 0.00 | 0.51 | 0.51 | 0.00 |
| **1999** | 193.79 | 193.79 | 0.00 | 65.28 | 65.28 | 0.00 | 0.59 | 0.59 | 0.00 |
| **2000** | 187.74 | 187.74 | 0.00 | 63.24 | 63.24 | 0.00 | 0.57 | 0.57 | 0.00 |
| **2001** | 190.76 | 190.76 | 0.00 | 64.26 | 64.26 | 0.00 | 0.58 | 0.58 | 0.00 |
| **2002** | 193.79 | 193.79 | 0.00 | 65.28 | 65.28 | 0.00 | 0.59 | 0.59 | 0.00 |
| **2003** | 196.82 | 196.82 | 0.00 | 66.30 | 66.30 | 0.00 | 0.60 | 0.60 | 0.00 |
| **2004** | 205.90 | 205.90 | 0.00 | 69.36 | 69.36 | 0.00 | 0.62 | 0.62 | 0.00 |
| **2005** | 211.96 | 211.96 | 0.00 | 71.40 | 71.40 | 0.00 | 0.64 | 0.64 | 0.00 |
| **2006** | 218.02 | 218.02 | 0.00 | 73.44 | 73.44 | 0.00 | 0.66 | 0.66 | 0.00 |
| **2007** | 233.16 | 233.16 | 0.00 | 78.54 | 78.54 | 0.00 | 0.71 | 0.71 | 0.00 |
| **2008** | 236.18 | 242.24 | 6.06 | 79.56 | 81.60 | 2.04 | 0.72 | 0.74 | 0.02 |
| **2009** | 242.24 | 224.07 | -18.17 | 81.60 | 75.48 | -6.12 | 0.74 | 0.68 | -0.06 |
| **2010** | 230.13 | 233.16 | 3.03 | 77.52 | 78.54 | 1.02 | 0.70 | 0.71 | 0.01 |
| **2011** | 224.07 | 236.18 | 12.11 | 75.48 | 79.56 | 4.08 | 0.68 | 0.72 | 0.04 |
| **2012** | 214.99 | 260.41 | 45.42 | 72.42 | 87.72 | 15.30 | 0.65 | 0.79 | 0.14 |
| **2013** | 208.93 | 269.49 | 60.56 | 70.38 | 90.78 | 20.40 | 0.63 | 0.82 | 0.18 |
| **2014** | 227.10 | 296.75 | 69.64 | 76.50 | 99.96 | 23.46 | 0.69 | 0.90 | 0.21 |

### *3.2.17.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend*

#### d. Recalculations in 1.A.3.b in response to the EU ESD review

The emission factors of $N_2O$ for gasoline PCs and gasoline motorcycles for 2000 – 2014 were changed on the basis of the ESD review held in June 2016,. On the basis of the recommendations, the original country specific EFs were replaced by Tier 1 EFs given in the EMEP/EEA emission inventory guidebook 2016, page 23, table 3-7. See the differences in in tables and figures below.

**Tab. 3-72 EFs $N_2O$ 2000 – 2014 before recalculation**

| Year | Old EFs $N_2O$ (g/kg) | | | |
|---|---|---|---|---|
| | 1.A.3.b.i Gasoline | | | 1.A.3.b.iv Gasoline |
| | conventional | EURO 1 and 2 | EURO 3 and higher | all |
| **2000** | 0.31 | 0.7 | 1.1 | 0.0587 |
| **2001** | 0.31 | 0.7 | 1.1 | 0.0587 |
| **2002** | 0.31 | 0.7 | 1.1 | 0.0587 |
| **2003** | 0.31 | 0.7 | 1.07 | 0.0587 |
| **2004** | 0.31 | 0.7 | 1.03 | 0.0587 |
| **2005** | 0.31 | 0.7 | 1.01 | 0.0587 |
| **2006** | 0.31 | 0.7 | 0.98 | 0.0587 |
| **2007** | 0.31 | 0.7 | 0.95 | 0.0587 |
| **2008** | 0.31 | 0.7 | 0.9 | 0.0587 |
| **2009** | 0.31 | 0.7 | 0.9 | 0.0587 |
| **2010** | 0.31 | 0.7 | 0.9 | 0.0587 |
| **2011** | 0.31 | 0.7 | 0.9 | 0.0587 |
| **2012** | 0.31 | 0.7 | 0.9 | 0.0587 |
| **2013** | 0.31 | 0.7 | 0.9 | 0.0587 |
| **2014** | 0.31 | 0.7 | 0.9 | 0.0587 |

**Tab. 3-73 Efs $N_2O$ 2000 – 2014 after recalculation**

| Year | New EFs $N_2O$ (g/kg) | | | |
|---|---|---|---|---|
| | 1.A.3.b.i Gasoline | | | 1.A.3.b.iv Gasoline |
| | conventional | EURO 1 and 2 | EURO 3 and higher | all |
| **2000** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2001** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2002** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2003** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2004** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2005** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2006** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2007** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2008** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2009** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2010** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2011** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2012** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2013** | 0.206 | 0.206 | 0.206 | 0.059 |
| **2014** | 0.206 | 0.206 | 0.206 | 0.059 |

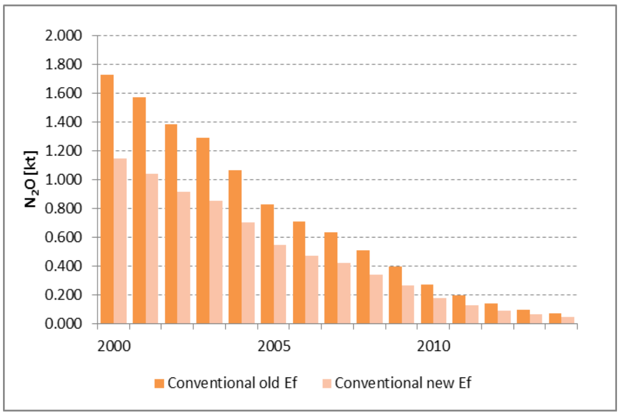



**Fig. 3-27 Comparison of $N_2O$ emissions 2000 – 2014, 1.A.3.b.i Gasoline before and after recalculation for conventional PCs**

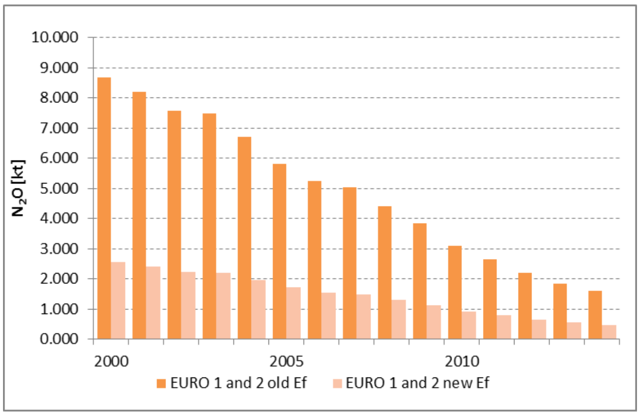



**Fig. 3-27 Comparison of $N_2O$ emissions 2000 – 2014, 1.A.3.b.i Gasoline before and after recalculation for EURO 1 and 2 PCs**

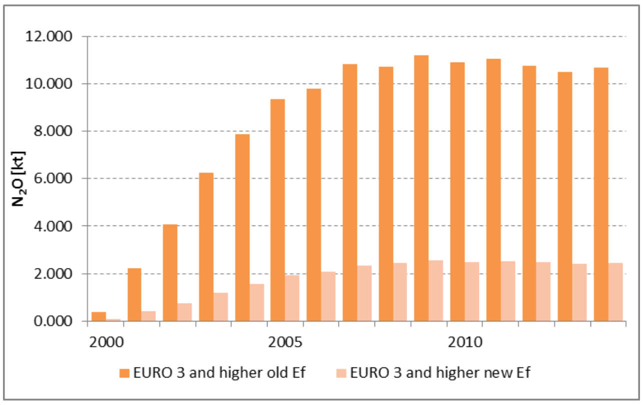



**Fig. 3-27 Comparison of $N_2O$ emissions 2000 – 2014, 1.A.3.b.i Gasoline before and after recalculation for EURO 3 sand higher PCs**

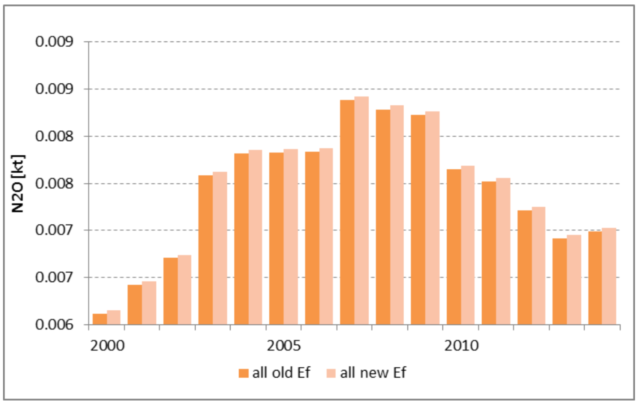



**Fig. 3-27 Comparison of $N_2O$ emissions 2000 – 2014,1.A.3.b.iv Gasoline before and after recalculation for gasoline motorcvcles**

## e. Recalculations in 1.A.3.b due to UNFCCC review

Emission estimates stated in NFR for 2014 was incorrectly copied from Czech model to CRF form in category 1.A.3.b. Road transportation. This mistake concerns $CO_2$, $CH_4$ and $N_2O$ emission estimates for gasoline, diesel oil and gaseous fuels. This mistake resulted in was different fuel consumption and implied EFs for incorrect values for pollutants and fuels mentioned above. For corrected results please see tables below.

**Tab. 3-74 Comparison of original and updated emission estimates**

| Year | Emissions $CO_2$ (kt) | | | | | |
|---|---|---|---|---|---|---|
| | Gasoline | | | Diesel Oil | | |
| | original estimate | revised estimate | difference | original estimate | revised estimate | difference |
| **2014** | 4468.35 | 4480.25 | 11.90 | 11365.04 | 11372.71 | 7.67 |

**Tab. 3-75 Comparison of original and updated emission estimates**

| Year | Emissions $CH_4$ (kt) | | | Emissions $N_2O$ (kt) | | |
|---|---|---|---|---|---|---|
| | Gaseous fuels | | | Gaseous fuels | | |
| | original estimate | revised estimate | difference | original estimate | revised estimate | difference |
| **2014** | 0.0948 | 0.0950 | 0.0002 | 0.00309 | 0.00310 | 0.00001 |

**Tab. 3-76 Comparison of original and updated values of fuel consumption**

| Year | Fuel consumption (TJ) | | | | | |
|---|---|---|---|---|---|---|
| | Gasoline | | | Diesel Oil | | |
| | original value | updated value | difference | original value | updated value | difference |
| **2014** | 64478.33 | 64650.02 | 171.69 | 153374.34 | 153477.87 | 103.53 |

**Tab. 3-77 Comparison of original and updated values of fuel consumption**

| Year | Fuel consumption (TJ) | | |
|---|---|---|---|
| | Gasesous fuels | | |
| | original value | updated value | difference |
| **2014** | 1030.89 | 1032.84 | 1.94 |

**Tab. 3-78 Comparison of implied emissions factors**

| Pollutant | Original IEFs | revised IEFs |
|---|---|---|
| **$CO_2$ Gasoline (t/TJ)** | 69.12 | 69.30 |
| **$CO_2$ Diesel oil(t/TJ)** | 74.05 | 74.05 |
| **$CH_4$ Gaseous fuels(kg/TJ)** | 91.83 | 92.00 |
| **$N_2O$ Gaseous fuels(kg/TJ)** | 2.99 | 3.00 |

#### *3.2.17.6 Source-specific planned improvements, including tracking of those identified in the review process*

The planned improvements are related mainly to performance of projects to measure country-specific emission factors in key categories of road transportation. The greatest emphasis will be placed on acquisition of sufficient data for $CO_2$ and $N_2O$ emission calculations and refinement of methodologies for each category of transport. The next improvement will be to split the activity data for PC and LDT into separate categories and implementing COPERT 5 for conditions in CZ.

## 3.2.18 Other Sectors – Commercial/Institutional (1.A.4.a)

### 3.2.18.1 Category description (CRF 1.A.4.a)

The structure of fuels, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.A.4.a, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Structure of Fuels | Activity data [TJ] | $CO_2$ EF [t $CO_2$/TJ] | $CO_2$ OxF | $CO_2$ Emission [kt] | $CH_4$ EF [kg $CH_4$/TJ] | $CH_4$ Emission [kt] | $N_2O$ EF [kg $N_2O$/TJ] | $N_2O$ Emission [kt] |
| **LPG** | 275.7 | 65.86*) | 1 | 18.15 | 5 | 0.0014 | 0.1 | 0.00003 |
| **Other kerosene** | 128.4 | 71.90 | 1 | 9.23 | 10 | 0.0013 | 0.6 | 0.00008 |
| **Heating and Other Gasoil** | 127.8 | 74.10 | 1 | 9.47 | 10 | 0.0013 | 0.6 | 0.00008 |
| **Fuel Oil - Low Sulphur** | 276.5 | 77.40 | 1 | 21.40 | 10 | 0.0028 | 0.6 | 0.00017 |
| **Fuel Oil - High Sulphur** | 79.0 | 77.40 | 1 | 6.11 | 10 | 0.0008 | 0.6 | 0.00005 |
| **Other Bituminous Coal** | 50.6 | 94.36*) | 0.971*) | 4.64 | 10 | 0.0005 | 1.5 | 0.00008 |
| **Brown Coal + Lignite** | 466.4 | 100.17*) | 0.985*) | 46.00 | 10 | 0.0047 | 1.5 | 0.00070 |
| **Coke** | 143.2 | 107.00 | 1 | 15.32 | 10 | 0.0014 | 1.5 | 0.00021 |
| **Brown Coal Briquets** | 316.7 | 97.50 | 0.985*) | 30.40 | 10 | 0.0032 | 1.5 | 0.00048 |
| **Natural Gas** | 43 668.0 | 55.42*) | 1 | 2 420.09 | 5 | 0.2183 | 0.1 | 0.00437 |
| **Wood/Wood Waste** | 659.0 | 112.00 | 1 | 73.81 | 300 | 0.1977 | 4.0 | 0.00264 |
| **Gaseous Biomass** | 847.0 | 54.60 | 1 | 46.25 | 5 | 0.0042 | 0.1 | 0.00008 |
| **Total year 2015** | **47 038.2** | | | **2 700.87** | | **0.4375** | | **0.00895** |
| **Total year 2014** | 46 983.7 | | | 2 687.93 | | 0.3965 | | 0.00844 |
| **Index 2015/2014** | 1.00 | | | 1.00 | | 1.10 | | 1.06 |
| **Total year 1990** | 121 435.7 | | | 10 023.61 | | 1.0166 | | 0.10207 |
| **Index 2015/1990** | 0.39 | | | 0.27 | | 0.43 | | 0.09 |

*) *Country specific data*

The origin of the data, the emission factors used and the method of calculating the level of emissions for the individual gases are shown in details in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Structure of Fuels | Source of Activity data | Emission factors $CO_2$ | Emission factors $CH_4$ | Emission factors $N_2O$ | Method used $CO_2$ | Method used $CH_4$ | Method used $N_2O$ |
| **LPG** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Other kerosene** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Heating and Other Gasoil** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Fuel Oil - Low Sulphur** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Fuel Oil - High Sulphur** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Other Bituminous Coal** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Brown Coal + Lignite** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Coke** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Brown Coal Briquets** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Waste - fossil fraction** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Gaseous Biomass** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

The whole category 1.A.4 includes emissions which are not included in the 1.A.1 and 1.A.2 categories. They can be generally defined as heat production processes for internal consumption.

The main driving force for $CO_2$ emissions in category 1.A.4 is energy consumption for purposes of space heating. The fluctuations in consumption then can be ascribed to differences in cold winter periods. The trend of decreasing $CO_2$ emissions is a result of higher standards for new buildings and of successful execution of energy-efficiency-oriented modernisations of existing buildings. The trend has also been supported by shifting to fuels with lower $CO_2$ emissions (emission factors). The importance of Solid Fuels at the beginning of the period constantly decreases in time. On the other hand, the consumption of

Natural Gas increased during the period as well as Biomass consumption. Liquid Fuels play a minor role in this category.

$CO_2$ emissions produced in category 1.A.4.a represent in 2015 24% of whole 1.A.4, which is 3% of $CO_2$ emissions from the Energy sector 1.A.

The 1.A.4.a subcategory includes all combustion sources that utilize heat combustion for heating production halls and operational buildings in institutions, commercial facilities, services and trade.

In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in capture Other sectors under the item:

- Commercial and Public Services
- Non-specified (Other)

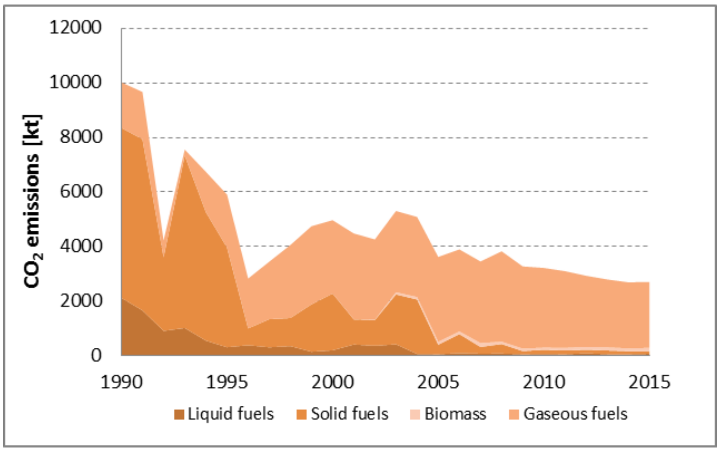



**Fig. 3-28 Development of $CO_2$ emissions in source category 1.A.4.a**

Last point is included under 1.A.4.a Commercial/Institutional on the basis of an agreement with CzSO. There are embodied the fuels of economic part according to NACE Rev. 2 Commercial/Institutional: NACE Divisions 35 excluding 1.A.1.a and 1.A.3.e, 36 – 39, 45 – 99 excluding 1.A.3.e and 1.A.5.a.

The graph (Fig. 3-28) shows that at the beginning of the period in the subsector 1.A.4.a predominated the consumption of fossil fuels, which was coupled with liquid fuels, and gradually substituted primarily with natural gas. The share of biofuels in this subsector is a minority. The overall decrease in fuel consumption is about 50%, which resulted in a decrease in $CO_2$ emissions by about 65%. Higher decrease in emissions than the one in the fuel consumption is determined by the changes in the structure of fuels in favour of natural gas.

Outlier values in the fuel consumption are apparent at the beginning of the time series. This unusual trend will be the subject of detailed revision of the activity data. This aspect is also included in the Improvement plan.

### *3.2.18.2 Methodological issues (CRF 1.A.4.a)*

During processing data for the subsector 1.A.4.a among the used fuels are also included fuels, which are in the questionnaires of CzSO, listed in section "Transport sector". The amounts of these fossil fuels is given in Tab. 3-79 in TJ.

**Tab. 3-79 Quantities of fuels used in the sector transport in stationary sources**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TJ/year | 12.7 | 35.2 | 33.7 | 35.9 | 12.4 | 12.5 | 12.2 | 12.3 | 12.5 | 37.3 | 37.3 | 12.7 | 35.2 | 33.7 |

According to the communication to CzSO, this is a fuel for heating the buildings of the state-owned company Czech Railways and that is why its combustion was situated in the subsector 1.A.4.a. This is the consumption of bituminous coal, lignite and coke oven coke worth 1-2 kt per year. The amount of these fuels in the total balance of 1.A.4.a virtually has no effect.

No other sector-specific methodological issues are applied, the general issues are given in chapter 3.2.4.

### 3.2.18.3 Uncertainties and time-series consistency (CRF 1.A.4.a)

See chapter 3.2.5.

### 3.2.18.4 Category-specific QA/QC and verification (CRF 1.A.4.a)

See chapter 3.2.6.

### 3.2.18.5 Category-specific recalculations (CRF 1.A.4.a)

Quite extensive updates were provided in activity data by CzSO, which resulted in recalculation of this category.

**Tab. 3-80 Changes after recalculation in 1.A.4.a for Liquid Fuels**

| Fuel consumption | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 930.5 | 628.2 | 634.2 | 591.1 | 600.7 | 548.4 | 555.4 |
| **Submission 2017** | TJ | 1 022.4 | 674.1 | 756.7 | 683.0 | 1 146.1 | 725.7 | 699.7 |
| **Difference** | TJ | 91.9 | 45.9 | 122.4 | 91.9 | 545.4 | 177.3 | 144.3 |
| | % | 9.9 | 7.3 | 19.3 | 15.5 | 90.8 | 32.3 | 26.0 |
| $CO_2$ emission | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 68.38 | 46.70 | 46.73 | 43.53 | 43.35 | 39.96 | 39.73 |
| **Submission 2017** | kt | 74.43 | 49.72 | 55.82 | 49.58 | 82.91 | 52.09 | 48.77 |
| **Difference** | kt | 6.05 | 3.03 | 9.09 | 6.05 | 39.56 | 12.13 | 9.05 |
| | % | 8.9 | 6.5 | 19.4 | 13.9 | 91.2 | 30.4 | 22.8 |
| $CH_4$ emission | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0088 | 0.0063 | 0.0061 | 0.0057 | 0.0053 | 0.0048 | 0.0044 |
| **Submission 2017** | kt | 0.0093 | 0.0065 | 0.0071 | 0.0061 | 0.0096 | 0.0059 | 0.0049 |
| **Difference** | kt | 0.0005 | 0.0002 | 0.0010 | 0.0005 | 0.0043 | 0.0011 | 0.0005 |
| | % | 5.2 | 3.7 | 16.3 | 8.1 | 81.0 | 22.6 | 11.9 |
| $N_2O$ emission | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.000512 | 0.000377 | 0.000358 | 0.000332 | 0.000292 | 0.000260 | 0.000218 |
| **Submission 2017** | kt | 0.000522 | 0.000382 | 0.000408 | 0.000341 | 0.000504 | 0.000298 | 0.000213 |
| **Difference** | kt | 0.000009 | 0.000005 | 0.000050 | 0.000009 | 0.000212 | 0.000037 | -0.000005 |
| | % | 1.8 | 1.2 | 14.1 | 2.8 | 72.8 | 14.4 | -2.4 |

**Tab. 3-81 Changes after recalculation in 1.A.4.a for Solid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 1 541.2 | 1 210.5 | 1 306.0 | 1 583.1 | 735.2 |
| **Submission 2017** | TJ | 1 597.7 | 1 375.8 | 1 324.7 | 1 380.8 | 1 110.6 |
| **Difference** | TJ | 56.6 | 165.3 | 18.7 | -202.3 | 375.4 |
| | % | 3.7 | 13.7 | 1.43 | -12.8 | 51.1 |
| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 150.925 | 119.805 | 128.918 | 155.165 | 73.495 |
| **Submission 2017** | kt | 156.987 | 135.881 | 130.440 | 135.132 | 109.640 |
| **Difference** | kt | 6.061 | 16.076 | 1.522 | -20.033 | 36.144 |
| | % | 4.0 | 13.4 | 1.18 | -12.9 | 49.2 |
| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0154 | 0.0121 | 0.0131 | 0.0158 | 0.0074 |
| **Submission 2017** | kt | 0.0160 | 0.0138 | 0.0132 | 0.0138 | 0.0111 |
| **Difference** | kt | 0.0006 | 0.0017 | 0.0002 | -0.0020 | 0.0038 |
| | % | 3.7 | 13.7 | 1.43 | -12.8 | 51.1 |
| $N_2O$ emission *) | | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.0022 | 0.0017 | 0.0018 | 0.0022 | 0.0010 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Submission 2017** | kt | 0.0024 | 0.0021 | 0.0020 | 0.0021 | 0.0017 |
| **Difference** | kt | 0.00024 | 0.00037 | 0.00016 | -0.00015 | 0.00064 |
| | % | 11.1 | 21.8 | 8.7 | -6.5 | 61.8 |

*)combination of change in activity data and change in $N_2O$ emission factor (ERT recommendation 2016)

**Tab. 3-82 Changes after recalculation in 1.A.4.a for Natural Gas**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| **Submission 2016** | TJ | 60 378.4 | 56 949.1 | 52 437.1 | 53 338.9 |
| **Submission 2017** | TJ | 52 904.9 | 50 898.9 | 47 280.2 | 45 087.8 |
| **Difference** | TJ | -7 473.6 | -6 050.2 | -5 157.0 | -8 251.2 |
| | % | -12.4 | -10.6 | -9.8 | -15.5 |
| **$CO_2$ emission** | | **2010** | **2011** | **2012** | **2013** |
| **Submission 2016** | kt | 3 338.1 | 3 147.0 | 2 894.6 | 2 949.7 |
| **Submission 2017** | kt | 2 925.0 | 2 812.7 | 2 609.9 | 2 493.4 |
| **Difference** | kt | -413.2 | -334.3 | -284.7 | -456.3 |
| | % | -12.4 | -10.6 | -9.8 | -15.5 |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** |
| **Submission 2016** | kt | 0.3019 | 0.2847 | 0.2622 | 0.2667 |
| **Submission 2017** | kt | 0.2645 | 0.2545 | 0.2364 | 0.2254 |
| **Difference** | kt | -0.0374 | -0.0303 | -0.0258 | -0.0413 |
| | % | -12.4 | -10.6 | -9.8 | -15.5 |
| **$N_2O$ emission** | | **2010** | **2011** | **2012** | **2013** |
| **Submission 2016** | kt | 0.0060 | 0.0057 | 0.0052 | 0.0053 |
| **Submission 2017** | kt | 0.0053 | 0.0051 | 0.0047 | 0.0045 |
| **Difference** | kt | -0.0007 | -0.0006 | -0.0005 | -0.0008 |
| | % | -12.4 | -10.6 | -9.8 | -15.5 |

Further, following the recommendation of ERT $N_2O$ emission factor was updated to 1.5 kg $N_2O$/TJ for solid fuels, which caused increase in $N_2O$ emissions by 7.14%.

**Tab. 3-83 Changes after update of $N_2O$ emission factor in 1.A.4.a**

| $N_2O$ emission | | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.0771 | 0.0448 | 0.0296 | 0.0049 | 0.0022 | 0.0017 | 0.0018 | 0.0022 | 0.0010 |
| **Submission 2017** | kt | 0.0825 | 0.0479 | 0.0317 | 0.0053 | 0.0024 | 0.0021 | 0.0020 | 0.0021 | 0.0017 |
| **Difference** | kt | 0.0054 | 0.0032 | 0.0021 | 0.0004 | 0.0002 | 0.0004 | 0.0002 | -0.0001 | 0.0006 |
| | % | 7.1 | 7.1 | 7.1 | 7.1 | 11.1 | 21.8 | 8.7 | -6.5 | 61.8 |

### *3.2.18.6 Category-specific planned improvements (CRF 1.A.4.a)*

Detailed research of data at the beginning of 90s is planned for the future submissions.

## 3.2.19 Other Sectors – Residential (1.A.4.b)

### *3.2.19.1 Category description (CRF 1.A.4.b)*

The structure of fuels, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.A.4.b, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity** | **$CO_2$** | | | **$CH_4$** | | **$N_2O$** | |
| | **data** | **EF** | **OxF** | **Emission** | **EF** | **Emission** | **EF** | **Emission** |
| | **[TJ]** | **[t $CO_2$/TJ]** | | **[kt]** | **[kg $CH_4$/TJ]** | **[kt]** | **[kg $N_2O$/TJ]** | **[kt]** |
| **LPG** | 1 975.7 | 65.9 | 1 | 130.1 | 5 | 0.0099 | 0.1 | 0.0002 |
| **Other Bituminous Coal** | 8 710.1 | 94.4*) | 0.971*) | 797.8 | 300 | 2.6130 | 1.5 | 0.0131 |
| **Brown Coal + Lignite** | 18 013.0 | 100.2*) | 0.985*) | 1776.6 | 300 | 5.4039 | 1.5 | 0.0270 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Coke** | 916.4 | 107.0 | 1 | 98.1 | 300 | 0.2749 | 1.5 | 0.0014 |
| **Brown Coal Briquets** | 2 434.5 | 97.5 | 0.985*) | 233.7 | 300 | 0.7304 | 1.5 | 0.0037 |
| **Natural Gas** | 75 087.3 | 55.4*) | 1 | 4161.4 | 5 | 0.3754 | 0.1 | 0.0075 |
| **Wood/Wood Waste** | 73 398.0 | 112.0 | 1 | 8220.6 | 300 | 22.0194 | 4.0 | 0.2936 |
| **Charcoal** | 710.4 | 112.0 | 1 | 79.6 | 200 | 0.1421 | 1.0 | 0.0007 |
| **Total year 2015** | **181 245.4** | | | **15497.7** | | **31.5690** | | **0.3471** |
| **Total year 2014** | 173 761.5 | | | 15012.5 | | 31.1133 | | 0.3416 |
| **Index 2015/2014** | 1.04 | | | 1.03 | | 1.01 | | 1.02 |
| **Total year 1990** | 222 730.7 | | | 20 682.1 | | 51.8513 | | 0.3710 |
| **Index 2015/1990** | 0.81 | | | 0.75 | | 0.61 | | 0.94 |

*) *Country specific data*

The origin of the data, the emission factors used and the method of calculating the level of emissions for the individual gases are shown in details in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Source for** | **Emission factors** | | | **Method used** | | |
| | **Activity data** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **LPG** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Other Bituminous Coal** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Brown Coal + Lignite** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Coke** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Brown Coal Briquets** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Wood/Wood Waste** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Charcoal** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

Fuel consumption in households is determined on the basis of the results of the statistical study "Energy consumption in households", published in 1997 and 2004 by the Czech Statistical Office according to the PHARE/EUROSTAT method.

In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in capture Other Sector under the item:

Residential

The fraction of $CO_2$ emissions in subsector 1.A.4.b in $CO_2$ emissions in sector 1.A.4 equalled 66% in 2014. It contributed 8% to $CO_2$ emissions in the whole Energy sector 1.A.

At the beginning of the period, a majority of households in the Czech Republic used coal as a heating fuel (mainly brown coal + lignite). This habit has changed over time and Natural Gas began to be used more than Solid Fuels. The same trend appears in the institutional sphere. The number of households using biomass for heating (biomass boilers) in the Czech Republic has increased in the last few years. This trend is also apparent in the Fig. 3-29.

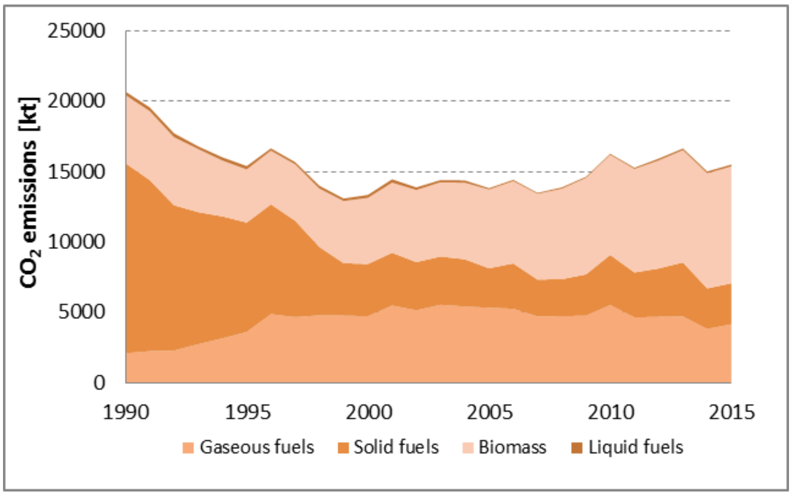



**Fig. 3-29 Development of $CO_2$ emissions in source category 1.A.4.b**

The graph shows that at the beginning of the period in the subsector 1.A.4.b dominated consumption of fossil fuels, which have been gradually substituted primarily by natural gas, but also biofuels (in the case of households, it is mainly firewood). The share of liquid fuels (LPG) is negligible. Small annual fluctuations in fuel consumption are to be attributed to the average annual temperatures. Throughout the sector Residential, a slight decrease can be observed in fuel consumption, which was affected by the replacement of old boilers with more modern with higher efficiency and most importantly building insulations, which is controlled by the national programs "Green Savings". Increasing share of biomass has a positive effect on reducing $CO_2$ emissions, which are included in total greenhouse gas emissions. While the total fuel consumption declines in this subsector generally slightly (only about 20%), $CO_2$ emissions from the combustion of fossil fuels decreased by about 50%.

### 3.2.19.2 Methodological issues (CRF 1.A.4.b)

No specific methodological approaches were applied - general approaches are given in section 3.2.4.

### 3.2.19.3 Uncertainties and time-series consistency (CRF 1.A.4.b)

See chapter 3.2.5.

### 3.2.19.4 Category-specific QA/QC and verification (CRF 1.A.4.b)

See chapter 3.2.6.

### 3.2.19.5 Category-specific recalculations (CRF 1.A.4.b)

Quite extensive updates were provided in activity data by CzSO, which resulted in recalculation of this category.

**Tab. 3-84 Changes after recalculation in 1.A.4.b for Liquid Fuels**

| Fuel consumption | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 781.1 | 275.7 | 183.8 | 183.8 | 183.8 | 183.8 | 183.8 |
| **Submission 2017** | TJ | 1 424.3 | 1 194.6 | 1 056.7 | 1 378.4 | 1 929.7 | 1 700.0 | 1 975.7 |
| **Difference** | TJ | 643.2 | 918.9 | 873.0 | 1 194.6 | 1 745.9 | 1 516.2 | 1 791.9 |
| | % | 82.4 | 333.3 | 475.0 | 650.0 | 950.0 | 825.0 | 975.0 |
| | | | | | | | | |
| **$CO_2$ emission** | | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 51.439 | 18.155 | 12.103 | 12.103 | 12.103 | 12.103 | 12.103 |
| **Submission 2017** | kt | 93.800 | 78.671 | 69.594 | 90.774 | 127.084 | 111.955 | 130.110 |
| **Difference** | kt | 42.361 | 60.516 | 57.490 | 78.671 | 114.981 | 99.852 | 118.007 |
| | % | 82.4 | 333.3 | 475.0 | 650.0 | 950.0 | 825.0 | 975.0 |
| | | | | | | | | |
| **$CH_4$ emission** | | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.00391 | 0.00138 | 0.00092 | 0.00092 | 0.00092 | 0.00092 | 0.00092 |
| **Submission 2017** | kt | 0.00712 | 0.00597 | 0.00528 | 0.00689 | 0.00965 | 0.00850 | 0.00988 |
| **Difference** | kt | 0.00322 | 0.00459 | 0.00436 | 0.00597 | 0.00873 | 0.00758 | 0.00896 |
| | % | 82.4 | 333.3 | 475.0 | 650.0 | 950.0 | 825.0 | 975.0 |
| | | | | | | | | |
| **$N_2O$ emission** | | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.00008 | 0.00003 | 0.00002 | 0.00002 | 0.00002 | 0.00002 | 0.00002 |
| **Submission 2017** | kt | 0.00014 | 0.00012 | 0.00011 | 0.00014 | 0.00019 | 0.00017 | 0.00020 |
| **Difference** | kt | 0.00006 | 0.00009 | 0.00009 | 0.00012 | 0.00017 | 0.00015 | 0.00018 |
| | % | 82.4 | 333.3 | 475.0 | 650.0 | 950.0 | 825.0 | 975.0 |

**Tab. 3-85 Changes after recalculation in 1.A.4.b for Solid Fuels**

| Fuel consumption | | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 22 516 | 22 783 | 26 063 | 26 213 | 25 542 | 26 120 | 29 602 | 21 661 |
| **Submission 2017** | TJ | 26 884 | 27 010 | 30 276 | 37 015 | 32 852 | 35 645 | 40 164 | 29 774 |
| **Difference** | TJ | 4 368 | 4 226 | 4 213 | 10 801 | 7 310 | 9 525 | 10 561 | 8 113 |
| | % | 19.4 | 18.6 | 16.2 | 41.2 | 28.6 | 36.5 | 35.7 | 37.5 |

| $CO_2$ emission | | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 2 193.7 | 2 211.6 | 2 524.4 | 2 536.7 | 2 494.4 | 2 537.7 | 2 849.8 | 2 121.2 |
| **Submission 2017** | kt | 2 621.1 | 2 623.4 | 2 933.7 | 3 556.4 | 3 193.0 | 3 435.3 | 3 842.0 | 2 887.0 |
| **Difference** | kt | 427.3 | 411.8 | 409.3 | 1 019.7 | 698.6 | 897.6 | 992.2 | 765.8 |
| | % | 19.5 | 18.6 | 16.2 | 40.2 | 28.0 | 35.4 | 34.8 | 36.1 |
| **$CH_4$ emission** | | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 6.755 | 6.835 | 7.819 | 7.864 | 7.663 | 7.836 | 8.881 | 6.498 |
| **Submission 2017** | kt | 8.065 | 8.103 | 9.083 | 11.104 | 9.856 | 10.693 | 12.049 | 8.932 |
| **Difference** | kt | 1.310 | 1.268 | 1.264 | 3.240 | 2.193 | 2.857 | 3.168 | 2.434 |
| | % | 19.4 | 18.6 | 16.2 | 41.2 | 28.6 | 36.5 | 35.7 | 37.5 |
| **$N_2O$ emission *)** | | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Submission 2016** | kt | 0.0315 | 0.0319 | 0.0365 | 0.0367 | 0.0358 | 0.0366 | 0.0414 | 0.0303 |
| **Submission 2017** | kt | 0.0403 | 0.0405 | 0.0454 | 0.0555 | 0.0493 | 0.0535 | 0.0602 | 0.0447 |
| **Difference** | kt | 0.0088 | 0.0086 | 0.0089 | 0.0188 | 0.0135 | 0.0169 | 0.0188 | 0.0143 |
| | % | 27.9 | 27.0 | 24.5 | 51.3 | 37.8 | 46.2 | 45.4 | 47.3 |

**)combination of change in activity data and change in $N_2O$ emission factor (ERT recommendation 2016)*

**Tab. 3-86 Changes of activity data, recalculation in 1.A.4.b for Biomass**

| Fuel consumption | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 33 929 | 26 896 | 23 360 | 22 193 | 25 214 | 24 004 | 25 193 | 24 886 | 28 321 | 28 874 |
| **Submission 2017** | TJ | 43 259 | 43 705 | 43 176 | 39 995 | 35 439 | 33 677 | 34 034 | 35 733 | 37 056 | 39 424 |
| **Difference** | TJ | 9 330 | 16 809 | 19 816 | 17 802 | 10 225 | 9 673 | 8 841 | 10 847 | 8 735 | 10 550 |
| | % | 27.5 | 62.5 | 84.83 | 80.2 | 40.55 | 40.3 | 35.09 | 43.6 | 30.84 | 36.5 |
| | | | | | | | | | | | |
| **$CO_2$ emission** | | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** |
| **Submission 2016** | kt | 3 800.0 | 3 012.4 | 2 616.3 | 2 485.6 | 2 824.0 | 2 688.4 | 2 821.6 | 2 787.2 | 3 172.0 | 3 233.9 |
| **Submission 2017** | kt | 4 845.0 | 4 895.0 | 4 835.7 | 4 479.4 | 3 969.2 | 3 771.8 | 3 811.8 | 4 002.1 | 4 150.3 | 4 415.5 |
| **Difference** | kt | 1 045.0 | 1 882.6 | 2 219.4 | 1 993.8 | 1 145.2 | 1 083.4 | 990.2 | 1 214.9 | 978.3 | 1 181.6 |
| | % | 27.5 | 62.5 | 84.83 | 80.2 | 40.55 | 40.3 | 35.09 | 43.6 | 30.84 | 36.5 |
| | | | | | | | | | | | |
| **$CH_4$ emission** | | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** |
| **Submission 2016** | kt | 10.171 | 8.063 | 7.003 | 6.654 | 7.562 | 7.200 | 7.557 | 7.465 | 8.493 | 8.656 |
| **Submission 2017** | kt | 12.970 | 13.105 | 12.948 | 11.995 | 10.629 | 10.102 | 10.209 | 10.719 | 11.113 | 11.821 |
| **Difference** | kt | 2.799 | 5.043 | 5.945 | 5.341 | 3.068 | 2.902 | 2.652 | 3.254 | 2.621 | 3.165 |
| | % | 27.5 | 62.5 | 84.89 | 80.3 | 40.57 | 40.3 | 35.10 | 43.6 | 30.86 | 36.6 |
| | | | | | | | | | | | |
| **$N_2O$ emission** | | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** |
| **Submission 2016** | kt | 0.135 | 0.107 | 0.093 | 0.089 | 0.101 | 0.096 | 0.101 | 0.100 | 0.113 | 0.115 |
| **Submission 2017** | kt | 0.173 | 0.175 | 0.173 | 0.160 | 0.142 | 0.135 | 0.136 | 0.143 | 0.148 | 0.158 |
| **Difference** | kt | 0.037 | 0.067 | 0.079 | 0.071 | 0.041 | 0.039 | 0.035 | 0.043 | 0.035 | 0.042 |
| | % | 27.5 | 62.6 | 84.97 | 80.3 | 40.58 | 40.3 | 35.11 | 43.6 | 30.87 | 36.6 |
| **Fuel consumption** | | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| **Submission 2016** | TJ | 30 501 | 33 605 | 29 596 | 34 645 | 36 936 | 37 289 | 40 378 | 46 906 | 44 449 | 43 794 |
| **Submission 2017** | TJ | 41 947 | 44 477 | 45 786 | 47 103 | 48 574 | 50 019 | 52 223 | 54 386 | 57 380 | 61 217 |
| **Difference** | TJ | 11 446 | 10 872 | 16 190 | 12 458 | 11 638 | 12 730 | 11 845 | 7 480 | 12 931 | 17 423 |
| | % | 37.53 | 32.4 | 54.70 | 36.0 | 31.51 | 34.1 | 29.34 | 15.9 | 29.09 | 39.8 |
| | | | | | | | | | | | |
| **$CO_2$ emission** | | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| **Submission 2016** | kt | 3 416.1 | 3 763.8 | 3 314.8 | 3 880.2 | 4 136.8 | 4 176.4 | 4 522.3 | 5 253.5 | 4 978.3 | 4 904.9 |
| **Submission 2017** | kt | 4 698.1 | 4 981.4 | 5 128.0 | 5 275.5 | 5 440.3 | 5 602.1 | 5 849.0 | 6 091.2 | 6 426.5 | 6 856.3 |
| **Difference** | kt | 1 282.0 | 1 217.7 | 1 813.3 | 1 395.3 | 1 303.5 | 1 425.8 | 1 326.6 | 837.8 | 1 448.3 | 1 951.4 |
| | % | 37.53 | 32.4 | 54.70 | 36.0 | 31.51 | 34.1 | 29.34 | 15.9 | 29.09 | 39.8 |
| | | | | | | | | | | | |
| **$CH_4$ emission** | | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| **Submission 2016** | kt | 9.144 | 10.073 | 8.870 | 10.379 | 11.063 | 11.166 | 12.089 | 14.042 | 13.306 | 13.108 |
| **Submission 2017** | kt | 12.578 | 13.335 | 13.727 | 14.116 | 14.554 | 14.985 | 15.643 | 16.286 | 17.186 | 18.335 |
| **Difference** | kt | 3.434 | 3.262 | 4.857 | 3.737 | 3.491 | 3.819 | 3.554 | 2.244 | 3.879 | 5.227 |
| | % | 37.55 | 32.4 | 54.76 | 36.0 | 31.56 | 34.2 | 29.39 | 16.0 | 29.15 | 39.9 |

| $N_2O$ emission | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.122 | 0.134 | 0.118 | 0.138 | 0.147 | 0.149 | 0.161 | 0.187 | 0.177 | 0.174 |
| **Submission 2017** | kt | 0.168 | 0.178 | 0.183 | 0.188 | 0.194 | 0.199 | 0.208 | 0.217 | 0.229 | 0.244 |
| **Difference** | kt | 0.046 | 0.043 | 0.065 | 0.050 | 0.047 | 0.051 | 0.047 | 0.030 | 0.052 | 0.070 |
| | % | 37.58 | 32.4 | 54.83 | 36.1 | 31.62 | 34.3 | 29.47 | 16.0 | 29.23 | 40.0 |

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 48 879 | 46 728 | 48 183 | 51 094 | 50 348 |
| **Submission 2017** | TJ | 63 528 | 65 656 | 68 508 | 71 242 | 72 990 |
| **Difference** | TJ | 14 649 | 18 928 | 20 325 | 20 148 | 22 642 |
| | % | 29.97 | 40.5 | 42.18 | 39.4 | 44.97 |

| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 5 474.5 | 5 233.5 | 5 396.5 | 5 722.5 | 5 639.0 |
| **Submission 2017** | kt | 7 115.2 | 7 353.5 | 7 672.9 | 7 979.1 | 8 174.9 |
| **Difference** | kt | 1 640.7 | 2 120.0 | 2 276.4 | 2 256.5 | 2 535.9 |
| | % | 29.97 | 40.5 | 42.18 | 39.4 | 44.97 |

| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 14.624 | 13.978 | 14.412 | 15.285 | 15.033 |
| **Submission 2017** | kt | 19.024 | 19.639 | 20.487 | 21.310 | 21.826 |
| **Difference** | kt | 4.399 | 5.661 | 6.076 | 6.025 | 6.793 |
| | % | 30.08 | 40.5 | 42.16 | 39.4 | 45.18 |

| $N_2O$ emission | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.194 | 0.186 | 0.191 | 0.203 | 0.199 |
| **Submission 2017** | kt | 0.253 | 0.261 | 0.272 | 0.283 | 0.290 |
| **Difference** | kt | 0.059 | 0.075 | 0.081 | 0.080 | 0.091 |
| | % | 30.22 | 40.5 | 42.12 | 39.4 | 45.45 |

Further, following the recommendation of ERT $N_2O$ emission factor was updated to 1.5 kg $N_2O$/TJ for solid fuels, which caused increase in $N_2O$ emissions by 7.14%.

**Tab. 3-87 Changes after update of $N_2O$ emission factor in 1.A.4.b**

| $N_2O$ emission | | 1990 | 1995 | 2000 | 2005 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.181 | 0.104 | 0.053 | 0.040 | 0.032 | 0.032 | 0.036 | 0.037 | 0.036 | 0.037 | 0.041 | 0.030 |
| **Submission 2017** | kt | 0.194 | 0.112 | 0.057 | 0.043 | 0.040 | 0.041 | 0.045 | 0.056 | 0.049 | 0.053 | 0.060 | 0.045 |
| **Difference** | kt | 0.013 | 0.007 | 0.004 | 0.003 | 0.009 | 0.009 | 0.009 | 0.019 | 0.014 | 0.017 | 0.019 | 0.014 |
| | % | 7.1 | 7.1 | 7.1 | 7.1 | 27.9 | 27.0 | 24.5 | 51.3 | 37.8 | 46.2 | 45.4 | 47.3 |

#### *3.2.19.6 Category-specific planned improvements (CRF 1.A.4.b)*

Currently there are no planned improvements in this category.

### 3.2.20 Other Sectors – Agriculture/Forestry/Fishing (1.A.4.c)

The subsector is further divided into:

- Stationary sources – 1.A.4.c.i
- Off-road Vehicles and Other Machinery – 1.A.4.c.ii

The structure of the fuels throughout the subsector 1.A.4.c, their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.A.4.c, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity data [TJ]** | **$CO_2$ EF [t $CO_2$/TJ]** | **OxF** | **Emission [kt]** | **$CH_4$ EF [kg $CH_4$/TJ]** | **Emission [kt]** | **$N_2O$ EF [kg $N_2O$/TJ]** | **Emission [kt]** |
| **LPG** | 183.8 | 65.86*) | 1 | 12.10 | 5.0 | 0.0009 | 0.1 | 0.00002 |
| **Gasoline** | 266.9 | 69.30 | 1 | 18.50 | 6.90*) | 0.0018 | 19.27*) | 0.00514 |
| **Diesel Oil** | 13 570.0 | 74.10 | 1 | 1005.54 | 5.43*) | 0.0737 | 4.94*) | 0.06703 |
| **Fuel Oil - Low Sulphur** | 118.5 | 77.40 | 1 | 9.17 | 10 | 0.0012 | 0.6 | 0.00007 |
| **Other Bituminous Coal** | 50.6 | 94.36*) | 0.97*) | 4.64 | 300 | 0.0152 | 1.5 | 0.00008 |
| **Brown Coal + Lignite** | 239.8 | 100.17*) | 0.98*) | 23.65 | 300 | 0.0720 | 1.5 | 0.00036 |
| **Coke** | 28.6 | 107.00 | 1 | 3.06 | 300 | 0.0086 | 1.5 | 0.00004 |
| **Natural Gas** | 2 079.2 | 55.42*) | 1 | 115.23 | 5 | 0.0104 | 0.1 | 0.00021 |
| **Wood/Wood Waste** | 366.0 | 112.00 | 1 | 40.99 | 300 | 0.1098 | 4.0 | 0.00146 |
| **Gaseous Biomass** | 4 805.0 | 54.60 | 1 | 262.35 | 5 | 0.0240 | 0.1 | 0.00048 |
| **Total year 2015** | **21 708.5** | | | **1 495.24** | | **0.3176** | | **0.07489** |
| **Total year 2014** | 22 316.8 | | | 1 536.44 | | 0.3218 | | 0.07677 |
| **Index 2015/2014** | 0.97 | | | 0.97 | | 0.99 | | 0.98 |
| **Total year 1990** | 47 622.9 | | | 3 790.22 | | 5.4137 | | 0.08558 |
| **Index 2015/1990** | 0.46 | | | 0.39 | | 0.06 | | 0.88 |

*) *Country specific data*

The high emissions of $CH_4$ in 1990 is mainly due to the high consumption of other bituminous coal and lignite in the early periods, that have high emission factors (300 kg $CH_4$/TJ) compared to other fuels. At the end of the period there was a significant decrease in the consumption of solid fossil fuels.

The origin of the data, the emission factors used and the method of calculating the level of emissions for each gas is detailed in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Source for** | **Emission factors** | | | **Method used** | | |
| | **Activity data** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **LPG** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Gasoline** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Diesel Oil** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Fuel Oil - Low Sulphur** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Other Bituminous Coal** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Brown Coal + Lignite** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Coke** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Natural Gas** | CzSO | CS | D | D | Tier 2 | Tier 1 | Tier 1 |
| **Wood/Wood Waste** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |
| **Gaseous Biomass** | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

This subcategory includes both combustion at stationary sources for heating buildings, breeding and cultivation halls and other operational facilities. These are areas from the agriculture (crop and livestock production), forest and fishing. In rural areas is also about the very energy-intensive operations, such as greenhouses, drying grain and hops.

Unlike previous submission, here are presented also the off-road means of transport and machinery. In accordance with the IPCC 2006 Gl., data on fuel consumption and emission data are divided into two subcategories, as mentioned above. In rural areas is mainly about fuel consumption for land cultivation and harvesting mechanisms, in forestry are mainly mining mechanisms. The fishing area has minor importance in the Czech Republic and is concentrated almost exclusively on fish farming.

In the CzSO Questionnaire (CzSO, 2016), the consumption of the individual kinds of fuels in this sector is reported in capture Industry Sector under the item:

- Agriculture/Forestry
- Fishing

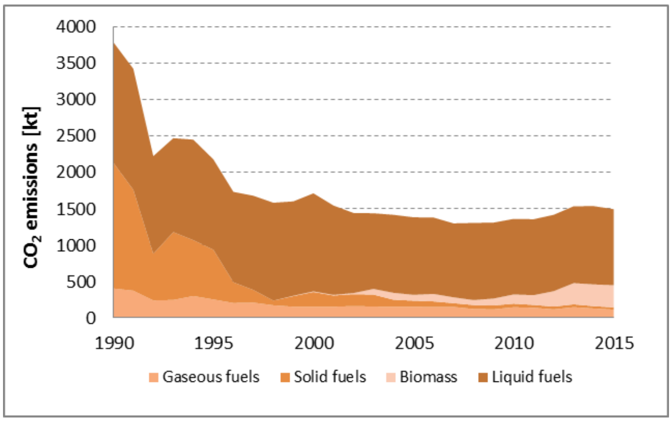



**Fig. 3-30 Development of $CO_2$ emissions in source category 1.A.4.c**

The distribution of fuels is done according to their nature - motor fuels are allocated to the subcategory 1.A.4.c.ii, all other fuels -into subcategory 1.A.4.c.i. This division is subsequently agreed annually with the CzSO during mutual consultation.

There are embodied the fuels of economic part according to NACE Rev. 2 Agriculture/Forestry/Fisheries: NACE Divisions 01 – 03.

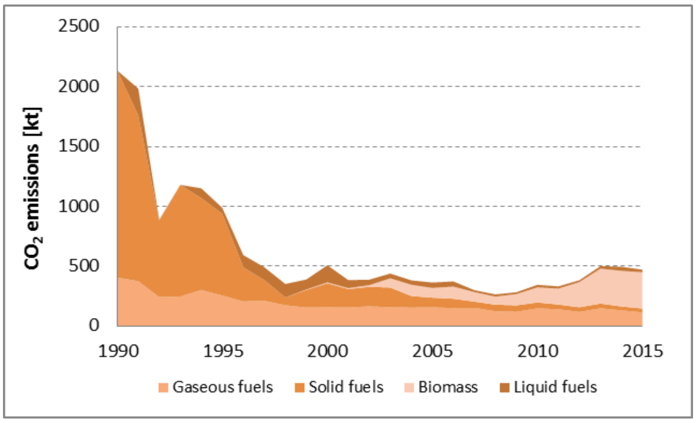



**Fig. 3-31 Development of $CO_2$ emissions in source category 1.A.4.c.i**

The fraction of $CO_2$ emissions in subsector 1.A.4.c in $CO_2$ emissions in sector 1.A.4 equalled 10% in 2015. It contributed 1.3% to $CO_2$ emissions in the whole Energy sector.

Development of fuel consumption and the corresponding $CO_2$ emissions throughout the subcategory 1.A.4.c are visible on Fig. 3-30.

From the graph on Fig. 3-30 is evident, that the stake in the entire subsector and in the overall period is for the liquid fuel (as it will be shown later, it is mainly about propellant fuel). At the beginning of the period a significant share is for the fossil fuels, but their consumption during the entire period declines due to the cancelation of the inefficient ways of heating of buildings and process plants. Biofuels are increasingly used until the end of the period.

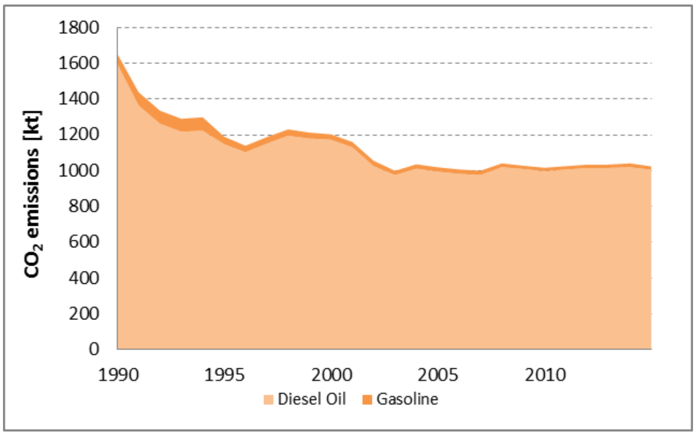



**Fig. 3-32 Development of $CO_2$ emissions in source category 1.A.4.c.ii**

In the next chart is shown the fuel consumption and the corresponding $CO_2$ emissions of only stationary sources and in the following graphs (Fig. 3-31, Fig. 3-32) are represented the consumption of fuels in off-road transportation and other mechanisms in the agriculture, forestry and fisheries.

In the stationary sources decreased decisively consumption of fossil solid and liquid fuels. The role of natural gas throughout the period was virtually stable and at the end of the period is evident an increased use of biofuels, especially biogas, produced in the biogas stations, built on individual agricultural farms.

To the mobile sources and other mechanisms are to a large extent attributed the consumption of diesel fuels, motor gasoline has minor importance, other fuels are virtually absent. During the period, a noticeable decrease in fuel consumption roughly in the first half of the period is observed, which was caused by higher technical level of engines and especially a decline in demand in all subsectors for agricultural products.

#### 3.2.20.1 Methodological issues (CRF 1.A.4.c)

The basic requirement for processing fuel consumption from mobile sources is their division between subsectors 1.A.3 Transport, 1.A.4.c.ii Off-road vehicles and other machinery and 1.A.5 Other. This distribution is done in coordination with CDV. The aim is that no fuel is included in the balance twice, nor that any fuel is omitted. Therefore, the following distribution is performed:

Motor fuels, which are consumed in the subsector 1.A.4.c.ii are used only for off-road vehicles and other mechanisms.

Motor fuels, which are consumed in the subsector 1.A.5 are allocated to 1.A.3. This is the fuel consumption of the army (transport on and off road, kerosene jet fuel consumption for air transport), and consumption in the fields of construction, extraction of fuels and minerals, industry (only areal transport). Furthermore, the consumption of motor fuels for mobile sources in the public sector (ambulance, fire brigade, etc.), both on and off roads as well as the consumption of aviation fuel are included here.

#### 3.2.20.2 Uncertainties and time-series consistency (CRF 1.A.4.c)

See chapter 3.2.5.

#### 3.2.20.3 Category-specific QA/QC and verification (CRF 1.A.4.c)

QA/QC procedures in this subsector must be coordinated with CDV. KONEKO, as the company responsible for processing the entire sector 1.A, performs before each submission distribution of motor fuels between the various subsectors 1.A.3, 1.A.5 and 1.A.4.c.ii. Simultaneously, after processing the data part of the submission, checks whether the predetermined distribution of fuel was properly applied and if it is necessary proposes corrections in order to avoid double counting of fuels, or their omission.

Other QA/QC and verification - see section 3.2.6.

#### 3.2.20.4 Category-specific recalculations (CRF 1.A.4.c)

Quite extensive updates were provided in activity data by CzSO, which resulted in recalculation of this category.

**Tab. 3-88 Changes after recalculation in 1.A.4.c for Liquid Fuels**

| Fuel consumption | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | TJ | 211.0 | 211.0 | 211.0 | 256.4 | 216.7 | 262.7 | 256.3 |
| **Submission 2017** | TJ | 257.0 | 211.0 | 296.6 | 256.4 | 216.7 | 302.1 | 460.3 |
| **Difference** | TJ | 45.9 | | 85.6 | | | 39.4 | 203.9 |
| | % | 21.8 | | 40.6 | | | 15.0 | 79.6 |
| $CO_2$ emission | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 15.274 | 15.270 | 15.269 | 18.254 | 15.182 | 18.208 | 18.249 |
| **Submission 2017** | kt | 18.300 | 15.270 | 21.367 | 18.254 | 15.182 | 21.261 | 33.504 |
| **Difference** | kt | 3.026 | | 6.098 | | | 3.053 | 15.255 |
| | % | 19.8 | | 39.9 | | | 16.8 | 83.6 |
| $CH_4$ emission | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.00165 | 0.00165 | 0.00165 | 0.00187 | 0.00148 | 0.00171 | 0.00187 |
| **Submission 2017** | kt | 0.00188 | 0.00165 | 0.00228 | 0.00187 | 0.00148 | 0.00210 | 0.00368 |
| **Difference** | kt | 0.00023 | | 0.00063 | | | 0.00039 | 0.00181 |
| | % | 13.9 | | 38.0 | | | 23.1 | 96.6 |
| $N_2O$ emission | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Submission 2016** | kt | 0.00008 | 0.00008 | 0.00008 | 0.00008 | 0.00006 | 0.00007 | 0.00008 |
| **Submission 2017** | kt | 0.00009 | 0.00008 | 0.00011 | 0.00008 | 0.00006 | 0.00009 | 0.00018 |
| **Difference** | kt | 0.00000 | | 0.00003 | | | 0.00002 | 0.00010 |
| | % | 5.7 | | 35.2 | | | 36.0 | 117.1 |

*in 2009, 2011 and 2012 no changes occur*

**Tab. 3-89 Changes after recalculation in 1.A.4.c for Solid Fuels**

| Fuel consumption | | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| **Submission 2016** | TJ | 528.1 | 450.6 | 436.0 | 450.7 |
| **Submission 2017** | TJ | 500.5 | 397.6 | 394.5 | 404.6 |
| **Difference** | TJ | -27.7 | -53.0 | -41.5 | -46.1 |
| | % | -5.2 | -11.8 | -9.52 | -10.2 |
| $CO_2$ emission | | 2010 | 2011 | 2012 | 2013 |
| **Submission 2016** | kt | 51.568 | 44.513 | 42.973 | 43.547 |
| **Submission 2017** | kt | 48.879 | 39.043 | 38.645 | 39.097 |
| **Difference** | kt | -2.689 | -5.470 | -4.329 | -4.450 |
| | % | -5.2 | -12.3 | -10.07 | -10.2 |
| $CH_4$ emission | | 2010 | 2011 | 2012 | 2013 |
| **Submission 2016** | kt | 0.1584 | 0.1352 | 0.1308 | 0.1352 |
| **Submission 2017** | kt | 0.1501 | 0.1193 | 0.1184 | 0.1214 |
| **Difference** | kt | -0.0083 | -0.0159 | -0.0125 | -0.0138 |
| | % | -5.2 | -11.8 | -9.52 | -10.2 |
| $N_2O$ emission *) | | 2010 | 2011 | 2012 | 2013 |
| **Submission 2016** | kt | 0.0007 | 0.0006 | 0.0006 | 0.0006 |
| **Submission 2017** | kt | 0.0008 | 0.0006 | 0.0006 | 0.0006 |
| **Difference** | kt | 0.00001 | -0.00003 | -0.00002 | -0.00002 |
| | % | 1.5 | -5.5 | -3.1 | -3.8 |

**)combination of change in activity data and change in $N_2O$ emission factor (ERT recommendation 2016)*

**Tab. 3-90 Changes after recalculation in 1.A.4.c for Natural Gas**

| Fuel consumption | | 2012 | $CH_4$ emission | | 2012 |
|---|---|---|---|---|---|
| **Submission 2016** | TJ | 2 119.1 | **Submission 2016** | kt | 0.010595 |
| **Submission 2017** | TJ | 2 146.1 | **Submission 2017** | kt | 0.010731 |
| **Difference** | TJ | 27.1 | **Difference** | kt | 0.000135 |
| | % | 1.3 | | % | 1.3 |
| $CO_2$ emission | | 2012 | $N_2O$ emission | | 2012 |
| **Submission 2016** | kt | 117.0 | **Submission 2016** | kt | 0.000212 |
| **Submission 2017** | kt | 118.5 | **Submission 2017** | kt | 0.000215 |

| | | | | | |
|---|---|---|---|---|---|
| **Difference** | kt | 1.5 | **Difference** | kt | 0.000003 |
| | % | 1.3 | | % | 1.3 |

Further, following the recommendation of ERT $N_2O$ emission factor was updated to 1.5 kg $N_2O$/TJ for solid fuels, which caused increase in $N_2O$ emissions by 7.14%.

**Tab. 3-91 Changes after update of $N_2O$ emission factor in 1.A.4.c**

| $N_2O$ emission | | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 0.02451 | 0.009453 | 0.002851 | 0.001144 | 0.000739 | 0.000631 | 0.00061 | 0.000631 | 0.000456 |
| **Submission 2017** | kt | 0.02626 | 0.010127 | 0.003055 | 0.001226 | 0.000751 | 0.000596 | 0.000592 | 0.000607 | 0.000488 |
| **Difference** | kt | 0.00175 | 0.00067 | 0.00020 | 0.00008 | 0.00001 | -0.00003 | -0.00002 | -0.00002 | 0.00003 |
| | % | 7.1 | 7.1 | 7.1 | 7.1 | 1.5 | -5.5 | -3.1 | -3.8 | 7.1 |

#### 3.2.20.5 Improvements (CRF 1.A.4.c)

Currently there are no planned improvements in this category.

### 3.2.21 Other (1.A.5)

The subsector is further divided into:

- Stationary sources – 1.A.5.a (Non specified stationary; Emissions from fuel combustion in stationary sources that are not specified elsewhere)
- Mobile sources – 1.A.5.b (Non specified mobile; Mobile Emissions from vehicles and other machinery, marine and aviation (not included in 1.A.4.c.ii or elsewhere). Includes emissions from fuel delivered for aviation and water-borne navigation to the country's military as well as fuel delivered within that country but used by the militaries of other countries that are not engaged in.)

The structure of fuels throughout the subsector 1.A.5. their consumption, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.A.5.b, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Activity** | **$CO_2$** | | | **$CH_4$** | | **$N_2O$** | |
| | **data** | **EF** | **OxF** | **Emission** | **EF** | **Emission** | **EF** | **Emission** |
| | **[TJ]** | **[t $CO_2$/TJ]** | | **[kt]** | **[kg $CH_4$/TJ]** | **[kt]** | **[kg $N_2O$ TJ]** | **[kt]** |
| **Gasoline** | 311.4 | 69.3 | 1 | 21.58 | 6.90*) | 0.0021 | 19.27*) | 0.0060 |
| **Kerosene Jet Fuel** | 1 385.6 | 71.5 | 1 | 99.07 | 14.38*) | 0.0199 | 10.26*) | 0.0142 |
| **Diesel Oil** | 3 349.6 | 74.1 | 1 | 248.20 | 5.43*) | 0.0182 | 4.94*) | 0.0165 |
| **Total year 2015** | **5 046.6** | | | **368.85** | | **0.0403** | | **0.0368** |
| **Total year 2014** | 4 223.1 | | | 309.44 | | 0.0296 | | 0.0296 |
| **Index 2015/2014** | 1.19 | | | 1.19 | | 1.36 | | 1.24 |
| **Total year 1990** | n.a | | | n.a | | n.a | | n.a |
| **Index 2015/1990** | - | | | - | | - | | - |

*) *Country specific data*

The origin of the data, the emission factors used and the method of calculating the level of emissions for each gas is detailed in the following outline.

| 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Structure of Fuels** | **Source of** | **Emission factors** | | | **Method used** | | |
| | **Activity data** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
| **Gasoline** | CzSO | D | CS | CS | Tier 1 | Tier 2 | Tier 2 |
| **Kerosene Jet Fuel** | CzSO | D | CS | CS | Tier 1 | Tier 2 | Tier 2 |
| **Diesel Oil** | CzSO | D | CS | CS | Tier 1 | Tier 2 | Tier 2 |

Given that all stationary sources have been reported in subsectors 1.A.1., 1.A.2. and 1.A.4., in this subsector (starting with this submission) will be reported only mobile sources, which were not disclosed in the subsectors 1.A.3. and 1.A.4.c.

In accordance with the IPCC 2006 Gl., the subsector 1.A.5.b. is subdivided into:

- 1.A.5.b.i – Mobile (aviation component)
- 1.A.5.b.iii – Mobile (other)

In the subsector 1.A.5.bi is reported fuel consumption and corresponding emissions of greenhouse gases from aviation, besides the public air transport. This is primarily the consumption of aviation fuels in the army, in state institutions (aerial vehicles from Integrated Rescue System) or private air transport.

Subsector 1.A.5.b.ii is not exploited in the submission of the Czech Republic, especially as it relates to maritime transport which is not present in the Czech Republic.

Subsector 1.A.5.b.iii is used for the reporting of all remaining fuels (and greenhouse gases) that have not been reported elsewhere; it is mainly the consumption of motor fuels for ground vehicles in the military and in governmental institutions (Integrated Rescue System). Furthermore, it includes the consumption in the fields of construction, mining of fuels and minerals, industry (only areal transport).

The fraction of $CO_2$ emissions in subsector 1.A.5 in 2015 contributed 0.3% to $CO_2$ emissions in the whole Energy sector 1.A.

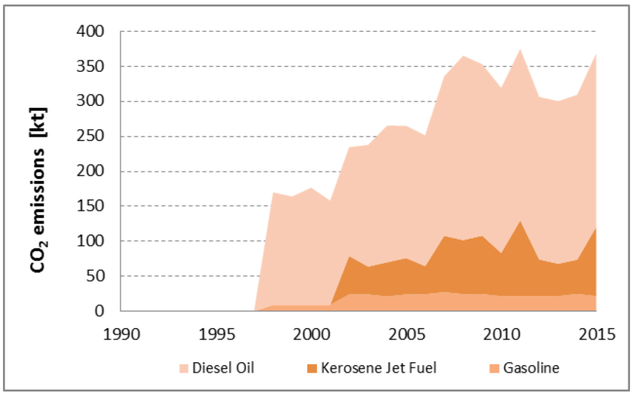



**Fig. 3-33 Development of $CO_2$ emissions in source category 1.A.5.b.**

Development of fuel consumption and the corresponding $CO_2$ emissions throughout the subcategory 1.A.5.b. are seen in Fig. 3-33.

Data before 1998 are not available in sufficient details. Shares of fuels and corresponding emissions before 1998 are reported in the sector 1.A.3. Transport.

The graph on Fig. 3-33 shows that a decisive proportion has diesel oil, another significant share is appertain to kerosene jet fuel (mainly army), the proportion of gasoline is minor.

### *3.2.21.1 Methodological issues (CRF 1.A.5.b)*

The basic requirement for processing fuel consumption by mobile sources is their division between subsectors 1.A.3 Transport and 1.A.4.c.ii and 1.A.5. This distribution is carried out in coordination with CDV. The aim is to ensure that no fuel is included in the balance twice and that no fuel is omitted. Therefore, the following distribution was performed:

Motor fuels which are consumed in subsector 1.A.4.c.ii are used only for off-road vehicles and other mechanisms in the agricultural sector, forestry and fisheries.

Subsector 1.A.5.b.i reports fuels from aviation, which have been reallocated from consumption in 1.A.3 since 1998. This corresponds to the consumption of kerosene jet fuel by the army and aviation in state organizations (aerial rescue equipment). Subsector 1.A.5.b.iii reports motor fuels for ground transport systems, which have been reallocated from consumption in 1.A.3 since 1998. This corresponds to the consumption of motor fuels for mobile sources by the army and the public sector (ambulance, fire brigade, etc.), both on and off road.

#### 3.2.21.2 Uncertainties and time-series consistency (CRF 1.A.5.b)

See chapter 3.2.5.

#### 3.2.21.3 Category-specific QA/QC and verification (CRF 1.A.5.b)

QA/QC procedures in this subsector must be coordinated with CDV. KONEKO, as the company responsible for processing the entire sector 1.A, evaluates the distribution of motor fuels among the various subsectors 1.A.3, 1.A.5 and 1.A.4.c.ii before each submission. Simultaneously, after processing the data portion of the submission, it checks whether the predetermined distribution of fuels was properly applied and, if necessary, proposes corrections in order to avoid double counting of fuels or their omission.

Other QA/QC and verification - see section 3.2.6.

#### 3.2.21.4 Category-specific recalculations (CRF 1.A.5.b)

No recalculations performed in this submission.

#### 3.2.21.5 Category-specific planned improvements (CRF 1.A.5.b)

Currently there are no planned improvements in this category.

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

Mining, treatment and all handling of fossil fuels are sources of fugitive emissions. In the Czech Republic, $CH_4$ emissions from underground mining of Hard Coal are significant, while emissions from surface mining of Brown Coal, Oil and Gas production, transmission, storage and distribution are less important.

The current inventory includes $CH_4$ emissions for the following categories:

- 1.B.1 Solid fuels
- 1.B.2 Oil and Natural Gas

In 1.B Fugitive Emissions from Fuels category, especially 1.B.1.a Coal Mining and Handling was evaluated as a key category (Tab. 3-1). Category 1.B.2 also was identified as a key category by the latest assessment, but only in one from the four tests (LA). Moreover, identifiers placed this category just over the borderline between key and non-key categories.

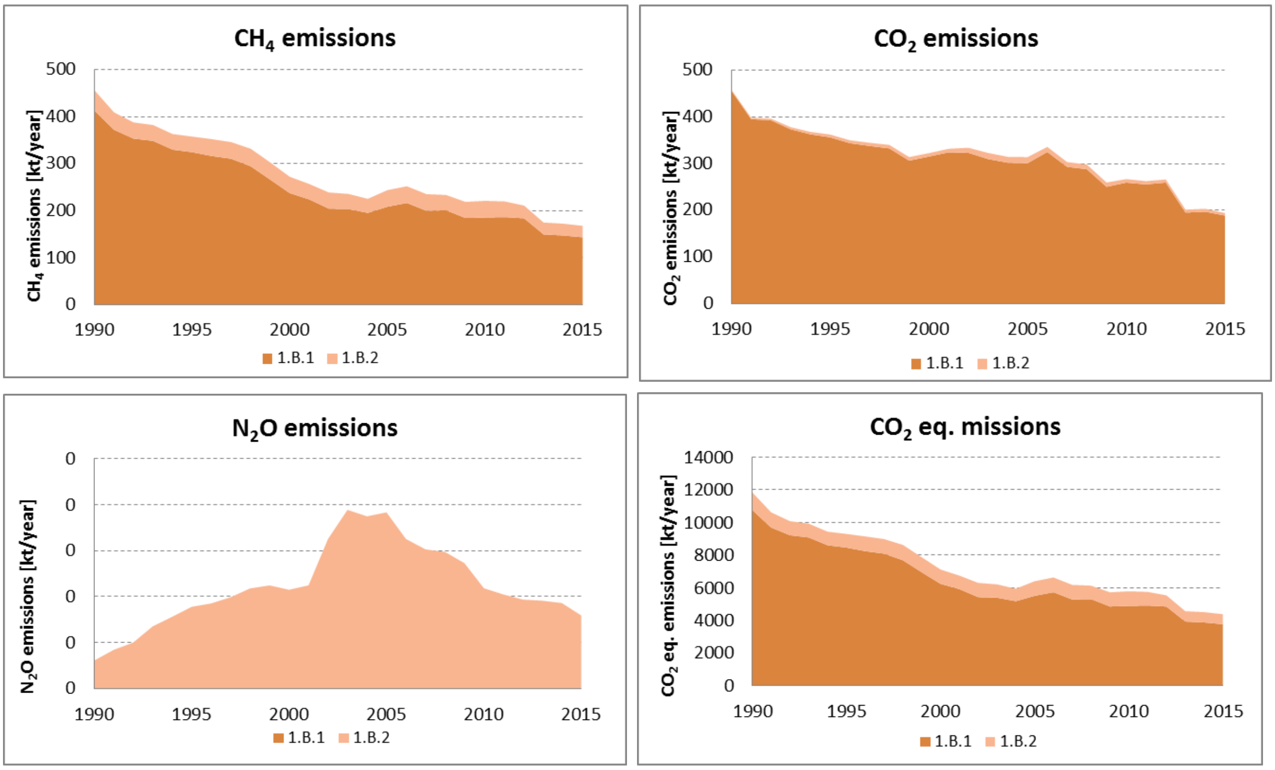



**Fig. 3-34 GHG emissions trends from Fugitive emissions from fuels [kt/year]**

Development of individual emissions of greenhouse gases in sector 1.B is shown on the graphs in Fig. 3-34.

Sector 1.B is dominated by methane emissions from subcategory 1.B.1. - Solid fuels, while emissions from sector 1.B.2. - Oil and Natural gas represents on average 15% of the total emissions. $CO_2$ emissions arise primarily in subcategory 1.B.1 - Solid fuels (share of the subcategory 1.B.2 has low importance-

about 2% of total $CO_2$ emissions). $N_2O$ emissions originate only from the subsector 1.B.2.a - Oil and there are insignificant.

The importance of individual greenhouse gases from the total emissions, expressed as $CO_2$ equivalent, is visible from Fig. 3-35.

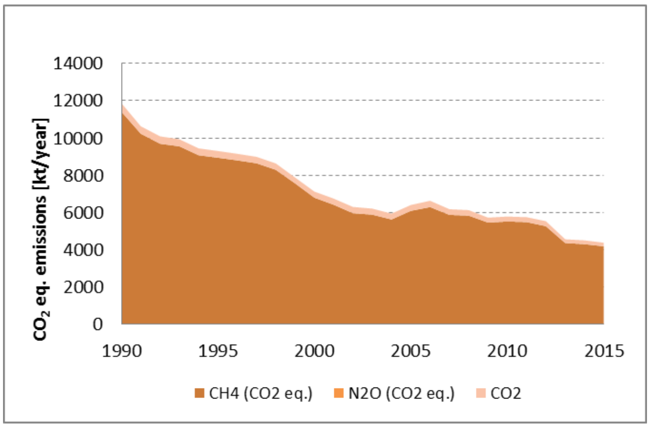



**Fig. 3-35 The share of individual GHG emissions from the total emissions, expressed as $CO_2$ eq. (1.B.)**

From the graphs on Fig. 3-34 and Fig. 3-35 is also clear that during the period occurred a significant decrease in GHG emissions across category 1.B. As it is shown below, the decrease was mainly due to a decrease in subcategory 1.B.1. - Solid fuels, in which vital source of emissions is underground mining of hard coal. For 2015, the decrease of total GHG emissions is 62.8% compared to the 1990 level.

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

The category is further divided into the following subcategories according to IPCC 2006 Gl.:

- 1.B.1.a Coal mining and handling
  - 1.B.1.a.1 Underground mines
    - 1.B.1.a1.i Mining
    - 1.B.1.a.1.ii Post-mining seam gas emissions
    - 1.B.1.a.1.iii Abandoned underground mines
  - 1.B.1.a.2 Surface mines
    - 1.B.1.a.2.i Mining
    - 1.B.1.a.2.ii Post-mining seam gas emissions
- 1.B.1.b Solid fuel transformation
- 1.B.1.c Other

#### *3.3.1.1 Category description (CRF 1.B.1)*

The structure of the sector, corresponding activity data, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

| 1.B.1, 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of sector** | | **Activity data** | **$CH_4$** | | **$CO_2$** | | **$N_2O$** | |
| | | | **EF** | **Emission** | **EF** | **Emission** | **EF** | **Emission** |
| | | **[Gg]** | **[kg $CH_4$/t]** | **[kt]** | **[t $CO_2$/t]** | **[kt]** | **[kg $N_2O$/t]** | **[kt]** |
| **1.B.1.a** | Coal mining/handl. | 46 419 | | 143.25 | | 188.53 | | NO |
| **1.B.1.a.1** | Underground mines | 8 314 | | 89.64 | | 188.53 | | NA |
| **1.B.1.a.1.i** | Mining | | 8.75 | 72.75 | 22.70 | 188.53 | NA | NA |
| **1.B.1.a.1.ii** | Post-mining activ. | | 1.675 | 13.93 | NA | NA | NA | NA |
| **1.B.1.a.1.iii** | Abandoned mines | +) | | 2.96 | | NA | NA | NA |
| **1.B.1.a.2** | Surface mines | 38 105 | | 53.61 | | NA | | NA |
| **1.B.1.a.2.i** | Mining | | 1.34 | 51.06 | NA | NA | NA | NA |
| **1.B.1.a.2.ii** | Post-mining activ. | | 0.067 | 2.55 | NA | NA | NA | NA |
| **1.B.1.b** | Solid fuel transformation | 6,00 | 30 | 0.18 | NO | NE | NA | NA |
| **Total year 2015** | | | | **143.43** | | **188.53** | | **NA** |
| **Total year 2014** | | | | 147.41 | | 196.83 | | NA |
| **Index 2015/2014** | | | | 0.97 | | 0.96 | | NA |
| **Total year 1990** | | | | 412.93 | | 456.24 | | NA |
| **Index 2015/1990** | | | | 0.35 | | 0.41 | | NA |

*+) Methodology and emission factors are explained in 3.3.1.2.*

The origin of the data, the emission factors used and the method of calculating the level of emissions for each gas is shown in detail in the following outline.

| 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure of sector** | | **Source of Activity data** | **Emission factors** | | | **Method used** | | |
| | | | **$CH_4$** | **$CO_2$** | **$N_2O$** | **$CH_4$** | **$CO_2$** | **$N_2O$** |
| **1.B.1.a** | Coal mining/handl. | CzSO | | | | Tier 1-2 | Tier 1-2 | - |
| **1.B.1.a.1** | Underground mines | CzSO | | | | Tier 1-2 | Tier 1-2 | - |
| **1.B.1.a.1.i** | Mining | CzSO | CS | CS | NA | Tier 2 | Tier 2 | - |
| **1.B.1.a.1.ii** | Post-mining activ. | CzSO | D | D | NA | Tier 1 | Tier 1 | - |
| **1.B.1.a.1.iii** | Abandoned mines | various+) | D | D | NA | Tier 1 | Tier 1 | - |
| **1.B.1.a.2** | Surface mines | CzSO | | | | Tier 1 | Tier 1 | - |
| **1.B.1.a.2.i** | Mining | CzSO | D | D | NA | Tier 1 | Tier 1 | - |
| **1.B.1.a.2.ii** | Post-mining activ. | CzSO | D | D | NA | Tier 1 | Tier 1 | - |
| **1.B.1.b** | Solid fuel transformation | FAOSTAT | D | D | NA | Tier 1 | Tier 1 | - |

*+) Methodology and emission factors are explained in 3.3.1.2.*

The source category 1.B.1 Solid Fuels consists of three sub – source categories: source category 1B.1.a Coal mining and Handling, source category 1.B.1.b Coal transformation and source category 1.B.1.c Other.

The main process that emits more than 80% of methane emissions from the category 1.B.1 Solid Fuels category is underground mining of Hard Coal in the Ostrava-Karviná area. A lesser source consists in Brown Coal mining by surface methods and post-mining treatment of Hard and Brown Coal. Coal mining (especially Hard Coal mining) is accompanied by an occurrence of methane. Methane, as a product of the coal-formation process, is physically bonded to the coal mass or is present as the free gas in pores and cracks in the coal and in the surrounding rocks.

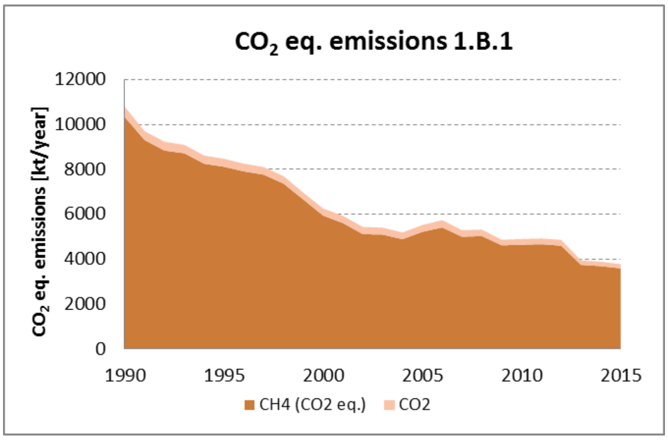



**Fig. 3-37 The trend of GHG emissions and the relationship between emissions of $CO_2$ and $CH_4$ (1.B.1)**

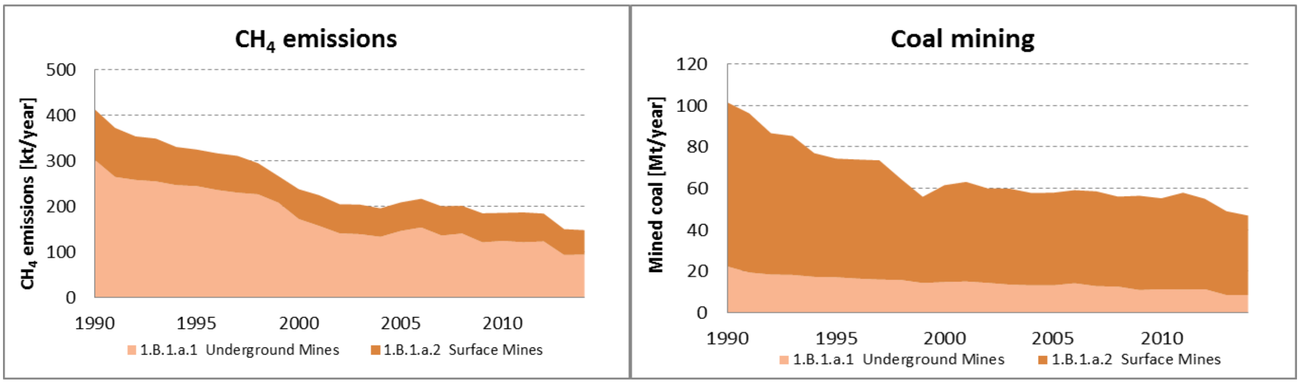



**Fig. 3-36 The ratio of methane emissions from Underground mines and Surface mines and the corresponding development of mining of Hard Coal and Lignite (1.B.1)**

Besides methane, during mining of coal mass a certain amount of carbon dioxide is released, that accompanies methane in the firedamp. $CO_2$ is reported only for the underground mining of hard coal, for surface mining of lignite emission factor is not available.

The proportion of subcategory 1.B.2 - Solid fuel transformation in the total emissions of greenhouse gases is quite minor. Subcategory 1.B.1.c - Other is not used, because for reporting the previous subcategories are used.

The graph on Fig. 3-36 shows the time trend of total emissions of greenhouse gases in the entire subsector 1.B.1. The chart also demonstrates the share of $CO_2$ emissions in the total GHG emissions, which on average makes about 6%.

The contribution of the individual subsectors to the total emissions of $CH_4$, depending on the volume of mining from underground mines (hard coal) and surface mines (lignite) in category 1.B.1 is shown on the graph in Fig. 3-37.

The Czech Republic has historically mined and is still mining large volumes of lignite, primarily for energy purposes. Hard coal is used for energy purposes, as well as for the production of metallurgical coke. Hard coal mining, although its volume is about 20% of the total volume, is accompanied by considerably more significant $CH_4$ emissions than mining of lignite.

#### 3.3.1.1.1 Coal Mining and Handling (CRF 1.B.1.a)

In the Czech Republic, mainly Hard Coal is mined in underground mines (i.e. Hard Coal: Coking Coal and Bituminous Coal). Currently, underground mines are in operation in the Ostrava-Karviná coalmining area. In the past, Hard Coal was also mined in the vicinity of the city of Kladno. These mines were closed in 2003. Brown Coal is mined in only one underground mine in the Northern Bohemia. Emissions from this mine are reported together with surface mining of Brown Coal – Lignite in subcategory 1.B.1.a.2 Surface Mines.

Data for mining of various types of coal are taken from the CzSO report for the IEA/EUROSTAT (the report CZECH_COAL.xls). For control purposes are used data from the miners yearbooks issued by the State Mining Administration and the Employers' Association of Mining and Oil Industries.

***Underground Mines (CRF 1.B.1.a.1)***

In underground Hard Coal mining, $CH_4$ is released from the coal mass and from the surrounding rocks into the mine air and must be removed to the surface to prevent formation of dangerous concentrations in the mine.

*Underground Mining Activities (1.B.1.a.1.i)*

Hard-coal mining is the principal source of fugitive emissions of $CH_4$. The mine ventilation must be regulated according to the amounts of gas released to keep its concentration on safe level. At the end of 1950’s mine gas removal systems were introduced in opening new mines and levels in the Ostrava – Karviná coal-mining area, which permitted separate exhaustion of partial methane released in the mining activity in the mixture containing the mine air. The total amount of methane emitted can be balanced quite accurately from the methane concentrations in the mine air and their total annual volume.

*Post-Mining Activities (1.B.1.a.1.ii)*

The activity data are the same as in category 1.B.1.a.1.i Mining Activities. It is assumed that the entire mined volume undergoes manipulation during which residual methane is released.

*Abandoned underground mines (1.B.1.a.1.iii)*

Abandoned underground mines in the Czech Republic are located in Kladno Basin (near Kladno, 30 km northwest of Prague) and in the Ostrava-Karvina coalfield - OKR (North Moravia). In terms of methane emissions are relevant only abandoned mines in OKR. Coal mining in the Kladno Basin was terminated in 2002. In these mines methane was absent, so the methane emissions estimate is made only from OKR mines.

In the Ostrava-Karvina coalfield coal has been extracted for more than two hundred years. Crucial decline of mining in this area started in 1991, but the closure of mines occurred in the 20s of the 20th century.

Ostrava mines have always been a significant sources of coal seam gas and in terms of mine safety regulations they were categorized under the mines with greatest threat of occurrence of methane. Methane is observed more than 100 years and reached its peak in the sixties when was the maximum in mining in Ostrava. At that time, exceeded the daily amount of gas is 500 thousand. $m^3$ $CH_4$. The gas was discharged from the mines using ventilation with 17 air pits and mine degassing. Amount on the gas in abandoned mines today, after the destruction of almost all pits, is stabilized at around 40 thousand. $m^3$ $CH_4$ per day. Based on the amount of methane escaped in recent years and using the international experience, can be forecasted that the gas will continue to be released from the underground spaces in Ostrava for a number of years.

Parts of abandoned mines have $CH_4$ recovery systems. There is company, which has established mining areas for mining of fire-damp in Ostrava-Karviná area. In the abandoned mines there are automatic suction devices and firedamp stations. Firedamp arises from abandoned mining pits and surface boreholes into abandoned areas. Mined firedamp is used at the place of mining in autonomous cogeneration units (aggregate for electricity energy production with an ignition combustion engine)( http://www.dpb.cz/).

***Surface Mines (CRF 1.B.1.a.2)***

*Surface Mining Activities (1.B.1.a.2.i)*

Lignite (Brown Coal) is mined in surface mines in the Czech Republic. Lignite is mined primarily in the Northern Bohemia area. Small parts of very young Lignite mines are located in Southern Moravia.

Prior to the commencement of surface mining in northern Bohemia, where today a decisive amount of lignite in the Czech Republic is mined, there were underground mines. The abundance of methane in these mines has never been a problem. If there was an explosion in the mines, it was caused by swirling of coal dust. Surface mining began in the 50s of the 20th century and in the period after 1990 the underground mines were already not in use.

*Post-Mining Activities (1.B.1.a.2.ii)*

The activity data are the same as in category 1.B.1.a.2.i Mining Activities. It is assumed that the entire mined volume undergoes treatment during which residual methane is released.

#### 3.3.1.1.2 Solid Fuel Transformation (CRF 1.B.1.b)

*Production of Coke from Coking Coal*

Fugitive methane emissions from coal treatment prior to the actual coking process are listed under 1.B.1.a.1.ii Post-Mining Activities. Emissions from the actual production of Coke are given under 2. Industry.

*Production of briquettes from Brown Coal*

Fugitive methane emissions from coal treatment prior to the actual briquetting process are listed under 1.B.1.a.1.ii Post-Mining Activities. $CO_2$ emissions from the actual production of briquettes are included in subcategory 1.A.2.g.

*Production of charcoal*

$CH_4$ emissions from charcoal production were estimated by using EF provided by the Revised 1996 Guidelines (IPCC, 1997); the value of 1000 kg $CH_4$/TJ of charcoal produced was used. Since there are no available official activity data about charcoal production in the Czech Republic, the un-official data from FAOSTAT statistics were used. The missing data were extrapolated. The default net calorific value 30 MJ/kg (Table 1-13 in Revised 1996 Guidelines) was used to convert activity data to the energy units. Resulting $CH_4$ emissions please see in the Tab. 3-26. Unfortunately IPCC 2006 Guidelines (IPCC, 2006) don't provide default emissions factors for fugitive emissions from charcoal production. From this reason the emission factor provided in Revised 1996 Guidelines (IPCC, 1997) is still used. Since these emissions are very low national inventory team consider this approach to be relevant in this case.

**Tab. 3-92 $CH_4$ emissions from charcoal production**

| 1.B.1.b Solid Fuel Transformation | | | |
|---|---|---|---|
| | Production | Production | $CH_4$ emissions |
| | kt/year | TJ/year | kt/year |
| **1990** | 1.00 | 30.00 | 0.03 |
| **1991** | 1.00 | 30.00 | 0.03 |
| **1992** | 1.00 | 30.00 | 0.03 |
| **1993** | 1.00 | 30.00 | 0.03 |
| **1994** | 1.00 | 30.00 | 0.03 |
| **1995** | 1.00 | 30.00 | 0.03 |
| **1996** | 1.00 | 30.00 | 0.03 |
| **1997** | 1.00 | 30.00 | 0.03 |
| **1998** | 1.80 | 54.00 | 0.05 |
| **1999** | 2.60 | 78.00 | 0.08 |
| **2000** | 3.40 | 102.00 | 0.10 |
| **2001** | 4.20 | 126.00 | 0.13 |
| **2002** | 5.00 | 150.00 | 0.15 |
| **2003** | 6.00 | 180.00 | 0.18 |
| **2004** | 6.00 | 180.00 | 0.18 |
| **2005** | 6.00 | 180.00 | 0.18 |
| **2006** | 6.00 | 180.00 | 0.18 |
| **2007** | 6.00 | 180.00 | 0.18 |
| **2008** | 6.00 | 180.00 | 0.18 |
| **2009** | 6.00 | 180.00 | 0.18 |
| **2010** | 6.60 | 198.00 | 0.20 |
| **2011** | 6.40 | 192.00 | 0.19 |
| **2012** | 6.00 | 180.00 | 0.18 |
| **2013** | 6.00 | 180.00 | 0.18 |
| **2014** | 6.00 | 180.00 | 0.18 |
| **2015** | 6.00 | 180.00 | 0.18 |

Fugitive $CO_2$ emissions are not estimated or are negligible and no known method is available for their determination in this category (notation key NE). Fugitive $N_2O$ emissions are not estimated because, according to the current state of knowledge, these emissions cannot occur (notation key NA) and also IPCC 2006 Guidelines (IPCC, 2006) do not provide default emission factor.

#### 3.3.1.1.3 Other (CRF 1.B.1.c)

No other subcategory of fugitive methane emissions is known in the Czech Republic.

### *3.3.1.2 Methodological issues*

***Underground Mines (CRF 1.B.1.a.1)***

*Underground Mining Activities (1.B.1.a.1.i)*

Country specific emission factors were determined for calculation of fugitive methane emissions in underground mines in the second half of the 1990's: the ratio between mining and the volume of methane emissions is given in Tab. 3-94, see (Takla and Nováček, 1997).

**Tab. 3-93 Coal mining and $CH_4$ emissions in the Ostrava - Karvina coal-mining area**

| | Coal mining | $CH_4$ emissions | Emission factors |
|---|---|---|---|
| | [mil. t/year] | [mil. $m^3$/year] | [$m^3$/t] |
| **1960** | 20.90 | 348.9 | 16.7 |
| **1970** | 23.80 | 589.5 | 24.7 |
| **1975** | 24.11 | 523.8 | 21.7 |
| **1980** | 24.69 | 505.3 | 20.5 |
| **1985** | 22.95 | 479.9 | 20.9 |
| **1990** | 20.60 | 381.1 | 19.0 |
| **1995** | 15.60 | 270.7 | 17.4 |
| **1996** | 15.10 | 276.0 | 18.3 |
| **Total** | **167.31** | **3 375.3** | **20.2** |
| **1990 till 1996** | 50.76 | 927.8 | 18.3 |

Only the values for 1990, 1995 and 1996 were used from this table to determine the emission factors.

The average value of the emission factor of 18.3 $m^3$/t was recalculated to 12.261 kg/t using a density of methane of 0.67 $m^3$/kg. This emission factor is used for coal mined in the Ostrava-Karviná coalmining area for years 1990 - 1999. The emission factor set by estimation at 50% of this value was used for the remaining Hard Coal from underground mines in other areas. This is valid for coal with minimum coal gas capacity (coal from the Kladno area to 2002 and coal from the Žacléř area from 1998).

For the period after 2000 were determined new, revised emission factors $CH_4$/t mined coal.

The management of OKD, a.s. (Ostrava-Karviná mines, joint share company) was contacted since this company monitors in very detail the issues about methane production. In response to a request from the reporting team, the company provided a document in which the total amount of gas released by OKD mines was determined, together with the amount of methane withdrawn by degassing, the amounts of methane used for industrial purposes, venting of methane from degassing and the total amount of methane released into the atmosphere. A summary of the information provided is given in Tab. 3-95.

**Tab. 3-94 Methane production from gas absorption of mines and its use**

| | mil.$m^3$ $CH_4$ * $year^{-1}$ | | | | |
|---|---|---|---|---|---|
| year | total amount of gas | pumped out by gas absorption | industrial use | venting from gas absorption into the atmosphere | released into the atmosphere - total |
| **2000** | 236.7 | 84.1 | 77.9 | 6.2 | 158.8 |
| **2001** | 210.7 | 73.9 | 71.1 | 4.0 | 140.8 |
| **2002** | 210.0 | 81.0 | 70.3 | 1.3 | 130.3 |
| **2003** | 200.6 | 74.8 | 72.8 | 2.0 | 127.8 |
| **2004** | 194.6 | 77.1 | 73.4 | 3.2 | 120.7 |
| **2005** | 207.7 | 73.9 | 70.3 | 3.6 | 137.4 |
| **2006** | 221.1 | 76.9 | 75.9 | 0.8 | 145.0 |
| **2007** | 194.7 | 71.5 | 71.0 | 0.5 | 123.7 |
| **2008** | 199.5 | 68.8 | 68.5 | 0.3 | 131.0 |

This data was used to calculate the emission factors and to determine the average emission factor, which is used for the period after 2000-2008.

The emission factors given in Tab. 3-29 are used for 2000 – 2008. After 2008, the emission factor calculated as the average value from the values for 2000-2008, i.e. 8.12 t/kt, is used. Research with aim to develop this emission factor was performed in 2011.

**Tab. 3-95 Calculation of emission factors from OKD mines for period 2000 onwards**

| year | OKD mining | $CH_4$ emissions | EF |
|---|---|---|---|
| | [kt/year] | [t/year] | [t $CH_4$/kt] |
| **2000** | 11 514 | 106 396 | 9.24 |
| **2001** | 11 844 | 94 336 | 7.96 |
| **2002** | 12 049 | 87 301 | 7.25 |
| **2003** | 11 301 | 85 626 | 7.58 |
| **2004** | 10 901 | 80 869 | 7.42 |
| **2005** | 10 822 | 92 058 | 8.51 |
| **2006** | 11 656 | 97 150 | 8.33 |
| **2007** | 10 153 | 82 879 | 8.16 |
| **2008** | 10 030 | 87 770 | 8.75 |
| **2000 - 2008** | 100 270 | 814 385 | 8.12 |

For years 2000 – 2008 were used emission factors given in Tab. 3-96 for calculation of emission factors from OKD mines. For years onwards 2008 is used average emission factors from the period 2000-2008; 8.12 t/kt of mined hard coal, for period before 1999 the value is same as in previous submission 12.3 t/kt of mined coal (Takla and Nováček, 1997).

This emission factor can be considered as emissions factor on the level Tier II – it is country-specific emission factor, which is applicable for Ostrava-Karviná area.

For other mines in the Czech Republic where hard coal was also mined, the value of 6.7 t/kt was used – the same as in previous submissions. However it is necessary to remind that underground mining in the mines of other areas than OKD is really minor and at the end of the first decade of 21st century was completely stopped.

Country specific emission factors were determined for calculation of fugitive carbon dioxide emissions. An extra study was performed to determine the $CO_2$ emission factor for underground hard coal mining. Monthly data on the concentrations and amounts of $CO_2$ were processed for all the exhaust air shafts in the OKD area for 2009, 2010 and for part of 2011. These data yielded an average value of the emission factor, which is related to the volume of mining. The emission factor is equal to 22.75 t $CO_2$/kt of mined coal and this emission factor is country specific – Tier II level. This value is valid for the OKD area. The author of the study recommended that the determined emission factor for 1990 – 2009 be used. He determined an emission factor 22.68 t $CO_2$/kt of mined coal for 2010 and it was recommended that this value also be used for the subsequent years. These emission factors were used to extend the data for $CO_2$ emissions for underground hard coal mining; the values are given in the Tab. 3-96.

**Tab. 3-96 Emission factors and emissions from underground mining of hard coal**

| year | production OKD | emission factor | emission of $CO_2$ |
|---|---|---|---|
| | [kt/year] | [t $CO_2$/kt] | [kt $CO_2$/year] |
| **1990** | 20 059 | 22.75 | 456.3 |
| **1991** | 17 371 | 22.75 | 395.1 |
| **1992** | 17 271 | 22.75 | 392.9 |
| **1993** | 16 419 | 22.75 | 373.5 |
| **1994** | 15 942 | 22.75 | 362.6 |
| **1995** | 15 661 | 22.75 | 356.2 |
| **1996** | 15 109 | 22.75 | 343.7 |
| **1997** | 14 851 | 22.75 | 337.8 |
| **1998** | 14 620 | 22.75 | 332.6 |
| **1999** | 13 468 | 22.75 | 306.4 |
| **2000** | 13 855 | 22.75 | 315.2 |
| **2001** | 14 246 | 22.75 | 324.1 |
| **2002** | 14 200 | 22.75 | 323.0 |

| | | | |
|---|---|---|---|
| **2003** | 13 614 | 22.75 | 309.7 |
| **2004** | 13 272 | 22.75 | 301.9 |
| **2005** | 13 227 | 22.75 | 300.9 |
| **2006** | 14 280 | 22.75 | 324.8 |
| **2007** | 12 886 | 22.75 | 293.1 |
| **2008** | 12 622 | 22.75 | 287.1 |
| **2009** | 11 001 | 22.75 | 250.2 |
| **2010** | 11 435 | 22.68 | 259.3 |
| **2011** | 11 265 | 22.68 | 255.4 |
| **2012** | 11 440 | 22.68 | 259.4 |
| **2013** | 8 594 | 22.68 | 194.9 |
| **2014** | 8 680 | 22.68 | 196.8 |
| **2015** | 8 314 | 22.68 | 188.5 |

*Post-Mining Activities (CRF 1.B.1.a.1.ii)*

Methane emissions in the subcategory of Post-Mining Activities are calculated using a uniform emission factor based on the default value of 1.64 kg $CH_4$/t coal; the activity data are employed at the same level as in subcategory 1.B.1.a.1.i Mining Activities.

Tab. 3-97 contains of fugitive methane emissions from post-mining operations with Hard Coal from Underground mines.

**Tab. 3-97 Used emissions factors and calculation of $CH_4$ emissions from underground coal mining – post mines operations in period 1990 - 2015**

| year | production OKD | emission factor | emission of $CO_2$ |
|---|---|---|---|
| | [kt/year] | [t $CH_4$/kt] | [kt $CH_4$/year] |
| **1990** | 22 371 | 1.675 | 37.47 |
| **1991** | 19 461 | 1.675 | 32.60 |
| **1992** | 18 481 | 1.675 | 30.96 |
| **1993** | 18 297 | 1.675 | 30.65 |
| **1994** | 17 376 | 1.675 | 29.10 |
| **1995** | 17 169 | 1.675 | 28.76 |
| **1996** | 16 532 | 1.675 | 27.69 |
| **1997** | 16 069 | 1.675 | 26.92 |
| **1998** | 15 863 | 1.675 | 26.57 |
| **1999** | 14 419 | 1.675 | 24.15 |
| **2000** | 14 855 | 1.675 | 24.88 |
| **2001** | 15 138 | 1.675 | 25.36 |
| **2002** | 14 470 | 1.675 | 24.24 |
| **2003** | 13 643 | 1.675 | 22.85 |
| **2004** | 13 302 | 1.675 | 22.28 |
| **2005** | 13 252 | 1.675 | 22.20 |
| **2006** | 14 292 | 1.675 | 23.94 |
| **2007** | 12 895 | 1.675 | 21.60 |
| **2008** | 12 662 | 1.675 | 21.21 |
| **2009** | 11 001 | 1.675 | 18.43 |
| **2010** | 11 435 | 1.675 | 19.15 |
| **2011** | 11 265 | 1.675 | 18.87 |
| **2012** | 11 440 | 1.675 | 19.16 |
| **2013** | 8 594 | 1.675 | 14.39 |
| **2014** | 8 680 | 1.675 | 14.54 |
| **2015** | 8 314 | 1.675 | 13.93 |

*Abandoned underground mines (CRF 1.B.1.a.1.ii)*

Calculation of methane emissions from abandoned mines has been carried out in accordance with the methodology IPCC 2006 Gl. at the level Tier 1. For the purposes of this calculation, the number of closed mines in the Ostrava-Karvina coalfield was determined in prescribed intervals (intervals years 1901-1925, 1926-1950, 1951-1975 , 1976 - 2000 2001 to the present). Given that in the Ostrava-Karvina coalfield occur only mines with high amount of the gas, were used values for the percentage of coal mines that are gassy from the column High (2006 IPCC Guidelines for National Greenhouse Gas Inventories: Tab. 4.1.5: TIER 1 – ABANDONED UNDERGROUND MINES, DEFAULT VALUES - PERCENTAGE OF COAL MINES THAT ARE GASSY, page 4.24.), the following:

1901 – 1925: 0%

1926 – 1950: 50%

1951 – 1975: 75%

1976 – 2014: 100%

Emission factors from Table 4.1.6, p. 4.25 were used for calculating the emissions (TABLE 4.1.6: TIER 1 - Abandoned UNDERGROUND MINES - EMISSION FACTOR, MILLION M3 methane/MINE).

Since 2005, total emissions of methane from abandoned mines have gradually decreased in the context of increased degassing of abandoned mines by the Green Gas company (electricity generation at cogeneration units, stationed for on-site extraction of methane). The overall data and the calculation procedure are shown in Tab. 3-98.

**Tab. 3-98 Emission of $CH_4$ on abandoned mines**

| year | $CH_4$ emission in period [kt/year] | | | | Calculated | Use of $CH_4$ | Total |
|---|---|---|---|---|---|---|---|
| | 1926 - 1950 | 1951 - 1975 | 1976 - 2000 | 2001 - 2013 | emission | [%] | emission |
| 1990 | 0.46 | 2.40 | 0.00 | | 2.86 | | 2.86 |
| 1991 | 0.46 | 2.36 | 1.79 | | 4.60 | | 4.60 |
| 1992 | 0.45 | 2.32 | 3.96 | | 6.73 | | 6.73 |
| 1993 | 0.45 | 2.28 | 7.18 | | 9.90 | | 9.90 |
| 1994 | 0.44 | 2.24 | 9.27 | | 11.95 | | 11.95 |
| 1995 | 0.44 | 2.21 | 10.49 | | 13.13 | | 13.13 |
| 1996 | 0.43 | 2.17 | 10.43 | | 13.04 | | 13.04 |
| 1997 | 0.43 | 2.14 | 9.87 | | 12.43 | | 12.43 |
| 1998 | 0.43 | 2.11 | 9.38 | | 11.92 | | 11.92 |
| 1999 | 0.42 | 2.08 | 9.46 | | 11.96 | | 11.96 |
| 2000 | 0.42 | 2.05 | 9.55 | | 12.03 | | 12.03 |
| 2001 | 0.42 | 2.02 | 9.19 | | 11.63 | | 11.63 |
| 2002 | 0.41 | 1.99 | 8.86 | | 11.27 | | 11.27 |
| 2003 | 0.41 | 1.97 | 8.56 | 1.18 | 12.12 | | 12.12 |
| 2004 | 0.41 | 1.94 | 8.31 | 0.97 | 11.63 | | 11.63 |
| 2005 | 0.40 | 1.92 | 8.05 | 0.85 | 11.22 | 5.0 | 10.66 |
| 2006 | 0.40 | 1.90 | 7.84 | 0.76 | 10.90 | 7.5 | 10.08 |
| 2007 | 0.40 | 1.87 | 7.62 | 0.69 | 10.59 | 20.0 | 8.47 |
| 2008 | 0.40 | 1.85 | 7.44 | 0.64 | 10.33 | 25.0 | 7.75 |
| 2009 | 0.39 | 1.83 | 7.26 | 1.80 | 11.29 | 50.0 | 5.65 |
| 2010 | 0.39 | 1.81 | 7.09 | 1.70 | 10.99 | 60.0 | 4.40 |
| 2011 | 0.39 | 1.79 | 6.94 | 1.61 | 10.73 | 70.0 | 3.22 |
| 2012 | 0.38 | 1.77 | 6.79 | 1.53 | 10.48 | 70.0 | 3.15 |
| 2013 | 0.38 | 1.76 | 6.65 | 1.47 | 10.25 | 70.0 | 3.08 |
| 2014 | 0.38 | 1.74 | 6.53 | 1.41 | 10.05 | 70.0 | 3.02 |
| 2015 | 0.38 | 1.73 | 6.41 | 1.36 | 9.86 | 70.0 | 2.96 |

### *Surface Mines (CRF 1.B.1.a.ii)*

Total emissions, used activity data and emission factors for proper extraction of lignite (Brown Coal) from surface mines and post-mining related adjustments are presented in the Tab. 3-99.

**Tab. 3-99 Used activity data, emissions factors and calculation of $CH_4$ emissions from surface coal mining and post mines operations in period 1990 - 2015**

| year | Brown Coal production | Emission factors for activities mines | post-mines | emission of $CH_4$ |
|---|---|---|---|---|
| | [kt/year] | [t $CH_4$/kt] | [t $CH_4$/kt] | [kt $CH_4$/year] |
| **1990** | 78 983 | 1.34 | 0.067 | 111.13 |
| **1991** | 76 680 | 1.34 | 0.067 | 107.89 |
| **1992** | 68 084 | 1.34 | 0.067 | 95.79 |
| **1993** | 66 884 | 1.34 | 0.067 | 94.11 |
| **1994** | 59 568 | 1.34 | 0.067 | 83.81 |
| **1995** | 57 163 | 1.34 | 0.067 | 80.43 |
| **1996** | 57 356 | 1.34 | 0.067 | 80.70 |
| **1997** | 57 446 | 1.34 | 0.067 | 80.83 |
| **1998** | 48 619 | 1.34 | 0.067 | 68.41 |
| **1999** | 41 524 | 1.34 | 0.067 | 58.42 |
| **2000** | 46 655 | 1.34 | 0.067 | 65.64 |
| **2001** | 47 960 | 1.34 | 0.067 | 67.48 |
| **2002** | 45 480 | 1.34 | 0.067 | 63.99 |
| **2003** | 46 240 | 1.34 | 0.067 | 65.06 |
| **2004** | 44 498 | 1.34 | 0.067 | 62.61 |
| **2005** | 44 619 | 1.34 | 0.067 | 62.78 |
| **2006** | 44 849 | 1.34 | 0.067 | 63.10 |
| **2007** | 45 664 | 1.34 | 0.067 | 64.25 |
| **2008** | 43 362 | 1.34 | 0.067 | 61.01 |
| **2009** | 45 416 | 1.34 | 0.067 | 63.90 |
| **2010** | 43 774 | 1.34 | 0.067 | 61.59 |
| **2011** | 46 639 | 1.34 | 0.067 | 65.62 |
| **2012** | 43 533 | 1.34 | 0.067 | 61.25 |
| **2013** | 40 385 | 1.34 | 0.067 | 56.82 |
| **2014** | 38 177 | 1.34 | 0.067 | 53.72 |
| **2015** | 38 105 | 1.34 | 0.067 | 53.61 |

Determination of activity data and emission factors for mining and post-mining treatment is given in the description of the individual activities on surface mines.

*Surface Mining Activities (1.B.1.a.2)*

*Post-Mining Activities (1.B.1.a.2.ii)*

Data from the source part of the questionnaire completed in the CzSO Questionnaire (CzSO, 2016), was employed to determine activity data on extraction of Brown Coal and Lignite. The mining yearbooks and other data sources continue to be used only for control purposes.

During surface mining, escaping methane is not related to specific flow of air and thus it is far more difficult to monitor the amount of methane escaping into the air. Consequently, default IPCC emission factors are employed to calculate methane emissions from surface mining and from post-mining treatment (IPCC, 2006).

#### 3.3.1.2.1 Solid Fuel Transformation (CRF 1.B.1.b)

Emission calculation was performed for the production of wood charcoal at Tier I, using default emission factors - see chapter 3.3.1.1.2.

$CH_4$ emissions from charcoal production were estimated by using EF provided by the Revised 1996 Guidelines (IPCC, 1997); the value of 1000 kg $CH_4$/TJ of charcoal produced was used. Since there are no available official activity data about charcoal production in the Czech Republic, the un-official data from FAOSTAT statistics were used. The missing data were extrapolated. The default net calorific value 30 MJ/kg (Table 1-13 in Revised 1996 Guidelines) was used to convert activity data to the energy units. Unfortunately IPCC 2006 Guidelines (IPCC, 2006) don't provide default emissions factors for fugitive emissions from charcoal production. From this reason the emission factor provided in Revised 1996 Guidelines (IPCC, 1997) is still used. Since these emissions are very low the team consider this approach to be relevant in this case.

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

The inventory methods used in this inventory were consistently employed across the whole reporting period from the base year of 1990 to 2015. The uncertainties in the activity rate result primarily from inaccuracies in weighing of extracted coal. Extensive research concerning new evaluation of uncertainties was performed last year. Uncertainties in determining the activity data were estimated at 4%.

Uncertainties in calculating methane emissions further follow from the emission factors employed. The emission factors for determining emissions from underground mining of hard coal are based on measurement of the methane concentrations in the air ventilated from underground mines in the second half of the 1990's. The uncertainty in the emission factors is considered to be at the level of 12.9%.

The uncertainty in the $CO_2$ emission factor is considered to be at the level of 25%.

Summary of uncertainty estimates provides Tab. 3-34.

**Tab. 3-100 Uncertainty estimates for fugitive emissions from Solid Fuels**

| Gas | Source category | AD uncertainty [%] | EF uncertainty [%] | Origin of actual level of uncertainty |
|---|---|---|---|---|
| $CO_2$ | 1.B.1.a Coal Mining and Handling | 4 | 25 | V. Neuzil, P. Fott, AD unc. in line with 2006 Guidelines, EF unc. expert judgement |
| $CH_4$ | 1.B.1.a Coal Mining and Handling | 4 | 13 | V. Neuzil, P. Fott, AD unc. in line with 2006 Guidelines, EF unc. expert judgement |

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

General quality control and source-specific quality control (Tier 1 and Tier 2), in conformance with the requirements of the QSE handbook and its associated applicable documents, have been performed to the full extent.

QC activities at the level of Tier 1 were performed according to the QA/QC plan by the sector compiler. Routine control was performed in the framework of the following activities:

- activity data employed,
- emission factors employed,
- calculation procedures employed,

- transfer of numerical data from the working set to the CRF Reporter.

During control of the activity data, the CzSO data were compared with the data from the Mining Yearbook. Good agreement was found.

In control of the emission factors employed, the emission factors used in the Czech Republic methodology were compared with the emission factors of Slovakia, Poland and Germany in the context with the default emission factors. It was found that the emission factors employed for calculation of emissions in the Czech Republic methodology correspond, in their range, to the emission factors employed in the other countries.

Furthermore, the correct usage of the methodology at Tier I level for the calculation of $CH_4$ emissions from abandoned mines and the performance of own calculations were checked. The calculation procedure was consulted with an independent expert from the VSB-Technical University of Ostrava. It was concluded that the input data and the method of calculation are in line with the methodology.

Control that the transfer of numerical data from the working set to the CRF Reporter does not reveal any differences. The final working set in EXCEL format is locked to prevent intentional rewriting of values and archived at the coordination workplace. The protocols on the performed QA/QC procedures are stored too.

### 3.3.1.5 Category-specific recalculations

After UNFCCC review in September 2016 two recalculations were carried out. Firstly, emission factors for $CH_4$, 1.B.1.A.1.ii - Underground mines, Post-Mining Activities were updated (to 1.675 kg $CH_4$/t coal). This recalculation yields to higher emissions.

**Tab. 3-101 Impact of recalculation after $CH_4$ EF change in 1.B.1.A.1.ii**

| $CH_4$ emission | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 34.32 | 29.77 | 29.08 | 28.08 | 27.03 | 26.62 | 25.66 | 25.11 | 24.75 | 22.68 |
| **Submission 2017** | kt | 37.47 | 32.60 | 30.96 | 30.65 | 29.10 | 28.76 | 27.69 | 26.92 | 26.57 | 24.15 |
| **Difference** | kt | 3.15 | 2.82 | 1.88 | 2.56 | 2.07 | 2.14 | 2.03 | 1.80 | 1.82 | 1.47 |
| | % | 9.2 | 9.5 | 6.5 | 9.1 | 7.7 | 8.0 | 7.9 | 7.2 | 7.4 | 6.5 |
| | | | | | | | | | | | |
| **$CH_4$ emission** | | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| **Submission 2016** | kt | 23.35 | 23.92 | 23.47 | 22.36 | 21.80 | 21.73 | 23.45 | 21.16 | 20.78 | 18.06 |
| **Submission 2017** | kt | 24.88 | 25.36 | 24.24 | 22.85 | 22.28 | 22.20 | 23.94 | 21.60 | 21.21 | 18.43 |
| **Difference** | kt | 1.54 | 1.43 | 0.77 | 0.49 | 0.48 | 0.47 | 0.49 | 0.44 | 0.42 | 0.37 |
| | % | 6.6 | 6.0 | 3.3 | 2.2 | 2.2 | 2.2 | 2.1 | 2.1 | 2.0 | 2.0 |
| | | | | | | | | | | | |
| **$CH_4$ emission** | | **2010** | **2011** | **2012** | **2013** | **2014** | | | | | |
| **Submission 2016** | kt | 18.77 | 18.49 | 18.78 | 14.11 | 14.25 | | | | | |
| **Submission 2017** | kt | 19.15 | 18.87 | 19.16 | 14.39 | 14.54 | | | | | |
| **Difference** | kt | 0.38 | 0.38 | 0.38 | 0.29 | 0.29 | | | | | |
| | % | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | | | | | |

Secondly, emission factors for $CH_4$, 1.B.1.A.2.i - Surface mines, Mining Activities (to 1.34 kg $CH_4$/t coal from z 0.077 kg $CH_4$/t coal) This recalculation represents increase for 73.9%.

**Tab. 3-102 Impact of recalculation after $CH_4$ EF change in 1.B.1.A.2.i**

| $CH_4$ emission | | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016** | kt | 60.86 | 44.04 | 35.95 | 34.38 | 33.73 | 35.94 | 33.54 | 31.12 | 29.42 |
| **Submission 2017** | kt | 105.84 | 76.60 | 62.52 | 59.79 | 58.66 | 62.50 | 58.33 | 54.12 | 51.16 |
| **Difference** | kt | 44.98 | 32.55 | 26.57 | 25.41 | 24.93 | 26.56 | 24.79 | 23.00 | 21.74 |
| | % | 73.9 | 73.9 | 73.9 | 73.9 | 73.9 | 73.9 | 73.9 | 73.9 | 73.9 |

#### *3.3.1.6 Category-specific planned improvements*

Given that the issue of emissions from abandoned mines was included in the same time as the transition to new methodology IPCC 2006 Gl., Tier 1 approach was used. Planned improvements assume a change to a higher level, at least Tier II. In terms of the planned improvements, was ensured a cooperation with the specialist on the issue of leakage of methane from abandoned mines in the Ostrava-Karvina coalfield.

In the other sub-sectors no improvements are planned at the present.

### 3.3.2 Oil and Natural Gas (CRF 1.B.2)

The category is divided according to IPCC 2006 Gl. and CRF Reporter into subcategories:

- 1.B.2.a Oil
  - 1.B.2.a.1 Exploration
  - 1.B.2.a.2 Production
  - 1.B.2.a.3 Transport
  - 1.B.2.a.4 Refining/Storage
  - 1.B.2.a.5 Distribution of Oil Products
  - 1.B.2.a.6 Other
- 1.B.2.b Natural Gas
  - 1.B.2.b.1 Exploration
  - 1.B.2.b.2 Production
  - 1.B.2.b.3 Processing
  - 1.B.2.b.4 Transmission and Storage
  - 1.B.2.b.5 Distribution
  - 1.B.2.b.6 Other
- 1.B.2.c Venting and Flaring
  - 1.B.2.c.1 Venting
  - 1.B.2.c.2 Flaring

### 3.3.2.1 Category description (CRF 1.B.2)

The structure of the sector, the corresponding activity data, the used emission factors and emissions of individual greenhouse gases can be seen on the following outline.

| 1.B.2, 2015 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Structure of sector | | Activity data [PJ] | $CH_4$ EF [t $CH_4$/PJ] | $CH_4$ Emission [kt] | $CO_2$ EF [t $CO_2$/PJ] | $CO_2$ Emission [kt] | $N_2O$ EF [kg $N_2O$/PJ] | $N_2O$ Emission [kt] |
| **1.B.2.a.1** | Exploration | NO | | | | | | |
| **1.B.2.a.2** | Production and Upgr. | 5.43 | 4.746 | 0.026 | 7.576 | 0.041 | NA | - |
| **1.B.2.a.3** | Transport | 306.0 | 0.146 | 0.045 | 0.013 | 0.004 | NA | - |
| **1.B.2.a.4** | Refining | 306.0 | 0.585 | 0.179 | NA | - | NA | - |
| **1.B.2.a.5** | Distrib. of Oil Prod. | 306.0 | NA | - | NA | - | NA | - |
| **1.B.2.a.6** | Other | NO | | | | | | |
| **1.B.2.b.1** | Exploration | NO | | | | | | |
| **1.B.2.b.2** | Production | 7.718 | 42.119 | 0.325 | +) | 0.0001 | NA | - |
| **1.B.2.b.3** | Processing | NO | | | | | | |
| **1.B.2.b.4** | Transmission and | 1 215.0 | 4.520 | 5.492 | +) | 0.022 | NA | - |
| | Storage | 185.9 | 3.891 | 0.72 | +) | 0.003 | NA | - |
| **1.B.2.b.5** | Distribution | 116.3 | 139.7 | 16.25 | +) | 0.065 | NA | - |
| **1.B.2.b.6** | Other | I.E. | | | | | | |
| **1.B.2.c.1** | Venting - Oil | 5.43 | 235.4 | 1.278 | 48.70 | 0.264 | NA | - |
| **1.B.2.c.2** | Flaring - Oil | 5.43 | 0.568 | 0.003 | 919.9 | 4.993 | 0.015 | 0.0001 |
| **Total year 2015** | | | | **24.321** | | **5.392** | | **0.0001** |
| **Total year 2014** | | | | 25.019 | | 6.304 | | 0.0001 |
| **Index 2015/2014** | | | | 0.97 | | 0.86 | | 0.85 |
| **Total year 1990** | | | | 43.196 | | 2.202 | | 0.00003 |
| **Index 2015/1990** | | | | 0.56 | | 2.45 | | 2.61 |

*+) As emission factor is used the average annual $CO_2$ content in natural gas*

The origin of the data, the emission factors used and the method of calculating the level of emissions for each gas is shown in details in the following outline.

| 2015 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Structure of sector | | Source of Activity data | Emission factors $CH_4$ | Emission factors $CO_2$ | Emission factors $N_2O$ | Method used $CH_4$ | Method used $CO_2$ | Method used $N_2O$ |
| **1.B.2.a.1** | Exploration | NA | | | | | | |
| **1.B.2.a.2** | Production and Upgrading | CzSO | CS | D | NA | Tier 2 | Tier 1 | - |
| **1.B.2.a.3** | Transport | CzSO | D | D | NA | Tier 1 | Tier 1 | - |
| **1.B.2.a.4** | Refining | CzSO | D | NA | NA | Tier 1 | - | - |
| **1.B.2.a.5** | Distribution of Oil Products | NA | | | | | | |
| **1.B.2.a.6** | Other | NO | | | | | | |
| **1.B.2.b.1** | Exploration | NO | | | | | | |
| **1.B.2.b.2** | Production | CzSO | CS | CS | NA | Tier 2 | Tier 2 | - |
| **1.B.2.b.3** | Processing | NO | | | | | | |
| **1.B.2.b.4** | Transmission and | CzSO | CS | CS | NA | Tier 2 | Tier 2 | - |
| | Storage | ERU | CS | CS | NA | Tier 2 | Tier 2 | - |
| **1.B.2.b.5** | Distribution | ERU | CS | CS | NA | Tier 2 | Tier 2 | - |
| **1.B.2.b.6** | Other | NO | | | | | | |
| **1.B.2.c.1** | Venting - Oil | CzSO | D | D | NA | Tier 1 | Tier 1 | - |
| **1.B.2.c.2** | Flaring - Oil | CzSO | D | D | D | Tier 1 | Tier 1 | Tier 1 |

Approximately 93% of emissions are formed in the Czech Republic from gas industry in extraction, storage, transport and distribution of Natural Gas and in its final use. Crude Oil extraction and refining processes are very less important.

Determination of methane emissions from the processes of refining of Crude Oil is based on the recommended (default) emission factors according to the 2006 IPCC methodology.

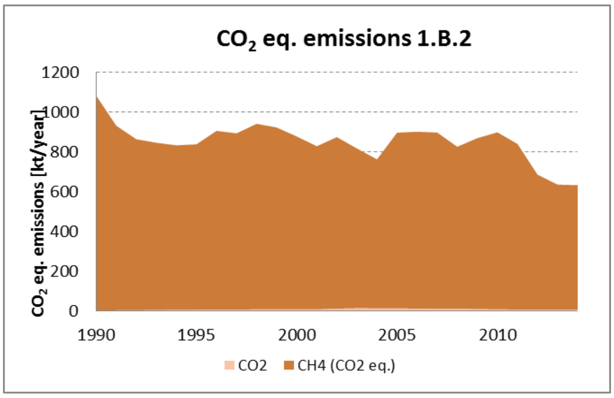



**Fig. 3-38 The trend of GHG emissions and the relationship between $CO_2$ and $CH_4$ emissions (1.B.2)**

Methane emissions from the gas industry were determined using national emission factors based on the specific emission factors for the individual parts of the gas industry system.

The graph in Fig. 3-38 gives an overview of the trend in emissions in this category in the time series since 1990.

The graph on Fig. 3-38 shows that the proportion of total $CO_2$ emissions from the total GHG emissions is negligible (approximately 0.1%).

The contribution of the individual subsectors (Oil and Natural Gas) to the total $CH_4$ emissions throughout the period in the category 1.B.2 is shown on Fig. 3-39.

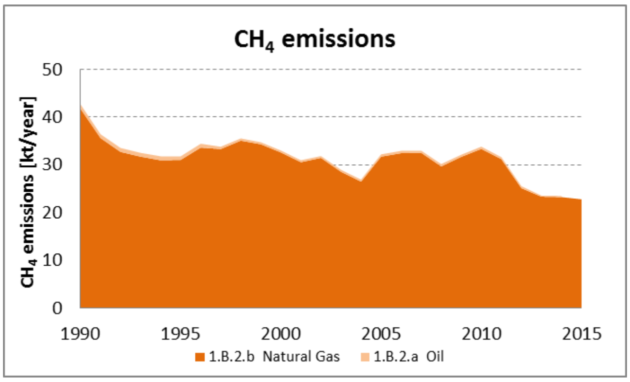



**Fig. 3-39 The ratio of methane emissions from subsector Oil (1.B.2.a) and Natural Gas (1.B.2.b)**

As shown on Fig. 3-39 for the amount of $CH_4$ emissions in sector 1.B.2. Oil and Natural Gas are therefore crucial the emissions, produced in the gas industry.

### 3.3.2.1.1 Oil (CRF 1.B.2.a)

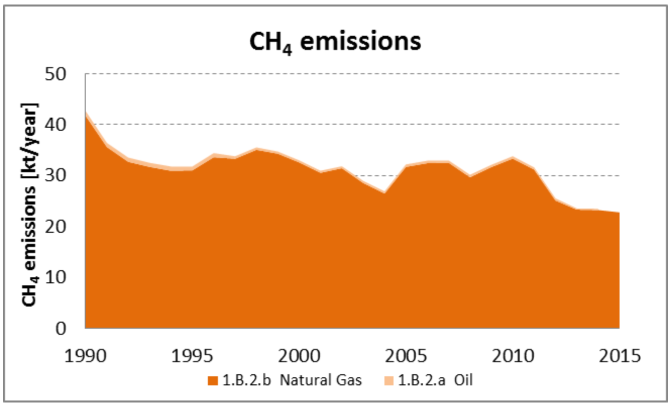



**Fig. 3-40 Crude Oil production end import in the CR in 1990 – 2015**

In subcategory Oil are reported emissions from mining, processing of domestic crude oil and emissions from refining of imported crude oil. The share of domestic crude oil is very small - about 3% (from 0.7 to 4.8%). The time profile of domestic production and imports of crude oil in the Czech Republic is shown on Fig. 3-40.

GHG emissions from Crude Oil transport and refining and from Crude Oil production, which is performed in the Czech Republic in combination with mining of Natural Gas, are reported in this category. $CO_2$ emissions from the refinery resulting from combustion processes (including flaring) are included in 1.A.1.b Crude Oil Refining.

*Exploration (1.B.2.a.iii.1)*

Exploration is not systematically performed in the Czech Republic.

*Production and Upgrading (1.B.2.a.iii.2)*

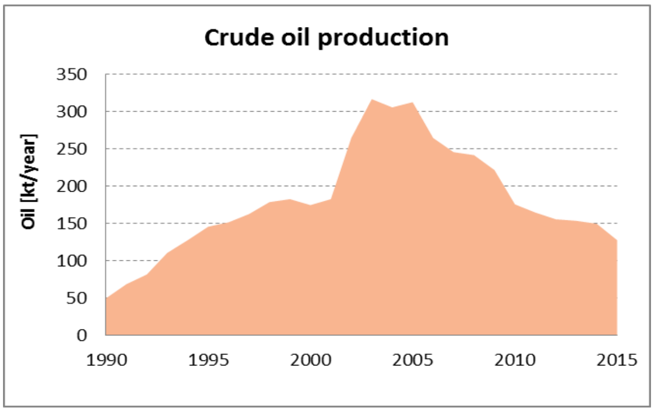



**Fig. 3-41 Crude Oil production in the CR in 1990 – 2015**

Crude Oil is mined in the Czech Republic in Southern Moravia. The following Fig. 3-41 gives the amount of mined Crude Oil in the territory of the Czech Republic.

The quantity of crude oil extracted in each year depends on the amount of recoverable reserves. From Fig. 3-41 is visible that the maximum extraction was in the period from 2003 to 2006. It is expected that the decline in production until 2014 will continue.

*Transport (1.B.2.a.iii.3)*

Transport of Crude Oil in the territory of the Czech Republic is performed only in closed systems (pipeline transport – Oil pipeline Družba from Russia and Ingolstat from Germany). Default emission factors were used to calculate fugitive $CH_4$ and $CO_2$ emissions in this subsector.

*Refining (1.B.2.a.iii.4)*

Crude Oil is processed in the territory of the Czech Republic in two main refinery facilities. The total volume of Crude Oil processed in the Czech Republic is presented in Fig. 3-41.

*Distribution of Oil Products (1.B.2.a.iii.5)*

The final products after processing Crude Oil no longer contain dissolved methane or carbon dioxide and thus fugitive emissions are not considered in this subcategory. For completeness, activity data corresponding to the volume of processed Crude Oil in the individual years were recorded in CRF.

*Other (1.B.2.a.iii.6)*

No other operations are considered.

### 3.3.2.1.2 Natural Gas (CRF 1.B.2.b)

In the subcategory Natural Gas are reported GHG emissions from domestic natural gas production and emissions related to the operation of individual parts of the gas system (import, transit, storage and distribution to end users). The share of the domestic natural gas production is very small - about 3% (from 1.4 to 4.8%). The time profile of domestic

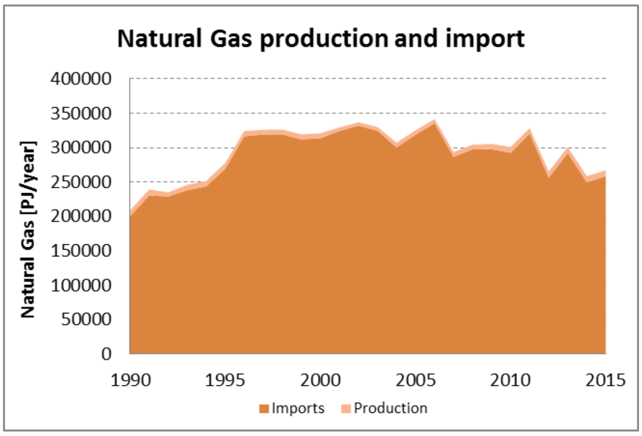



**Fig. 3-42 Natural Gas production end import in the CR in 1990 – 2015**

production and import of natural gas in the Czech Republic is shown on Fig. 3-42.

*Exploration (1.B.2.b.iii.1)*

Emissions formed in exploratory boreholes are reported in this subcategory. This activity is not performed in the Czech Republic, or only completely random.

*Production (1.B.2.b.iii.2)*

Natural Gas is extracted in the Czech Republic in the area of Southern Moravia, accompanying extraction of Crude Oil, and in Northern Moravia, where it is derived from degassing of hard coal deposits. The following Fig. 3-43 gives the amount of production Natural Gas in the territory of the Czech Republic.

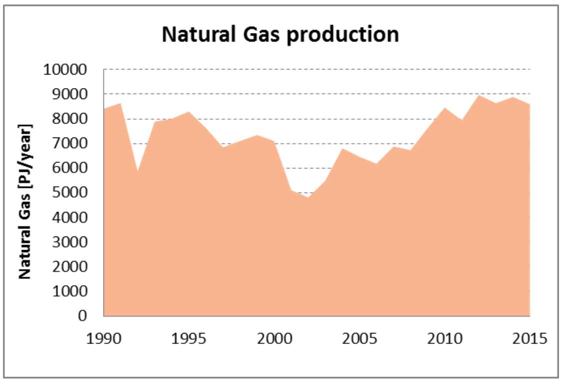



**Fig. 3-43 Natural Gas production in the area of CR in 1990 – 2015**

The development of domestic extraction is relatively stable over time. Fluctuations in individual years are due to technical and geological conditions of mining and market demand.

*Processing (1.B.2.b.iii.3)*

Gas treatments, except for drying, are not performed in the Czech Republic. The drying process is not a source of GHG emissions.

*Transmission and Storage (1.B.2.b.iii.4)*

The calculation of GHG emissions in this subcategory, is carried out in two steps: independently in the first step is carried out an estimation of the emissions for the transit system and high-pressure gas pipelines, and in the second step emissions from underground gas storage facilities are estimated. For each part of the gas system is used a different methodological approach.

A transit gas pipeline runs through the territory of the Czech Republic, transporting Natural Gas from Russia to the countries of Western Europe, with a length of 3,821 km. In addition to this central gas pipeline, a system of high-pressure gas pipelines is in operation in the territory of the Czech Republic, providing supplies of Natural Gas from the transit gas pipeline and underground gas storage areas to centres of consumption. In 2015, the high-pressure gas pipelines had an overall length of 12,899 km.

This subcategory also includes all the technical equipment on high-pressure gas pipelines. On the transit gas pipeline, this consists primarily of compressor stations and transfer stations, while measuring and regulation stations are located on domestic long-distance gas pipelines.

Methane emissions formed during controlled technical discharge of Natural Gas at compressor stations, during inspections and repairs to pipelines and emissions from pipeline accidents are estimated. These emissions are recorded by the gas companies. In addition, escapes of Natural Gas from leaks in the entire pipeline system, including technical equipment, are also evaluated.

Emissions from storage (injection and mining) of Natural Gas in the territory of the Czech Republic are reported in this subcategory. The total turnover (injection and mining) of Natural Gas in underground storage areas corresponded to 5,460 mil. $m^3$ in 2015.

*Distribution (1.B.2.b.iii.5)*

Emissions from distribution gas pipelines, with an overall length in 2014 of 48 475 km, and during consumption at the end consumer are reported in this category. The distribution networks are being continuously lengthened and the number of customers is increasing.

*Other (1.B.2.b.iii.6)*

No additional emissions are reported.

### 3.3.2.1.3 Venting and Flaring (CRF 1.B.2.c)

In the Czech Republic there is only one deposit, which is in South Moravia. Crude oil extraction takes place there, along with natural gas production.

Tab. 3-103 gives the $CH_4$ and $CO_2$ emissions from Venting for domestic production (mining) of Crude Oil; $N_2O$ emissions are not included in this subcategory since no emission factor is available for their calculation. Tab. 3-103 further contains values of emissions $CH_4$, $CO_2$ and $N_2O$ from Flaring in domestic production of Crude Oil. From the table it is clear that this is a minor proportion from the total emissions in whole subcategory Oil and Gas (1.B.2.a).

**Tab. 3-103 Emissions of $CH_4$, $CO_2$ and $N_2O$ from Venting and Flaring in 1990 – 2015**

| | Venting - emissions [t/year] | | Flaring - emissions [t/year] | | |
|---|---|---|---|---|---|
| | $CH_4$ | $CO_2$ | $CH_4$ | $CO_2$ | $N_2O$ |
| **1990** | 0.49 | 0.10 | 0.001 | 1.92 | 0.00003 |
| **1991** | 0.68 | 0.14 | 0.002 | 2.64 | 0.00004 |
| **1992** | 0.80 | 0.17 | 0.002 | 3.14 | 0.00005 |
| **1993** | 1.09 | 0.23 | 0.003 | 4.25 | 0.00007 |
| **1994** | 1.25 | 0.26 | 0.003 | 4.90 | 0.00008 |
| **1995** | 1.43 | 0.30 | 0.003 | 5.59 | 0.00009 |
| **1996** | 1.49 | 0.31 | 0.004 | 5.82 | 0.00009 |
| **1997** | 1.60 | 0.33 | 0.004 | 6.24 | 0.00010 |
| **1998** | 1.75 | 0.36 | 0.004 | 6.85 | 0.00011 |
| **1999** | 1.81 | 0.37 | 0.004 | 7.06 | 0.00011 |
| **2000** | 1.73 | 0.36 | 0.004 | 6.76 | 0.00011 |
| **2001** | 1.81 | 0.37 | 0.004 | 7.06 | 0.00011 |
| **2002** | 2.62 | 0.54 | 0.006 | 10.24 | 0.00016 |
| **2003** | 3.13 | 0.65 | 0.008 | 12.23 | 0.00019 |
| **2004** | 3.02 | 0.62 | 0.007 | 11.78 | 0.00019 |
| **2005** | 3.08 | 0.64 | 0.007 | 12.05 | 0.00019 |
| **2006** | 2.62 | 0.54 | 0.006 | 10.23 | 0.00016 |
| **2007** | 2.44 | 0.50 | 0.006 | 9.52 | 0.00015 |
| **2008** | 2.39 | 0.50 | 0.006 | 9.35 | 0.00015 |
| **2009** | 2.19 | 0.45 | 0.005 | 8.58 | 0.00014 |
| **2010** | 1.76 | 0.36 | 0.004 | 6.86 | 0.00011 |
| **2011** | 1.65 | 0.34 | 0.004 | 6.44 | 0.00010 |
| **2012** | 1.56 | 0.32 | 0.004 | 6.08 | 0.00010 |
| **2013** | 1.54 | 0.32 | 0.004 | 6.01 | 0.00010 |
| **2014** | 1.50 | 0.31 | 0.004 | 5.85 | 0.00009 |
| **2015** | 1.28 | 0.26 | 0,003 | 4.99 | 0.00008 |

### *3.3.2.2 Methodological issues*

During the 1990's, Czech refineries have undergone a quite extensive process of innovation and reconstruction, to decrease technical losses of raw materials and final products. Comprehensive verification has been carried out of the seals of the individual fittings, pumps and all the technical equipment. This entire process, which was carried out mainly for economic reasons, also led to a decrease in overall emissions, especially of NMVOCs. Consequently, the emission factors taken from the IPCC methodology (IPCC, 2006) can be considered to correspond to the current technical condition of refineries in this country. In this connection, it should be pointed out that fugitive emissions from refinery technology couldn't be determined by direct measurements, as they are not connected with specific air outlets or chimneys. Thus, they can be determined only on the basis of professional estimates from balance losses or using emission factors. The resultant emissions of the individual substances were compared with the data in the national emission database and are of the same order of magnitude.

In general, it can be stated that fugitive greenhouse gas emissions occur in this subcategory only in operations in which Crude Oil saturated in carbon dioxide and methane is in contact with the atmosphere. All operations involving Crude Oil in the Czech Republic are hermetically sealed. Thus, fugitive emissions are formed only through leaks in the technical equipment. Following thermal treatment of Crude Oil, the resultant products no longer contain any dissolved gases and no fugitive emissions need be considered in subsequent operations.

#### 3.3.2.2.1 Oil (CRF 1.B.2.a)

$CH_4$ emissions from Crude Oil transport and refining and from Crude Oil mining, which is performed in the Czech Republic in combination with mining of Natural Gas, are reported in this category. $CO_2$ emissions from the refinery resulting from combustion processes (including flaring) are included in 1.A.1.b Crude Oil Refining.

*Exploration (1.B.2.a.iii.1)*

Exploration is not systematically performed in the Czech Republic. For this reason, there are no known procedures for the determination of emissions in this subsector.

Activity data: number of mined boreholes – notation key NO, default emission factors have not been published for $CO_2$ and $CH_4$ – notation key NO. $N_2O$ emissions: notation key NA: $N_2O$ emissions are practically not formed in exploratory work.

*Production and Upgrading (1.B.2.a.iii.2)*

Activity data for determining $CH_4$ and $CO_2$ emissions are taken from the CzSO – IEA questionnaires and controlled using data from the Mining Yearbook.

$CH_4$ emissions are determined as the product of annual Crude Oil mining and the emission factor. The emission factor has a value of 4,746 kg/PJ and was determined on the basis of published data in (Zanat et al.,1997). The emission factor was determined as the sum of the individual emission factors from pumping of raw Crude Oil and from storage of raw Crude Oil. These data were obtained by direct measurement. The resultant emission factor was increased by an estimate of fugitive emissions at mining boreholes (probes).

$CO_2$ emissions are estimated based on the default emission factor (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operation in developed countries, page 4.52).

EF $CO_2$: 2.8E-04 Gg per $10^3$ $m^3$ total oil production = 7 576 kg/PJ

For the estimation of $N_2O$ emissions, no emission factor was available.

*Transport (1.B.2.a.iii.3)*

In this case, the activity data correspond to the total amount of petroleum transported through the territory of the Czech Republic by the pipeline system in the individual years. This amount corresponds to the Total Crude Oil input to refineries. The default emission factors from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operation in developed countries, page 4.52 are employed to calculate the $CH_4$ and $CO_2$ emissions.

EF $CH_4$: 5.4E-06 Gg per $10^3$ $m^3$ oil transported by pipeline = 146 kg/PJ

EF $CO_2$: 4.9E-07 Gg per $10^3$ $m^3$ oil transported by pipeline = 13 kg/PJ

These emission factors were used to calculate fugitive emissions for the years since 1990.

For the estimation of $N_2O$ emissions, no emission factor was available.

*Refining (1.B.2.a.iii.4)*

Methane emissions from refining are calculated using IPCC Tier 1 methodology (Table 4.2.4 in 2006 IPCC Guidelines). Emissions are calculated by multiplying the amount of Crude Oil input to refinery by the emission factor. The emission factor value used was 585 kg/PJ.

This emission factor is based on the data from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operation in developed countries, page 4.52

EF $CH_4$: $2.6 \times 10^{-6}$ to $41.0 \times 10^{-6}$ Gg per $10^3$ $m^3$ oil refined = 585 kg/PJ (average)

The IPCC method does not give any EF for $CO_2$ or $N_2O$. Consequently, the notation key NA is used in CRF.

*Distribution of Oil Products (1.B.2.a.iii.5)*

The available IPCC methodology does not provide any EF for $CO_2$, $CH_4$ or $N_2O$ – notation key – NA. The products which originate during oil processing cannot contain $CO_2$ or $CH_4$. There isn't known process by which could arise fugitive $CO_2$ or $CH_4$ emissions during the distribution of oil products.

*Other (1.B.2.a.iii.6)*

Activity data: notation key: NO; $CH_4$, $CO_2$ and $N_2O$ emissions – notation key NO.

#### 3.3.2.2.2 Natural Gas (CRF 1.B.2.b)

Leakages in the distribution network and household distribution pipes can be considered to constitute the most serious source of emissions. In the 1990's, the distribution network was newly constructed almost entirely from welded plastics and the old pipeline was reconstructed to a major degree in the same manner. Household distribution pipes are subject to strict standards and any poor seals can be identified by the characteristic smell. In addition to safety aspects, all leakages also have an economic impact both for the distribution company and for the end user, so this aspect is carefully monitored and, as soon as possible, immediately remedied. As a whole, the gas distribution in the CR is at a high technical level and it can be stated that all leakages are carefully sought out and eliminated.

As a method was developed in the last few years for determining methane emissions in the gas industry using specific emission factors, this sophisticated method of calculation continues to be used, although, from the standpoint of ref. (IPCC, 2006), calculation using default values would probably suffice. Qualified estimation of methane emissions is thus carried out using specific emission factors for the individual parts of the gas industry system (Table 4.2.8. Classification of Gas losses as low, medium or high at selected types of Natural gas facilities, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, page 4.71)

The total emission value given corresponds to about 0.3% of the total consumption of Natural Gas in the Czech Republic. The detailed calculation given corresponds to Tier 2.

In general, it can be stated that the determined methane emissions in category 1.B.2 Gas are basically formed in several ways:

- through poor seals in the flanges and joints, fittings, probes in mining and storage fields and other parts of the pipeline system,
- through pipeline perforation,
- through technical discharge of gas into the air,
- through accidents.

*Exploration (1.B.2.b.iii.1)*

Exploration is not performed in the Czech Republic and thus the notation key NO is used in the CRF Report for the emissions and activity data.

*Production (1.B.2.b.iii.2)*

*Transmission and Storage (1.B.2.b.iii.4)*

*Distribution (1.B.2.b.iii.5)*

Fugitive methane emissions are calculated in these subcategories using an internal calculation model based on the methodology proposed in 1997 in IGU (Alfeld, 1998). Calculations of emissions are supplemented by data from the national Integrated Pollution Register (IPR) and investigations at individual distribution companies on registered units of Natural Gas.

**Tab. 3-104 Model calculation of $CH_4$ emissions in the Natural Gas sector (2015)**

| | EF | | Activity data | | Losses of NG |
|---|---|---|---|---|---|
| | value | units | value | units | mil.m$^3$/year |
| **production** | 0.2 | % vol. | 247 | mil. m$^3$ | 0.49 |
| **high pressure pipelines** | 600 | m$^3$/km.year | 13 028 | km | 7.60 |
| **transmission pipelines**$^{*)}$ | | | | | 1.15 |
| **compressors**$^{**)}$ | | | | | 0.20 |
| **storage**$^{***)}$ | | | | | 1.10 |
| **regulation stations** | 1 000 | m$^3$/station | 4 465 | pcs | 4.39 |
| **distribution network** | 300 | m$^3$/km.year | 48 475 | km | 14.28 |
| **final comsumption** | 2 | m$^3$/consumer | 2 844 334 | pcs | 5.59 |
| **Total** | | | | | **34.02** |
| **Emissions in Gg (0.67 kg/m$^3$)** | | | | | **23.34** |

*$^{*)}$ data from IRZ (Integrated Pollution Register of Czech Republic – Czech version of E-PRTR) - company NET4GAS*
*$^{**)}$ data from operating records of leakage Natural Gas - company RWE*
*$^{***)}$ data from operating records of leakage Natural Gas - company RWE Gas Storage*

Emissions calculated in this model are then transformed to the structure of the sectors and subsectors according to the IPCC methodology.

#### 3.3.2.2.3 Venting and Flaring (CRF 1.B.2.c)

The estimations of $CO_2$, $CH_4$ and $N_2O$ emissions from venting and flaring in the course of oil production were obtained by using the default EFs provided by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (see table 4.2.4, pages 4.48 – 4.54). In this case the following EFs were taken:

Venting (Default Weighted Total)

$CH_4$: 8.7E-03 Gg per $10^3$ $m^3$ total oil production

$CO_2$: 1.8E-03 Gg per $10^3$ $m^3$ total oil production

$N_2O$: NA

Flaring (Default Weighted Total)

$CH_4$: 2.1E-05 Gg per $10^3$ $m^3$ total oil production

$CO_2$: 3.4E-02 Gg per $10^3$ $m^3$ total oil production

$N_2O$: 5.4E-07 Gg per $10^3$ $m^3$ total oil production

Owing to the fact that activity data are required in kg/PJ, the value was converted to kg/PJ by using the typical value of density for crude oil of 880 kg/t and value NCV was taken from CzSO questionnaires IAE as a simple average for domestic oil (42 MJ/kg):

Venting

$CH_4$: 235 390 kg/PJ

$CO_2$: 48 701 kg/PJ

Flaring

$CH_4$: 568.2 kg/PJ

$CO_2$: 919 913 kg/PJ

$N_2O$: 14.61 kg/PJ

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

The inventory methods used in this inventory were consistently employed across the whole reporting period from the base year of 1990 to 2009. Uncertainties in determining the activity data are estimated at 7%. This estimate is based on the precision of measurement of the volumes of Crude Oil, Crude Oil products and Natural Gas.

The emission factors for determining emissions in extraction of Natural Gas and Crude Oil are based on specific measurements, accompanied by an error of approx. 10%. Emission factors used to determine emissions in transport and distribution of Natural Gas are based on isolated measurements and estimates by experts in the gas industry. The uncertainty in these emission factors is considered to be at the level of 25%. Determination of gas leaks in technical operations, starting-up of compressors and accidents, as appropriate, are evaluated on the basis of calculations with knowledge of the necessary technical parameters, such as the gas pressure, pipeline volume, etc. The uncertainties then correspond to knowledge of these technical parameters – 10%. The other emission factors were taken from the IPCC methodology as default values, considered to have an uncertainty of 80% in this methodology. Overall, the uncertainty in the emission factors in category 1.B.2 Oil and Natural Gas is estimated to equal 75%.

Summary of uncertainty values provides Tab. 3-105.

**Tab. 3-105 Uncertainty estimates for fugitive emissions from Oil and Natural Gas**

| Gas | Source category | AD uncertainty [%] | EF uncertainty [%] | Origin of actual level of uncertainty |
|---|---|---|---|---|
| $CO_2$ | 1.B.2 Oil and Natural Gas | 7 | 75 | V. Neuzil, P. Fott, AD and EF unc. in line with 2006 Guidelines |
| $CH_4$ | 1.B.2 Oil and Natural Gas | 7 | 75 | V. Neuzil, P. Fott, AD unc. in line with 2006 Guidelines, EF unc. expert judgement |

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

General quality control and source-specific quality control (Tier 1 and Tier 2), in conformance with the requirements of the QSE handbook and its associated applicable documents, have been performed to the full extent.

QC activities at the level of Tier 1 were performed according to the QA/QC plan by the sector compiler. Routine control was performed in the framework of the following activities:

- activity data employed,
- emission factors employed,
- calculation procedures employed,
- transfer of numerical data from the working set to the CRF Reporter.

In control of the activity data, the CzSO data were compared with the data from the Mining Yearbook (Mining Yearbook, 2016) and with data obtained by an investigation at the individual gas distribution companies. Good agreement was found. In control of the emission factors employed, the emission factors used in the Czech Republic methodology were compared with the emission factors of Slovakia, Poland and Germany in the context with the default emission factors. It was found that the emission factors employed for calculation of emissions in the Czech Republic methodology correspond, in their range, to the emission factors employed in the other countries. Comparison of the emission factors used in the Czech Republic with the emission factors of the surrounding countries corresponds to the level of Tier 2.

Control of the transfer of numerical data from the working set to the CRF Reporter did not reveal any differences.

The final working set in EXCEL format was locked to prevent intentional rewriting of values and archived at the coordination workplace.

The protocols on the performed QA/QC procedures are stored in the archive of the sector compiler.

### *3.3.2.5 Category-specific recalculations*

No recalculations were performed in this submission.

### *3.3.2.6 Category-specific planned improvements*

Currently there are no planned improvements in this category.

## 3.4 $CO_2$ transport and storage (CRF 1.C)

Not performed in the Czech Republic.

# 4 Industrial processes and product use (CRF Sector 2)

The sector of industrial processes of GHG emission inventory includes emissions from technological processes and not from fuel combustion used to supply energy for carrying out these processes. Consistent emphasis is put on the distinction between the emissions from fuel combustion in the Energy sector and the emissions from technological processes and production.

For example, in the production of cement, consideration is given only to emissions derived from the thermal decomposition of mineral raw materials (specifically $CO_2$ emissions from the decomposition of limestone) and not from fuel used to heat the rotary kiln (considered in category 1.A.2.f). However, the situation in iron and steel production is more complicated. Evaluation of the $CO_2$ emissions is based on consumption of metallurgical coke in blast furnaces, where coke is used dominantly as a reducing agent (iron is reduced from iron ores), even though the resulting blast furnace gas is also used for energy production, mainly in metallurgical plants.

In 2015, the total aggregate GHG emissions from industrial processes were 15413,84 kt of $CO_2$ equivalents, which represent decrease of -2.37% compared to the previous year. Emissions decreased by 9.76% compared to the reference year 1990.

## 4.1 Overview of sector

### 4.1.1 General description and key categories identification

The major share of $CO_2$ emissions in this sector comes from sub-source categories 2.C.1 Iron and Steel Production and 2.A Mineral Industry. Important category is also 2.F.1 Refrigeration and Air Conditioning. $N_2O$ emissions coming from 2.B Chemical Industry are less significant. Iron and Steel, Cement Production, F-gases Use in Refrigeration and Air Conditioning, Petrochemical and carbon black production, Lime Production, Nitric Acid Production and Ammonia production can be considered to be key categories (KC) according to IPCC 2006 Guidelines (IPCC, 2006). Tab. 4-1 gives a summary of the main sources of direct greenhouse gases in this sector, shows share of national emissions in 2015 and lists type of key category analysis for key categories.

**Tab. 4-1 Overview of key categories in sector Industrial Processes (2015)**

| Category | Gas | KC A1 | KC A2 | KC A1 incl. LULUCF | KC A1 excl. LULUCF | KC A2 incl. LULUCF | KC A2 excl. LULUCF | % of total GHG incl. LULUCF | % of total GHG excl. LULUCF |
|---|---|---|---|---|---|---|---|---|---|
| **2.C.1 Iron and Steel Production** | $CO_2$ | LA | LA | yes | yes | yes | yes | 5.37 | 5.67 |
| **2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.)** | HFC | LA, TA | LA, TA | yes | yes | yes | yes | 2.68 | 2.82 |
| **2.A.1 Cement Production** | $CO_2$ | LA, TA | LA | yes | yes | yes | yes | 1.21 | 1.28 |
| **2.B.8 Petrochemical and carbon black production** | $CO_2$ | LA | LA | yes | yes | yes | no | 0.56 | 0.59 |
| **2.B.2 Nitric Acid Production** | $N_2O$ | TA | TA | yes | yes | yes | yes | 0.22 | 0.23 |
| **2.B.1 Ammonia Production** | $CO_2$ | LA | | yes | yes | | | 0.58 | 0.61 |
| **2.A.2 Lime Production** | $CO_2$ | LA, TA | | yes | yes | | | 0.48 | 0.50 |

### 4.1.2 Emissions trends

This chapter describes the emissions of greenhouse gases in more disaggregated way than chapter 2: Trends in Greenhouse Gas emissions.

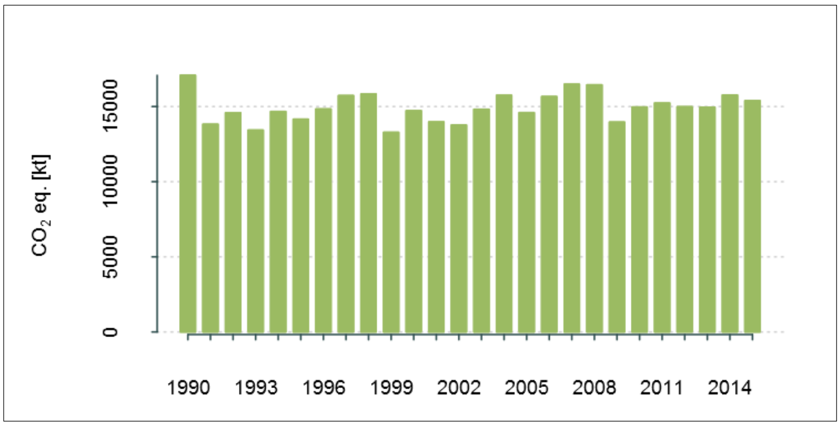



**Fig. 4-1 Trend of emissions from IPPU [kt $CO_2$ eq.]**

GHG emissions in this category are driven mainly by economic development, supply and demand of products, where abatement technology is used only in specific cases (e.g. nitric acid production) or the driving force is different (e.g. ozone depleting substances). GHG emission trends from Industrial Processes and Product Use from base year 1990 to 2015 are depicted in Fig. 4-1. $CO_2$ eq. emissions have shown stable trend since 2010 with minor fluctuation.

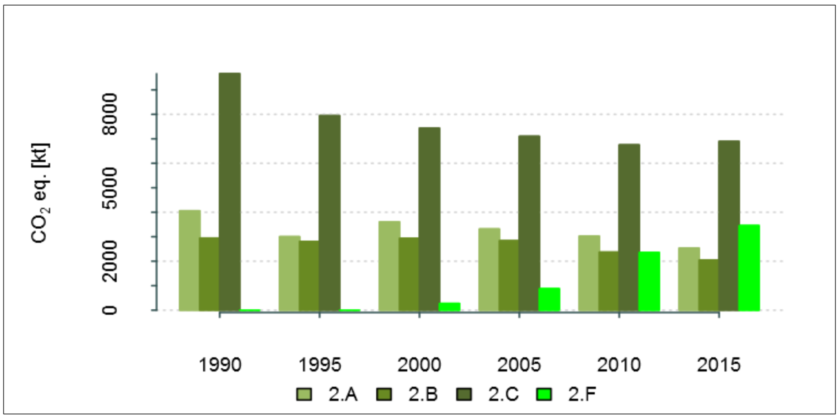



**Fig. 4-2 Emissions from principal subcategories of IPPU [kt $CO_2$ eq.]**

GHG emission trends for the principal categories of IPPU are depicted on Fig. 4-2 for years 1990, 1995, 2000, 2005, 2010 and 2015. Emissions in 2009 and 2010 were rather influenced by the economic crisis. It can be seen that the emissions of fluorinated greenhouse gases from category 2.F are constantly increasing while emissions from category 2.A, 2.B, 2.C are decreasing. A brief description of the relevant category trends is provided for all the categories in the following chapters.

Category 2.A Mineral Products includes practically only emissions of $CO_2$ as well as category 2.C Metal Production. $CO_2$ emissions from the 2.B Chemical Industry comes from 2.B.1 Ammonia Production, while $N_2O$ emissions originate from 2.B.2 Nitric Acid Production. Industrial $CH_4$ emissions are insignificant.

## 4.2 Mineral Industry (CRF 2.A)

This category describes GHG emissions from the non-combustion processes from the following categories: 2.A.1 Cement Production, 2.A.2 Lime Production, 2.A.3 Glass Production, 2.A.4 Other Process Uses of Carbonates.

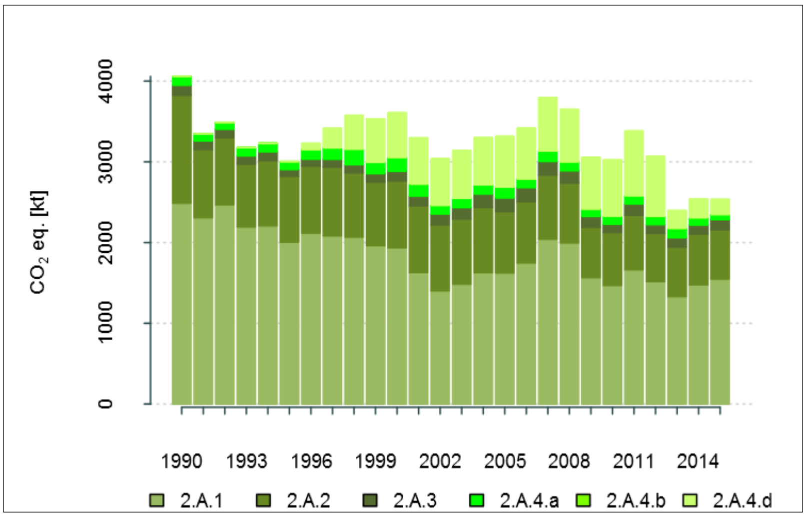



Fig. 4-3 Trend of emissions from 2.A Mineral Industry and share of specific subcategories [kt $CO_2$]

Emission trend for category 2.A Mineral Industry is depicted on Fig. 4-3. The major share 61.15% belongs to 2.A.1 Cement Production, 24.06% belongs to 2.A.2 Lime Production, 4.95% belongs to 2.A.3 Glass Production and 9.83% to 2.A.4 Other Process Uses of Carbonates.

Tab. 4-2 lists the $CO_2$ emissions in the individual subcategories in 2.A Mineral Products in 2015.

**Tab. 4-2 $CO_2$ emissions in individual subcategories in 2.A Mineral Products category in 1990 – 2015**

| | Category 2.A - $CO_2$ emissions [kt] | | | | | |
|---|---|---|---|---|---|---|
| | 2.A.1 Cement Production | 2.A.2 Lime Production | 2.A.3 Glass Production | 2.A.4.a Ceramics | 2.A.4.b Other use of Soda Ash | 2.A.4.d Other |
| 1990 | 2 489.18 | 1 336.65 | 123.66 | 109.15 | NO | NO |
| 1991 | 2 308.92 | 844.66 | 106.02 | 86.26 | NO | NO |
| 1992 | 2 468.42 | 831.46 | 104.61 | 81.82 | NO | NO |
| 1993 | 2 194.55 | 778.67 | 101.47 | 101.12 | NO | NO |
| 1994 | 2 208.38 | 806.53 | 109.71 | 103.83 | NO | NO |
| 1995 | 2 005.01 | 817.53 | 83.20 | 96.33 | NO | NO |
| 1996 | 2 116.49 | 830.73 | 87.50 | 118.01 | NO | 76.00 |
| 1997 | 2 083.36 | 852.73 | 97.00 | 140.79 | NO | 240.63 |
| 1998 | 2 067.65 | 797.00 | 101.20 | 192.31 | NO | 417.31 |
| 1999 | 1 962.91 | 787.47 | 104.20 | 139.84 | NO | 536.94 |
| 2000 | 1 936.86 | 828.53 | 119.70 | 169.70 | NO | 552.77 |
| 2001 | 1 628.84 | 827.06 | 120.30 | 149.86 | 0.10 | 571.20 |
| 2002 | 1 403.48 | 815.33 | 134.90 | 108.33 | 0.21 | 576.40 |
| 2003 | 1 484.85 | 808.00 | 141.60 | 114.87 | 0.33 | 589.07 |
| 2004 | 1 626.76 | 808.73 | 166.20 | 113.61 | 0.44 | 584.10 |
| 2005 | 1 624.53 | 762.82 | 165.40 | 135.53 | 0.47 | 625.84 |
| 2006 | 1 748.45 | 758.02 | 175.00 | 107.24 | 0.35 | 627.62 |
| 2007 | 2 043.08 | 794.07 | 168.80 | 129.04 | 0.50 | 659.02 |
| 2008 | 1 996.15 | 742.01 | 151.92 | 109.83 | 0.56 | 648.19 |
| 2009 | 1 566.08 | 625.43 | 132.93 | 90.84 | 0.41 | 639.40 |
| 2010 | 1 469.27 | 655.77 | 102.25 | 100.47 | 0.86 | 694.57 |
| 2011 | 1 664.53 | 676.44 | 138.08 | 100.52 | 1.06 | 800.71 |
| 2012 | 1 517.03 | 597.44 | 108.84 | 101.43 | 1.09 | 740.41 |
| 2013 | 1 331.79 | 612.99 | 115.76 | 116.93 | 1.03 | 215.71 |
| 2014 | 1476.74 | 629.04 | 111.93 | 90.14 | 1.12 | 229.69 |
| 2015 | 1549.54 | 609.75 | 125.47 | 63.95 | 1.01 | 184.20 |

Tab. 4-3 gives an overview of the emission factors and methodology used for computations of emissions in category 2.A Mineral Products in 2015.

**Tab. 4-3 $CO_2$ emission factors and methodology used for computations of 2015 emissions in category 2.A**

| | Emission factor $CO_2$ | Unit | Source or type of EF | Methodology |
|---|---|---|---|---|
| **2.A.1 Cement Production** | 0.53 | t $CO_2$/t sinter | CS (EU ETS) | Tier 3 |
| **2.A.2 Lime Production** | 0.77 | t $CO_2$/t CaO | CS (EU ETS) | Tier 3 |
| **2.A.3 Glass Production** | 0.10 | t $CO_2$/t Glass | Default (IPCC, 2006) | Tier 1 |
| **2.A.4.a Ceramics** | 0.09 | t $CO_2$/tiles thousand $m^2$ | CS (EU ETS) | Tier 3 |
| | 0.04 | t $CO_2$/brick unit | CS (EU ETS) | Tier 3 |
| | C | t $CO_2$/roofing tiles | CS (EU ETS) | Tier 3 |
| **2.A.4.b Other uses of Soda Ash** | 0.42 | t $CO_2$/t soda ash | IEF | Tier 3 |
| **2.A.4.d Other (Flue-gas desulfurisation)** | C | t $CO_2$/t desulfurated flue-gas | CS (EU ETS) | Tier 3 |
| **(Mineral wool production)** | 0.25 | t $CO_2$/t mineral wool | Default (IPCC, 2006) | Tier 1 |

*The column source or type of EF indicates the way how was the certain emission factor determined. Detailed information for each emission factor is given in the relevant chapters.*

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

$CO_2$ emissions from cement production have decreased since 1990 by 37.75%. Total $CO_2$ emissions equal to 1550 kt in 2015. The decrease in the emissions during 1990's was caused by the transition from planned economy to market economy. This led to decline in industrial production and consequently to decrease in emissions. Since 2003, the cement production began to recover and production has increased. Decrease in emissions since 2008 was caused by the economic crisis and related construction constraints. Cement production was identified as a key category in this year's submission.

#### *4.2.1.1 Source category description*

Cement production is one of the traditional anthropogenic sources of carbon dioxide included in inventories; however, its importance is incomparably smaller than the total combustion of fossil fuels. Approx. 60% of the $CO_2$ is emitted during transformation of raw materials (mainly decarbonisation of limestone). Process-related $CO_2$ is emitted during the production of clinker (calcination process) when calcium carbonate ($CaCO_3$) is heated in a cement kiln up to temperatures of about 1 500 °C. During this process, calcium carbonate is converted into lime (CaO - calcium oxide) and carbon dioxide. $CO_2$ emissions from combustion processes taking place in the cement industry (especially heating of rotary kilns) have been reported in IPCC category 1.A.2.f Limestone (and dolomite). This category contains also small amount of magnesium carbonate ($MgCO_3$) and fossil carbon (C), which will also calcinate or oxidize in the process causing $CO_2$ emissions.

#### *4.2.1.2 Methodological issues*

$CO_2$ emissions from 2.A.1 Cement Production can be calculated according to the IPCC 2006 Guidelines (IPCC, 2006). This methodology describes an approach based on direct data from individual operators of cement kilns (Tier 3). Since 2006 submission methodology Tier 3 has been employed. $CO_2$ emissions are based on data submitted by the cement kiln operators in the EU ETS system. EU ETS system covers all cement kiln operators in the Czech Republic. Information submitted directly by the cement kiln operators is available for years 1990, 1996, 1998 - 2002 and 2005 - 2015. For these years, the emission factor value was derived from individual installation data collected for EU ETS (emissions) and from CCA (Czech Cement Association) data (activity data about production of clinker). For other years the EFs were interpolated. The content of calcium/magnesium oxide (CaO/MgO) and composition of the limestone and dolomite are measured and independently verified. These parameters are used for calculation of the $CO_2$ emissions and, therefore, substantial attention is devoted to their determination.

The methodology used for $CO_2$ emissions must be in accordance with national legislation (Zákon 383/ 2012 o podmínkách obchodování s povolenkami na emise skleníkových plynů/Act No. 383/2012 Coll., the Greenhouse Gas Emission Allowance Trading Act) and the EU legislation (Commission Decision of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council).

All operating cement plants in the Czech Republic are equipped with dust control technology and the dust is then recycled to the kiln. Only in one cement plant is a small part of the CKD discarded, for technical reasons. Use of dolomite or amount of magnesium carbonate in the raw material, as well as fissile carbon (C) content is known, all above mentioned variables are used for emissions estimates in the EU ETS system.

Data on cement clinker production is published by the Czech Cement Association (CCA) (CCA, 2016), which associates all Czech cement producers. Clinker production data together with interpolated EF was used for years without direct data from cement kiln operators. IEF, which is calculated based on $CO_2$ emissions and clinker production, varies from 0.527 to 0.553 t $CO_2$/t clinker.

Tab. 4-4 introduces the activity data for clinker production, emission factor and $CO_2$ emissions for the whole time series.

**Tab. 4-4 Activity data, $CO_2$ emission factor and $CO_2$ emissions in 2.A.1 Cement Production category in 1990 - 2015**

| | unit | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Clinker production** | kt | 4 726 | 4 368 | 4 653 | 4 122 | 4 134 | 3 740 | 3 934 | 3 829 | 3 758 | 3 547 |
| **EF $CO_2$** | t $CO_2$/t clinker | 0.527 | 0.529 | 0.531 | 0.532 | 0.534 | 0.536 | 0.538 | 0.544 | 0.550 | 0.553 |
| **Emissions $CO_2$** | kt | 2 489 | 2 309 | 2 468 | 2 195 | 2 208 | 2 005 | 2 116 | 2 083 | 2 068 | 1 963 |

| | unit | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Clinker production** | kt | 3 537 | 2 954 | 2 549 | 2 725 | 3 017 | 3 045 | 3 288 | 3 837 | 3 759 | 2 923 |
| **EF $CO_2$** | t $CO_2$/t clinker | 0.548 | 0.551 | 0.551 | 0.545 | 0.539 | 0.533 | 0.532 | 0.532 | 0.531 | 0.536 |
| **Emissions $CO_2$** | kt | 1 937 | 1 629 | 1 403 | 1 485 | 1 627 | 1 625 | 1 748 | 2 043 | 1 996 | 1 566 |

| | unit | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| **Clinker production** | kt | 2 748 | 3 132 | 2 838 | 2 472 | 2 792 | 2919 |
| **EF $CO_2$** | t $CO_2$/t clinker | 0.535 | 0.531 | 0.535 | 0.539 | 0.529 | 0.531 |
| **Emissions $CO_2$** | kt | 1 469 | 1 665 | 1 517 | 1 332 | 1 477 | 1550 |

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

In 2012 a research was conducted in order to develop new uncertainty estimates. The uncertainties for this category are based on the 2006 Guidelines (IPCC, 2006). Since Tier 3 method is used for determining emissions in this category the uncertainties were estimated at the level of 2% both for activity data and emission factors. Overall uncertainty data are given in Chapter 1.6.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2015.

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

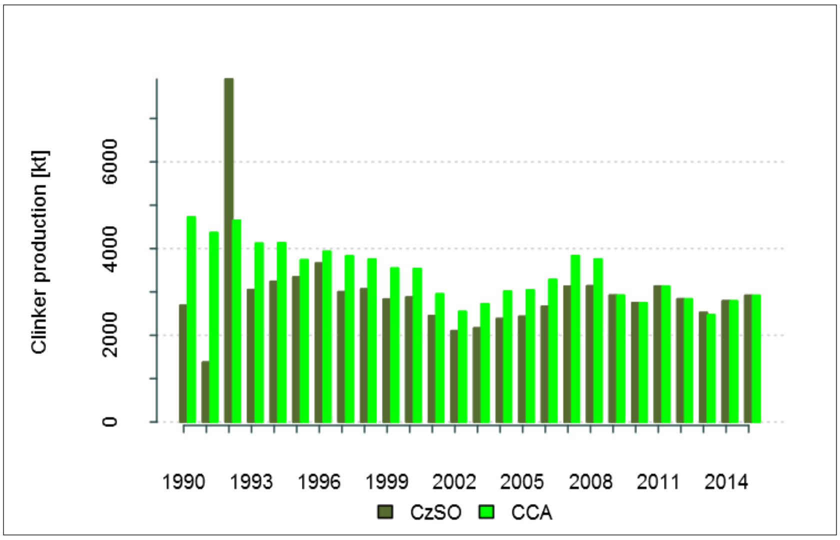



**Fig. 4-4 Comparison of clinker production data provided by CzSO and CCA**

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

In addition to verification of the input data, the inter-annual changes of the implied emission factors are analysed. The clinker production data provided by CCA, which are used as input activity data for the submission are compared with data provided by the Czech Statistical Office. Comparison of clinker production data provided by CzSO and CCA is displayed in Fig. 4-4.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

#### 4.2.1.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

During QC procedures, an error was identified in the amount of $CO_2$ emissions reported under category 2.A.1 Cement production for 2014. In the previous submission, the reported amount of $CO_2$ emissions was 1482.00 kt. This amount of $CO_2$ emissions was corrected to 1476.74 kt.

#### 4.2.1.6 Source-specific planned improvements, including tracking of those identified in the review process

Since the Tier 3 method is used for emission calculations in this category, no significant improvements are planned.

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

$CO_2$ emissions from lime production have decreased considerably since 1990 by 54.38%. The decrease in emissions between 1990 and 1991 was caused by the transition from a planned economy to a market economy and closing of lime kilns, together with a decrease in industrial production. Since then, lime production has varied slightly around 1 100 kt/year. In 2012 the production of lime dropped to a minimum for the whole period of 758 kt. After that in 2015 production of lime slightly increased to 790 kt. Lime production was identified as a key category in this year's submission.

#### 4.2.2.1 Source category description

From a chemical point of view, lime is calcium oxide. $CO_2$ is released during calcination. During the production of lime, the limestone is heated up which leads to decomposition (i.e. calcination) of $CaCO_3/MgCO_3$ to the lime ($CaO$, $CaO \cdot MgO$) and $CO_2$ is being released into the atmosphere.

### 4.2.2.2 Methodological issues

$CO_2$ emissions from 2.A.2 Lime Production are calculated according to the IPCC 2006 Guidelines (IPCC, 2006). $CO_2$ emissions are based on data submitted by the lime producers in the EU ETS system. The ETS data are available for time period 2010 - 2015 for each process. This data are at the Tier 3 level. Emission factor for calculation is based on the actual carbonates present. LKD is included in the EU ETS data for lime production, thus emission estimates include LKD. For reasons of confidentiality this data cannot be provided in details in NIR.

EU ETS data are also available for the 2005-2009 period, but only in the form of total emissions for each plant (including emissions which are reported in the Energy sector) and this is not sufficient for their use for this submission. For the 1990-2009 period, in which EU ETS was not implemented in the Czech Republic, data were kept from CLA (Czech Lime Association) and emissions were calculated by using the Tier 1 method.

Only $CO_2$ emissions generated in the process of the calcination step of lime treatment are considered in this category. $CO_2$ emissions from combustion processes (heating of kilns and furnaces) are reported under category 1.A.2.f. The national EF, used for time period 1990-2009, reflects the production of lime and quick lime (0.7884 t $CO_2$/t lime) (Vácha, 2004). Furthermore, it takes into account the average purity (93%) (Vácha, 2004) of the lime produced in the Czech Republic, thus applied emission factor is 0.733 t $CO_2$/t lime.

In 2015, research was carried out related to the country-specific emission factor from lime production (Beck, 2015). This research clarified the very small fluctuation of the emission factor (depending on the composition of the limestone) and further successfully defended the connection between Tier 1 data for the 1990 - 2009 period and Tier 3 data for the 2010 - 2015 period. Detailed information about the research is provided in Annex 3.

For time period 2010 - 2015, the activity data are based on data from EU ETS (EU ETS, 2015), which publishes data on pure lime production. These data were considered to be more accurate than the data provided by CzSO, which do not differentiate between lime and hydrated lime. For time period 1990 - 2009 activity data were obtained from CLA (Czech Lime Association).

Tab. 4-5 lists activity data for lime production, emission factors and $CO_2$ emissions for the whole time series.

**Tab. 4-5 Activity data, $CO_2$ emission factor and $CO_2$ emissions in 2.A.2 Lime Production category in 1990 - 2015**

| | unit | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Lime production** | kt | 1 823 | 1 152 | 1 134 | 1 062 | 1 100 | 1 115 | 1 133 | 1 163 | 1 087 | 1 074 |
| **EF $CO_2$** | t $CO_2$/t $CaCO_3$ | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 |
| **Emissions $CO_2$** | kt | 1 337 | 845 | 831 | 779 | 807 | 818 | 831 | 853 | 797 | 787 |

| | unit | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Lime production** | kt | 1 130 | 1 128 | 1 112 | 1 102 | 1 103 | 1 040 | 1 034 | 1 083 | 1 012 | 853 |
| **EF $CO_2$** | t $CO_2$/t $CaCO_3$ | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 |
| **Emissions $CO_2$** | kt | 829 | 827 | 815 | 808 | 809 | 763 | 758 | 794 | 742 | 625 |

| | unit | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| **Lime production** | kt | 832 | 858 | 758 | 778 | 814 | 790 |
| **EF $CO_2$** | t $CO_2$/t $CaCO_3$ | 0.788 | 0.788 | 0.788 | 0.788 | 0.772 | 0.772 |
| **Emissions $CO_2$** | kt | 656 | 676 | 597 | 613 | 629 | 610 |

### 4.2.2.3 Uncertainties and time-series consistency

The uncertainties for this category are in line with the 2006 Guidelines (IPCC, 2006). Since activity data are based on the EU ETS for time period 2009-2015, which include all the lime producers in the Czech Republic, the uncertainty in the activity data was estimated at the level of 2%.

For time period 1990-2009, the country-specific emission factor is used and the uncertainty was estimated to be at the same level as that for the activity data, i.e. 2%. The overall uncertainty data are given in Chapter 1.6.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2015.

### 4.2.2.4 Source-specific QA/QC and verification

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

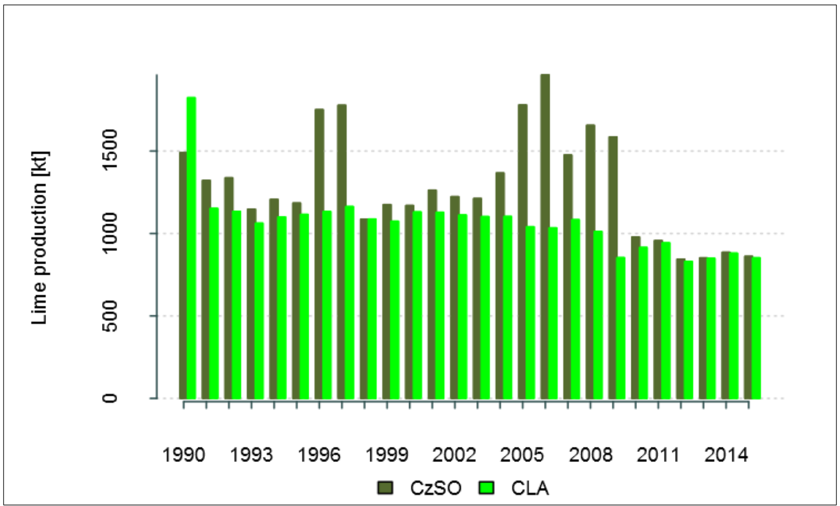



**Fig. 4-5 Comparison of lime production data provided by CzSO and CLA**

The calculations in the lime production category are based on data taken from the EU ETS and Czech Lime Association and are used for verification of the $CO_2$ emissions. The EU ETS reports are proved by independent verifiers. The lime production data provided by the Czech Lime Association are compared with data provided by the Czech Statistical Office. Comparison of lime production data provided by CzSO and CLA is displayed on Fig. 4-5. Emission estimates are compared with the sum of the emissions from technological processes reported by individual kiln operators. The country-specific emission factor was compared with the emission factors used by individual operators for the calculation. Differences in the last year indicate that the country-specific emission factor is slightly overestimated. Verification of this difference is planned for future submissions.

Sector-specific QA/QC plan was formulated, closely related to the QA/QC plan of the National Inventory System.

### 4.2.2.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

No recalculations performed in this submission.

### 4.2.2.6 Source-specific planned improvements, including tracking of those identified in the review process

Since the Tier 3 method is used for emission calculations in this category, no significant improvements are planned.

### 4.2.3 Glass Production (CRF 2.A.3)

$CO_2$ emissions from glass production have increased by 1.46% since 1990. The production of glass reached a maximum value in 2006, equalling 1750 kt. $CO_2$ emissions from 2.A.3 Glass production equalled 125 kt $CO_2$ in 2015.

#### *4.2.3.1 Source category description*

$CO_2$ emissions from Glass Production (2.A.3*)* are derived particularly from the decomposition of alkaline carbonates added to glass-making sand.

#### *4.2.3.2 Methodological issues*

The emission factor value for Tier 1 method of 0.20 t $CO_2$/t glass was taken from the 2006 Guidelines (IPCC, 2006). Cullet ratio of 50% was taken likewise from 2006 Guidelines (IPCC, 2006).

Activity data were collected and published by the Association of the Glass and Ceramic Industry of the Czech Republic in previous years. Starting 2014 submission, the activity data are available and used from CzSO.

Tab. 4-6 lists activity data for glass production, emission factors and $CO_2$ emissions for the whole time series.

**Tab. 4-6 Activity data, $CO_2$ emission factor and $CO_2$ emissions in 2.A.3 Glass Production category in 1990 - 2015**

| | unit | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Glass production** | kt | 1237 | 1060 | 1046 | 1015 | 1097 | 832 | 875 | 970 | 1012 | 1042 |
| **EF $CO_2$** | t $CO_2$/t glass | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| **Emissions $CO_2$** | kt | 124 | 106 | 105 | 101 | 110 | 83 | 88 | 97 | 101 | 104 |

| | unit | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Glass production** | kt | 1197 | 1203 | 1349 | 1416 | 1662 | 1654 | 1750 | 1688 | 1519 | 1329 |
| **EF $CO_2$** | t $CO_2$/t glass | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| **Emissions $CO_2$** | kt | 120 | 120 | 135 | 142 | 166 | 165 | 175 | 169 | 152 | 133 |

| | unit | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| **Glass production** | kt | 1023 | 1381 | 1088 | 1158 | 1119 | 1255 |
| **EF $CO_2$** | t $CO_2$/t glass | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| **Emissions $CO_2$** | kt | 102 | 138 | 109 | 116 | 112 | 125 |

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

The uncertainties for this category are in line with the IPCC 2006 Guidelines (IPCC, 2006), i.e. at the level of 5% for the activity data and 10% for the $CO_2$ emission factor. Overall uncertainty data are given in Chapter 1.7.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2015.

#### *4.2.3.4 Source-specific QA/QC and verification*

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

The data on glass production provided by CzSO were discussed with a representative of the Association of the Glass and Ceramic Industry, who confirmed their reliability.

Sector-specific QA/QC plan is formulated, closely related to the QA/QC plan of the National Inventory System.

#### *4.2.3.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend*

During QC procedures, an error was identified in the activity data for category 2.A.3 Glass production, reported for 2012. The error was corrected. The error in the activity data had no influence on $CO_2$ emissions in this category.

#### *4.2.3.6 Source-specific planned improvements, including tracking of those identified in the review process*

In further submission it is planned to implement EU ETS (European Union Emission Trading System) data which are available since 2010. This data are on Tier 3 level. However this data are not available for the whole time series thus using these data leads to a problem with consistency of the time series. This issue will be resolved in future research in an upcoming submission.

### 4.2.4 Other Process Uses of Carbonates (CRF 2.A.4)

The 2.A.4 category Other Process Uses of Carbonates summarizes, in the Czech Republic, $CO_2$ emissions from 2.A.4.a Ceramics, 2.A.4.b Other uses of Soda Ash and from 2.A.4.d Other. $CO_2$ emissions from Other Process Uses of Carbonates have increased since 1990 by 128.26%.

$CO_2$ emissions from 2.A.4.a Ceramics equalled to 63.95 kt in 2015. The decrease in emissions in 2015 was caused by changes in methodology of laboratory analysis for emission estimates used by one of the ceramics manufacturers in EU ETS. $CO_2$ emissions from 2.A.4.b Other uses of Soda Ash amounted to 1.01 kt $CO_2$ in 2015. $CO_2$ emissions from 2.A.4.d Other amounted to 184.20 kt $CO_2$ in 2015.

#### *4.2.4.1 Source category description*

$CO_2$ emissions from 2.A.4.a Ceramics are derived particularly from the decomposition of alkaline carbonates, fossil and biogenic carbon-based substances included in the raw materials.

$CO_2$ emissions from 2.A.4.b Other Uses of Soda Ash category come from soda ash use for the Glass production category, soda ash is used in only one other installation. $CO_2$ emissions from this category are small and insignificant (varied between 0.1 and 1.1 kt $CO_2$) compared to the other categories.

$CO_2$ emissions from the 2.A.4.d Other category include emissions from mineral wool production and flue-gas desulphurisation. The CRF reporter does not allow separation of these two categories by adding new nodes under Other category 2.A.4.d. Consequently, these two categories are reported collectively.

#### *4.2.4.2 Methodological issues*

The EF value for 2.A.4.a Ceramics was derived from the individual installation data collected for EU ETS (emissions and AD) since 2010. Activity data from CzSO (production) were used for the 1990 - 2010 period and the average of EU ETS emission factors was used for country specific emission factor within the same time frame. The calculation is based on the total production of ceramic products (fine ceramics, tiles, roofing tiles, and bricks) and the emission factor value.

In category 2.A.4.b Other Uses of Soda Ash is considered, that for each mole of soda ash use, one mole of $CO_2$ is emitted, so that the mass of $CO_2$ emitted from the use of soda ash can be estimated from a consideration of the consumption data and the stoichiometry of the chemical process. The data, considering the amount and purity of the soda ash used, were obtained directly from the installation operator.

$CO_2$ emissions from the 2.A.4.d Other category include emissions from mineral wool production and flue-gas desulphurisation. Emissions from mineral wool production are estimated according to Tier 1 methodology, using default EF. Activity data about mineral wool production are obtained by Czech Statistical Office. Activity data are available for time period 2000 - 2002 and 2007 - 2015. Reported amount of $CO_2$ emissions for time period 2003 - 2006 were interpolated.

Emissions from flue-gas desulphurization are obtained from EU ETS forms, which correspond to Tier 3 methodology with CS EF. $CO_2$ emissions from sulphur removal were calculated from coal consumption for electricity production, the sulphur content and the effectiveness of sulphur removal units between 1996, when the first sulphur removal units came into operation, and 2005. In 2005, these data were verified by comparison with data from the individual operators, which were collected for EU ETS preparation and cover the years 1999 - 2005. The EU ETS data form have been used since 2006. The methodology used for estimation of the $CO_2$ emissions must be in accordance with the national legislation (Zákon č. 383/2012 Sb. Zákon o podmínkách obchodování s povolenkami na emise skleníkových plynů /Act No. 383/2012 Coll. The Act on conditions for trading in greenhouse gas emission allowances) and the EU legislation (Commission Decision of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council).

These two categories (mineral wool production and flue-gas desulphurization) are reported collectively in CRF Reporter. Activity data for this category are reported as C (NK), because data from EU ETS are used, and these are confidential.

Tab. 4-7 lists the $CO_2$ emissions in the individual subcategories in 2.A.4 Other Process Uses of Carbonates for time period 1990 - 2015.

**Tab. 4-7 $CO_2$ emissions in individual subcategories in 2.A.4 Other Process Uses of Carbonates category in 1990 - 2015**

| | Category 2.A.4 - $CO_2$ emissions [kt] | | | |
|---|---|---|---|---|
| | 2.A.4.a Ceramics | 2.A.4.b Other uses of Soda Ash | 2.A.4.d Mineral wool production | 2.A.4.d Flue-gas desulphurization |
| **1990** | 109.15 | NO | NO | NO |
| **1991** | 86.26 | NO | NO | NO |
| **1992** | 81.82 | NO | NO | NO |
| **1993** | 101.12 | NO | NO | NO |
| **1994** | 103.83 | NO | NO | NO |
| **1995** | 96.33 | NO | NO | NO |
| **1996** | 118.01 | NO | NO | 76.00 |
| **1997** | 140.79 | NO | NO | 240.63 |
| **1998** | 192.31 | NO | NO | 417.31 |
| **1999** | 139.84 | NO | NO | 536.94 |
| **2000** | 169.70 | NO | 13.08 | 539.69 |
| **2001** | 149.86 | 0.10 | 19.82 | 551.38 |
| **2002** | 108.33 | 0.21 | 25.02 | 551.38 |
| **2003** | 114.87 | 0.33 | 29.03 | 560.04 |
| **2004** | 113.61 | 0.44 | 33.04 | 551.06 |
| **2005** | 135.53 | 0.47 | 37.06 | 588.79 |
| **2006** | 107.24 | 0.35 | 41.07 | 586.55 |
| **2007** | 129.04 | 0.50 | 45.08 | 613.93 |

| Category 2.A.4 - $CO_2$ emissions [kt] | | | | |
|---|---|---|---|---|
| | 2.A.4.a Ceramics | 2.A.4.b Other uses of Soda Ash | 2.A.4.d Mineral wool production | 2.A.4.d Flue-gas desulphurization |
| **2008** | 109.83 | 0.56 | 41.19 | 607.00 |
| **2009** | 90.84 | 0.41 | 39.40 | 600.00 |
| **2010** | 100.47 | 0.86 | 43.57 | 651.00 |
| **2011** | 100.52 | 1.06 | 61.31 | 739.40 |
| **2012** | 101.43 | 1.09 | 41.63 | 698.78 |
| **2013** | 116.93 | 1.03 | 42.83 | 172.88 |
| **2014** | 90.14 | 1.12 | 46.89 | 182.80 |
| **2015** | 63.95 | 1.01 | 47.62 | 136.58 |

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

The uncertainties for this category are in line with the IPCC 2006 Guidelines (IPCC, 2006), i.e. at the level of 5% for the activity data and 10% for the $CO_2$ emission factor. Overall uncertainty data are given in Chapter 1.6.

For 2.A.4.a Ceramics the time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2015.

For 2.A.4.b Other uses of Soda Ash the time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year of 2001, when the use of soda started, to 2015.

For 2.A.4.d Other the time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period for mineral wool production from 2000 to 2015 and for flue-gas desulphurization from 1996 to 2015.

#### *4.2.4.4 Source-specific QA/QC and verification*

The calculations are based on data provided directly by the operators, who verify the data annually. The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

Sector-specific QA/QC plan is formulated, closely related to the QA/QC plan of the National Inventory System.

#### *4.2.4.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend*

Subcategory 2.A.4.a Ceramics was recalculated due to double counting observed between this subcategory and 2.A.4.d Other for the 2010 to 2014 period. Parts of the activity data from 2.A.4.a Ceramics were incorrectly accounted for in 2.A.4.d Other.

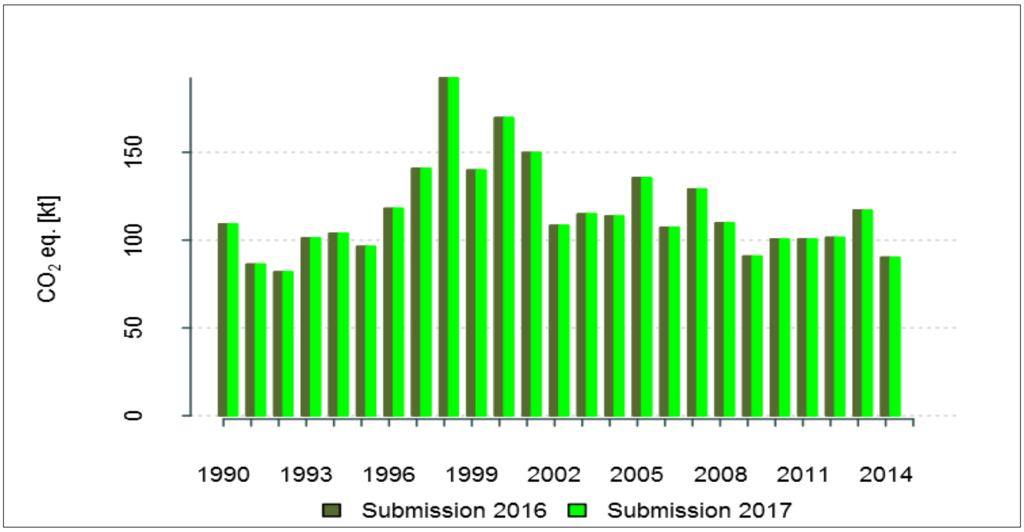



**Fig. 4-6 Recalculation in category 2.A.4.a Ceramics due to double counting**

Subcategory 2.A.4.d Other was recalculated by using activity data on mineral wool production for 2000 - 2003 provided by CzSO. The activity data for 2003 to 2006 are not available. Reported $CO_2$ emissions for these years were interpolated. This subcategory also includes emissions from flue-gas desulphurisation. These emissions were recalculated for the 2013 and 2014 period due to double counting occurring between this subcategory and 2.A.4.a Ceramics.

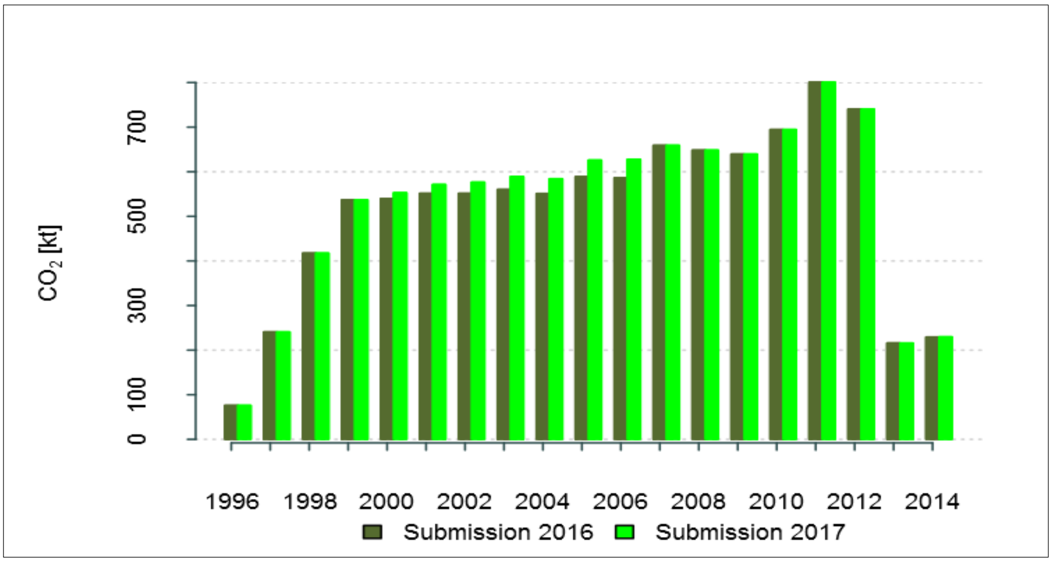



**Fig. 4-7 Recalculation in category 2.A.4.d Other due to new activity data about mineral wool production and due to double counting**

### *4.2.4.6 Source-specific planned improvements, including tracking of those identified in the review process*

It is planned to verify emission estimates with data from the EU ETS system and other available sources. Since plant-specific data and simple stoichiometry are used for computation in this category there is no significant improvement planned in this category.

## 4.3 Chemical Industry (CRF 2.B)

From the categories of sources classified under the Chemical industry (2.B), categories Ammonia Production (2.B.1), Nitric Acid Production (2.B.2), Caprolactam (2.B.4.a), Titanium Dioxide Production (2.B.6), Petrochemical and Carbon Black Production (2.B.8) are relevant for the Czech Republic, while Adipic Acid Production (2.B.3), Glyoxal (2.B.4.b), Glyoxylic Acid (2.B.4.c), Carbide Production (2.B.5), Soda Ash Production (2.B.7) and Fluorochemical Production (2.B.9) are not occurring. The subcategory 2.B.10 Other (please specify) includes two subcategories: Other non-energy use in chemical industry and Non selective catalytic reduction.

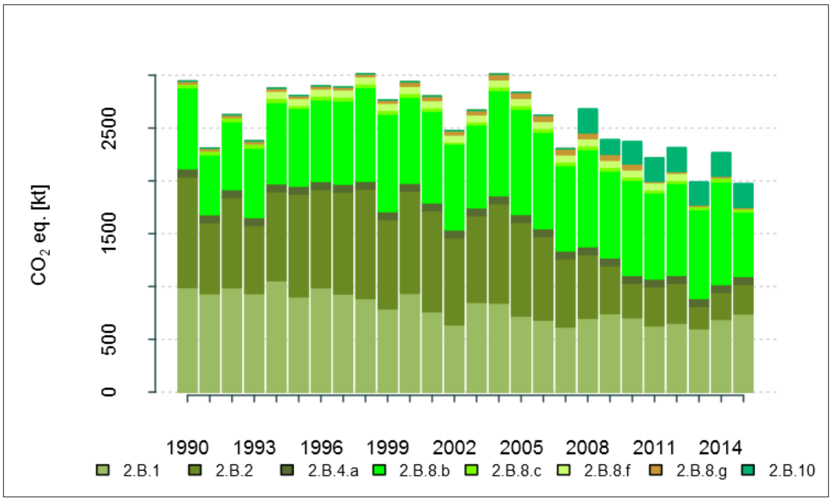



**Fig. 4-8 Trend of emissions from 2.B Chemical Industry and share of specific subcategories [kt $CO_2$ eq.]**

The major share 36.31% belongs to 2.B.8 Petrochemical and Carbon Black Production, 35.81% belongs to 2.B.8 Ammonia Production, 13.52% to 2.B.2 Nitric Acid Production, 10.76% to 2.B.10 Other and 3.60% belongs to 2.B.4.a Caprolactam Production.

$CO_2$ and $CH_4$ emissions in 2.B.8.f are reported as C (confidential) since 2013, similar to $CO_2$ emissions in 2.B.8.g since 2011. The emission trend for the category 2.B Chemical Industry is depicted in Fig. 4-8.

Tab. 4-8 lists the exact amount of $CO_2$ eq. emissions from the individual subcategories in 2.B Chemical Industry for time period 1990 - 2015.

**Tab. 4-8 $CO_2$ eq. emissions in individual subcategories in 2.B Chemical industry category in 1990–2015**

| | Category 2.B - $CO_2$ eq. emissions [kt] | | | | |
|---|---|---|---|---|---|
| | 2.B.1 Ammonia Production | 2.B.2 Nitric Acid Production | 2.B.4.a Caprolactam Production | 2.B.8 Petrochemical and Carbon Black Production | 2.B.10 Other |
| **1990** | 990.8 | 1050.29 | 74.5 | 828.63 | IE |
| **1991** | 933.44 | 673.06 | 74.5 | 628.41 | IE |
| **1992** | 989.89 | 853.9 | 74.5 | 706.5 | IE |
| **1993** | 933.98 | 644.93 | 74.5 | 724.17 | IE |
| **1994** | 1055.82 | 842.51 | 74.5 | 903.61 | IE |
| **1995** | 903.19 | 972.95 | 74.5 | 857.57 | IE |
| **1996** | 989.2 | 932.1 | 74.5 | 902.2 | IE |
| **1997** | 931.15 | 963.55 | 74.5 | 919.89 | IE |
| **1998** | 886.5 | 1036.69 | 74.5 | 1015.73 | IE |
| **1999** | 788.9 | 846.51 | 74.5 | 1056.47 | IE |
| **2000** | 936.02 | 967.79 | 74.5 | 958.76 | IE |
| **2001** | 761.75 | 956.3 | 74.5 | 1009.21 | IE |
| **2002** | 638.58 | 823.26 | 74.5 | 939.43 | IE |
| **2003** | 850.6 | 820.74 | 74.5 | 921.55 | IE |
| **2004** | 843.43 | 942.22 | 74.5 | 1149.93 | IE |
| **2005** | 721.7 | 886.89 | 74.5 | 1154.8 | IE |
| **2006** | 683.27 | 790.51 | 74.5 | 1072.27 | IE |
| **2007** | 617.11 | 646.36 | 74.5 | 965.93 | IE |
| **2008** | 700.21 | 603.31 | 74.5 | 1078.11 | 222.76 |

| | Category 2.B - $CO_2$ eq. emissions [kt] | | | | |
|---|---|---|---|---|---|
| | 2.B.1 Ammonia Production | 2.B.2 Nitric Acid Production | 2.B.4.a Caprolactam Production | 2.B.8 Petrochemical and Carbon Black Production | 2.B.10 Other |
| **2009** | 744.18 | 453.58 | 74.5 | 979.92 | 136.47 |
| **2010** | 705.45 | 326.16 | 74.5 | 1054.79 | 210.16 |
| **2011** | 628.05 | 369.46 | 74.5 | 963.41 | 220.22 |
| **2012** | 653.79 | 377.89 | 74.5 | 1026.28 | 224.54 |
| **2013** | 601.13 | 211.88 | 74.5 | 991.29 | 214.76 |
| **2014** | 689.05 | 255.62 | 74.5 | 1135.02 | 219.52 |
| **2015** | 741.66 | 280.12 | 74.5 | 751.97 | 222.81 |

Tab. 4-9 gives an overview of the emission factors used for computations of emissions in category 2.B Chemical Industry for year 2015.

**Tab. 4-9 Emission factors used for computations of 2015 emissions in category 2.B**

| | Emission factor | Unit | Source or type of EF | Methodology |
|---|---|---|---|---|
| **2.B.1 Ammonia Production** | 3.27 | kt $CO_2$/kt $NH_3$ | CS | Tier 1 |
| **2.B.2 Nitric Acid Production** | 1.67 | kg $N_2O$ / t $HNO_3$ | IEF | Tier 1 |
| **2.B.4 Caprolactam, Glyoxal and Glyoxilic Acid Production** | Constant value of $N_2O$ emissions reported for each year | | | |
| **2.B.8 Petrochemical and Carbon Black production** | 1.90 | t $CO_2$/t ethylene | Default (IPCC, 2006) | Tier 1 |
| | 3.00 | kg $CH_4$/t ethylene | Default (IPCC, 2006) | Tier 1 |
| | 0.29 | t $CO_2$/t VCM | Default (IPCC, 2006) | Tier 1 |
| | 0.02 | t $CH_4$/t VCM | Default (IPCC, 2006) | Tier 1 |
| | 2.62 | t $CO_2$/t carbon black | Default (IPCC, 2006) | Tier 1 |
| | 0.06 | kg $CH_4$/t carbon black | Default (IPCC, 2006) | Tier 1 |
| | C | t $CO_2$/t styrene | CS | Tier 3 |
| | 0.004 | t $CH_4$/t styrene | Default (IPCC, 2006) | Tier 1 |
| **2.B.10 Other** | 2.70 | t $CO_2$/t Other | IEF | Tier 1 |

*The column source or type of EF indicates the way how was the certain emission factor determined. Detailed information for each emission factor is given in the relevant chapters.*

### 4.3.1 Ammonia Production (CRF 2.B.1)

The production of ammonia constitutes an important source of $CO_2$ derived from non-energy use of fuels in the chemical industry. $CO_2$ emissions from ammonia production in 2015 equalled to 741.66 kt of $CO_2$, corresponding to approx. 0.58% of total greenhouse gas emissions without LULUCF. These emissions decreased by 25.15% compared to 1990; however, emissions in period 2005 - 2012 are almost constant, with slight fluctuations. For years 2014 and 2015, slight increase of emissions from ammonia production compare to previous years was noticed. Increase is mainly caused by the end of urea production, which has not been produced since 2014. Ammonia production ($CO_2$ emissions) was identified as a key category in this year's submission.

#### *4.3.1.1 Source category description*

Industrial ammonia production is based on the catalytic reaction between nitrogen and hydrogen:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Nitrogen is obtained by cryogenic rectification of air and hydrogen is prepared using starting materials containing bonded carbon (such as, e.g., Natural Gas, Residual Oil, Heating Oil, etc.). Carbon dioxide is generated in the preparation of these starting materials.

In the Czech Republic, hydrogen for ammonia production is derived from residual oil from petroleum refining, which undergoes partial oxidation in the presence of water vapour. In order to increase the hydrogen production, the second step involves conversion of carbon monoxide, which is formed by partial oxidation, in addition to carbon dioxide and hydrogen. The final products of this two-step process are hydrogen and carbon dioxide. The production technology has practically not changed since 1990.

#### *4.3.1.2 Methodological issues*

Emissions are calculated from the corresponding amount of ammonia produced, using the default emission factor provided in IPCC 2006 Gl. 3.273 kt $CO_2$/kt $NH_3$. This emission factor was obtained from IPCC 2006 Gl. Volume 3, Chapter 3 page 3.15 table 3.1, corresponding to the total fuel requirement, which is 44.65 GJ (NCV)/tonne $NH_3$. Total $CO_2$ emissions from ammonia production where lowered by $CO_2$ used in urea production, consequently / therefore the portion of $CO_2$ emissions to $NH_3$ is not constant as mentioned in the study (Bernauer and Markvart, 2016). The urea production decreased to 1.1 kt for 2013. Since 2014, urea has not been produced in the Czech Republic.

A potential uncertainty in the emission factor for ammonia would not influence the total sum of $CO_2$ emissions, because a corresponding amount of oil is not considered in the energy sector. The relevant activity data and corresponding emissions are given in Tab. 4-10. Related $CO_2$ emissions from ammonia production are reported in Table1.A(d) under Other Oil, which is the feedstock used, as well (please see chapter 3.2.3. for details).

**Tab. 4-10 Activity data and $CO_2$ emissions from ammonia production in 1990 – 2015**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Residual fuel oil used for $NH_3$ product [TJ]** | 14 997 | 14 534 | 14 985 | 14 012 | 15 644 | 13 812 | 14 865 | 13 623 | 14 044 | 11 963 |
| **Ammonia produced [kt]** | 335.86 | 325.51 | 335.59 | 313.8 | 350.35 | 309.32 | 332.91 | 305.1 | 314.52 | 267.91 |
| **$CO_2$ from 2.B.1 [kt]** | 990.80 | 933.44 | 989.89 | 933.98 | 1055.82 | 903.19 | 989.20 | 931.15 | 886.50 | 788.9 |
| **$CO_2$ consumed in urea production [kt]** | 108.48 | 131.94 | 108.48 | 93.09 | 90.89 | 109.22 | 100.42 | 67.44 | 142.94 | 87.96 |

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Residual fuel oil used for $NH_3$ product [TJ]** | 13 690 | 11 522 | 10 052 | 13 084 | 12 987 | 11 326 | 10 802 | 10 119 | 11 453 | 11 793 |
| **Ammonia produced, [kt]** | 306.59 | 258.04 | 225.12 | 293.03 | 290.84 | 253.65 | 241.91 | 226.62 | 256.49 | 264.10 |
| **$CO_2$ from 2.B.1 [kt]** | 936.02 | 761.75 | 638.58 | 850.60 | 843.43 | 721.70 | 683.27 | 617.11 | 700.21 | 744.18 |
| **$CO_2$ consumed in urea production [kt]** | 67.44 | 82.83 | 98.22 | 108.48 | 108.48 | 108.48 | 108.48 | 124.61 | 139.27 | 120.21 |

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| **Residual fuel oil used for $NH_3$ product [TJ]** | 11 484 | 10 278 | 10 659 | 8 212 | 9 400 | 10 118 |
| **Ammonia produced [kt]** | 257.19 | 230.18 | 238.72 | 183.91 | 210.53 | 226.60 |
| **$CO_2$ from 2.B.1 [kt]** | 705.45 | 628.05 | 653.79 | 601.13 | 689.05 | 741.66 |
| **$CO_2$ consumed in urea production [kt]** | 136.34 | 125.34 | 127.54 | 0.81 | NO | NO |

#### 4.3.1.3 Uncertainties and time-series consistency

Uncertainty estimates of activity data and emission factors have been so far based mainly on expert judgment.

In 2014, estimates of the uncertainty parameters were again verified in the study (Bernauer and Markvart, 2015) which, in addition to an expert opinion, also takes into account data given in the 2006 Guidelines (IPCC, 2006). The uncertainty in the activity data remains unchanged at 5% and the uncertainty in the emission factor ($CO_2$ EF) was also left at a value of 7%.

Time series consistency is ensured as the above mentioned methodology are employed identically across the whole reporting period from the base year 1990 to 2015.

#### 4.3.1.4 Source-specific QA/QC and verification

Attention was focused on identifying gaps. Attention was also focused on checking sources from inter-sector boundaries (Energy, Industry) that they are neither omitted nor counted twice. Therefore $CO_2$ emissions from residual oil used for ammonia production are not taken into account in Energy sector. This part of QA/QC procedure is carried out in cooperation with KONEKO marketing, Ltd. (see Chapter 3.6).

According to the QA/QC plan, data and calculations are provided by the external consultants (M. Markvart and B. Bernauer) are checked by the experts from CHMI and vice versa.

#### 4.3.1.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

In this year, no recalculations were performed in this sector.

#### 4.3.1.6 Source-specific planned improvements, including tracking of those identified in the review process

No improvement is planned for the next submission.

### 4.3.2 Nitric Acid Production (CRF 2.B.2)

The production of nitric acid constitutes one of the most important sources of $N_2O$ in the chemical industry. $N_2O$ emissions from production of nitric acid in 2015 equalled to 0.94 kt $N_2O$, corresponding to approx. 0.22% of total greenhouse gas emissions without LULUCF. These emissions have decreased by 73.33% compared to 1990; the substantial decrease in recent years has been a consequence of the gradual introduction of mitigation technology and improving its effectiveness. In 2015, the production of nitric acid ($N_2O$ emissions) was identified as a key category by trend assessment. In this submissions this category was identified as a key source.

#### 4.3.2.1 Source category description

The production of nitric acid is one of the traditional chemical processes in the Czech Republic. It is carried out in three factories, where one of them manufactures more than 60% of the total amount. Nitric acid is produced using the classical method, high-temperature catalytic oxidation of ammonia (Ostwald process) and subsequent absorption of nitrogen oxides in water. Nitrous (dinitrogen) oxide is formed at ammonia oxidation reactor as an unwanted side product.

The nitric acid is manufactured at three pressure levels (at atmospheric pressure, slightly elevated pressure (approx. 0.4 MPa) and at elevated pressure (0.7 - 0.8 MPa). While production processes prior to 2003 mostly progressed at atmospheric pressure and only to a lesser degree at medium elevated pressure, the process at elevated pressure had predominated since 2004.

All the nitric acid production processes in the Czech Republic are equipped with technologies for removal of nitrogen oxides, $NO_X$, based on selective or non-selective catalytic reduction. Non-selective catalytic reduction also makes a substantial contribution to removal of $N_2O$. Since 2004, the technology to reduce $N_2O$ emissions, based on catalytic decomposition of this oxide, has been gradually introduced at units working at elevated pressure. It has been possible to substantially improve the effectiveness of this process in recent years.

### 4.3.2.2 Methodological issues

Nitrous oxide emissions from 2.B.2 Nitric Acid Production are generated as a by-product in the catalytic process of oxidation of ammonia. It follows from domestic studies (Markvart and Bernauer, 1999, 2000, 2003), describing conditions prior to 2004, that the resulting emission factor depends on the technology employed: higher emission factor values are usually given for processes carried out at normal pressure, while lower values are usually given for medium-pressure processes. Two types of processes were carried out in this country before 2004, at pressures of 0.1 MPa and 0.4 MPa. The amount of nitrous oxide in the exit gases is also affected by the type of process employed to remove nitrogen oxides, $NO_X$ (i.e. NO and $NO_2$). In this country, the process of Selective Catalytic Reduction (SCR) is mostly used, which slightly increases the amount of $N_2O$, and also to a certain degree Non-Selective Catalytic Reduction (NSCR), which also removes $N_2O$ to a considerable degree.

Studies (Markvart and Bernauer, 2000, 2003) recommend the following emission factors for various types of production technology and removal processes that are given in Tab. 4-11. The emission factors for the basic process (without $DENO_X$ technology) are in accord with the principles given in the above-cited IPCC methodology. The effect of the $NO_X$ removal technology on the emission factor for $N_2O$ was evaluated on the basis of the balance calculations presented in studies (Markvart and Bernauer, 2000, 2003).

**Tab. 4-11 Emission factors for $N_2O$ recommended by (Markvart and Bernauer, 2000) for 1990 - 2003**

| Pressure in $HNO_3$ production | 0.1 MPa | | | 0.4 MPa | | |
|---|---|---|---|---|---|---|
| **Technology $DENO_X$** | -- | SCR | NSCR | -- | SCR | NSCR |
| **Emission factors $N_2O$ [kg $N_2O$/t $HNO_3$]** | 9.05 | 9.20 | 1.80 | 5.43 | 5.58 | 1.09 |

Collection of activity data for $HNO_3$ production is difficult, because of the present legislation, which complicates the releasing of statistical data on manufactured products where the number of producers is smaller than (or equal to) three. Therefore, it was necessary to obtain them by questioning/interviewing all three producers in the Czech Republic, see (Markvart and Bernauer, 2000, 2003, 2004).

During 2003, conditions changed substantially as a result of the installation of new technologies operating under higher pressure of 0.7 MPa. At the same time, some older units operating under atmospheric pressure of 0.1 MPa were phased out. These changes in technology were monitored in the study of Markvart and Bernauer (Markvart and Bernauer, 2005). This study presents a slightly modified table of $N_2O$ emission factors, while those for new technologies were obtained from a set of continuous emission measurements lasting several months. Other values are based on several discrete measurements. A table of these technology-specific emission factors is given below.

**Tab. 4-12 Emission factors for $N_2O$ recommended by Markvart and Bernauer, for 2004 and thereafter**

| Pressure in $HNO_3$ production | 0.1 MPa | 0.4 MPa | 0.4 MPa | 0.7 MPa |
|---|---|---|---|---|
| **Technology $DENO_X$** | SCR | SCR | NSCR | SCR |
| **Emission factors $N_2O$ [kg $N_2O$/t $HNO_3$]** | 9.05 | 4.9 | 1.09 | 7.8 [a)] |

[a)] *EF without $N_2O$ mitigation. Cases of $N_2O$ mitigation in 2005 -2008 are shown in Tab. 4-11*

In the last quarter of 2005, a new $N_2O$ mitigation unit based on catalytic decomposition of $N_2O$ was experimentally installed for 0.7 MPa technology, and became the most important such unit in the Czech Republic. As a consequence of this technology, the relevant EF decreased from 7.8 to 4.68 kg $N_2O$/t $HNO_3$ (100%). Therefore, the mean value in 2005 for the 0.7 MPa technology was equal to 7.02 kg $N_2O$/t $HNO_3$ (100%), (Markvart and Bernauer, 2006).

In 2006 - 2015, the mitigation unit described above was utilized in a more effective way, see Markvart and Bernauer, 2007 - 2016. The decrease in the emission factor for 0.7 MPa technology as a result of installation of the $N_2O$ mitigation unit and gradual improvement of the effectiveness is given in Tab. 4-13.

Two high temperature $N_2O$ decomposition catalytic systems were used in the above-mentioned high pressure nitric acid technology (0.7 MPa) in 2009; these systems were more efficient in comparison with the catalytic systems used in previous years. The first system consisting of Raschig rings provided by Heraeus was used in the January-June 2009 period and the measured EF $N_2O$ was 3.10 kg $N_2O$/ t $HNO_3$ (100%); in the July-November 2009 period, EF $N_2O$ was 3.30 kg $N_2O$/ t $HNO_3$ (100%). The second system consisting of high temperature $N_2O$ decomposition catalyst developed by YARA company, decreased EF $N_2O$ in the November-December 2009 period to the value 0.95 kg $N_2O$/ t $HNO_3$ (100%) in a high-pressure nitric plant. The catalytic activity of the high temperature decomposition system has decreased slightly due to both increasing selectivity of the Pt-Rh ammonia oxidation catalyst towards $N_2O$ and slow deactivation of the $N_2O$ decomposition catalyst. Thus, the mean value of EF $N_2O$ for this high pressure nitric acid technology in 2009 was assessed at a value of 2.85 kg $N_2O$/ t $HNO_3$ (100%) (Tab. 4-13).

The most efficient decomposition catalyst provided by YARA was used in this high pressure nitric acid technology during whole year of 2010. It is expected that, if high temperature $N_2O$ decomposition catalyst (i.e. YARA catalyst) is employed, the EF $N_2O$ would be approximately close to 1.3 kg $N_2O$/ t $HNO_3$ (100%).

YARA's catalyst, which was also used in 2012, exhibits excellent stability with respect to $N_2O$ conversion and the catalyst efficiency was practically constant during the last three years in the high-pressure (0.7 MPa) nitric acid unit.

**Tab. 4-13 Decrease in the emission factor for 0.7 MPa technology due to installation of the $N_2O$ mitigation unit**

| | 2004 a) | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EF, kg $N_2O$/t $HNO_3$ (100%)** | 7.8 | 7.02 | 5.94 | 4.37 | 4.82 | 2.85 | 1.29 | 1.30 | 1.45 | 1.65 | 2.51 | 2.72 |
| **Effectiveness of mitigation,%** | - | 10 | 23.9 | 43.9 | 38.2 | 63.4 | 83.4 | 83.3 | 81.4 | 78.8 | 67.8 | 65.19 |

[a)] *EF without $N_2O$ mitigation.*

The emission factors used in the Czech Republic are compared with the EFs presented in the IPCC methodology (IPCC, 2006) in the Tab. 4-14.

**Tab. 4-14 Comparison of emission factors for $N_2O$ from $HNO_3$ production**

| Production process | $N_2O$ Emission factor (kg $N_2O$/t 100% $HNO_3$) | Reference |
|---|---|---|
| Plants with NSCR (all processes)<br>Plants with processed integrated or tailgas $N_2O$ destruction<br>Atmospheric presssure plants (low pressure)<br>Medium pressure combustion plants<br>High pressure plants | 2.00 ± 10%<br>2.50 ± 10%<br>5.00 ± 10%<br>7.00 ± 20%<br>9.00 ± 40% | (IPCC, 2006) |
| Czech Republic<br>Atmospheric pressure plants<br>Medium pressure plants with SCR<br>Medium pressure plants with NSCR<br>High pressure plants SCR (no $N_2O$ decomposition)<br>High pressure plants SCR (with $N_2O$ decomposition) | <br>9.05<br>4.90<br>1.09<br>7.80<br>4.82 – 1.29 | (Markvart and Bernauer, 2009, 2010) |

Tab. 4-15 gives the $N_2O$ emissions from production of nitric acid, including the production values.

**Tab. 4-15 Emission trends for $HNO_3$ production and $N_2O$ emissions in 1990-2015**

| | Production of $HNO_3$, [kt $HNO_3$ (100%)] | Emissions of $N_2O$ [kt $N_2O$] from $HNO_3$ production | Implied Emission Factor IEF [Mg $N_2O$/ kt $HNO_3$] |
|---|---|---|---|
| **1990** | 530.00 | 3.52 | 6.65 |
| **1991** | 349.56 | 2.26 | 6.46 |
| **1992** | 439.39 | 2.87 | 6.52 |
| **1993** | 335.95 | 2.16 | 6.44 |
| **1994** | 439.79 | 2.83 | 6.43 |
| **1995** | 505.32 | 3.26 | 6.55 |
| **1996** | 484.80 | 3.13 | 6.45 |
| **1997** | 483.10 | 3.23 | 6.69 |
| **1998** | 532.50 | 3.48 | 6.53 |
| **1999** | 455.00 | 2.84 | 6.24 |
| **2000** | 505.00 | 3.25 | 6.43 |
| **2001** | 505.08 | 3.21 | 6.35 |
| **2002** | 437.14 | 2.76 | 6.32 |
| **2003** | 500.58 | 2.75 | 5.50 |
| **2004** | 533.73 | 3.16 | 5.92 |
| **2005** | 532.21 | 2.98 | 5.59 |
| **2006** | 543.11 | 2.65 | 4.88 |
| **2007** | 554.22 | 2.17 | 3.91 |
| **2008** | 506.96 | 2.02 | 3.99 |
| **2009** | 505.17 | 1.52 | 3.01 |
| **2010** | 441.70 | 1.09 | 2.48 |
| **2011** | 561.82 | 1.24 | 2.21 |
| **2012** | 550.46 | 1.27 | 2.30 |
| **2013** | 514.94 | 0.71 | 1.38 |
| **2014** | 541.02 | 0.86 | 1.56 |
| **2015** | 562.77 | 0.94 | 1.67 |

While the slight fluctuations in IEF to 2004 were caused by slow changes in the relative contributions of the individual technologies with various technologically specific emission factors given in Tab. 4-11 and Tab. 4-12, since 2005 the reduction in IEF has been caused mainly by the gradual increase in the effectiveness of the mitigation units employed for the dominant technology (see Tab. 4-13) to 2010. A further reduction in IEF in 2011 was then caused by an increasing contribution of this dominant technology (0.7 MPa) to 56% of the annual production of $HNO_3$.

#### 4.3.2.3 Uncertainties and time-series consistency

All uncertainty estimates for the activity data and emission factors have so far been based on expert judgment. Their improvement is ongoing and some uncertainty values for $HNO_3$ production have been recently revised and used in the two last submissions: uncertainty in activity data was lowered from 10% to 5% and uncertainty of the mean $N_2O$ EF was lowered from 25% to 20%.

In 2014, the estimates of the uncertainty parameters were again refined on the basis of in the study (Markvart and Bernauer, 2013), which takes into account the data in the 2006 Guidelines (IPCC, 2006). The uncertainty in the activity data following adjustment equalled to 4% and the uncertainty in the average emission factor ($N_2O$ EF) was reduced to 15% in relation to the increasing number of direct measurements.

Time series consistency is ensured as inventory approaches concerned are employed identically across the whole reporting period from the base year of 1990 to 2015.

#### 4.3.2.4 Source-specific QA/QC and verification

The sector-specific QA/QC plan follows from the overall plan described in Chapter 1. According to the QA/QC plan, data and calculations are provided by the external consultants (M. Markvart and B. Bernauer) are checked by the experts from CHMI and vice versa.

Technology-specific methods for $N_2O$ emission estimates have been improved by incorporating direct emission measurements, especially for new technology (0.7 MPa), which is now predominant in the Czech Republic.

#### 4.3.2.5 Source-specific recalculations, including changes made in response to the review process and impact on emissions trend

During QC procedures, an error was identified in the activity data for the category 2.B.2 Nitric Acid production, reported for year 1995. The error in activity data had no influence on $CO_2$ emissions from this category. For category 2.B.2 activity data used for years 2014 and 2015 were obtained from CzSO. Emission estimates are based on data from EU ETS.

#### 4.3.2.6 Source-specific planned improvements, including tracking of those identified in the review process

No improvement is planned for the next submission.

### 4.3.3 Adipic Acid Production (CRF 2.B.3)

Adipic Acid production is not occurring in the Czech Republic.

### 4.3.4 Caprolactam, Glyoxal and Glyoxylic Acid Production (CRF 2.B.4)

#### 4.3.4.1 Source category description

There is only one facility for production of caprolactam in the Czech Republic. Glyoxal and Glyoxylic Acid are not produced in the Czech Republic. Information provided in this chapter is related to caprolactam production.

Caprolactam is prepared by traditional technology from cyclohexanone and hydroxylamine sulphate, which is prepared by the Rasching process. Cyclohexanone reacts with hydroxylamine sulphate yielding cyclohexanonoxime, from which caprolactam is produced by the Beckmann rearrangement. Then caprolactam is isolated from the reaction mixture by neutralisation with ammonium hydroxide.

#### *4.3.4.2 Methodological issues*

As mentioned in the references (Markvart and Bernauer, 2004 – 2013) and (Bernauer and Markvart, 2014 - 2016), there is only one caprolactam production plant in the Czech Republic; this is not a very important source of $N_2O$ emissions. CzSO does not monitor production data on the production of caprolactam; however, the series of studies by Bernauer and Markvart (Bernauer and Markvart, 2014-2016), based on a study in the production factory, yield an approximate value of 0.25 kt $N_2O$ which is reported as a constant value for each year.

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

In relation to the relatively insignificant greenhouse gas emissions from category 2.B.4, uncertainties derived from the sources included in this category have no great impact on the overall uncertainty in the determination of GHG emissions in the Czech Republic. Thus, it does not matter greatly that the uncertainty in emissions from these sources was determined by an expert estimate.

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

In relation to the relatively unimportant greenhouse gas emissions from category 2.B.4, only QC, Tier 1 procedures were used, in accordance with the QA/QC plan.

Data from the EU ETS forms cannot be used for emission estimates because the facility reports all sources of emissions together and thus it is not possible to separate the data for caprolactam. However, according the EU ETS forms of this facility, it can be stated that the emissions from caprolactam production are not greater than the estimated amount of 0.25 kt $N_2O$.

#### *4.3.4.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend*

In this year, no recalculations were performed in this sector.

#### *4.3.4.6 Category-specific planned improvements, including tracking of those identified in the review process*

No improvement is planned for the next submission. Emissions are estimated according a series of studies (Markvart and Bernauer, 2004 – 2013) and (Bernauer and Markvart, 2014 - 2016). Data from EU ETS forms include only the aggregated amount of emissions, which cannot be linked with specific chemicals.

### 4.3.5 Carbide Production (CRF 2.B.5)

Carbides are not produced in the Czech Republic.

### 4.3.6 Titanium Dioxide Production (CRF 2.B.6)

In the Czech Republic titanium dioxide is produced using sulphate route process and as it is stated in the IPCC 2006 Guidelines that this process does not give rise to process greenhouse gas emissions that are of significance.

### 4.3.7 Soda Ash Production (CRF 2.B.7)

Soda Ash is not produced in the Czech Republic.

### 4.3.8 Petrochemical and Carbon Black Production (CRF 2.B.8)

Emissions from category 2.B.8 decreased by 365.76 kt $CO_2$ eq compared to the previous year. This sharp decrease was caused by an accident in the refinery plant with ethylene unit in August of 2015. The accident resulted in an unplanned shutdown of the petrochemical part of the production plant. Category 2.B.8 was identified as a key source.

#### *4.3.8.1 Source category description*

This category includes carbon dioxide and methane emissions from the production of carbon black, ethylene, ethylene dichloride and styrene. These are all less important sources (excluding emission of $CO_2$ from ethylene production).

#### *4.3.8.2 Methodological issues*

Default emissions from the IPCC 2006 Guidelines (IPCC, 2006) are employed to determine carbon dioxide and methane emissions from the production of carbon black, ethylene, ethylene dichloride and styrene. Related $CO_2$ emissions from Petrochemical and Carbon Black Production are reported in Table1.A(d) under Naphtha, which is the major feedstock used, as well (please see chapter 3.2.3. for details).

***$CO_2$ and $CH_4$ emissions from the production of ethylene***

Ethylene in the Czech Republic is produced by pyrolysis of petroleum fractions, composed of a very wide range from fractions of C3-C4 (propane) to the higher boiling fractions. The ethylene unit contains several pyrolysis furnaces that process raw gas (LPG, ethane and propane) and liquids (HCVD - hydrocracked vacuum distillate, naphtha, and in very limited quantities of diesel fuel). Basically, a thermal, non-catalytic fission in the presence of steam is performed and its major products are ethylene, propylene, benzene and C4 fraction. Reliable data for the production of ethylene are available from CzSO. The IPCC methodology provides a value of 1.73 tonnes $CO_2$/tonne ethylene produced (with correction factor 110% for countries of Eastern Europe) and 3 kg $CH_4$/tonne ethylene produced as default emission factors. In the period 1990 – 2015, $CO_2$ emissions varied between 545 to 959 kt $CO_2$ and methane emissions varied between 0.9 and 1.5 kt $CH_4$, detailed values for each year are available in Tab. 4-16.

**Tab. 4-16 Emission trends from $CO_2$ and $CH_4$ emissions from production of ethylene in 1990-2015**

| | Category 2.B.8.b | | |
|---|---|---|---|
| | Ethylene Production [kt] | $CO_2$ Emissions [kt] | $CH_4$ Emissions [kt] |
| **1990** | 388.02 | 738.40 | 1.16 |
| **1991** | 286.45 | 545.12 | 0.86 |
| **1992** | 325.37 | 619.17 | 0.98 |
| **1993** | 332.68 | 633.10 | 1.00 |
| **1994** | 389.53 | 741.28 | 1.17 |
| **1995** | 373.34 | 710.47 | 1.12 |
| **1996** | 390.80 | 743.69 | 1.17 |
| **1997** | 399.09 | 759.46 | 1.20 |
| **1998** | 448.94 | 854.34 | 1.35 |
| **1999** | 466.32 | 887.40 | 1.40 |
| **2000** | 411.66 | 783.39 | 1.23 |
| **2001** | 439.16 | 835.72 | 1.32 |
| **2002** | 412.12 | 784.26 | 1.24 |
| **2003** | 396.88 | 755.27 | 1.19 |
| **2004** | 503.86 | 958.85 | 1.51 |
| **2005** | 503.86 | 958.85 | 1.51 |
| **2006** | 462.14 | 879.46 | 1.39 |
| **2007** | 408.55 | 777.47 | 1.23 |
| **2008** | 464.73 | 884.38 | 1.39 |
| **2009** | 416.10 | 791.83 | 1.25 |
| **2010** | 454.97 | 865.80 | 1.36 |
| **2011** | 412.07 | 784.17 | 1.24 |
| **2012** | 441.08 | 839.37 | 1.32 |
| **2013** | 425.62 | 809.95 | 1.28 |
| **2014** | 491.50 | 935.32 | 1.47 |
| **2015** | 308.44 | 586.96 | 0.93 |

### *$CO_2$ and $CH_4$ emissions from the production of ethylene dichloride*

1,2-dichloroethane known, also as ethylene dichloride, is produced in the Czech Republic at the same integrated facility as vinyl chloride monomer (VCM), which is subsequently used for PVC production (Bernauer and Markvart, 2016). The data on production of PVC are obtained from CzSO. While CzSO does not publish information on the amount of VCM, it does give data on the amount of PVC produced, which are practically the same as VCM data. The IPCC 2006 Guidelines methodology provides a value of emissions of carbon dioxide 0.294 tonne $CO_2$/tonne VCM produced and for methane 0.0226 kg $CH_4$/tonne VMC produced as default emission factors. Carbon dioxide emissions varied in the period 1990 - 2015 between 16.7 kt $CO_2$ and 40.3 kt $CO_2$. Due to the low emission factors' value, the values of methane emissions varied in the period 1990 – 2015 between 0.001 and 0.003 kt $CH_4$, which is considered as insignificant value. In 2015, emissions of carbon dioxide equalled to 29.57 kt and methane emissions equalled to 0.0023 kt $CH_4$.

### *$CO_2$ and $CH_4$ emissions from the production of carbon black*

The production of carbon black is approximately 26 kt of  p.a.  Exact information on activity data is available since 2013; thus, the data for other years were taken from the study (Bernauer and Markvart, 2016).  Since 2013, the activity data and $CO_2$ emissions have been based on data from EU ETS. In the Czech Republic, only one facility is involved in carbon black production and thus the activity data and emissions are reported as confidential C (NK) in the CRF reporter. Data are available for review experts in calculation sheets upon a request. The emission factor taken from the IPCC 2006 Gl. methodology equals to 0.06 kg $CH_4$/tonne carbon black produced and 2.62 t $CO_2$ /t carbon black produced. The highest value of methane emissions over the past few years is practically insignificant (0.00153 kt).

***$CO_2$ and $CH_4$ emissions from the production of styrene***

Because of the growing consumption of polystyrene, the production of styrene has gradually increased since 1990. CzSO also does not publish any information on the production of styrene. Thus, the necessary activity data were estimated on the basis of production capacities:

| | |
|---|---|
| 1990 - 1998 | 70 kt styrene p.a. |
| 1999 | 80 kt styrene p.a. |
| 2000 - 2003 | 110 kt styrene p.a. |
| 2004 | 140 kt styrene p.a. |
| 2005 - 2010 | 150 kt styrene p.a. |
| from 2011 | exact production from EU ETS forms |

These estimates on the amount of styrene produced, mentioned in the study (Bernauer and Markvart, 2016), are based on the data given in the article (Dvořák and Novák, 2010). The emission factor taken from the IPCC methodology equals to 0.004 kt $CH_4$/kt styrene. The emission factor for $CO_2$ emissions is 0.27 kt $CO_2$/kt styrene (Bernauer and Markvart, 2015). Since 2011, activity data and $CO_2$ emissions are based on data from EU ETS. In the Czech Republic, only one facility is involved in production of styrene, thus the activity data and emissions are reported as confidential C (NK) in CRF reporter. Data are available for review experts in calculation sheets upon a request.

In the period 1990 - 2015, methane emissions varied between 0.3 and 0.7 kt $CH_4$ and carbon dioxide emissions varied between 18.9 and 45.9 kt $CO_2$.

#### 4.3.8.3 Uncertainties and time-series consistency

In relation to the relatively insignificant greenhouse gas emissions from category 2.B.8, uncertainties derived from the sources included in this category have no great impact on the overall uncertainty in the determination of GHG emissions in the Czech Republic. Thus, it does not matter greatly that the uncertainty in emissions from these sources was determined by an expert estimate.

Time series consistency is ensured as inventory approaches concerned are employed identically across the whole reporting period for each subcategories.

#### 4.3.8.4 Source-specific QA/QC and verification

In relation to the relatively unimportant greenhouse gas emissions from category 2.B.8, only QC, Tier 1 procedures were used, in accordance with the QA/QC plan.

#### 4.3.8.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

During the QC procedures, an error was identified in the activity data for subcategory 2.B.8.g Other, reported for 2010. The error in the activity data had no influence on reported $CO_2$ emissions in this category.

#### 4.3.8.6 Source-specific planned improvements, including tracking of those identified in the review process

No improvements are planned.

### 4.3.9 Fluorochemical Production (2.B.9)

Fluorinates are not produced in the Czech Republic.

### 4.3.10 Other (2.B.10)

$CO_2$ emissions from category 2.B.10, which includes other non-energy use in chemical industry and non-selective catalytic reduction equalled to 222.81 kt $CO_2$ in 2015.

#### *4.3.10.1 Source category description*

Subcategory 2.B.10 Other is divided into two subcategories. The first sub-category includes $CO_2$ emissions from non-selective catalytic reduction (NSCR) of output gases from nitric acid production; the second one includes emissions for hydrogen production by steam reforming in the petrochemical and chemical industry (excluding hydrogen used for $NH_3$ production, which is based on other feedstock than NG, see section 4.3.1). Emissions from NSCR are not very significant (about 15 kt of $CO_2$). Emissions from steam reforming of NG are somewhat more significant (about 200 kt of $CO_2$)).

#### *4.3.10.2 Methodological issues*

Subcategory 2.B.10 Other includes $CO_2$ emissions from non-energy use of natural gas (NG) in the chemical industry since 2008, when CzSO began to report activity data for NG consumption in the chemical industry for non-energy use separately from energy use. Only aggregated data for non-energy and energy use of NG are available for the 1990 – 2007 period. Therefore all $CO_2$ emissions from NG in the chemical industry for the 1990 – 2007 period are reported under 1.A.2.c (combustion in chemical industry). Owing to the lack of reliable information concerning processes of non-energy use of NG in the chemical industry, this way of reporting emissions under 1.A.2.c continued until the 2014 submission.

Thanks to intensive consultation with experts from CzSO and the Institute of Chemical Technology in Prague (VSCHT), it is now possible to reliably specify emissions from non-energy use and thus reallocate activity data, which were reported under 1.A.2.c in previous submissions, in accordance with IPCC 2006 Gl.

Tab. 4-17 gives an overview of the $CO_2$ emissions from category 2.B.10 Other. Related $CO_2$ emissions from 2.B.10 are reported in Table1.A(d) under Natural Gas as well (please see chapter 3.2.3. for details).

**Tab. 4-17 Emission trends for category 2.B.10 Other in 2008-2015**

| | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| **Other non-energy use in chemical industry** | $CO_2$ emissions [kt] | 208.34 | 123.08 | 195.74 | 206.72 | 210.01 | 201.27 | 204.75 | 206.97 |
| **Non selective catalytic reduction** | $CO_2$ emissions [kt] | 14.42 | 13.39 | 14.42 | 13.49 | 14.52 | 13.49 | 14.77 | 15.83 |

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

The uncertainty of the activity data and emission factors used for computations of emissions from category 2.B. 10 correspond to the uncertainty estimates from the Energy sector, category 1.A.2 Manufacturing industries and construction. The uncertainties are for this category are in line with IPCC 2006 Guidelines (IPCC,2006), i.e. at the level of 3% for the activity data and 2.5% for the emission factor.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from 2008 to 2015.

#### *4.3.10.4 Source-specific QA/QC and verification*

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

Data and calculations are provided by the external consultants, calculations are checked by the experts from CHMI and vice versa.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

#### *4.3.10.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend*

In this year, no recalculations were performed in this sector.

#### *4.3.10.6 Source-specific planned improvements, including tracking of those identified in the review process*

In further submissions it is planned to investigate the possibility of disaggregating data for non-energy and energy use of NG for the 1990-2007 period. $CO_2$ emissions from NG in the chemical industry were reported for this period under 1.A.2.c.

## 4.4 Metal Industry (CRF 2.C)

This category includes mainly $CO_2$ emissions from 2.C.1 Iron and Steel Production, 99.8% of $CO_2$ emissions arise from 2.C.1. $CO_2$ emissions from iron and steel are identified as a key category (by both level and trend assessments). A small amount of $CH_4$ is also emitted. Ferro-alloys were manufactured in limited amounts in a small production unit in the Czech Republic; this process could constitute an unsubstantial source of $CO_2$ emissions. This year specific data were obtained straight from the operator – there is only one producer of ferrovanadium. For the production of Lead and Zinc data are also obtained straight from the operators, however there is only one producer of secondary lead and one producer of zinc.

Investigation revealed one smaller production plant, which reported that aluminium was used as a reducing agent; this did not lead to $CO_2$ emissions. In 2009 this production was stopped.

### 4.4.1 Iron and Steel Production (CRF 2.C.1)

#### *4.4.1.1 Category description*

Iron is produced in the Czech Republic in two large metallurgical facilities located in the cities of Ostrava and Třinec in the Moravian-Silesian Region, in the north-eastern part of the Czech Republic. Both these metallurgical works employ blast furnaces and also lines for the production of steel, coking furnaces and other supplementary technical units. Another large steel plant is located immediately next to the metallurgical works in Ostrava, taking raw iron (in the liquid state) from the nearby blast furnaces (located in the area of the Ostrava metallurgical works).

2.C.1. was identified as key category in this submission.

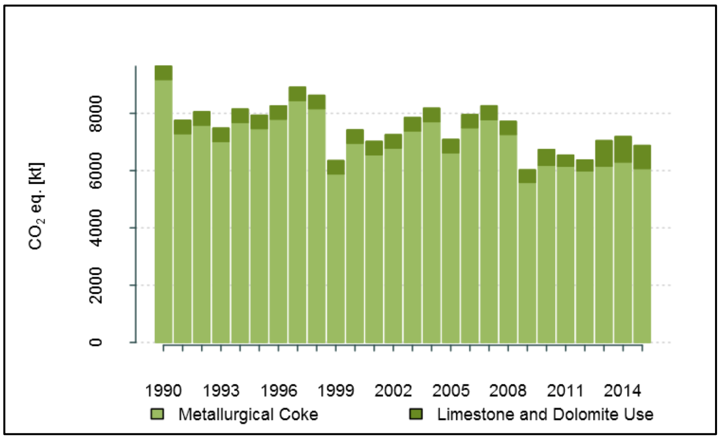



**Fig. 4-9 Trend of $CO_2$ emissions in 2.C.1, 1990 – 2015 [kt $CO_2$]**

### *4.4.1.2 Methodological issues*

The $CO_2$ emissions from iron and steel production were calculated using the national approach which can be considered as Tier 2. However, Tier 2 emission estimations based in IPCC 2006 Guidelines (IPCC, 2006) include recommendations to also include emissions arising from combustion of Blast Furnace and Oxygen Steel Furnace Gas in other than metallurgical complexes (for instance in Energy category 1.A.1.a). However, it is expected in the Czech Republic that all Blast Furnace and Oxygen Steel Furnace Gases are combusted directly in the metallurgical complexes. This means that the national approach to emission estimations contains a few aspects from Tier 1, as some parts of the equation are available for the computation. An important aspect of the computation is the amount of carbon in the reducing agent (i.e. in metallurgical coke) and thus also the amount of carbon in scrap and in steel. Further, small amount of Bituminous Coal in 2014 and 2015 was also used as reducing agent in the blast furnace, as well as Coal Tar in years 2007 till 2013. Thus, the approach used is considered to be as close to Tier 2 based on IPCC 2006 Gl. (IPCC, 2006) as possible.

The calculation in IPCC 2006 Gl. (IPCC, 2006) also includes $CO_2$ emissions from limestone and dolomite used in iron and steel metallurgy. Since the 2015 submission, these emissions have been reported under 2.C.1. Data reported under EU ETS were used for these emissions, i.e. Tier 3.

The computational approach as well as the parameters used were consulted in general with a representative of The Steel Federation, Inc. Related $CO_2$ emissions from 2.C.1 are reported in Table1.A(d) under Coke Oven Coke (1990-2015), Other bituminous coal (2014-2015) and Coal Tar as well (2007-2013) as well (please see chapter 3.2.3. for details).

**Tab. 4-18 The amounts of metallurgical coke consumed and $CO_2$ emissions in 1990 – 2015**

| | Coke consumed in blast furnaces | Other Bituminous Coal | Coal Tar | Use of limestone and dolomite | $CO_2$ from 2.C.1 [kt] |
|---|---|---|---|---|---|
| **1990** | 3211 | NO | NO | 891.04 | 9180.08 |
| **1991** | 2559 | NO | NO | 891.03 | 7288.52 |
| **1992** | 2624 | NO | NO | 891.03 | 7586.98 |
| **1993** | 2426 | NO | NO | 891.04 | 7017.23 |
| **1994** | 2663 | NO | NO | 891.03 | 7681.43 |
| **1995** | 2587 | NO | NO | 891.04 | 7468.43 |
| **1996** | 2701 | NO | NO | 891.05 | 7794.96 |
| **1997** | 2846 | NO | NO | 891.01 | 8445.47 |
| **1998** | 2750 | NO | NO | 891.05 | 8163.11 |
| **1999** | 1941 | NO | NO | 891.08 | 5884.38 |
| **2000** | 2327 | NO | NO | 890.88 | 6955.91 |

| | Coke consumed in blast furnaces | Other Bituminous Coal | Coal Tar | Use of limestone and dolomite | $CO_2$ from 2.C.1 [kt] |
|---|---|---|---|---|---|
| **2001** | 2175 | NO | NO | 891.20 | 6554.08 |
| **2002** | 2252 | NO | NO | 891.16 | 6788.61 |
| **2003** | 2459 | NO | NO | 890.29 | 7385.89 |
| **2004** | 2628 | NO | NO | 892.15 | 7710.92 |
| **2005** | 2260 | NO | NO | 891.06 | 6622.17 |
| **2006** | 2480 | NO | NO | 887.65 | 7497.33 |
| **2007** | 2570 | NO | 35 | 897.73 | 7780.79 |
| **2008** | 2366 | NO | 59 | 887.78 | 7262.12 |
| **2009** | 1801 | NO | 56 | 877.45 | 5588.83 |
| **2010** | 2082 | NO | 33 | 927.97 | 6187.50 |
| **2011** | 2086 | NO | 26 | 857.92 | 6156.34 |
| **2012** | 2007 | NO | 23 | 846.47 | 5992.92 |
| **2013** | 2057 | NO | 7 | 1079.53 | 6159.04 |
| **2014** | 1886 | 276 | NO | 1051.93 | 6298.91 |
| **2015** | 1780 | 300 | NO | 947.59 | 6071.42 |

The amounts of blast furnace coke consumed and corresponding emissions are given in Tab. 4-18.

Estimation of $CH_4$ from metal production is based on the IPCC 2006 Guidelines Tier 1 methodology. Default emission factors 0.1 g $CH_4$ per tonne of coke produced and 0.07 kg $CH_4$ per tonne of sinter produced were used. In this case, the relevant activity data correspond to the amount of coke produced from the Energy Balances of the CR are given in CRF Tables and official statics data of sinter produced.

Emission estimates of precursors for the relevant subcategories have been transferred from NFR to CRF, as described in previous chapters and in Chapter 9.

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

The uncertainty estimates have so far been based on expert judgment. Their improvement is ongoing and some uncertainty estimates for Iron and steel production have been revised in previous submissions (CHMI, 2012b). The new estimate of EF ($CO_2$) is now 10%, which is in accordance with the 2006 Guidelines (IPCC, 2006) and is slightly higher than the former value (5%). The estimate for AD (7%) remained unchanged, because this value is in good agreement with the recommendation in the Regulation of Commission (EU) No. 601/2012 (EU, 2012). Further improvement of uncertainty estimates is planned for the next submission.

Consistency of the time series is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year of 1990 to 2015.

#### *4.4.1.4 Source-specific QA/QC and verification*

The sector-specific QA/QC plan follows from the overall plan described in Chapter 1. The greatest attention was focused on identifying gaps and imperfections using the new reporting software (CRF Reporter), specifically by observing trends in figures and by checking IEFs. Attention was also focused on checking sources from inter-sector boundaries (Energy, Industry) that they are neither omitted nor counted twice. $CO_2$ emissions from coke used in blast furnaces are not considered in Energy sector (see Chapter 3.2).

Activity data available in the official CzSO materials in relation to QA/QC were independently determined by experts from CHMI and KONEKO and were mutually compared. Experts at CHMI additionally checked most of the calculations carried out by experts at KONEKO and vice versa. For another QA, especially QA of computational approach, is also used former coordinator of National Inventory System.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

#### 4.4.1.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

The CzSO provided quite extensive updated in the activity data, which yield to the recalculation of this category. There are updated data of coke used in blast furnaces in 2009 till 2014, as well as newly included data for bituminous coal and coal tar used as reducing agent. The amount of coal tar and bituminous coal used in blast furnaces used as reducing agent is in comparison to the amount of coke negligible. Fig. 4-10 represents change of data after the recalculation. Affected years are 2007-2014.

The data of Limestone and Dolomite use in 2.C.1 remains unchanged.

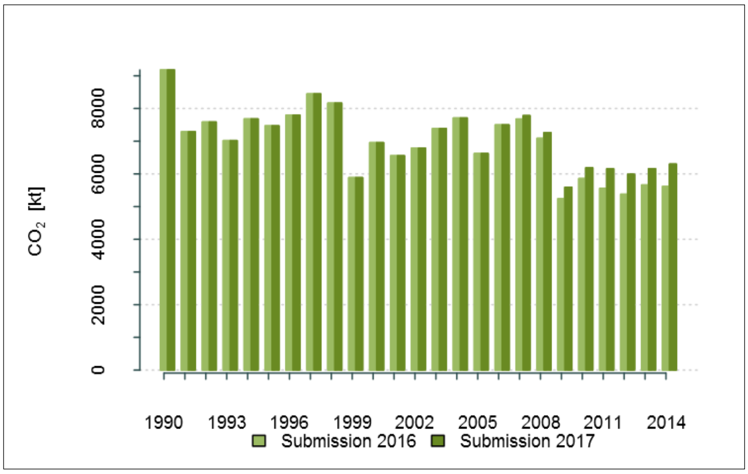



**Fig. 4-10 Recalculation in 2.C.1 after the change of activity data of reducing agents**

#### 4.4.1.6 Source-specific planned improvements, including tracking of those identified in the review process

In future submissions is planned to investigate data relevant for potential implementation of Tier 3 methodology in this category. Specific steps were already taken in 2016, however the issue need further detailed activity data, which will be discussed with relevant representatives.

### 4.4.2 Ferroalloys Production (CRF 2.C.2)

#### 4.4.2.1 Source category description

Ferroalloys Production is production of concentrated alloys of iron and or more metals such as silicon, manganese, chromium, molybdenum, vanadium and tungsten. In the Czech Republic is only one producer of ferrovanadium. Therefore, activity data are reported as confidential.

#### 4.4.2.2 Methodological issues

The activity data were obtained straight from the operator, where ferrovanadium is produced. IPCC 2006 Guidelines (IPCC, 2006) does not provide emission factors of this type of ferroalloy. However, IPCC 2006 Guidelines provides emission factors based on specific share of Si in the ferroalloy. Chemical composition of the ferrovanadium produced in the Czech republic is known. Using the simple proportion rule, emission factors were calculated for $CO_2$, as well as for $CH_4$. This can be considered as conservative approach.

**Tab. 4-19 Evaluation of emission factors used for 2.C.2 emission estimates**

| Composition of ferrovanadium | | IPCC 2006 Gls. EF | | EF $CO_2$ (1.5% od Si) | EF $CH_4$ (1.5% od Si) |
|---|---|---|---|---|---|
| **Vanadium** | 75-85% | FeSi 45% Si | 2.5 | 0.083333*) | |
| **Aluminum** | 1.5% max | FeSli 65% Si | 3.6 | 0.083077 | 0.023077*) |
| **Silicon** | 1.5% max | FeSi 75%Si | 4 | 0.08 | 0.02 |
| **Carbon** | 0.25% max. | FeSi90%Si | 4.8 | 0.08 | 0.018333 |
| **Phosphorus** | 0.08% max. | | | | |
| **Sulfur** | 0.08% max. | | | | |

**)emission factors used for computation*

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

Since default emission factors were used for emission computations, the uncertainty of emission factors were considered default, i.e. provided in table 4.9 in IPCC 2006 Guidelines (IPCC, 2006) as 25%. The uncertainty of activity data is estimated on the level of 5%.

### 4.4.2.4 *Source-specific QA/QC and verification*

The sector-specific QA/QC plan follows from the overall plan described in Chapter 1. General QC procedures were applied in this sector. The activity data and composition of ferroalloys were discussed with representative of The Steel Federation, Inc.

### 4.4.2.5 *Source-specific recalculations, including changes made in response to the review process and impact on emission trend*

Update activity data were obtained straight from the operator. Further, emission factors were updated since the type of ferroalloy is known since this submission. This affects whole time series emission estimates. Fig. 4-11 represents data before and after the recalculation.

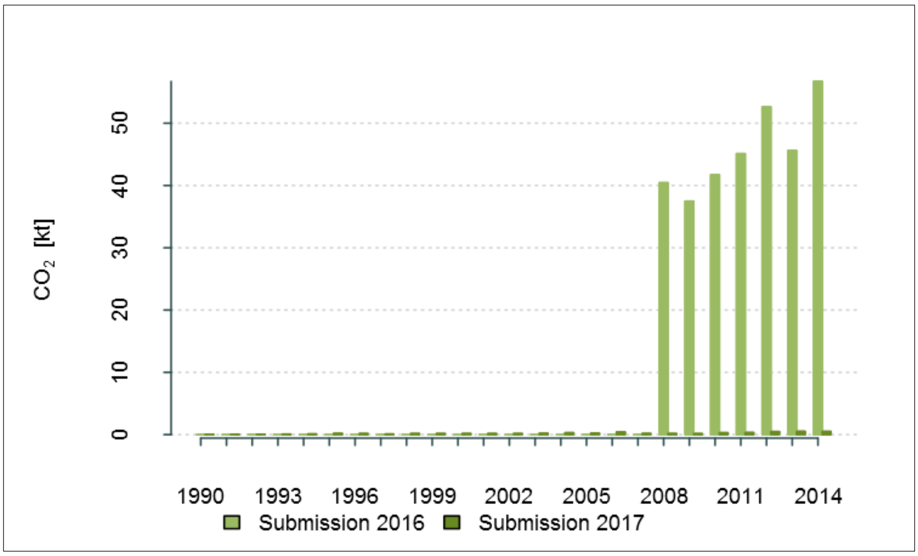



**Fig. 4-11 Recalculation in 2.C.2**

#### 4.4.2.6 Source-specific planned improvements, including tracking of those identified in the review process

Further investigation of activity data is planned for the future submissions.

### 4.4.3 Lead Production (2.C.5)

#### 4.4.3.1 Source category description

In the Czech Republic there is no primary production of lead, however secondary production and recycling is happening. There is one installation specialised for this production.

#### 4.4.3.2 Methodological issues

Research was performed on potential Lead producers in the Czech Republic. The data were obtained straight from the operator; the data has to be displayed as confidential. The $CO_2$ emissions were estimated at the level of Tier 1 methodology based on the IPCC 2006 Guidelines (IPCC, 2006) using the default $CO_2$ emission factor 0.2 t $CO_2$/t of lead. $CO_2$ emissions in 2015 equalled 8.8 kt.

#### 4.4.3.3 Uncertainties and time-series consistency

Since default emission factors were used for emission computations, the uncertainties were based in IPCC 2006 Gl. recommendation, i.e. 10% for activity data and 50% for emission factor.

#### 4.4.3.4 Source-specific QA/QC and verification

The sector-specific QA/QC plan follows from the overall plan described in Chapter 1. General QC procedures were applied in this sector. The activity data and composition of ferroalloys were discussed with representative of The Steel Federation, Inc.

#### 4.4.3.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

Update activity data were obtained straight from the operator and the category were consequently recalculated. Also following the potential problem after UNFCCC review in 2016 the emission factor was updated to the default emission factor for secondary lead production. Fig. 4-12 represents the impact of the recalculations.

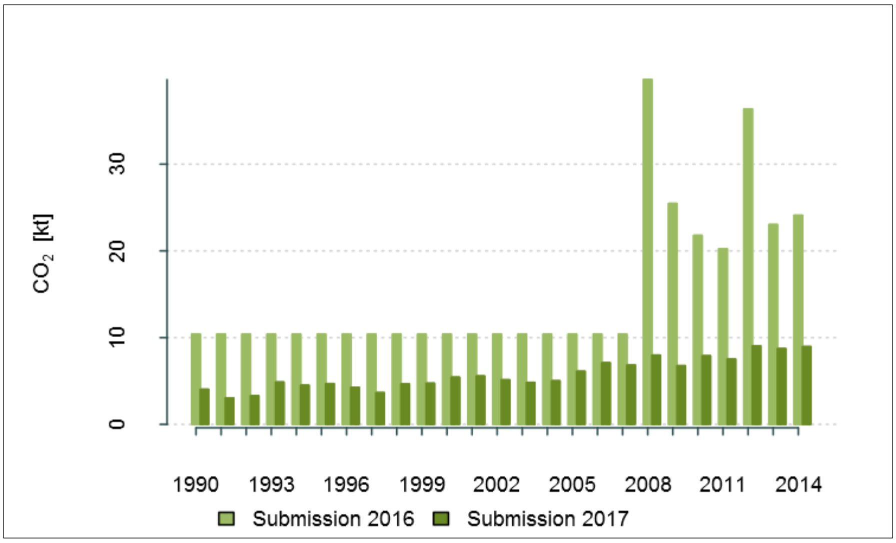



**Fig. 4-12 Recalculation in 2.C.5**

#### 4.4.3.6 Source-specific planned improvements, including tracking of those identified in the review process

No improvement are planned in the moment for this category.

### 4.4.4 Zinc Production (2.C.6)

#### 4.4.4.1 Source category description

There is no primary production of Zinc in the Czech Republic, however secondary production is occurring. The reported emission are all from secondary production, there is one producer of zinc, which is operating since 1998.

#### 4.4.4.2 Methodological issues

The research of potential Zinc producers in the Czech Republic were performed. Detailed data were obtained straight from the operator, the data has to be displayed as confidential. The $CO_2$ emissions were estimated on the level Tier 1 methodology based on IPCC 2006 Guidelines (IPCC, 2006) using default $CO_2$ emission factor 1.72 t $CO_2$/t of zinc. $CO_2$ emissions in 2015 equalled 0.41 kt, which presents negligible share in the whole inventory.

#### 4.4.4.3 Uncertainties and time-series consistency

Since default emission factors were used for emission computations, the uncertainties were based in IPCC 2006 Gl. recommendation, i.e. 10% for activity data and 50% for emission factor.

#### 4.4.4.4 Source-specific QA/QC and verification

The sector-specific QA/QC plan follows from the overall plan described in Chapter 1. General QC procedures were applied in this sector.

### 4.4.4.5 *Source-specific recalculations, including changes made in response to the review process and impact on emission trend*

Recalculation due to new obtained activity data was performed for 1998 - 2014. The transparency of reporting was increased due to this recalculation.

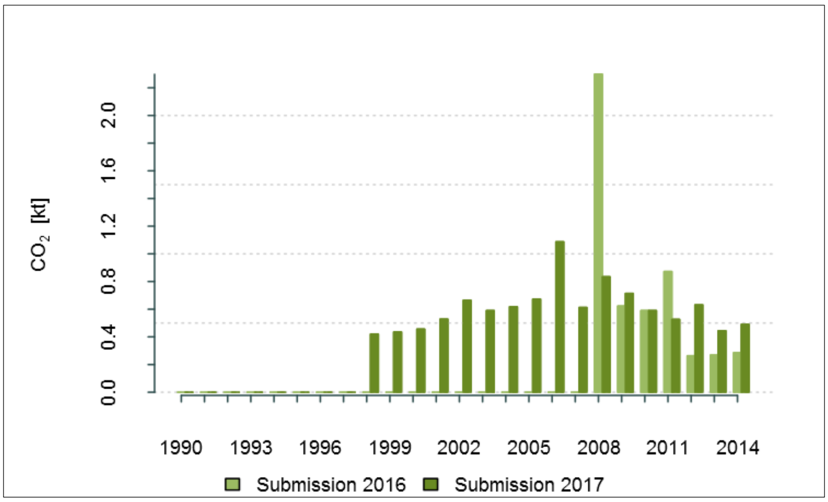



**Fig. 4-13 Recalculation in 2.C.6**

### 4.4.4.6 *Source-specific planned improvements, including tracking of those identified in the review process*

In future submissions is planned further investigation of activity data.

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

This subcategory includes the emissions from the first use of fossil fuels as products, where their primary use is other than combustion for energy production or use as a reducing agent in industrial processes.

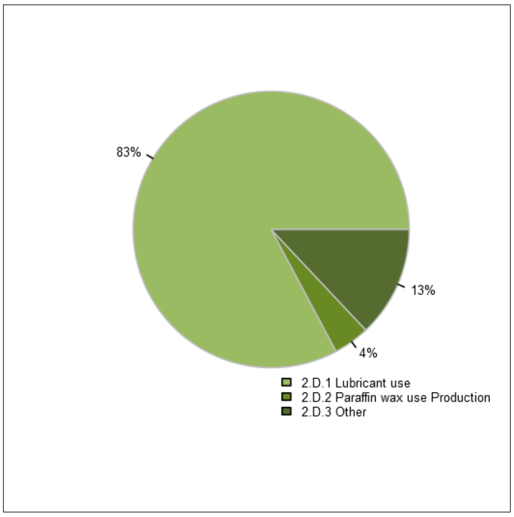



**Fig. 4-14 The share of individual subcategories for $CO_2$ emissions in 2.D in 2015 [kt $CO_2$]**

Products reported in this subcategory include Lubricants, Paraffins, Asphalts and Solvents. Emissions from other (secondary) use or disposal of these products are included in the relevant sectors (e.g. Energy, Waste).

Fig. 4-14 shows the share of individual subcategories in 2.D. 83% of 2.D $CO_2$ emissions are produced from Lubricant Use, followed by Urea used as catalysts (13%) and the use of Paraffin Wax (4%).

### 4.5.1 Lubricant Use (2.D.1)

#### *4.5.1.1 Source category description*

Lubricants are produced from refining of crude oil in petrochemical installations. There can be distinguished between engine oils and industrial oil or grease.

#### *4.5.1.2 Methodological issues*

The activity data are provided by CzSO in the official Energy balance of the Czech Republic. The non-energy use of fuels is also included. The amount of lubricants used for other than energy production is included in this category as activity data.

Tier 1 methodology from the IPCC 2006 Guidelines was used for $CO_2$ emission estimations. The default emission factor 20 kg C/GJ was used; the Oxidised During Use (ODU) factor was used as a default value equal to 0.2. $CO_2$ emissions from this category in 2015 were equal to 115.5 kt $CO_2$. Related $CO_2$ emissions from 2.D.1 are reported in Table1.A(d) under Lubricants as well (please see chapter 3.2.3. for details).

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

Since the activity data used are from official statics, the suggested 5% uncertainty (IPCC, 2006) was applied for this category. Since default ODU factor was used, suggested 50% uncertainty from IPCC 2006 Gl. was applied for emission factor uncertainty.

#### *4.5.1.4 Source-specific QA/QC and verification*

Standard QA/QC procedures were applied for this subcategory. Special attention was paid to cross-sectoral issues (Energy x IPPU), so no emissions are omitted, nor counted twice.

#### *4.5.1.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend*

No recalculation performed in this submission.

#### *4.5.1.6 Source-specific planned improvements, including tracking of those identified in the review process*

No improvements are planned in this subcategory.

### 4.5.2 Paraffin Wax Use (2.D.2)

#### *4.5.2.1 Source category description*

This category includes use of products separated from fossil fuels called paraffins, waxes or vaseline. From chemical point of view they are mixtures of solid paraffinated hydrocarbons obtained from crude oils. Different types are characterised by point of solidification and amount of oil contained.

#### *4.5.2.2 Methodological issues*

Activity data reported in official Energy balance of CzSO as non-energy use are used for emission estimation in this category. Tier 1 methodology from IPCC 2006 Guidelines was used for $CO_2$ emission estimation. Default emission factor 20 kg C/GJ was used, Oxidised During Use (ODU) factor was used default equal to 0.2. $CO_2$ emissions in 2015 from this category were equal to 5.9 kt $CO_2$.

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

Since the activity data used are from official statics, the suggested 5% uncertainty (IPCC, 2006) was applied for this category. Since default ODU factor was used, suggested 50% uncertainty from IPCC 2006 Gl. was applied for emission factor uncertainty.

#### *4.5.2.4 Source-specific QA/QC and verification*

Standard QA/QC procedures were applied for this subcategory. Special attention was paid to cross-sectoral issues (Energy x IPPU), so no emissions are omitted, nor counted twice.

#### *4.5.2.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend*

No recalculation performed in this submission.

#### *4.5.2.6 Source-specific planned improvements, including tracking of those identified in the review process*

No improvements are planned in this subcategory.

### 4.5.3 Other (2.D.3)

#### *4.5.3.1 Source category description*

***Solvent Use***

This category includes particularly emissions of NMVOC (ozone precursor) from the use of solvents, which based in IPCC 2006 Guidelines (IPCC, 2006) are not considered to be a source of direct $CO_2$ emissions.

***Road Paving With Asphalt***

This category includes particularly emissions of ozone precursors in 1990 – 2005 time - series. Based on the IPCC 2006 Gl. (IPCC, 2006) only NMVOC emission should be reported. Data in reporting for the UNECE/CLRTAP inventory in NFR are used. Emissions from Road Paving with Asphalt are not considered to be a source of $CO_2$ emissions (IPCC, 2006).

***Urea used as catalyst***

IPCC 2006 Gl. incorporate this category as source of $CO_2$ emissions. However, based on methodology temissions from this process should be included in Energy sector, 1.A.3. Since the emissions does not arise from fuel combustion, the emissions are covered under IPPU sector.

#### 4.5.3.2 Methodological issues

***Solvent Use***

The IPCC methodology (IPCC, 2006) uses the CORINAIR methodology (EMEP/CORINAIR Guidelines, 1999) for processing NMVOC emissions in this category. This manual also gives the following conversions for the relevant activities, which can be used in conversion of data from the CORINAIR (i.e. SNAP) structure to the IPCC classification.

Inventory of NMVOC emissions for 2015 for this sector is based on a study prepared by SVÚOM Ltd. Prague (Geimplová, 2015). This study is elaborated annually for the UNECE/CLRTAP inventory in NFR and is also adopted for the National GHG inventory.

Solvent Use activity data are based on the following sources of information:

- statistical information on producers and imports from the Czech Statistical Office,
- REZZO data,
- annual reports of the Association of Coatings Producers (AVNH) and Association of Industrial Distilleries (APL),
- information from the Customs Administration,
- regular monitoring of economic activities and economic developments in the CR, knowledge and monitoring of important operations in the sphere of surface treatments, especially in the area of application of coatings, degreasing and cleaning,
- regular monitoring of investment activities is performed in the CR for technical branches affecting the consumption of solvents and for overall developmental technical trends of all branches of industry,
- monitoring of implementation of BAT in the individual technical branches,
- technical analysis of consumption of solvents in households; NMVOC emissions from households are entirely fugitive and, according to qualified estimates, contribute approximately 16.5% to total NMVOC emissions.

The activity data for Solvent Use were extracted from the official Energy balance. Form the whole amount of non-energy use of Other oil products were extracted the Oil needed for $NH_3$ production. Sum of the rest of Other Oil and non-energy use of White spirit was considered as the best available data for Solvent Use. This approach was approved with relevant experts from CzSO.

***Road Paving With Asphalt***

The activity data from last submission were used. Emissions are used from UNECE/CLRTAP inventories.

***Urea used as catalyst***

Since no detailed data about urea used as catalyst is available, the default approach was used, i.e. the activity level is 1% to 3% of diesel consumption by the vehicle. For the Czech Republic conservative estimate of 2% was used. 2% of the amount of diesel used in road transport was used as activity data. This approach was used for the emission estimates for 1998 – 2015 time series, which was consulted as appropriate time series, when this process can occur. The computational approach presented in Eq. 3.2.2 in IPCC 2006 Gl. was applied to estimate $CO_2$ emissions. $CO_2$ emissions in 2015 from this category were equal to 18.11 kt $CO_2$.

#### 4.5.3.3 Uncertainties and time-series consistency

***Solvent Use***

Uncertainty of NMVOC emissions is considered to be quite large, based on IPCC 2006 Gl. (IPCC, 2006) it is considered as 50%. The uncertainty of activity data is considered based on expert judgement as 25%.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2015.

***Road Paving With Asphalt***

Since no $CO_2$, $CH_4$ or $N_2O$ emission were estimated in this category, no uncertainties were considered in this category.

***Urea used as catalyst***

Suggested default range for uncertainty was applied for 2.D.3 category, i.e. 5% for activity data and 5% for emission factor uncertainty. However even though the emission are reported under 2.D.3, the range was applied based on IPCC 2006 Gl. Vol. 2 Energy, where methodology for emission estimation from urea used as catalyst is provided.

#### 4.5.3.4 Source-specific QA/QC and verification

***Solvent Use***

The emission data in this section were taken from the UNECE/CLRTAP inventories in NFR. Annual reports are available on the method of calculation for the individual years since 1998. Following transfer of the emission data to the new CRF Reporter, it was apparent that trends in the emissions did not exhibit any significant deviations.

A control was performed of the company processing the data (SVÚOM Ltd. Prague) and the coordinator of processing of UNECE/CLRTAP inventories in NFR.

***Road Paving With Asphalt***

No specific QA/QC or verification procedures is applied.

***Urea used as catalyst***

Standard QA/QC procedures were applied for this subcategory. Activity data estimate was discussed with the expert for transport.

#### 4.5.3.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

***Solvent Use***

No recalculations performed in this submission.

***Road Paving With Asphalt***

No recalculations performed in this submission.

***Urea used as catalyst***

This category is newly incorporated in the reporting since this submission.

#### 4.5.3.6 Source-specific planned improvements, including tracking of those identified in the review process

***Solvent Use***

No improvements are planned in this category.

***Road Paving With Asphalt***

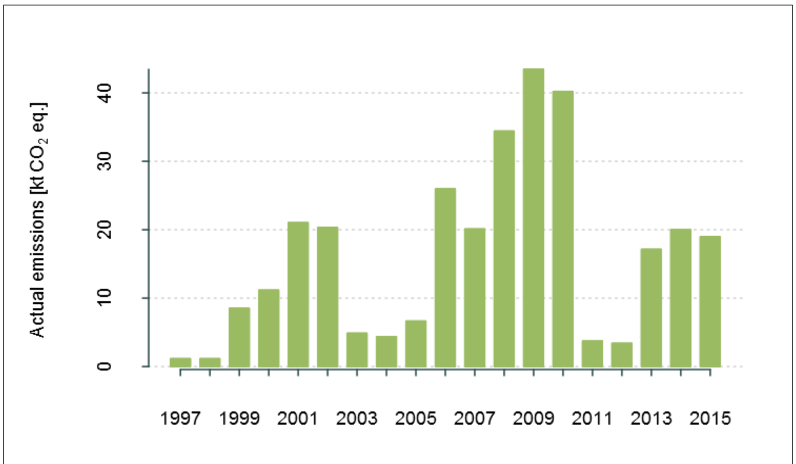
No improvements are planned in this category.

***Urea used as catalyst***

Further investigation of activity data is planned for the future submissions.

## 4.6 Electronics Industry (CRF 2.E)

Of the categories of sources classified under the Electronics Industry (2.E), only the Integrated Circuit or Semiconductor (2.E.1) category is relevant for the Czech Republic. This category includes the gases HFC-23, $CF_4$, $C_2F_6$, $SF_6$ and $NF_3$.




The emission trend for the category 2.E Electronics Industry, which also represent the emission trend of subcategory 2.E.1 is depicted in Fig. 4-15 from year 1997, when the use of $CF_4$ began to 2015. Emissions of F-gases equalled to 18.97 kt $CO_2$ eq. in 2015. Total emissions of F-gases from 2.E were lower in 2015 by 1.03 kt $CO_2$ eq. compared to previous year

**Fig. 4-15 Trend of emissions from 2.E Electronics Industry [kt $CO_2$ eq.]**

Tab. 4-20 lists the exact amount of $CO_2$ eq. emissions from category 2.E.

**Tab. 4-20 Emissions from category 2.E. Electronics Industry in time period 1997-2015**

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Emissions [kt $CO_2$ eq.]** | 1.14 | 1.14 | 8.51 | 11.17 | 21.03 | 20.30 | 4.87 | 4.36 | 6.64 | 29.97 |

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| **Emissions [kt $CO_2$ eq.]** | 20.10 | 34.41 | 43.45 | 40.20 | 3.74 | 3.40 | 17.13 | 20.01 | 18.97 |

Tab. 4-21 gives an overview of the emission factors and methodology used for computations of emissions in category 2.E. Electronics Industry in 2015.

**Tab. 4-21 Type of $CO_2$ emissions factors used for computations of 2015 emissions in category 2.E Electronics Industry**

| | F-gas reported | Source or type EF | Methodology |
|---|---|---|---|
| **2.E.1 Integrated Circuit or Semiconductor** | HFC-23, $CF_4$, $C_2F_6$, $SF_6$, $NF_3$ | Default (IPCC, 2006) | Tier 2a |

## 4.6.1 Integrated Circuit or Semiconductor (CRF 2.E.1)

### *4.6.1.1 Source category description*

In this category are included gases $C_2F_6$, $CF_4$, $SF_6$, $CHF_3$ (HFC-23) and $NF_3$. All of these gases are used for manufacturing of semiconductors. As the GWPs of these gases indicate, they are persistent pollutants with the time of presence in the atmosphere reaching up to thousands of years.

Gases $SF_6$ and $NF_3$ are significant for semiconductor manufacturing. $SF_6$ is used in semiconductor industry for etching and melting Mg and Al. Huge energy companies are the main contributors to the $SF_6$ emissions. $SF_6$ consumption can be considered as stagnant in the last years. $NF_3$ is used for semiconductor manufacturing since year 2012. The consumption of $NF_3$ reached a maximum value in year 2013 and after that is the consumption stagnant. The major share (85.61%) on total emissions from 2.E.1 has gas $SF_6$.

## 4.6.2 Methodological issues

Because of the lack of detailed information, the data about gases $C_2F_6$, $CF_4$, $SF_6$, $CHF_3$ (HFC-23) and $NF_3$ are reported for category 2.E.1 Integrated Circuit or Semiconductor. Activity data about consumption of F-gases are available since 1997.

Basic data about new equipment and services was obtained from questionnaires, conducted by Řeháček, 2016. This equipment is produced by only one company and is serviced by several other companies. Activity data about consumption are confidential, thus they are reported as C(NK).

Emissions from this category are calculated using Tier 2a methodology described in IPCC 2006 Gl., equation 6.2 without using fractions $a_i$ and $d_i$, which are considered by expert judgement to be negligible and further using equation 6.3 for estimation of by-product emissions of $CF_4$. By-product emissions of $CF_4$ are reported together with regular $CF_4$ emissions.

The manufacturers of electrical equipment maintain very eco-friendly policies (involving treatment, training of staff, certificate etc.). Operational leakages are not measured (legislation does not force operators to do so) but can be estimated based on stock change. After a consultation with the main operator in the country the leakages are virtually non-existent and depend solely on accidents. Leakages represent less than 100 kg/yr in total. Such a low amount of $SF_6$ is not required to be reported from the operator into national database "Integrated system of reporting obligations" (*Integrovaný systém plnění ohlašovacích povinností* - ISPOP).

The emission factors employed are summarized in Ta. 4-22. The default emission factors for the gases HFC-23, $CF_4$, $C_2F_6$, $SF_6$ and $NF_3$ were chosen from IPCC, 2006, volume 3, part 2 Electronic Industry emissions, Table 6.3. The fraction of gas remaining in shipping container after use is for emission estimates based on our sectoral expert judgement. The fraction of gas remaining in shipping container (h) is 0.05%.

**Tab. 4-22 Emissions factors used for computations of 2015 emissions from 2.E.1 Integrated Circuit or Semiconductor**

| F-gas | 2006 Guidelines (IPCC) | | | |
|---|---|---|---|---|
| | (1-Ui) | $B_{CF4}$ | $B_{C2F6}$ | $B_{C3F8}$ |
| HFC-23 ($CHF_3$) | 0.4 | 0.07 | NA | NA |
| $CF_4$ | 0.9 | NA | NA | NA |
| $C_2F_6$ | 0.6 | 0.2 | NA | NA |
| $SF_6$ | 0.2 | NA | NA | NA |
| $NF_3$ | 0.2 | 0.09 | NA | NA |

### 4.6.3 Uncertainties and time-series consistency

The uncertainty estimates were based on expert judgment (see Guidelines IPCC, 2006 Volume 1 Chapter 3 Uncertainties). Improvement of uncertainty estimation is in progress.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1997 to 2015.

### 4.6.4 Source -specific QA/QC and verification

Validation was performed by comparing the data obtained from the customs authorities, questionnaires and reports from Ministry of the Environment. This comparison revealed a number of errors that were subsequently corrected.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

### 4.6.5 Source -specific recalculations, including changes made in response to the review process and impact on emission trend

In this year, no recalculations were performed in this sector.

### 4.6.6 Source -specific planned improvements, including tracking of those identified in the review process

Although the current survey considered factors $a_i$ and $d_i$ in Tier 2a methodology as negligible, it is planned to explore this technology further in more details in future submissions, no later than the introduction of F-gases in the EU ETS trading.

Furthermore, planned improvement for this category is to contact industry facilities which use $SF_6$ or $NF_3$ for detailed information about stocks and emissions.

Improvement of uncertainty estimation is in progress.

## 4.7 Product Uses as Substitutes for Ozone Depleting Substances (ODS) (CRF 2.F)

This category describes emissions of F-gases from the following categories: 2.F.1 Refrigeration and Air Conditioning, 2.F.2 Foam Blowing Agents, 2.F.3 Fire Protection, 2.F.4 Aerosols and 2.F.5 Solvents.

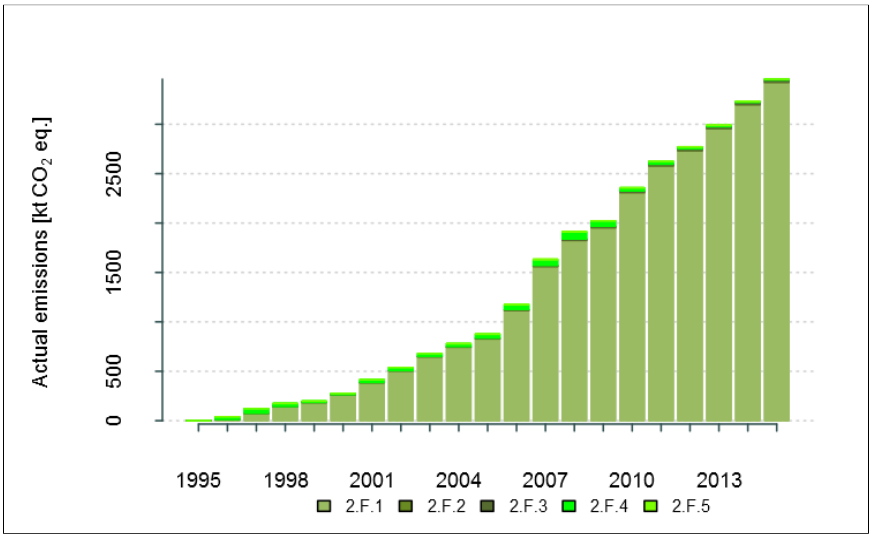



**Fig. 4-16 Trend of emissions from 2.F Product Uses as Substitutes for Ozone Depleting Substances and share of specific subcategories [kt $CO_2$ eq.]**

The emission trend for category 2.F is depicted in Fig. 4-16. The major share of 99.05% in the range of actual emissions for year 2015 corresponds to category 2.F.1. Actual emissions from other categories under 2.F are insignificant compared to category 2.F.1. Actual emissions of F-gases increased from 0.33 kt $CO_2$ eq. in 1995 to 3456.60 kt $CO_2$ eq. in 2015. This significant leap forward by orders of magnitude has been driven mainly by substantial increase in the use of HFCs in refrigeration and much less by the already in 2010 peaked use of PFCs.

Detailed information about actual emissions is given in Tab. 4-23 and in the CRF Tables. The higher level of emissions during the last years could be explained by growth of large users, such as automotive industry and manufacturing of stationary air-conditioning. The vast majority of F-gases remain from production of refrigerators and air conditioners.

**Tab. 4-23 Actual emissions of HFCs and PFCs in 1995 - 2015 [kt $CO_2$ eq.]**

| | Category 2.F - emissions of PFCs and HFCs [kt $CO_2$ eq.] | | |
|---|---|---|---|
| | Emissions of PFCs and HFCs | Emissions of PFCs | Emissions of HFCs |
| **1995** | 0.33 | 0.01 | 0.32 |
| **1996** | 38.70 | 0.68 | 38.02 |
| **1997** | 121.69 | 1.73 | 119.96 |
| **1998** | 175.20 | 1.66 | 173.54 |
| **1999** | 197.87 | 1.10 | 196.78 |
| **2000** | 277.61 | 4.69 | 272.92 |
| **2001** | 420.75 | 9.75 | 411.01 |
| **2002** | 550.66 | 16.39 | 534.27 |
| **2003** | 680.36 | 8.55 | 671.81 |
| **2004** | 783.84 | 12.81 | 771.03 |
| **2005** | 882.63 | 14.89 | 867.74 |
| **2006** | 1197.57 | 31.09 | 1166.49 |
| **2007** | 1653.43 | 29.00 | 1624.43 |
| **2008** | 1941.90 | 39.76 | 1902.14 |
| **2009** | 2056.25 | 45.44 | 2010.82 |
| **2010** | 2396.99 | 48.01 | 2348.97 |
| **2011** | 2628.30 | 8.13 | 2620.17 |
| **2012** | 2772.36 | 6.36 | 2765.99 |
| **2013** | 2993.56 | 4.55 | 2989.02 |
| **2014** | 3232.55 | 3.02 | 3229.53 |
| **2015** | 3457.04 | 1.96 | 3455.08 |

Emissions of F-gases (HFCs, PFCs, $SF_6$) in the Czech Republic are at relatively low level due to the absence of large industrial sources. Furthermore all of the F-gases in the Czech Republic are imported; therefore there are no fugitive emissions from manufacturing. Additionally, there is no production of other fluorinated gases (CFCs, HCFCs, etc.) that could lead to by-product F-gases emissions and there is no primary aluminium and magnesium industry in the Czech Republic.

Tab. 4-24 gives an overview of the emissions factors and methodology used for computations of emissions in category 2.F Product Uses as Substitutes for Ozone Depleting Substances in 2015.

**Tab. 4-24 Type of emissions factors used for computations of 2015 emissions in category 2.F**

| | Reported emissions | Source or type EF | Methodology |
|---|---|---|---|
| **2.F.1 Refrigeration and Air Conditioning** | HFCs, PFCs | CS and Default (IPCC, 2006) | Tier 2a |
| **2.F.2 Foam Blowing Agents** | HFCs | Default (IPCC, 2006) | Tier 1a |
| **2.F.3 Fire protection** | HFCs, PFCs | Default (IPCC, 2006) | Tier 1a |
| **2.F.4 Aerosols** | HFCs | Default (IPCC, 2006) | Tier 1a |
| **2.F.5 Solvents** | HFCs | Default (IPCC, 2006) | Tier 1a |

Currently, the national F-gas inventory is based on the method of actual emissions, according to the IPCC 2006 Guidelines (IPCC, 2006). Due to the relatively short time of use of F-gases, the disposed amount is rather small and considered negligible for the inventory process. In 2015, a small amount of destroyed F-gases was reported. They were usually mixtures of old CFC-12 and HCFC-22. Five companies in the country are reported to provide disposal services for used F-gases. One of these is reported to experiment with regeneration using the distilling process but is still not officially operating on the market. The main part of F-gases was imported to CR for destruction and did not come from equipment operating in CR. The actual emissions methodology is specified for each category.

As these substances are not produced nationally, import and export information coming from official customs authorities is of key importance. Individual F-gases did not have separate custom codes in the customs tariff list as individual chemical substances until year 2014. HFCs and PFCs were listed as totals in the cluster of halogen derivatives of acyclic hydrocarbons. In order to determine the exact amounts of these substances, it is essential to obtain information from the customs statistics and from individual importers and exporters, about (a) the imported and exported amounts and (b) types of substances (or their mixtures), (c) the amounts and types of disposed F-gases and also (d) the areas of usage. Data about direct import/export, use and destruction were obtained from ISPOP ("Integrated system of reporting obligations") and F-gas register (Questionnaire on production, import, export, feedstock use and destruction of the substances listed in Annexes I or II of the F-Gas regulation). ISPOP is the national system of environmental reporting; all importers, exporters and users of more than a threshold amount of 100 kg are obliged to report information about the type and amount of F-gas used. The threshold for submitting imported F-gases to the F-gas register is more than one metric tonne of F-gases imported into the EU. The threshold refers to the sum of F-gases, not each imported gas separately. This allows us to include data about gases imported into the Czech Republic with smaller charge (<3kg). All the importers, exporters and users were requested to complete a specific questionnaire on export and import of F-gases and to support the questionnaire by additional information on the quantity, composition and use. More detailed description of the methodology is available under separate document (Řeháček and Michálek, 2005) - a study which also contains all the relevant information on calculations of actual emissions.

### 4.7.1 Refrigeration and Air Conditioning (CRF 2.F.1)

#### *4.7.1.1 Source category description*

This category describes emissions of F-gases from the following subcategories: 2.F.1.a Commercial Refrigeration, 2.F.1.b Domestic Refrigeration, 2.F.1.c Industrial Refrigeration, 2.F.1.d Transport Refrigeration, 2.F.1.e Mobile Air Conditioning, 2.F.1.f Stationary Air Conditioning.

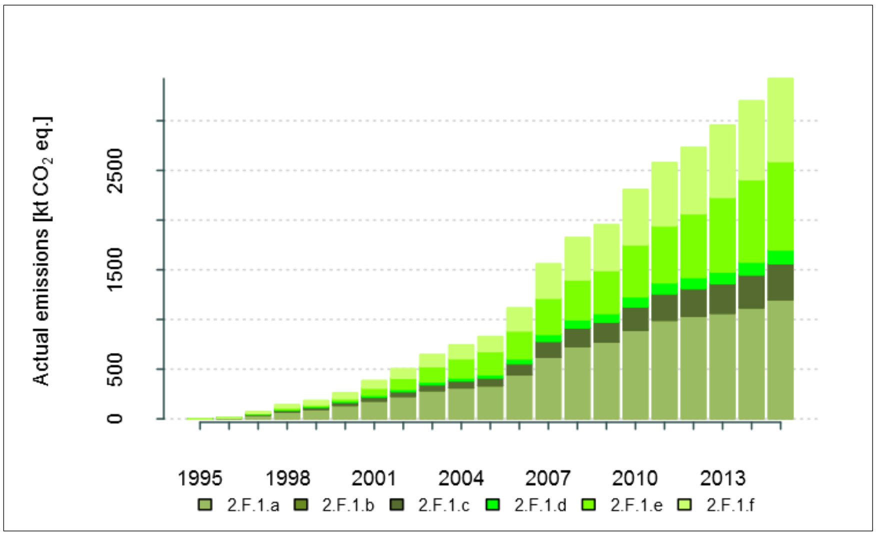



**Fig. 4-17 Trend of emissions from 2.F.1 Refrigeration and Air conditioning and share of specific subcategories [kt $CO_2$ eq.]**

The major share 34.98% in the range of actual emissions for year 2015 belongs to the subcategory 2.F.1.a, share 25.99% belongs to the subcategory 2.F.1.e, share 24.31% belongs to the subcategory 2.F.1.f, share 10.61% belongs to the 2.F.1.c., share 4.06% belongs to the 2.F.1.d and share 0.04% belongs to the 2.F.1.b. Trend of emissions from 2.F.1 is depicted on Fig. 4-17. 2.F.1 was identified as a key category in this submission.

An overview of reported gases under specific subcategory is presented in Tab. 4-25.

**Tab. 4-25 An overview of the F-gases reported under subcategory 2.F.1**

| Source category | Reported F-gases |
|---|---|
| **2.F.1.a Commercial Refrigeration** | HFC-125, HFC-143a, HFC-23, HFC-134a, HFC-227ea, HFC-32, HFC-152a, $C_6F_{14}$, $C_3F_8$, $C_2F_6$ |
| **2.F.1.b Domestic Refrigeration** | HFC-134a |
| **2.F.1.c Industrial Refrigeration** | HFC-32, HFC-125, HFC-134a, HFC-143a |
| **2.F.1.d Transport Refrigeration** | HFC-32, HFC-125, HFC-134a, HFC-143a |
| **2.F.1.e Mobile Air Conditioning** | HFC-134a |
| **2.F.1.f Stationary Air Conditioning** | HFC-32, HFC-125, HFC-134a, HFC-143a |

#### *4.7.1.2 Methodological issues*

In this year, new calculation model for emission estimates from category 2.F.1 was implemented. The input data are based on the Custom Office, ISPOP (Integrated system of reporting obligations) and F-gas register. These data are then verified by a sectoral expert. Detailed information on the data and methodology used are included in a special report prepared by external sector expert, Ing. Řeháček (Řeháček, 2016).

Wholesale distributors supply F-gases to consumers, which use them across multiple categories. Unfortunately, wholesale distributors and even consumers do not provide exact information about distribution of F-gases into detailed categories according to their usage. The data cannot be divided direct into the sub application for the purpose of the national inventory; therefore the new calculation model uses expert judgement to estimate the relative share of each type of equipment as shown in Tab.

4-26. For 2.F.1.b the relative share of the gas HFC-134a was 1%, considering that almost all domestic refrigeration in the Czech Republic used hydrocarbons before 2015. Since 2015, according to the F-gas regulation (Regulation EU No 517/2014) there has been a ban on the sale of domestic refrigeration that contains HFCs with GWP of 150 or more, which includes HFC-134a. The relative share of gas HFC-134a has been considered to equal 0% since 2015. The exact amount of HFC-134a in 2.F.1.e is obtained from an F-gas expert report (Řeháček, 2016).

**Tab. 4-26 Distribution of HFCs and PFCs use by application area used for emission calculations in 2015**

| Reported F-gases | 2.F.1.a Commercial Refrigeration | 2.F.1.b Domestic Refrigeration | 2.F.1.c Industrial Refrigeration | 2.F.1.d Transport Refrigeration | 2.F.1.f Stationary Air Conditioning |
|---|---|---|---|---|---|
| **HFC-125** | 40% | x | 15% | 5% | 40% |
| **HFC-143a** | 60% | x | 15% | 5% | 20% |
| **HFC-23** | 100% | x | x | x | x |
| **HFC-134a** | 60% | 0% | 15% | 5% | 20% |
| **HFC-227ea** | 100% | x | x | x | x |
| **HFC-32** | 40% | x | 15% | 5% | 40% |
| **HFC-152a** | 100% | x | x | x | x |
| **$C_6F_{14}$** | 100% | x | x | x | x |
| **$C_3F_8$,** | 100% | x | x | x | x |
| **$C_2F_6$** | 100% | x | x | x | x |

Emissions from this category are calculated using Tier 2a Method (emission-factor approach) described in 2006 IPCC Gl., Vol. 3-2. The parameters were established by an expert judgement and Table 7.9, 2006 IPCC Gl., Vol. 3-2. The product life factors for subcategory 2.F.1.a and 2.F.1.c are based on the product life factors used by our neighbouring countries and other countries in Europe. Neighbouring countries were selected because it is assumed that conditions for estimating of emissions factors would be very similar. Other specific European countries were selected, because they use very similar methodology and approaches and it is anticipated that the conditions in these countries would not be very different from the conditions in the Czech Republic, because the status of their industry is not very different. It is planned to investigate the emission factors in more detail for future submission.

Percentages of captured and emitted F-gases were estimated by a sectoral expert (expert judgement) based on consultations with companies (Řeháček, 2016) and ISPOP data on ecological burning of captured F-gases. The disposal of domestic refrigeration is partly performed by a company outside Europe.

Detailed model parameters for this submission are shown in Tab. 4-27.

**Tab. 4-27 Parameters used for emission calculations for category 2.F.1 in new calculation model**

| Source category | Lifetimes [years] | Emission Factors [% of initial charge/year] | | End-of-Life emissions [%] | |
|---|---|---|---|---|---|
| Factor in equation | (d) | (k) | (x) | ($\eta_{rec,d}$) | (p) |
| | | Initial Emissions | Operation Emissions | Recovery Efficiency | Initial Charge Remaining |
| **2.F.1.a Commercial Refrigeration** | 10.50 | 1.00 | 13.00 | 55.00 | 70.00 |
| **2.F.1.b Domestic Refrigeration** | 13.50 | 0.50 | 0.25 | 55.00 | 70.00 |
| **2.F.1.c Industrial Refrigeration** | 17.00 | 1.00 | 11.00 | 55.00 | 70.00 |
| **2.F.1.d Transport Refrigeration** | 8.50 | 0.50 | 17.50 | 55.00 | 30.00 |
| **2.F.1.e Mobile Air Conditioning** | 13.50 | 0.50 | 12.50 | 10.00 | 30.00 |
| **2.F.1.f Stationary Air Conditioning** | 13.50 | 0.50 | 6.50 | 55.00 | 70.00 |

Emissions from decommissioning are calculated using Gaussian distribution model with mean at lifetime expectancy. The model takes into account different approach for serviced equipment and newly filled equipment, assuming only half life-expectancy for the serviced equipment, resp. the amount of service-filled gas.

The coolant media type used for the purpose of mobile air-conditioning is HFC-134a and the main type used for stationary air conditioning/refrigeration is R-410, a mixture of HFC-32 and HFC-125 in a ratio of 1:1. Other types of HFCs like HFC-23 and HFC-32 are used in small amounts in refrigeration mixtures as additive for adjustment of properties of mixtures of refrigerants.

In 2015 no significant changes occurred in the collection and treatment policies of discarded refrigeration appliances. Only two companies in Czech Republic are dealing with regeneration of HFC coolants.

They used privately constructed distilling machinery to process app. 5 tonnes of HFC-134a contaminated with mineral oil fractions. The HFC was collected and stored during previous years. Emissions from this process are not included in the inventory.

Most of the discarded refrigeration appliances contained old refrigerant's media - CFC-12 and HCFC-22 and old insulating materials - CFC-11. Appliances containing HFCs are still being disposed in negligible amounts, considering their 6-30 year life cycle (IPCC 2006 Gl., Volume 3, Chapter 7, table 7.9.) which depends on the type of device. According to ISPOP database in the Czech Republic were eliminated by ecological burning or regenerated 4.81 t of HFC-134a, 7.67 t of HFC-125, 2.30 t of HFC-143a, 5.32 t of HFC-32 and 0.89 t of $SF_6$. However in the next 5 years we can expect an increase in appliances disposal with a lifetime of about 20 years such as industrial refrigeration, residential and commercial air-conditioning etc.

A mixture of retrieved cooling media is being incinerated in specialized facilities. In one case, the retrieved mixture of ODS is exported as a raw material for a different industrial processes than air-conditioning or refrigeration. A very small amount of coolant medium (R 410) is exported for purposes of regeneration, where this amount depends on claims in the automobile market and remains at a level of in 0-3 t p.a.

In some years notation key NE is used under 2.F.1 for the amount remaining in products at decommissioning and the emissions from the disposal and recovery of HFC-134a and HFC-32 gases. Notation key NE is used in accordance with decision 24/CP.19. Emissions are considered to be insignificant. The level of emissions is below 0.05% of the national total GHG emissions and the CRF reporter does not allow report emissions lower than 1.0E-14. A number lower than 1.0E-14 is rounded off to 0.00 by the CRF reporter. Specific subcategories with notation key NE and the related year are shown in Tab. 4-28.

**Tab. 4-28 Subcategories in which is used notation key NE for gases HFC-134a and HFC-32 with related year**

| Source category | Reported F-gas | Year |
|---|---|---|
| **2.F.1.a Commercial Refrigeration** | HFC-134a | 1996 |
| | HFC-32 | 1998, 1999 |
| **2.F.1.b Domestic Refrigeration** | HFC-134a | 1996 |
| **2.F.1.c Industrial Refrigeration** | HFC-32 | 1998, 1999 |
| | HFC-134a | 1996 |
| **2.F.1.d Transport Refrigeration** | HFC-32 | 1998 |
| | HFC-134a | 1996 |
| **2.F.1.e Mobile Air Conditioning** | HFC-134a | 1998, 1999, 2000, 2001 |
| **2.F.1.f Stationary Air Conditioning** | HFC-32 | 1998, 1999 |
| | HFC-134a | 1996 |

### 4.7.2 Foam Blowing Agents (CRF 2.F.2)

This category includes only emissions from subcategory 2.F.2.a Closed cells. Emissions from following gases are occurring from this category in the Czech Republic: HFC-134a (from stocks, from disposal), HFC-227ea (from stocks), HFC-245fa (from stocks). Use of HFC for foam blowing was not reported in 2015.

F-gases were used in the Czech Republic only for producing hard foam. Solely HFC-143a was used regularly for foam blowing. HFC-227ea and HFC-245fa were used occasionally in previous years for testing purposes. Due to high costs, HFCs are being replaced by other hydrocarbons. The contribution of foam blowing to total emissions of 2.F category equals to 0.07% in 2015.

#### *4.7.2.1 Methodological issues*

Emissions from this category are calculated by default methodology and EF described in IPCC, 2006 equation 7.7 for foam blowing.

### 4.7.3 Fire Protection (CRF 2.F.3)

Emissions from following gases are occurring in category 2.F.3 Fire protection: HFC-227ea, HFC-236fa, $C_3F_8$ (only from stocks and disposal). The share of this category in the total actual emissions from 2.F was 0.66% in 2015.

#### *4.7.3.1 Methodological issues*

Emissions from this category are calculated on the basis of IPCC 2006 Gl., equation 7.17. Calculations are based on data concerning production of new equipment and servicing the old equipment. It was revealed in consultations with servicing companies that first-fill leakages are very low and remain below 2% of the total emissions. Operational leakages are virtually non-existent and depend solely upon activation of fire alarms.

In the equipment servicing process, the original halons are sucked out and usually re-used again. The halons are recycled either with simple filtration or distillation. Re-use of original media without any treatment may also occur. Old types of halons (prohibited in the years before 2000) can no longer be manufactured but some of the mixtures can be reused after regeneration. A major part of new equipment employs HFC-227ea, while some installations are filled with HFC-236fa. Due to reuse of regenerated old halon mixtures, HFCs are being introduced rather slowly.

### 4.7.4 Aerosols (Propellants and Solvents) (CRF 2.F.4)

A small amount of HFC-134a used in metered dose inhalers was reported in the Czech Republic in 2015. The contribution of this category to the total actual 2.F emissions equals to 0.19% in 2015.

#### *4.7.4.1 Methodological issues*

Emissions from this category are based on IPCC, 2006, equation 7.6; EF equals to 50% (default). The consumption of HFC-134a used as a propellant for aerosols decreased compared to the previous years. F-gases as propellants for aerosols are currently being replaced by cheaper propellants, specifically dimethyl ether and other hydrocarbons (butane, isobutane and propane).

### 4.7.5 Solvents (Non-Aerosol) (CRF 2.F.5)

Emissions from use of HFC-245fa are only occurring in year 2015. HFC-245fa was newly relocated to the category 2.F.5. According to the F-gas expert HFC-245fa is used only as a solvent in this country. The contribution of this category to the total actual 2.F emissions equals to 0.02% in 2015.

#### *4.7.5.1 Methodological issues*

Emissions from this category are based on IPCC, 2006, equation 7.5; EF equals to 50% (default).

### 4.7.6 Uncertainties and time-series consistency

The uncertainty estimates were based on expert judgment (see Guidelines IPCC, 2006, volume 1, Chapter 3, Uncertainties). Improvement of uncertainty estimation is in progress.

Time series consistency is ensured as the above mentioned methodologies for all categories under 2.F. are employed identically across the whole reporting period.

### 4.7.7 Source-specific QA/QC and verification

The quality control was held by fulfilling the QA/QC form presented in Annex 5. The input information and calculations are archived by the sectoral experts and the coordinator of NIS.

Verification has been performed by comparison of data received from the customs authorities, from submitted questionnaires and from reports to MoE by significant importers and/or exporters. The methodology and calculations were performed twice independently and were compared. This comparison indicated few errors, which had been corrected.

### 4.7.8 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

Category 2.F.1 has undergone recalculation due to implementation of a new calculation model. The calculation model allows division of the input data into the sub applications. Division is based on expert judgement. After implementation of the calculation model, the following changes are occurring:

Based on the new calculation model HFC-134a is reported under category F.1.b Domestic Refrigeration instead of unspecified mix of HFCs and PFCs.

Under category F.1.c Domestic Refrigeration: HFC-32, HFC-125, HFC-134a and HFC-143a are reported instead of unspecified mix of HFCs and PFCs.

Under category F.1.d Transport Refrigeration: HFC-32, HFC-125, HFC-134a and HFC-143a are reported instead of unspecified mix of HFCs and PFCs.

Under category F.1.f Stationary air-conditioning: HFC-32, HFC-125, HFC-134a and HFC-143a are reported instead of unspecified mix of HFCs and PFCs.

From category 2.F.1.a Commercial refrigeration, HFC-245fa was relocated to category 2.F.5 Solvents.

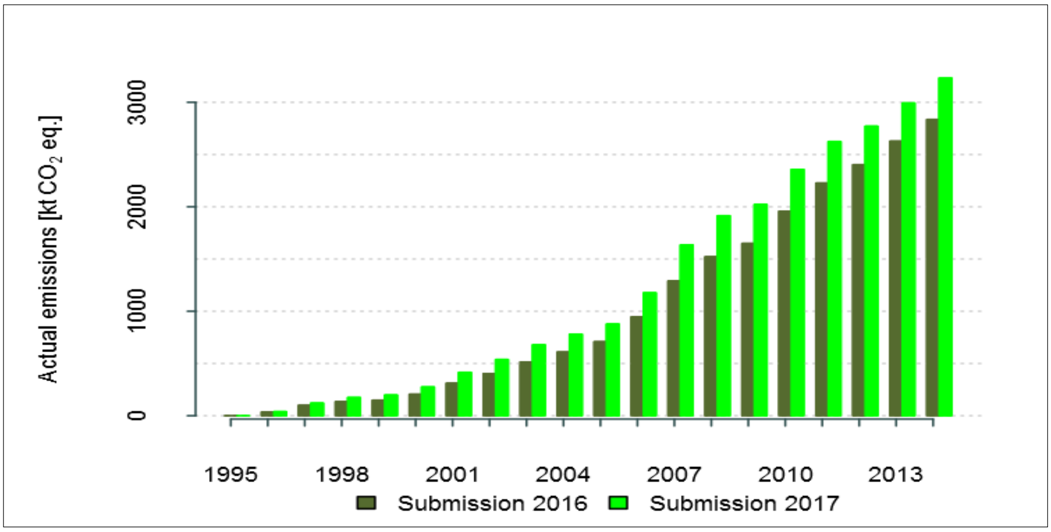



**Fig. 4-18 Recalculation in 2.F category due to implementation of the new calculation model**

### 4.7.9 Source-specific planned improvements, including tracking of those identified in the review process

In future submission it is planned to investigate the emission factors used under category 2.F.1. Now, emission factors are based on discussions with our sectoral expert, the opinions of a sectoral expert from another European country and Table 7.9, 2006 IPCC Gl., Vol. 3-2. It is planned to investigate the country - specific conditions and properly document the reasons for our choice, which will lead to improvement in the transparency of our reporting.

Accounting for F-gases contained in products (cars, air containers, etc.) is still being developed and its inclusion is planned for future submissions.

## 4.8 Other Product Manufacture and Use (CRF 2.G)

This category describes GHG emissions from the following categories: 2.G.1 Electrical Equipment, 2.G.2 $SF_6$ and PFCs from Other Product Use, 2.G.3 $N_2O$ from Product Uses and Category 2.G.4 Other. Under the 2.G. category are reported $SF_6$ and $N_2O$ emissions.

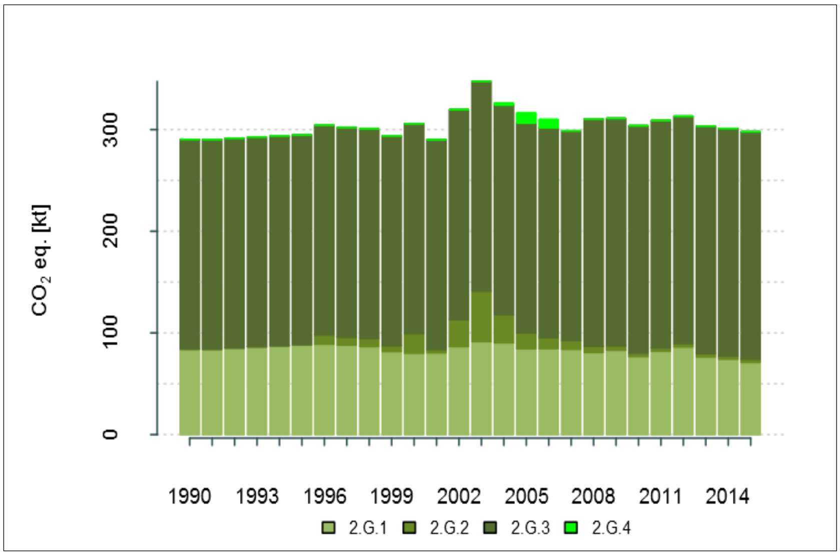



**Fig. 4-19 Trend of emissions from 2.G Other Product Manufacture and Use and share of specific subcategories [kt $CO_2$ eq.]**

The emission trend for category 2.G is depicted in Fig. 4-19 .The major share of 75.05% of GHG emissions for year 2015 belongs to category 2.G.3 and the share 23.87% belongs to category 2.G.1. Total GHG emissions from 2.G were lower by 3.23 kt $CO_2$ eq. in 2015 compared to the previous year.

Tab. 4-29 lists the exact amount of $CO_2$ emissions from the individual subcategories in 2.G. Other Product Manufacture and Use for the 1990 to 2015 period.

**Tab. 4-29 $CO_2$ eq. emissions in individual subcategories in 2.G Other Product Manufacture and Use category in 1990-2015**

| | Category 2.G - emissions [kt $CO_2$ eq.] | | | |
|---|---|---|---|---|
| | 2.G.1 Electrical Equipment | 2.G.2 $SF_6$ and PFCs from Other Product Use | 2.G.3 $N_2O$ from Product Uses | 2.G.4 Other |
| **1990** | 84.10 | NO | 206.22 | NO |
| **1991** | 83.94 | NO | 206.22 | NO |
| **1992** | 85.23 | NO | 206.22 | NO |
| **1993** | 86.40 | NO | 206.22 | NO |
| **1994** | 87.48 | NO | 206.22 | NO |
| **1995** | 88.47 | NO | 206.22 | NO |
| **1996** | 89.03 | 9.03 | 206.22 | NO |
| **1997** | 88.12 | 7.71 | 206.22 | NO |
| **1998** | 86.71 | 7.86 | 206.22 | NO |
| **1999** | 81.76 | 5.75 | 206.22 | NO |
| **2000** | 80.09 | 19.32 | 206.22 | NO |
| **2001** | 80.47 | 3.29 | 206.22 | NO |
| **2002** | 86.72 | 26.64 | 206.22 | NO |
| **2003** | 91.59 | 49.57 | 206.22 | NO |
| **2004** | 90.36 | 27.52 | 206.22 | 1.89 |
| **2005** | 84.46 | 15.72 | 206.22 | 9.87 |
| **2006** | 84.58 | 10.99 | 206.22 | 7.98 |
| **2007** | 83.96 | 8.58 | 206.22 | NO |
| **2008** | 80.91 | 6.02 | 223.50 | NO |
| **2009** | 82.99 | 4.46 | 223.50 | NO |
| **2010** | 76.84 | 3.39 | 223.50 | NO |
| **2011** | 82.03 | 3.36 | 223.50 | NO |
| **2012** | 86.31 | 3.32 | 223.50 | NO |
| **2013** | 76.50 | 3.29 | 223.50 | NO |
| **2014** | 74.28 | 3.26 | 223.50 | NO |
| **2015** | 71.08 | 3.22 | 223.50 | NO |

Tab. 4-30 gives an overview of the emission factors and methodology used for computations of emissions in category 2.G for year 2015.

**Tab. 4-30 Type of emissions factors used for computations of 2015 emissions in category 2.G Other Product Manufacture and Use**

| | Reported emissions | Source or type EF | Methodology |
|---|---|---|---|
| **2.G.1 Electrical Equipment** | $SF_6$ | Default (IPCC, 2006) | T1 |
| **2.G.2 $SF_6$ and PFCs from Other Product Use** | $SF_6$ | Default (IPCC, 2006) | D |
| **2.G.3 $N_2O$ from Product Uses** | $N_2O$ | Default (IPCC, 2006) | D |

### 4.8.1 Electrical Equipment (2.G.1)

#### *4.8.1.1 Source category description*

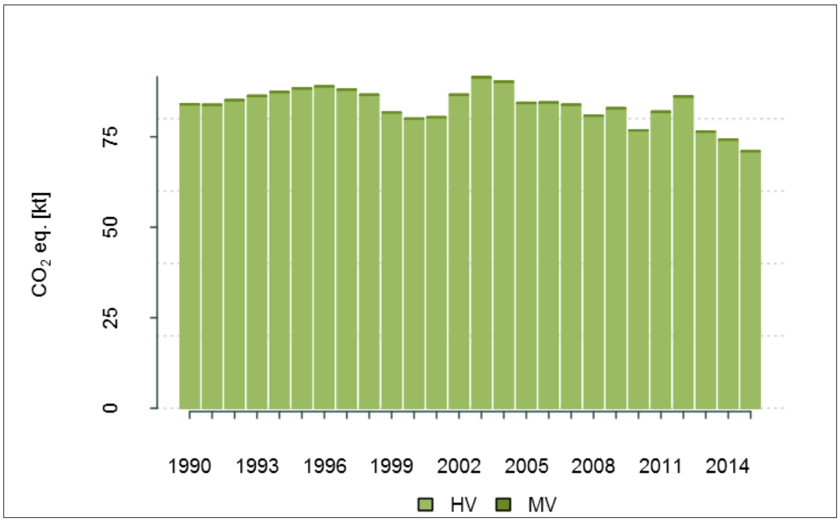



**Fig. 4-20 Trend of emissions from 2.G.1 Electrical equipment and share of HV and MV equipment [kt $CO_2$ eq.]**

Recently this subcategory was divided into Medium Voltage (MV) Electrical equipment (< 52 kV) and High Voltage (HV) Electrical Equipment (> 52 kV) containing $SF_6$. The emission trend for this category is depicted in Fig. 4-18. The division into the two groups was based on data from two large and one smaller facility for energy transmission and distribution. According to the data almost 98.4% of the electrical equipment in this country is attributed to HV Electrical Equipment and 1.6% to MV Electrical equipment.

Basic data about the new equipment and services was obtained from questionnaires, conducted by Řeháček, 2016. $SF_6$ for use in electrical equipment is mainly imported as part of the equipment, which is filled below operational amount. First servicing could be then considered as "first fill". Bulk imports are mostly being transferred for the purpose of operational stock-in-trade.

#### *4.8.1.2 Methodological issues*

Emissions from this category are calculated in line with IPCC 2006 Gl., specifically Equation 8.1, which is called the Tier 1 method. Emissions for MV Electrical equipment and HV Electrical Equipment were estimated separately using default emission factors (Table 8.2, 2006 IPCC Gl., Vol. 3-2 for MV Switchgear, Table 8.3, 2006 IPCC Gl., Vol. 3-2 for HV Switchgear). The CRF reporter does not allow separation of the subcategory 2.G.1 Electrical equipment into two groups. Emissions of $SF_6$ from MV Electrical equipment and HV Electrical Equipment are reported collectively.

Operational leakage is not measured (legislation does not force operators to do so) but operators usually distinguish between amount of $SF_6$ used for servicing or filling to new equipment. According to consultations with the main operator in the country, the leakage is virtually non-existent and depends solely on accidents; leakage usually remains below 100 kg p.a. in total. Such a low amount of $SF_6$ does not even require the operator to report $SF_6$ usage in ISPOP.

$SF_6$ for use in electrical equipment is mainly imported as the part of the equipment which is filled below the operational amount. First servicing is then considered as "first fill". Bulk imports are mostly imported for the purpose of operational stock-in-trade.

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

The uncertainty estimates were based on expert judgment (see Guidelines IPCC, 2006 Volume 1 Chapter 3 Uncertainties). Improvement of uncertainty estimation is in progress.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2015.

#### *4.8.1.4 Source -specific QA/QC and verification*

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

Validation was performed by comparing the data obtained from the customs authorities, questionnaires and reports from Ministry of the Environment.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

#### *4.8.1.5 Source -specific recalculations, including changes made in response to the review process and impact on emission trend*

For subcategory 2.G.1 Electrical equipment, a new activity data on recovery since 2013 were obtained. Recently, the subcategory was recalculated due to division of the activity data into two categories: Medium Voltage (MV) Electrical equipment (< 52 kV) and High Voltage (HV) Electrical Equipment (> 52 kV) containing SF6. The division into the two groups was based on data from two large and one smaller facility for energy transmission and distribution. The tier 1 Method from IPCC 2006, Eq. 8.1, was applied for calculation of emissions using the default emissions factors from Tables 8.2 and 8.3.

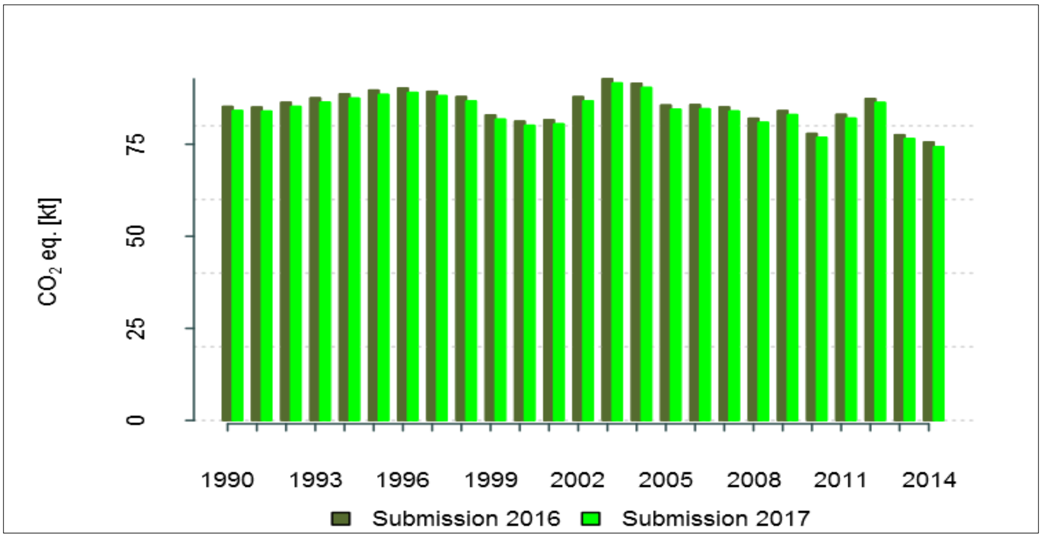



**Fig. 4-21 Recalculation in category 2.G.1 due to division of activity data to MV and HV equipment**

#### *4.8.1.6 Source -specific planned improvements, including tracking of those identified in the review process*

In further submissions it is planned to contact other facilities for energy transmission and distribution to verify the current division of activity data into MV and HV electrical equipment or update this division to more accurate version.

### 4.8.2 $SF_6$ and PFCs from Other Product Use (CRF 2.G.2)

#### *4.8.2.1 Source category description*

This category includes estimates emissions from double-glazed sound-proof windows (CRF - 2.G.2.c). In the Czech Republic for several years $SF_6$ for manufacturing sound-proof windows is not used. Lifetime of windows filled with $SF_6$ is assumed to be 25 years. $SF_6$ was replaced by nitrogen and argon. Emissions occur only from stocks, which can be in the current situation difficult to estimate.

#### 4.8.2.2 Methodological issues

Emissions from this category (Sound-proof glazing) are calculated in line with IPCC 2006 Gl., specifically Equation 8.20, 8.21 and 8.22.

#### 4.8.2.3 Uncertainties and time-series consistency

The uncertainty estimates were based on expert judgment (see Guidelines IPCC, 2006 Volume 1 Chapter 3 Uncertainties). Improvement of uncertainty estimation is in progress.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2015.

#### 4.8.2.4 Source-specific QA/QC and verification

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

Validation was performed by comparing the data obtained from the customs authorities, questionnaires and reports from Ministry of the Environment.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

#### 4.8.2.5 Source-specific recalculations, including changes made in response to the review process

In this year no recalculations in the whole sector were performed.

#### 4.8.2.6 Source-specific planned improvements, including those in response to the review process

No improvements are currently planned in this category in next submission.

### 4.8.3 $N_2O$ from Product Uses (CRF 2.G.3)

#### 4.8.3.1 Source category description

This category (2.G.3) includes $N_2O$ emissions from the use of this substance in the food industry (aerosol cans) and in health care (anaesthesia).

#### 4.8.3.2 Methodological issues

The calculation of emissions from this category, are based on IPCC, 2006, Volume 3 Chapter 8 equation 8.24. These not very significant emissions corresponding to 0.75 kt $N_2O$ were derived from production in the Czech Republic (0.6 kt $N_2O$) and from import of $N_2O$ (0.15 kt $N_2O$), see (Markvart and Bernauer, 2010-2013 and Bernauer and Markvart 2014-2016).

So far, in the Czech Republic, no relevant data have been available to distinguish between $N_2O$ used in anaesthesia and for aerosol cans. Therefore, the existing split (50% for anaesthesia) was based only on a rough estimate.

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

The uncertainty estimates were based on expert judgment (see Guidelines IPCC, 2006 Volume 1 Chapter 3 Uncertainties). Improvement of uncertainty estimation is in progress.

Uncertainties for activity data in this category at the level of 50% were estimated. No uncertainty was determined for the emission factor since we assumed that all the gas is emitted (the emission factor is equal 1 t/t $N_2O$). Overall uncertainty data are given in Chapter 1.7.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2015.

#### *4.8.3.4 Source-specific QA/QC and verification*

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

According to the QA/QC plan, data and calculations are provided by the external consultants (M. Markvart and B. Bernauer) and are checked by the experts from CHMI and vice versa.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

#### *4.8.3.5 Source-specific recalculations, including changes made in response to the review process*

In this year, no recalculations were performed in this sector.

#### *4.8.3.6 Source-specific planned improvements, including those in response to the review process*

In further submissions it is planned to collect activity data about the amount of $N_2O$ imported into the Czech Republic and investigate the division of activity data according their use.

### 4.8.4 Other (CRF 2.G.4)

#### *4.8.4.1 Source category description*

This category includes estimated emissions from Laboratory (experimental) use. This category was included in the 2006 submission for the first time and encompasses emissions of $SF_6$ from laboratory use. Emissions of F-gases were not identified in this category in 2015.

#### *4.8.4.2 Methodological issues*

Data were obtained from the customs authorities and sectoral expert Ing. Řeháček.

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

The uncertainty estimates were based on expert judgment (see Guidelines IPCC, 2006 Volume 1 Chapter 3 Uncertainties). Improvement of uncertainty estimation is in progress.

#### *4.8.4.4 Source-specific QA/QC and verification*

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

Validation was performed by comparing the data obtained from the customs authorities, questionnaires and reports from Ministry of the Environment.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

#### *4.8.4.5 Source-specific recalculations, including changes made in response to the review process*

No recalculation performed in this submission.

#### *4.8.4.6 Source-specific planned improvements, including those in response to the review process*

No improvements are currently planned in this category in next submission.

## 4.9 Acknowledgement

The authors would like to thank representatives from the Czech Ministry of the Environment, Department of Climate Change, Unit of Emission Trading for providing EU ETS. However, these data are still not available for the complete time-series.

The authors would also like to thank representatives of companies that willingly respond to our surveys and therefore help to bring to life these emission estimates.

# 5 Agriculture (CRF Sector 3)

## 5.1 Overview of sector

Agricultural greenhouse gas emissions under Czech national conditions consist mainly of emissions from enteric fermentation ($CH_4$ emissions only), manure management ($CH_4$ and $N_2O$ emissions), agricultural soils (only $N_2O$ emissions), urea application and liming (only $CO_2$ emissions). The other IPCC subcategories – rice cultivation, prescribed burning of savannas, field burning of agricultural residues and "other" – are not relevant for the Czech Republic.

Methane emissions are derived from animal breeding. These emissions originated primarily from enteric fermentation (digestive processes), which is manifested most for ungulate animals (in this country mostly cattle). Other emissions are derived from fertilizer management, where methane is formed under anaerobic conditions (with simultaneous formation of ammonia which, however, is not monitored in the framework of greenhouse gas inventories).

Nitrous oxide emissions are formed mainly by nitrification and denitrification processes in soils. The anthropogenic contribution that is determined in the national inventory of greenhouse gases is caused by nitrogenous substances derived from inorganic nitrogen-containing fertilizers, manure from animal breeding, application of sewage sludge to soils, nitrogen contained in parts of agricultural crops that are returned to the soil and N mineralized in soils. In addition, emissions are also included from stables and fertilizer management, together with indirect emissions derived from atmospheric deposition and from nitrogenous substances flushed into water courses and reservoirs.

Carbon oxide emissions are derived from application of non-organic fertilizers to agricultural soils, mainly based on application of industrially produced urea and limestone to the soils.

### 5.1.1 Key categories

For Agriculture, six categories of sources were evaluated by analysis decribed in IPCC (2006) as key categories. An overview of sources, including their contribution to aggregate emissions, is given in Tab. 5-1.

**Tab. 5-1 Overview of significant categories in this sector (2015)**

| Category | Gas | KC A1 | KC A2 | KC A1 incl. LULUCF | KC A1 excl. LULUCF | KC A2 incl. LULUCF | KC A2 excl. LULUCF | % of total GHG incl. LULUCF | % of total GHG excl. LULUCF |
|---|---|---|---|---|---|---|---|---|---|
| **3.D.1 Agricultural Soils, Direct $N_2O$ emissions** | $N_2O$ | LA, TA | LA, TA | yes | yes | yes | yes | 2.01 | 2.12 |
| **3.A Enteric Fermentation** | $CH_4$ | LA, TA | LA, TA | yes | yes | yes | yes | 2.26 | 2.39 |
| **3.D.2 Agricultural Soils, Indirect $N_2O$ emissions** | $N_2O$ | LA, TA | LA | yes | yes | yes | yes | 0.69 | 0.73 |
| **3.B Manure Management** | $N_2O$ | LA, TA | LA, TA | yes | yes | yes | yes | 0.79 | 0.83 |
| **3.B Manure Management** | $CH_4$ | LA, TA | TA | yes | yes | yes | yes | 0.60 | 0.64 |
| **3.G Liming** | $CO_2$ | TA | TA | yes | yes | yes | yes | 0.13 | 0.13 |

### 5.1.2 Quantitative overview

Agriculture is the third largest sector in the Czech Republic producing 7% of total GHG emissions incl. LULUCF (6.6% excl. LULUCF) in 2015 with 8 483 kt $CO_2$ eq.; 41% of emissions came from Agricultural Soils, 34% from Enteric Fermentation and 21% from Manure Management. Carbon dioxide emissions from liming and urea application on managed soils contribute 4% towards total 2015 agricultural emissions. During the 1990 - 2015 period, emissions from Agriculture decreased by more than 50%. The quantitative overview and emission trends in the reported period are provided in Tab. 5-2 and Fig.5-1.

**Tab. 5-2 Emissions of Agriculture in the 1990-2015 period (sorted by categories)**

| Year | TOTAL | Enteric Fermentation (3.A) | Manure Management (3.B) | Managed soils (3.D) | Liming (3.G) | Urea Application (3.H) |
|---|---|---|---|---|---|---|
| | Unit [kt $CO_2$ eq.] | | | | | |
| 1990 | 17050 | 5755 | 4211 | 5797 | 1178 | 109 |
| 1991 | 14776 | 5430 | 4017 | 4883 | 313 | 132 |
| 1992 | 12837 | 4862 | 3701 | 4058 | 108 | 109 |
| 1993 | 11358 | 4211 | 3364 | 3588 | 103 | 93 |
| 1994 | 10315 | 3688 | 2962 | 3471 | 103 | 91 |
| 1995 | 10246 | 3588 | 2797 | 3641 | 110 | 109 |
| 1996 | 9978 | 3553 | 2806 | 3406 | 112 | 100 |
| 1997 | 9593 | 3319 | 2704 | 3411 | 92 | 67 |
| 1998 | 9203 | 3106 | 2597 | 3267 | 90 | 143 |
| 1999 | 9272 | 3175 | 2631 | 3291 | 87 | 88 |
| 2000 | 8976 | 3048 | 2510 | 3258 | 112 | 48 |
| 2001 | 9082 | 3071 | 2449 | 3380 | 105 | 77 |
| 2002 | 8855 | 3005 | 2427 | 3261 | 99 | 64 |
| 2003 | 8389 | 2972 | 2374 | 2903 | 79 | 61 |
| 2004 | 8583 | 2906 | 2273 | 3257 | 76 | 70 |
| 2005 | 8257 | 2848 | 2178 | 3093 | 64 | 74 |
| 2006 | 8112 | 2807 | 2134 | 3010 | 78 | 83 |
| 2007 | 8265 | 2837 | 2116 | 3111 | 80 | 122 |
| 2008 | 8383 | 2868 | 2039 | 3280 | 95 | 100 |
| 2009 | 7930 | 2800 | 1881 | 3099 | 64 | 85 |
| 2010 | 7762 | 2720 | 1833 | 3037 | 61 | 111 |
| 2011 | 7904 | 2726 | 1755 | 3232 | 80 | 111 |
| 2012 | 7896 | 2759 | 1718 | 3168 | 116 | 136 |
| 2013 | 8129 | 2759 | 1759 | 3350 | 135 | 126 |
| 2014 | 8281 | 2817 | 1753 | 3503 | 150 | 57 |
| 2015 | 8483 | 2896 | 1779 | 3458 | 163 | 187 |

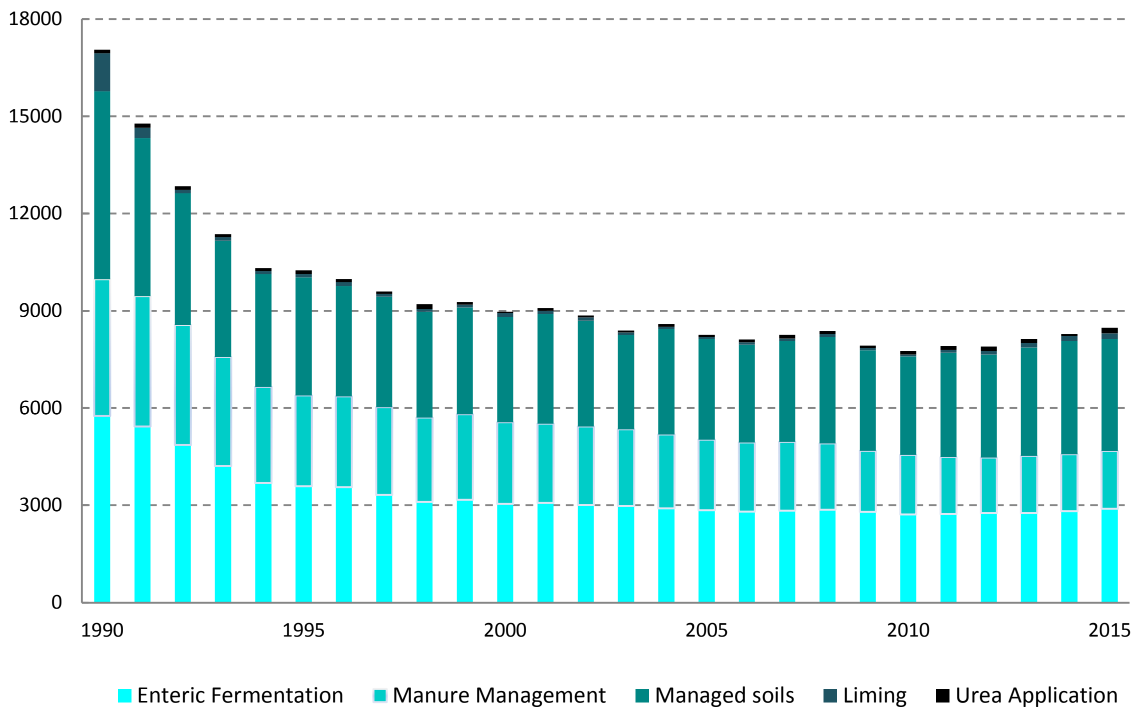



**Fig. 5-1 The emission trend of agricultural sector in period 1990-2015 [Gg $CO_2$ eq.]**

The trend series are consistent for both methane and nitrous oxide. For methane, the decrease in emissions for enteric fermentation since 1990 is connected with the decrease in the numbers of animals while the decrease in emissions derived from manure is not as great, as there has been a smaller decrease in the number of head of swine. It would seem that conditions in agriculture have stabilized somewhat since 1994.

An overview of the former recalculations is given in Chapter 10. The submission is in accordance with the IPCC 2006 Guidelines. According to the recommendations and requests of TERT and ERT reviews, the following improvements were implemented in the 2017 annual NIR submission:

- According to ERT recommendation the Nitrogen excretion rates were corrected for swine (3.B.2.3) and cattle population (3.B.2.1). Protein content for all cattle feed was reduced from 18% to 16.5%. This value is based on the paper of Task Force of Reactive Nitrogen (TFRN), Table ES2 with the mean protein content for "low ambition" for dairy cattle. Annual average N excretion (Nex) for swine was changed based on the correction of average swine weight (originally calculated based on the slaughter weight).

- The $N_2O$ emissions from leached nitrogen in 3B were deleted, because leaching from the animal manure is already reported under 3D. The notation key NE was used for the category Indirect emissions from Manure Management. The fractions ($Frac_{GasMS}$ and $Frac_{LossMS}$) of N loss from Manure Management System (MMS) were updated to coordinate reporting for $N_2O$ emissions from Manure Management and $N_2O$ emissions from managed soils.

- According to ERT recommendation the value of $Frac_{REMOVE}$ (3.D.1.4) was changed from 0.5 to zero, because survey data of country experts required (page 11.14, 2006 IPCC Gl.) is not available.

- The factor 0.9, originally applied to reduce the input data of synthetic fertilizers in category 3.D.1.1 (Direct N2O emissions) to consider emitting $NH_3$ and $NO_x$, was cancelled.

Inventory team decided to adopt the recommendation of 2006 IPCC Guidelines and changed EF1 from 1.25% to 1%. It resulted in decreased $N_20$ emissions from mineral fertilizers (3.D.1).

- Tier 1 approach and input data from the LULUCF sector (kt C from Forest land and Grassland converted to Cropland) were used to estimate N mineralized in mineral soils as a result of loss of soil C associated with change in land use ($F_{SOM}$) according to Eq. 11.8. (4.B.2.2)

- The amount of sewage sludge was added to the Eq. 11.9., the activity data including amount of sewage sludge (part of FON), crop residues (FCR) and N mineralized in mineral soils (FSOM), were added to Eq. 11.10. (3.D.1.2b).

- During QA/QC procedure the technical error was identified in category Manure Management of cattle. The Gross energy intakes (GE) and then also Emission factors (EF) of Manure Management for cattle (3.A.1) were corrected.

The recalculations were performed for the entire reporting period 1990-2015 in the relevant reporting tables under 3B and 3D categories. These improvements and methodological changes resulted in an increase of agricultural emissions as reported in NIR 2017 vs. NIR 2016 submission. A detailed description of the GHG emission estimation in the Czech Republic is presented in the corresponding NIR chapters.

### 5.1.3 Overview of source specific QA/QC and verification

Following the recommendation of the latest in-country review, a sector-specific QA/QC plan was formulated, tightly linked to the corresponding QA/QC plan of the National Inventory System, chapter 1.5. The plan describes the key procedures of inventory compilation, provides a table of personal responsibilities and a timetable of sector-specific QA/QC procedures. This plan consolidates the quality assurance procedures and facilitates effective quality control of the Agriculture inventory. The Institute of Forest Ecosystem Research (IFER) is the sector-solving institution for this category.

The agricultural greenhouse gas inventory is compiled by an experienced expert from IFER, including performance of self-control. The Czech University of Life Sciences, the Institute of Animal Science Prague, the Research Institute for Cattle Breeding and the Research Institute of Agricultural Engineering are additional institutes contributing the information used in the Agriculture sector. Slovak agricultural experts (SHMI) also participate in debates on inventory improvements.

Potential errors and inconsistencies are documented and corrections are made if necessary. In addition to the official review process, emission inventory methods and results are internally reviewed by the technical experts involved in the emission inventory of the Agriculture and LULUCF sectors. To comply with QA/QC, it is necessary to check:

- The inclusion of all activity data for animal categories, annual crop production, amount of synthetic fertilizers, sewage sludge, liming and urea applied to managed soils (Czech official statistics, urea production data)
- The consistency of time-series activity data and emission factors
- The update of national zoo-technical data
- All the emission factors and used parameters/fractions

QA/QC includes checking activity data, emission factors and the methods employed. All the differences are discussed and, if necessary, also corrected. The procedure of inventory compiling is initiated by IFER, where all the necessary data, obtained from the Czech Statistical Office (CzSO), are inserted into the excel spreadsheets. The excel files are verified by other IFER experts. Some more specific parameters, not available from CzSO, are required to estimate the country-specific emission factors for cattle (Tier 2). The zoo-technical national data (esp. cattle breeding) are supplied by experts from the agricultural institute (see above). The appropriate values in the calculation spreadsheets are updated at IFER, replacing the older values. The verified data are transferred to the CRF Reporter, where the data are again technically verified. A completeness check of CRF tables was performed for final time-series approval.

A responsible person (IFER expert) fills in QA/QC forms, including information from checking and verifying activity data, CRF data and NIR content separately for the reported emission inventory categories. The QA/QC forms are archived in IFER and CHMI (ftp server). All the information used for the inventory report is archived by the author and by the NIS coordinator. Hence, all the background data and calculations are verifiable.

At the beginning of July 2015, a peer-review with colleagues from the Slovak national emission team was held in Bratislava, focusing on improvement plans of for GHG national inventories. During the 2-day session, several key issues were discussed to explain the different or similar approaches in the national emission inventory assessments used by Czech or Slovak agricultural experts.

## 5.2 Livestock (CRF 3.1)

The methods for estimating $CH_4$ and $N_2O$ emissions from livestock require definitions of livestock sub-categories, annual populations (see Tab. 5-3) and, for higher Tier 2 methods (cattle), also feed intake and other characterizations. Coordinated livestock characterization was used to ensure consistency across the following source categories for the whole emission inventory.

**Tab. 5-3 Animal population in the period 1990-2015 (heads)**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|
| **Cattle** | 3 506 222 | 3 359 979 | 2 949 576 | 2 511 754 | 2 161 429 | 2 029 826 |
| **Pigs** | 4 789 898 | 4 569 304 | 4 609 149 | 4 598 821 | 4 070 898 | 3 866 568 |
| **Sheep** | 429 714 | 429 106 | 342 069 | 254 301 | 196 030 | 165 345 |
| **Poultry** | 31 981 100 | 33 278 468 | 30 756 308 | 28 219 580 | 24 974 149 | 26 688 376 |

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|
| **Cattle** | 1 988 810 | 1 865 901 | 1 700 788 | 1 657 326 | 1 573 527 | 1 582 295 |
| **Pigs** | 4 016 246 | 4 079 590 | 4 012 943 | 4 000 720 | 3 687 967 | 3 469 802 |
| **Sheep** | 134 009 | 120 921 | 93 557 | 86 047 | 84 108 | 87 539 |
| **Poultry** | 27 875 356 | 27 572 714 | 29 035 455 | 30 222 187 | 30 784 432 | 28 864 561 |

| | 2002 | 2003 | 2004 | 2005[1)] | 2006 | 2007 |
|---|---|---|---|---|---|---|
| **Cattle** | 1 520 145 | 1 473 822 | 1 428 327 | 1 397 324 | 1 373 645 | 1 391 396 |
| **Pigs** | 3 440 925 | 3 362 801 | 3 126 539 | 2 876 834 | 2 840 375 | 2 830 415 |
| **Sheep** | 96 286 | 103 129 | 115 852 | 140 197 | 148 412 | 168 910 |
| **Poultry** | 29 946 846 | 26 873 408 | 25 493 559 | 25 372 333 | 25 736 003 | 24 592 085 |

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|
| **Cattle** | 1 401 607 | 1 363 213 | 1 349 286 | 1 343 686 | 1 353 685 | 1 352 822 | 1 373 560 | 1 407 132 |
| **Pigs** | 2 432 984 | 1 971 417 | 1 909 232 | 1 749 092 | 1 578 827 | 1 586 627 | 1 617 061 | 1 559 648 |
| **Sheep** | 183 618 | 183 084 | 196 913 | 209 052 | 221 014 | 220 521 | 225 397 | 231 694 |
| **Poultry** | 27 316 866 | 26 490 848 | 24 838 435 | 21 250 147 | 20 691 308 | 23 265 358 | 21 463 815 | 22 508 192 |

### 5.2.1 Enteric fermentation (CRF 3.A)

#### *5.2.1.1 Source category description*

This chapter describes estimation of $CH_4$ emissions from Enteric Fermentation. In 2015, 2.4% of agricultural $CH_4$ emissions arose from this source category. This category includes emissions from cattle (dairy and non-dairy), swine, sheep, horses and goats. Camels, llamas, mules and asses do not occur in the Czech Republic. A few buffaloes are kept by several private farmers (as a private zoo). Enteric fermentation emissions from poultry have not been estimated; the IPCC Guidelines do not provide a default emission factor for this animal category.

#### *5.2.1.2 Methodological issues*

Emissions from enteric fermentation of domestic livestock were calculated using the Tier 1 and Tier 2 (cattle category) methodologies presented in the 2006 IPCC Guidelines, which are linked to the previous methodologies IPCC (1997 and 2000). Methane emissions for cattle, which are a dominant source in this category, were calculated using Tier 2 method, while the Tier 1 method was used for other livestock. The contribution of emissions from livestock other than cattle to the total emissions from enteric fermentation was not significant.

***Enteric fermentation of cattle***

As the most important output of the national study (Kolar, Havlikova and Fott, 2004), a system of calculation spreadsheets have been drawn up and used for all the relevant calculations of $CH_4$ emissions.

The emission factor for methane from fermentation (EF) in kg/head p.a. is proportional to the daily food intake and the conversion factor. It thus holds that

$$EF_i = GE \cdot \frac{365}{55.65} \cdot Y$$

where the "daily food intake" (GE in MJ/day) is taken as the mean feed ration for the given type of cattle (there are several subcategories of cattle) and Y is the conversion factor, which is considered to be 0.065 for cattle (see Table 10.12, Volume 4, IPCC 2006). Coefficient 55.65 has dimensions of MJ/kg $CH_4$.

In principle, this equation should be solved for each cattle subcategory, denoted by index i. The Czech Statistical Office, see Statistical Yearbooks (CzSO, 1990–2015), provides the following categorization of cattle:

- Calves younger than 6 months[1] of age (male and female)

[1] *Since 2009 the age limit for "Calves" shifted up to 8 months.*

- Young bulls and heifers (6-12 months of age[2])
- Bulls and bullocks (1 – 2 years, over 2 years)
- Heifers (1 – 2 years, over 2 years)
- Mature cows (dairy and suckler)

More disaggregated sub-categories given above in parenthesis are given in the study by external agricultural consultants of CHMI (Hons and Mudrik, 2003).

In the calculation, it is also very important to distinguish between dairy and suckler cows, where the fraction of suckler cows (suckler/all cows) gradually increased in the 1990-2015 time period.

According to the IPCC methodology (Tier 2, 2006 IPCC Gl.), the "daily food intake" for each subcategory of cattle is not measured directly, but is calculated from national zoo-technical inputs, mainly weight, weight gain (for growing animals), daily milk production including the percentage of fat (for cows) and the feeding situation (stall, pasture). The national zoo-technical inputs (noted above) were updated by an expert from the Czech University of Life Sciences in Prague in 2006 and 2011. Examples of the input data used (Hons and Mudřík, 2003, Mudřík and Havránek, 2006, Kvapilík J. 2010 and 2011 – pers.com.) are given below, Tab. 5-4 and Tab 5-5. The numbers of grazing days for individual cattle categories are presented in Tab. 5-6.

**Tab. 5-4 Weights of individual categories of cattle, 1990–2015, in kg**

| Categories of cattle | 1990 – 94 | 1995 – 98 | 1999 – 04 | 2005 – 09 | 2010 - now |
|---|---|---|---|---|---|
| **Mature cows (dairy and suckler)** | 520 | 540 | 580 | 585 | 590 |
| **Heifers > 2 years** | 485 | 490 | 505 | 510 | 515 |
| **Bulls and bullocks > 2 years** | 750 | 780 | 820 | 840 | 850 |
| **Heifers 1-2 years** | 380 | 385 | 395 | 395 | 390 |
| **Bulls 1-2 years** | 490 | 510 | 530 | 540 | 560 |
| **Heifers 6-12 months** | 275 | 280 | 285 | 285 | 290* |
| **Bulls 6-12 months** | 325 | 330 | 335 | 340 | 350* |
| **Calves to 6 months** | 128 | 132 | 133 | 135 | 135* |

*Note: * Since 2009 the age limit for "Calves" shifted up to 8 months.*

[2] *Since 2009 the age limit for "Young bulls and heifers" shifted up to 8 -12 months.*

**Tab. 5-5 Feeding situation, 1990–2015, in % of pasture, otherwise stall is considered**

| Categories of cattle | 1990 – 94 | 1995 – 98 | 1999 – 04 | 2005 – 09 | 2010 - now |
|---|---|---|---|---|---|
| **Dairy cows** | 10 | 20 | 20 | 22 | 15 |
| **Suckler cows** | 10 | 20 | 20 | 50 | 95 |
| **Heifers > 2 years** | 30 | 30 | 30 | 35 | 50 |
| **Bulls > 2 years.** | 30 | 40 | 40 | 40 | 25 |
| **Heifers 1-2 years** | 30 | 40 | 40 | 40 | 50 |
| **Bulls 1-2 years** | 30 | 40 | 40 | 40 | 25 |
| **Heifers 6-12 months** | 30 | 40 | 40 | 40 | 50* |
| **Bulls 6-12 months** | 30 | 40 | 40 | 40 | 50* |

*Note: * Since 2009 the age limit for "Calves" shifted up to 8 months.*

**Tab. 5-6 Grazing days for individual cattle categories for the entire period**

| Categories of cattle | 1990 – 94 | 1995 – 98 | 1999 – 04 | 2005 – 09 | 2010 - now |
|---|---|---|---|---|---|
| **Dairy cows** | 18 | 20 | 36 | 40 | 27 |
| **Suckler cows** | 18 | 20 | 36 | 90 | 171 |
| **Heifers > 2 years** | 54 | 54 | 54 | 63 | 90 |
| **Bulls > 2 years.** | 54 | 72 | 72 | 72 | 45 |
| **Heifers 1-2 years** | 54 | 72 | 72 | 72 | 90 |
| **Bulls 1-2 years** | 54 | 72 | 72 | 72 | 45 |
| **Heifers 6-12 months** | 54 | 72 | 72 | 72 | 90* |
| **Bulls 6-12 months** | 54 | 72 | 72 | 72 | 90* |

*Note: * Since 2009 the age limit for "Calves" shifted up to 8 months.*

Percentages of pasture are related only to the summer part of the year (180 days), while only the stall type is used in the rest of year. The daily milk production statistics (Tab. 5-7), in which only milk from dairy cows is considered, increased to 21.92 l/day/head in 2015, with an average fat content of 3.84%. A relevant daily milk production of non-dairy cows is 3.5 l/day/head. The activity data for milk production comes from the official statistics (CzSO) and these are verified in the Yearbook of cattle in the Czech Republic (annual report).

As the official statistics, specifically from CzSO, provide population values for cows and other cattle, the resulting EFs in the CRF Tables are defined for the categories of "Dairy cows" and "Non-dairy cattle". The animal population numbers are based on livestock surveys (up to 1991 as at 1.1., from 1992 to 2002 as at 1.3., since 2003 as at 1.4.).

The weighted average values for the non-dairy cattle feeding situation and pregnancy % were calculated and entered in the CRF tables. The weighted feeding situation is mostly affected by time in the pasture feeding of suckler cows (95%), as well as for pregnancy (90% of suckler cows are pregnant, 0% for the other cattle species).

The country-specific parameter DE (digestibility, in %) for cattle was estimated based on existing publications. The average digestibility for cattle was estimated on the basis of the individual OMD (organic matter digestibility) values for the most common feed (e.g. corn silage, hay and straw, green fodder – alfalfa and clover, etc.). The estimated average digestibility corresponds to approximately 70% (Koukolová and Homolka 2008 and 2010, Tománková and Homolka 2010, Jančík et al. 2010, Petrikovič et al. 2000, Petrikovič and Sommer 2002, Sommer 1994, Zeman et. al. 2006, Třináctý 2010, Čermák et al. 2008). Dr. Pozdíšek (expert from the Research Institute for Cattle Breeding, Ltd., pers. com.) determined the conservative average digestibility values for 3 basic cattle sub-categories. These digestibility values were employed for the emission estimation:

- Dairy cattle DE = 67%
- Suckler cows DE = 62%
- Other cattle DE = 65%

The coefficients ($C_{fi}$) for calculating the Net energy for maintenance ($N_{EM}$) of cattle are the default values from Table 10.4 (2006 IPCC Gl.).

Details of the calculation are given in the above-mentioned study (Kolar, Havlikova and Fott, 2004) and the results are illustrated in Tab. 5-8. It is obvious that the EFs have increased slightly since 1990 because of the increasing weight and milk production for cows and because of the increasing weight and weight gain for other cattle. On the other hand, $CH_4$ emission from enteric fermentation of cattle decreased during the 1990-2015 period to about one half of the former values due to the rapid decreases in the numbers of animals kept.

**Tab. 5-7 Milk production of dairy cows and fat content (1990–2015)**

| | Dairy cows | Daily production | Fat content |
|---|---|---|---|
| | [thousands] | [liters/day head] | [%] |
| **1990** | 1206 | 10.67 | 4.03 |
| **1995** | 732 | 11.34 | 4.02 |
| **2000** | 548 | 13.55 | 4.00 |
| **2005** | 438 | 17.13 | 3.90 |
| **2010** | 384 | 18.91 | 3.86 |
| **2015** | 376 | 21.92 | 3.84 |

**Tab. 5-8 Methane emissions from enteric fermentation, cattle (Tier 2, 1990–2015)**

| | Dairy cows | Other cattle | EF. cows | EF. other | Emissions cows | Emissions other | Emissions total |
|---|---|---|---|---|---|---|---|
| | [thous.] | [thous.] | [kg $CH_4$/hd] | [kg $CH_4$/hd] | [kt $CH_4$] | [kt $CH_4$] | [kt $CH_4$] |
| **1990** | 1206 | 2300 | 96.68 | 44.47 | 116.61 | 102.27 | 218.88 |
| **1991** | 1165 | 2195 | 93.06 | 44.57 | 108.45 | 97.81 | 206.26 |
| **1992** | 1006 | 1943 | 94.85 | 45.69 | 95.44 | 88.78 | 184.23 |
| **1993** | 902 | 1609 | 95.17 | 45.40 | 85.88 | 73.06 | 158.95 |
| **1994** | 796 | 1366 | 97.17 | 45.38 | 77.32 | 61.97 | 139.29 |
| **1995** | 732 | 1298 | 101.21 | 47.59 | 74.11 | 61.75 | 135.86 |
| **1996** | 713 | 1275 | 102.83 | 47.92 | 73.37 | 61.11 | 134.48 |
| **1997** | 656 | 1210 | 100.99 | 48.65 | 66.28 | 58.84 | 125.13 |
| **1998** | 598 | 1103 | 105.53 | 48.80 | 63.09 | 53.82 | 116.91 |
| **1999** | 583 | 1074 | 110.16 | 51.65 | 64.23 | 55.49 | 119.72 |
| **2000** | 548 | 1026 | 112.61 | 52.11 | 61.69 | 53.45 | 115.14 |
| **2001** | 529 | 1053 | 114.51 | 52.92 | 60.62 | 55.72 | 116.34 |
| **2002** | 496 | 1024 | 118.21 | 53.88 | 58.67 | 55.17 | 113.84 |
| **2003** | 490 | 984 | 120.81 | 54.23 | 59.23 | 53.34 | 112.57 |
| **2004** | 476 | 952 | 123.20 | 54.15 | 58.63 | 51.58 | 110.21 |
| **2005** | 438 | 960 | 125.72 | 55.25 | 55.04 | 53.01 | 108.06 |
| **2006** | 424 | 950 | 126.91 | 55.30 | 53.81 | 52.52 | 106.33 |
| **2007** | 410 | 981 | 128.55 | 55.66 | 52.75 | 54.60 | 107.35 |
| **2008** | 406 | 996 | 130.48 | 56.36 | 52.91 | 56.13 | 109.05 |
| **2009** | 400 | 964 | 131.53 | 56.48 | 52.55 | 54.43 | 106.98 |
| **2010** | 384 | 966 | 132.02 | 54.96 | 50.63 | 53.08 | 103.71 |
| **2011** | 374 | 970 | 134.49 | 55.46 | 50.28 | 53.79 | 104.07 |
| **2012** | 373 | 981 | 137.08 | 55.42 | 51.15 | 54.34 | 105.49 |
| **2013** | 367 | 985 | 137.67 | 55.70 | 50.57 | 54.89 | 105.46 |
| **2014** | 373 | 1001 | 140.54 | 55.33 | 52.37 | 55.38 | 107.75 |
| **2015** | 376 | 1031 | 142.90 | 55.44 | 53.75 | 57.15 | 110.90 |

### *Enteric fermentation of other livestock*

Compared to cattle, the contribution of other farm animals to the total $CH_4$ emissions from enteric fermentation is much smaller (4.3%). Therefore, $CH_4$ emissions from enteric fermentation of other farm animals (other than cattle) are estimated using the Tier 1 approach. Because of some features of keeping livestock in the Czech Republic that are similar to those in the neighbouring countries of Germany and Austria, default EFs for the Tier 1 approach recommended for Developed countries were employed. The obsolete national approach used in the past, which was found not to be comparable with other European countries (Dolejš, 1994 and Jelínek et.al., 1996), was definitively abandoned. The estimated values are presented for the whole period since 1990.

Sheep, goats, swine and horses

The Czech Statistical Office (CzSO) publishes data on the number of goats, sheep, swine, horses and poultry annually in the Statistical Yearbooks (1990-2015).

Considering the rather small numbers in these animal categories, default coefficients from the IPCC method have been used for estimating methane emissions: 8 kg of methane annually per head for sheep, 5 kg of methane for goats, 1.5 kg of methane for swine and 18 kg of methane for horses.

Poultry

IPCC guidelines do not define or require estimates of quantities of methane from enteric fermentation.

#### *5.2.1.3 Uncertainty and time-series consistency*

As mentioned above, methane emissions from the breeding of farm animals are caused both by enteric fermentation and also by the decomposition of animal excrements (manure). Determination of these emissions was prepared at the level of both Tier 1 and Tier 2. As enteric fermentation is considered according to Tab. 5-1 to constitute a key source, preference should be given to determination in Tier 2.

For quite a long time calculations were based on historical studies (Dolejš, 1994) and (Jelínek et al, 1996). In principle, emissions from animal excrements could be calculated according to Tier 1 (this is not a key source); however, for reasons of tradition and for consistency of the time series, the final values were also calculated according to Tier 2 using the emission factors from above-mentioned studies (Dolejš, 1994; Jelínek et al, 1996). An approach based on historical studies was indicated to be obsolete in many reviews organized by UNFCCC. Moreover, IEFs (implied emission factors) were mostly found as outliers: especially EFs for enteric fermentation in cattle seemed to be substantially underestimated. Details of the historical approach are given in former NIRs (submitted before 2006).

The Czech team accepted critical remarks put forth by the International Expert Review Teams (ERT) and prepared a new concept for calculation of $CH_4$ emissions. This concept, in accordance with the plan for implementing Good Practice, is based on the following decisions:

1) Emissions of methane from enteric fermentation of livestock (a key source) come predominantly from cattle. Therefore Tier 2, as described in Good Practice (Good Practice Guidance, 2000) is applied only to cattle.
2) $CH_4$ emissions from enteric fermentations of other farm animals are estimated by Tier 1 approach. Because of some features of keeping livestock in the Czech Republic that are similar to the neighbouring countries of Germany and Austria, default EFs for Tier 1 approaches recommended for developed countries were employed.

Increased attention was firstly paid to enteric fermentation. It was stated that cooperation with specialized agricultural experts is crucial to obtain new consistent and comparable data of suitable quality. The relevant nationally specific data, milk production, weight, weight gain for growing animals, type of stabling, etc. were collected by our external experts (Hons and Mudrik, 2003). Moreover, statistical data for sufficiently detailed classification of cattle, which are available in the Czech Republic, were also collected at the same time. Calculation of enteric fermentation of cattle using the Tier 2 approach was described in a study (Kolar, Havlikova and Fott, 2004) for the whole time series since 1990 using the above-mentioned country-specific data. The necessary QA/QC procedures were performed in cooperation with experts from IFER. The nationally specific data like the weights of individual categories of cattle, weight gains in these categories and the recent feeding situation were revised in 2006. The new values were estimated in a similar way by our external experts (Mudrik and Havranek, 2006) for the following period.

The national zoo-technical inputs (mainly weight, weight gain, daily milk production including the percentage of fat and the feeding situation) were updated in this submission in conjunction with an expert from the Research Institute of Animal Production. Also in this submission, the sub-category "Suckler cows" was reallocated from “Dairy cattle” to “Non-dairy cattle”; more accurate cattle population data was used. Additionally, the new digestibility values (DE) were employed for cattle, affecting the implied emission factors for cattle categories. These changes in the activity data and input parameters resulted in changes in emissions for the entire reporting period.

In 2015, the emission factors for estimation of methane emissions from Enteric Fermentation by cattle (dairy and non-dairy) were recalculated following revision of the coefficient for calculating the net energy for maintenance (Cfi) and cattle methane conversion factor (Ym). These new default parameters were employed according to the 2006 IPCC Guidelines for the entire period. A cattle methane conversion factor Ym equal to 0.065 was employed for the estimates in Table 10.12 (2006 IPCC Gl.) and coefficients Cfi for dairy and non-dairy cattle were employed from Table 10.4 (2006 IPCC Gl.). The mentioned changes generated new Gross Energy values (GE) and updated emission factors for estimation of methane emissions from Enteric Fermentation.

Uncertainty estimates are based on expert judgment. The uncertainty in the activity data equals to 5%. The uncertainty in the emission factor equals 20%. The combined uncertainty, calculated according to the IPCC Tier 1 methodology, equals 20.6%.

#### 5.2.1.4 Source-specific QA/QC and verification

A detailed description of source-specific QA/QC and inventory verification of agriculture is presented in section 5.1.3.

#### 5.2.1.5 Source-specific recalculations, including changes made in response to the review process and impact of emission trend

No recalculations were performed in this submission.

#### 5.2.1.6 Source-specific planned improvements, including tracking of those identified in the review process

The analysis of uncertainties is currently in progress.

### 5.2.2 Manure management (CRF 3.B)

This chapter describes the estimation of $CH_4$ (43%) and direct (43%) and indirect (14%) $N_2O$ emissions from animal manure management. Total emissions from Manure Management ($CH_4$ and $N_2O$) equalled 1779 Gg $CO_2$ eq. in 2015. For detailed information see Tab. 5-9.

Good agricultural practices were developed based on agricultural policies and structures that support the trends in the animal waste management system allocation. These practices aim to use techniques to reduce emissions, protecting the environment while incurring low costs. These procedures include inexpensive and austerity measures, such as the incorporation of relevant proteins in livestock feed, regular cleaning of stables or proper timing of manure applications to agricultural land in the period when plants absorb the maximum amount of nutrients. These measures may also involve complicated procedures, such as using low-emission techniques for application and storage of manure and livestock housing.

#### 5.2.2.1 Source category description

During the 1990-2015 period, the emissions from Manure Management decreased by 58%. Emissions from cattle and swine predominate in this trend. The reduction in the cattle population is partly counterbalanced by an increase in cow efficiency (increasing gross energy intake and milk production).

This emission source covers manure management for domestic livestock. Both nitrous oxide ($N_2O$) and methane ($CH_4$) emissions from manure management of livestock (cattle, swine, sheep, horses, goats and poultry) are reported. The animal waste management systems (AWMS) are distinguished for $N_2O$ emission estimations: liquid system, daily spread, solid storage & dry lot and other manure management systems. Nitrous oxide is produced by the combined nitrification and denitrification processes occurring in the manure. Methane is produced in manure during the decomposition of organic material by anaerobic and facultative bacteria under anaerobic conditions. The amount of emissions is dependent on the amount of organic material in the manure and climatic conditions.

**Tab. 5-9 List of emissions from Manure Management during 1990-2015 (in kt $CO_2$ eq.)**

| | Total ($CO_2$ eq.) | $CH_4$ (kt) | $N_2O$ (kt) |
|---|---|---|---|
| **1990** | 4211.40 | 70.08 | 8.25 |
| **1995** | 2796.78 | 48.34 | 5.33 |
| **2000** | 2509.64 | 43.17 | 4.80 |
| **2005** | 2178.08 | 39.80 | 3.97 |
| **2010** | 1832.57 | 32.44 | 3.43 |
| **2015** | 1779.28 | 30.86 | 3.38 |

#### 5.2.2.2 Methodological issues

**Methane emissions (CRF 3.B.1)**

$CH_4$ emissions from manure management were identified as a *key source* by trend and level assessments (TA, LA). The estimation of methane emissions from Manure Management is provided of cattle by Tier 2. This category of emissions was identified based on analysis of National Inventory System (NIS) as a key category by trend assessment (see Tab. 5-1).

##### Cattle category

The activity data as cattle population distributed by age was obtained from the Czech Statistical Office (CzSO). This is a consistent time series of the number of animals during the entire reported period (1990-2015). Gross energy (GE) values are estimated based on the national study of Kolář *et al*. (2004) and the 2006 IPCC Gl. These GE parameters are reported in CRF as country-specific data for the entire reported period (Tab. 5-10).

**Tab. 5-10 Gross Energy (GE, MJ/head/day) of cattle in 5-year period (1990-2015)**

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 |
|---|---|---|---|---|---|---|
| **Dairy cows** | 226.8 | 237.4 | 264.1 | 294.9 | 309.7 | 335.2 |
| **Other cattle** | 104.3 | 111.6 | 122.2 | 129.6 | 128.9 | 130.0 |

The current updated data for the AWMS distribution were employed for emission estimation. The other specific parameters for estimation of the emission factors for cattle were obtained (Bo, MCF) from Dämmgen *et al.* (2012). The specific parameters recommended for use by study in neighbouring countries (Dämmgen *et al.* 2012) are comparable to the default values (2006 IPCC Guidelines) and correspond to Czech climate conditions. The parameters recommended in Dämmgen *et al.* (2012) were utilized for the emission estimations (Tab. 5-11). The VS parameters calculated by Dämmgen *et al.* (2012) on the basis of the $B_0$, ASH and MCF values and EF for estimation of methane emissions are presented in Table 5-12.

**Tab. 5-11 List of parameters for methane emission factor estimation in Manure Management in Czech conditions**

| Parameters | Dairy cows | Other cattle |
|---|---|---|
| $B_o$ | 0.24 | 0.17 |
| ASH | 8% | |
| MCF values: | | |
| **Liquid system** | 17% | |
| **Daily spread** | 0.1% | |
| **Solid storage and dry lot** | 2% | |
| **Pasture range and paddock** | 1% | |

The equations for determination of emission factors and estimation of methane emissions were taken from the IPCC (2006).

1. The Eq. 10.22 (2006 IPCC, p. 10.37) was used to estimate the methane emissions:

$$CH_{4\,emissions}\left[\frac{kt}{year}\right] = \sum\left(\frac{EF \cdot cattle\ population}{10^6}\left[\frac{kg}{kt}\right]\right)$$

2. The Eq. 10.24 (2006 IPCC, p. 10.42) was utilized to estimate the VS parameter:

$$VS = GE \cdot \left[\frac{1-DE}{100} + (UE \cdot GE)\right] \cdot \frac{1-ASH}{18.45}$$

3. The methane emission factors were estimated using by Eq. 10.23 (2006 IPCC, p. 10.41):

$$EF = VS \cdot 365 \cdot B_o \cdot 0.67 \cdot \sum(MCF \cdot MS)$$

**Tab. 5-12 Parameter VS, EF (kg $CH_4$/h/yr) and methane emissions from Manure Management in period 1990-2015**

| | Dairy cows | | Other cattle | |
|---|---|---|---|---|
| | VS | EF | VS | EF |
| **1990** | 4.18 | 13.91 | 2.35 | 8.22 |
| **1991** | 4.03 | 13.39 | 2.34 | 8.20 |
| **1992** | 4.10 | 13.65 | 2.30 | 8.10 |
| **1993** | 4.12 | 13.69 | 2.29 | 8.06 |
| **1994** | 4.21 | 13.66 | 2.29 | 8.07 |
| **1995** | 4.38 | 13.61 | 2.39 | 8.08 |
| **1996** | 4.45 | 10.55 | 2.40 | 8.15 |
| **1997** | 4.37 | 8.52 | 2.43 | 8.30 |
| **1998** | 4.57 | 8.90 | 2.44 | 8.35 |
| **1999** | 4.77 | 9.42 | 2.57 | 8.87 |

| | | | | |
|---|---|---|---|---|
| **2000** | 4.87 | 11.76 | 2.59 | 8.98 |
| **2001** | 4.96 | 12.10 | 2.63 | 9.80 |
| **2002** | 5.12 | 15.10 | 2.67 | 10.04 |
| **2003** | 5.23 | 17.99 | 2.68 | 10.12 |
| **2004** | 5.33 | 18.34 | 2.68 | 10.11 |
| **2005** | 5.44 | 18.55 | 2.74 | 10.39 |
| **2006** | 5.49 | 18.72 | 2.74 | 10.41 |
| **2007** | 5.56 | 18.96 | 2.76 | 10.22 |
| **2008** | 5.65 | 19.25 | 2.79 | 10.08 |
| **2009** | 5.69 | 19.40 | 2.81 | 9.80 |
| **2010** | 5.71 | 20.11 | 2.78 | 9.21 |
| **2011** | 5.82 | 20.48 | 2.80 | 9.19 |
| **2012** | 5.93 | 20.88 | 2.80 | 9.10 |
| **2013** | 5.96 | 20.97 | 2.81 | 9.13 |
| **2014** | 6.08 | 21.41 | 2.80 | 9.04 |
| **2015** | 6.18 | 21.76 | 2.81 | 9.04 |

### *Other livestock category*

The emissions from farm animals other than cattle are estimated by the Tier 1 approach. Default EFs for developed countries were employed for similar reasons as in the previous paragraph (Tab. 5-13). In relation to the decreasing trend in the animal population (especially cattle and swine) the emissions from *Manure Management* rapidly declined during 1990-2003.

**Tab. 5-13 Default emission factors used to estimate $CH_4$ emissions from Manure Management**

| Livestock type | EF (kg/head/yr) |
|---|---|
| **Sheep** | 0.19 |
| **Goats** | 0.13 |
| **Horses** | 1.56 |
| **Swine** | 6.00 |
| **Poultry*** | 0.173 |

** The emission factor for poultry was assessed as a weighted average of two default EFs for different breeding systems (13% wet and 87% dry systems; 0.173 = 1.13 x 0.13 + 0.03 x 0.87).*

### Nitrous oxide emissions (CRF 3.B.2)

$N_2O$ emissions from manure management were identified as a key source; Tier 2 methodology is used for emission estimations for the cattle category (Tier 2 for other animals). Emissions are calculated on the basis of N excretion per animal and the animal waste management system. Following the guidelines, all emissions of $N_2O$ taking place before the manure is applied to soils are reported under Manure Management. The IPCC Guidelines method for estimating $N_2O$ emissions from manure management entails multiplying the total amount of N excretion (from all animal species/categories) in each type of manure management system by an emission factor for that type of manure management system.

Input data consists in the mass fraction Xi,j of animal excrement in animal category i (i = dairy cows, other cattle, pigs, …) for various types of excrement management (AWMS - Animal Waste Management System) j (j = anaerobic lagoons, liquid manure, solid manure, pasturage, daily spreading in fields, other). Here, it holds that Xi, 1 + Xi, 2 + ... + Xi, 6 = 1. For Tier 1, gives only the values of matrix X for typical means of management of animal excrement in Europe. AWMS parameters presented in the IPCC methodology (IPCC, 2006) were determined for the Czech conditions. The Czech specific AWMS parameters are distributed to dairy and non-dairy cattle categories (Tab. 5-15).

The manure storage capacity corresponds to the actual production for 6 months. This does not apply to the storage of solid manure on agricultural land prior to use. Solid manure may be stored on agricultural land for a maximum period of 24 months (Decree No. 274/1998 Coll.). If the company is active in vulnerable areas, solid storage on agricultural land is permitted for a maximum period of 12 months (Regulation 103/2003 Coll.). The company/owner can store manure for fertilizer again on the same agricultural land four years after soil cultivation of the agricultural land. Liquid manure is to be stored in leak-proof tanks or scrub areas in stables. Reservoirs and tanks or areas in the stables must correspond to a capacity of at least four months estimated production of liquid manure or share a minimum of three months estimated production of liquid manure and dung, depending on the climatic conditions of the region.

The Nex values for dairy and non-dairy cattle were revised (see Tab. 5-14) according to technical corrections in GE values (unification to GE values for $CH_4$ estimation). The distribution ratio of manure per AWMS is presented in Tab. 5-15 (set up by Kvapilík J. 2011 – pers.com.).

The Nex values were also revised for the other than cattle animal categories. The Nex were determined based on the national data for Typical Animal Mass (TAM) and Eq. 10.30. The new Nex were calculated for sheep, swine, horses, goats and poultry (see Tab. 5.16). The national values for nitrogen excretion (Nex) and distribution of AWMS systems for other animal categories (excl. cattle) are presented in Tab. 5-16. The emissions are then summed over all the manure management systems. The manure production data for individual AWMS in 2015 are reported in Tab. 5-17.

**Tab. 5-14 Czech national Nex (nitrogen excretion) values used to estimate $N_2O$ emissions from Manure Management**

| | Nitrogen excretion (Nex) | |
|---|---|---|
| | Dairy cows | Non-dairy cattle (AVG value) |
| | [kg/head/year] | |
| **1990** | 98.29 | 54.54 |
| **1995** | 102.57 | 57.41 |
| **2000** | 112.38 | 61.78 |
| **2005** | 121.68 | 65.21 |
| **2010** | 126.03 | 65.94 |
| **2015** | 132.55 | 66.55 |

**Tab. 5-15 Czech national distribution of AWMS systems for cattle category only**

| Dairy cows | Fraction of Manure Nitrogen per AWMS (in %) | | | |
|---|---|---|---|---|
| | Liquid | Daily spread | Solid | PRP |
| **1990** | 25 | 2 | 68 | 5 |
| **1995** | 23 | 1 | 66 | 10 |
| **2000** | 15 | 1 | 74 | 10 |
| **2005** | 26 | 1 | 62 | 11 |
| **2011 - now** | 27 | 1 | 65 | 7 |

| Non-dairy cattle (AVG) | Liquid | Daily spread | Solid | PRP |
|---|---|---|---|---|
| **1990** | 45 | 1 | 42 | 12 |
| **1995** | 43 | 1 | 39 | 17 |
| **2000** | 44 | 1 | 38 | 17 |
| **2005** | 49 | 1 | 34 | 16 |
| **2006** | 49 | 1 | 34 | 16 |
| **2007** | 48 | 1 | 33 | 18 |
| **2008** | 47 | 1 | 32 | 20 |
| **2009** | 45 | 1 | 32 | 22 |
| **2010** | 43 | 1 | 32 | 24 |
| **2011 - now** | 42 | 1 | 32 | 25 |

**Tab. 5-16 The nitrogen excretion (Nex) and distribution of AWMS systems for other animal categories in 2015**

| Livestock type | Typical animal mass (kg/head) | Nex (kg/head/yr) | Type of AWMS | | | | |
|---|---|---|---|---|---|---|---|
| | | | Liquid | Daily spread | Solid | PRP | Other |
| | | | Fraction of Manure Nitrogen per AWMS (in %) | | | | |
| **Sheep** | 49 | 15 | 0 | 0 | 2 | 87 | 11 |
| **Swine** | 59 | 16 | 76 | 0 | 23 | 0 | 1 |
| **Poultry** | 2 | 0.6 | 13 | 0 | 1 | 2 | 84 |
| **Horses** | 498 | 47 | 0 | 0 | 0 | 96 | 4 |
| **Goats** | 19 | 9 | 0 | 0 | 0 | 96 | 4 |

**Tab. 5-17 Manure production distributed by individual AWMS in 2015**

| AWMS | Nitrogen Production in Manure (kg N/yr) |
|---|---|
| **Liquid systems** | 62 587 596 |
| **Daily spread** | 1 115 200 |
| **Solid storage & drylot** | 59 392 959 |
| **Pasture range and paddock** | 27 121 291 |
| **Other** | 12 054 086 |
| **Totals** | 162 271 132 |

### *Emission factors*

To estimate $N_2O$ emissions from manure management, the default emission factors for the different animal waste management systems were taken from the Table 10.21 (2006 IPCC), see Tab. 5-18.

**Tab. 5-18 IPCC default emission factors of animal waste per different AWMS**

| AWMS | Emission Factor ($EF_3$) |
|---|---|
| | [kg $N_2O$-N per kg N excreted] |
| **Liquid** | 0.005 |
| **Solid Storage** | 0.02 |
| **Other Systems** | 0.01 |

## Indirect Emissions from Manure Management (CRF 3.B.2.5)

Indirect emissions result from volatile nitrogen losses that occur primarily in the form of ammonia and NOx. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure collection and storage depends primarily on time and, to a lesser degree, temperature. Nitrogen losses begin at the point of excretion in buildings and other animal production areas and continue through on-site management in manure management systems.

Tier 1 calculation of N volatilization in the form of $NH_3$ and $NO_x$ from MMS is based on multiplication of the amount of nitrogen excreted (from all the livestock categories) and managed in each MMS by a fraction of volatilized nitrogen (Eq. 10.26). N losses are then summed over all the MMS´s. The Tier 1 method is applied using national nitrogen excretion data, MMS data and default fractions of N losses from MMS due to volatilization (Table 10.22). In order to estimate indirect $N_2O$ emissions from Manure Management, the fraction of nitrogen losses due to volatilization and the default indirect factor $EF_4$ associated with these losses were employed (Table 11.3, IPCC 2006 Gl.).

According to methodology 2006 IPCC the fraction of manure nitrogen that leaches from manure management systems ($Frac_{LeachMS}$) is highly uncertain and should be developed as a country-specific value employed in the Tier 2 method. Because the value of the fraction is not available in Czech Republic (no measurements or national survey), estimation of this category cannot be included in the emission inventory. The CRF tables contain the notation key NE.

#### 5.2.2.3 Uncertainty and time-series consistency

On the basis of the recommendations of ERT 2009, the estimation of manure management $N_2O$ emissions from horses and goats is reported as two individual groups of animals (category Other livestock was regrouped to two categories), applying the IPCC Tier 1 method and the IPCC default values. The total emissions from the “N2O emissions from Manure Management” category were not affected.

The $CH_4$ emissions from Manure Management of cattle were recalculated in 2011. In line with IPCC, a higher-tier method to estimate the $CH_4$ emissions from Manure Management (cattle only) was implemented in the 2014 submission. The aim of the recalculation was to review the estimation of methane emissions from the Manure Management for cattle by Tier 2. The study by Exnerova (2013, in Czech) describing a new method was elaborated.

Based on the new zoo-technical data and updated country-specific parameters and activity data, the emissions from Manure management for the dairy and non-dairy cattle categories were calculated by Tier 2. The $N_2O$ emissions from Manure management were revised using the new Nex values for dairy and non-dairy cattle with the updated parameters (feed consumption, nitrogen feed intake and protein content of milk, to estimate the amount of N retained in milk). Eq. 10.32 and Eq. 10.33 (2006 IPCC) were used to revise Nex and to calculate the variables for nitrogen intake and retained nitrogen retained (milk production and growth). The results were used as an input for Eq. 10.31. The parameters for estimation of the revised Nex for cattle were collected from the literature and from personal communications with agricultural experts. The protein content in milk was determined as 3.3% (Poustka 2007, Ingr 2003 and Turek 2000) and the protein content in feed (in dry matter) as 18% (Zeman - Czech feed standards 12-21%, Central Institute for Supervising and Testing in Agriculture 18%, Karabcová pers. commun. 16-18%). The $N_2O$ emissions from Manure Management were recalculated using new national parameters: feed consumption, nitrogen feed intake and protein content of milk and feed (revised Nex value). In addition, the values of digestible energy expressed as a percentage of the gross energy (DE) for cattle were revised (the default values were replaced by national values). Further national data on the distribution of manure management practices across AWMS were collected and updated (Kvapilík J. 2010 and 2011– pers.com.).

The country-specific redistribution of manure management practices across AWMS for cattle was taken from Hons and Mudrik (2003) for the 1990-1999 period and updated data from Kvapilík J. (2010, 2011 personal commun.) was used for the 2000-2011 period. Dr. Kvapilik (Institute of Animal Science in Prague) also provided national data on grazing animals (cattle feed situation, Tab. 5-5 and Tab. 5-6).

Uncertainty estimates are based on expert judgment. The uncertainty in the activity data equals to 5%. The uncertainty in the emission factor for estimation of $CH_4$ emissions equals to 20%; for estimation of

$N_2O$ emissions, this value equals to 30%. The combined uncertainty for $CH_4$ emissions equals to 20.6% and that for $N_2O$ emissions equals to 30.41%.

#### 5.2.2.4 Source-specific QA/QC and verification

A detailed description of source-specific QA/QC and inventory verification of agriculture is presented in section 5.1.3.

#### 5.2.2.5 Source-specific recalculations, including changes made in response to the review process and impact of emission trend

According to ERT recommendation the Nitrogen excretion rates were corrected for swine (3.B.2.3) and cattle population (3.B.2.1). Protein content for all cattle feed was reduced from 18% to 16.5%. This value is based on the paper of Task Force of Reactive Nitrogen (TFRN), Table ES2 with the mean protein content for "low ambition" for dairy cattle. Annual average N excretion (Nex) for swine was changed based on the correction of average swine weight (originally calculated based on the slaughter weight).

The $N_2O$ emissions from leached nitrogen in 3B were deleted, because leaching from the animal manure is already reported under 3D. The notation key NE was used for the category Indirect emissions from Manure Management. The fractions ($Frac_{GasMS}$ and $Frac_{LossMS}$) of N loss from Manure Management System (MMS) were updated to coordinate reporting for $N_2O$ emissions from Manure Management and $N_2O$ emissions from managed soils.

During QA/QC procedure the technical error was identified in category Manure Management of cattle. The Gross energy intakes (GE) and then also Emission factors (EF) of Manure Management for cattle (3.A.1) were corrected.

#### 5.2.2.6 Source-specific planned improvements, including tracking of those identified in the review process

The analysis of uncertainties is in progress.

## 5.3 Rice cultivation (CRF 3.C)

At present, no commercial rice cultivation is being carried out in the Czech Republic. The “NO” notation key is reported in the CRF tables.

## 5.4 Agricultural soils (CRF 3.D)

### 5.4.1 Source category description

This source category includes direct and indirect nitrous oxide emissions from agricultural soils. Both of these categories (direct and indirect) are key sources of $N_2O$ soil emissions (Tab. 5-19). Nitrous oxide is produced in agricultural soils as a result of microbial nitrification and denitrification processes. The processes are influenced by chemical and physical characteristics (availability of mineral N substrates and carbon, soil moisture, temperature and pH). Thus, addition of mineral nitrogen in the form of synthetic fertilizers, animal manure applied to soils, crop residue/renewal and sewage sludge enhance the formation of nitrous oxide emissions.

Nitrous oxide emissions from agricultural managed soils include these subcategories:

- The direct emissions (synthetic fertilizers, animal manure applied to soils, crop residues,, sewage sludge, N mineralized in mineral soils)
- The emissions from pasture manure (PRP)
- The indirect emissions (atmospheric deposition and nitrogenous substances flushed into water courses and reservoirs -leaching)

In 2015, 77% of total $N_2O$ emissions from Agriculture originated from Agricultural Soils, while the rest originated from Manure Management (23%). The trend in $N_2O$ emissions from this category is during reporting period 1990-2015 decreasing. Tab. 5-19 presents the $N_2O$ emissions of Agricultural soils by the individual sub-categories.

**Tab. 5-19 $N_2O$ emissions come from Agricultural Soils in period 1990-2015 in kt $N_2O$**

| Year | Total emissions | Direct emissions | | | | | Pasture Manure | Indirect emissions | |
|---|---|---|---|---|---|---|---|---|---|
| | | a | b | c | d | e | | Atmosph. deposition | Leaching |
| **1990** | 19.45 | 6.57 | 3.05 | -- | 3.66 | 0.03 | 0.82 | 1.77 | 3.56 |
| **1991** | 16.39 | 4.67 | 2.92 | -- | 3.43 | 0.03 | 0.78 | 1.53 | 3.02 |
| **1992** | 13.62 | 3.55 | 2.67 | -- | 2.81 | 0.03 | 0.70 | 1.33 | 2.53 |
| **1993** | 12.04 | 2.83 | 2.39 | -- | 2.80 | 0.03 | 0.58 | 1.15 | 2.25 |
| **1994** | 11.65 | 3.19 | 2.09 | -- | 2.60 | 0.02 | 0.49 | 1.08 | 2.17 |
| **1995** | 12.22 | 3.60 | 1.97 | -- | 2.60 | 0.02 | 0.69 | 1.10 | 2.23 |
| **1996** | 11.43 | 2.99 | 1.98 | -- | 2.62 | 0.02 | 0.68 | 1.04 | 2.10 |
| **1997** | 11.45 | 3.23 | 1.90 | -- | 2.52 | 0.02 | 0.64 | 1.04 | 2.10 |
| **1998** | 10.96 | 3.19 | 1.82 | -- | 2.34 | 0.02 | 0.59 | 1.00 | 2.01 |
| **1999** | 11.04 | 3.15 | 1.84 | -- | 2.40 | 0.02 | 0.60 | 1.00 | 2.03 |
| **2000** | 10.93 | 3.35 | 1.76 | -- | 2.24 | 0.02 | 0.58 | 0.99 | 2.00 |
| **2001** | 11.34 | 3.55 | 1.74 | -- | 2.39 | 0.02 | 0.58 | 1.00 | 2.07 |
| **2002** | 10.94 | 3.57 | 1.72 | 0.01 | 2.08 | 0.02 | 0.56 | 0.99 | 1.99 |
| **2003** | 9.74 | 3.01 | 1.67 | 0.02 | 1.76 | 0.02 | 0.55 | 0.92 | 1.78 |
| **2004** | 10.93 | 3.40 | 1.61 | 0.02 | 2.42 | 0.02 | 0.54 | 0.94 | 1.99 |
| **2005** | 10.38 | 3.25 | 1.55 | 0.02 | 2.20 | 0.02 | 0.56 | 0.90 | 1.88 |
| **2006** | 10.10 | 3.38 | 1.51 | 0.03 | 1.88 | 0.02 | 0.55 | 0.90 | 1.83 |
| **2007** | 10.44 | 3.52 | 1.50 | 0.03 | 1.97 | 0.02 | 0.61 | 0.92 | 1.88 |
| **2008** | 11.01 | 3.74 | 1.46 | 0.03 | 2.18 | 0.02 | 0.68 | 0.94 | 1.97 |
| **2009** | 10.40 | 3.48 | 1.36 | 0.02 | 2.09 | 0.02 | 0.70 | 0.88 | 1.85 |
| **2010** | 10.19 | 3.55 | 1.32 | 0.04 | 1.90 | 0.02 | 0.68 | 0.87 | 1.81 |
| **2011** | 10.85 | 3.75 | 1.27 | 0.04 | 2.26 | 0.02 | 0.71 | 0.88 | 1.92 |
| **2012** | 10.63 | 3.90 | 1.26 | 0.03 | 1.93 | 0.02 | 0.74 | 0.89 | 1.88 |
| **2013** | 11.24 | 4.10 | 1.37 | 0.03 | 2.10 | 0.02 | 0.74 | 0.91 | 1.97 |
| **2014** | 11.75 | 4.21 | 1.28 | 0.03 | 2.47 | 0.02 | 0.75 | 0.93 | 2.08 |
| **2015** | 11.60 | 4.24 | 1.30 | 0.01 | 2.28 | 0.02 | 0.78 | 0.94 | 2.05 |

*Note: (a) Synthetic fertilizers, (b) Animal manure applied to soils, (c) Sewage sludge, (d) Crops residues, (e) N mineralized in mineral soils*

### 5.4.2 Methodological issues

Although agricultural soils are a key source, emissions of $N_2O$ are estimated and analysed using the Tier 1 approach of the IPCC methodology (2006 IPCC). A set of interconnected spreadsheets in MS Excel has been used for the relevant calculations for several years. The emissions from nitrogen excreted onto pasture range and paddocks by animals are reported under animal production in the CRF table. The nitrogen from manure that is spread daily is consistently included in the manure nitrogen applied to soils.

#### 5.4.2.1 Activity data

The standard calculation of Tier 1 required the following input information based on Statistical Yearbooks of the Czech Republic (Statistical Yearbooks, 1990-2015):

- The amount of nitrogen applied in the form of industrial nitrogen fertilizers (CzSO data);
- The farm animal population data (CzSO data presented in Tab. 5-3);
- The annual yields (i.e. harvests, see Tab. 5-22)
- The manure production during grazing of animals (PRP category, see Tab. 5-17).
- The annual sewage sludge directly applied to the agricultural soils
- The annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter (FSOM) as a result of changes to land use or management

#### 5.4.2.2 Direct emissions from managed soils (CRF 3.D.1)

The emission factors used for calculation of direct $N_2O$ emissions are shown in Tab. 5-20. The IPCC default fraction values are used to estimate $N_2O$ emissions.

**Tab. 5-20 The emission factors for the estimation of the direct emissions from managed soils (Table 11.1, 2006 IPCC Gl.)**

| | | |
|---|---|---|
| Direct emissions | Synthetic fertilizer | $EF_1$ = 0.01 kg $N_2O$-N/kg N |
| | Animal Waste | |
| | Sewage Sludge | |
| | N-crop residues | |
| | Mineralized N | |
| Pasture, range & paddock manure | Cattle, pigs, poultry | $EF_3$ = 0.02 kg $N_2O$-N/kg N |
| | Sheep, others | $EF_3$ = 0.01 kg $N_2O$-N/kg N |

***Synthetic N fertilizers ($F_{SN}$, CRF 3.D.1.1)***

The application of agricultural fertilizers was formerly intensive in the Czech Republic, but decreased radically during the 1990s. The activity data are taken from official statistical offices (CzSO). The amount of nitrogen fertilizers applied in 1990 equalled over 418 kt, which had decreased to 270 kt by 2015. This corresponds to the trend reported for the use of fertilizers, which decreased substantially in the early 1990s (Sálusová et al., 2006).

***Organic N applied as fertilizer (FON incl. animal manure and sewage sludge, CRF 3.D.1.2)***

The amount of organic N inputs applied to soils was calculated using Equation 11.3 (2006 IPCC Guidelines). This includes applied animal manure and sewage sludge applied to soils. In order to estimate the amount of animal manure nitrogen that is directly applied to soils, it is necessary to reduce the total amount of nitrogen excreted by animals in managed systems by the losses of N through volatilisation. To coordinate with reporting for $N_2O$ emissions from managed soils, Eq. 10.34 and the default values for nitrogen loss from Table 10.22 (2006 IPCC) were used to estimate the amount of animal manure nitrogen that is directly applied to soils.

A newly reported sub-category includes the emissions generated by direct application of sewage sludge to agricultural soils. The verifiable activity data from CzSO in tonnes of dry mass has been available since 2002. The national specific value of nitrogen content of 3.7% (Černý *et al.* 2009) and default emission factor ($EF_1$, see Table 11.1., 2006 IPCC Guidelines) were utilized to estimate the emissions from sewage sludge.

### *Urine and dung N deposited on pasture by grazing animals (FPRP, CRF 3.D.1.3)*

The annual amount of N deposited on pasture, range and paddock soils by grazing animals was estimated using Eq. 11.5 from the number of animals of each livestock species, the annual average amount of N excreted by each livestock species and the fraction of this N deposited on pasture, range and paddock soils by each livestock species. The data needed for this estimation can be obtained from PRP (cattle, swine and poultry) in the livestock category. The default emission factors (Tab. 5-21) are used to estimate emissions from different animal categories. The fraction of livestock N excreted and deposited onto soil during grazing ($Frac_{GRAZ}$) varied from 0.085 in 1990 to 0.167 in 2015.

**Tab. 5-21 IPCC default emission factors of animal waste for PRP**

| | $EF_3$ [kg $N_2O$-N per kg N excreted] |
|---|---|
| **PRP (cattle, swine, poultry)** | 0.02 |
| **PRP (sheep, others)** | 0.01 |

### *N-crop residues (FCR, CRF 3.D.1.4)*

This category includes the amount of N in crop residues (above-ground and below-ground), including N-fixing crops, returned to soils annually. It also includes the N from N-fixing and non-N-fixing forages mineralised during forage or pasture renewal. This is estimated from crop yield statistics (CzSO) and default factors for above-/below-ground residues: yield ratios and residual N contents (see Tab. 5-22). The zero values were applied as the parameters $Frac_{REMOVE}$ and $Frac_{BURN}$.

**Tab. 5-22 Annual yield of agricultural products (t/ha)**

| | Grains | Pulses | Potatoes | Sugar beets | Fodder | Soya beans |
|---|---|---|---|---|---|---|
| **1990** | 5.42 | 2.68 | 16.00 | 33.89 | 6.77 | 3.67 |
| **1995** | 4.17 | 2.38 | 17.04 | 39.63 | 6.13 | 1.29 |
| **2000** | 3.92 | 2.09 | 21.32 | 45.62 | 5.60 | 1.25 |
| **2005** | 4.81 | 2.44 | 28.08 | 53.31 | 6.20 | 2.04 |
| **2010** | 4.71 | 1.86 | 24.56 | 54.36 | 6.05 | 1.69 |
| **2015** | 5.89 | 2.89 | 22.26 | 59.38 | 5.74 | 1.64 |

**Tab. 5-23 Data from Table 11.2 (2006 IPCC)**

| | Grains | Pulses | Potatoes | Sugar beets | Fodder | Soya beans |
|---|---|---|---|---|---|---|
| **Dry mater** | 0.88 | 0.91 | 0.22 | 0.22 | --- | 0.91 |
| **$R_{AG}$** | calc | calc | calc | calc | calc | calc |
| **$AG_{DM}$** | calc | calc | calc | calc | calc | calc |
| **$Frac_{Remove}$** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **NAG** | 0.006 | 0.008 | 0.019 | 0.019 | 0.027 | 0.008 |
| **$R_{BG}$-BIO** | 0.22 | 0.19 | 0.2 | 0.2 | 0.4 | 0.19 |
| **$N_{BG}$** | 0.009 | 0.008 | 0.014 | 0.014 | 0.022 | 0.008 |

*Note: The parameters $R_{AG}$ and $AG_{DM}$ are calculated by using Eq. 11.6 (2006 IPCC Gl.) and adequate parameters.*

Since different crop types vary in residue, yield ratios, renewal time and nitrogen contents, separate calculations are performed for major crop types and then the nitrogen values for all the crop types are summed up. Crops are segregated into: 1) non-N-fixing grain crops, 2) N-fixing grains and pulses, 3) potatoes, 4) sugar beets, 5) N-fixing forage crops (alfalfa, clover) and 6) soya. Eq. 11.6 is used to estimate N from crop residues and forage/pasture renewal for a Tier 1 approach.

Data on crop yield statistics (yields and area harvested, by crop) were obtained from national sources (CzSO). Since yield statistics for many crops are reported as field-dry or fresh weight, a correction factor was applied to estimate dry matter yields where appropriate (Eq. 11.7). The default values for dry matter content from Table 11.2 were employed (Tab. 5-23). Only forage production activity data are presented as dry matter in the CzSO statistics.

***Mineralization/Immobilization Associated with Loss/Gain of Soil Organic Matter (FSOM, CRF 3.D.1.5)***

The annual amount of N in mineral soils that is mineralised, in association with loss of soil carbon from soil organic matter ($F_{SOM}$) is a result of changes to land use or management. The activity data are taken from the LULUCF sector inventory, as an annual amount of carbon in mineral soils from Forest land (CRF Table 4.B.2.1) and Grassland (CRF Table 4.B.2.2) converted to Cropland (in kg C/year). The Eq. 11.8 (2006 IPCC Gl.) is used to estimate the N mineralised as a consequence of this loss of soil C, where the default value 15 is used as C:N ratio of the soil organic matter.

EQUATION 11.8
N MINERALISED IN MINERAL SOILS AS A RESULT OF LOSS OF SOIL C THROUGH CHANGE IN LAND USE OR MANAGEMENT (TIERS 1 AND 2)

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

### 5.4.2.3 Indirect emissions from managed soils (CRF 3.D.2)

In addition to the direct emissions of $N_2O$ from managed soils that occur through a direct pathway (i.e. directly from the soils to which N is applied), emissions of $N_2O$ also take place through two indirect pathways. The first of these ways is the volatilization of N as $NH_3$ and oxides of N ($NO_x$), and the deposition of these gases and their products $NH_4^+$ and $NO_3^-$ onto soils and the surface of lakes and other waters.

The method for estimating indirect $N_2O$ emissions includes two emission factors (Tab. 5-25): one associated with volatilized and re-deposited N ($EF_4$), and the second associated with N lost through leaching/runoff ($EF_5$). The overall value for $EF_5$ equals 0.0075 kg $N_2O$-N/kg N leached/ in runoff water. The method also requires values for the fractions of N that are lost through volatilization ($Frac_{GASF}$ and $Frac_{GASM}$) or leaching/runoff ($Frac_{LEACH}$). The default values of these fractions are presented in Tab. 5-24.

**Tab. 5-24 The IPCC default parameters/fractions used for indirect emission estimation (Table 11-3, 2006 IPCC Gl.)**

| Parameters/Fractions | Default values |
|---|---|
| **$Frac_{GASM}$** | 0.20 |
| **$Frac_{GASF}$** | 0.10 |
| **$Frac_{LEACH-(H)}$** | 0.30 |

**Tab. 5-25 Emission factors (EFs) for indirect emission estimation**

| | | |
|---|---|---|
| **Indirect emissions** | Atmospheric Deposition | $EF_4$ = 0.01 kg $N_2O$-per kg emitted $NH_3$ and $NO_X$ |
| | Nitrogen Leaching | $EF_5$ = 0.0075 kg $N_2O$ - per kg of leaching N |

***Volatilization***

The $N_2O$ emissions from atmospheric deposition of N volatilized from managed soil are estimated using Equation 11.9, where FON includes also sewage sludge inputs. The conversion of $N_2O$-N emissions to $N_2O$ emissions for reporting purposes is performed by factor 44/28.

**EQUATION 11.9**
**$N_2O$ FROM ATMOSPHERIC DEPOSITION OF N VOLATILISED FROM MANAGED SOILS (TIER 1)**

$$N_2O_{(ATD)}-N = [(F_{SN} \bullet Frac_{GASF}) + ((F_{ON} + F_{PRP}) \bullet Frac_{GASM})] \bullet EF_4$$

***Leaching/Runoff***

The $N_2O$ emissions from leaching and runoff in regions, where leaching and runoff occurs, are estimated using Equation 11.10, where $F_{ON}$ includes also sewage sludge inputs. The conversion of $N_2O$-N emissions to $N_2O$ emissions for reporting purposes is performed by factor 44/28.

**EQUATION 11.10**
**$N_2O$ FROM N LEACHING/RUNOFF FROM MANAGED SOILS IN REGIONS WHERE LEACHING/RUNOFF OCCURS (TIER 1)**

$$N_2O_{(L)}-N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \bullet Frac_{LEACH-(H)} \bullet EF_5$$

### 5.4.3 Uncertainty and time-series consistency

In relation to the consistency of the emission series for $N_2O$ (agricultural soils), it should be mentioned that emission estimates have been calculated consistently according to the default methodology of the IPCC 2006 Guidelines (IPCC, 2006).

The quantitative overview and emission trends during the 1990-2015 period are shown in Fig. 5-1 and the trend in $N_2O$ emissions from agricultural soils is summarized in Tab. 5-19. During 1990-2015, total emissions from agricultural soils decreased by 40% (rapidly during the 1990-1995 period).

Following ERT, the Czech emission inventory team verified the activity data required for this category and found that the previously reported data based on expert judgment of the areas could not be confirmed and verified from the official statistics. According to the expert common consensus (I. Skořepová, P. Fott, E. Cienciala and Z. Exnerová), there are no cultivated histosols on agricultural land in this country and hence also no data for this category. Organic soils mostly occur on forest land and are reported under LULUCF sector.

On the basis of the recommendations of ARR (2009), several recalculations were performed ($N_2O$ emissions from Animal manure applied to soils, Crop residues, N-fixing crops) and technical errors in the emission inventory of agricultural soils in the 2010 submission were corrected.

In 2011, the Nex for cattle was revised, which led to changes in $N_2O$ emissions from i) animal manure applied to soils, ii) PRP, iii) atmospheric deposition and iv) N lost through leaching and run-off.

Based on the ERT recommendations (2011) country-specific data was obtained and the following improvements were implemented into the submission:

1. N-fixing forage crops such as alfalfa and clover were included in the calculations of $N_2O$ emissions and
2. Potatoes and sugar beet crops produced in the country were included in the estimations of $N_2O$ emissions from crop residues returned to soils.

On the basis of the recommendations of TERT and ERT the Direct $N_2O$ emissions from agricultural soils were recalculated and reported in the 2016 resubmission. This led to changes in $N_2O$ emissions from Synthetic fertilizers, Animal manure applied to soils, Crop residues and N mineralized in soils.

Uncertainty estimates are based on expert judgment. The uncertainty in the activity data for estimation of direct and indirect emissions from agricultural soils equals 20%; for Pasture, Range and Paddock Manure (PRP) this value equals 10%. The uncertainty in the emission factor for estimation of direct and indirect emissions from agricultural soils equals 50%; for estimation of emissions from PRP this value equals 100%. The combined uncertainty for the direct and indirect emissions from agricultural soils equals 53.85%; for N2O emissions from PRP Manure this value equals 100.5%.

### 5.4.4 Source-specific QA/QC and verification

A detailed description of source-specific QA/QC and inventory verification of agriculture is presented in section 5.1.3.

### 5.4.5 Source-specific recalculations, including changes made in response to the review process and impact of emission trend

According to ERT recommendation the value of $Frac_{REMOVE}$ (3.D.1.4) was changed from 0.5 to zero, because survey data of country experts required (page 11.14, 2006 IPCC Gl.) is not available.

The factor 0.9, originally applied to reduce the input data of synthetic fertilizers in category 3.D.1.1 (Direct N2O emissions) to consider emitting $NH_3$ and $NO_x$, was cancelled.

Inventory team decided to adopt the recommendation of 2006 IPCC Guidelines and changed EF1 from 1.25% to 1%. It resulted in decreased $N_20$ emissions from mineral fertilizers (3.D.1).

Tier 1 approach and input data from the LULUCF sector (kt C from Forest land and Grassland converted to Cropland) were used to estimate N mineralized in mineral soils as a result of loss of soil C associated with change in land use ($F_{SOM}$) according to Eq. 11.8. (4.B.2.2)

The amount of sewage sludge was added to the Eq. 11.9., the activity data including amount of sewage sludge (part of FON), crop residues (FCR) and N mineralized in mineral soils (FSOM), were added to Eq. 11.10. (3.D.1.2b).

### 5.4.6 Source-specific planned improvements, including tracking of those identified in the review process

The analysis of uncertainties is in progress.

## 5.5 Prescribed burning of savanna (CRF 3.E)

This activity is prohibited by the Czech Law (Air Protection Act), thus prescribed burning of savanna does not occur in the Czech Republic.

## 5.6 Field burning of agricultural residues (CRF 3.F)

This activity is prohibited by the Czech Law (Air Protection Act), thus field burning of agricultural residues does not occur in the Czech Republic.

## 5.7 Liming (CRF 3.G)

### 5.7.1 Source category description

Liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. Adding carbonates to soils in the form of lime (e.g., limestone or dolomite) leads to $CO_2$ emissions as the carbonate lime dissolve and release bicarbonate, which evolves into $CO_2$ and water. The liming on all managed soils is reported under this category, i.e. arable lands, grasslands and forest lands.

### 5.7.2 Methodological issues

However, the reactions associated with limestone application also lead to evolution of $CO_2$, which must be quantified. The activity data is derived from the official national statistics and Green Report of Forestry (see Tab. 5-26). Of the reported total limestone used in agriculture, 95% was ascribed to agricultural soils in cropland (5% to grassland) based on expert judgment (V. Klement, Central Institute for Supervising and Testing in Agriculture – pers. comm. 2005).

The share of liming of forest lands in total liming in the Czech Republic was the highest in the 2000 – 2002 period, when the value was over 10% and as much as 18% in 2000. In 2015 the liming in forests equals almost 5%.

**Tab. 5-26 The limestone quantity applied to managed soils (in thousand tons)**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CL+GL** | 2650 | 700 | 230 | 220 | 230 | 248 | 255 | 210 | 204 | 196 | 209 | 210 | 196 |
| **FL** | 26.9 | 12.1 | 16.2 | 13.9 | 4.8 | 2.4 | 0.3 | 0.0 | 1.0 | 1.0 | 46.7 | 27.8 | 29.2 |
| | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
| **CL+GL** | 172 | 158 | 143 | 160 | 174 | 203 | 145 | 135 | 182 | 263 | 308 | 342 | 353 |
| **FL** | 6.5 | 15.3 | 2.6 | 16.8 | 7.2 | 12.3 | 0.1 | 5.1 | 0.0 | 0.0 | 0.0 | 0.0 | 18 |

*Notes: CL = Cropland, GL = Grassland, FL = Forest land*

The quantification followed the Tier 1 method (Eq. 11.12, IPCC 2006 Gl.), with an emission factor of 0.12 t C/t $CaCO_3$. To convert $CO_2$–C emissions into $CO_2$ factor 44/12 was used. Separate data are not available for limestone and dolomite, hence the aggregate estimates for total lime applications are reported. The application of agricultural limestone was previously intensive in this country, but decreased radically during the 1990s. The activity data corresponds to the trend reported for use of fertilizers, which decreased a lot in early 1990s (Sálusová *et al*., 2006). The application of limestone on agricultural land (incl. forest) in 2015 reached more than 370 thousand tons, while almost 5% of liming was applied on forest areas.

### 5.7.3 Uncertainties and time-series consistency

Uncertainty estimates are based on expert judgment (AD) and default value (EF). The uncertainty in the activity data for estimation of emissions from Liming equals to 20%, the uncertainty in the emission factor equals to 50%. The combined uncertainty of emission estimation from Liming equals to 53.85%.

### 5.7.4 Source-specific QA/QC and verification

A detailed description of source-specific QA/QC and inventory verification of agriculture is presented in section 5.1.3.

### 5.7.5 Source-specific recalculations, including changes made in response to the review process and impact of emission trend

No recalculation was performed in this submission.

### 5.7.6 Source-specific planned improvements, including tracking of those identified in the review process

The analysis of uncertainties is in progress.

## 5.8 Urea Application (CRF 3.H)

### 5.8.1 Source category description

Adding urea to soils during fertilization leads to a loss of $CO_2$ that was fixed in the industrial production process. Urea is converted into ammonium, hydroxyl ion and bicarbonate, in the presence of water and urea enzymes. This source category is included because the $CO_2$ removal from the atmosphere during urea manufacturing is estimated in the Industrial Processes and Product Use Sector (IPPU Sector).

### 5.8.2 Methodological issues

Tier 1 and Eq. 11.13 are utilized to estimate $CO_2$ emissions. Domestic production records for urea were used to obtain an approximate estimate of the amount of urea applied to soils on an annual basis (Tab. 5-27). The default emission factor is 0.20 for carbon emissions from urea applications, which is equivalent to the carbon content of urea on an atomic weight basis. To estimate the total $CO_2$-C emissions, the product of the amount of urea is multiplied by the emission factor. $CO_2$-C emissions are converted into $CO_2$ by multiplying by 44/12.

Until 2013, the values of urea application to agricultural land have ranged from 92 to 190 thousand tons. An extreme decline in urea production and its application to managed soils was recorded in 2013 (1100 tons only), due to significant restrictions on Czech production and a transition to the import policy. In the previous submission, the new activity data were obtained and applied to the inventory. The statistical production data were replaced by more precise data corresponding to the real consumption by the Ministry of Agriculture. These data available since 2000 until 2015 are based on farmers' fertilizer records. The application of urea to agricultural land in 2015 reached almost 225 kt of urea, which is the highest ever level since 1990.

**Tab. 5-27 Domestic production of urea (IPPU) applied to managed soils**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Urea (kt)** | 148 | 180 | 148 | 127 | 124 | 149 | 137 | 92 | 195 | 120 | 65 | 106 | 87 |
| | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
| **Urea (kt)** | 83 | 96 | 101 | 113 | 166 | 137 | 117 | 152 | 151 | 185 | 171 | 78 | 255 |

### 5.8.3 Uncertainties and time-series consistency

Uncertainty estimates are based on expert judgment (AD) and default value (EF). The uncertainty in the activity data for estimation of emissions from Urea application equals to 20%, the uncertainty in the emission factor equals to 50%. The combined uncertainty of emission estimation from Urea application equals to 53.85%.

### 5.8.4 Source-specific QA/QC and verification

A detailed description of source-specific QA/QC and inventory verification of agriculture is presented in a section 5.1.3.

### 5.8.5 Source-specific recalculations, including changes made in response to the review process and impact of emission trend

No recalculation was performed in this submission.

### 5.8.6 Source-specific planned improvements, including tracking of those identified in the review process

The analysis of uncertainties is in progress.

# 6 Land Use, Land-Use Changes and Forestry (CRF Sector 4)

## 6.1 Overview of sector

The emission inventory of the Land Use, Land Use Change and Forestry (LULUCF) sector includes emissions and removals of greenhouse gases (GHG) resulting from land use, land-use change and forestry. The inventory was originally based on application of the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003, further also abbreviated as GPG for LULUCF) and the reporting format adopted by the 9th Conference of the Parties (COP) to UNFCCC. The reporting guidelines were revised at the 19th COP in 2013 by decision 24/CP.19. It demands that, starting in 2015, Parties included in Annex I to the Convention should apply the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) that are linked to the previously used methods outlined in Chapter 3 of GPG for LULUCF (IPCC 2003). In addition, decision 24/CP.19 encourages the use of the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC 2014a) in preparing the annual inventories under the Convention due in 2015 and beyond. The current LULUCF reporting is also guided by the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC 2014b). This material is used, together with IPCC (2006), to prepare the assessment and reporting of annual changes in carbon stocks and associated $CO_2$ emissions and removals from the Harvested Wood Products (HWP contribution), which has been mandatorily reported under LULUCF since the 2015 NIR submission.

Reporting of the LULUCF sector in the Czech Republic has gradually incorporated the specific requirements on the inventory based on IPCC (2003, 2006, 2014a, 2014b) in the previous submissions. The current inventory of the LULUCF sector uses the revised reporting structure, including the estimated HWP contribution. In terms of land use representation and land-use change identification required for emission estimation for the LULUCF land use categories, the Czech inventory employs a refined system of land use identification at the level of the individual cadastral units. Although the Czech LULUCF inventory is still in the process of further refinement and consolidation, it represents a solid system for providing information on GHG emissions and removals in the LULUCF sector, as well as for providing additional information on the LULUCF activities required under the Kyoto protocol.

The current inventory includes $CO_2$ emissions and removals, and emissions of non-$CO_2$ gases ($CH_4$, $N_2O$, $NO_X$ and CO) from biomass burned in forestry and disturbances associated with land-use conversion. The inventory covers all major LULUCF land-use categories, namely 4.A Forest Land, 4.B Cropland, 4.C Grassland, 4.D Wetlands, 4.E Settlements and 4.F Other Land, all linked to the Czech cadastral classification of lands. It also includes the HWP contribution, which is reported under category 4.G Harvested Wood Products. The emissions and/or removals of greenhouse-gases are reported for all the mandatory categories.

The current submission covers the whole reporting period from the base year of 1990 to 2015. The currently reported estimates changed in comparison with the previously reported values as a result of further refinements in adopted emission factors affecting emission estimates for some categories that resulted in recalculations for the entire reporting period. The current and previously reported sectoral estimates of greenhouse-gas emissions and removals are depicted in Fig. 6-1. The implemented changes led to only marginally different estimates for the individual years compared to the previously reported emission removals. The data shown in Fig. 6-1 include emissions and removal for all land use categories and estimate of the HWP contribution. Detailed information on the implemented changes and performed recalculations is provided below for the individual LULUCF categories.

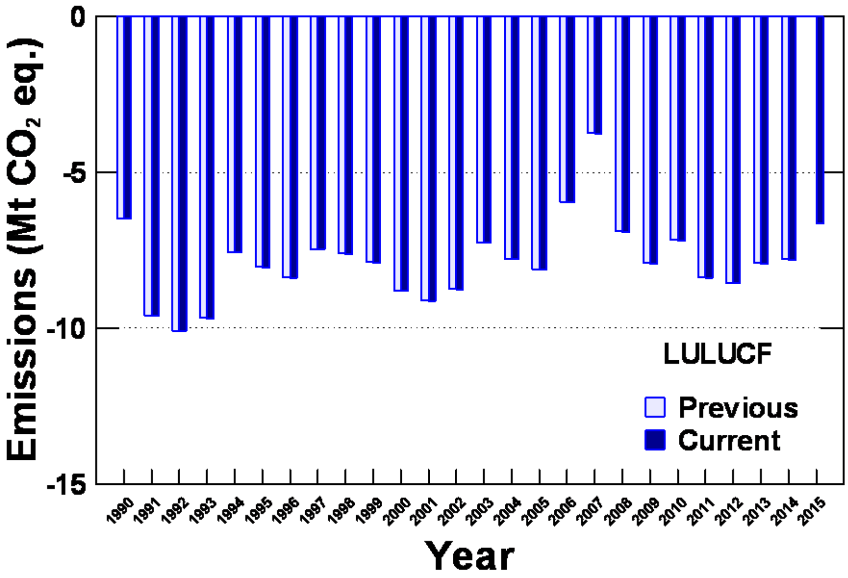



**Fig. 6-1 The current and previously reported estimates of emissions for the LULUCF sector. The values are negative, hence correspond to net removals of green-house gases.**

### 6.1.1 Estimated emissions

Tab. 6-1 provides a summary of the LULUCF GHG estimates for the base year of 1990 and the most recently reported year, 2015.

**Tab. 6-1 GHG estimates in Sector 4 (LULUCF) and its categories in 1990 (base year) and 2015**

| Sector/category | Emissions 1990 kt $CO_2$ eq. | Emissions 2015 kt $CO_2$ eq. |
|---|---|---|
| **4 Total LULUCF** | -6 488 | -6 641 |
| **4.A Forest Land** | -4 859 | -6 053 |
| **4.A.1 Forest Land remaining Forest Land** | -4 537 | -5561 |
| **4.A.2 Land converted to Forest Land** | -321 | -482 |
| **4.B Cropland** | 121 | 5 |
| **4.B.1 Cropland remaining Cropland** | -2 | -84 |
| **4.B.2 Land converted to Cropland** | 123 | 89 |
| **4.C Grassland** | -145 | -550 |
| **4.C.1 Grassland remaining Grassland** | 0 | -276 |
| **4.C.2 Land converted to Grassland** | -145 | -274 |
| **4.D Wetlands** | 22 | 25 |
| **4.D.1 Wetlands remaining Wetlands** | (0) | (0) |
| **4.D.2 Land converted to Wetlands** | 22 | 25 |
| **4.E Settlements** | 85 | 88 |
| **4.E.1 Settlements remaining Settlements** | (0) | (0) |
| **4.E.2 Land converted to Settlements** | 85 | 88 |
| **4.F Other Land** | (0) | 8 |
| **4.G Harvested Wood Products** | -1 713 | -164 |

*Note: Emissions of non-$CO_2$ gases ($CH_4$ and $N_2O$) are also included.*

In 2015, the net GHG flux for the LULUCF sector, estimated as the sum of emissions and removals, equalled -6641 Gg $CO_2$ eq., thus representing a net removal of GHG gases. In relation to the estimated emissions in other sectors in the country for the inventory year 2014, the removals realized within the LULUCF sector decrease the GHG emissions generated in other sectors by 6.3%. Correspondingly, for the base year of 1990, the total emissions and removals in the LULUCF sector equalled -6488 Gg $CO_2$ eq. In relation to the emissions generated in all the other sectors, the inclusion of the LULUCF estimate reduces the total emissions by 3.3% for the base year of 1990. It is important to note that the emissions within the LULUCF sector exhibit high inter-annual variability (Fig. 6-1) and the values shown in Tab. 6-1 should not be interpreted as trends. The entire data series can be found in the corresponding CRF Tables.

### 6.1.2 Key categories

**Tab. 6-2 Key categories of the LULUCF sector (2015)**

| Category | Gas | KC A1 | KC A2 | KC A1 incl. LULUCF | KC A1 excl. LULUCF | KC A2 incl. LULUCF | KC A2 excl. LULUCF | % of total GHG incl. LULUCF |
|---|---|---|---|---|---|---|---|---|
| **4.A.1 Forest Land remaining Forest Land** | $CO_2$ | LA, TA | LA, TA | yes | no | yes | no | 4.42 |
| **4.G Harvested wood products** | $CO_2$ | TA | TA | yes | no | yes | no | 0.13 |

*KC: key category, LA - identified by level assessment, TA - identified by trend assessment*
*% of total GHG: relative contribution of category to net GHG (including LULUCF)*

Of the main categories listed in Tab. 6-1, two were identified as a key category according to the IPCC Good Practice (2006 IPCC Guidelines). One is 4.A.1 Forest Land remaining Forest Land with a contribution of 4.42%, which is the major LULUCF category identified by both the level and trend assessment for 2015 (Tab. 6-2). The emissions in this category are mostly determined by changes in the biomass carbon stock. The second is 4.G Harvested wood products. Its contribution reached more marginal 0.13%, which however still qualifies it among the key categories by the level assessment for 2015.

### 6.1.3 Coverage of pools and methodological tiers

The current inventory submission of the LULUCF sector includes all the mandatory categories and carbon pools, as well as emissions related to HWP. The specific information related to methodological tiers and pools included in the category estimates is provided under the individual chapters by the IPCC land use categories (Chapters 6.4 to 6.9) and the category of HWP contribution (Chapter 6.10).

## 6.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The reporting format requires the estimation of GHG emissions into the atmosphere by sources and sinks for six land-use categories and, since reporting year 2013, also for the land-unspecific category of Harvested wood products (4.G). The land-use categories are Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land. Each of these categories is divided into lands remaining in the given category during the inventory year, and lands that are newly converted into the category from a different one. Accordingly, GPG for LULUCF (IPCC 2003) and its follow up 2006 IPCC Guidelines (IPCC 2006) outline the appropriate methodologies for estimation of emissions.

Consistent representation of land areas and identification of land-use changes constitute the key steps in the inventory of the LULUCF sector in accordance with the 2006 IPCC Guidelines (IPCC 2006). The adopted system of land-use representation and land-use change identification was constructed gradually. Since the 2008 NIR submission, this has been exclusively based on the cadastral land use information of the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz). The Czech land-use representation and the land-use change identification system use annually updated COSMC data, elaborated at the level of about 13 thousand individual cadastral units. The system was constructed in several steps, including 1) source data assembly 2) linking land-use definitions 3) identification of land-use change 4) complementing time series. These steps are described below. The result is a system of consistent representation of land areas having the attributes of both Approach 2 and Approach 3 (IPCC 2006), permitting accounting for all land-use transitions in the annual time step. The individual steps are described below.

### 6.2.1 Source data compilation

The methodology requirements and principles associated with the approaches recommended by the GPG for LULUCF (2006 IPCC Guidelines) imply that, for the reported period of 1990 to 2015, the required land use should be available for the period starting from 1969. Information on land use was obtained from the Czech Office for Surveying, Mapping and Cadastre (COSMC), which administers the database of "Aggregate areas of cadastral land categories" (AACLC). The AACLC data were compiled at the level of the individual cadastral units (1992-2015) and individual districts (since 1969). There are over 13 000 cadastral units, the number of which varies due to separation or division for various administrative reasons. In the period from 1992 to 2015, the total number of cadastral units varied between 13 027 and 13 091.

To identify the administrative separation and division of cadastral units within a given year, two approaches were employed. Previous to 2004, the cadastral units were crosschecked by comparing the areas in subsequent years using a threshold of half-hectare difference. Starting in 2004, the explicit change of land use was quantified within and for each year directly by the data provider, i.e., COSMC, at the request of the inventory team. The latter approach does not require reconciliation of individual cadastral units between the consecutive years, as it adopts the addressed land use change information available in the COSMC database.

To obtain information on land-use and land-use changes prior to 1993, a complementary data set from COSMC at the level of 76 district units was prepared. It covered the period since 1969 and was required for application of the IPCC default transition time period of 20 years for carbon stock change in soils. The spatial coverage of cadastral and district units is also shown in Fig. 6-2.

### 6.2.2 Linking land-use definitions

The analysis of land use and land-use change is based on the data from the "Aggregate areas of cadastral land categories" (AACLC), centrally collected and administered by COSMC and regulated by Act No. 265/1992 Coll., on Registration of proprietary and other material rights to real estate, and Act No. 344/1992 Coll., on the real estate cadastre of the Czech Republic (the Cadastral Act), both as amended by later regulations. AACLC distinguishes ten land categories, six of them belonging to land utilized in agriculture (arable land, hop-fields, vineyards, gardens, orchards, grassland) and four under other use (forest land, water surfaces, built-up areas and courtyards, and other land). For the explicitly addressed within-year land use change identification, three additional specific land-use subcategories were distinguished, namely water surface – waterlogged soil, other land – waterlogged soil and other land – unfertile land. The AACLC land use categories and sub-categories of the COSMC database were linked so as to most closely match the default definitions of the six major land-use categories (Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land ) as given by the 2006 Guidelines for National Greenhouse Gas Inventories (IPCC 2006). The country-specific definition content can be found in the respective Chapters 6.4 to 6.9 devoted to each of the major land-use categories.

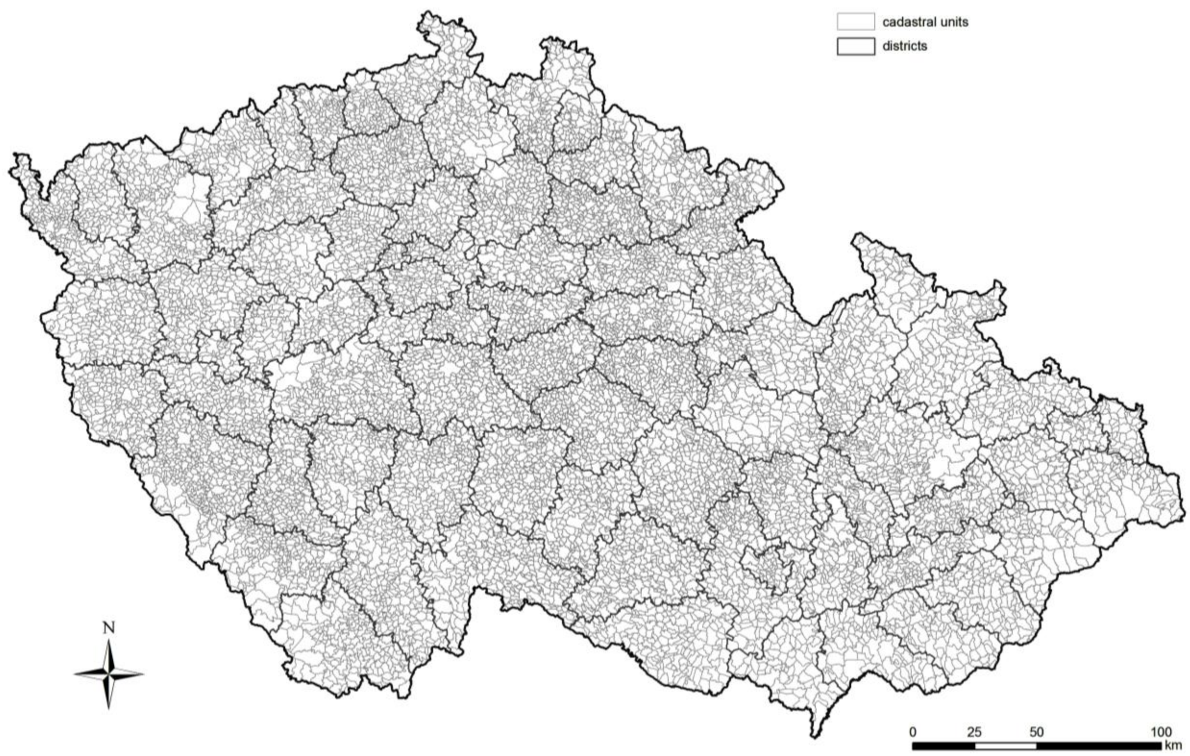



**Fig. 6-2 Cadastral units (grey lines; n = 13 091) and districts (black lines; n=79), the basis of the Czech land use representation and land use change identification system.**

### 6.2.3 Land-use change identification

The critical issue of any LULUCF emission inventory is the quantitative determination of land-use change. This inventory adopts two approaches for identifying and quantifying land-use changes on an annual basis: i) until 2003 by balancing the six major land-use areas for each of the individual or integrated cadastral units on use of the subsequent years of the available period and ii) since 2004, using the within-year explicitly addressed land-use conversions registered and estimated by COSMC, the authorized administrator of cadastral information in the country. Although both the approaches are in principle identical, the later approach is more accurate, as it captures virtually all changes within each individual cadastral unit, including theoretically possible bi-directional changes involving the same pair of land use categories within one particular year. In practice, the actual effect of the more advanced, latter approach is not significant under the conditions of the Czech Republic. However, it greatly improves the transparency of the system and the data are basically readily usable as supplied by the data provider (COSMC) without further processing. The resolution of the implemented land use representation and land use change identification system is demonstrated in Fig. 6-3. In the example of the cadastral unit of Kácov (ID 656305), it can be observed that during 2011, two land-use categories lost their land, while the other two increased their area. However, as shown in the table, there were six specific land-use changes involved in these land use changes, where Forest land and Grassland were partly converted to Settlements and Cropland. The latter approach and more detailed data available since 2004 also allowed an explicit estimation of changes associated with the category of Other land representing unfertile land with no specific type of land use, which was considered to be constant until 2003 (Fig. 6-4). All identified land-use transfers estimated at the individual cadastral unit level are summarized by each type of land-use change on an annual basis to be further used for estimation of the associated emissions.

| Year (date) | ID CU (Name) | Forest land | Cropland | Grassland | Wetlands | Setttlements | Other land | Total |
|---|---|---|---|---|---|---|---|---|
| 1.1.2011 | 661635 (Kácov) | 1992637 | 2627349 | 1186759 | 376350 | 1124451 | 291370 | 7598916 |
| 31.12.2011 | 661635 (Kácov) | 1979724 | 2633115 | 1181825 | 376350 | 1136533 | 291371 | 7598918 |
| **Difference** | | -12913 | 5766 | -4934 | 0 | 12082 | 1 | 2 |

| Conversion type | Area ($m^2$) |
|---|---|
| Forest land - Cropland | 977 |
| Forest land - Settlements | 11936 |
| Cropland - Settlements | 247 |
| Grassland - Cropland | 4897 |
| Grassland - Settlements | 38 |
| Settlements - Cropland | 139 |

**Fig. 6-3 Example of land-used change identification for 2011 and cadastral unit 661635 (Kácov); all spatial units are given in m$^2$.**

### 6.2.4 Complementing time-series

The above described calculation of land-use changes at the level of individual cadastral units was performed for 1993 to 2015, because the data on that spatial resolution has been available only since 1992. For the years preceding 1993, i.e., for land-use change attributed to 1970 to 1992, an identical approach to that described above was used, but with aggregated cadastral input data at the level on the individual districts. Due to the IPCC default time period of 20 years used for reporting the converted land, the source information contains data on land use in the Czech Republic since 1969.

### 6.2.5 Land use representation and land use change identification system - status and development

Development of the Czech LULUCF land use representation and land use change identification system as described above involved collaboration with the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz), which administers the source information on land use used in the LULUCF emission inventory[3]. Based on internal analysis and the recommendations of COSMC, the current inventory retains exclusively use of the original data on land use without any further corrections and provides explicit information on land use for all six IPCC land use categories. The inventory team is working in collaboration with COSMC on further consolidation of the system to provide the specific information required for KP LULUCF activities.

## 6.3 Land- use definitions and the classification systems used and their correspondence to the land use, land-use change and forestry categories

The IPCC land use categories were linked to the Czech cadastral classification system, namely that of "Aggregate areas of cadastral land categories" (AACLC), centrally collected and administered by COSMC, as described in detail in Section 6.2 above. The specific attribution and linking of cadastral land use

[3] *The work of the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz) is based on digitalisation of cadastral land use information in the Czech Republic, which is planned to be finalized in 2019. This major reconciliation of land-use information is in progress and explains the nature of the ongoing area rectifications in the official reports on areas of land and land use categories in the country.*

categories to IPCC land use categories is given in the source category description text under the corresponding Sections 6.4 to 6.9 below.

### 6.3.1 Land-use change – overall trends and annual matrices

The overall trends in the areas of the major land-use categories in the Czech Republic for the 1970 to 2015 period are shown in Fig. 6-4. A largest quantitative change is associated with the Cropland and Grassland land-use categories.

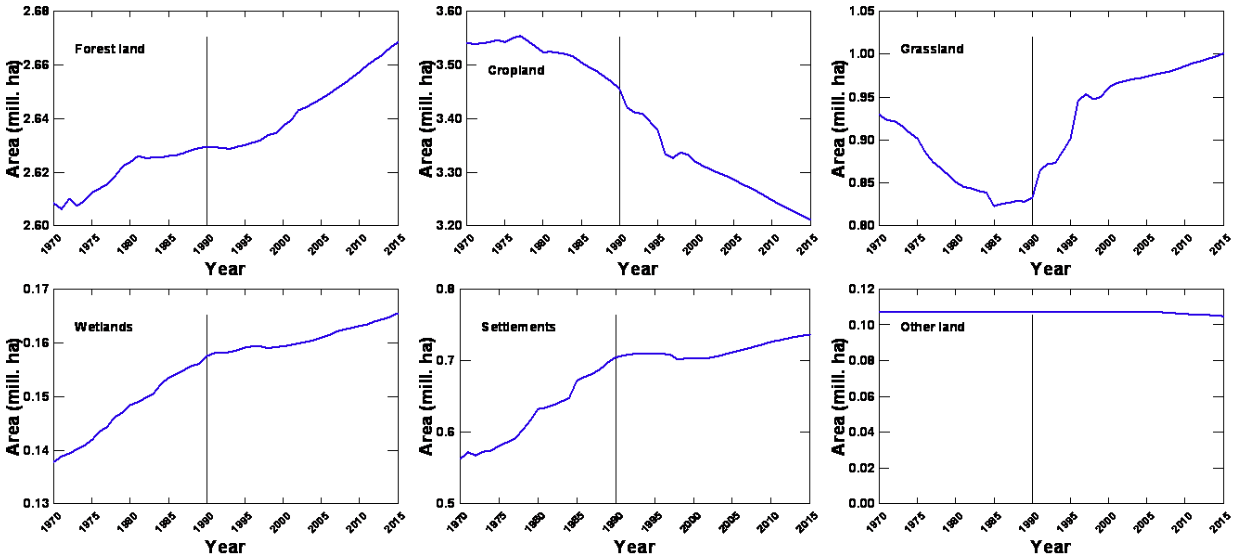



**Fig. 6-4 Trends in areas of the six major land-use categories in the Czech Republic between 1970 and 2015 (based on information from the Czech Office for Surveying, Mapping and Cadastre).**

**Tab. 6-3 Land-use matrices describing annual initial and final areas of particular land-use categories and the identified annual land-use conversions among these categories, shown for 1990 and 2015.**

| | 1990 | Initial (1989) | | | | | | *Area (kha)* |
|---|---|---|---|---|---|---|---|---|
| | Category | Forest land | Cropland | Grassland | Wetlands | Settlements | Other land | |
| Final (1990) | Forest Land | 2628.6 | 0.5 | 0.4 | 0.0 | 0.0 | 0.0 | **2629.5** |
| | Cropland | 0.0 | 3454.5 | 0.4 | 0.0 | 0.1 | 0.0 | **3455.0** |
| | Grassland | 0.1 | 8.8 | 823.6 | 0.0 | 0.0 | 0.0 | **832.5** |
| | Wetlands | 0.0 | 0.4 | 0.4 | 155.9 | 0.8 | 0.0 | **157.5** |
| | Settlements | 0.3 | 3.7 | 3.7 | 0.1 | 696.9 | 0.0 | **704.6** |
| | Other Land | 0.0 | 0.0 | 0.0 | 0 | 0 | 107.2 | **107.2** |
| | *Area (kha)* | 2629.0 | 3467.9 | 828.5 | 156.1 | 697.8 | 107.2 | **7886.4** |
| | | | | | | | | |
| | 2015 | Initial (2015) | | | | | | *Area (kha)* |
| | Category | Forest land | Cropland | Grassland | Wetlands | Settlements | Other land | |
| Final (2015) | Forest Land | 2665.9 | 0.7 | 0.5 | 0.1 | 0.9 | 0.4 | **2668.4** |
| | Cropland | 0.1 | 3210.1 | 0.5 | 0.0 | 0.3 | 0.2 | **3211.3** |
| | Grassland | 0.1 | 4.3 | 995.5 | 0.1 | 0.4 | 0.3 | **1000.6** |
| | Wetlands | 0.0 | 0.5 | 0.2 | 164 | 0.1 | 0.1 | **165.5** |
| | Settlements | 0.2 | 2.2 | 0.4 | 0.2 | 733.1 | 0.2 | **736.3** |
| | Other Land | 0.0 | 0.6 | 0.1 | 0.0 | 0.1 | 104.0 | **104.9** |
| | ***Area (kha)*** | **2666.3** | **3218.5** | **997.2** | **164.9** | **734.9** | **105.1** | **7887.0** |

An insight into the net trends shown in Fig. 6-4 is provided by the analysis of gross land-use changes as described in Section 6.2. Tab. 6-3 shows a product of that analysis (for the base year 1990 and 2015), namely the areas of land-use change among the major land-use categories in the form of land-use change matrices for the individual years. This is available for all years of the reporting period. It is important to note that the annual totals for the individual years in the matrices do not necessarily correspond to the areas that appear in the CRF Tables, which account for the progressing 20-year transition period that began in 1970. This is the recommended assumption of IPCC (2006) for estimation of changes in soil carbon stock.

## 6.4 Forest Land (CRF 4.A)

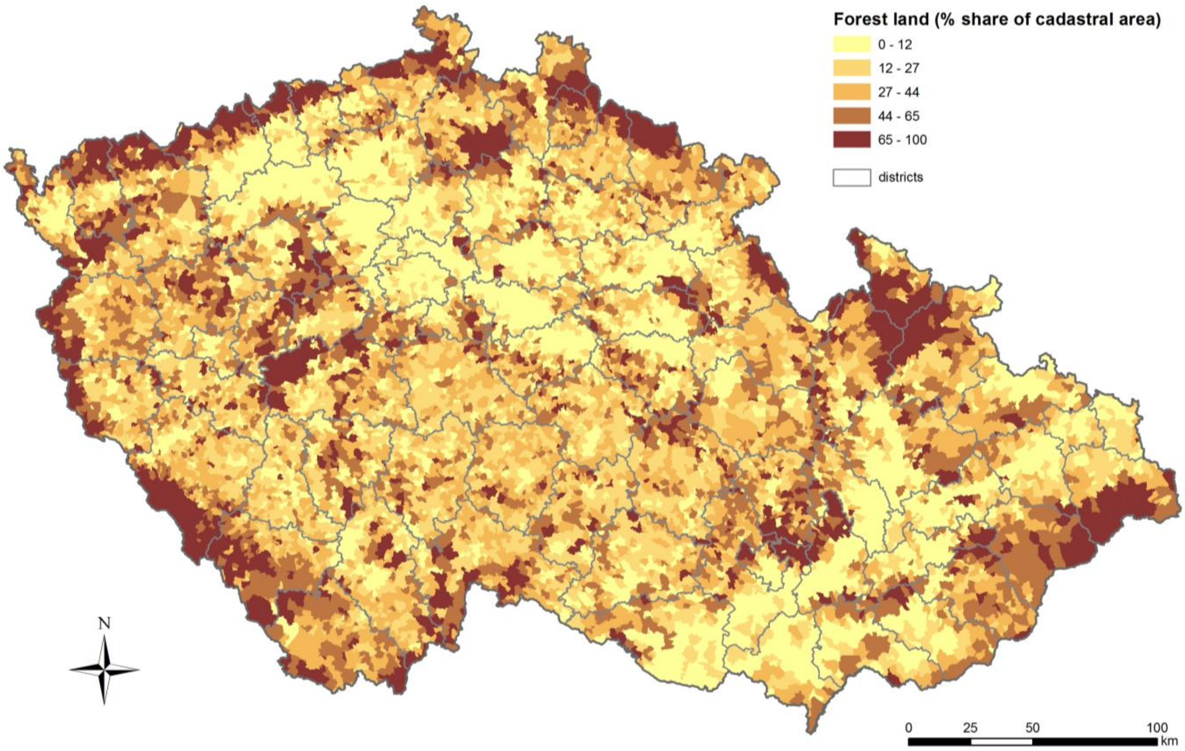



**Fig. 6-5 Forest land in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2015).**

### 6.4.1 Source category description

The Czech Republic is a country with a long forestry tradition. Practically all the forests can be considered to be temperate-zone managed forests under the IPCC definition of forest management (2006 IPCC Guidelines, Volume 4). Within the Czech land use representation and land use change identification system, land use category 4.A Forest land is represented by the forest land category of the Czech cadastral system. With respect to the definition thresholds of the Marrakesh Accords, forest is defined as land with woody vegetation and with tree crown cover of at least 30%, over an area exceeding 0.05 ha containing trees able to reach a minimum height of 2 m at maturity[4]. As this definition of forest excludes the areas of permanently unstocked cadastral forest land, such as forest roads, forest nurseries and land under power transmission lines, these are discounted in all emission estimates involving Forest Land using the annually updated information on the ratio of timberland to cadastral forest land. In this way,

*[4] These parameters, together with the minimum width of 20 m for linear forest formations, were given in the Czech Initial Report under the Kyoto Protocol*

the area of cadastral forest land is also linked to the national definition of timberland (Czech Forestry Act 84/1996). In 2015 (1990), the area of Forest Land equalled 2 668 (2 629) th. ha, whereas the stocked forest area (timberland) corresponded to 2605 (2 583) thousand ha, representing 97.6 (98.2)% of the cadastral forest land in the Czech Republic. Hence, the permanently unstocked area represents 2.4 (1.8)% of the forest land according to the Czech cadastral data.

Forests (cadastral forest land) currently occupy 34% of the area of the country (MAF, 2016). The tree species composition is dominated by conifers, which represent 72.3% of the timberland area. The four most important tree species in this country are spruce, pine, beech and oak, which account for 50.6, 16.5, 8.2 and 7.1% of the timberland area, respectively (MAF, 2016). Broadleaved tree species have been favoured in new afforestation since 1990. The proportion of broadleaved tree species increased from 21% in 1990 to over 26% in 2015. The total growing stock (merchantable wood volume) in forests in the country has increased during the reported period from 564 mil. $m^3$ in 1990 to 693 mil. $m^3$ (under bark) in 2015 (MAF, 2016).

Several sources of information on forests are available in the Czech Republic. The primary source of activity data on forests used for this emission inventory is the forest taxation data in Forest Management Plans (further denoted as FMP), which are administered centrally by the Forest Management Institute (FMI), Brandýs n. L. and supervised (since 2012) by Czech Forests, s.e. With a forest management plan cycle of 10 years, the annual update of the FMP database is related to 1/10 of the total forest area scattered throughout the country. The information in FMP represents an ongoing national stand-wise type of forest inventory. The auxiliary source of information corresponds to data from the statistical (sample based, tree level) National Forest Inventory (NFI). The first NFI cycle was performed during 2001-2004 by FMI and its aggregated results were released three years later (FMI, 2007). The second NFI cycle ran during the years 2011 to 2015. Its results have been gradually released during 2016 and 2017. The other auxiliary statistical information on forests at a county level is provided by the Czech landscape inventory (CzechTerra; www.czechterra.cz). It run as a project funded by the Ministry of Environment (Černý 2009, SP/2d1/93/07) complementing its first cycle in 2008/2009. The second CzechTerra cycle was conducted in 2014/2015 as part of the project funded by the Czech Science Foundation (GA ČR 14-12262S). These results were published by the end of 2015 (Cerny et al. 2015, Cienciala et al. 2015). Some of these data have already implemented in this emission inventory report. However, the emission inventory is still based on the FMP data, which represent the only data source used for all the international reporting on forests in the Czech Republic to date. However, wherever feasible, information from the above mentioned inventory programs and/or other sources has also been utilized.

The FMP data were aggregated in line with the country-specific approaches at the level of the four major tree species (i-beech: all broadleaved species except oaks, ii-oak: all oak species, iii-pine: pines and larch, iv-spruce: all conifers except pines and larch) and age-classes (10-year intervals). For these categories, growing stock (merchantable volume, defined as tree stem and branch volume under bark with a minimum diameter threshold of 7 cm), the corresponding areas and other auxiliary information were available for each inventory year. It can be observed that the area of broadleaved species has steadily increased during the reporting period, mainly at the expense of spruce (Fig. 6-6). In addition to the four major categories by predominant tree species, clear-cut areas are also distinguished (Fig. 6-6), forming another, specific sub-category of Forest Land. A clear-cut area is defined as a temporarily unstocked area following final or salvage harvest of forest stands. It ceases to exist once it is reforested, which must occur within two years according to the Czech Forestry Act. There is no detectable carbon stock change for this category and it is introduced solely for the purpose of consolidated, transparent and consistent reporting of forest land. In 2015, clear-cut areas represented 1.2% of timberland area within Forest Land.

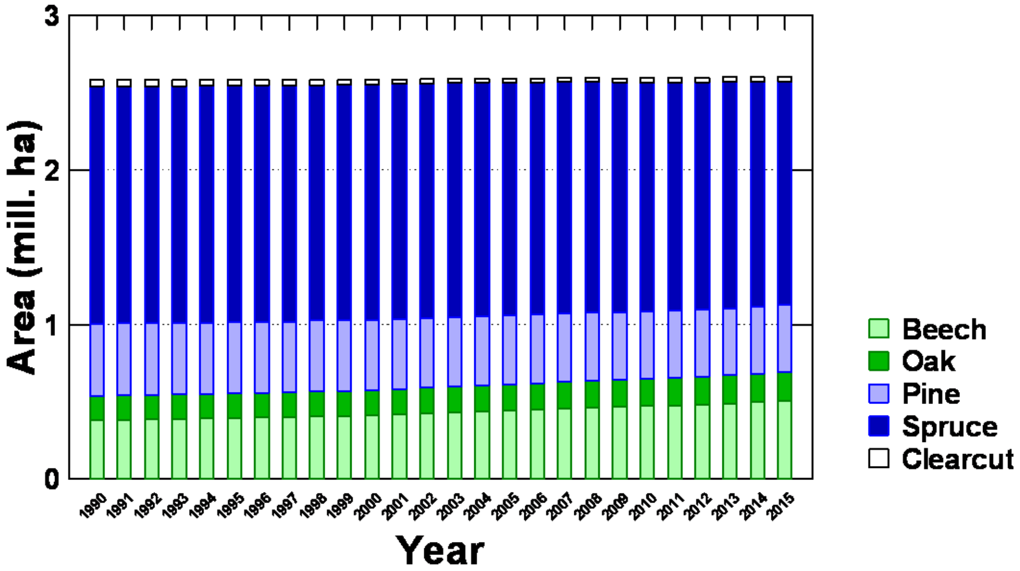



**Fig. 6-6 Activity data – area for the four major groups of species and clearcut area during 1990 to 2015.**

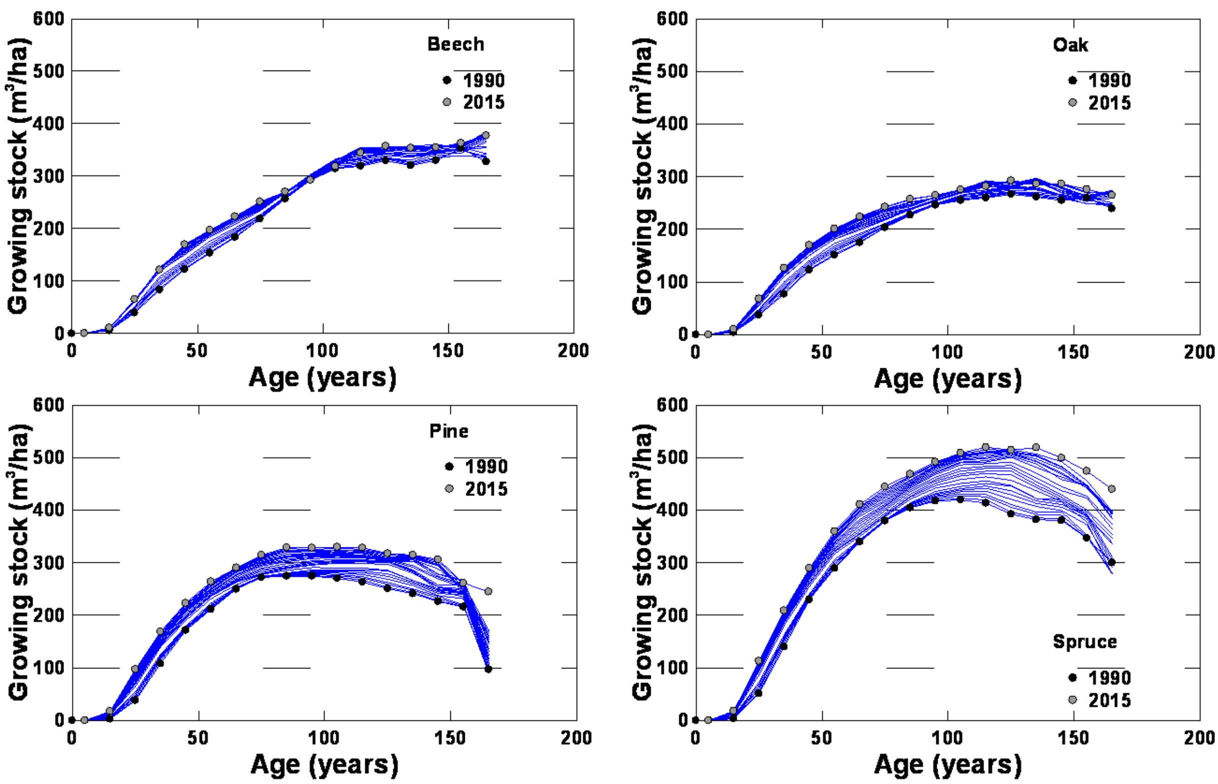



**Fig. 6-7 Activity data – mean growing stock volume against stand age for the four major groups of species during 1990 to 2015; each line corresponds to an individual inventory year. The symbols identify only the situation in 1990 and 2015.**

Fig. 6-7 shows the average growing stock for all tree species groups. It has increased steadily for all tree species groups since 1990 in this country.

The annual harvest volume constitutes the other key information related to forestry. This value is available from the Czech Statistical Office (CzSO). CzSO collects this information on the basis of about 600 country respondents (relevant forest companies and forest owners) and includes commercial harvest and fuel wood, with compensation for the forest areas not covered by the respondents. According to this information, the total drain of merchantable wood from forests increased from 13.3 mil. $m^3$ in 1990 to 16.2 mil. $m^3$ (under bark) in 2015, down from the all-time high of 18.5 mil. $m^3$ harvested in 2007 (all data refer to under-bark volumes, MAF 2015).

The Czech emission inventory also includes the harvest loss due to disturbance events and for other reasons, the estimate of which has been revised for this inventory submission. Specifically, this includes the officially reported estimates from the Czech Statistical Office (CzSO), which have become available since 2009. This complements the previously employed harvest loss estimates increasing the reported harvest by an extra 5 and 15% applied to final and salvage logging volumes, respectively (see Section 6.4.2 below). Salvage logging operations are predominantly related to stands affected by windstorms, snow and bark-beetle calamities in this country. On this basis, the Czech emission inventory includes an explicit estimate of disturbance, which includes the categories of natural disasters, pollution, insects and other effects (CzSO, J. Kahuda, personal communication 2013). Therefore, the total applicable harvest loss is linked to the actual share of salvage logging that is annually reported by CzSO and elsewhere (MAF 2015). In 2015, the applicable volume of total annual harvest drain reached 18.2 mill. $m^3$, down from the maximum of nearly 21 mill. $m^3$ estimated for 2007. The harvest drain applicable for the emission inventory for the entire reporting period since 1990 to 2015 is shown in Fig. 6-8, and also for 1990 and 2015 in Tab. 6-4.

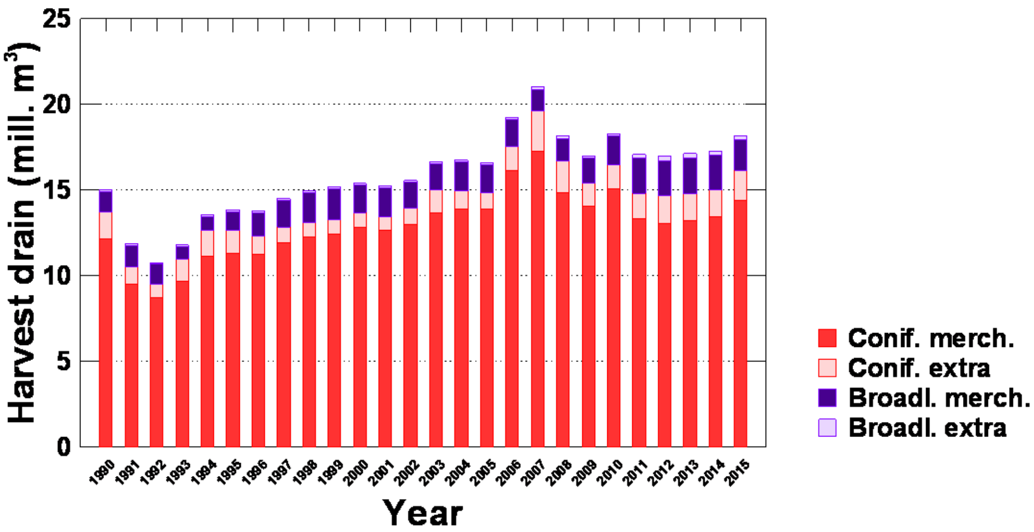



**Fig. 6-8 The applicable total annual harvest drain for coniferous (Conif.) and broadleaved (Broadl.) tree species, which includes both the reported quantities of merchantable wood for the two categories (Conif. merch, Broadl. merch.) and the associated harvest loss (Conif. extra, Broadl. extra) for the entire reporting period of 1990 to 2015.**

**Tab. 6-4 The reported harvest, mean share of salvage logging and associated applicable additional harvest loss (1990 and 2015 shown) for beech, oak, pine and spruce species groups, respectively.**

| Variable | Unit | Year 1990 | Year 2015 |
|---|---|---|---|
| | | Species group | |
| | | Beech, Oak, Pine, Spruce | Beech, Oak, Pine, Spruce |
| **Reported harvest** | $Mm^{-3}$ | 0.84; 0.31; 1.33; 10.84 | 1.37; 0.41; 1.56; 12.83 |
| **Share of salvage logging** | % | 71 | 50 |
| **Additional loss (IFER, CzSO)** | $Mm^{-3}$ | 0.10; 0.04; 0.16; 1.31 | 0.17; 0.05; 0.19; 1.59 |

### 6.4.2 Methodological issues

Category 4.A Forest Land includes emissions and sinks of $CO_2$ associated with forests and non-$CO_2$ gases generated by burning in forests. This category is composed of 4.A.1 Forest Land remaining Forest Land, and 4.A.2 Land converted to Forest Land. The following text describes the major methodological aspects related to emission inventories for both forest sub-categories.

The methods of area identification described in Section 6.1.2 distinguish the areas of forest with no land-use change over the 20 years prior the reporting year. These lands are included in subcategory 4.A.1 Forest Land remaining Forest Land. The other part represents subcategory 4.A.2 Land converted to Forest Land, i.e., the forest areas "in transition" that were converted from other land-use categories over the 20 years prior to the reporting year. The areas of forest subcategories, i.e., 4.A.1 and 4.A.2 accumulated over a 20-year rolling period can be found in the corresponding CRF Tables. The annual matrices of identified land-use and land-use changes are given in Tab 6-3 above.

#### *6.4.2.1 Forest Land remaining Forest Land*

Carbon stock change in category 4.A.1 Forest Land remaining Forest Land is given by the sum of changes in living biomass, dead organic matter and soils. The carbon stock change in living biomass was estimated using the default method[5] according to eq. 2.7 of the 2006 IPCC Guidelines for LULUCF. This method is based on separate estimation of increments and removals, and their difference.

The reported growing stock of merchantable volume from the database of FMP formed the basis for assessment of the carbon increment (Eqs. 2.9 and 2.10 of 2006 IPCC Guidelines for LULUCF). The key input to calculate the carbon increment is the volume increment ($I_v$) data. In the Czech Republic, these values have been traditionally calculated at FMI[6] (FMP database administrator; see also Acknowledgment) and reported to the national and international statistics. The calculation is performed at the level of the individual stands and species using the available growth and yield data and models. The increment data were partly revised in the earlier NIR (2008) to unify two different base information sources (Schwappach, 1923; Černý et al., 1996) for increment estimates and to employ only the latest source across the entire reporting period. This procedure was implemented to comply with the GPG for LULUCF requirements of consistent time series. No change, apart from entering the actual increment for the latest reported year, has been made to the increment in the inventory submissions thereafter (Fig. 6-9).

*[5] Alternative approaches of the stock-change method (Eq. 2.8; IPCC 2006) were also analyzed (Cienciala et al. 2006a) for this category. However, for several reasons the default method was finally adopted and is discussed in the cited study.*
*[6] Since 2012, Czech Forests, s.e. has supervised the administration of FMP and estimates of the increment are provided on request by the Czech Ministry of Agriculture, which is responsible for the forestry sector including Czech Forests, s.e.*

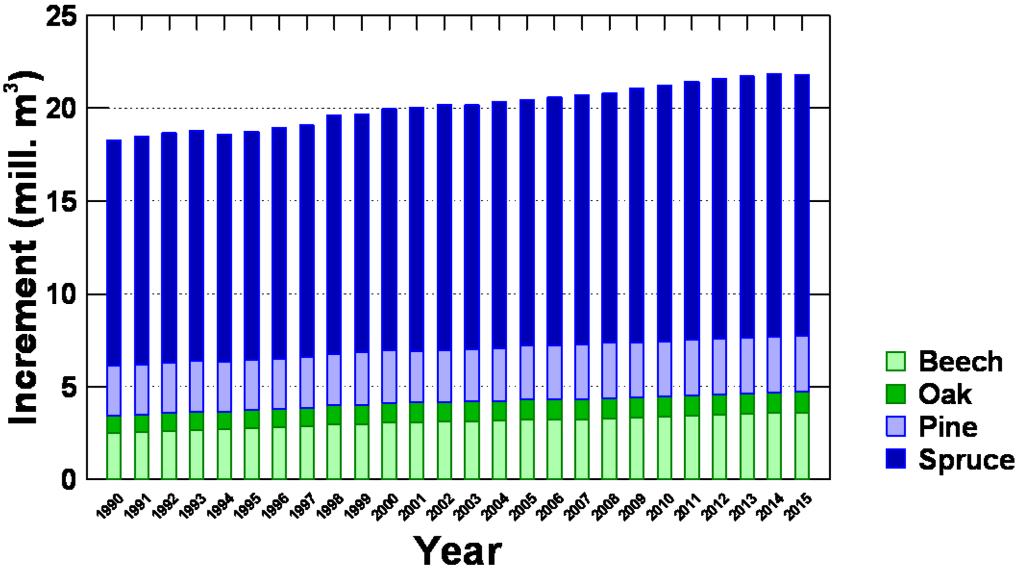



**Fig. 6-9 Current annual increment (Increment, mill. m$^3$ underbark) by the individual tree species groups as used in the reporting period 1990 to 2015.**

The merchantable volume increment ($I_v$) is converted to the biomass increment ($G_{Total}$), biomass conversion and expansion factors applicable for increment ($BCEF_i$) using Eqs. 2.9 and 2.10 (AFOLU, 2006) as follows:

$$\Delta C_G = \sum_j (A_j * G_{Total_j} * CF_j \quad (1)$$

where $A_j$ and $CF_j$ represent the actual stand area (ha) and carbon fraction of dry matter (t C per t dry matter), respectively, for each major tree species type *j* (beech, oak, pine, spruce), while $G_{Total}$ is calculated for each *j* as follows:

$$G_{Total} = \sum \{I_V * BCEF_i * (1 + R)\} \quad (2)$$

where *R* is a root/shoot ratio to include the below-ground component. The total biomass increment is multiplied by the carbon fraction and the applicable forest land area. Tab. 6-5 lists the factors used in the calculation of the biomass carbon stock increment.

**Tab. 6-5 Input data and factors used in carbon stock increment calculation (1990 and 2014 shown) for beech, oak, pine and spruce species groups, respectively**

| Variable or conversion factor | Unit | Year 1990 | Year 2015 |
|---|---|---|---|
| | | Species group | |
| | | Beech, Oak, Pine, Spruce | Beech, Oak, Pine, Spruce |
| **Area of forest land remaining forest land (*A*)** | kha | 381; 156; 466; 1539 | 508; 189; 434; 1454 |
| **Biomass conv. & exp. factor, incr. ($BCEF_i$)** | Mg m$^{-3}$ | 0.74; 0.86; 0.52; 0.60 | 0.74; 0.85; 0.53; 0.60 |
| **Carbon fraction in biomass (*CF*)** | t C/t biomass | 0.48; 0.48; 0.49; 0.49 | 0.48; 0.48; 0.49; 0.49 |
| **Root/shoot ratio (*R*)** | - | 0.20 | 0.20 |
| **Volume increment ($I_v$)** | m$^3$ha$^{-1}$ | 6.55; 5.96; 5.84; 7.89 | 7.19; 6.04; 7.05; 9.68 |

In Tab. 6-5, *A* represents only the areas of 4.A.1 Forest Land remaining Forest Land*,* updated annually. The applied biomass conversion and expansion factors applicable for the increment ($BCEF_i$) and growing stock volumes ($BCEF_h$) are based on national allometric studies (Cienciala et al., 2006a, 2006b, 2008a) or biomass compilations that include data from the Czech Republic (Wirth et al., 2004, Wutzler et al., 2008). Since the biomass conversion and expansion factors are age-dependent (Lehtonen et al., 2004, 2007), they respect the actual age-class distribution of the dominant tree species. Hence, the $BCEF_i$ values shown in Tab. 6-5 are weighted means considering the actual volumes of the individual age classes for each of the major tree species. In addition to the allometric equations noted above, the source dendrometrical material used for derivation of the country-specific $BCEF_i$ values consisted in the data from the CzechTerra landscape inventory program (Černý, 2009). The tree level data together with the information on age were used to assess the median $BCEF_i$ values for each age class and major tree species. Starting in the 2014 inventory submission, the carbon fraction in woody biomass (*CF*) of 0.50, a generally accepted default constant (IPCC 2003), has been replaced by somewhat more conservative values of 0.48 and 0.49 for broadleaved and coniferous tree species, respectively (Tab. 6-5). This is in accordance with the values suggested by IPCC (2006) based on a more extensive literature survey. *R* was selected as a conservative value from the range recommended for temperate-zone forests by IPCC (2003). It corresponds well to the available relevant experimental evidence (Černý, 1990; Green et al., 2006), as well as to the evidence apparent from the parameterized allometric equations for the major tree species (Wirth et al., 2004, Wutzler et al., 2008). $I_v$ is the annually updated volume increment estimated per hectare and species group as described above.

The estimation of carbon drain (*L*; eq. 3) in the category 4.A.1 Forest Land remaining Forest Land basically follows Eqs. 2.11, 2.12 and 2.13 (AFOLU, 2006). It uses the annual amount of total harvest removals reported by CzSO for individual tree species in the country as well as the associated harvest loss, which is newly (since 2009) explicitly reported by CzSO. Therefore, the total harvest drain (*H*) covers thinning and final cut, the amount of fuel wood, which is reported as an assortment under the conditions of Czech Forestry, as well as the associated harvest loss. To include the biomass loss associated with harvest, factor $F_{HL}$ was applied to the reported harvest volume; it was calculated from the annual harvest data and the share of salvage logging, assuming 5% loss under the planned forest harvest operations and 15% for accidental/salvage harvest. Hence, the harvest volume entering the actual emission calculation (*H* in eq. 3 below) includes correction by the above-described factor, $F_{HL}$. This estimate was used to account for harvest loss associated the reported harvest of merchantable wood volume until 2010. Since 2011, however, the newly introduced harvest loss estimate of CzSO is used exclusively. The calculation of the total carbon drain (*L*; loss of carbon) associated with wood removals follows Eq. 2.12 (AFOLU 2006) as

$$L_{wood\ removals} = H * BCEF_h * (1 + R) * CF \qquad (3)$$

where $BCEF_h$ represents the biomass expansion and conversion factor applicable to harvested volumes, derived from national studies or regional compilations that include the data from the Czech Republic as noted and mentioned above. The application of $BCEF_h$ considers the share of the planned harvested volume and the actual salvage logging that was not planned. In the case of planned harvest volumes, the age-dependent $BCEF_h$ values also consider the mean felling age, which is taken from the national reports of the Ministry of Agriculture. For salvage logging, $BCEF_h$ represents the volume-weighted mean of all age classes for the individual dominant tree species, as the actual stand age of those harvested volumes is unknown. The other factors (*CF, R*) are identical to those described under Tab. 6-5. The specific values of the input variables and conversion factors used to calculate *L* are listed in Tab. 6-6.

**Tab. 6-6 Specific input data and factors used in calculation of the carbon drain (1990 and 2015 shown) for beech, oak, pine and spruce species groups, respectively**

| Variable or conversion factor | Unit | Year 1990 | Year 2015 |
|---|---|---|---|
| | | Species group | |
| | | Beech, Oak, Pine, Spruce | Beech, Oak, Pine, Spruce |
| **Harvest drain volume (*H, incl.* $F_{HL}$)** | $Mm^3$ | 0.95; 0.35; 1.49; 12.16 | 1.54; 0.46; 1.75; 14.41 |
| **Biomass expansion factor ($BCEF_h$)** | $Mg\ m^{-3}$ | 0.69; 0.81; 0.52; 0.59 | 0.71; 0.83; 0.52; 0.58 |

The impact of disturbances (Eq. 2.14, AFOLU, 2006) is included in full in the total harvest drain volume (*H*). The available data on salvage logging from CzSO (and MAF 2016) can also be traced as the disturbance origin by categories including natural disaster, air pollution, insect and other. This information is mandatorily reported by the forestry practice, which must always prioritize salvage logging on account of the planned harvest. In this way, the prescribed (planned) logging volume is commonly composed of planned and salvage logging. Consequently, any salvage felling is flexibly allocated to the desired amount of planned wood removals, and it is thereby accounted for in the reported harvest volumes within Eq. 3. This also includes the occasional events of more significant local salvage loggings, when forest managers may request and receive temporary permissions to increase the planned harvest volumes for the affected forestry districts.

The assessment of the net carbon stock change in organic matter (deadwood and litter) followed the Tier 1 (default) GPG for LULUCF assumption of zero change in these carbon pools. This is a safe assumption, as the country did not experience significant changes in forest types, disturbance or management regimes within the reporting period.

The above assumption also applies to the soil carbon pool, in which the net carbon stock change was considered to equal zero (Tier 1, IPCC 2006). This concerns both mineral and organic soils. The organic soils occur only in the areas of the Spruce sub-category on 4.A.1 Forest Land remaining Forest Land. They represent protected peat areas in mountainous regions dominated by spruce stands, with no or specific management practices. No such areas occur under the other sub-categories with the predominant species of beech, oak and pine.

Emissions in category 4.A.1 Forest Land remaining Forest Land include, in addition to $CO_2$, also other greenhouse gases ($CH_4$, CO, $N_2O$ and $NO_X$) resulting from burning. This encompasses both prescribed fires associated with burning of biomass residues and also emissions due to wildfires. The emissions from burning of biomass residues were estimated according to eq. 2.27 and the emission and combustion factors in Table 2.5 and 2.6 (Tier 1, IPCC 2006). Under the conditions in this country, part of the biomass residues is burned in connection with the final cut. Hence, this practice is limited to category 4.A.1 and does not occur in 4.A.2 Land converted to Forest land. There is no official estimate of the biomass fraction burned in forests in the country. The expert judgment employed in this inventory considers that 15% of the biomass residues including bark is burned. This is less than assumed for the inventory years until 2010, which corresponds with the trend in current forest management practices in the country. The biomass fraction burned was quantified on the basis of the annually reported amount of final felling volume of broadleaved and coniferous species, $BCEF_h$ and *CF* as applied to harvest removals (above). The amount of biomass burned (dry matter) was estimated as 590 Gg in 1990 and 393 Gg in 2015.

The emissions of greenhouse gases due to wildfires were estimated on the basis of known areas burned annually by forest fires and the average biomass stock in forests according to eq. 2.14 (IPCC 2006). This equation used a default factor for biomass left to decay after burning (0.45; Table 2.6). The associated amounts of non-$CO_2$ gases ($CH_4$, CO, $N_2O$ and $NO_X$) were estimated according to eq. 2.27. The amount of biomass (dry matter) burned in wildfires was estimated as 10.2 Gg in 1990 and 25.8 Gg in 2015. The most extreme year of the reporting period was 1997, when about 228 Gg of biomass was burned due to wildfires on an area of almost 3.5 th. ha. In 1990 and 2015, the reported forest areas under wildfire were 168 and 344 ha, respectively. During the reporting period since 1990, there has been no single year without reported wildfire. The mean annual forest area affected by forest wildfires reached 634 ha during the 1990 to 2015 period. The full time series and the associated emissions of non-$CO_2$ gases can be found in the corresponding CRF Tables.

There are no direct $N_2O$ emissions from N fertilization on Forest Land, as there is no practice of nitrogen fertilization of forest stands in the Czech Republic. Similarly, non-$CO_2$ emissions related to drainage of wet forest soils are not reported, as this activity no longer occurs in practice.

#### 6.4.2.2 Land converted to Forest Land

The methods employed to estimate emissions in the 4.A.2 Land converted to Forest Land category are similar to those for the category of Forest Land remaining Forest Land, but they differ in some assumptions, which follow the recommendations of GPG for LULUCF (IPCC 2003) and AFOLU (IPCC 2006).

For estimation of the net carbon stock change in living biomass on Land converted to Forest Land by the Tier 1 method (IPCC 2006), the carbon increment is proportional to the extent of afforested areas and the growth of biomass. The revised methodology of land-use change identification (Section 6.2) provides areas of all conversion types updated annually. Land areas are considered to be under conversion for a period of 20 years, according the Tier 1 assumption of GPG for LULUCF. Under the conditions in this country, all newly afforested lands are considered as intensively managed lands under the prescribed forest management rules as specified by the Czech Forestry Act.

Until 2006, the increment applicable to age classes I and II (stand age up to 20 years) was estimated from the actual wood volumes and areas that were available per major species groups. Using the available activity stand level data categorized by species and age classes and the national growth and yield model SILVISIM (Černý, 2005), the wood increment was derived for all the age classes above 20 years. For age class one (1-10 years), the increment was simply calculated from the reported areas and volumes, assuming a mean age of five years. The increment of age class two (11 to 20 years) was estimated from linear interpolation between the increment of age classes I and III. For 2007 and the following years, the increment is derived for individual tree species using the ratio of increments for individual tree species to the total stand increment estimated for the 2000 to 2006 period.

Since the specific species composition of the newly converted land is unknown, the increment estimated for the major tree species was averaged using the weight of actual areas for the individual tree species known from the unchanged (remaining) forest land. Expressed in terms of aboveground biomass, the estimated aggregated mean increment for 2015 was 3.24 t/ha, a value matching that for temperate coniferous (3 t/ha) and somewhat lower than that for broadleaved (4 t/ha) forests given as defaults in GPG for LULUCF. The estimation of increments in terms of aboveground biomass is facilitated by the age- and species-dependent $BCEF_i$ values as described in Section 6.2.1 above. The estimated species-specific values of $BCEF_i$ applicable for young trees to 20 years of age were 0.99, 1.25, 0.65 and 0.93 for beech, oak, pine and spruce, respectively.

The carbon loss associated with biomass in the category of Land converted to Forest Land was assumed to be insignificant (zero). This is because the first significant thinning occurs in older age classes, which are implicitly accounted for within the category Forest Land remaining Forest Land. It is also important to note (in response to the previous inventory reviews) that under the conditions in this country, there is no biomass loss due to disturbance on the land converted to forest land. It actually represents the land of a newly established forest with tree age of 1 to 20 years. As is also apparent from the national statistics, there is no volume of salvage logging reported for this category, which reflects the actual conditions of forest ecosystems of the age concerned.

The net changes of carbon stock in dead organic matter (DOM) were estimated in accordance with the guidance of the Tier 1 method (IPCC 2006), using available country specific information. This approach assumes that deadwood and litter carbon pools increase linearly from zero to the reference default values for the given country-specific conditions. The changes in DOM were estimated separately for deadwood and litter components. For deadwood, conservative values of the transition period for developing deadwood carbon stock (100 years) and the reference mean carbon stock held in deadwood (0.7 t C/ha; CzechTerra landscape inventory 2009 and 2015, Cienciala et al. 2015) were used, respectively. For litter, the default (IPCC 2006) period of 20 years was used together with the country-specific estimate of reference mean carbon stock held in litter (11.12 t C/ha; CzechTerra landscape inventory 2009, Cienciala et al. 2015).

The net change of carbon stock in mineral soils was estimated using the country-specific Tier 2/Tier 3 method. This was based on the vector map of topsoil organic carbon content (Macků et al., 2007; Šefrna and Janderková 2007; see Fig. 6-9). The map constructed for forest soils utilized over six thousand soil samples, linking the forest ecosystem units - stand site types and ecological series available in maps 1:5 000 and 1:10 000, as used in the Czech system of forest typology (Macků et al., 2007). This represents the soil organic carbon content to a reference depth of 30 cm, including the upper organic horizon. The carbon content on agricultural soils was prepared so as to match the forest soil map in terms of reference depth and categories of carbon content, although based on interpretation of coarser 1:50 000 and 1:500 000 soil maps (Šefrna and Janderková, 2007). The polygonal source maps were used to obtain the mean carbon content per individual cadastral unit (n = 13 091 in 2015), serving as reference levels of soil carbon stock applicable to forest and agricultural soils. Since agricultural soils include both Cropland and Grassland land-use categories, the bulk soil carbon content obtained from the map was adjusted for the two categories. This was performed by applying a ratio of 0.85 relating the soil carbon content between Cropland and Grassland (J. Šefrna, personal communication 2007) and considering the actual areas of Cropland and Grassland in the individual cadastral units. This system permitted estimation of the soil carbon stock change among categories 4.A Forest Land, 4.B Cropland and 4.C Grassland. The estimated quantities of carbon stock change at the level of the individual spatial units were entered into 20-year accumulation matrices distributing carbon into fractions over 20 years (IPCC 2006). These quantities, together with the accumulated areas under the specific conversion categories, were used for estimation of emissions and removals of $CO_2$.

The net changes in carbon stock in organic soils, occurring only in the sub-category of stands dominated by spruce, were assumed to be insignificant (zero). This is in accordance with the general assumption of the Tier 1 method applicable for forest soils, as no other specific methodology is available for organic soils except for drained ones (IPCC 2006).

Non-$CO_2$ emissions from burning are not estimated for category 4.A.2 Land converted to Forest Land, as this practice is not employed in this country. The same applies to $N_2O$ emissions from nitrogen fertilization, which is not carried out in this country on forest land.

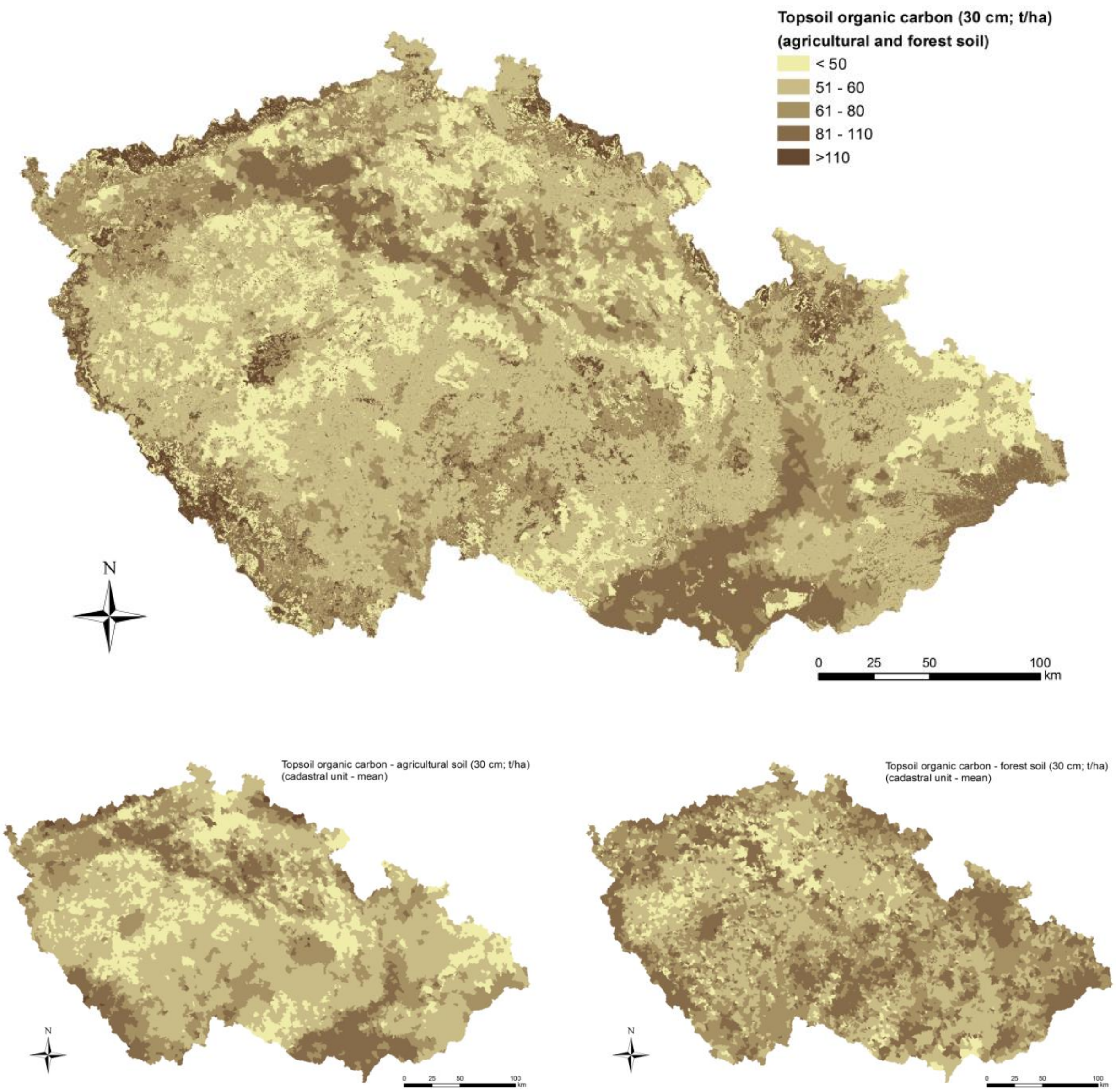



**Fig. 6-10 Top - topsoil (30 cm) organic carbon content map adapted from Macků et al. (2007), Šefrna and Janderková (2007); bottom –topsoil carbon content for agricultural (left) and forest (right) soils estimated as cadastral unit means from the source maps. The unit (t/ha) and unit categories are identical for all the maps.**

### 6.4.3 Uncertainties and time-series consistency

The methods used in this inventory were consistently employed across the whole reporting period from the base year of 1990 to 2015.

The uncertainty estimation was guided by the Tier 1 methods outlined in GPG for LULUCF (IPCC, 2003) and IPCC 2006 Gl. (IPCC, 2006) employing the following equations:

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2} \qquad (4)$$

where $U_{total}$ is the percentage uncertainty in the product of the quantities and $U_i$ denotes the percentage uncertainties with each of the quantities (Eq. 3.1, Volume 1, Chapter 3, IPCC 2006).

For the quantities that are combined by addition or subtraction, we used the following equation to estimate the uncertainty:

$$U_{total} = \frac{\sqrt{(U_1 * x_1)^2 + (U_2 * x_2)^2 + \ldots + (U_n * x_n)^2}}{|x_1 + x_2 + \ldots + x_n|} \quad (5)$$

where $U_{total}$ is the percentage uncertainty of the sum of the quantities, $U_i$ is the percentage uncertainty associated with source/sink *i*, and $x_i$ is the emission/removal estimate for source/sink *i* (Eq. 3.2, Volume 1, Chapter 3, IPCC 2006).

It should be noted, however, that Eq. 5 as also exemplified in GPG for LULUCF is not well applicable for the LULUCF sector. Summing negative (removals) and positive (emission) members ($x_i$) in the denominator of equation 5 may easily produce unrealistically high uncertainties and theoretically lead to division by zero, which is not possible. In this respect, this approach is not correct. In previous inventory reports, we stressed this issue and recommended focusing on individual uncertainty components prior the resulting product of Eq. 5.

The adopted uncertainty values are listed below and/or under the corresponding subchapters of other land use categories. In addition to IPCC (2006), the source information for adjusted uncertainty values was obtained from the recently conducted CzechTerra statistical landscape inventory of the Czech Republic (Černý et al., 2009, Cienciala et al. 2015). Otherwise, the uncertainty estimation utilized primarily the default uncertainty values as recommended by UNFCCC (2005) and IPCC (2003, 2006) that concern areas of land use (5%), biomass increment (6%), amount of harvest (20%), carbon fraction in dry wood mass (7%), root/shoot factor (30%) and factor ($1-f_{BL}$; 75%), used in calculation of emissions from forest fires. The uncertainty applicable to *BCEF* was 22%, which was derived from the work of Lehtonen et al. (2007). The uncertainty associated with fractions of unregistered loss of biomass under felling operations was set by expert judgment at 30%.

The approach of uncertainty combination for individual sub-categories of tree species is based on calculating the mean error estimate from the components of carbon stock increase and carbon stock loss, which are both given in identical mass units of carbon per year. At the same time, we retained the recommended logics of combining uncertainties on the level of the entire land use category or on the level of the entire LULUCF sector according Eq. 5. This is calculated on the basis of $CO_2$ or $CO_2$ eq. units and the corresponding uncertainty estimates respect the actual direction of the source and sink categories to be combined.

For 2015, the uncertainty estimates for categories 4.A.1 Forest Land remaining Forest Land and 4.A.2 Land converted to Forest Land using the above described approach reached 20% and 29%, respectively. Correspondingly, the uncertainty for the entire 4.A Forest Land category reached 17%.

### 6.4.4 Source-specific QA/QC and verification

Following the recommendation of the previous in-country review, a sector-specific QA/QC plan was formulated, tightly linked to the corresponding QA/QC plan of the National Inventory System. The plan describes the key procedures of inventory compilation and provides a table of personal responsibilities and a timetable of sector-specific QA/QC procedures. This plan consolidates the quality assurance procedures and facilitates effective quality control of the LULUCF inventory.

Basically all the calculations are based on the activity data taken from the official national sources, such as the Forest Management Institute and the Ministry of Agriculture, the Czech Statistical Office, the Czech Office for Surveying, Mapping and Cadastre (COSMC) and the Ministry of the Environment. Data sources are verifiable and updated annually. The gradual development of survey methods and implementation of information technology, checking procedures and increasing demand on quality result in increasing accuracy of the emission estimates. The QA/QC procedures generally cover the elements listed in Table 6.1 of 2006 IPCC Guidelines (Volume1, Chapter 6, IPCC 2006).

The input information and calculations are archived by the expert team and the coordinator of NIR. Hence, all the background data and calculations are verifiable.

Apart from official review process, emission inventory methods and results are internally reviewed among the technical experts involved in the emission inventory of the Agriculture and LULUCF sectors. Whenever feasible, the methods are subject to peer-review in case of the cited scientific publications, and expert team reviews within the relevant national research projects.

In 2014, a voluntary supplementary review of the Czech LULUCF inventory was conducted within the framework of the EU MS Assistance Program. Specifically, it was reviewed by Dr. Zoltan Somogyi, who together with the Czech LULUCF experts discussed the reporting issues and suggested improvements to be considered for gradual implementation. The full report of this expert venue is available on request from the Czech LULUCF inventory team.

### 6.4.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trends

Since the last submission, the emission estimates were recalculated for the entire category and reporting period. This was due to the corrections associated with the adopted emission factors related to carbon fractions used for estimation of emissions from burning and forest fires. The effect of these corrections performed for category 4.A Forest Land can be seen in Fig. 6-11. On average, the emission removals increased by 0.6% compared to the previously reported estimates.

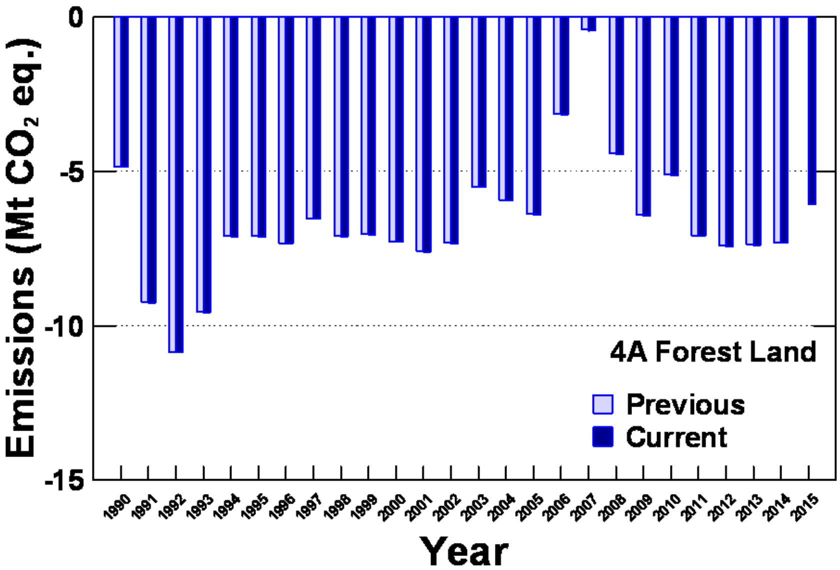



**Fig. 6-11 Current and previously reported assessment of emissions for category 4.A Forest Land. The values are negative, hence representing net removals of green-house gases**

### 6.4.6 Source-specific planned improvements, including those in response to the review process

The current inventory report applicable for 4.A Forest Land used the rectified land area data for the entire data set required for the LULUCF inventory and improved emission estimates for the carbon stock change on land converted to Forest Land, which was implemented in the previous submission. There were no other review suggestions of the review conducted in the previous year. Other improvements initiated by the inventory team remain under planning. This includes a further improvement in the uncertainty assessment (exploring the Monte-Carlo approaches) and further formalization and enhancement of QA/QC procedures. Over a longer term, further utilization of the new data from the statistical inventory programs is planned, including the repeated survey of the Czech National Forest Inventory and CzechTerra Landscape inventory.

## 6.5 Cropland (CRF 4.B)

### 6.5.1 Source category description

In the Czech Republic, Cropland (Fig. 6-12) is predominantly represented by arable land (92.5% of the category in 2015), while the remaining area includes hop-fields, vineyards, gardens and orchards. These categories correspond to five of the six real estate categories for agricultural land from the database of "Aggregate areas of cadastral land categories" (AACLC), collected and administered by COSMC.

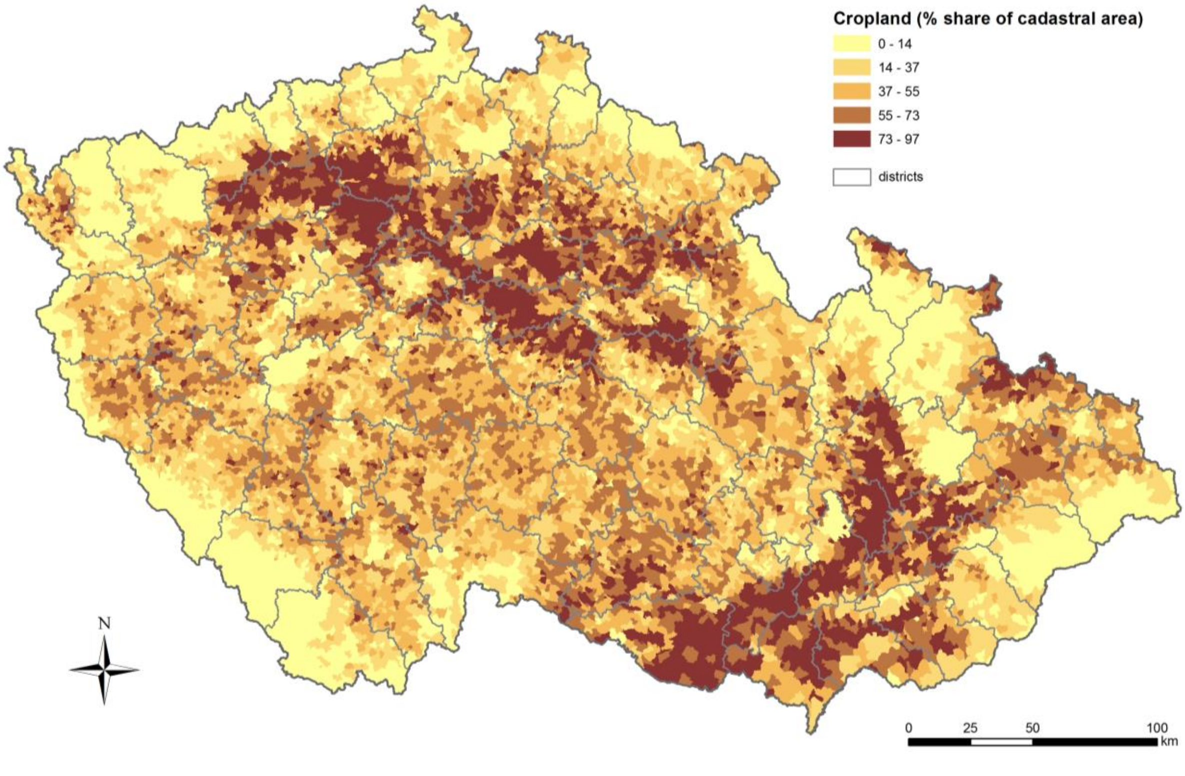



**Fig. 6-12 Cropland in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2015).**

Cropland is spatially the largest land-use category in the country. Simultaneously, the area of Cropland has constantly decreased since the 1970s, with a particularly strong decreasing trend since 1990 (Fig. 6-4). While, in 1990, Cropland represented approx. 44% of the total area of the country, this share decreased to less than 41% in 2015. It can be expected that this trend will continue. The conversion of arable land to grassland is actively promoted by state subsidies. Conversion to grassland concerns mainly lands of less productive regions of alpine and sub-alpine regions. In addition, there is a growing demand for land for infrastructure and settlements.

### 6.5.2 Methodological issues

The emission inventory of Cropland concerns sub-categories 4.B.1 Cropland remaining Cropland and 4.B.2 Land converted to Cropland. The emission inventory of Cropland considers changes in living biomass, dead organic matter and soil. In addition, $N_2O$ emissions associated with soil disturbance during land-use conversion to cropland are quantified for this category.

#### *6.5.2.1 Cropland remaining Cropland*

For category 4.B.1 Cropland remaining Cropland, the changes in biomass can be estimated only for perennial woody crops. Under the conditions in this country, this might be applicable to the categories of vineyards, gardens and orchards. Hence, to estimate emissions associated with biomass on Cropland, a default factor for the biomass accumulation rate (2.1 t C/ha/year, Table 5.1, IPCC 2006) was applied to estimate biomass carbon pool changes for the areas concerned.

The carbon stock change of dead organic matter follows the Tier 1 method assumption of IPCC (2006) that dead wood and litter stocks are not present on Cropland or are at equilibrium. Hence, no change is assumed for this pool.

The carbon stock change in soil in the category Cropland remaining Cropland is given by changes in mineral and organic soils. Organic soils basically do not occur on Cropland; they occur as peatland in mountainous regions on Forest Land. Hence, emissions were estimated for mineral soils. The estimation procedure was revised for this category following the recommendation of the recent inventory reviews. It used the locally-specific average carbon content on Cropland estimated specifically for each of the over 13 thousand cadastral units from the detailed soil carbon maps (Fig. 6-10). Next, the country-specific factor for cropland management ($F_{MG}$; 1.1035) was derived from the actual share of ecological agriculture and specific soil treatment (no- and reduced tillage, Hůla et al. 2010). The actual share (2015, 2.37%) of ecological agriculture on Cropland was derived from the detailed spatially explicit database of Land Parcel Identification System (LPIS), while the historical share was derived from the official annual report on Agriculture (MAA 2015). The other factors included the relative stock change factor for land use ($F_{LU}$; 1.0) applicable for cropland and input of organic matter ($F_I$; 1.0), respectively (Table 5.5; IPCC 2006). In line with the IPCC (2006) recommendation, the estimated quantity of soil carbon stock change is thereafter distributed over a 20-year period starting from the actual inventory year.

Until the NIR submission 2014, the Cropland category also included emissions due to liming. Due to the specific trend in lime application in this country, emissions from liming made the former 4.B.1 Cropland remaining Cropland the key category by trend. However, since the 2015 NIR submission, the emissions from liming are excluded from 4.B.1 Cropland remaining Cropland and reported under category 3.G Liming in the sector of Agriculture instead.

Non-$CO_2$ greenhouse gas emissions from burning do not occur in category 4.B.1 Cropland remaining Cropland, as there is this practice is not implemented on Cropland in this country.

#### *6.5.2.2 Land converted to Cropland*

Category 4.B.2 Land converted to Cropland includes land conversions from other land-use categories. Cropland has generally decreased in area since 1990, by far most commonly converted to Grassland. However, the adopted detailed system of land-use representation and land use change identification system is able to detect land conversions in the opposite direction, i.e., to Cropland.

The estimation of carbon stock changes in biomass in category 4.B.2 Land converted to Cropland was based on quantifying the difference between the carbon stock before and after the conversion, including the estimation of one year of cropland growth (5 t C/ha; Table. 5.9, IPCC 2006), which follows Tier 1 assumptions of GPG for LULUCF and the recommended default values for the temperate zone. For biomass carbon stock on Forest Land prior conversion, the annually updated average growing stock volumes, species-specific volume-weighted biomass conversion and expansion factors (*BCEF*), and other factors such as the below-ground biomass ratio were used as described in the 4.A Forest Land category in Section 6.2.1 above. For biomass carbon stock on Grassland prior to the conversion, the default factor of 6.8 t/ha for above-ground and below-ground biomass was used (Table 6.4, IPCC 2006). A biomass content of 0 t/ha was assumed after land conversion to 4.B Cropland.

The estimation of net carbon stock change in dead organic matter concerns land use conversion from Forest Land. In this case, the input information on standing and lying deadwood was obtained from the available statistical inventories in the country: the National Forest Inventory (FMI 2007) and the recently conducted field campaigns (2009 and 2015) of the CzechTerra landscape inventory (Cerny, 2009; Cienciala et al. 2015, www.czechterra.cz). They provide data on the mean standing deadwood biomass and volume of lying deadwood classified in four categories according to degree of decomposition. These categories are defined as follows: i) basically solid wood; ii) peripheral layers soft, central hard; iii) peripheral layers hard, central soft; iv) totally rotten wood. The amount of carbon held in lying deadwood was estimated as the product of the wood volume, density weighted by mean growing stock volume of major tree species (0.433 t/m$^3$), reduction coefficients of 0.8, 0.5, 0.5, 0.2 (Cerny et al., 2002; Carmona et al., 2002) applicable to the above described decomposition categories, respectively, and the carbon fraction in the wood (0.5 t C/t biomass). A default, conservative assumption that no deadwood is present following the land use change was adopted in this calculation.

Estimation of the carbon stock change in soils for category 4.B.2 Land converted to Cropland in the Czech Republic concerns mineral soils. The soil carbon stock changes following the conversion from Forest Land and Grassland were quantified by the country-specific Tier 2/Tier 3 approach and are described in detail in Section 6.4.2.2 above.

The Land converted to Cropland category represents a source of non-$CO_2$ gases, namely emissions of $N_2O$ due to mineralization. The estimation followed the Tier 1 approach of Eqs. 2.25 and 11.8 (IPCC 2006). Accordingly, direct $N_2O$ emissions were quantified on the basis of the detected changes in mineral soils employing a default emission factor of 0.01 kg $N_2O$-N/kg N (EF1, IPCC 2006), and C:N ratio of 15. Linked to this, indirect $N_2O$ emissions from atmospheric deposition of N volatized from managed soils were estimated using Eq. 11.10 and the emission factor 0.0075 (EF5, IPCC 2006).

Other non-$CO_2$ emissions may be related to those from burning. However, this is not a common practice in this country and no other non-$CO_2$ emissions besides those described above are reported in the LULUCF sector.

### 6.5.3 Uncertainties and time-series consistency

The methods used in this inventory were consistently employed across the whole reporting period from the base year of 1990 to 2015, and this also applies to the Cropland land use category. The uncertainty estimation was guided by the Tier 1 methods outlined in the 2006 IPCC Guidelines (IPCC 2006) and described in Section 6.4.3. The uncertainty estimation utilized primarily the default uncertainty values as recommended by UNFCCC (2005) and IPCC (2003, 2006). The following uncertainty values were used: land use areas 5%, biomass accumulation rate 75%, average above-ground to below-ground biomass ratio *R* (root-shoot-ratio) 68%, average growing stock volume in forests 8%, stock change factor for land use 50%, stock change factor for management regime 5%, reference biomass carbon stock prior and after land-use conversion 75%, average amount of standing deadwood 27%, average amount of lying deadwood 20%, carbon fraction of dry woody matter 7%. The uncertainty applicable to *BCEF* was 22%, which was derived from the work of Lehtonen et al. (2007). The adopted uncertainty associated with the emission factors involved in estimation of direct and indirect $N_2O$ emissions was 250%.

For 2015, using the above uncertainty values, the total estimated uncertainty for category 4.B.1 Cropland remaining Cropland was 51%. The corresponding uncertainty for category 4.B.2 Land converted to Cropland was 38%. The overall uncertainty for category 4.B Cropland was estimated to be 30%, using absolute values of quantities estimated in the respective emission categories.

### 6.5.4 Source-specific QA/QC and verification

The emission estimates are based on the activity data taken from the official national sources and follow the recommendations of the 2006 IPCC Guidelines (IPCC 2006). The data sources are verifiable and updated annually. All the input information and calculations are archived by the expert team and the coordinator of NIR. Hence, all the background data and calculations are verifiable. Other QA/QC elements were adopted in the same manner as described in Section 6.4..4 above, following the application of the QA/QC plan applicable for the LULUCF sector.

### 6.5.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

Since the last submission, the emission estimates have not been recalculated. The last recalculation regarding emission estimates of Cropland was made in the previous submission, adopting new estimates of soil carbon stock change in Cropland remaining Cropland following the suggestions in the recent reviews. Also, new activity data for changes in dead organic matter, applicable for land-use conversions from Forest land to Cropland were adopted in the previous submission. With no new changes in the current submission regarding category 4.B Cropland, there are also no differences between the previous and the current estimates (Fig. 6-13).

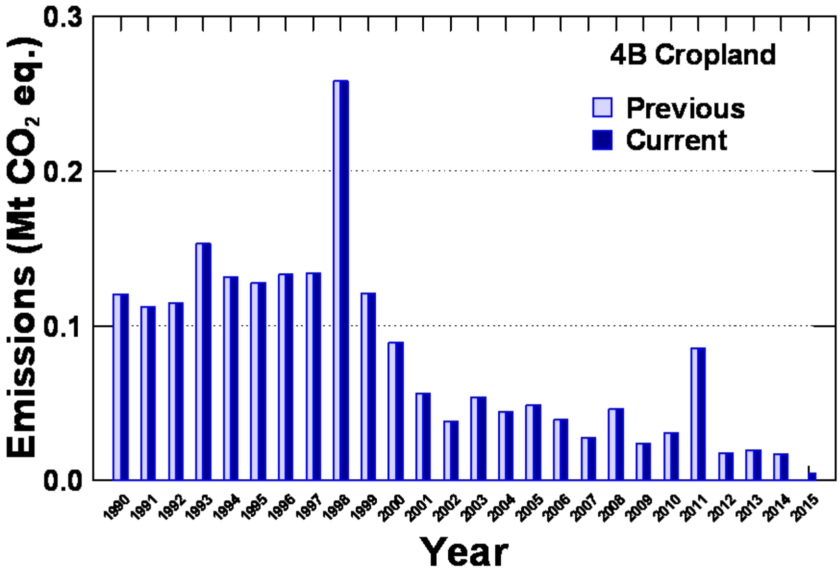



**Fig. 6-13 Current and previously reported assessment of emissions for category 4.B Cropland**

### 6.5.6 Source-specific planned improvements, including those in response to the review process

Similarly as for other categories, additional efforts will be exerted to further consolidate the current estimates for Cropland. Specific attention will be paid to estimates of soil carbon stock changes, involving additional activity data (soil erosion) and more relevant emission factors. Further improvements in uncertainty estimates are also planned for this category.

## 6.6 Grassland (CRF 4.C)

### 6.6.1 Source category description

Through its spatial share of nearly 13% in 2015, the category of Grassland ranks third among land-use categories in the Czech Republic. Its area has been increasing since 1990, specifically in the early 1990s (Fig. 6-4). Grassland as defined in this inventory corresponds to the grassland real estate category, one of the six such categories of agricultural land in the database of “Aggregate areas of cadastral land categories” (AACLC), collected and administered by COSMC. This land is mostly used as pastures for cattle and meadows for growing feed.

The importance of Grassland will probably increase in this country, both for its role in production and for preserving biodiversity in the landscape. According to the national agricultural programs, the fraction of Grassland should further increase to about 18% of the area of the country. The dominant portion should be converted from Cropland, the share of which is still considered excessive. After implementation of subsidies in the 1990s, the area of Grassland has increased by over 20% (in 2015) since 1990.

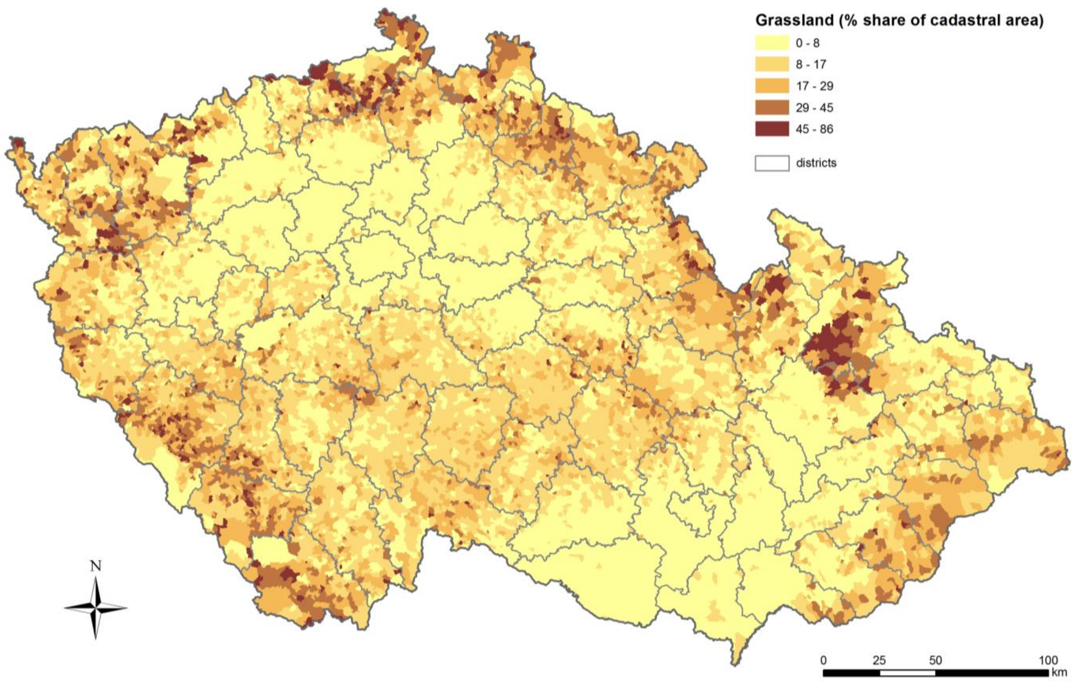



**Fig. 6-14 Grassland in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2015).**

### 6.6.2 Methodological issues

The emission inventory of 4.C Grassland concerns sub-categories 4.C.1 Grassland remaining Grassland and 4.C.2 Land converted to Grassland. The emission inventory of 4.C Grassland considers changes in living biomass, dead organic matter and soil.

#### *6.6.2.1 Grassland remaining Grassland*

The assumption of no change in carbon stock held in living biomass was employed for category 4.C.1 Grassland remaining *Grassland*, in accordance with the Tier 1 approach of IPCC (2006). This is a safe assumption for the conditions in this country and any application of higher tier approaches would not be justified with respect to data requirements and the expected insignificant carbon stock changes.

Similarly as for living biomass, the carbon stocks associated with dead organic matter (DOM), including deadwood and litter, are considered to be at equilibrium, i.e., it is assumed that there are no changes in carbon stocks.

The emissions from changes in soil carbon stock were estimated for category 4.C.1 Grassland remaining Grassland. These are given by changes in mineral and organic soils. Organic soils basically do not occur on Grassland; they occur as peatland in mountainous regions on Forest Land. Hence, emissions were estimated for mineral soils. The estimation procedure was revised for this category following the recommendations of the recent inventory reviews. It used the locally-specific average carbon content on Grassland estimated for each of the over 13 thousand cadastral units from the detailed soil carbon maps (Fig. 6-10). Next, the country-specific factor for grassland management ($F_{MG}$; 1.07) was derived from the actual spatial share of ecological agriculture and its specific management; the value is more conservative than that recommended by IPCC (2006) in its Table 6.2 due to uncertainty in the activity data (grazing area). The actual share (2015; 41.7%) of ecological agriculture on Grassland was derived from the detailed spatially explicit database of the Land Parcel Identification System (LPIS), while the historical share was derived from the official annual report on Agriculture (MAA 2016). The other factors included the relative stock change factor for land use ($F_{LU}$; 1.0) applicable for Grassland and input of organic matter ($F_I$; 1.0), respectively (Table 6.2; IPCC 2006). In accordance with the IPCC (2006) recommendation, the estimated quantity of soil carbon stock change is hereafter distributed over a 20-year period starting from the actual inventory year.

Until the 2014 NIR submission, the Grassland category also included emissions due to liming. However, similarly as for Cropland, since the 2015 NIR submission the emissions from liming have been reported under category 3.G Liming in the sector of 3 Agriculture instead.

Non-$CO_2$ gases on category 4.C.1 Grassland remaining Grassland are not relevant for the LULUCF sector in the Czech Republic.

#### *6.6.2.2 Land converted to Grassland*

For category 4.C.2 Land converted to Grassland, the estimation is related to carbon stock changes in living biomass, dead organic matter and soils.

For living biomass, the calculation used eq. 2.11 (IPCC 2006) with the assumed carbon content before the conversion of 4.B Cropland set at 5t C/ha (Table 364; IPCC 2006) and that of Forest Land calculated from the mean growing stock volumes as described in Section 6.5.2.2 above. The biomass carbon content immediately after the conversion was assumed to equal zero and carbon stock from one-year growth of grassland vegetation following the conversion was assumed to be 6.5 t C/ha (Table 6.4; IPCC 2006).

For dead organic matter, emissions are reported due to changes in deadwood and litter that are both relevant for category 4.C.2 Forest Land converted to Grassland. Apart from the actual areas concerned, the emission estimation is identical to that described in Section 6.5.2.2 (Land converted to Cropland) above.

The estimation of carbon stock change in soils for category 4.C.2 Land converted to Grassland in the Czech Republic is related to the changes in mineral soils. The soil carbon stock changes following the conversion from 4.A Forest Land and 4.B Cropland were quantified by the country-specific Tier 2/Tier 3 approach described in detail in Section 6.4.2.2 above.

### 6.6.3 Uncertainties and time series consistency

Similarly as for other land-use categories, the methods used in this inventory for Grassland were consistently employed across the whole reporting period from the base year of 1990 to 2015. The uncertainty estimation was guided by the Tier 1 methods outlined in 2006 IPCC Guidelines (IPCC 2006) and described in Section 6.4.3. The uncertainty estimation utilized primarily the default uncertainty values as recommended by IPCC (2003, 2006). The following uncertainty values were used: converted land use areas 5%, average growing stock volume in forests prior to conversion 8%, average biomass stock in cropland and grassland prior conversion 75%, biomass carbon stock after land-use conversion 75%, average amount of standing deadwood 27%, average amount of lying deadwood 20%, average above-ground to below-ground biomass ratio *R* (root-shoot-ratio) 68%, stock change factor for land use 50%, stock change factor for management regime 5%, and reference biomass carbon stock prior to and after land-use conversion 75%. The uncertainty applicable to *BCEF* was 22%, which was derived from the work of Lehtonen et al. (2007).

For 2015, the total estimated uncertainty for category 4.C.1 Grassland remaining Grassland reached 17%. The corresponding uncertainty for category 4.C.2 Land converted to Grassland reached 21%. The overall combined uncertainty for category 4. Grassland is 13%.

### 6.6.4 Source-specific QA/QC and verification

The emission estimates are based on the activity data taken from the official national sources and follow the recommendations of the adopted 2006 IPCC Guidelines (IPCC 2006). Data sources are verifiable and updated annually. All the input information and calculations are archived by the expert team and the coordinator of NIR. Hence, all the background data and calculations are verifiable. Other QA/QC elements were adopted in the same manner as described in Section 6.4.4 above, following the application of the QA/QC plan applicable for the LULUCF sector.

### 6.6.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

No recalculations were made for the category 4.C Grassland. The most recent recalculation for this category was prepared for the submission of the previous year. That was based on the revised activity data on land use, revised estimation of soil carbon stock changes and revised estimates for stock changes for deadwood, applicable for land-use conversions from Forest Land.

With no new changes in the current submission regarding category 4.C Grassland, there are also no differences between the previous and the current estimates (Fig. 6-15).

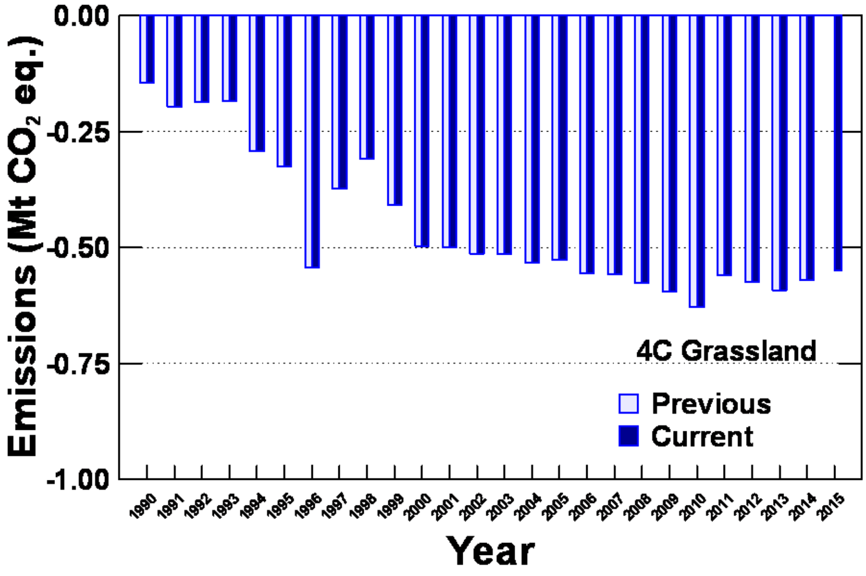



**Fig. 6-15 Current and previously reported assessment of emissions for category 4.C Grassland. The values are negative, hence representing net removals of green-house gases.**

### 6.6.6 Source-specific planned improvements, including those in response to the review process

Further efforts to consolidate the emission estimates are expected for the category of Grassland. Specific attention will be paid to estimates of soil carbon stock changes, involving additional activity data (soil erosion) and more relevant emission factors. A further improvement in uncertainty estimates are also planned in this category.

## 6.7 Wetlands (CRF 4.D)

### 6.7.1 Source category description

Category 4.D Wetlands as classified in this emission inventory includes riverbeds and water reservoirs such as lakes and ponds, wetlands and swamps. These areas correspond to the real estate category of water area of the “Aggregate areas of cadastral land categories” (AACLC), collected and administered by COSMC.

The area of 4.D Wetlands currently covers 2.1% of the total territory. It has been increasing steadily since 1990 (Fig. 6-4) with even a stronger trend earlier. It can be expected that this trend will continue and that the area of Wetlands will increase further. This is mainly due to programs aimed at increasing the water retention capacity of the landscape, specifically in relation to adaptation strategies proposed to deal with changing climate[7].

[7] *Based on the land-use history, the growth potential could be considered to be rather large. For example, as of 1990, the category included 50.7 th. ha of ponds, which represented only 28% of their extent during the peak period in the 16th Century (Marek 2002)*

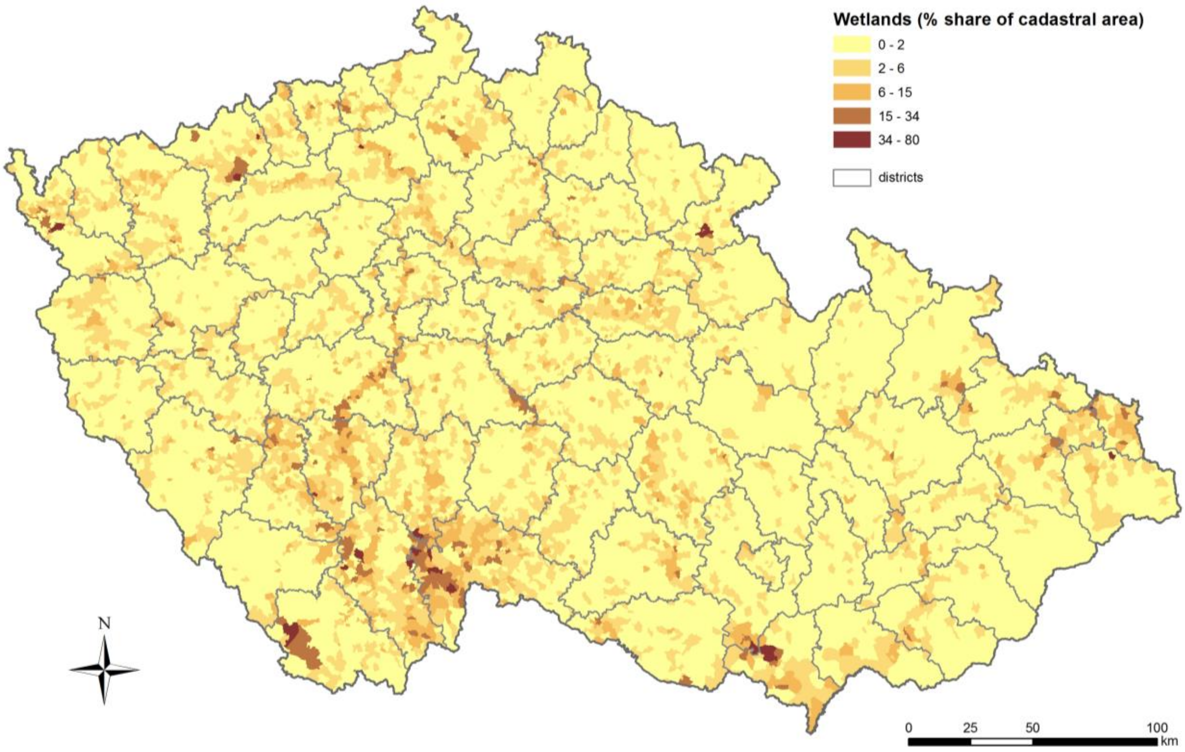



**Fig. 6-16 Wetlands – distribution calculated as a spatial share of the category within individual cadastral units (as of 2015).**

### 6.7.2 Methodological issues

The emission inventory of sub-category 4.D.1 Wetlands remaining Wetlands can address the areas in which the water table is artificially changed, which correspond to peat-land draining or lands affected by water bodies regulated through human activities (flooded land). Both categories are insignificant under the conditions in this country. Hence, the emissions for 4.D.1 Wetlands remaining Wetlands were not explicitly estimated and they can safely be considered negligible.

Sub-category 4.D.2 Land converted to Wetlands encompasses conversion from 4.A Forest Land, 4.B Cropland and 4.C Grassland. This corresponds to a very minor land-use change identified in this country, which corresponds to the category of land converted to flooded land. The emissions associated with this type of land-use change are derived from the carbon stock changes in living biomass and, for conversion from Forest land, also deadwood. The emissions were generally estimated using the Tier 1 approach and eq. 2.11 of the 2006 IPCC Guidance for LULUCF, which simply relates the biomass stock before and after the conversion. The corresponding default values were employed: the biomass stock after conversion equalled zero, while the mean biomass stock prior to the conversion in the 4.A Forest Land, 4.B Cropland and 4.C Grassland categories was estimated and/or assumed identically as described above in Sections 6.4.2.2 and 6.5.2.2. The latter section also describes the estimation of emissions related to the deadwood component, which was applied identically in this land use category.

### 6.7.3 Uncertainties and time series consistency

The methods used in this inventory for Wetlands were consistently employed across the whole reporting period from the base year of 1990 to 2014. Similarly as for the other land-use categories, the uncertainty estimation was guided by the Tier 1 methods outlined in 2006 IPCC Guidelines (IPCC 2006) and described in Section 6.4.3. It utilized primarily the default uncertainty values as recommended by IPCC (2003, 2006). The following uncertainty values were used: converted land use areas 5%, average growing stock volume in forests prior conversion 8%, average biomass stock in cropland and grassland prior conversion 75%, biomass carbon stock after land-use conversion 75%, average amount of standing deadwood 27%, average amount of lying deadwood 20%, carbon fraction of dry woody matter 7%, and average above-ground to below-ground biomass ratio *R* (root-shoot-ratio) 68%. The uncertainty applicable to *BCEF* was 22%, which was derived from the work of Lehtonen et al. (2007).

Since the emission estimate concerns only category 4.D.2 Land converted to Wetlands, the uncertainty is estimated for this category. For 2015, the estimated uncertainty for category 4.D.2 was 64%.

### 6.7.4 Source-specific QA/QC and verification

The emission estimates are based on the activity data taken from the official national sources and follow the recommendations of IPCC 2006 Guidelines (IPCC 2006). Data sources are verifiable and updated annually. All the input information and calculations are archived by the expert team and the coordinator of NIR. Hence, all the background data and calculations are verifiable. Other QA/QC elements were adopted in the same manner as described in Section 6.4.4 above, following the application of the QA/QC plan applicable for the LULUCF sector.

### 6.7.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

There has been no recalculation of emission estimates performed for this submission. Hence, the emission estimates do not differ between the current and the previous submission (Fig. 6-17).

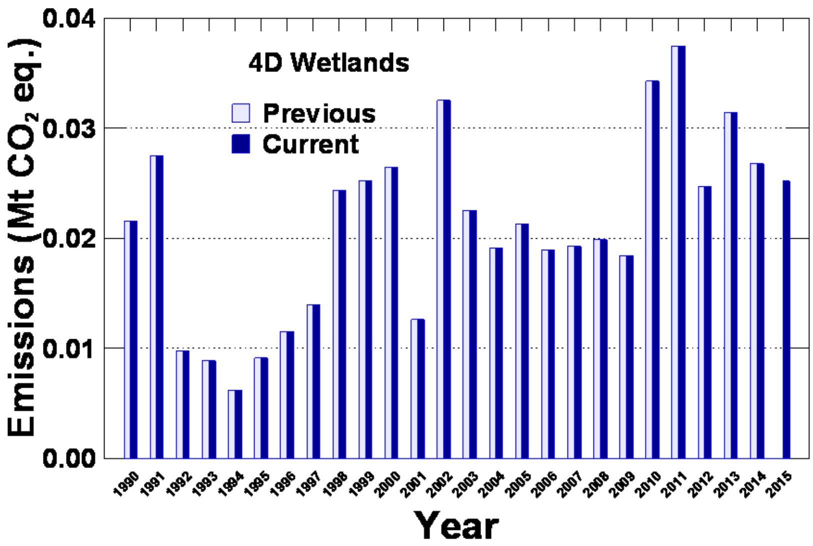



**Fig. 6-17 Current and previously reported assessment of emissions for category 4.D Wetlands**

### 6.7.6 Source-specific planned improvements, including those in response to the review process

For category of 4.D Wetlands, attention will be paid to further consolidation of the uncertainty assessment.

## 6.8 Settlements (CRF 4.E)

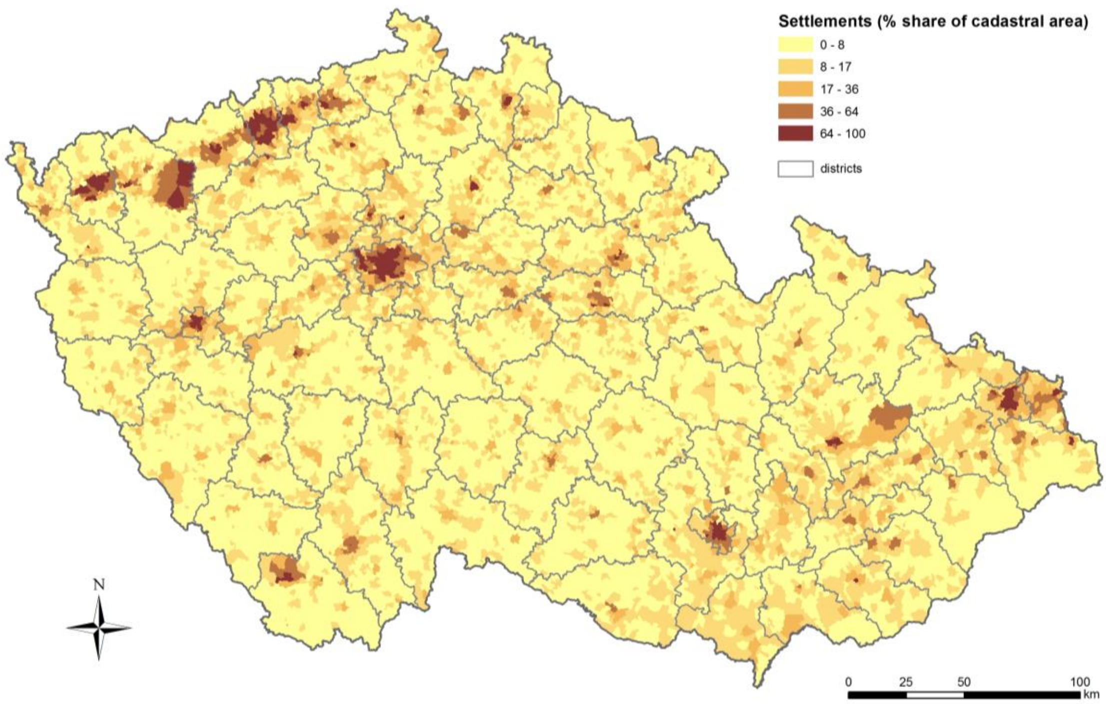



**Fig. 6-18 Settlements – distribution calculated as a spatial share of the category within individual cadastral units (as of 2015).**

### 6.8.1 Source category description

Category 4.E Settlements is defined by IPCC (2006) as all developed land, including transportation infrastructure and human settlements. The area definition under category 4.E Settlements was revised since the NIR 2013 submission to better match the IPCC (2006) default definition. The category currently includes two categories of the "Aggregate areas of cadastral land categories" (AACLC) database, collected and administered by COSMC, namely "Built-up areas and courtyards" and "Other lands". Of the latter AACLC category, all types of land-use were included with the exception of "Unproductive land", which corresponds to category 4.F Other Land. Hence, the Settlements category also includes all land used for infrastructure, as well as that of industrial zones and city parks. This category also includes all military areas (earlier considered as Grassland) in the country.

The category of Settlements as defined above currently represents about 9.3% of the area of the country. The area of this category has increased since 1990, especially during the most recent years (see Fig. 6-4).

### 6.8.2 Methodological issues

Following Tier 1 assumption of IPCC (2006), the carbon stocks in biomass, dead organic matter and soil are considered in balance for category 4.E.1 Settlements remaining Settlements. Hence, the emission inventory for this category concerns primarily 4.E.2 Land converted to Settlements.

Hence, emissions quantified in this inventory are related to category 4.E.2 Land converted to Settlements, specifically Forest land converted to Settlement. The emissions result from changes in biomass carbon stock and dead organic matter (DOM). The biomass carbon stock change was quantified based on eq. 2.11 (IPCC 2006). Changes in DOM were related to the deadwood carbon pool.

The corresponding default values were employed: the biomass stock after conversion equalled zero, while the mean biomass stock prior to the conversion was estimated and/or assumed identically as described above in Sections 6.4.2.2 and 6.5.2.2. The latter section describes estimation of the emissions related to the deadwood component, which was employed identically in this land use category. The carbon stock prior conversion was estimated as described in Section 6.4.2. All biomass is assumed to be lost during the conversion, according to the Tier 1 assumption of Guidelines for LULUCF. An additional contribution to emissions comes from the deadwood component, using the actual areas of the land use change concerned.

### 6.8.3 Uncertainties and time series consistency

The methods used in this inventory for 4.E Settlements were consistently employed across the whole reporting period from the base year of 1990 to 2015. The uncertainty estimation was guided by the Tier 1 methods outlined in 2006 IPCC Guidelines (IPCC 2006) and described in Section 6.4.3. It utilized primarily the default uncertainty values as recommended by IPCC (2006). As reported above, uncertainty estimation was revised for this submission, which applies also to this land use category. The following uncertainty values were used: carbon fraction in dry matter 7%, land use areas 3%, reference biomass carbon stock prior and after land-use conversion 75%, average growing stock volume in forests 8%, average amount of standing deadwood 27%, average amount of lying deadwood 20% and average above-ground to below-ground biomass ratio *R* (root-shoot-ratio) 68%. The uncertainty applicable to *BCEF* was 22%,derived from the work of Lehtonen et al. (2007).

The emission estimate concerns only category 4.E.2 Land converted to Settlements; therefore, the uncertainty is estimated only for this category. For 2015, the estimated uncertainty for category 4.E.2 was 102%.

### 6.8.4 Source-specific QA/QC and verification

The emission estimates are based on the activity data taken from the official national sources and follow the recommendations of the 2006 IPCC Guidelines (IPCC 2006). The data sources are verifiable and updated annually. All the input information and calculations are archived by the expert team and the NIR coordinator. Hence, all the background data and calculations are verifiable. Other QA/QC elements were adopted in the same manner as described in Section 6.5.4 above, following the application of the QA/QC plan applicable for the LULUCF sector.

### 6.8.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

There has been no recalculation made for the category 4.E Settlements. The last recalculation was made in the previous submission, which was due to the revised activity data on land use and data on deadwood related to land use conversion from Forest Land.

With no new changes in the current submission regarding category 4.E Settlements, there are also no differences between the previous and the current estimates (Fig. 6-19).

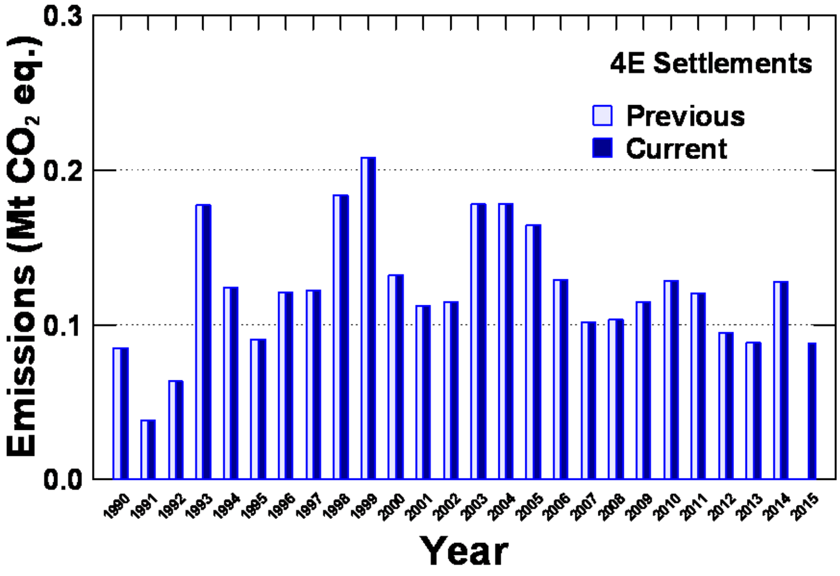



**Fig. 6-19 Current and previously reported assessment of emissions for the category 4.E Settlements**

Further efforts to consolidate the emission estimates are expected for the category of Settlements. Specifically, the inventory team considers revising the definition of the Other land use category, which might be fully included under the Settlement category. This would further enhance the transparency and accuracy of the inventory involving these two land-use categories. Further improvements are also planned for uncertainty assessment.

## 6.9 Other Land (CRF 4.F)

### 6.9.1 Source category description

Since the NIR 2008 submission, category 4.F Other Land has represented unmanaged (unmanageable) land areas, matching the IPCC (2006) default definition. These areas were assessed from the database of "Aggregate areas of cadastral land categories" (AACLC), collected and administered by COSMC. It is part of the AACLC "Other lands" category with the specific "Unproductive land" land use category assessed from the 2006 land census of COSMC. Since the 2016 inventory submission, the newly acquired data on land use from COSMC permitted a more detailed assessment of changes in areas of "Unproductive land" since 2004. Hence, this category was considered to be constant until 2004, involving land-use conversions only since that year. The Other Land category represents only 1.3% of the territory of the country.

### 6.9.2 Methodological issues

Changes in carbon stocks and non-$CO_2$ emissions are not considered for 4.F.1 Other Land remaining Other Land (IPCC 2006). However, emissions are estimated for 4.F.2 Land converted to Other Land, which is included in this inventory.

The emission estimates specifically concern Forest land converted to Cropland. The emissions result from changes in biomass carbon stock and dead organic matter (DOM). Biomass carbon stock change was quantified based on eq. 2.11 (IPCC 2006). Changes in DOM were related to the deadwood carbon pool.

The corresponding default values were employed: the biomass stock after conversion equalled zero, while the mean biomass stock prior to the conversion was estimated and/or assumed identically to that described above in Sections 6.4.2.2 and 6.5.2.2. The latter section describes the estimation of emissions related to the deadwood component, which was applied identically in this land use category. The carbon stock prior to conversion was estimated as described in Section 6.4.2. All biomass is assumed to be lost during the conversion, according to the Tier 1 assumption of the Guidelines for LULUCF. An additional contribution to emissions comes from the deadwood component, using the actual areas of the land use change concerned.

### 6.9.3 Uncertainties and time series consistency

The uncertainty estimates follow the procedure described in Chapter 6.8.3 above.

The emission estimate concerns only category 4.F.2 Land converted to Other Land; therefore, the uncertainty is estimated only for this category. For 2015, the estimated uncertainty for the category 4.F.2 was 101%.

### 6.9.4 Source-specific QA/QC and verification

The QA/QC elements were adopted in the same manner as described in Section 6.5.4 above, following the application of the QA/QC plan applicable for LULUCF sector 7, limited to those elements relevant for this specific land-use category.

### 6.9.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

No recalculations were made for the category 4.F Other Land in this submission. Hence, there are also no differences between the previous and the current estimates (Fig. 6-20).

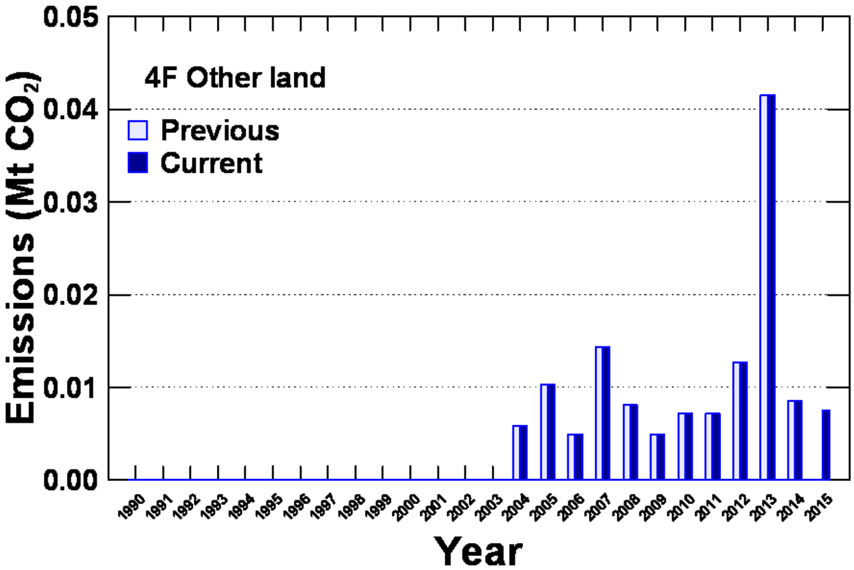



**Fig. 6-20 Current and previously reported assessment of emissions for the category 4.F Other Land**

### 6.9.6 Source-specific planned improvements, including those in response to the review process

The current revision based on newly acquired activity data from COSMC on land use areas is considered temporary. The inventory team considers unifying areas of “Other land” with the category of “Settlements, which would apparently not affect the joint emission estimates, but would further improve the consistency of the reporting.

## 6.10 Harvested Wood Products (CRF 4.G)

### 6.10.1 Source category description

The contribution of Harvested wood products (HWP), mandatorily included by Decision 2/CMP7 in emission inventories under UNFCCC and KP since the 2015 inventory submission, is also estimated for the Czech emission inventory. Changes in the pool of HWP may represent $CO_2$ emissions or removals, which are included within the LULUCF sector as a specific category (CRF 4.G) in addition to the six IPCC land use categories. The HWP pool considers primary woody products generated from wood produced in the country. Hence, these emissions originate in land use category 4.A Forest land. The eventual fraction of wood from deforested land, i.e., Forest land converted to any other land use categories, is also considered, although it is treated differently (see Section 6.10.2 below).

### 6.10.2 Methodological issues

The methodology for estimating the contribution of HWP to emissions and removals was based on IPCC (2006) and IPCC (2014b). The latter material was followed to adopt the agreed principles on accounting for HWP, which includes only domestically produced and consumed HWP. The estimation follows the Tier 2 method of first order decay, which is based on Eq. 2.8.5 (IPCC 2014). This equation considers carbon stock in the particular HWP categories, which is reduced by an exponential decay function using the specific decay constants. The default half-life constants were used for the major HWP categories: 35 years for sawnwood, 25 years for wood-based panels and 2 years for paper and paperboard. The second part of Eq. 2.8.5 (IPCC 2014) adds the material inflow in the particular year and HWP categories.

The activity data (production and trade of sawnwood, wood-based panels and paper and paperboard) were derived and/or directly used from the FAO database on wood production and trade (http://faostat3.fao.org/download/F/FO/E). The data have been available since 1961 as an aggregate for the former Czechoslovakia. Since 1993, when Czechoslovakia was split into the Czech Republic and Slovakia, data have been available specifically for the two countries. To estimate the corresponding share of HWP in the 1961 to 1992 period, the data applicable for Czechoslovakia were multiplied by a country-specific share that was derived for each HWP category from the data reported for each follow-up country in the 1993 to 1997 period (Cienciala and Palán 2014). The conversion factors are used for disaggregated HWP categories as in Table 2.8.1 (IPCC, 2014).

The fraction corresponding to source material originating from deforested land was estimated based on deforested areas as reported under Act. 3.3 Deforestation of the Kyoto protocol. Although quantitatively insignificant (0.016 and 0.017% in 1990 and 2015, respectively), the HWP contribution of this fraction was estimated using instantaneous oxidation, which is a formal requirement of the IPCC guidelines (IPCC 2014).

**Tab. 6-7 The country-specific shares applicable for the HWP quantities as given for the former Czechoslovakia in the FAO database, derived from the period 1993-1997**

| | Production | | Import | | Export | |
|---|---|---|---|---|---|---|
| Country / HWP category | Czech Republic | Slovakia | Czech Republic | Slovakia | Czech Republic | Slovakia |
| **Sawn wood** | 0.834 | 0.166 | 0.868 | 0.132 | 0.723 | 0.277 |
| **Wood-based panels** | 0.716 | 0.284 | 0.719 | 0.281 | 0.851 | 0.149 |
| **Paper and paperboard** | 0.655 | 0.345 | 0.772 | 0.228 | 0.598 | 0.402 |

The resulting estimates of the HWP contribution including domestically produced and consumed wood for the reporting period 1990 to 2015 are shown in Fig. 6-21 below. The emissions fluctuate during the reporting period, where the mean contribution reached -1.01 Mt $CO_2$/year.

### 6.10.3 Uncertainties and time series consistency

The uncertainty estimates use the following inputs: roundwood harvest 20%, sawnwood, wood panel and paper products 15%, wood density factors 25%, carbon content in wood products 10%, half-life factors 50%. Using Eq. 4 for combining uncertainties, this gives an approximate uncertainty estimation of 62% for the HWP contribution, which is general for all the HWP categories.

Time series consistency is ensured as the inventory approaches and/or assumptions are applied identically across the whole reporting period from the base year of 1990 to 2015.

### 6.10.4 Source-specific QA/QC and verification

The QA/QC elements were adopted in the same manner as described in Section 6.5.4 above, following the application of the QA/QC plan applicable for LULUCF sector 7, limited to those elements relevant for this specific land-use category.

### 6.10.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

No recalculations were made for the category 4.G HWP. Hence, the estimates do not differ between the current and the previous submission (Fig. 6-21).

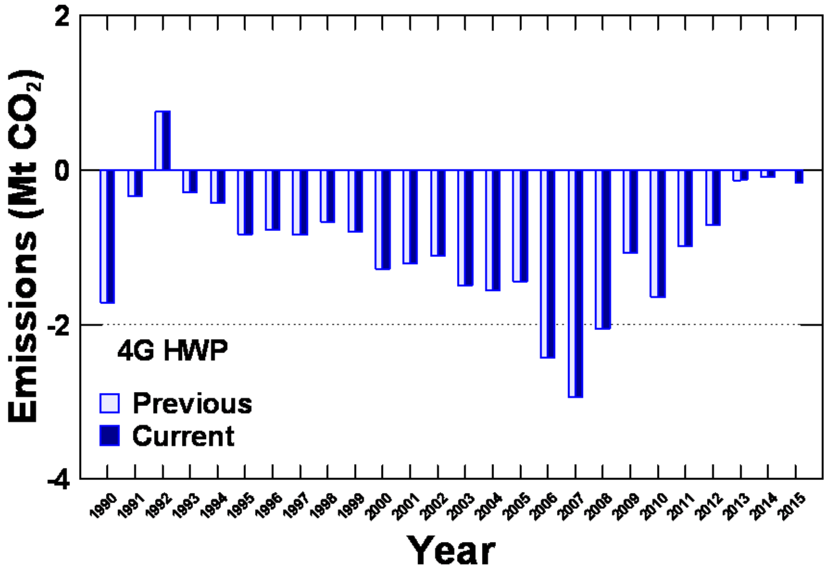



**Fig. 6-21 The reported assessment of HWP contribution to emissions in the LULUCF sector for the category 4.G HWP**

### 6.10.6 Source-specific planned improvements, including those in response to the review process

No specific improvements are planned for this category for the next submission.

## Acknowledgement

The authors would like to thank Jan Hána, Patrik Pacourek and Miroslav Zeman, Forest Management Institute in Brandýs n. Labem, for compiling the required increment data concerning forests in previous years. Some of the analyses required for this inventory were performed within the CzechCarbo project (VaV/640/18/03), while some of the critical data were obtained from the CzechTerra project funded by the Czech Ministry of the Environment (SP/2d1/93/07) and the Czech Science Foundation (14-12262S). We greatly appreciate the assistance of the staff at the Czech Office for Surveying, Mapping and Cadastre, specifically Petr Kokeš, Petr Souček, David Legner, Zuzana Loulová, Bohumil Janeček and Helena Šandová, related to data on land use areas and advice in related issues. The authors would also like to thank Jan Apltauer, former IFER employee, for his contribution to previous NIRs. Thanks belong to IFER employees Ondřej Černý, who significantly assisted with land use activity data compilation and to Šárka Holá for her technical assistance with the current NIR submission.

# 7 Waste (CRF sector 5)

## 7.1 Overview of sector

The waste sector comprises emissions from human activities associated with waste management in general. Most human and economic activities result in the production of waste; therefore, performance of this sector is closely connected with the economic state of the country. Most processes in the sector originate in biological or biochemical processes and therefore it takes longer for changes in management practices to be reflected in emissions. An overview of the whole sector is shown on Fig. 7-1.

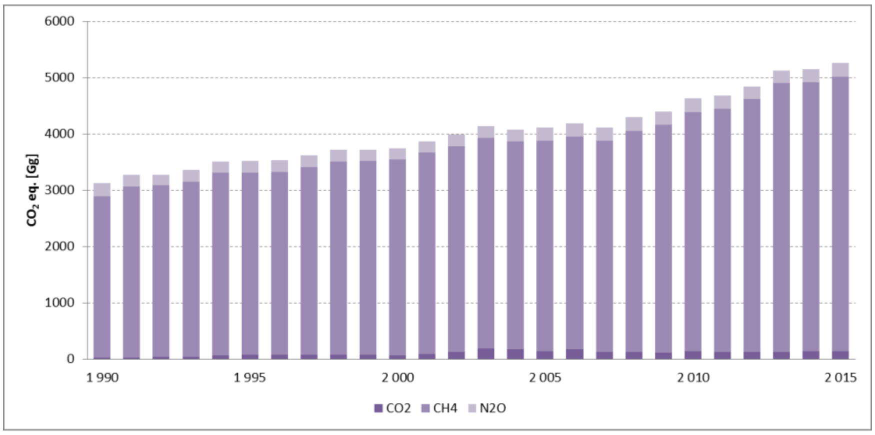



**Fig. 7-1 Development of Waste sector by gasses, 1990-2015**

The sector encompasses several categories. The main source category of this sector is 5.A Solid waste disposal. In 2015, this category emitted approximately 135 Gg of $CH_4$, equalling 3385 Gg of $CO_2$ eq. The second largest source category is 5.D Wastewater Treatment and Discharge, followed by two additional categories, quantifying emissions from waste incineration and from biological treatment of waste. An additional category quantifying emissions from waste management is the incineration of waste for energy purposes which is, however, reported in category 1.A.1.a Other fuels.

The waste sector as a final output sector for all economic activities is very dependent on the state of the economy, the purchasing power of the population and waste management policies. In recent years, there has been a decline of landfilling (although the effect on emissions is delayed due to the time lag in decomposition processes) and an increase in other types of waste management, especially composting. As the economy of the Czech Republic is also growing, as is industrial production in the country, emissions from industrial waste water are also increasing. The new technology of anaerobic digestion is being widely adopted due to subsidies on biogas production and is another growing source category in this sector. Significant categories in this sector are shown in Tab. 7-1. The Waste sector is quantified and managed by the Charles University Environmental Center (CUEC).

**Tab. 7-1 Overview of significant source categories in this sector (2015)**

| Category | Gas | KC A1 | KC A2 | KC A1 incl. LULUCF | KC A1 excl. LULUCF | KC A2 incl. LULUCF | KC A2 excl. LULUCF | % of total GHG incl. LULUCF | % of total GHG excl. LULUCF |
|---|---|---|---|---|---|---|---|---|---|
| **5.A Solid Waste Disposal on Land** | $CH_4$ | LA, TA | LA, TA | yes | yes | yes | yes | 2.65 | 2.79 |
| **5.B Biological treatment of solid waste** | $CH_4$ | LA | TA | yes | no | yes | yes | 0.50 | 0.52 |
| **5.D Wastewater treatment and discharge** | $CH_4$ | LA | | yes | yes | | | 0.67 | 0.71 |

*KC: key category*

# 7.2 Solid Waste Disposal (CRF 5.A)

## 7.2.1 Managed Waste Disposal Sites (CRF 5.A.1)

### *7.2.1.1 Source category description*

The treatment and disposal of municipal, industrial and other solid waste could produce significant amounts of methane ($CH_4$). The decomposition of organic material, derived from biomass sources (e.g., crops, food, textile, wood), is the primary source of $CO_2$, released from waste. These $CO_2$ emissions are not included in the national totals, because the carbon is of biogenic origin and net emissions are accounted for under land use change and forestry.

This source category might also produce emissions of other micropollutants, such as non-methane volatile organic compounds (NMVOCs), as well as smaller amounts of nitrous oxide ($N_2O$), nitrogen oxides ($NO_X$) and carbon monoxide (CO). In line with the IPCC 2006 methodology, only $CH_4$ is addressed in this chapter. An overview of this category is shown in Fig. 7-2.

### *7.2.1.2 Methodological issues*

***Waste disposal to SWDS***

The key activity data for methane quantification from 5.A.1 is the amount of waste, disposed in landfills. The annual disposal is given in Tab. 7-2. The data for annual disposal are obtained from mixed sources, since the application of the FOD model requires data from 1950 to the present day. These data are not available in the country and therefore assumptions about the past had to be used. These assumptions are described in the working paper (Havránek, 2007), but the method can be simply described as intrapolation and extrapolation between points in time; correlation of waste production with the social product (predecessor of the current GDP) as a test method was performed. The higher of the two estimates was used in the quantification.

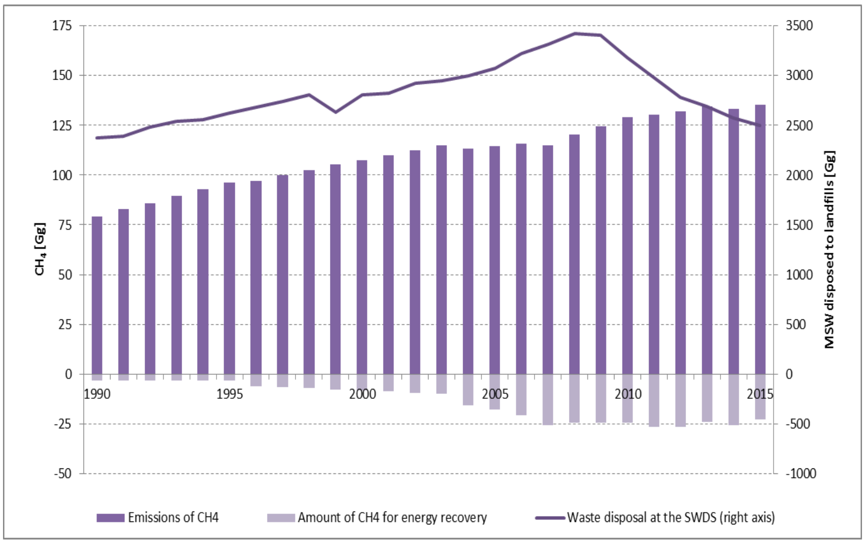



**Fig. 7-2 Development of emissions from SWDS and total amount of waste disposed to SWDS. 1990-2015**

The data, used for present years, are based on the public information system of waste management in the Czech Republic (VISOH) and its non public version (ISOH), both managed by CENIA – the Czech Environmental Information Agency. The system contains bottom up data from more than 60 000 respondents, where reporting obligation to this system is based on the national legislation. Since 2011, the waste deposited in landfills has decreased slightly for for the first time in modern history. A decrease in landfilled waste is a long term target of the Czech national environmental policy.

National legislation on landfill management is based on the European legislation. In general, it sets conditions on how landfilling can be done, specifies the relevant actors and state bodies responsible for the administration and control, duties and obligation of all the stakeholders. The main regulations in this area are Act 185/2001 Coll. “Act on waste” and the main directive relevant for the landfilling Decree 294/2005 Coll. “Decree on the conditions for depositing waste in landfills and its use on the surface of the ground”. Management of waste is complicated and the full regulative framework can be found on the website of the Ministry of Environment.

**Tab. 7-2 MSW disposal in SWDS in the Czech Republic [Gg], 1990-2015**

| Year | MSW in SWDS | Year | MSW in SWDS | Year | MSW in SWDS | Year | MSW in SWDS |
|---|---|---|---|---|---|---|---|
| **1990** | 2371 | **1997** | 2739 | **2004** | 3000 | **2011** | 2981 |
| **1991** | 2388 | **1998** | 2804 | **2005** | 3070 | **2012** | 2786 |
| **1992** | 2484 | **1999** | 2632 | **2006** | 3221 | **2013** | 2692 |
| **1993** | 2543 | **2000** | 2803 | **2007** | 3314 | **2014** | 2570 |
| **1994** | 2561 | **2001** | 2826 | **2008** | 3424 | **2015** | 2499 |
| **1995** | 2621 | **2002** | 2920 | **2009** | 3406 | | |
| **1996** | 2683 | **2003** | 2952 | **2010** | 3185 | | |

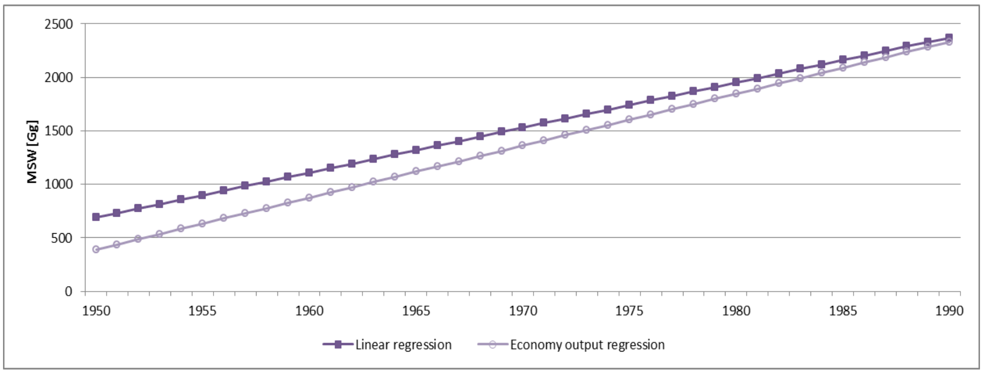



**Fig. 7-3 MSW disposal in SWDS in the Czech Republic, 1950-1990**

The method, used for estimation of methane emissions from this source category, is the Tier 1 FOD approach (first-order decay model). The first-order decay (FOD) model assumes gradual decomposition of waste, disposed in landfills. The GHG emissions were calculated from the IPCC Spreadsheet for Estimating Methane Emissions from Solid Waste Disposal Sites, which is part of the 2006 Guidelines (IPCC, 2006) referred further to as the IPCC model (IPCC, 2006).

***Waste composition, sludge, k-rate and Degradable Organic Carbon (DOC)***

Waste composition is crucial for emission estimations. Several attempts have been made to obtain country-specific data about waste composition (Tab. 7-3). The data for the 1990 – 1995 period are based on the IPCC default values for Eastern Europe, while the data for the 1996 – 2000 and 2002 – 2004 periods are based on intrapolation between data points. The data for 2001 and the 2005-2009 period are based on waste surveys performed in R&D projects dealing with waste composition. There are no data for the current years and therefore the latest available data was used. An endeavour was made to encourage continuation of waste composition monitoring.

As can be seen, the table does not include all possible waste streams which might be deposited in a landfill. The missing item is sludge. This is because the projects from which the expert derived the waste composition did not include any sludge as part of the waste mixture. However, the inventory team is aware that the research covered only a limited number of landfills. Furthermore, since the practice of sludge deposition is not widespread (if it is used, this is mostly with dirt for covering landfills), the researchers did not encounter its deposition. Therefore sludge is not calculated in the waste mixture, although in reality some small amounts of sludge might end up in landfills. However, this did not mean that the emissions were underestimated because the mass deposited in landfills already included sludge (the data are bottom-up total mass data for landfills) and the average DOC obtained using the current waste mixture is larger than the default DOC for sludge.

The table also contains the methane generation rate (k-rate) employed. This rate is closely related to the compostion of a particular substance and the available moisture. The IPCC default k-rates for a wet temperate climate were used (the average temperature of the Czech Republic is about 7 °C and the annual precipitation is higher than the potential evapotranspiration). The average DOC for a particular waste stream is also based on the IPCC default values for individual categories of waste. The average DOC for each particular year is given in the last column of the table.

**Tab. 7-3 MSW composition for the Czech Republic used in the quantification (fractions of total, 1990-2015)**

| | Paper | Food | Textil | Wood and straw | DOC (calculated) |
|---|---|---|---|---|---|
| **k-*rate*** | 0.06 | 0.185 | 0.06 | 0.03 | |
| **DOC (default)** | 0.4 | 0.15 | 0.24 | 0.43 | |
| | | **Share of particular waste streams** | | | |
| **1990-1995** | 0.22 | 0.30 | 0.05 | 0.08 | 0.176 |
| **1996** | 0.22 | 0.29 | 0.05 | 0.08 | 0.179 |
| **1997** | 0.23 | 0.28 | 0.06 | 0.08 | 0.181 |
| **1998** | 0.24 | 0.27 | 0.06 | 0.08 | 0.184 |
| **1999** | 0.25 | 0.26 | 0.07 | 0.08 | 0.187 |
| **2000** | 0.26 | 0.25 | 0.07 | 0.08 | 0.191 |
| **2001** | 0.27 | 0.23 | 0.08 | 0.08 | 0.195 |
| **2002** | 0.24 | 0.25 | 0.08 | 0.09 | 0.194 |
| **2003** | 0.22 | 0.27 | 0.07 | 0.11 | 0.193 |
| **2004** | 0.19 | 0.30 | 0.07 | 0.13 | 0.192 |
| **2005** | 0.16 | 0.32 | 0.07 | 0.14 | 0.191 |
| **2006** | 0.16 | 0.32 | 0.07 | 0.14 | 0.187 |
| **2007** | 0.17 | 0.32 | 0.08 | 0.13 | 0.193 |
| **2008** | 0.16 | 0.32 | 0.07 | 0.14 | 0.188 |
| **2009-2015*** | 0.16 | 0.35 | 0.08 | 0.13 | 0.194 |

**Since 2009 last available data is used*

### *Methane correction factor*

The methane correction factor (MCF) is a value, expressing the overall management of landfills in the country. Better-managed and deeper landfills have higher MCF value. Shallow SWDS ensure that far more oxygen penetrates into the body of the landfill to aerobically decompose DOC. The suggested IPCC values are given in Tab. 7-4.

Tab. 7-5 gives the values, used in this inventory. The choice of values is based on data for recent years (1992+) and expert judgement in the early years of the timeline.

**Tab. 7-4 Methane correction values (IPCC, 2006)**

| | MCF |
|---|---|
| **Unmanaged, shallow** | 0.4 |
| **Unmanaged, deep** | 0.8 |
| **Managed, anaerobic** | 1.0 |
| **Managed, semi-aerobic** | 0.5 |
| **Uncategorised** | 0.6 |

**Tab. 7-5 MCF values employed, 1950-2015**

| | MCF |
|---|---|
| **1950 – 1959** | 0.6 |
| **1960 – 1969** | 0.6 |
| **1970 – 1979** | 0.8 |
| **1980 – 1989** | 0.9 |
| **1990 – 2015** | 1.0 |

***Oxidation factor***

As methane moves from the anaerobic zone to the aerobic and semi-aerobic zones close to the landfill surface, part of it becomes oxidized to $CO_2$. There is no conclusive agreement in the scientific community on the intensity of the oxidation of methane. The oxidation is indeed site-specific and depends on the effects of local conditions (including fissures and cracks, compacting, landfill cover etc.). No representative measurements or estimations of the oxidation factor are available for the Czech Republic. Some studies are quoted in Straka, 2001, which mentions a non-zero oxidation factor, but these figures seem to be site-specific and have very high values compared to the default value, perhaps due to specific practices at the site. Therefore, they cannot be used as representative for the whole country. However, the methodology (IPCC, 2006) suggests that an oxidation factor greater than 0.1 should not be used if no site measurements are available (a larger value adds uncertainty). The author used the recommended oxidation factor of 0.1 in the report.

***Delay time***

When waste is disposed in SWDS, decomposition (and methanogenesis) do not start immediately. The assumption, used in the IPCC model, is that the reaction starts on the first of January in the year after deposition, which is equivalent to an average delay time of six months before decay to methane commences. It is good practice to assume an average delay of two to six months. If a value greater than six months is chosen, evidence to support this must be provided. The Czech Republic has no representative country-specific value for the delay time, so the author used a default value of 6 months.

***Fraction of methane***

This parameter indicates the share (mass) of methane in the total amount of Landfill Gas (LFG). A value 0.61 was used in previous calculations of methane emissions from SWDS (NIR, 2004). This figure was based on measurement of a limited number of sites (Straka, 2001). This value is higher than the range of 0.5-0.6 suggested by IPCC. Revision of these values was based on collected data from MIT (MIT, 2005+). MIT receives annual reports from landfills capturing LFG; SWDS report the net calorific value of their captured LFG. This value was compared with the gross calorific value of pure methane and yielded a value of 0.55, which fits well within the IPCC range and is therefore used in the quantification.

***Recovered methane***

On SWDS in the country, methane is sometimes collected by an LFG collection systems and incinerated for energy purposes. Based on 2006 Guidelines (IPCC, 2006), this methane that is being converted to $CO_2$ and has biogenic origin is not considered to constitute a GHG emission and hence recovered methane (R) is substracted from the total emissions. There is no default value for R, so country estimates were used, based on various sources. As mentioned in the previous paragraph, the Ministry of Industry and Trade conducts an annual survey of all SWDS. All the energy data about LFG used for energy purposes were collected. An attempt is made to update old estimates as much as possible. Since starting the survey in 2005, it has been possible to provide estimates for the time series between 2003 and 2014. The estimates in Straka, 2001 were used for the 1990-1996 period. Linear intrapolation of recovered methane was used for the period between 1996 and 2003. In 2014 more than 60 facilities were recovering LFG in the country.

Total emissions of methane are based on the equation from the IPCC $CH_4$ model. The detailed time series from 1950, including the breakdown into individual waste components, are given in the paper by Havranek 2007. The following table 7-6 lists methane emissions from this category.

**Tab. 7-6 Emissions of methane from SWDS [Gg], Czech Republic, 1990-2015**

| | $CH_4$ generation | $CH_4$ recovery | $CH_4$ oxidized | $CH_4$ emission |
|---|---|---|---|---|
| **1990** | 91 | 3.3 | 9.1 | 79.2 |
| **1991** | 95 | 3.3 | 9.5 | 82.8 |
| **1992** | 99 | 3.5 | 9.9 | 86.0 |
| **1993** | 103 | 3.5 | 10.3 | 89.5 |
| **1994** | 107 | 3.5 | 10.7 | 93.0 |
| **1995** | 110 | 3.5 | 11.0 | 96.2 |
| **1996** | 114 | 6.0 | 11.4 | 97.1 |
| **1997** | 118 | 6.6 | 11.8 | 99.9 |
| **1998** | 121 | 7.1 | 12.1 | 102.6 |
| **1999** | 125 | 7.7 | 12.5 | 105.5 |
| **2000** | 127 | 8.2 | 12.7 | 107.3 |
| **2001** | 131 | 8.8 | 13.1 | 109.8 |
| **2002** | 134 | 9.3 | 13.4 | 112.3 |
| **2003** | 138 | 9.9 | 13.8 | 115.1 |
| **2004** | 142 | 15.6 | 14.2 | 113.4 |
| **2005** | 145 | 18.0 | 14.5 | 114.7 |
| **2006** | 149 | 20.6 | 14.9 | 116.0 |
| **2007** | 154 | 25.9 | 15.4 | 114.8 |
| **2008** | 158 | 24.6 | 15.8 | 120.4 |
| **2009** | 163 | 24.5 | 16.3 | 124.5 |
| **2010** | 168 | 24.7 | 16.8 | 129.0 |
| **2011** | 171 | 26.6 | 14.4 | 130.2 |
| **2012** | 173 | 26.5 | 14.6 | 131.9 |
| **2013** | 174 | 24.2 | 15.0 | 134.6 |
| **2014** | 174 | 25.7 | 14.8 | 133.2 |
| **2015** | 173 | 22.7 | 14.9 | 135.4 |

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

Overall quantification of the uncertainity for this category is still incomplete. This is considered a high priority and will be conducted in the following years as soon as budget constraints permit. This category entails the difficulty, that the uncertainty does permeate through the whole waste management period of 1950-2015 and therefore it cannot be correctly quantified by simple analysis. Combined uncertainty was estimated by the expert judgement based on default factors and activity data uncertainties (tab. 1-7).

**Tab. 7-7 Uncertainty estimates for 5.A category**

| Gas | Category | AD uncertainity [%] | EF uncetrainity [%] | Origin of the parameters |
|---|---|---|---|---|
| $CH_4$ | 5.A.1 SWDS | 30 | 40 | Combined uncertainty of quantification parameters Expert judgement M. Havránek, verification P. Slavíková (CENIA) |

### *7.2.1.4 Source-specific QA/QC and verification*

Quality assurance entails structured checklists of activities, which are dated and signed by the sector reporter and verified by external control of the activity data. The activity data used for this sector are approved by the data producer, who verifies them before they are used for further calculation.

Since the waste sector is fairly small, external QC is not provided; instead QC is performed by a NIS coordinator and the results are communicated to the sectoral expert.

The activity data from the national agencies and ministries are the subjects of internal QA/QC mechanisms and the NIS team has only limited insights into them. Processes are in place at all state agencies and ministries to ensure that they produce accurate data.

#### 7.2.1.5 Source-specific recalculations, including changes made in response to the review process

The data for 2014 were recalculated because of changes in the activity data last year. This is a fairly regular recalculation, as some data needed for this source category are available only in a preliminary version before the inventory is submitted.  The change in the 2014 activity data is 9 Gg of MSW deposited on to landfills and the change is not distinguishible in the inventory numbers.

#### 7.2.1.6 Source-specific planned improvements, including those in response to the review process

Next year we plan to review the F factor (share of methane in LFG, see above) because there is a growing pool of data on which we can base our estimate. We plan to review waste composition as the new Waste management plan of the Czech Republic contains some estimates about particular waste streams in MSW which might be used as a basis for actualisation of the waste composition in this country.

### 7.2.2 Unmanaged Waste Disposal Sites (CRF 5.A.2)

This category is not relevant for the Czech Republic.

### 7.2.3 Uncategorized Waste Disposal Sites (CRF 5.A.3)

This category is not relevant for the Czech Republic.

## 7.3 Biological Treatment of Solid Waste (CRF 5.B)

The biological treatment of waste includes two categories. Aerobic processes for treating organic waste include 5.B.1 Composting and 5.B.2 Anaerobic digestion. Composting is mostly an aerobic process and thus the production of methane is insignificant. Anaerobic digestion has greatly increased in recent years and there is active state support for this type of waste treatment (i.e. energy production from biogas). However, it is a controlled process mainly directed towards capturing the produced biogas and thus emissions from this source category are also relatively small. An overall survey of this source category is shown in Fig. 7-4.


**Fig. 7-4 Development of emissions from biological treatment of solid waste, 2003-2015**

### 7.3.1 Composting (CRF 5.B.1)

#### *7.3.1.1 Source category description*

This category quantifies emissions from industrial composting facilities. No attempt was made to estimate emissions from household compost heaps, as this would introduce high levels of uncertainty in the results (no data is available) and these emissions are considered to be negligible, as household compost heaps are in general very small, ensuring that the processes do not generate any methane emissions.

#### *7.3.1.2 Methodological issues*

This source category quantifies emissions from composting, based on statistical data about waste management. The composting data are obtained from VISOH-ISOH systems managed by CENIA (for more details about ISOH, see source category 5.A.1).

In accordance line with IPCC 2006, composted waste was split into two groups – municipal solid waste (MSW) and other waste. Composted MSW is a self-explanatory category. Composted other waste is a collective category of all waste streams that are denoted in ISOH as composted, but the exact nature of the waste stream is unknown. However, as they are composted, we can assume that certain composition standards are met; therefore, both categories use identical EF. Fresh (wet) weight data and default EF from IPCC 2006 were used for both streams. No data is available for either category before 2005, so further research has been launched to determine the reasons for this. Considering that industrial composting is a relatively new field in this country, the data for earlier years could be non-existent because this activity did not occur. The amount of composted MSW is gradually increasing and this is a long term aim of Czech environmental policy. Overall development of the category is shown in Tab. 7-8.

**Tab. 7-8 Emissions of GHG from composting [Gg], Czech Republic, 2005-2015**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **MSW [tons]** | 48 760 | 61 475 | 79 801 | 114 437 | 134 601 | 144 136 | 181 914 | 153 500 | 202 832 | 303 110 | 373 985 |
| **Other waste [tons]** | 288 814 | 222 672 | 296 390 | 428 739 | 221 276 | 358 242 | 190 058 | 228 284 | 247 045 | 207 233 | 249 411 |
| **Emission factor [kg $CH_4$/ton]** | | | | | | 4 | | | | | |
| **Emission factor [kg $N_2O$/ton]** | | | | | | 0.24 | | | | | |
| **Total Composting $CH_4$ [Gg]** | 1.35 | 1.14 | 1.50 | 2.17 | 1.42 | 2.01 | 1.49 | 1.53 | 1.80 | 2.04 | 2.49 |
| **Total Composting $N_2O$ [Gg]** | 0.08 | 0.07 | 0.09 | 0.13 | 0.09 | 0.12 | 0.09 | 0.09 | 0.11 | 0.12 | 0.15 |
| **Total composting GHG [Gg $CO_2$ eq.]** | 57.90 | 48.74 | 64.52 | 93.17 | 61.04 | 86.17 | 63.80 | 65.48 | 77.16 | 87.53 | 106.92 |

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

This category has default uncertainty, as only default factors are used. The uncertainty of the reported activity data is estimated to be small (+/- 5%); however, the largest source of uncertainty is not captured by the official data – the uncertainty in household composting.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2015.

#### 7.3.1.4 Source-specific QA/QC and verification

The QA/QC plan for the sector was updated during the previous year. Quality assurance entails structured checklists of activities, which are dated and signed by the sector reporter and verified by external control of the activity data. The activity data used for this sector are approved by the data producer, who verifies them before they are used for further calculation.

Since the waste sector is fairly small, external QC is not provided; instead QC is performed by a NIS coordinator and the results are communicated to the sectoral expert.

Activity data from national agencies and ministries are the subjects of internal QA/QC mechanisms and the NIS team has only limited insights into them. Processes in place at all state agencies and ministries to ensure that they produce accurate data.

#### 7.3.1.5 Source-specific recalculations, including changes made in response to the review process

This year no recalculation was carried out in this source category.

#### 7.3.1.6 Source-specific planned improvements, including those in response to the review process

Research was initiated to obtain data about composting before 2005. In future submissions, if resources permit, an attempt will be made to estimate the emissions from household compost heaps. However, because of the almost negligible emissions from industrial composting and the lack of an IPCC method and emission factors, this is not of high priority.

### 7.3.2 Anaerobic Digestion at Biogas Facilities (CRF 5.B.2)

#### 7.3.2.1 Source category description

Anaerobic digestion (AD) accounts for emissions from digestion facilities. AD in the Czech Republic has increased from 21 digesting facilities to more than 400 facilities in 2015. This rapid increase is fuelled by the increasing availability of the technology and subsidies for energy from biogas produced using AD.

#### 7.3.2.2 Methodological issues

Default emission factors were used for estimation of the emissions from AD. Since production of biogas from AD facilities is carefully monitored (thanks to government subsidies) the data about biogas production was used as activity data. The Ministry of Industry and Trade monitors the amount of biogas and additional data, such as calorific value of the produced gas, the energy produced and the total volume of gas. The heating value of methane was used to convert the above-mentioned values to mass units of produced methane. Production does not necessarily mean emission of biogas. IPCC 2006 states that leakages are very small in controlled AD facilities focused on energy production, ranging between 0-10 percent. A mean value of 5% for all produced methane was used for estimation of the emissions of biogas from AD.

Since data about production are used as activity data, all the possible emissions from AD are calculated, not just emissions from digested waste. Some of the material used in AD might not be waste by definition (e.g. agricultural residues, industrial by-products etc.). An overview of the sector is shown in Tab. 7-9.

**Tab. 7-9 Emissions from Anaerobic digestion stations, 2003-2015**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of biogas stations [count] | 8 | 10 | 9 | 14 | 21 | 49 | 86 | 115 | 186 | 317 | 388 | 404 | 443 |
| Energy [TJ] | 121 | 105 | 104 | 291 | 555 | 1 007 | 2 503 | 4 481 | 7 294 | 12 630 | 20 002 | 22 674 | 23 015 |
| Convertsion [TJ/Gg] | 50.009 | | | | | | | | | | | | |
| Activity data [Gg $CH_4$] - R | 2.8 | 2.4 | 2.4 | 6.5 | 11.8 | 22.6 | 56.1 | 93.2 | 150.9 | 254.4 | 420.7 | 449.4 | 457.3 |
| Emissions (default 5%) [Gg $CH_4$] | 0.14 | 0.12 | 0.12 | 0.32 | 0.59 | 1.13 | 2.81 | 4.66 | 7.55 | 12.72 | 21.04 | 22.47 | 22.87 |

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

The time series are consistent, since same method, factors and data source are used. Uncertainty in this source category is given by the EF range from -100% to +100%.

**Tab. 7-10 Uncertainty estimates for 5.B category**

| Gas | Category | AD uncertainity [%] | EF uncetrainity [%] | Origin of the parameters |
|---|---|---|---|---|
| $CH_4$ | 5.B.1 Composting | 20 | NA | AD Expert judgement M. Havránek; EF IPCC default, verification of AD Jiří Valta (CENIA) |
| $N_2O$ | 5.B.1 Composting | 20 | NA | AD Expert judgement M. Havránek; EF IPCC default, verification of AD Jiří Valta (CENIA) |
| $CH_4$ | 5.B.2 Anaerobic digestion | 20 | 100 | AD Expert judgement M. Havránek; EF IPCC default, verification of AD Jiří Valta (CENIA) |

### 7.3.2.4 *Source-specific QA/QC and verification*

The QA/QC plan for the sector was updated during 2015 and 2016. Quality assurance entails structured checklists of activities, which are dated and signed by the sector reporter and verified by external control of the activity data. The activity data used for this sector are approved by the data producer and who verifies them before they are used for further calculation.

Since the waste sector is fairly small, external QC is not provided; instead QC is performed by a NIS coordinator and the results are communicated to the sectoral expert.

The activity data from national agencies and ministries are the subjects of internal QA/QC mechanisms and the NIS team has only limited insights into them. Processes are in place at all state agencies and ministries to ensure that they produce accurate data.

### 7.3.2.5 *Source-specific recalculations, including changes made in response to the review process*

Since the last inventory, the data has been recalculated and we have obtained up-dated activity data about biogas production. The data provider split categorisation of biogas stations into AD and industrial and domestic waste water treatment. These changes in categorisation make it possible to more precisely attribute different activity data to different source categories. The recalculated emissions are slightly higher for the source category. Table 7-11 shows the difference resulting from recalculation. Years 2013 and 2014 were unaffected.

**Tab. 7-11 Recalculation of anaerobic digestion [Gg $CH_4$], Czech Republic, 2003-2012**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| **2016 submission** | 0.1 | 0.1 | 0.1 | 0.3 | 0.6 | 1.0 | 2.5 | 4.5 | 7.3 | 12.6 |
| **2017 submission** | 0.14 | 0.12 | 0.12 | 0.32 | 0.59 | 1.13 | 2.81 | 4.66 | 7.55 | 12.72 |
| | | | | | | | | | | |
| **Difference [Gg]** | +0.04 | +0.02 | +0.02 | +0.02 | -0.01 | +0.13 | +0.31 | +0.16 | +0.25 | +0.12 |
| **Difference (ref. 2016)** | +40% | +20% | +20% | +7% | -2% | +13% | +12% | +4% | +3% | +1% |

### *7.3.2.6 Source-specific planned improvements, including those in response to the review process*

Improvements in this category are planned in terms of reviewing the data sources of emissions before 2003 and verifying the factor for estimated leakages, which is crucial for the whole quantification. This improvement is of moderate priority.

## 7.4 Incineration and Open Burning of Waste (CRF 5.C)

### 7.4.1 Waste Incineration (CRF 5.C.1)

This category contains emissions from waste incineration in the Czech Republic. The types of waste, incinerated include industrial, hazardous and clinical waste. Waste incineration is defined as the combustion of waste in controlled incineration facilities. Modern waste incinerators have tall stacks and specially designed combustion chambers, which ensure high combustion temperatures, long residence times, and efficient waste agitation, while introducing air for more complete combustion. This category includes emissions of $CO_2$, $CH_4$ and $N_2O$ from these practices.

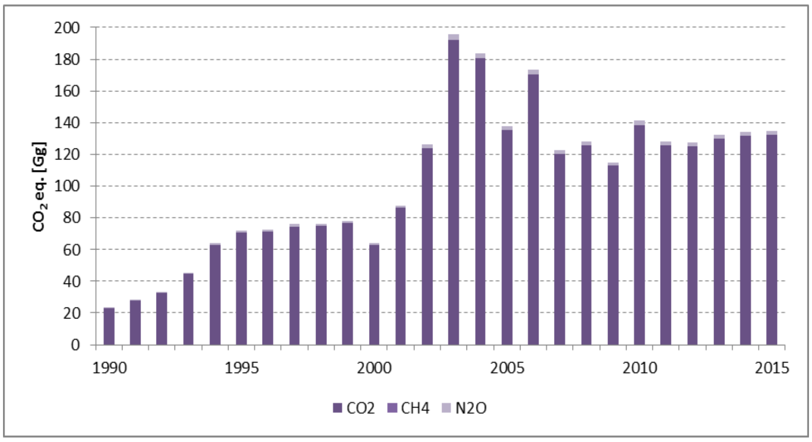



**Fig. 7-5 Development of emissions from waste incineration, 1990-2015**

Waste used as a fuel is included in the Energy sector. This chapter includes only waste that is not used for energy production. Development of this category is shown in Fig. 7-5 and in detail in Tab 7-11.

### *7.4.1.1 Source category description*

There are three MSW incinerators in the country, thaat are not accounted for this source category and there are 76 other facilities, incinerating or co-incinerating industrial and hazardous waste with a total capacity of 600 Gg of waste. However, most of this capacity is not used.

### *7.4.1.2 Methodological issues*

In this source category only $CO_2$ emissions resulting from oxidation of the fraction of fossil carbon in waste (e.g. plastics, rubber, liquid solvents, and waste oil) during incineration are considered in the net emissions and are included in the national $CO_2$ emissions estimates. In addition, incineration plants produce small amounts of methane and nitrous oxide. All the emissions are reported in category 5.C.1.

Estimations of emissions from hazardous/industrial waste (H/IW) biomass are reported under the same category, but the $CO_2$ emissions are described as an information item and are not included in the national totals.

Estimation of $CO_2$ emissions from H/IW incineration is based on the Tier 1 approach (IPCC, 2006). This assumes that the total fossil carbon dioxide emissions are dependent on the amount of carbon in the waste, on the fraction of fossil carbon and on the combustion efficiency of the waste incineration. Due to the lack of country-specific data for the necessary parameters, the default data for the calculations were taken from the IPCC 2006 Guidelines, see Tab. 7-12. To save room in the table, the results are divided into biogenic and non-biogenic waste fractions only for the important gas – $CO_2$. Methane and nitrous oxide are listed together in the table although they are reported in the UNFCCC reporter separately for the biogenic and fossil waste fractions.

The activity data are the main issue in this category. This year the 2005-2014 timeline was recalculated to correspond to the official statistics. The activity data are based on the statistical surveys performed by VISOH (VISOH is a public waste management registry and there is also a non-public part ISOH, which is used for inventory activity data). The system uses categorization of waste management activities and this source category is listed in the ISOH system under D10 – incineration on land. The problem is that the system does not contain data before 2002 and incineration data in VISOH-ISOH have been consistent since 2005 when the new methodology began to be used; hence, estimates obtained from MIT were used prior to that date. MIT issued a special report on the history of incineration in the Czech Republic, which was used to derive data for this category prior to 2005. The Czech legislation does not distinguish explicitly between the types of wastes required by the IPCC methodology (there are only two types, "hazardous" waste and "other" waste). However, it is certain that all MSW is incinerated for energy purposes (R1 category by ISOH) and hence the author concluded that category D10 consists of waste components with hazardous quality (which is supported by the evidence in ISOH where applicable).

**Tab. 7-12 H/IW incineration in 1990 – 2015 with the used parameters and results**

| | Used factors | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Amount of carbon fraction** | 0.5 | | | | | | | | | |
| **Fossil carbon fraction** | 0.9 | | | | | | | | | |
| **Combust efficiency fraction** | 0.995 | | | | | | | | | |
| **C-$CO_2$ ratio** | 3.7 | | | | | | | | | |
| **Emission factor [Gg $CH_4$/Gg]** | 5.6E-07 | | | | | | | | | |
| **Emission factor [Gg $N_2O$/Gg]** | 1.0E-04 | | | | | | | | | |
| | **1990** | **1995** | **2000** | **2005** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
| **Waste incinerated [Gg]** | 14.1 | 43.1 | 38.4 | 82.3 | 84.4 | 76.7 | 76.3 | 79.2 | 80.2 | 80.7 |
| **Total $CO_2$ [Gg $CO_2$] Fossil** | 23.1 | 70.7 | 63.0 | 135.2 | 138.6 | 125.8 | 125.2 | 130.1 | 131.7 | 132.4 |
| **Total $CO_2$ [Gg $CO_2$] Bio.** | 2.6 | 7.9 | 7.0 | 15.0 | 15.40 | 14.0 | 13.91 | 14.45 | 14.64 | 14.71 |
| **Total $CH_4$ [Gg $CH_4$]** | 7.9E-06 | 2.4E-05 | 2.2E-05 | 4.6E-05 | 4.7E-05 | 4.3E-05 | 4.3E-05 | 4.4E-05 | 4.5E-05 | 4.5E-05 |
| **Total $N_2O$ [Gg $N_2O$]** | 1.4E-03 | 4.3E-03 | 3.8E-03 | 8.2E-03 | 8.4E-03 | 7.7E-03 | 7.6E-03 | 7.9E-03 | 8.0E-03 | 8.1E-03 |

The suggested default emission factors for hazardous waste incineration were 100 kg of $N_2O$ per Gg of incinerated HW and 0.56 kg of methane per Gg of incinerated HW. The biogenic emissions of $CO_2$ from this category were estimated last year. The approach is based on the default factor for fossil carbon, assuming that the rest of the carbon in the material is non-fossil in origin. The oxidation factor 0.995 is used for HW/IW combustion emission quantification. It is suggested that the default factor is 1.0, but this is contradictory to the evidence found in literature and in the bottom ash measurement, where the share of unburnt carbon can be measured, yielding a contradictory oxidation factor implying that all the carbon in the fuel is incinerated. The literature supporting this assumption is reviewed in annex V. The impact on the inventory is negligible; however, a factor of less than 100% is easier to manage in assessing the uncertainty.

#### 7.4.1.3 Uncertainties and time-series consistency

The activity data comes from two sources; hence there could be an inconsistency due to the different data providers. An effort has been made to tackle this inconsistency by choosing 2005 as the year of change to the new AD (in 2005 an effort was made to harmonise the methodology). However, switching to VISOH-ISOH is a more sustainable solution, as the system has institutional and legislative backing at MoE and provides and will probably continue to provide more reliable data about waste incineration in the future.

**Tab. 7-13 Uncertainty estimates for 5.C category**

| Gas | Category | AD uncertainity [%] | EF uncetrainity [%] | Origin of the parameters |
|---|---|---|---|---|
| $CO_2$ | 5.C.1 Waste incineration | 15 | 5 | AD Expert judgement M. Havránek; EF IPCC default |
| $N_2O$ | 5.C.1 Waste incineration | 20 | 70 | AD Expert judgement M. Havránek; EF IPCC default |
| $CH_4$ | 5.C.1 Waste incineration | 20 | 80 | AD Expert judgement M. Havránek; EF IPCC default |

#### 7.4.1.4 Source-specific QA/QC and verification

The QA/QC plan of the National inventory system was used for the whole waste category. For this particular subcategory, bottom-up data provided by the official sources (Ministry of Industry and Trade, MIT) and also the data from VISOH-ISOH – information system on waste management run by MoE/CENIA was used. However, the inaccuracy or uncertainty of this data is not quantified but is estimated by expert judgment. The compiler cross-checked the data on incineration with the top-down data, produced by other state agencies.

#### 7.4.1.5 Source-specific recalculations, including changes made in response to the review process

No recalculation was conducted in this source category.

#### 7.4.1.6 Source-specific planned improvements, including those in response to the review process

In future submissions, the inventory team is considering separating the reported part of the waste used for energy production and adding it to the Energy sector, as the data in this area becomes available. The inventory team continuously encourages the state administration to gather data useful for GHG inventories. This is a low-priority issue. An improvement is planned in the uncertainty assessment similar to the new assessment of the industrial waste water source category.

### 7.4.2 Open Burning of Waste (CRF 5.C.2)

Open burning of waste is illegal in this country and this category is not considered to occur. Nonetheless, to verify suspicion that this category does, in fact, occur, currently research is being launched on fringe phenomena like fires in landfills and fires in general, where a significant amount of material might be openly burned. This is a medium-priority improvement.

## 7.5 Wastewater Treatment and Discharge (CRF 5.D)

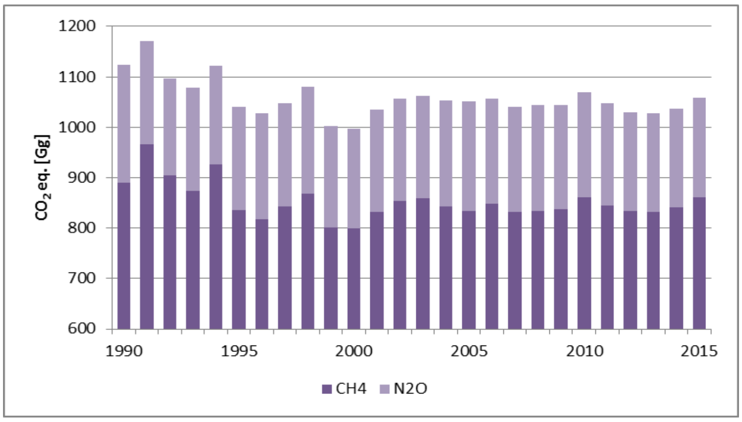



**Fig. 7-6 Development of emissions from wastewater treatment and discharge, 1990-2015**

This source category consists of two sub-categories – emissions from domestic wastewater treatment and emissions from industrial waste water treatment. Overall developments in this source category are shown in Fig. 7-6. The main drivers of the emissions are population size, industrial production and the share of the particular treatment options.

### 7.5.1 Domestic Wastewater Treatment (CRF 5.D.1)

#### *7.5.1.1 Source category description*

Treatment of domestic wastewater in the Czech Republic is mostly centralised and more than 82% of the population is connected to sewage systems. The rest of the population, mainly rural population in small municipalities, has on-site treatment facilities – septic tanks, sump tanks, latrines or household treatment plants. Wastewater treatment plants treat about 97% of all the collected water. Anaerobic technology is being increasingly used to produce biogass from sludge.

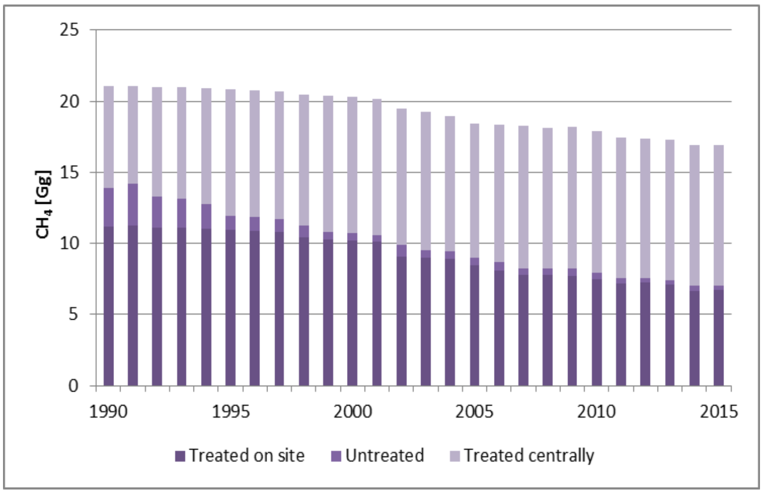



**Fig. 7-7 Development of 5.D.1 emission of $CH_4$ by types of treatment**

This category was recalclulated in 2016 to fully reflect the complexity and pathways that are used to treat wastewater in this country, effectively replacing Tier 1.

#### *7.5.1.2 Methodological issues*

The content of organic pollution in the water is the basic factor for determining methane emissions from wastewater management. The content of organic pollution in municipal wastewater and sludge is given as $BOD_5$ (the biochemical oxygen demand).

The current IPCC methodology employs BOD for evaluation of municipal wastewater and sludge and Chemical Oxygen Demand (COD) for industrial wastewater. The new method is based on default Tier 1 where sludge treatment is not considered; however available data about biogass production from sludge treatment are used to reduce TOW (total organic waste). Outline of TOW flow is given in the folowing figure (Fig. 7-8).

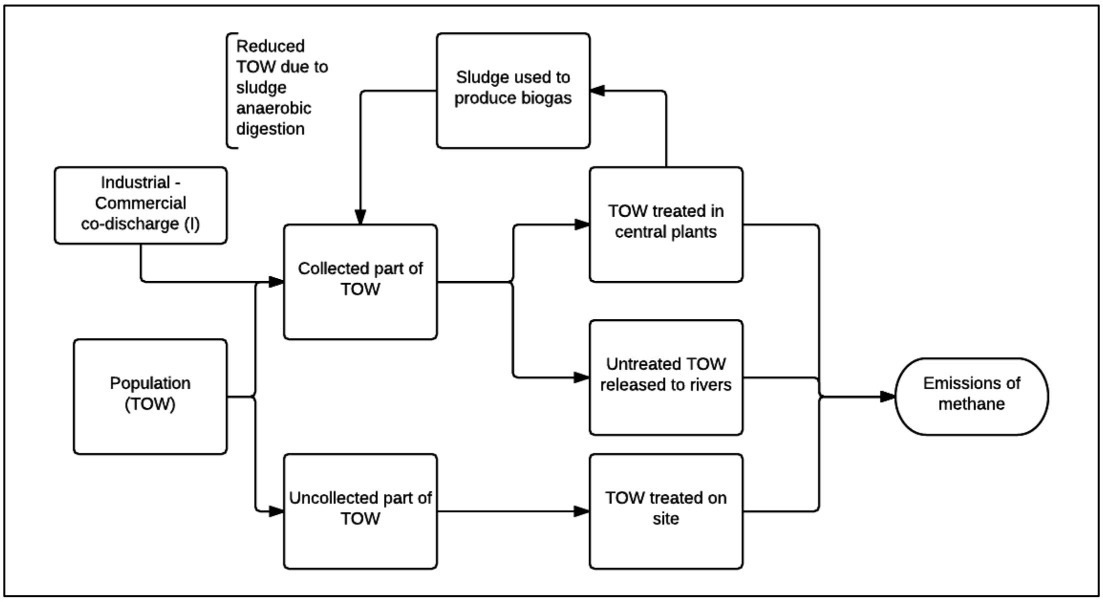



**Fig. 7-8 Outline of total organic waste flow in 5D1**

The basic activity data (and their sources) for determining emissions from this subcategory are as follows, tabelar overview of those factors is given in Tab. 7-14 to Tab. 7-15:

- The number of inhabitants (source: Czech Statistical Office).
- The organic pollution produced per inhabitant (source: IPCC default value).
- The conditions under which the wastewater is treated (source: Czech Statistical Office, with some specific national factors).
- The amount of proteins in the diet of the population (source: FAO).
- The amount of biogas produced from wastewater treatment plants (source: MIT).

The methodological steps as follows:

- Estimation of the total TOW of the country by using the population and default BOD value production.
- Split total TOW into two streams, one is corresponding to TOW collected by central wastewater treatment plants and, the other to uncollected TOW (mixture of latrines, septic tanks, root treatment plants and household biodisc plants, etc.).
- Uncollected TOW is multiplied by the implied EF based on IPCC Gl 2006 resulting in methane emissions.
- Collected TOW is multiplied by the default co-discharge correction factor.
- Biogass produced by wastewater treatment plants is converted to the TOW required to produce this biogass and is substracted from collected TOW.
- Collected TOW is divided into two streams treated TOW and untreated TOW.
- Treated TOW is treated by well managed central treatment plants (default factors) resulting in methane emissions.
- Untreated TOW is discharged in to watersheds resulting in methane emissions
- Methane emissions from all three sources are summed up resulting in emissions from this source category.

**Tab. 7-14 Activity data used for 5.D.1 category, 1990-2015, Czech Republic**

| | Total population [thous. pers.] | Sewer connection [%] | Water treated [%] | | Total population [thous. pers.] | Sewer connection [%] | Water treated [%] |
|---|---|---|---|---|---|---|---|
| **1990** | 10 363 | 72.6 | 73.0 | **2003** | 10 202 | 77.7 | 94.5 |
| **1991** | 10 309 | 72.3 | 69.6 | **2004** | 10 207 | 77.9 | 94.9 |
| **1992** | 10 318 | 72.7 | 78.7 | **2005** | 10 234 | 79.1 | 94.6 |
| **1993** | 10 331 | 72.8 | 78.9 | **2006** | 10 267 | 80.0 | 94.2 |
| **1994** | 10 336 | 73.0 | 82.2 | **2007** | 10 323 | 80.8 | 95.8 |
| **1995** | 10 331 | 73.2 | 89.5 | **2008** | 10 486 | 81.1 | 95.3 |
| **1996** | 10 315 | 73.3 | 90.3 | **2009** | 10 492 | 81.3 | 95.2 |
| **1997** | 10 304 | 73.5 | 90.9 | **2010** | 10 517 | 81.9 | 96.2 |
| **1998** | 10 295 | 74.4 | 91.3 | **2011** | 10 496 | 82.6 | 96.8 |
| **1999** | 10 283 | 74.6 | 95.0 | **2012** | 10 509 | 82.5 | 97.1 |
| **2000** | 10 273 | 74.8 | 94.8 | **2013** | 10 511 | 82.8 | 97.4 |
| **2001** | 10 224 | 74.9 | 95.5 | **2014** | 10 524 | 83.9 | 96.9 |
| **2002** | 10 201 | 77.4 | 92.6 | **2015** | 10 553 | 84.2 | 97.0 |

**Tab. 7-15 Parameters used for 5.D.1 category, 1990-2015**

| Used parameters | | | |
|---|---|---|---|
| **B0 [kg $CH_4$/kg BOD]** | TOW [g BOD/person/year] | **Correction factor for industrial co-discharge** | **NCV of $CH_4$ [MJ/kg]** |
| **0.6** | 60 | 1.25 | 50.009 |

**Tab. 7-16 Methane emissions from 5.D.1 category, 1990-2015**

| | Uncollected TOW emissions [Gg of $CH_4$] | Untreated TOW emissions [Gg of $CH_4$] | Treated TOW emissions [Gg of $CH_4$] | Biogas reduction (fraction of treated TOW) | Total emissions [Gg of $CH_4$] |
|---|---|---|---|---|---|
| **MCF** | **0.3** | **0.1** | **0.1** | | |
| **1990** | 11.2 | 2.7 | 7.2 | 0.20 | 21.1 |
| **1991** | 11.3 | 3.0 | 6.8 | 0.20 | 21.0 |
| **1992** | 11.1 | 2.2 | 7.7 | 0.20 | 21.0 |
| **1993** | 11.1 | 2.1 | 7.8 | 0.20 | 21.0 |
| **1994** | 11.0 | 1.8 | 8.1 | 0.20 | 20.9 |
| **1995** | 10.9 | 1.0 | 8.9 | 0.20 | 20.9 |
| **1996** | 10.9 | 1.0 | 9.0 | 0.20 | 20.8 |
| **1997** | 10.8 | 0.9 | 9.0 | 0.20 | 20.7 |
| **1998** | 10.4 | 0.9 | 9.2 | 0.20 | 20.5 |
| **1999** | 10.3 | 0.5 | 9.6 | 0.20 | 20.4 |
| **2000** | 10.2 | 0.5 | 9.6 | 0.20 | 20.3 |
| **2001** | 10.1 | 0.5 | 9.6 | 0.20 | 20.2 |
| **2002** | 9.1 | 0.8 | 9.6 | 0.20 | 19.5 |
| **2003** | 9.0 | 0.6 | 9.9 | 0.19 | 19.5 |
| **2004** | 8.9 | 0.6 | 9.7 | 0.21 | 19.2 |
| **2005** | 8.4 | 0.5 | 9.7 | 0.23 | 18.6 |
| **2006** | 8.1 | 0.6 | 9.8 | 0.23 | 18.5 |
| **2007** | 7.8 | 0.4 | 10.2 | 0.22 | 18.4 |
| **2008** | 7.8 | 0.5 | 10.1 | 0.24 | 18.3 |
| **2009** | 7.7 | 0.5 | 10.2 | 0.23 | 18.5 |
| **2010** | 7.5 | 0.4 | 10.2 | 0.25 | 18.2 |
| **2011** | 7.2 | 0.3 | 10.2 | 0.26 | 17.7 |
| **2012** | 7.2 | 0.3 | 10.4 | 0.25 | 17.9 |
| **2013** | 7.1 | 0.3 | 10.4 | 0.25 | 17.8 |
| **2014** | 6.7 | 0.3 | 10.7 | 0.24 | 17.8 |
| **2015** | 6.6 | 0.3 | 10.9 | 0.23 | 17.9 |

Determination of the $N_2O$ emissions from municipal wastewater is part of a broader complex of calculations, concerned particularly with the area of agriculture. Tier 1 calculation is based on the number of inhabitants and estimation of the average annual protein consumption, together with a correction for co-discharge from industry. Data and factors used for the estimation of this source sub category are shown in Tab. 7-17.

**Tab. 7-17 Indirect $N_2O$ [Gg] from 5.D.1 and 5.D.2, 1990-2015, Czech Republic**

| | Proteins [g/capita/day[8]] | Population [number, thous. pers.] | Fnpr [kg N/kg protein] | Fnon-noc | Find-com | Nefluent [kg N/yr] | EF [kg $N_2O$/kg N] | Emissions [Gg $N_2O$] |
|---|---|---|---|---|---|---|---|---|
| **1990** | 105.77 | 10 363 | | | | 100016115 | | 0.786 |
| **1991** | 92.98 | 10 309 | | | | 87463239 | | 0.687 |
| **1992** | 87.37 | 10 318 | | | | 82258845 | | 0.646 |
| **1993** | 92.75 | 10 331 | | | | 87432447 | | 0.687 |
| **1994** | 88.36 | 10 336 | | | | 83338924 | | 0.655 |
| **1995** | 93.14 | 10 331 | | | | 87801379 | | 0.690 |
| **1996** | 95.59 | 10 315 | | | | 89976569 | | 0.707 |
| **1997** | 93.31 | 10 304 | | | | 87730746 | | 0.689 |
| **1998** | 96.91 | 10 295 | | | | 91038567 | | 0.715 |
| **1999** | 91.40 | 10 283 | | | | 85760989 | | 0.674 |
| **2000** | 90.29 | 10 273 | | | | 84634767 | | 0.665 |
| **2001** | 92.84 | 10 224 | | | | 86615776 | | 0.681 |
| **2002** | 92.97 | 10 201 | 0.16 | 1.25 | 1.25 | 86538394 | 0.005 | 0.680 |
| **2003** | 92.99 | 10 202 | | | | 86564452 | | 0.680 |
| **2004** | 96.08 | 10 207 | | | | 89487156 | | 0.703 |
| **2005** | 99.33 | 10 234 | | | | 92760403 | | 0.729 |
| **2006** | 95.26 | 10 267 | | | | 89242564 | | 0.701 |
| **2007** | 95.06 | 10 323 | | | | 89541327 | | 0.704 |
| **2008** | 93.79 | 10 430 | | | | 89260824 | | 0.701 |
| **2009** | 92.58 | 10 491 | | | | 88631338 | | 0.696 |
| **2010** | 92.80 | 10 517 | | | | 89060048 | | 0.700 |
| **2011** | 90.82 | 10 497 | | | | 86989332 | | 0.683 |
| **2012** | 86.86 | 10 509 | | | | 83296338 | | 0.654 |
| **2013** | 87.47 | 10 511 | | | | 83892749 | | 0.659 |
| **2014** | 87.47 | 10 525 | | | | 84005003 | | 0.660 |
| **2015** | 87.47 | 10 554 | | | | 84236949 | | 0.662 |

The values of the factors in the table are the default factors. Factor Fnon-con is average between default factor for developed countries (1.4) and developing countries (1.1) to reflect nature of Czech wastewater treatment system in transition. The activity data about population were obtained from the Czech Statistical Office and the amount of proteins consumed in the Czech Republic was derived from the nutrition statistics of FAO (Faostat, 2017).

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

The whole time series was recalculated and should be more consistent in terms of data sources. The uncertainty in this category is high because the data about organic pollution are based on the population alone and the science behind the formation of $N_2O$ is also not robust and varies significantly.

[8] *The latest available data is used for 2014 and 201;, data for Czechoslovakia are used for 1990-1992.*

**Tab. 7-18 Uncertainty estimates for 5.D.1 category**

| Gas | Category | AD uncertainity [%] | EF uncertainity [%] | Origin of the parameters |
|---|---|---|---|---|
| $CH_4$ | 5.D.1 Domestic wastewater | 21 | 50 | Combined uncertainty of quantification parameters Expert judgement M. Havránek |
| $N_2O$ | 5.D.1 Domestic wastewater | 26 | 50 | AD Expert judgement M. Havránek; EF IPCC default |

### 7.5.1.4 Source-specific QA/QC and verification

Quality assurance entails structured checklists of activities, which are dated and signed by the sector reporter and verified by external control of the activity data. Activity data used for this sector are approved by the data producer who verifies them before they are used for calculation.

Because the waste sector is fairly small, an external subject is not used to provide QC; instead QC is performed by a NIS coordinator and the results are communicated to the sectoral expert.

Activity data from national agencies and ministries are the subjects of internal QA/QC mechanisms and the NIS team has only limited insights into them. Processes are in place on all state agencies and ministries to ensure that state agencies produce the correct data.

### 7.5.1.5 Source-specific recalculations, including changes made in response to the review process

This year, the whole time series was recalculated. The methane emissions from industrial waste water treatment were recalculated to better correspond to the national reality and data. Methane recovery formerly reported solely under this category has now been divided between categories 5D1 and 5D2 and, because R is a core part of the emission estimates, the whole timeline was recalculated. The new industrial wastewater emission estimate is better suited to the activity data available in this country and is in better accordance with the default IPCC method. The nitrous oxide estimate was recalculated because FAO actualised the data about protein consumption in the Czech Republic, and therefore whole timeline was changed slightly, as is shown in the table below. All the recalculated results are shown in Tab. 7-19. Recalculation yielded, on an average, increased emissions of methane and decreased emissions of nitrous oxide. The changes are insignificant, equal to a maximum of a few percentage points in the most recent years.

**Tab. 7-19 Recalculation of 5.D.1 category, [Gg] $CH_4$, $N_2O$ eq., 1990-2014**

| $CH_4$ | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2017 submission** | 21.08 | 21.05 | 20.96 | 20.96 | 20.92 | 20.85 | 20.79 | 20.71 | 20.45 | 20.38 | 20.30 | 20.18 | 19.46 |
| **2016 submission** | 21.08 | 21.05 | 20.96 | 20.96 | 20.92 | 20.85 | 20.79 | 20.71 | 20.45 | 20.38 | 20.30 | 20.18 | 19.46 |
| **Difference** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Difference (rel. to 2016)** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| **$CH_4$** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | |
| **2017 submission** | 19.47 | 19.16 | 18.63 | 18.48 | 18.44 | 18.35 | 18.47 | 18.15 | 17.73 | 17.95 | 17.84 | 17.76 | |
| **2016 submission** | 19.25 | 18.95 | 18.44 | 18.33 | 18.26 | 18.13 | 18.22 | 17.89 | 17.43 | 17.36 | 17.27 | 16.94 | |
| **Difference [Gg]** | +0.22 | +0.21 | +0.19 | +0.15 | +0.19 | +0.22 | +0.24 | +0.26 | +0.30 | +0.59 | +0.58 | +0.82 | |
| **Difference (rel. to 2016)** | +1.14 % | +1.13 % | +1.05 % | +0.83 % | +1.03 % | +1.20 % | +1.34 % | +1.44 % | +1.71 % | +3.39 % | +3.34 % | +4.85 % | |
| **$N_2O$** | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** |
| **2017 submission** | 0.79 | 0.69 | 0.65 | 0.69 | 0.65 | 0.69 | 0.71 | 0.69 | 0.72 | 0.67 | 0.66 | 0.68 | 0.68 |
| **2016 submission** | 0.79 | 0.69 | 0.65 | 0.69 | 0.66 | 0.69 | 0.71 | 0.69 | 0.71 | 0.67 | 0.66 | 0.68 | 0.68 |
| **Difference** | 0 | 0 | 0 | -0.001 | -0.000 | -0.000 | -0.000 | 0 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| **Difference (rel. to 2016)** | 0.0% | 0.0% | 0.0% | -0.1% | 0.0% | 0.0% | 0.0% | +0.1% | +0.1% | +0.1% | +0.2% | +0.2% | +0.1% |
| **$N_2O$** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2017 submission** | 0.68 | 0.70 | 0.73 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.68 | 0.65 | 0.66 | 0.66 |
| **2016 submission** | 0.68 | 0.70 | 0.73 | 0.70 | 0.70 | 0.70 | 0.69 | 0.70 | 0.68 | 0.68 | 0.68 | 0.68 |
| **Difference [Gg]** | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.002 | 0.001 | - 0.029 | - 0.024 | - 0.025 |
| **Difference (rel. to 2016)** | +0.1% | +0.1% | +0.1% | +0.1% | +0.1% | +0.1% | +0.2% | +0.3% | +0.1% | -4.3% | -3.6% | -3.6% |

#### *7.5.1.6 Source-specific planned improvements, including those in response to the review process*

It is planned to quantify the uncertainity range in a similar way as in category 5D2 using the upper and lower margins of the esimates to estimate the uncertainity in more quantitative terms. This aspect is of moderate importance.

### 7.5.2 Industrial Wastewater (CRF 5.D.2)

#### *7.5.2.1 Source category description*

This source category deals with emissions from the treatment of industrial wastewaters. Most of the industries in the country have their own wastewater treatment systems; however, a significant fraction of industries are part of municipal sewage systems. This does not create a problem, as both categories 5.D.1 and 5.D.2 are based on production statistics not on collection systems. Industrial waste water (IWW) treatment at bigger companies in the country is mostly managed on spot, utilizing aerobic techniques to treat the water. Anaerobic treatment of sludge is being increasingly used. There is no double counting in category 5B, as the data allow division between waste AD and water treatment digestion (and are sufficiently precise to allow division between domestic waste water and IWW). Separated sludge that is not used for biogas production is treated by a mixture of aerobic treatment options. Development of the category is shown in Fig. 7-9.

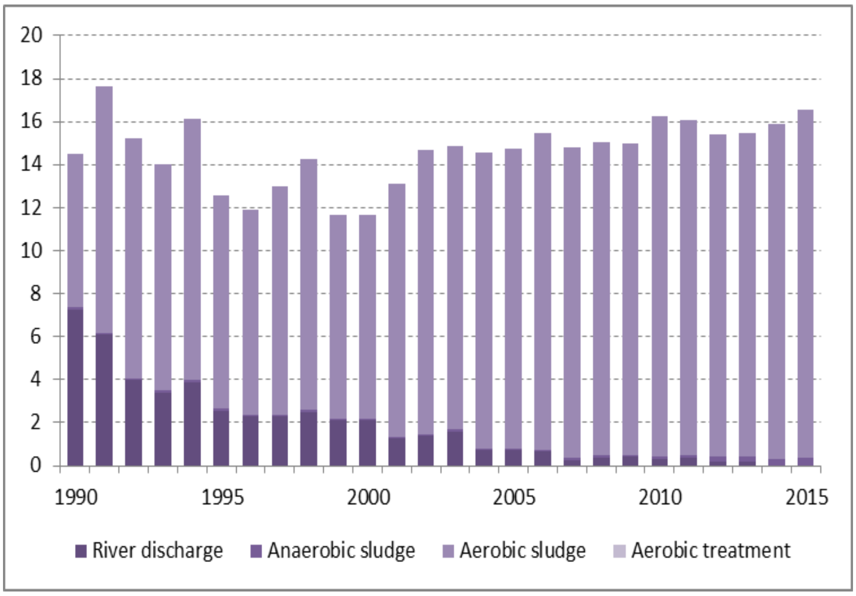



**Fig. 7-9 Development of 5.D.2 by types of emission sources**

#### *7.5.2.2 Methodological issues*

This entire category was recalculated this year. The recalculation method is based on Tier 1 of the methodology; however, we used country-specific data to ensure that it is based more on the available statistics. The main activity data for estimation of the methane emissions from this subcategory is determination of the amount of degradable pollution in industrial wastewaters. This part is identical with the previous calculation and was not changed. Specific production of pollution – the amount of pollution per production unit – kg COD / kg product is used in this source category. This value is then multiplied by the production or the value obtained from the overall amounts of industrial wastewater and from a qualified estimate of their concentrations (in kg COD/m$^3$). The approach used is based on the IPCC 2006 Guidelines. The necessary activity data were taken from the the annual report of CZSO (Statistical

Yearbook) and the other parameters required for the calculation were taken from the 2006 Guidelines (IPCC, 2006). In addition, it was estimated that the amount of sludge equaled 10% of the total pollution in industrial waters (25% was assumed in the Meat and Poultry, Paper and Pulp and Vegetables, Fruits and Juices categories). These estimates are based on Dohanyos and Zábranská (2000); Zábranská (2004), see Tab. 7-16. The fraction of industrial water treated by a particular technology is based on CZSO data about industrial waste water (IWW) treatment. Wastewater is divided into two big groups – untreated, which is water that is released into the watershed without treatment (now almost non-existent) and treated water. Treated water is managed in well-maintained aerobic facilities. Sludge separated from IWW is treated aerobically or anaerobically for methane production. Since sludge data is generally unavailable in the country we reverse use of R. Based on R we estimate necessary amount of sludge COD which is subtracted from total. The effect on total emission is identical, but we keep treatment streams separated. Data about R have been obtained on an annual basis from MIT renewable statistics since 2003; data about R prior 2003 are based on expert estimates. The detailed flow of quantification is shown in Fig. 7-10.

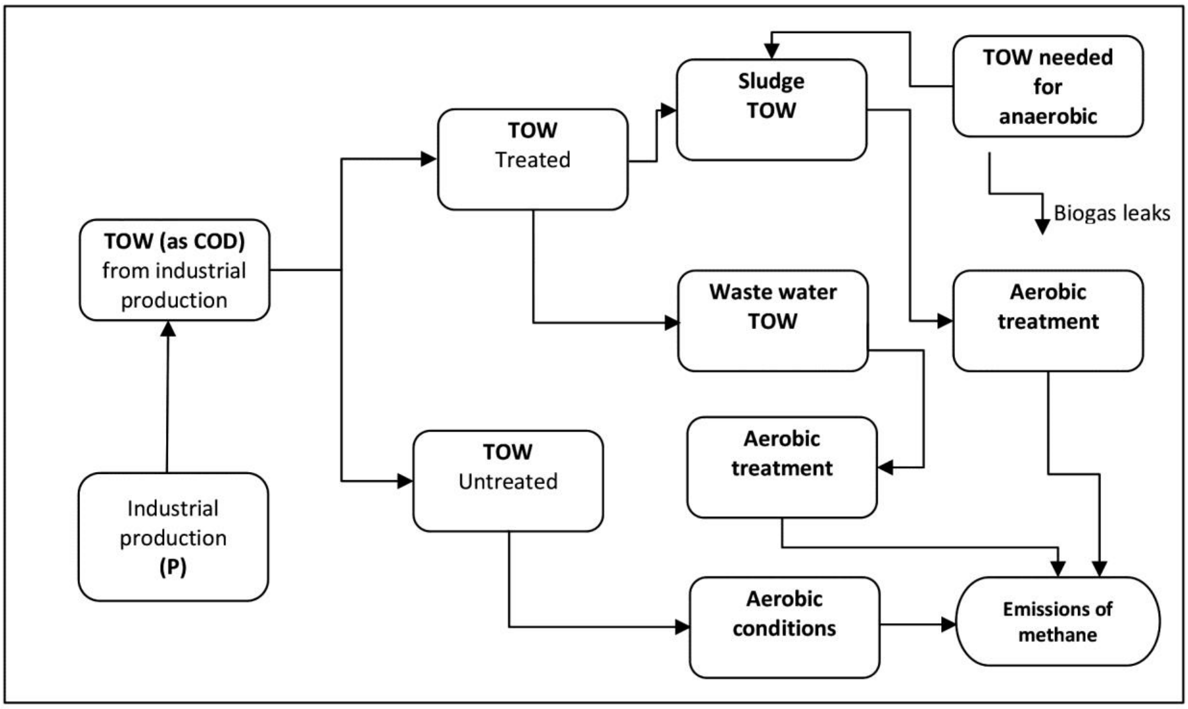



**Fig. 7-10 Outline of total organic waste flow in 5.D.2**

**Tab. 7-20 Industrial production data and used water generation and COD content factors, 1990-2015**

| | Alcohol Refining | Dairy Products | Beer & Malt | Meat & Poultry | Organic Chemicals | Petroleum Refineries | Plastics and Resins | Pulp & Paper (combined) | Soap and Detergents | Starch production | Sugar Refining | Vegetable Oils | Vegetables, Fruits & Juices | Wine & Vinegar |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **COD suggested [kg/m3]** | 11 | 2.7 | 2.9 | 4.1 | 3 | 1 | 3.7 | 9 | 0.9 | 10 | 3.2 | 0.9 | 5 | 1.5 |
| **Wastewater [m3/ton of product]** | 24 | 7 | 6.3 | 13 | 67 | 0.6 | 0.6 | 162 | 3 | 9 | 11 | 3.1 | 20 | 23 |
| **Industrial production [mil. tonnes]** | | | | | | | | | | | | | | |
| **1990** | 0.076 | 1.326 | 2.335 | 0.852 | 0.268 | 7.297 | 0.692 | 0.714 | 0.122 | 0.028 | 0.574 | 0.139 | 0.140 | 0.054 |
| **1991** | 0.091 | 1.118 | 2.175 | 0.779 | 0.188 | 6.445 | 0.554 | 0.566 | 0.079 | 0.021 | 0.565 | 0.119 | 0.140 | 0.056 |
| **1992** | 0.093 | 1.055 | 2.262 | 0.586 | 0.207 | 6.620 | 0.561 | 0.556 | 0.084 | 0.028 | 0.534 | 0.140 | 0.143 | 0.045 |
| **1993** | 0.092 | 1.142 | 2.124 | 0.497 | 0.227 | 6.205 | 0.584 | 0.524 | 0.054 | 0.038 | 0.518 | 0.094 | 0.137 | 0.051 |
| **1994** | 0.079 | 1.091 | 2.173 | 0.455 | 0.299 | 7.165 | 0.726 | 0.616 | 0.041 | 0.033 | 0.428 | 0.098 | 0.130 | 0.050 |
| **1995** | 0.078 | 0.906 | 2.200 | 0.436 | 0.302 | 7.096 | 0.673 | 0.492 | 0.042 | 0.033 | 0.506 | 0.115 | 0.135 | 0.046 |
| **1996** | 0.076 | 0.869 | 2.209 | 0.451 | 0.331 | 7.081 | 0.743 | 0.468 | 0.053 | 0.030 | 0.602 | 0.122 | 0.130 | 0.054 |
| **1997** | 0.072 | 0.900 | 2.243 | 0.457 | 0.294 | 7.000 | 0.796 | 0.527 | 0.053 | 0.030 | 0.598 | 0.128 | 0.130 | 0.056 |
| **1998** | 0.064 | 0.960 | 2.238 | 0.487 | 0.314 | 7.000 | 0.833 | 0.587 | 0.046 | 0.034 | 0.492 | 0.130 | 0.128 | 0.055 |
| **1999** | 0.068 | 0.949 | 2.202 | 0.497 | 0.310 | 7.000 | 0.862 | 0.467 | 0.046 | 0.038 | 0.420 | 0.126 | 0.133 | 0.056 |
| **2000** | 0.068 | 0.949 | 2.202 | 0.497 | 0.310 | 7.000 | 0.862 | 0.467 | 0.046 | 0.038 | 0.420 | 0.126 | 0.133 | 0.056 |
| **2001** | 0.057 | 0.851 | 2.343 | 0.531 | 0.216 | 7.000 | 0.869 | 0.598 | 0.050 | 0.049 | 0.482 | 0.109 | 0.129 | 0.061 |
| **2002** | 0.056 | 0.871 | 2.458 | 0.653 | 0.197 | 3.537 | 0.819 | 0.671 | 0.062 | 0.067 | 0.517 | 0.101 | 0.131 | 0.087 |
| **2003** | 0.056 | 0.871 | 2.458 | 0.653 | 0.197 | 3.537 | 0.819 | 0.671 | 0.062 | 0.067 | 0.517 | 0.101 | 0.131 | 0.087 |
| **2004** | 0.042 | 0.978 | 2.537 | 0.653 | 0.153 | 3.560 | 1.263 | 0.705 | 0.047 | 0.069 | 0.526 | 0.100 | 0.121 | 0.084 |
| **2005** | 0.049 | 0.978 | 2.536 | 0.618 | 0.155 | 5.241 | 1.317 | 0.712 | 0.042 | 0.071 | 0.573 | 0.100 | 0.137 | 0.088 |
| **2006** | 0.056 | 1.117 | 2.311 | 0.667 | 0.161 | - | - | 0.752 | 0.034 | 0.071 | 0.492 | 0.100 | 0.092 | 0.078 |
| **2007** | 0.059 | 1.117 | 2.355 | 0.415 | 0.168 | - | 1.096 | 0.752 | 0.029 | 0.083 | 0.383 | 0.111 | 0.109 | 0.060 |
| **2008** | 0.016 | 1.118 | 3.281 | 0.504 | 0.168 | - | 0.600 | 0.755 | 0.029 | 0.083 | 0.421 | 0.122 | 0.119 | 0.059 |
| **2009** | 0.016 | 1.118 | 3.281 | 0.504 | 0.168 | - | 0.600 | 0.755 | 0.029 | 0.083 | 0.421 | 0.122 | 0.119 | 0.059 |
| **2010** | 0.016 | 1.118 | 3.281 | 0.504 | 0.184 | - | 0.600 | 0.831 | 0.029 | 0.083 | 0.421 | 0.122 | 0.119 | 0.059 |
| **2011** | 0.021 | 1.229 | 3.281 | 0.347 | 0.153 | - | 0.552 | 0.825 | 0.029 | 0.081 | 0.570 | 0.123 | 0.111 | 0.060 |
| **2012** | 0.021 | 1.229 | 3.281 | 0.347 | 0.153 | - | 0.552 | 0.825 | 0.029 | 0.081 | 0.570 | 0.123 | 0.111 | 0.060 |
| **2013** | 0.021 | 1.229 | 3.281 | 0.347 | 0.153 | - | 0.552 | 0.825 | 0.029 | 0.081 | 0.570 | 0.123 | 0.111 | 0.060 |
| **2014** | 0.019 | 1.188 | 2.758 | 0.325 | 0.153 | - | 1.248 | 0.882 | 0.021 | 0.081 | 0.559 | 0.123 | 0.121 | 0.063 |
| **2015** | 0.020 | 1.242 | 2.885 | 0.340 | 0.160 | - | 1.305 | 0.922 | 0.022 | 0.085 | 0.585 | 0.129 | 0.127 | 0.066 |

In accordance with the 2006 Guidelines (IPCC, 2006), the maximum theoretical methane production $B_0$ was considered to be equal to 0.25 kg $CH_4$/kg COD. This value is in accordance with the national factors, presented in Dohanyos and Zábranská (2000).

Calculation of the emission factor for wastewater is based on the amount of recovered methane and the qualified estimate of the ratio of the use of individual technologies, during the entire recalculated time series.The MCFs used for quantification are shown in Tab. 7-21.

**Tab. 7-21 Used MCF for Industrial waste water treatment**

| | Sea. river and lake discharge | Aerobic treatment plant (well managed) | Aerobic treatment plant (ill managed) | Anaerobic digester for sludge | Anaerobic reactor | Anaerobic shallow lagoon | Anaerobic deep lagoon |
|---|---|---|---|---|---|---|---|
| **Lower bound** | 0 | 0 | 0.2 | 0.8 | 0.8 | 0 | 0.8 |
| **Default MCF** | 0.1 | 0 | 0.3 | 0.8 | 0.8 | 0.2 | 0.8 |
| **Upper bound** | 0.2 | 0.1 | 0.4 | 1 | 1 | 0.3 | 1 |

For the quantification we assume that wastewater that is treated in wastewater treatment plants (i.e. not released in to the watershed) is separated to a wastewater and sludge. Wastewater is treated aerobically. Because default MCF values were used, this treatment option does not produce any emissions. Sludge is divided into two parts. One is treated anaerobically producing methane (that is recovered) and emissions. The second part of the sludge is treated aerobically resulting, also in emissions.

**Tab. 7-22 Emissions of $CH_4$ [Gg] from 5.D.2, 1990-2015, Czech Republic**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$CH_4$ emission** | 14.5 | 17.6 | 15.2 | 14.0 | 16.2 | 12.6 | 11.9 | 13.0 | 14.3 | 11.7 | 11.7 | 13.1 | 14.7 |
| **Recovered $CH_4$** | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 |
| | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
| **$CH_4$ emission** | 14.9 | 14.6 | 14.7 | 15.4 | 14.8 | 15.0 | 15.0 | 16.3 | 16.0 | 15.4 | 15.4 | 15.9 | 16.6 |
| **Recovered $CH_4$** | 1.8 | 1.7 | 1.5 | 1.2 | 1.5 | 1.7 | 2.0 | 2.1 | 2.4 | 4.7 | 4.6 | 6.6 | 7.0 |

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

The uncertainty in most of the factors (default IPCC values) is determined according to the 2006 Guidelines. The overall uncertainty assessment (e.g. Monte-Carlo variation of unncertainity ranges) has not yet been fully quantified and it is anticipated that a software tool will be implemented for this purpose in the coming years.

In previous years, an IPCC expert team reviewed the waste sector and suggested and developed new uncertainty ranges that are listed in Tab. 7-23. During recalculation, all the variables were inserted in the equation as a parameters with lower and upper ranges and central (default where appliable) values. Based on this parametrisation, we were able to estimate the upper and lower boundaries of the emission estimate for this source category, as is shown in Fig. 7-11 (please note log scale in graph as there is three orders difference). The range now corresponds to the full scale of the uncertainity assesment, and indicates the minimum and maximum obtainable values by the distribution of the parameters used in the emission estimates; we foresee that running parametrized Monte Carlo simulation will lower the uncertainity range.

**Tab. 7-23 Uncertainty estimates for 5.D.2 category**

| Gas | Category | AD uncertainity [%] | EF uncetrainity [%] | Origin of the parameters |
|---|---|---|---|---|
| $CH_4$ | 5.D.2 Industrial wastewater | 40 | 50 | Combined uncertainty of quantification parameters + IPCC Default values, Expert judgement M. Havránek |

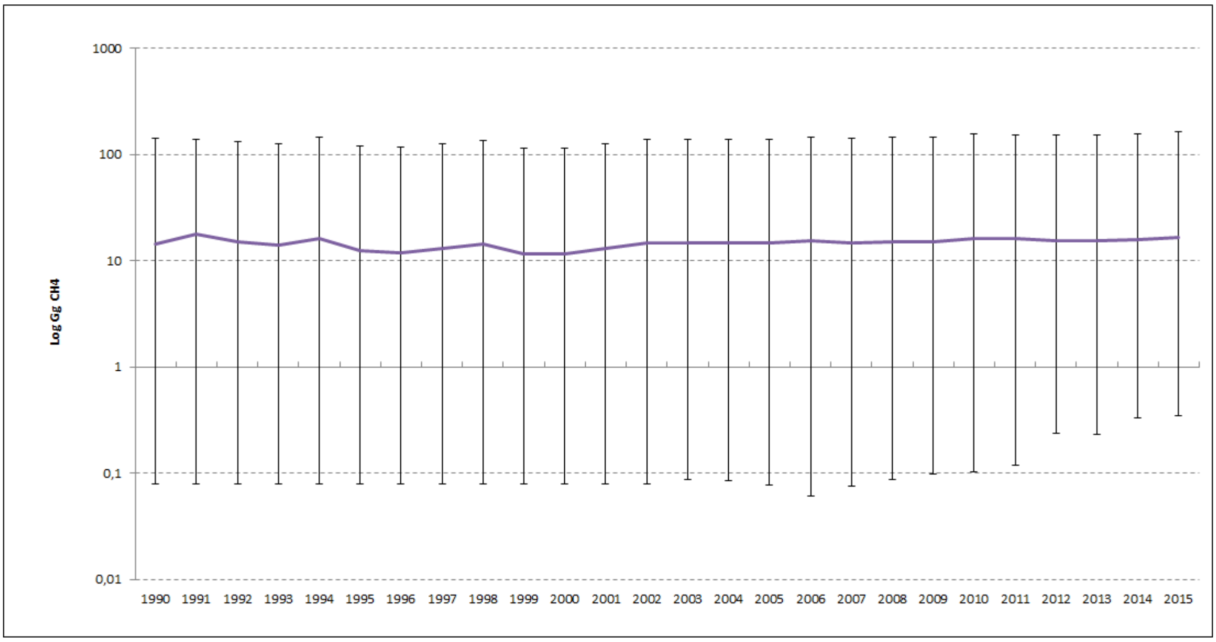



**Fig. 7-11 Maximum uncertainty range for 5.D.2 (log scale), 1990-2015**

#### *7.5.2.4 Source-specific QA/QC and verification*

Quality assurance entails structured checklists of activities, which are dated and signed by the sector reporter and verified by external control of the activity data. Activity data taken for this sector are approved by the data producer, who verifies them before they are used for calculation.

Because the waste sector is fairly small, we do not use an external subject to provide QC; instead QC is performed by a NIS coordinator and its results are communicated to the sectoral expert.

Activity data from national agencies and ministries are the subjects of internal QA/QC mechanisms but the NIS team has limited insights into them.

#### *7.5.2.5 Source-specific recalculations, including changes made in response to the review process*

The entire source category was recalculated. The recalculation was necessary because of the growing disparity between the methodological approach of tier 1 and the real data measured by MIT about usage of biogas from IWW. We recalculated the source category in a way that it is consistent with the measured data about biogas, expert knowledge about how IWW looks in practice and COD estimate by the Tier 1 approach. The difficulty with IWW is that a very limited amount of data is available, as industrial production is very vaguely defined and production of wastewater before treatment is not measured. Another reason was that ERT in last year's review suggested using MFC 0 for aerobic treatment, which effectively nullified the category, which is again in direct contradiction with the measured R and expert knowledge (and also examples from similar countries). Fig. 7-12 shows the emission development trajectories and gives a comparison between inventories submitted last year and this year's recalculation. Tab. 7-24 depicts relative effect of the recalculation for this source category.

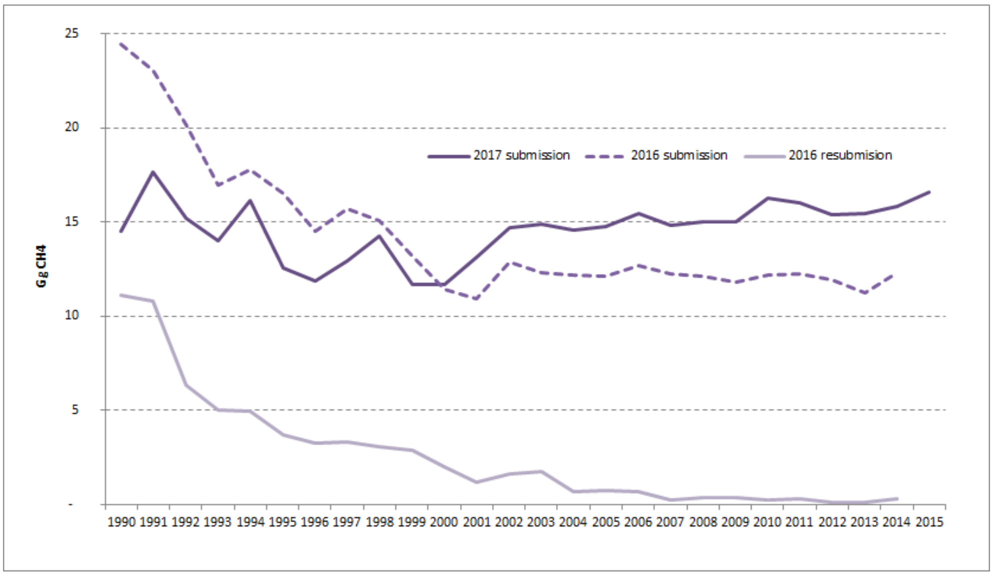



**Fig. 7-12 Recalculation for 5.D.2, 1990-2015**

**Tab. 7-24 Recalculation effect of 5.D.2 category**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 submission compared to 2016 submission | -41% | -24% | -25% | -17% | -9% | -24% | -18% | -17% | -5% | -11% | 2% | 20% | 14% |
| 2017 submission compared to 2016 re-submission | 31% | 63% | 140% | 180% | 225% | 239% | 264% | 292% | 358% | 304% | 473% | 1012% | 796% |

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 submission compared to 2016 submission | 21% | 19% | 22% | 22% | 21% | 24% | 27% | 34% | 31% | 29% | 37% | 29% |
| 2017 submission compared to 2016 re-submission | 734% | 1955% | 1825% | 2078% | 5601% | 3936% | 3953% | 5827% | 4939% | 9693% | 9582% | 4626% |

#### 7.5.2.6 Source-specific planned improvements, including those in response to the review process

It is planned to verify factor TOW derived from production statistics by comparison with real world data as the high uncertainty of this category and scarce data could mean that the top-down and bottom-up approaches will not match. Completing Monte-Carlo analysis of uncertainty in this category is another planned improvement. This activity has moderate priority.

## 7.6 Other (CRF 5.E)

This category is not relevant for the Czech Republic.

## 7.7 Long-term storage of carbon (CRF 5.F)

The long-term stored carbon in SWDS is reported as an information item in the Waste sector. Fossil and non-degradable biogenic carbon disposed in SWDS remains stored underground and does not contribute to anthropogenic climate change. The amount of carbon stored in SWDS is estimated by using the FOD model described in 5.A.1 using the same data described there. The data for 2013 were recalculated because of changes in the activity data (for details see 5.A.1). The results are shown in Tab. 7-1.

**Tab. 7-1 Long-term stored carbon, 1990-2015, Czech Republic**

| | Long-term stored carbon [Gg] | Accumulated Long-term stored carbon (since 1950) [Gg] |
|---|---|---|
| **1990** | 209 | 4 243 |
| **1991** | 210 | 4 453 |
| **1992** | 218 | 4 672 |
| **1993** | 224 | 4 895 |
| **1994** | 225 | 5 120 |
| **1995** | 230 | 5 351 |
| **1996** | 240 | 5 591 |
| **1997** | 249 | 5 839 |
| **1998** | 259 | 6 098 |
| **1999** | 247 | 6 345 |
| **2000** | 268 | 6 613 |
| **2001** | 276 | 6 889 |
| **2002** | 283 | 7 172 |
| **2003** | 285 | 7 457 |
| **2004** | 288 | 7 745 |
| **2005** | 293 | 8 038 |
| **2006** | 302 | 8 340 |
| **2007** | 321 | 8 660 |
| **2008** | 322 | 8 983 |
| **2009** | 330 | 9 313 |
| **2010** | 309 | 9 621 |
| **2011** | 289 | 9 910 |
| **2012** | 270 | 10 180 |
| **2013** | 261 | 10 441 |
| **2014** | 248 | 10 689 |
| **2015** | 242 | 10 932 |

# 8 Other (CRF sector 6)

No sector 6 is defined in the Czech inventory.

# 9 Indirect $CO_2$ and nitrous oxide emissions

## 9.1 Description of sources of indirect emissions in GHG inventory

The estimation of indirect $CO_2$ and $N_2O$ emissions is based on the official Czech inventories for the precursor gases (CO, NMVOC, $NH_3$ and $NO_x$) reported under the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the $CH_4$ emissions reported to the UNFCCC.

A detailed description of the methodology used to estimate these emissions should be available in Czech Informative Report (IIR), Submission under UNECE / CLRTAP Convention. Precursor gases totals correspond under both submissions, the differences between reporting formats (NFR-CRF) are taken into account.

In this chapter, indirect emissions and precursor gases are estimated from all sectors, except Agriculture and LULUCF, i.e. sectors Energy, IPPU and Waste. Tab. 9-1 presents a summary of emissions estimates for precursors and $SO_x$ for the period from 1990 to 2015 and the National Emission Ceiling (NEC) as set out in the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. These reduction targets should be met by 2010 by Parties to the UNECE / CLRTAP Convention signed this Protocol.

Emissions of precursor gases decreased in the period from 1990 to 2015, for NMVOC by 49.81%, for CO by 44.04% and for $NO_X$ by 72.31%. $SO_x$ (reported as $SO_2$) emissions decreased by 93.41% compared to 1990 level. $NH_3$ decreased by 93.13% in 2015 compared to the year 1990 (estimated data).

**Tab. 9-1 Precursor emissions and their trends from 1990 – 2015**

| | $NO_X$ | $NO_X$ w/o LULUCF | CO | CO w/o LULUCF | NMVOC | $SO_X$ | $NH_3$ |
|---|---|---|---|---|---|---|---|
| **1990** | 738.52 | 737.35 | 1068.65 | 1027.58 | 300.70 | 1870.91 | 65.72 |
| **1991** | 723.47 | 722.60 | 1153.05 | 1122.44 | 263.24 | 1767.49 | 40.13 |
| **1992** | 699.43 | 698.52 | 1158.34 | 1126.19 | 248.04 | 1554.42 | 20.92 |
| **1993** | 684.06 | 683.01 | 1189.96 | 1152.84 | 224.28 | 1466.04 | 11.46 |
| **1994** | 441.29 | 440.20 | 1070.96 | 1032.73 | 247.01 | 1284.80 | 9.71 |
| **1995** | 418.85 | 417.83 | 927.55 | 891.66 | 207.24 | 1090.23 | 8.18 |
| **1996** | 437.65 | 436.31 | 960.42 | 913.23 | 257.10 | 931.11 | 7.17 |
| **1997** | 461.65 | 460.21 | 976.32 | 925.43 | 263.80 | 977.45 | 8.91 |
| **1998** | 408.22 | 406.95 | 802.19 | 757.73 | 258.61 | 438.27 | 5.39 |
| **1999** | 375.14 | 373.98 | 720.98 | 679.86 | 239.94 | 264.35 | 5.89 |
| **2000** | 339.10 | 338.02 | 808.29 | 770.53 | 255.39 | 224.54 | 4.40 |
| **2001** | 339.67 | 338.56 | 834.33 | 795.04 | 254.72 | 223.85 | 4.43 |
| **2002** | 329.32 | 328.12 | 807.52 | 765.23 | 243.56 | 219.98 | 4.57 |
| **2003** | 329.89 | 328.39 | 840.69 | 787.77 | 240.24 | 215.59 | 4.86 |
| **2004** | 327.61 | 326.23 | 814.84 | 766.36 | 230.65 | 211.54 | 4.79 |
| **2005** | 320.54 | 319.23 | 773.13 | 726.87 | 223.33 | 208.26 | 4.91 |
| **2006** | 313.44 | 311.81 | 761.35 | 704.05 | 218.30 | 203.29 | 4.99 |
| **2007** | 311.59 | 309.48 | 784.66 | 710.17 | 212.14 | 208.78 | 5.09 |
| **2008** | 294.00 | 292.33 | 711.36 | 652.50 | 200.04 | 168.71 | 5.14 |
| **2009** | 272.20 | 270.78 | 660.24 | 610.54 | 189.23 | 165.87 | 5.06 |
| **2010** | 262.03 | 260.55 | 692.76 | 640.29 | 185.43 | 160.39 | 4.85 |
| **2011** | 248.02 | 247.36 | 610.98 | 587.77 | 169.32 | 160.53 | 4.83 |
| **2012** | 234.62 | 233.92 | 611.99 | 587.07 | 163.98 | 154.82 | 4.71 |
| **2013** | 222.35 | 221.69 | 617.46 | 594.38 | 161.60 | 138.03 | 4.53 |
| **2014** | 211.59 | 210.86 | 558.10 | 532.40 | 152.21 | 127.08 | 4.46 |
| **2015** | 204.47 | 203.66 | 598.07 | 569.40 | 150.92 | 123.29 | 4.52 |
| **Trend** | **-72.31%** | **-72.38%** | **-44.04%** | **-44.59%** | **-49.81%** | **-93.41%** | **-93.13%** |
| **NEC** | **286** | | **-** | | **220** | **265** | **101** |

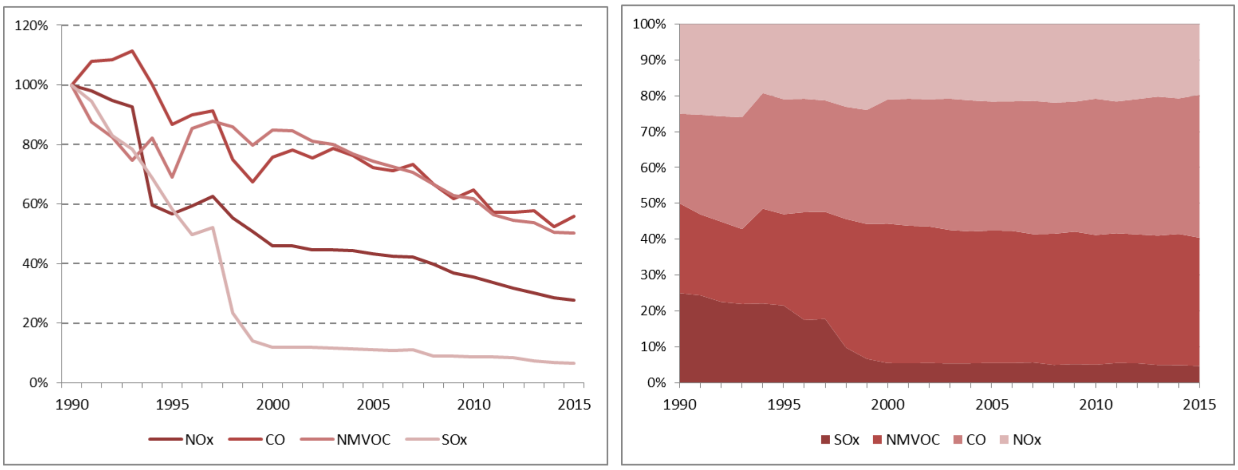



**Fig. 9-1 Indexed emissions of precursor gases for 1990-2015 (1990 =100%), [%] (left); Overall trend in percentual share of precursor gases (right)**

On Fig. 9-1 can be observed the overall decreasing trend, in percentage of precursor gases, where year 1990 is equal to 100%, further the overall trend in percentual share of total indirect GHG can be examined.

The categories with highest amounts of precursor gases for $NO_X$ are 1.A.1 Energy Industries, 1.A.3 Transport and 1.A.4 Other sectors; for CO are 1.A.2 Manufacturing industries and construction, 1.A.3

Transport, 1.A.4 Other sectors; for NMVOC are 1.A.3 Transport, 1.A.4 Other sectors and 2.D Non-energy products from fuels and solvent use; for $SO_X$ are 1.A.1 Energy industries, 1.A.2 Manufacturing industries and construction and 1.A.4 Other sectors. Total production from the main CRF categories can be seen on Tab. 9-2.

**Tab. 9-2 Precursor GHG emissions in sectors of origin for 2015**

| | $NO_X$ [Gg] | CO [Gg] | NMVOC [Gg] | $SO_X$ [Gg] | $NH_3$ [Gg] |
|---|---|---|---|---|---|
| **Total emissions** | **204.47** | **598.07** | **150.92** | **123.29** | **4.52** |
| **1. Energy** | 200.79 | 532.48 | 76.64 | 121.86 | 4.37 |
| **1A Fuel combustion** | 200.68 | 532.36 | 68.10 | 119.72 | 4.37 |
| **1A1 Energy Industries** | 55.09 | 10.12 | 5.19 | 78.55 | 0.01 |
| **1A2 Manufacturing industries and construction** | 22.22 | 108.58 | 1.57 | 19.30 | 0.15 |
| **1A3 Transport** | 78.33 | 132.70 | 31.72 | 0.27 | 4.20 |
| **1A4 Other sectors** | 44.84 | 280.81 | 29.61 | 21.60 | 0.01 |
| **1A5 Other** | IE | IE | IE | IE | IE |
| **1B Fugitive emissions from fuels** | 0.12 | 0.12 | 8.54 | 2.13 | 0.00 |
| **2. Industrial processes and product use** | 2.73 | 36.90 | 72.68 | 1.42 | 0.14 |
| **2A Mineral industry** | 0.23 | 0.01 | 0.08 | 0.09 | 0.04 |
| **2B Chemical industry** | 1.26 | 0.15 | 1.62 | 0.85 | 0.08 |
| **2C Metal industry** | 1.16 | 36.63 | 0.23 | 0.46 | 0.00 |
| **2D Non-energy products from fuels and solvent use** | 0.00 | 0.00 | 70.51 | 0.00 | 0.00 |
| **2G Other product manufacture and use** | 0.07 | 0.10 | 0.25 | 0.03 | 0.02 |
| **3. Agriculture** | - | - | - | - | - |
| **4. LULUCF** | 0.81 | 28.67 | - | - | - |
| **5.Waste** | 0.13 | 0.02 | 1.59 | 0.01 | 0.00 |

## 9.2 Production of indirect emissions from precursor gases

### 9.2.1 Indirect $N_2O$ emissions from nitrogen oxides

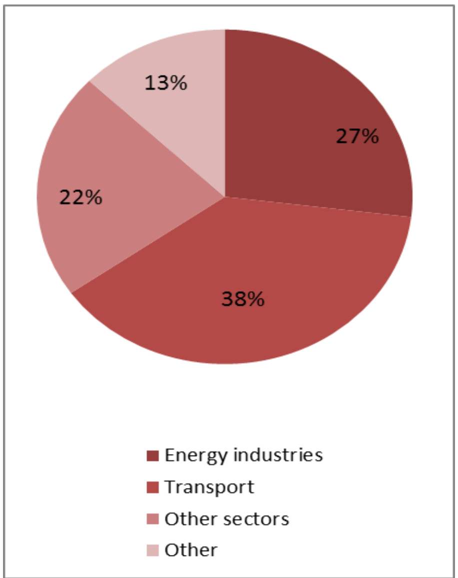



**Fig. 9-2 The share of sectors on NOx emissions in 2015**

Emissions of $NO_X$ are formed during the combustion of fuels, depending on the temperature of combustion, the content of nitrogen in fuels and the excess of combustion air. $NO_X$ emissions decreased from 739 to 204 kt during the period 1990 - 2015. In 2015, $NO_X$ emissions were 72.31% below the 1990 level. Slightly more than 98% of total $NO_X$ emissions originate from 1. Energy, mainly subsectors 1.A.1 Energy industries (26.9%), with subsector 1.A.1a Public electricity and heat production (25.0%); 1.A.3 Transport (38.3%), highest part, represented by 1.A.3.b Road transportation (36.5%) and 1.A.4 Other sectors (21.9%), mainly from 1.A.4.c Agriculture/Forestry/Fishing (15.8%) (Fig.9-2). Hence the indirect $N_2O$ emissions correspondingly decreased from 3.53 to 0.97 kt in 2015.

### 9.2.2 Indirect $N_2O$ from ammonia

Emissions of anthropogenic $NH_3$ for 2015 are mainly produced from categories: 1.A.3 Transport (92.95%), where 99.98% from the total production comes from 1.A.3.b Road transport and 1.A.2 Manufacturing industries and construction (3.34%) (Fig. 9-3). In 2015, emissions of $NH_3$ were 4.52 kt. The declining trend of the emissions is calculated based on the latest research of $NH_3$ emissions in the period between 1990 and 2000.

Total indirect $N_2O$ emissions from $NH_3$ for 2015 are 0.06 kt.

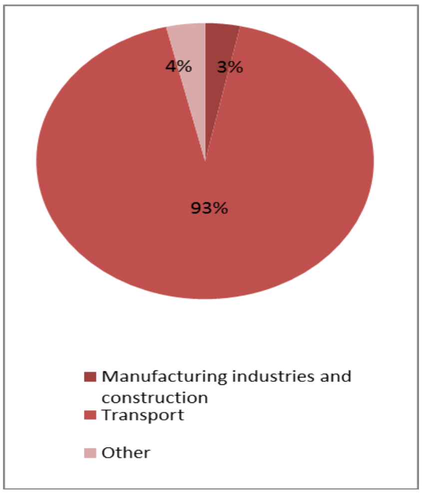



**Fig. 9-3 The share of sectors on $NH_3$ emissions in 2015**

### 9.2.3 Indirect $CO_2$ from carbon monoxide

Emissions of CO are produced during the combustion of carbon-containing fuels at low temperatures and by insufficient amount of combustion air. CO emissions decreased from 1,068 to 598 kt during the period 1990 - 2015. In 2015, CO emissions were 44.03% below the 1990 level. In 2015, approximately 89% of total CO emissions originated from 1. Energy, subsectors 1.A.2 Manufacturing industries and construction (18.2%); 1.A.3 Transport (22.2%), mostly resulting from 1.A.3.b Road transportation (21.9%) and 1.A.4 Other sectors (47.0%), mainly from 1.A.4.b Stationary: Residential stationary combustion (42.6%) (Fig. 9-4). Further subsector 2.C Metal industry contributes with 6.1% to the total emissions. Total indirect $CO_2$ emissions from CO in 2015 are 58.2 kt, which is 83.3% less than 1990.

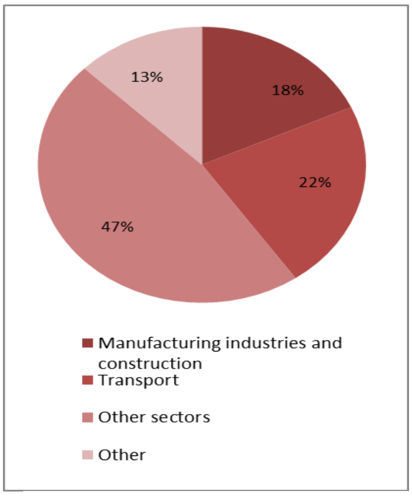



**Fig. 9-4 The share of sectors on CO emissions in 2015**

### 9.2.4 Indirect $CO_2$ from non-methane volatile organic compounds

NMVOC emissions decreased from 301 to 151 kt during the period between 1990 and 2015. In 2015, NMVOC emissions were 49.81% below the 1990 level. There are two main emission source categories: firstly 2. Industrial processes and product use (48.2% of the national total, with main subsector 2.D Non-energy products from fuels and solvent use, representing 46.7%) and secondly 1. Energy (50.8% - mainly subsectors 1.A.3 Transport (21.0%) and 1.A.4 Other sectors (19.6%) (Fig. 9-5). The release of NMVOC emissions is partly regulated, but most of these pollutants are released in the form of fugitive emissions and their reduction is difficult. NMVOC emissions are also produced by insufficient combustion of fossil fuels. Total indirect emissions from NMVOC in 2015 are 179 kt, which is 56.9% less than 1990.

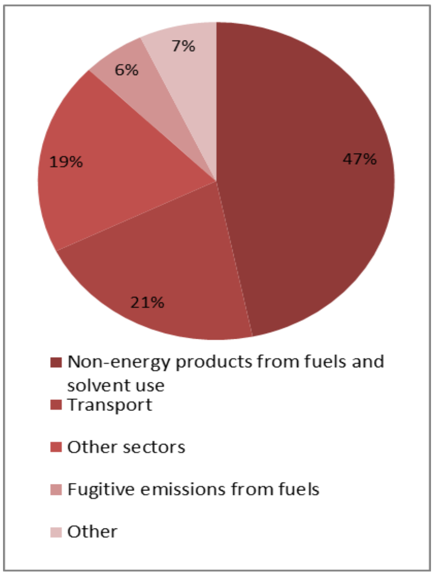



**Fig. 9-5 The share of sectors on NMVOC emissions in 2015**

### 9.2.5 Indirect $CO_2$ from methane

$CH_4$ emissions, used for the calculation of indirect emissions are mainly produced from categories 1.B.1 Solid fuels. For more information on $CH_4$ emissions, consult respective chapters. Total indirect $CO_2$ emissions from $CH_4$ produced in 2015 are 561.5 kt, which is 65.4% less than in 1990.

## 9.3 Production of indirect $CO_2$ and $N_2O$ emissions from source categories

Estimations of indirect $CO_2$ and $N_2O$ for the whole time series for each sector can be observed on Tab. 9-3.

**Tab. 9-3 Time series and trend of indirect emissions per sector and total**

| | Energy | | IPPU | | Waste | | Total | |
|---|---|---|---|---|---|---|---|---|
| | $CO_2$ [kt] | $N_2O$ [kt] | $CO_2$ [kt] | $N_2O$ [kt] | $CO_2$ [kt] | $N_2O$ [kt] | $CO_2$ [kt] | $N_2O$ [kt] |
| **1990** | 1276.64 | 4.26 | 747.22 | 0.11 | 97.88 | 0.006 | 2121.74 | 4.38 |
| **1991** | 1129.40 | 3.87 | 775.40 | 0.10 | 106.35 | 0.005 | 2011.15 | 3.98 |
| **1992** | 1070.36 | 3.52 | 804.33 | 0.09 | 99.45 | 0.004 | 1974.13 | 3.61 |
| **1993** | 1051.06 | 3.33 | 776.02 | 0.09 | 96.16 | 0.004 | 1923.23 | 3.42 |
| **1994** | 1002.41 | 2.16 | 640.85 | 0.07 | 101.94 | 0.004 | 1745.20 | 2.23 |
| **1995** | 987.56 | 2.05 | 665.74 | 0.06 | 91.89 | 0.004 | 1745.19 | 2.11 |
| **1996** | 968.50 | 2.12 | 659.09 | 0.06 | 89.92 | 0.004 | 1717.51 | 2.18 |
| **1997** | 951.15 | 2.26 | 657.77 | 0.06 | 92.62 | 0.004 | 1701.54 | 2.32 |
| **1998** | 916.91 | 1.97 | 537.97 | 0.05 | 95.46 | 0.004 | 1550.34 | 2.02 |
| **1999** | 836.57 | 1.82 | 475.76 | 0.05 | 88.10 | 0.003 | 1400.44 | 1.87 |
| **2000** | 779.61 | 1.66 | 288.00 | 0.02 | 87.94 | 0.001 | 1155.54 | 1.67 |
| **2001** | 737.86 | 1.66 | 285.48 | 0.01 | 91.74 | 0.001 | 1115.07 | 1.68 |
| **2002** | 688.22 | 1.61 | 279.11 | 0.01 | 93.98 | 0.001 | 1061.31 | 1.63 |
| **2003** | 679.36 | 1.62 | 272.46 | 0.01 | 94.55 | 0.001 | 1046.37 | 1.64 |
| **2004** | 649.13 | 1.61 | 264.53 | 0.01 | 92.83 | 0.001 | 1006.49 | 1.62 |
| **2005** | 699.85 | 1.57 | 291.50 | 0.02 | 91.86 | 0.001 | 1083.21 | 1.59 |
| **2006** | 722.50 | 1.54 | 281.11 | 0.02 | 93.37 | 0.001 | 1096.98 | 1.56 |
| **2007** | 675.92 | 1.53 | 281.47 | 0.01 | 91.53 | 0.001 | 1048.92 | 1.55 |
| **2008** | 671.98 | 1.45 | 262.98 | 0.01 | 91.82 | 0.001 | 1026.78 | 1.46 |
| **2009** | 630.96 | 1.35 | 236.90 | 0.01 | 92.13 | 0.001 | 959.99 | 1.36 |
| **2010** | 636.69 | 1.30 | 236.00 | 0.01 | 94.75 | 0.001 | 967.43 | 1.31 |
| **2011** | 632.76 | 1.23 | 220.33 | 0.01 | 92.96 | 0.001 | 946.05 | 1.25 |
| **2012** | 608.88 | 1.17 | 203.66 | 0.01 | 91.86 | 0.001 | 904.39 | 1.18 |
| **2013** | 509.47 | 1.11 | 210.34 | 0.01 | 91.59 | 0.001 | 811.39 | 1.12 |
| **2014** | 493.58 | 1.05 | 191.62 | 0.01 | 92.48 | 0.001 | 777.69 | 1.07 |
| **2015** | 480.29 | 1.02 | 223.70 | 0.01 | 94.71 | 0.001 | 798.70 | 1.03 |
| **Trend** | -62.4% | -76.1% | -70.1% | -86.8% | -3.2% | -89.8% | -62.4% | -76.4% |

In all sectors is noticed a decrease in emissions, only in Waste sector the trend is more or less steady.

On Fig. 9-6 is visually presented percentual division of indirect emissions of $CO_2$ and $N_2O$ between the examined sectors.

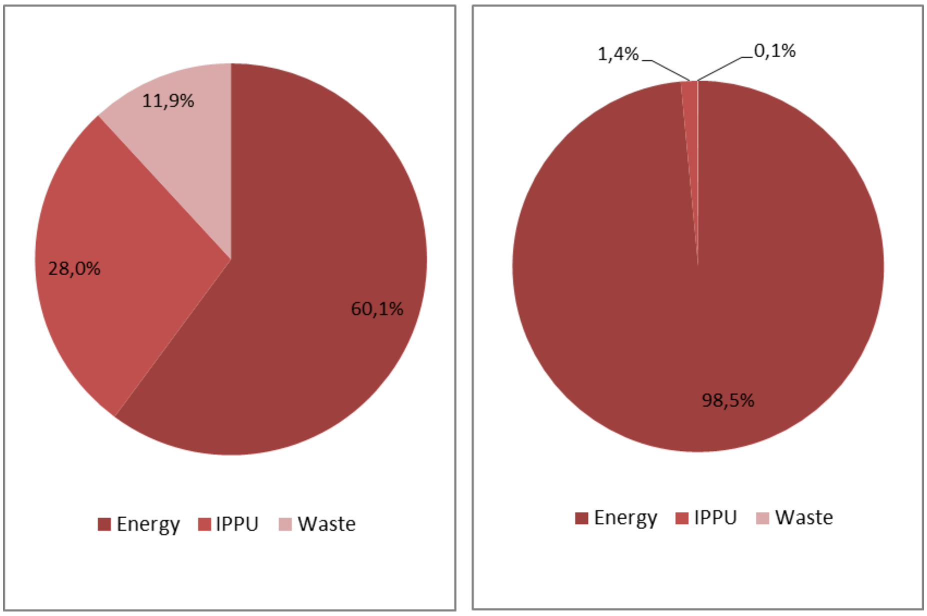



**Fig. 9-6 Division of indirect emission of $CO_2$ (left) and $N_2O$ (right) between the producing sectors for 2015 (in %)**

Energy sector covers 60.1% of the total production of indirect $CO_2$ and 98.5% of the total production of indirect $N_2O$. 99.9% of the $N_2O$ emissions from Energy are from 1.A Fuel combustion; 42.2% from which are from 1.A.3 Transport, followed by 1.A.1 Energy industries (25.9%) and 1.A.4 Other sectors (21.1%).

For sector IPPU, the main category, producing indirect $CO_2$ is 2.D Non-energy products from fuels and solvent use, with its NMVOC production, resulting to 69.5% of the total production from this sector. The distribution of the production of indirect $CO_2$ from sector 2.D is visually presented on fig.1-8. The most of the remaining emissions from the sector are attributed to category 2.C Metal industry (26.6%).

Indirect $N_2O$ emissions from IPPU are divided between the two categories: 2.B Chemical industry (47.3%) and 2.C Metal industry (37.2%). The total share of IPPU sector from the total production of indirect $CO_2$ is 28.0% and concerning indirect $N_2O$ is 1.4%.

Sector Waste represents 11.9% from the total indirect $CO_2$ emissions and 0.06% from total $N_2O$ emissions. Almost 100% from the Waste production of indirect $CO_2$ emissions are emitted from category 5.D Wastewater treatment and discharge and 97.7% from the indirect production of $N_2O$ are produced from category 5.C Incineration and open burning of waste.

## 9.4 Methodological issues

The above reported data is obtained from the Czech Informative Report (IIR), Submission under UNECE / CLRTAP Convention. The inventory is performed every year, in accordance with the national legislation for the prevention of air polluting and reduction of air pollution from 2012. The inventory combines the direct approach, i.e. the collection of data reported by the sources operators with the data from model calculations based on data, reported by the sources operators or gained within statistical surveys, carried out primarily by CzSO. The results of emission inventories are presented as emission balances processed according to various territorial and sector structures. Further, after obtaining the data, synchronization between the two reporting systems categorization (NFR-CRF) is conducted.

### 9.4.1 Indirect $CO_2$ emissions

Indirect emissions of $CO_2$ were calculated using the default IPCC Tier 1 method. The following equations were used for calculating the indirect emissions, respectively from CO, $CH_4$ and NMVOC.

$$Emissions_{CO2} = Emissions_{CO} \cdot \frac{44}{28}$$

$$Emissions_{CO2} = Emissions_{CH4} \cdot \frac{44}{16}$$

$$Emissions_{CO2} = Emissions_{NMVOC} \cdot Percent\ carbon\ in\ NMVOC\ by\ mass \cdot \frac{44}{12}$$

where percent carbon in NMVOC used for sectors Energy, IPPU (except category 2.D) and Waste is the default 60% given in IPCC 2006 Gl.

For estimation of indirect emissions from NMVOC from category 2.D Non-energy products from fuels and solvent use, it was assumed for years 1990-2015 that the average percent of carbon content is 80% by mass based on 2006 IPCC Guidelines. This factor was used for subcategories:

- Asphalt roofing
- Road paving

For the other subcategories of 2.D it was assumed for the whole time period that the average carbon content is 60% by mass according to the 2006 IPCC Guidelines and it was used for the following NFR categories:

- Domestic solvent use including fungicides
- Coating applications
- Degreasing
- Dry cleaning
- Chemical products
- Printing
- Other solvent use.

### 9.4.2 Indirect $N_2O$ emissions

The indirect $N_2O$ emissions from atmospheric deposition of nitrogen other than agriculture and LULUCF sources are estimated based on the amount of nitrogen emitted in the country multiplied with an emission factor, assuming 1% (default) of the nitrogen in the emissions to be converted to $N_2O$. The calculation method is the IPCC default Tier 1. Indirect $N_2O$ emissions were calculated using equation 7.1 (IPCC 2006, Vol. 1, section 7.3.1.).

## 9.5 Uncertainties and time-series consistency

In the process of calculation of emission inventories, data provided by the operators of stationary sources of air pollution, statistic data of the Czech Statistical Office (data on fuel consumption, number of vehicles, number of livestock and area of cultivated land) and data from the Population and housing census which was conducted in 2011 (information on household heating) are used. Further, emission factors and other sources of data are applied.

The data, from which the inventory has been compiled, are of varying quality. Emissions of individual point sources set on the basis of measurements are determined with less uncertainty than the emissions calculated on the basis of statistical data. The uncertainty of the emissions from point sources is below 5% (e.g. emissions from large combustion sources), the uncertainty of emission data based on a sophisticated model (e.g. emissions from household heating and exhaust emissions from transport) ranges between 10–15%. The uncertainty of emissions calculated from statistical data and predefined emission factors is estimated according to the methodology of the EMEP/EEA air pollutant emission inventory guidebook and ranged from 50 up to 200% (e.g. emissions from the use of solvents, animal production and non-combustion emissions from transport).

## 9.6 Source-specific QA/QC and verification

The emission estimates are based on the activity data taken from the Czech Informative Report (IIR), Submission under UNECE / CLRTAP Convention and follow the recommendations and QA/QC procedures of IPCC 2006 Guidelines (IPCC 2006). Source specific QA/QC is conducted in line with the QA/QC plan (Tier 1) of the National Inventory System.

## 9.7 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

The time series of indirect $CO_2$ and $N_2O$ emissions were recalculated for the whole time period 1990-2015, following the recommendations of the ERT, during EU and UNFCCC reviews and due to obtaining of more reliable data. Comparison of the total indirect emissions in $CO_2$ eq. reported in previous and current submissions can be observed on Fig. 9-7.

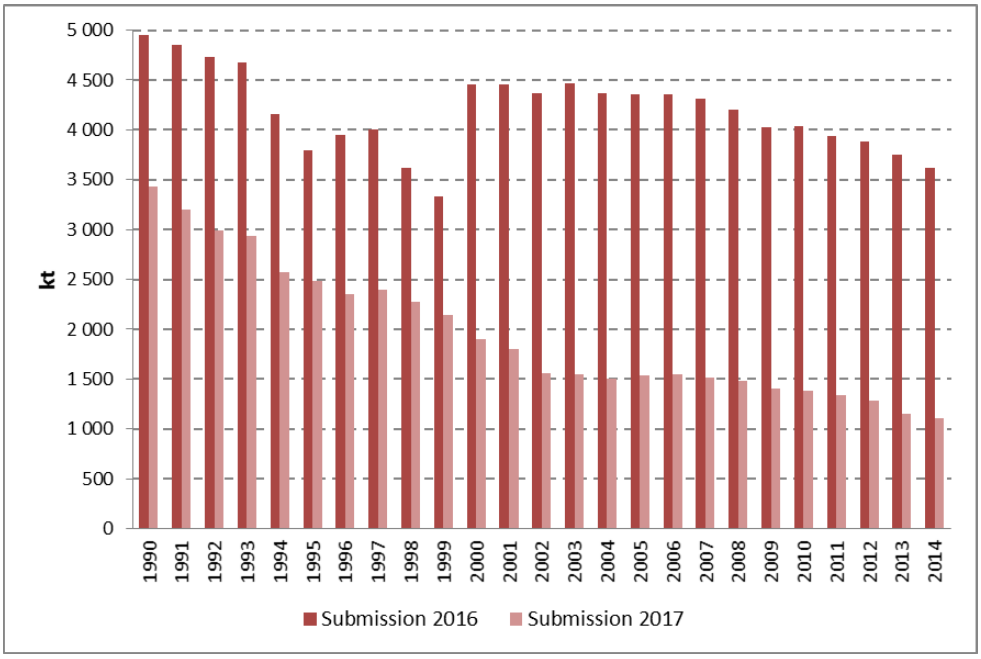



**Fig. 9-7 Comparison of total indirect emissions in $CO_2$ eq. between previous and current submissions**

Significant difference is observed for the whole time period due to the recalculations performed in this submission, following the recommendations received during the EU and UNFCCC reviews and research performed on data for $NH_3$ emissions for the whole period. In the previous submission only data for $NH_3$

emissions since 2000 were available. The percentual decrease between the two submissions can be observed on Tab. 9-4.

**Tab. 9-4 Percentual decrease between last and current submission**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2016 [kt $CO_2$ eq.]** | 4952 | 4856 | 4728 | 4674 | 4157 | 3800 | 3953 | 4006 | 3621 | 3336 | 4451 | 4459 | 4369 |
| **Submission 2017 [kt $CO_2$ eq.]** | 3427 | 3197 | 2994 | 2941 | 2574 | 2483 | 2350 | 2401 | 2273 | 2139 | 1904 | 1805 | 1556 |
| **Decrease** | 31% | 34% | 37% | 37% | 38% | 35% | 41% | 40% | 37% | 36% | 57% | 60% | 64% |
| | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | |
| **Submission 2016 [kt $CO_2$ eq.]** | 4467 | 4364 | 4358 | 4352 | 4314 | 4200 | 4031 | 4038 | 3938 | 3887 | 3756 | 3604 | |
| **Submission 2017 [kt $CO_2$ eq.]** | 1547 | 1505 | 1539 | 1544 | 1520 | 1481 | 1410 | 1385 | 1334 | 1288 | 1155 | 1107 | |
| **Decrease** | 65% | 66% | 65% | 65% | 65% | 65% | 65% | 66% | 66% | 67% | 69% | 69% | |

## 9.8 Source-specific planned improvements, including in response to the review process

Planned improvements for the future submissions is detailed examination of the indirect emissions produced from the individual categories.

# 10 Recalculations and improvements

The driving forces in applying recalculations in the Czech greenhouse gas inventory are provided by the implementation of the guidance given in the IPCC 2006 Guidelines (IPCC, 2006) and the recommendations from the UNFCCC inventory reviews. Recalculations of previously submitted inventory data are performed following the above-mentioned IPCC manuals only to improve the GHG inventory.

The driving forces in applying recalculations in the Czech greenhouse gas inventory are provided by the implementation of the guidance given in the IPCC *Good Practice Guidance* reports (IPCC, 2000; IPCC, 2003) and the recommendations from the UNFCCC inventory reviews.

Even though a QA/QC system helps to eliminate potential error sources, it is sometimes necessary to make some revisions (called recalculations) under the following circumstances:

- An emission source was not considered in the previous inventory.
- A source/data supplier has delivered new data. This could be because the previous data were only preliminary data (by estimation, extrapolation) or because the method of data collection has been improved.
- Some errors in data transfer or processing have been identified: wrong data, unit-conversion, software errors, etc.
- Methodological changes - when a new methodology must be applied to fulfil the reporting obligations for one of the following reasons:
    - to decrease uncertainties,
    - an emission source becomes a key source,
    - consistent input data needed for applying the methodology is no longer accessible,
    - input data for more detailed methodology is now available,
    - the methodology is no longer appropriate.

## 10.1 Explanations and justifications for recalculations, including in response to the review process

### 10.1.1 Recalculation performed in the submission 2014

#### *10.1.1.1 Recalculation in sector 1.A Energy– stationary combustion*

Expert review team (ERT) during Centralised review in September 2012 raised objection to using IPCC 2006 default emission factors instead of Revised 1996 Guidelines (IPCC, 1997) default emission factors in 1995-2010 period. This issue was identified as potential problem in Saturday paper. In following resubmission in October 2012 the recalculation of the whole sector 1.A Energy – stationary combustion was provide using Revised 1996 Guidelines (IPCC, 1997) default emission factors. Country specific emission factors are used for Coking Coal, Other Bituminous Coal, Brown Coal + Lignite and since this submission also for Natural Gas. For the rest of fuels (rest of Solid Fuels, Liquid Fuels and Biomass) were used default emission factors.

This recalculation also affected Reference Approach where emission factors were also revised.

#### 10.1.1.2 Recalculation of gaseous fuel in 1.A Energy

Another improvement provided by the Czech Republic consists in new country specific $CO_2$ emission factor for Natural Gas. The extensive research was performed using data of Natural Gas composition provided by NET4GAS, Ltd. company. This research was part of project assigned by State Environmental Fund of the Czech Republic. Detailed description of the research is given in Annex 2.

Since this submission updated emission factor is used for all categories in 1.A Energy.

#### 10.1.1.3 Recalculation/reallocation of solid fuels in sectors 1.A.1.c Energy - Manufacture of Solid Fuels and Other Energy Industries and 1.A.2 Energy- Manufacturing Industries and Construction

One of the improvements implemented by the Czech Republic considers reallocation of solid fuels and associated emissions between 1.A.1.c and 1.A.2. During QA/QC procedure Energy balance in these two sectors was compared with data provided by Czech Register of individual Sources and Emissions. This QA/QC discovered discrepancy in reporting of solid fuels in 1995-2010 period. There is one installation in CR for which solid fuels are in official statistics (CzSO Questionnaires) included in 1.A.2 autoproducers. The QA/QC procedure ascertained that this consumption of solid fuels should be included in 1.A.1.c category; in this submission solid fuels were reallocated. This reallocation affects consumption of solid fuels and associated emissions in 1.A.1.c category and in 1.A.2.a-1.A.2.f (autoproducers consumption).

#### 10.1.1.4 Recalculation in sector 1.A.2.c Energy - Manufacturing Industries and Construction, Chemicals

The ESD review team discovered during ESD review (June 2012) double counting of naphtha. Part of the naphtha is used as feedstock and as liquid fuels in 1.A.2.c, but instead of taking 20%, we had incorrectly taken 70% (in 2005) or 80% (in 2008-2010) of the naphtha as oxidized. This issue is now addressed in this submission.

#### 10.1.1.5 Recalculation in 1.A.3 Energy - Road Transportation - Diesel Oil

QC/QC procedures identified typographic error in this category - $N_2O$ emissions, 2010. This issue has been rectified.

#### 10.1.1.6 Recalculation in sector 1.A.4.b Energy - Other Sectors, Residential

Expert review team (ERT) during Centralized review in September 2012 raised recommendation to include emissions associated with charcoal use. This issue was noted as potential problem in Saturday paper. In following resubmission (October 2012) the $CH_4$ and $N_2O$ emissions were included in this subcategory using FAOSTAT data and Revised 1996 Guidelines (IPCC, 1997) default emission factors. To ensure consistency in reporting of greenhouse gases in this submission are included also $CO_2$ emissions using country specific emission factor.

#### 10.1.1.7 Recalculation in sector 1.A.D Energy - Feedstocks and non-energy use of fuels

In category 1.A.D 10 Other was necessary to provide recalculation for Other Oil (Solvents) in 2010 since in 3 Solvent and Other Product Use sector was performed recalculation due to ERT recommendation. Detailed information please see under description of sector 3 recalculations.

#### 10.1.1.8 Recalculation in sector 1.B.1.b Energy – Fugitive Emissions from Solid Fuels, Solid Fuel Transformation

Expert review team (ERT) raised recommendation during Centralized review in September 2012 to include emissions associated with charcoal production, which was also identified as potential problem. In following resubmission the emissions were included in this subcategory using FAOSTAT data and Revised 1996 Guidelines (IPCC, 1997) default emission factors.

#### 10.1.1.9 Recalculation in sector Cement Production (2.A.1)

In this submission the recalculation of $CO_2$ emissions was performed. In 2003-2005 period was discovered computational error, which was now corrected.

#### 10.1.1.10 Recalculation in sector Soda Ash Use (2.A.4.2)

The activity data for this category were verified for 2009 and 2010, which introduced also recalculation of $CO_2$ emissions.

#### 10.1.1.11 Recalculation in sector Other – Glass Production (2.A.7.1)

For 2005 was found the error in reported $CO_2$ emissions in this category. This discrepancy was corrected in this submission.

#### 10.1.1.12 Recalculation in sector 2.F.3 Industrial Processes, Fire Extinguishers

Technical Expert Review Team (TERT) raised recommendation during ESD review in July 2012 to include split for 1$^{st}$ filled products/serviced products based on ratio recorded in previous years. The exact numbers were unknown for 2009 and 2010, but over previous period the ratio is very stable. This issue has been rectified.

#### 10.1.1.13 Recalculation in sector 3 Solvent and Other Product Use

QC/QC procedures identified typographic errors in this sector – $CO_2$ emissions, 2010. This issue has been rectified.

#### 10.1.1.14 Recalculation in sector 4 Agriculture

During the centralized review in September 2012, the expert review team (ERT) identified as a potential problem the estimation of $N_2O$ Direct emissions from Agricultural soils. The ERT noted that: i) the Czech Republic has not included N-fixing forage crops such as alfalfa and clover in the calculations of $N_2O$ emissions for the entire time series and ii) the Czech Republic has not included potatoes and sugarbeet crops produced in the country in the estimations of $N_2O$ emissions from crop residues returned to soils for the entire time series. The revision of these emission categories was requested. The recalculation was submitted to ERT as a resolved issue of the “Saturday paper” regarding the 2012 NIR submission.

The ERT provided recommendations to improve the inventory estimates for Agriculture. Based on these recommendations and new obtained country-specific data, the following improvements were implemented in the 2013 submission:

1) N-fixing forage crops such as alfalfa and clover were included in the calculations of $N_2O$ emissions for the entire time series and

3) Potatoes and sugarbeet crops produced in the country were included in the estimations of $N_2O$ emissions from crop residues returned to soils for the entire time series

The "Saturday paper" recalculation led to increased emissions in 4.D.1 category (Direct emissions from agricultural soils) after recalculation by 6.9% in 2010. Using the above changes, the $N_2O$ direct emissions from Agricultural soils were calculated with Tier 2 method for the entire reporting period.

#### *10.1.1.15 Recalculation in sector 4.D Agricultural Soils (4.D.1.3, 4.D.1.4)*

The estimation of $N_2O$ Direct emissions from Agricultural soils for 1990-2010 was performed using the statistical crop production data and country-specific parameters.

***Category 4.D.1.3***

IPCC GPG was applied and available information on production of crops (alfalfa and clover) and national values were used to estimate $N_2O$ emissions. The information of production comes from Czech Statistical Office (CzSO). The country-specific data of the fraction of nitrogen (FracNCRBF); and the fraction of dry matter content (FracDM) in aboveground biomass of forage crops were applied to the emission inventory. For the fraction of dry matter and fraction of nitrogen, the materials (results of research projects) of Faculty of Agronomy, South Bohemia University (Jeteloviny –internal/study material, www.zf.jcu.cz), were used.

The equation used to estimate direct $N_2O$ emissions from Agricultural soils (N-fixing crops) has form

$$FBN = Crop * FracDM * FracNCRBF.$$

***Category 4.D.1.4***

$N_2O$ Direct Soil Emissions from Crop Residue (potatoes and sugarbeet) were estimated applying the IPCC GPG and using available information on crop production. The source of information is Czech Statistical Office (CzSO). The default emission factors were used in accordance with the IPCC GPG methodology.

The equation 4.29 (Tier 1b, GPG IPCC 2000, page 4.59) of the IPCC GPG was used to estimate these emissions. The default $N_2O$ emission factor for both crops (Table 4-17, IPCC 2000 GPG, page 4.60), the default values for the fractions of nitrogen in potatoes and sugarbeet (Table 4-16, IPCC 2000 GPG, page 4.58) and default fraction of crop residue that is removed from the field as crop (Table 4-17, IPCC 1997, Reference Manual, page 4.85) were used. The country- specific data for dry matter fraction was used: The value of FracDM for potatoes is based on study Cabajova, MU LF Brno (2009) and corresponds to other available sources. The value of FracDM for sugarbeet is based on study Blaha, CZU Praha (1986) and corresponds to other available sources. Both national parameters belong to interval of IPCC default values. The fraction of crop residue that is burned on the field equals zero.

#### *10.1.1.16 Recalculation in sector 5 "LULUCF" (5.G)*

No explicit recalculation was performed in this submission. However, the QC/QC procedures identified a typographic error in the category 5.A.1 Carbon stock change in living biomass, year 2010. Therefore, this issue was rectified.

### 10.1.2 Recalculation performed in the submission 2015

#### *10.1.2.1 Recalculation in sector 1.A Energy (1.A excluding 1.A.3)*

##### 10.1.2.1.1 Recalculations due to response to the last review process

***Recalculation of $N_2O$ emissions in 1.A.1.b Petroleum Refining sector***

As a response to the findings in Saturday paper provided by ERT from review process 2014, one recalculation in the Energy sector was performed. The mistake was caused during the transmission of the data into the CRF Reporter in the last submission. The correction was provided in 6 weeks after obtaining of the Saturday paper.

##### 10.1.2.1.2 Recalculation *caused by implementation of IPCC 2006 Guidelines*

***Change of the structure in the Sectoral approach***

Sector **1.A.1.a Main Activity Electricity and Heat Production** is based on the IPCC 2006 Gl. split into three subsectors:

1.A.1.a.i Electricity Generation
1.A.1.a.ii Combined Heat and Power Generation (CHP)
1.A.1.a.iii Heat Plants

Activity data and greenhouse gas emission estimates were in this submission reported in the subsector 1.A.1.a.i Electricity Generation since the differentiation between all three subsectors in the official data from CzSO is not considered to be reliable. The distribution of the data into all three subsectors is included in the current Improvement plan.

Sector **1.A.1.c Manufacture of Solid Fuels and Other Energy Industries** is based on the IPCC 2006 Gl. split into two subsectors:

1.A.1.c.i Manufacture of Solid Fuels
1.A.1.c.ii Other Energy Industries

Activity data and greenhouse gas emission estimates were in this submission reported in the subsector 1.A.1.c.i Manufacture of Solid Fuels since the differentiation between the subsectors in the official data from CzSO is not considered to be reliable. The distribution of the data into all three subsectors is included in the current Improvement plan.

The amount of subsectors in **1.A.2 Manufacturing Industries and Construction** increased from originally six (1.A.2.a till 1.A.2.f) to 13 (1.A.2.a till 1.A.2.m).

In the current submission was added just one subsector:

1.A.2.f Non-Metallic Minerals

All other subsectors 1.A.2.g till 1.A.2.m were reported in one v subsector

1.A.2.g Non-specified Industry

Validity of the data in official Energy balance provided by CzSO will be examined. The distribution of the data into all subsectors is included in the current Improvement plan.

Sector **1.A.4.c Agriculture/Forestry/Fishing** is based on the IPCC 2006 Gl. split into three subsectors:

1.A.4.c.i Stationary
1.A.4.c.ii Off-road Vehicles and Other Machinery

1.A.4.c.iii Fishing (mobile combustion)

Until now the activity data from mobile sources in Agriculture, Forestry and Fishing in the CR was reported in the sector 1.A.5. This division was used in order to differentiate the activity data from stationary combustion and from mobile combustion. In the new structure are used the sectors 1.A.4.c.i (original data for subsector 1.A.4.c) a 1.A.4.c.ii (original data were reported under 1.A.5.b Agriculture, Forestry and Fishing).

Sector **1.A.5 Non-Specified** is in the IPCC 2006 Gl. Split to

1.A.5.a Stationary
1.A.5.b Mobile

Subsector 1.A.5.a is not used, since all data about combustion processes were distributed in between the sectors 1.A.1 till 1.A.4. Subsector 1.A.5.b is further split into subsectors:

1.A.5.b.i Other mobile sources not included elsewhere
1.A.5.b.ii Agriculture and Forestry and Fishing

In the subsector 1.A.5.b.i are reported all emissions from the combustion in air transport, which are not included in 1.A.3. Subsector 1.A.5.b ii includes the sources not included in 1.A.4 subsector.

Described changes were performed in the whole time-series.

**Change of emission and oxidation factors**

IPCC 2006 Guidelines include updated emission factors for $CO_2$, $CH_4$ and $N_2O$. In case, where the country-specific emission factors are available, they are used for emission estimations. In other cases are used default emission factors.

Oxidation factors provided by IPCC 2006 Guidelines are equal to 1. Only in specific cases it allows to use country specific oxidation factors. Analysis of EU ETS data was performed in order to obtain country specific oxidation factors. This way country specific oxidation factors were estimated for Bituminous Coal, Coking Coal and Lignite. These country specific oxidation factors were used in the current inventory. In other cases are used default oxidation factors equal to 1.

### *Recalculation due to use of country specific conditions*

The methodology for development of country specific $CO_2$ emission factors from different kind of fuels was drawn up. Country specific oxidation factors were determined for chosen solid fuels. For the transition of the data from CzSO for different gases (which are reported in TJ using GCV) were developed country specific ratios of GCV/NCV.

For $CO_2$ emission estimation were used this country specific approach in the whole time series in all sectors of stationary combustion. Methodology will be discussed in detail in the March submission of the NIR in relevant Annex.

***Country specific $CO_2$ emission factors***

In the current submission are used newly determined country specific emission factors for $CO_2$ emission estimation for Bituminous Coal, Coking Coal and Lignite, which were determined based on the elementary analyses of each kind of fuel. The methodology for determination of country specific emission factors as a relation to the NCV was drawn up.

***Country specific oxidation factors for $CO_2$ computation***

For each kind of coal (Bituminous Coal, Coking Coal, Lignite, Briquettes) were determined country specific oxidation factors based on the EU ETS data reported for 2010-2013. Recalculation was provided for listed fuels with country specific values. For the rest of the fuels was used oxidation factor equal to 1.

***Country specific coefficient for the ratio between GCV and NCV for gaseous fuels***

The recalculation of activity data determination for Natural Gas and derived gases was performed. These gases are in the official data from CzSO reported in TJ, which are calculated based in GCV. So far was used for the transition to TJ correspondent to NCV the ratio 1: 1.1. This approach was many times issued by ERT. Following the recommendations the data about composition of each gas was collected and also GCV and NCV based on the data were determined. Based on this data the specific ratio GCV/NCV for each gas was determined. This country specific ration was used for the activity data determination in the current submission.

***Recalculations caused by changes in data and NCV in official CzSO data***

Czech statistical office closely cooperates with national inventory system team and in its UNECE/IEA/OEXD Questionnaires it is reacting also for different requirements from the NIS team. Except of this every year the data are getting more accurate, also the data from the past years are often clarified and changed. Reallocations between different subsectors are also occurring. Based on the NIS team proposition were also some NCVs updated. Important change in the last data reporting (from CzSO) occurred in the consumption of liquid fuels.

All these changes are included in the whole recalculation of the Energy sector. The changes are reflected in the whole time series and for all kinds of fuels. It is necessary to point out, that currently all reported data are now in line with the official statistical data in energy balance of the Czech Republic which is processed in line with IEA methodology. So far in the 1990 – 1994 period was used data from the former energy balance of the Czech Republic. The most apparent changes occur in the differentiation between energy and non-energy use of fuels for liquid fuels. More precise differentiation between energy and non-energy use helped also for more precise allocation of non-energy use of liquid fuels to the IPPU sector.

In the official data are the fuels consumptions reported in kt, which means the requirement for the transition to TJ. In the last official CzSO data were also added still missing NCV, which allow also recalculation for the whole time series of NCV. Until now the missing NCV data was replacing by the average values.

It is possible to state, that this recalculation was so far the most important and huge since the GHG inventory is performed. The comparison of the values before and after recalculation was also performed. The comparison showed that despise quite significant changes for some kind of fuels and sectors, the whole fuel consumption and $CO_2$ and $N_2O$ emissions didn't significantly change. $CH_4$ emissions indicate apparent changes, however this was caused by the apparent change in the emission factors.

#### *10.1.2.2 Recalculation in sector 1.A.3 Energy – Road Transportation*

##### 10.1.2.2.1 Recalculation caused by implementation of IPCC 2006 Guidelines

Sector **1.A.3.b Road Transportation** is based on the IPCC 2006 Gl. split into five subsectors:

| | |
|---|---|
| 1.A.3.b.i | Cars |
| 1.A.3.b.ii | Light Duty Trucks |
| 1.A.3.b.iii | Heavy Duty Trucks and Buses |
| 1.A.3.b.iv | Motorcycles |
| 1.A.3.b.v | Other |

Activity data and greenhouse gas emission estimates of subsector 1.A.3.b.ii Light Duty Trucks were in this submission included in the subsector 1.A.3.b.i Cars, because the differentiation between these two subsectors is not available. The distribution of the data into these two subsectors is included in the current Improvement plan.

### 10.1.2.3 Recalculation in sector 2 Industrial Processes and Product Use

#### 10.1.2.3.1 Recalculations due to response to the last review process

No recalculations were needed after the last review.

#### 10.1.2.3.2 Recalculation caused by implementation of IPCC 2006 Guidelines

***2.A Mineral Industry***

In the 2.A Mineral Industry subsector went through some reallocation issues. The subsector 2.A.3 doesn't include emissions from Limestone and Dolomite Use anymore, but includes the emissions from Glass Production (before included in the category 2.A.7.i). Category 2.A.4 includes now Other Process Uses of Carbonates and it is split into 4 subcategories

| | |
|---|---|
| 2.A.4.a | Ceramics (before included in 2.A.7.ii) |
| 2.A.4.b | Other Uses of Soda Ash (before included in 2.A.4.ii) |
| 2.A.4.c | Non Metallurgical Magnesia Production |
| 2.A.4.d | Other (please specify). |

The category 2.A.2 was recalculated in the 2010 - 2012 time series since new specific data were obtained. Further improvement is planned for the next submission and is included in the improvement plan. IPCC 2006 Gl. also include methodology for Glass production including emission factor and cullet ratio. Using these parameters were estimated emissions in 2.A.3 Glass Production sector.

***2.B Chemical Industry***

Chemical Industry is the sector with the biggest changes cause by the implementation of IPCC 2006 Gl. There are few new categories included.

Categories 2.B.1 Ammonia Production, 2.B.2 Nitric Acid Production and 2.B.3 Adipic Acid Production remained the same.

Category 2.B.4 now includes Caprolactam, Glyoxal and Glyoxylic Acid Production. Category 2.B.5 includes Carbide Production, 2.B.6 Titanium Dioxide Production, 2.B.7 Soda Ash Production. Category 2.B.8 Petrochemical and Carbon Black Production is split into categories:

| | |
|---|---|
| 2.B.8.a | Methanol |
| 2.B.8.b | Ethylene |
| 2.B.8.c | Ethylene Dichloride and Vinyl Chloride Monomer |
| 2.B.8.d | Ethylene Oxide |
| 2.B.8.e | Acrylonitrile |
| 2.B.8.f | Carbon Black |

Category 2.B.9 Fluorochemical Production is split into 2 subcategories and is not occurring in the Czech Republic. Last category in 2.B is category 2.B.10 Other, in which is included category Styrene production.

In case the process is occurring in the Czech Republic, the relevant emissions were estimated using methodology given by IPCC 2006 Gl.

***2.C Metal Industry***

New subcategories in the sector 2.C.1 Iron and Steel Production are 2.C.1.c Direct Reduced Iron and 2.C.1.e Pellet.

Categories 2.C.5 Lead Production and 2.C.6 Zinc Production are newly included in the IPCC 2006 Gl.

The emissions from limestone and dolomite use during the iron and steel production were included in the emission estimates in the category 2.C.1 Iron and Steel Production.

As a new source were included emissions from categories 2.C.5 Lead Production and 2.C.6 Zinc Production.

***2.D Non-Energy Products from Fuels and Solvent Use***

This category is newly included in the IPCC 2006 Gl. It includes use of fuels other than for combustion processes or for reducing agent in industry. This category is split into four subcategories

2.D.1 Lubricant Use
2.D Paraffin Wax Use
2.D.3 Other (please specify)

Category 2.D.3 Other is for the purposes of the Czech Republic's inventory split into categories 2.D.3.i Solvent Use and 2.D.3.ii Road paving with asphalt.

***2.E Electronic Industry***

Electronic Industry includes emissions of fluorinated carbons gases used predominantly for manufacturing of semiconductors. Subsector 2.E include sources from previous category 2.F.7 Semiconductor Manufacture and was furthermore extended for five more subcategories:

2.E.1 Integrated Circuit or Semiconductor
2.E.2 TFT Flat Panel Display
2.E.3 Photovoltaics
2.E.4 Heat Transfer Fluid
2.E.5 Other (please specify).

***2.F Product Uses as Substitutes for Ozone Depleting Substances***

This subsector has undergone a major changes caused by the implementation of IPCC 2006 Gl. One of the most important issues is that potential emissions are not reported anymore in addition to actual emissions. Moreover, the 2.F.7 Semiconductor Manufacturer category was reallocated to 2.E Electronic Industry. Also previous 2.F.8 Electrical Equipment and 2.F.9 Other (Sound-proof windows, Laboratory use) categories were reallocated in 2.G Other Product Manufacture and Use.

In the rest of the categories (2.F.1 to 2.F.5) there were only little changes such as an adjustment of category name or altering the classification of some subcategories.

***2.G Other Product Manufacture and Use***

As mentioned above, this new subsector introduce categories 2.G.1 Electrical Equipment, 2.G.2.c Soundproof Windows and 2.G.4 Laboratory (Experimental) use that have been reallocated from the previous subsector 2.F. This subsector includes also category 2.G.3 $N_2O$ from Product Uses, which was previously reported under Solvents and Other Product Use.

### 10.1.2.4 Recalculation in sector 3 Agriculture

#### 10.1.2.4.1 Recalculations due to response to the last review process

***Recalculation of $CH_4$ emissions in 3.A Livestock/Manure Management sector***

As a response to the findings in Saturday paper provided by ERT from the review process 2014, one recalculation in the Agriculture sector was performed. The discrepancy was caused by inconsistency of time-series data. One step input of change of grazing time data for cattle was utilized, where the slightly increasing trend of data was necessary. The correction was provided in 6 weeks after obtaining of the Saturday paper.

***Recalculation caused by implementation of IPCC 2006 Guidelines***

Sector 3.A Livestock is based on the IPCC 2006 Gl. split into three subsectors:

3.A.1 Enteric Fermentation
3.A.2 Manure Management

Activity data and greenhouse gas emission estimates are since this submission reported after new redistribution.

Sector 3.C Aggregate sources and non-$CO_2$ emissions sources on land is based on the IPCC 2006 Gl. split into ten subsectors, of which only four are reported under Agriculture sector in the Czech Republic:

3.C.3 Urea application
3.C.4 Direct $N_2O$ Emissions from managed soils
3.C.5 Indirect $N_2O$ Emissions from managed soils
3.C.6 Indirect $N_2O$ Emissions from manure management

Activity data and greenhouse gas emission estimates were in this submission reported in mentioned sectors.

In the current submission some subsectors were added. Newly the emissions from urea application on agricultural land (3.C.3) and Indirect $N_2O$ Emissions from manure management (3.C.6) were reported. The data of industry production of urea was applied to estimate emissions from 3.C.3 sector. To the sector 3.C.4 was added new source of emissions - direct application of sewage sludge to managed soils.

Described changes were performed in the time-series where the activity data are available.

***Change of emission factors***

IPCC 2006 Guidelines include updated emission factors for $CH_4$ and $N_2O$. In case there are country-specific emission factors available, they are used for emission estimation. In other cases are used default emission factors.

The emission factors provided by IPCC 2006 Guidelines for emission estimations from Manure Management (AWMS - EF3), Direct and Indirect emissions from managed soils (EF1 and EF5) were updated.

#### 10.1.2.4.2 Recalculation due to use of country specific conditions

***Country specific $CH_4$ and $N_2O$ emission factors***

Country-specific emission factors are applied if they are available. In Agriculture, the national specific emission factors are used in calculation of $CH_4$ and $N_2O$ emissions from Enteric Fermentation and Manure Management (both in cattle category).

The changes in country-specific factors in time period 2007-2011 were performed and reported based on recalculation due to response to the last review process.

***Recalculations caused by changes in data***

Czech statistical office is the main source of national inventory system data. Annually, the data are getting more accurate, reallocations between different subsectors are also occurring. All these changes are included in the recalculations of the Agriculture sector. The changes are reflected in the whole time series.

It possible to state, that this recalculation was so far the most important and huge since the GHG inventory is performed. The comparison of the values before and after recalculation was also performed. The comparison showed that emissions significantly change. Although it was added to the inventory some sources, the reported emissions were due to the different methodology, incl. updated emission factors, reduced.

### *10.1.2.5 Recalculation in sector 4 LULUCF and KP LULUCF activities*

#### 10.1.2.5.1 *Recalculations due to response to the last review process*

No recalculations were needed after the last review.

#### 10.1.2.5.2 Recalculation due to use of country specific conditions

No recalculations due to use of country specific conditions performed.

#### 10.1.2.5.3 Recalculation caused by implementation of IPCC 2006 Guidelines

The methodologies and recommendations IPCC 2006 Guidelines were implemented gradually during previous inventory submissions. Any identified difference in reported emissions at the higher grouping level is due to changes in reporting structure and moving some emission categories to sector 3 – Agriculture.

The recalculations have been made due to adopting the new global warming potential values for $CH_4$ and $N_2O$ (Decision 25/CP19). This concerns the emissions from burning and wildfires, as well as emissions from soils on land converted to cropland. Hence, these changes affect the estimates for the land use categories 4.A Forest land and 4B Cropland. Correspondingly, these changes were also implemented for estimates of Forest management activity under KP LULUCF reporting.

### *10.1.2.6 Recalculation in sector 5 Waste*

#### 10.1.2.6.1 *Recalculations due to response to the last review process*

Centralized review noted possible underestimation of $N_2O$ emissions from 5.D Wastewater treatment and discharge due to under estimated amount of protein in consumed food. Whole category received updated data about protein consumption from FAOSTAT for whole time series 1990 - 2013. Average change in amount of GHG in source category was about 14% per year.

##### 10.1.2.6.2 Recalculation due to use of country specific conditions

Category 5.A Solid waste disposal was recalculated, since new activity data, including data for recovered methane and amount of waste, became available. The difference is negligible.

##### 10.1.2.6.3 Recalculation caused by implementation of IPCC 2006 Guidelines

Category 5.B Biological treatment of solid waste is newly included in the IPCC 2006 Gl. It is split into two subcategories:

5.B.1 Composting

5.B.2 Anaerobic digestion at Biogas facilities

Each subcategory is further split into two categories, dividing the emissions between MSW treatment and other waste treatment, respectively 5.B.1.a Municipal solid waste, 5.B.1.b Other, and 5.B.2.a Municipal solid waste, 5.B.2.b Other. Calculations were performed following the 2006 Gl. for the whole time period.

The implementation of 2006 GL. caused division of category 5.C Incineration and open burning of waste into two subcategories:

5.C.1 Incineration

5.C.2 Open burning of waste

In this submission in category 5.C.1 no recalculations were conducted. Category 5.C.2 is reported as not occurring in the Czech Republic.

### 10.1.3 Recalculations performed in the submission 2016

#### *10.1.3.1 Recalculation in sector 1.A Energy (excluding 1.A.3)*

##### 10.1.3.1.1 New activity data

CzSO performed changes in the official energy balance data, which yielded to recalculations across whole 1A sector.

##### 10.1.3.1.2 Reallocation of non-energy use of Natural Gas from 1.A.2.c to 2.B.10

The non-energy use of Natural Gas occurred in the official energy balance of the Czech Republic. This Natural Gas is used in chemical Industry. The relevant amount of Natural Gas was reallocated into sector 2.B.10 for 2008 – 2013. Prior to 2008 the official data of non-energy use of Natural Gas is not available.

#### *10.1.3.2 Recalculation in sector 2 Industrial Processes and Product Use*

##### 10.1.3.2.1 Mineral Industry (2.A)

2.A.2 Lime production was recalculated in the 2010-2013 time series since new specific data were obtained.

The subcategory 2.A.4.a was also recalculated by using EU ETS data in the 2010-2014; 1990 – 2009 was calculated by using activity data provided by CzSO and country specific emission factor calculated from EU ETS data.

The subcategory 2.A.4.d Other (please specify) newly includes emissions from mineral wool production.

##### 10.1.3.2.2 Chemical Industry (2.B.)

The subcategory 2.B.10 Other (please specify) includes two new subcategories Other non-energy use in chemical industry and Non selective catalytic reduction. Subcategory Other non-energy use in chemical industry includes emission from non-energy use of natural gas for hydrogen production by steam reforming. Activity data from this subcategory are presented in TJ. The CRF reporter does not allow switching unit from kt to TJ in this subcategory. Activity data for non-energy use of Natural Gas was reallocated from 1.A.2.c, where they were reported till last submission. Non selective catalytic reduction subcategory includes emissions from non-selective catalytic reduction used in Nitric Acid production technology.

##### 10.1.3.2.3 Metal Industry (2.C)

For 2.C.2 Ferroalloys Production was obtained new updated activity data since 2008. Recalculation using these updated activity data was performed.

For 2.C.5 Lead Production was obtained new updated activity data since 2008. Recalculation using these updated activity data was performed.

For 2.C.6 Zinc Production was obtained new updated activity data since 2008. Recalculation using these updated activity data was performed.

##### 10.1.3.2.4 Non-Energy Products from Fuels and Solvent Use (2.D)

New category 2.D.3 Other – Urea used as catalyst is included in the reporting. The default approach based on 2006 IPCC Gl. Vol. 2 was applied for emission estimation.

##### 10.1.3.2.5 Electronic Industry (2.E)

Electronic Industry includes emissions of fluorinated carbons gases, $SF_6$ and $NF_3$ used predominantly for manufacturing of semiconductors. Subsector 2.E.1 Integrated Circuits or Semiconductors was recalculated including by-product emissions. In subsector 2.E.4 Heat Transfer Fluids the notation keys were changed to NE. Research of data for these issues is planned for future submissions.

##### 10.1.3.2.6 Product Uses as Substitutes for Ozone Depleting Substances (2.F)

This subsector has undergone several recalculations due to use of new more reliable data. Based on the recommendations of TERT from the trial review historical data were revaluated. Due to acquiring of more reliable data following recalculations were made: relocation of HFC-23, HFC-32, HFC-143a and HFC-125 from 2.F.1.e (Mobile Air conditioning) to 2.F.1.a (Commercial refrigeration), further the error classification of HFC-245ca was corrected to HFC-245fa. These recalculations were consulted and verified by the independent F-gas expert.

Furthermore, the subcategory 2.F.3 Fire Protection was recalculated by changing life factor and lifetime according to IPCC 2006 Gl. The subcategory 2.F.5 Solvents (gas HFC-245fa) was recalculated due to new more reliable data.

#### 10.1.3.2.7 Other Product Manufacture and Use

Research of data composition in the subsector 2.G.1 Electrical Equipment was conducted. Results of the research showed, that the emissions factor for HV switchgear (Table 8.3, 2006 IPCC Gl., Vol. 3-2) is more accurate for condition of the Czech Republic. Thus recalculation using emission factor for HV was performed in this submission.

Furthermore in the subcategory 2.G.4 Laboratory (Experimental) use recalculation for 2004-2006 were conducted using assumption of covering more than one year, since emissions are assumed to be continuous over the year (Eq. 8.23, 2006 IPCC Gl., Vol. 3-2).

### *10.1.3.3 Recalcualtions in sector 3 Agriculture*

#### 10.1.3.3.1 Recaulations caused by implementation of IPCC 2006 Guidelines

As a result of implementation of input parameters in accordance with 2006 Gl. IPCC, the recalculation of greenhouse gas emissions in some categories was performed for the entire reporting period.

***3.A Enteric Fermentation***

The emission factors for estimates of methane emissions from Enteric Fermentation of cattle (dairy and non-dairy) were recalculated following the revision of coefficient for calculating net energy for maintenance (Cfi) and cattle methane conversion factor (Ym). These new default parameters were applied according to 2006 IPCC Guidelines for the whole entire period. A cattle methane conversion factor Ym equals 0.065 was applied to the estimates from Table 10.12 (2006 Gl. IPCC) and coefficients Cfi for dairy and non-dairy cattle were applied from Table 10.4 (2006 Gl. IPCC). The mentioned changes generated new Gross Energy values (GE) and updated emission factors for estimation of methane emissions from Enteric Fermentation.

***3.B Manure Management***

The emission factors for estimation of $CH_4$ emissions for cattle category from Manure Management were recalculated following the adoption of Cfi and Ym parameters in accordance with 2006 Gl. IPCC. For $CH_4$ for manure management for pigs recalculated the $CH_4$ emission from pig manure, according to the 2006 Gl. IPCC, so it better fits the actual manure handling conditions in the Czech Republic. Instead of 3 kg/head/yr, a double value 6 kg/head/yr was used. Manure management $CH_4$ emission factors from Table 10A-9 for goats, horses and poultry were applied to the inventory. In case of poultry the default value (weighted average of types of breeding) was adjusted to the Czech conditions.

As a result of performed changes, the Nex values for cattle category were updated also. Due to application of the national Typical Animal Mass (TAM) for other than cattle categories (pig, sheep, goats, horses, poultry), the country-specific Nitrogen Excretion values (Nex) for the mentioned animals for the whole entire period were developed using by Equation 10.30 (2006 Gl. IPCC).

***3.D $N_2O$ Emissions from managed soils***

The recalculation of nitrous oxide emissions from Manure applied to soils and Pasture, Range and Paddock were performed following the revision of input parameters of Livestock. Because some outputs from Manure Management category correspond to inputs for estimates of nitrous oxide emissions from soils, then the update of Manure Management outputs resulted to update of emissions from soils. The changes of direct emissions resulted to changes of indirect emissions, so the recalculation of indirect $N_2O$ emissions from soils was also performed.

***3.H Urea application***

In this submission, the new activity data were obtained and applied to the inventory. The statistical production data were replaced by more precise data corresponding to the real consumption by Ministry of Agriculture. These data available for period 2000-2014 are based on the farmer´s fertilizer records. These data was used to recalculate the appropriate time-series (2000-2014).

### *10.1.3.4 Recalculations in sector 4 LULUCF and KP LULUCF Activities*

#### 10.1.3.4.1 Recalculations due to use of country specific conditions

***LULUCF***

The entire land-use assessment and land-use change identification system have been revised and significantly improved in collaboration with the data provider, the Czech Office for Surveying, Mapping and Cadastre (COSMC). COSMC administers the database of "Aggregate areas of cadastral land categories" (AACLC). Newly in this inventory, the system uses within-year explicitly addressed changes between all pairs of the six land-use categories, based on 13 explicitly reported land use categories of the AACLC or derived therefrom at the level of each cadastral unit. This is qualitatively a better assessment of land use as compared to the previously required balancing of land use categories between two consecutive years. The improved system using explicitly addressed within-year land use changes is adopted since year 2004 until 2014. For land use change prior 2004 (technically since 1970), the previously adopted system is retained. The new revision included rectification of linking AACLC land use categories to IPCC land use categories. Specifically, the following changes have been implemented: i) the un-stocked cadastral forest land remains within 4A Forest land (previously transferred to Grassland) ii) the military areas are retained within the category of Settlements (previously treated as Grassland) and iii) Other land is no longer constant, but since 2004 it is treated identically as all other land use categories, i.e., conversions from and to this land use categories are explicitly expressed according to the newly revised system based on the official data from COSMC. These changes have been implemented across the entire data period (1970 to 2014) required for the mandatory reporting (1990 to 2014) of land use changes and associated assessment of carbon stock changes and GHG emissions to ensure full consistency of the LULUCF reporting. The above implemented changes resulted in revised estimates of all LULUCF categories besides 4G HWP.

***4.A.2 Land converted to Forest land and Forest land converted to other LU categories***

The assessment of dead organic matter (deadwood and litter) has been improved, using the newly available activity data of the CzechTerra landscape inventory (deadwood, litter) and National Forest Inventory (deadwood). These changes concern category 4A and all sub-categories involving land use conversion from or to Forest land.

***4.B.1 Cropland remaining Cropland and 4C1 Grassland remaining Grassland***

Soil carbon stock change estimation has been revised for the categories 4B1 and 4C1, following the recommendations of the recent review and owing to the newly available data on management of agricultural soil.

***4.G Harvested Wood Products (HWP)***

The approach B was newly used for the estimates of HWP contribution in the category 4G HWP (approach A was used in NIR 2015).

***Table 4(IV) – Indirect N20 emissions***

Updated estimates of Indirect emissions from atmospheric deposition of N volatized from managed soils, rectifying the previous calculation.

***KP LULUCF***

Further improvement and revision of land use representation and land use change identification system as described for the section of LULUCF above also applies for the areas of KP LULUCF activities. There have been rectified based on the new data from COSMC. These changes concern areas of AR, D and FM activities

AR, D – revised estimates of deadwood and litter based on the newly available activity as described in the section of LULUCF for land use change categories involving Forest land

#### *10.1.3.5 Recalculations in sector 5 Waste*

##### 10.1.3.5.1 Recalculations due to use of country specific conditions

***Biological Treatment of Solid Waste***

Considering the 9th Corrigenda for the 2006 IPCC Guidelines from July 2015, recalculation for the whole time series in category 5.B were performed, using the provided emission factors for $N_2O$ and $CH_4$.

***Waste incineration***

Waste incineration for non-energy purposes was recalculated to harmonise activity data from ISOH. New data are more internally consistent with other source categories from waste sector.

***Wastewater treatment***

Domestic wastewater treatment was recalculated to better cover country specific condition. Tier 1 approach was modified with country specific data about methane generation from sludge.

Industrial wastewater treatment was recalculated for year 2000 by using improved activity data for this year.

### 10.1.4 Recalculations performed in the submission 2017

#### *10.1.4.1 Recalculation in sector 1.A Energy (excluding 1.A.3)*

##### 10.1.4.1.1 Update of emission factor for N2O, 1.A.1 Energy industries, 1.A.2 Manufacturing industries and construction, 1.A.4 Other sectors, Solid fuels

During UNFCCC review was identified incorrect emission factor for $N_2O$. Czech Republic accepted proposed change and submitted updated values using default emission factor from IPCC 2006 Gls. 1.5 kg/TJ for $N_2O$ for solid fuels. The recalculation was carried out for 1.A.1 Energy industries, 1.A.2 Manufacturing industries and construction, 1.A.4 Other sectors.

##### 10.1.4.1.2 Update of emission factors for 1.A.1.a - Public Electricity and Heat Production, Other fossil fuels

During UNFCCC review was identified incorrect emission factors in1.A.1.a - Public Electricity and Heat Production for $CO_2$, $CH_4$ and $N_2O$. Default emission factors from IPCC 2006 Gls. were used in response, i.e. 30 kg/TJ for $CH_4$, 91.7 t/TJ for $CO_2$ and 4 kg/TJ for $N_2O$.

#### 10.1.4.1.3 Update of emission factor for $N_2O$, 1.A.1.b - Petroleum Refining, Liquid fuels

During UNFCCC review was identified incorrect emission factor for $N_2O$ in 1.A.1.b - Petroleum Refining, liquid fuels. Czech Republic accepted proposed change and submitted updated values using default emission factor from IPCC 2006 Gls. 0.1 kg/TJ.

#### 10.1.4.1.4 Update of emission factors for $CH_4$, $N_2O$, 1.A.2.f Non-metallic minerals, Other fossil fuels

During UNFCCC review was identified incorrect emission factors in 1.A.2.f Non-metallic minerals for $CH_4$ and $N_2O$. Default emission factors from IPCC 2006 Gls. were used in response, i.e. 30 kg/TJ for $CH_4$ and 4 kg/TJ for $N_2O$.

#### 10.1.4.1.5 Update of emission factor for $N_2O$, 1.A.3.b Road transport

In response to the EU ESD review held in June 2016 were changed emission factor for $N_2O$ for gasoline PCs and gasoline motorcycles in the years 2000 – 2014. On recommendation, original country specific EFs was replaced by Tier 1 EFs stated in EMEP/EEA emission inventory guidebook 2016, page 23, table3-7.

#### 10.1.4.1.6 Incorrect values in data for 2014, 1.A.3.b Road transport

During the UNFCCC review was discovered discrepancy in CRF data for 2014. The data were updated in response to the review process.

#### 10.1.4.1.7 Update of LPG aktivity data

Due to updated activity data obtained from CzSO concerning LPG consumption in 1.A.3.b.i. Cars , the recalculation occured.

#### 10.1.4.1.8 Update of emission factors for $CH_4$, 1.B.1.A.1.ii – Underground mines, Post-Mining Activities

During UNFCCC review was identified incorrect emission factor for $CH_4$ in 1.B.1.A.1.ii – Underground mines, Post-Mining Activities. Czech Republic accepted proposed change and submitted updated values using default emission factor from IPCC 2006 Gls. 1.675 kg/t (average).

#### 10.1.4.1.9 Update of emission factors for $CH_4$, 1.B.1.A.2.i – Surface mines, Mining Activities

During UNFCCC review was identified incorrect emission factor for $CH_4$ in 11.B.1.A.2.i – Surface mines, Mining Activities. Czech Republic accepted proposed change and submitted updated values using default emission factor from IPCC 2006 Gls. 1.34 kg/t.

#### 10.1.4.1.10 Updated activity data after QA procedures

1.A.1.a.ii - Other fuels, 2014 – Whole amount of combusted municipal waste (Other fuels) was updated for 2014 from original 627 627. 23 t to 627 233. 79 t. After split for fossil fraction and bio fraction, the change of activity data in TJ is following:

**Tab. 10-1 Updated activity data for combustion of municipal waste**

| | | Original data | Updated data |
|---|---|---|---|
| | | 2014 | 2014 |
| **Municipal waste (non-renewable - fossil)** | [TJ/year] | 2 410.1 | 2 408.6 |
| **Municipal waste (renewable - bio)** | [TJ/year] | 3 615.1 | 3 612.9 |

Consequently, emissions were recalculated as well.

1.A.1.a.ii – Biofuels, 1990 – 2014 – Computational error in activity data used. Further, bio fraction of combusted municipal waste was updated in 2014. From this reason the amount of biofuels was updated and consequently emissions recalculated.

1.A.5.b mobile, 2014 – Since updated activity data for Kerosene Jet Fuel for about 310 TJ (-31%), consequently CO2, CH4 and $N_2O$ were recalculated as well.

### 10.1.4.1.11 Updated activity data due changes in official energy balance

Quite extensive updates of activity data were carried out by CzSO in the official energy balance. Mostly, the changes are for 2010 – 2014, however in same cases the changes are even before year 2010. For biofuel, 1.A.4. b Residential the change is done for the whole time-series. The changes are often in consumption of fuels by autoproducers, which is having further impact on the whole 1.A.2 Manufacturing industries and Construction category. Consequently emissions were recalculated on the basis of updated activity data.

Details of the changes are apparent from Tab. 3-2 – Tab. 3-5 .

**Tab. 10-2 Categories with updated activity data and emissions, solid fuels**

| Sector | Recalculation in years |
|---|---|
| 1A1ai Electricity Generation | 2010 to 2014 |
| 1A1c Manufacture of solid fuels and Other Energy Industries | 2008 to 2014 |
| 1A2a Iron and steel | 2010 to 2014 |
| 1A2b Non-ferrous metals | 2010, 2011 and 2013 |
| 1A2c Chemicals | 2010 to 2014 |
| 1A2d Pulp, paper and print | 2010 to 2014 |
| 1A2e Food processing, beverages and tobacco | 2010 to 2014 |
| 1A2f Non-Metallic Minerals | 2010 to 2014 |
| 1A2g Non-specified Industry | 2010 to 2014 |
| 1A4a Commercial/Institutional | 2010 to 2014 |
| 1A4b Residential | 2010 to 2014 |
| 1A4c Agriculture/Forestry/Fishing/Fish Farms | 2011 and 2012 |

**Tab. 10-3 Categories with updated activity data and emissions, liquid fuels**

| Sector | Recalculation in years |
|---|---|
| 1A1ai Electricity Generation | 2010 to 2014 |
| 1A2a Iron and steel | 2010 to 2013 |
| 1A2c Chemicals | 2010 to 2014 |
| 1A2d Pulp, paper and print | 2011 and 2013 |
| 1A2e Food processing, beverages and tobacco | 2010, 2011 and 2013 |
| 1A2f Non-Metallic Minerals | 2011 to 2013 |
| 1A2g Non-specified Industry | 2010 to 2014 |
| 1A4a Commercial/Institutional | 2008 to 2014 |
| 1A4b Residential | 2008 to 2014 |
| 1A4c Agriculture/Forestry/Fishing/Fish Farms | 2008, 2010 to 2014 |
| 1A5biii Mobile (other) | 2010 and 2014 |

**Tab. 10-4 Categories with updated activity data and emissions, natural gas**

| Sector | Recalculation in years |
|---|---|
| 1A1ai Electricity Generation | 2010 to 2014 |
| 1A2a Iron and steel | 2014 |
| 1A2c Chemicals | 2010 to 2013 |

| | |
|---|---|
| **1A2e Food processing, beverages and tobacco** | 2012 |
| **1A2f Non-Metallic Minerals** | 2012 |
| **1A2g Non-specified Industry** | 2010 and 2012 to 2013 |
| **1A4a Commercial/Institutional** | 2010 to 2013 |
| **1A4c Agriculture/Forestry/Fishing/Fish Farms** | 2012 |

**Tab. 10-5 Categories with updated activity data and emissions, biofuels**

| Sector | Recalculation in years |
|---|---|
| **1A4b Residential** | 1990 to 2014 |

#### *10.1.4.2 Recalculation in sector 2 Industrial Processes and Product Use*

##### 10.1.4.2.1 Mineral Industry (2.A)

During QC procedures, an error was identified in the amount of $CO_2$ emissions reported under category 2.A.1 Cement production for year 2014. The error was corrected.

During QC procedures, an error was identified in the activity data for the category 2.A.1 Glass production, reported for year 2012. The error was corrected.

Subcategory 2.A.4.a Ceramics was recalculated due to double counting observed between this subcategory and 2.A.4.d Other for the years 2010 to 2014. Parts of the activity data from 2.A.4.A.a Ceramics were incorrectly accounted for in 2.A.4.d Other.

The subcategory 2.A.4.d Other was recalculated by using activity data on mineral wool production for years 2000 - 2003 provided by CzSO. The activity data for years 2003 to 2006 are not available. Reported $CO_2$ emissions for these years were interpolated. This subcategory includes also emissions from flue-gas desulphurisation. These emissions were recalculated for the years 2013 and 2014 due to double counting occurring between this subcategory and 2.A.4.A.a Ceramics.

##### 10.1.4.2.2 Chemical Industry (2.B.)

During QC procedures, an error was identified in the activity data for the category 2.B.2 Nitric Acid production, reported for year 1995. The error was corrected. For category 2.B.2 activity data used for years 2014 and 2015 were obtained from CzSO. Emission estimates are based on data from EU ETS.

Since 2013, activity data and $CO_2$ emissions for subcategory 2.B.8.f Carbon Black are based on data from EU ETS. In the Czech Republic, only one facility is involved in carbon black production, thus the activity data and emissions are reported as confidential C (NK) in CRF reporter. Data are available for review experts in calculation sheets upon a request.

During QC procedures, an error was identified in the activity data for the subcategory 2.B.8.g Other, reported for year 2010. The error was corrected. For the time period between 1990 and 2010 the activity data were estimated on the basis of production capacities. Since 2011, EU ETS data were used for emission estimates in this subcategory. In the Czech Republic only one facility is involved in styrene production, thus the activity data and emissions are reported as confidential C (NK) in CRF Reporter. Data are available for review experts in calculation sheets upon a request.

##### 10.1.4.2.3 Metal Industry (2.C)

2.C.1 Iron and Steel Production was recalculated since new updated activity data of coke oven coke, bituminous coal and coal tar used in blast furnaces are available for 2010-2014. The data are officially updated by CzSO.

New information about ferroalloys production in the Czech Republic was obtained. In the Czech Republic is currently only one producer of ferroalloys, for which data since 2003 are available. Hence, activity data and consequently emission for 2.C.2 Ferroalloys Production were updated for this time period. The data are reported as confidential, detailed data are available for review experts in calculation sheets upon a request.

2.C.5 Lead Production was recalculated after UNFCCC review using appropriate emission factor for secondary production of lead.

#### 10.1.4.2.4 Product Uses as Substitutes for Ozone Depleting Substances (2.F)

Emissions from 2.F.1 Refrigeration and Air conditioning were recalculated due to the implementation of a new calculation model for this category. The input data are based on the Custom Office, ISPOP (Integrated system of reporting obligations) and F-gas register. These data are then verified by a sectoral expert. The data cannot be divided into the sub application; therefore the model uses an expert judgement to estimate the relative share of each type of equipment. The exact amount of HFC-134a in 2.F.1.e is obtained from an F-gas expert report. A research on more accurate F-gas division into subcategories is planned for future submissions.

Emissions from this category are calculated using Tier 2a Method described in 2006 IPCC Gl., Vol. 3-2. The parameters were established by an expert judgement and Table 7.9, 2006 IPCC Gl., Vol. 3-2.

Based on the new calculation model HFC-134a is reported under category F.1.b Domestic Refrigeration instead of unspecified mix of HFCs and PFCs.

Under category F.1.c Domestic Refrigeration: HFC-32, HFC-125, HFC-134a and HFC-143a are reported instead of unspecified mix of HFCs and PFCs.

Under category F.1.d Transport Refrigeration: HFC-32, HFC-125, HFC-134a and HFC-143a are reported instead of unspecified mix of HFCs and PFCs.

Under category F.1.f Stationary air-conditioning: HFC-32, HFC-125, HFC-134a and HFC-143a are reported instead of unspecified mix of HFCs and PFCs.

From category 2.F.1.a Commercial refrigeration, HFC-245fa was relocated to category 2.F.5 Solvents. According to the F-gas expert HFC-245fa is used only as a solvent in the country.

In some years is under 2.F.1 used notation key NE for amount remaining in products at decommissioning, emissions from disposal and recovery for gases HFC-134a and HFC-32. Notation key NE is used in accordance with decision 24/CP.19. Emissions are considered as insignificant. The level of emissions is below 0.05% of the national total GHG emissions and CRF reporter does not allow report emissions lower than 1.0E-14. The number lower than 1.0E-14 is rounded to 0.00 by CRF reporter. Specific subcategories with notation key NE and related year are shown in Tab. 3-6.

**Tab. 10-6 Subcategories in which is used notation key NE for gases HFC-134a and HFC-32 with related year**

| Subcategory | F-gas | Year |
|---|---|---|
| **2.F.1.a** | HFC-134a | 1996 |
| | HFC-32 | 1998, 1999 |
| **2.F.1.b** | HFC-134a | 1996 |
| **2.F.1.c** | HFC-32 | 1998, 1999 |
| | HFC-134a | 1996 |
| **2.F.1.d** | HFC-32 | 1998 |
| | HFC-134a | 1996 |
| **2.F.1.e** | HFC-134a | 1998, 1999, 2000, 2001 |

| | | |
|---|---|---|
| **2.F.1.f** | HFC-32 | 1998, 1999 |
| | HFC-134a | 1996 |

#### 10.1.4.2.5 Other Product Manufacture and Use (2.G)

For subcategory 2.G.1 Electrical equipment, a new activity data on recovery since 2013 were obtained. Recently this subcategory was divided into Medium Voltage (MV) Electrical equipment (< 52 kV) and High Voltage (HV) Electrical Equipment (> 52 kV) containing $SF_6$. The division into the two groups was based on data from two big and one smaller facility for energy transmission and distribution. According to the data almost 98.4% of electrical equipment in the country is attributed to HV Electrical Equipment and 1.6% to MV Electrical equipment. Emissions for MV Electrical equipment and HV Electrical Equipment were estimated separately using default emission factors (Table 8.2, 2006 IPCC Gl., Vol.3-2 for MV Switchgear and Table 8.3, 2006 IPCC Gl., Vol.3-2 for HV Switchgear). The CRF reporter does not allow separation of the subcategory 2.G.1 Electrical equipment into two groups. Emissions of $SF_6$ from MV Electrical equipment and HV Electrical Equipment are reported collectively.

### *10.1.4.3 Recalcualtions in sector 3 Agriculture*

#### 10.1.4.3.1 Manure Management (3.B)

According to EU ESD team recommendation the Nex values have been corrected for swine and cattle population. For cattle the protein content of 18% for all cattle feed was reduced to 16.5% for all cattle feed. The 16.5% is based on a paper from Task Force of Reactive Nitrogen (TFRN) Table ES2 with the mean protein content for "low ambition" for dairy cattle. The Nex values for swine were changed based on the correction of an average swine weight (originally calculated based on the slaughter weight), ie. the swine typical animal mass was reduced from 110 approx. to 60 kg.

The indirect $N_2O$ emissions from leached nitrogen in 3B have been deleted, the leaching from the managed soils is reported under 3D. No country-specific data for $Frac_{LeachMS}$ are available to estimate these emission category. The notation key NE was applied to the category Indirect emissions from Manure Management form leaching.

Further, during QA/QC procedure the technical error was found in the calculation of GE in Manure Management of cattle. The Gross energy intakes (GE) and then also the emission factors (EF) of Manure Management for cattle were corrected.

The fractions ($Frac_{GasMS}$ and $Frac_{LossMS}$) of N loss from MMS were updated to coordinate reporting for $N_2O$ emissions from Manure Management and $N_2O$ emissions from managed soils.

#### 10.1.4.3.2 $N_2O$ emissions from managed soils (3.D)

According to ERT recommendation the $Frac_{REMOVE}$ was changed from 0.5 to zero because of survey data of experts in country required on page 11.14 (2006 IPCC Gl.) is not available.

The factor 0.9, originally applied to reduce the input data of synthetic fertilizers in 3D1 category (direct emissions) to consider of emitting $NH_3$ and $NO_x$, was cancelled to avoid underestimation of emissions from this source category.

The activity data of category N mineralized in mineral soils was missing in the estimation of the Direct and Indirect emissions from managed soils. The Tier 1 approach and input data from LULUCF sector (kt C from Forest land and Grassland converted to cropland) were used to estimate N mineralized in mineral soils as a result of loss of soil C through change in land ($F_{SOM}$) according to Eq. 11.8.

The missing activity data of sewage sludge was added to the Eq. 11.9. The missing activity data (amount of sewage sludge (part of $F_{ON}$), crop residues ($F_{CR}$) and N mineralized in mineral soils ($F_{SOM}$)) were added to the Eq. 11.10.

In response to recalculations in subsectors 3B producing Animal manure applied to soils, the values of emissions from Direct and Indirect emissions from managed soils were recalculated.

### *10.1.4.4 Recalculations in sector 4 LULUCF and KP LULUCF Activities*

#### 10.1.4.4.1 LULUCF – 4.A.1 Forest Land Remaining Forest Land

**4(V) Biomass Burning - Wildfires**

A new carbon fraction applicable to biomass burning under wildfires was estimated based on species-specific representation (weighting by volume) in forest. This resulted in somewhat more conservative estimates of emissions from wildfires ($CO_2$, $N_2O$, $CH_4$). The entire time series since 1990 was recalculated.

#### 10.1.4.4.2 LULUCF – 4.G Harwested Wood Products

Emission contribution from HWP was recalculated for years 2013 and 2014 due to the rectified data of wood products at FAO database, the activity data used for the assessment of HWP contribution.

#### 10.1.4.4.3 KP LULUCF – Activity KP B.1 Forest Management

**Biomass Burning – Wildfires**

A new carbon fraction applicable to biomass burning under wildfires was estimated based on species-specific representation (weighting by volume) in forest. This resulted in somewhat more conservative estimates of emissions from wildfires ($CO_2$, $N_2O$, $CH_4$). The entire time series since 1990 was recalculated.

#### 10.1.4.4.4 KP LULUCF – Carbon stok changes in the harwested wood products pool

**From land subject to forest management**

Emission contribution from HWP was recalculated for years 2013 and 2014 due to the rectified data of wood products at FAO database, the activity data used for the assessment of HWP contribution.

### *10.1.4.5 Recalculations in sector 5 Waste*

#### 10.1.4.5.1 5.A Solid waste disposal

Category 5A Solid waste disposal was recalculated, because improved activity data, including data for recovered methane and amount of waste, for the last inventory year became available.

#### 10.1.4.5.2 5.D.2 Industrial wastewater treatment

Recalculation of 5.D.2 Industrial wastewater treatment was conducted as a result of review process. New results are in line with tier 1 methodology for the source category in question.

### *10.1.4.6 Recalculation of the precursors gases in indirect emissions*

Recalculations of indirect emissions for the whole time series were performed as a result of the review process. Double counting of indirect emissions of $CO_2$ in sectors Energy and Waste was corrected and new data are submitted.

**Tab. 10-7 Recalculation in indirect emissions**

| | Indirect GHG | (unit) | 1990 | 2014 |
|---|---|---|---|---|
| **Submission 2016** | **$CO_2$** | Gg | 3917.38 | 2233.05 |
| | **$N_2O$** | Gg | 3.53 | 4.68 |
| **Submission 2017** | **$CO_2$** | Gg | 2291.50 | 829.94 |
| | **$N_2O$** | Gg | 57.65 | 4.68 |
| **Difference** | **$CO_2$** | % | -41.50 | -62.85 |
| | **$N_2O$** | % | 16 times | 0 |

Data for precursors and indirect emissions will be recalculated due to expected recalculation of data in the newest UNECE/CLRTAP submission. Further emissions of $NH_3$ for the time period from 1990 to 2000 for all sectors were estimated and will be used until activity data becomes available.

## 10.2 Implications for emission levels

**Tab. 10-8 Implications on emission levels on example on 2014 emission levels**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excl. LULUCF% | Impact of recalculation on total emissions incl.LULUCF % |
|---|---|---|---|---|---|---|
| Total National Emissions and Removals | 112923.93 | 114707.90 | 1783.97 | 1.58% | 1.46% | 2% |
| 1. Energy | 95026.02 | 96618.86 | 1592.83 | 1.68% | 1.30% | 1% |
| A. Fuel combustion activities | 91063.04 | 92105.06 | 1042.02 | 1.14% | 0.85% | 1% |
| 1. Energy industries | 53151.11 | 53533.77 | 382.66 | 0.72% | 0.31% | 0% |
| 2. Manufacturing industries and construction | 10037.80 | 9703.89 | -333.91 | -3.33% | -0.27% | 0% |
| 3. Transport | 17157.13 | 16966.80 | -190.33 | -1.11% | -0.16% | 0% |
| 4. Other sectors | 10374.80 | 11581.60 | 1206.79 | 11.63% | 0.99% | 1% |
| 5. Other | 342.20 | 319.00 | -23.19 | -6.78% | -0.02% | 0% |
| B. Fugitive Emissions from Fuels | 3962.98 | 4513.80 | 550.81 | 13.90% | 0.45% | 0% |
| 1. Solid fuels | 3331.17 | 3881.99 | 550.81 | 16.54% | 0.45% | 0% |
| 2. Oil and natural gas | 631.81 | 631.81 | 0.00 | 0.00% | 0.00% | 0% |
| C. $CO_2$ transport and storage | NO | NO | NA | NA | NA | NA |
| 2. Industrial processes and product use | 12349.17 | 12458.21 | 109.05 | 0.88% | 0.09% | 0% |
| A. Mineral industry | 2543.48 | 2538.66 | -4.82 | -0.19% | 0.00% | 0% |
| B. Chemical industry | 2372.84 | 2372.84 | 0.00 | 0.00% | 0.00% | 0% |
| C. Metal industry | 7092.70 | 7206.57 | 113.87 | 1.61% | 0.09% | 0% |
| D. Non-energy products from fuels and solvent use | 116.64 | 116.64 | 0.00 | 0.00% | 0.00% | 0% |
| G. Other product manufacture and use | 223.50 | 223.50 | 0.00 | 0.00% | 0.00% | 0% |
| H. Other | NO | NO | NA | NA | NA | NA |
| 3. Agriculture | 8287.16 | 8280.62 | -6.54 | -0.08% | -0.01% | 0% |
| A. Enteric fermentation | 2817.27 | 2817.27 | 0.00 | 0.00% | 0.00% | 0% |
| B. Manure management | 2080.21 | 1753.38 | -326.83 | -15.71% | -0.27% | 0% |
| C. Rice cultivation | NO | NO | NA | NA | NA | NA |
| D. Agricultural soils | 3182.35 | 3502.64 | 320.29 | 10.06% | 0.26% | 0% |
| E. Prescribed burning of savannahs | NO | NO | NA | NA | NA | NA |
| F. Field burning of agricultural residues | NO | NO | NA | NA | NA | NA |
| G. Liming | 150.29 | 150.29 | 0.00 | 0.00% | 0.00% | 0% |
| H. Urea application | 57.03 | 57.03 | 0.00 | 0.00% | 0.00% | 0% |
| I. Other carbon-containing fertilizer | NO | NO | NA | NA | NA | NA |
| J. Other | NO | NO | NA | NA | NA | NA |
| 4. Land use, land-use change and forestry (net) | -7792.68 | -7801.09 | -8.42 | 0.11% | -0.01% | 0% |
| A. Forestland | -7310.63 | -7318.76 | -8.13 | 0.11% | -0.01% | 0% |
| B. Cropland | 17.14 | 12.53 | -4.61 | -26.90% | 0.00% | 0% |
| C. Grassland | -569.10 | -569.10 | 0.00 | 0.00% | 0.00% | 0% |
| D. Wetlands | 26.76 | 26.76 | 0.00 | 0.00% | 0.00% | 0% |
| E. Settlements | 127.60 | 127.60 | 0.00 | 0.00% | 0.00% | 0% |
| F. Other land | 8.55 | 8.55 | NA | NA | NA | NA |
| G. Harvested wood products | -94.13 | -94.41 | -0.29 | 0.30% | 0.00% | 0% |
| H. Other | NO | NO | NA | NA | NA | NA |
| 5. Waste | 5054.26 | 5151.31 | 97.05 | 1.92% | 0.08% | 0% |
| A. Solid waste disposal | 3330.79 | 3330.79 | 0.00 | 0.00% | 0.00% | 0% |
| B. Biological treatment of solid waste | 654.29 | 649.23 | -5.06 | -0.77% | 0.00% | 0% |

| | | | | | | |
|---|---|---|---|---|---|---|
| C. Incineration and open burning of waste | 134.13 | 134.13 | 0.00 | 0.00% | 0.00% | 0% |
| D. Waste water treatment and discharge | 935.05 | 1037.16 | 102.11 | 10.92% | 0.08% | 0% |
| E. Other | NO | NO | NA | NA | NA | NA |
| 6. Other (As specified in summary 1.A) | NA | NA | NA | NA | NA | NA |
| Memo items: | | | | | | |
| International bunkers | 882.76 | 882.76 | 0.00 | 0.00% | 0.00% | 0% |
| Aviation | 882.76 | 882.76 | 0.00 | 0.00% | 0.00% | 0% |
| Navigation | NO | NO | NA | NA | NA | NA |
| Multilateral operations | NO | NO | NA | NA | NA | NA |
| $CO_2$ emissions from biomass | 13247.69 | 15726.25 | 2478.56 | 18.71% | 2.02% | 2% |
| $CO_2$ captured | NO | NO | NO | NO | NO | NO |
| Long-term storage of C in waste disposal sites | 10689.37 | 39196.76 | 28507.39 | 266.69% | 23.27% | 25% |
| Indirect $N_2O$ | 1395.60 | 1395.61 | 0.00 | 0.00% | 0.00% | 0% |
| Indirect $CO_2$ | 2234.28 | 829.94 | -1404.34 | -62.85% | -1.15% | -1% |

## 10.3 Implications for emission trends, including time-series consistency

### 10.3.1 Implications for emission trend and time-series consistency of $CO_2$

The influence of the recalculations for the emission trend of $CO_2$ are illustrated on Fig. 10-1. Both curves are following the same pattern. The $CO_2$ emissions are higher on average by 0.12%, through the whole time period.

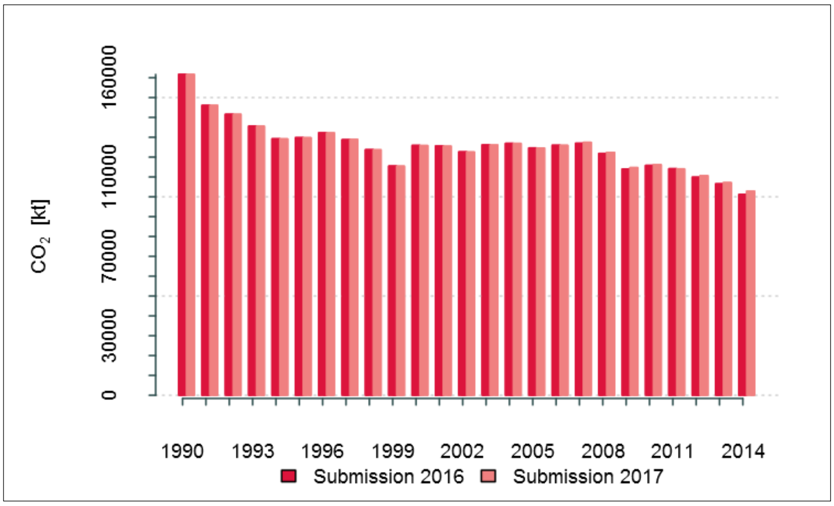



**Fig. 10-1 Difference in trends of $CO_2$ emissions in index form, between the submissions 2016 and 2017, due to recalculations (1990 = 100%)**

### 10.3.2 Implications for emission trend and time-series consistency of $CH_4$

The influence of the recalculations for the emission trend of $CH_4$ are illustrated on Fig. 10-2. Both curves are following the same pattern. The $CH_4$ emission trend is higher on average by 0.37%, through the whole time period.

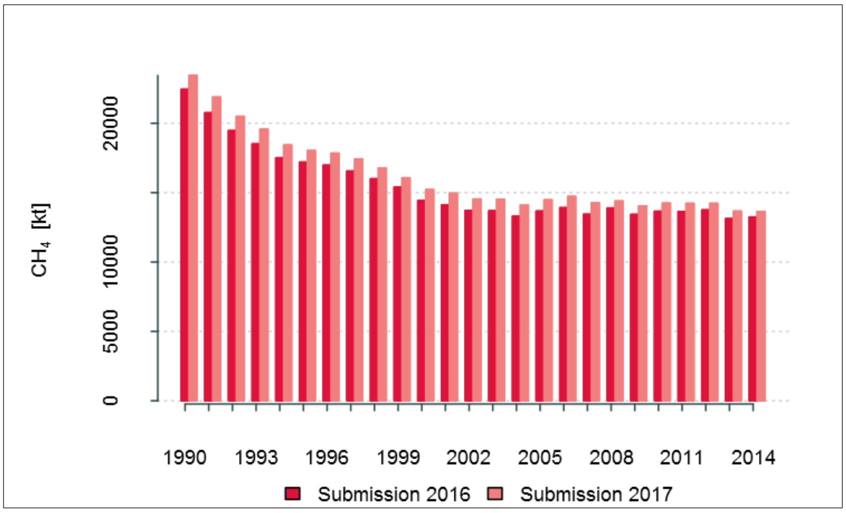



**Fig. 10-2 Difference in trends of $CH_4$ emissions in index form, between the submissions 2016 and 2017, due to recalculations (1990 = 100%)**

### 10.3.3 Implications for emission trend and time-series consistency of $N_2O$

The influence of the recalculations for the emission trend of $N_2O$ are illustrated on Fig. 10-3. Both curves are following the same pattern. The $N_2O$ emission trend is lower on average 1.2%, through the whole time period.

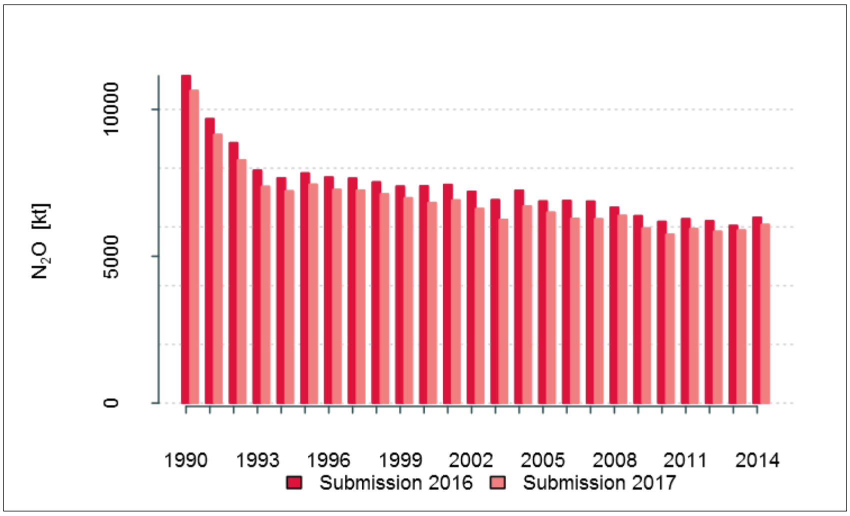



**Fig. 10-3 Difference in trends of $N_2O$ emissions in index form, between the submissions 2016 and 2017, due to recalculations (1990 = 100%)**

### 10.3.4 Implications for emission trends and time-series consistency of F-gases and $SF_6$

The influence of the recalculations for the emission trend of HFCs are illustrated on Fig. 10-4. Both curves are following the same pattern.

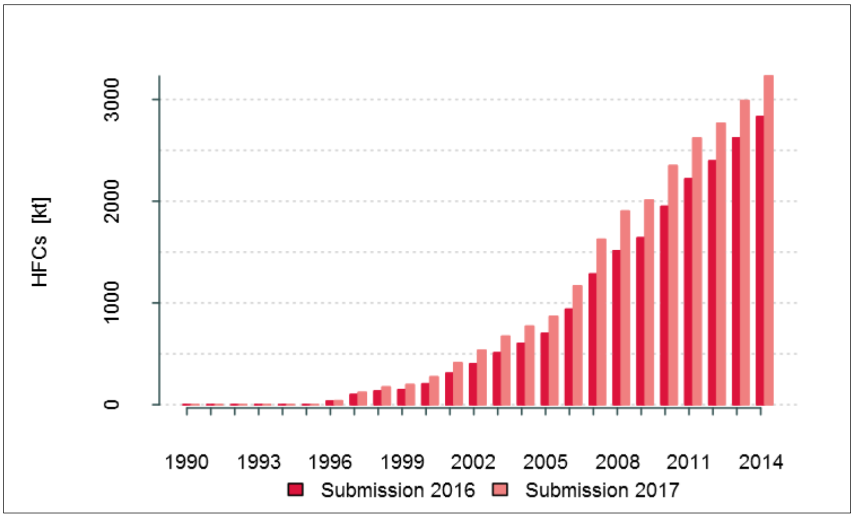



**Fig. 10-4 Difference in trends of HFCs emissions in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)**

The influence of the recalculations for the emission trend of PFCs are illustrated on Fig. 10-5. Both curves are following the same pattern.

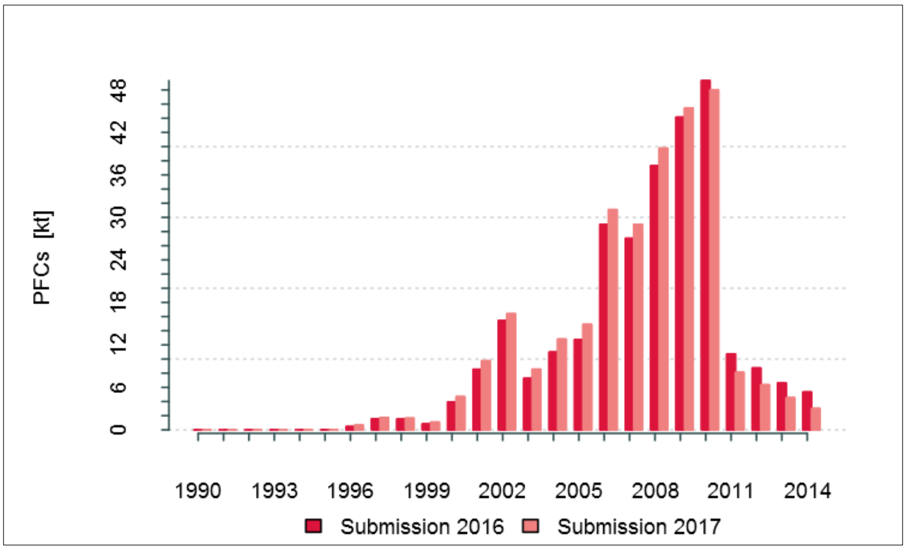



**Fig. 10-5 Difference in trends of PFCs emissions in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)**

The influence of the recalculations for the emission trend of $SF_6$ are illustrated on Fig. 10-6. Both curves are following the same pattern.

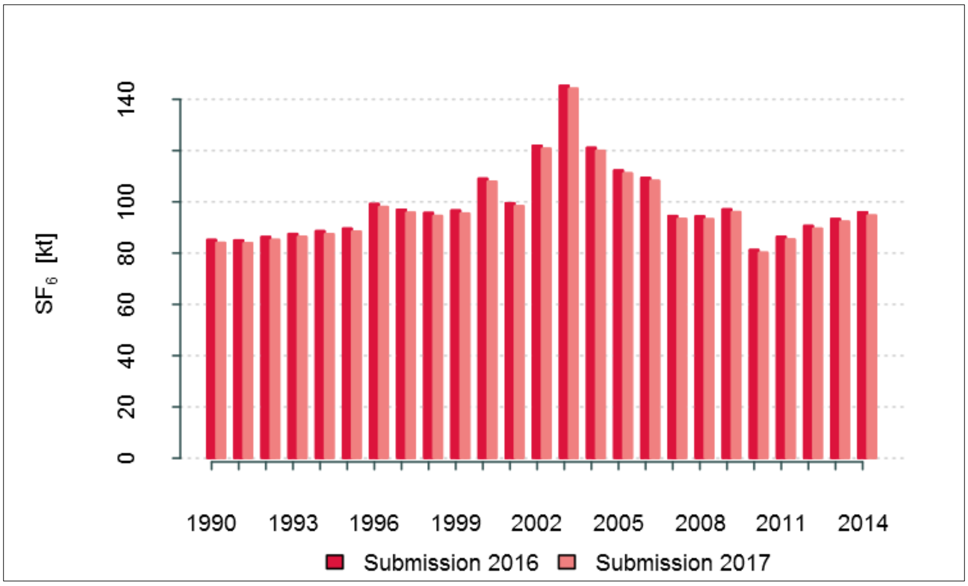



**Fig. 10-6 Difference in trends of $SF_6$ emissions in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)**

### 10.3.5 Implications for emission trends and time-series consistency of total emissions

The influence of the recalculations for the emission trend of total emissions, including LULUCF are illustrated on Fig. 10-7. Both curves are following the same pattern. The total emissions including LULUCF in trend is lower on average by 0.03% through the whole time period.

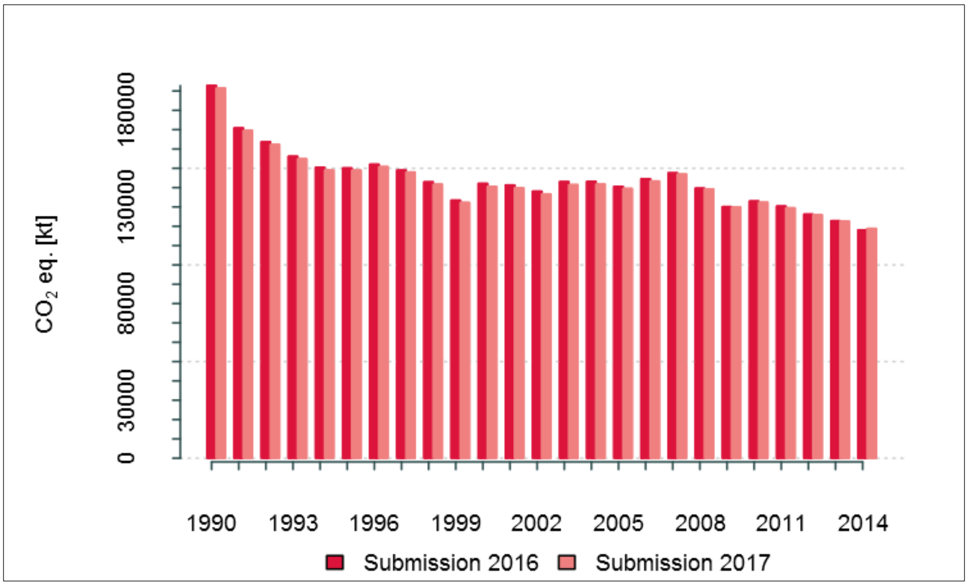



**Fig. 10-7 Difference in trends of total emissions including LULUCF in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)**

The influence of the recalculations for the emission trend of total emissions, excluding LULUCF are illustrated on Fig. 10-8. Both curves are following the same pattern. The total emissions excluding LULUCF in trend is higher on average by 0.01% through the whole time period.

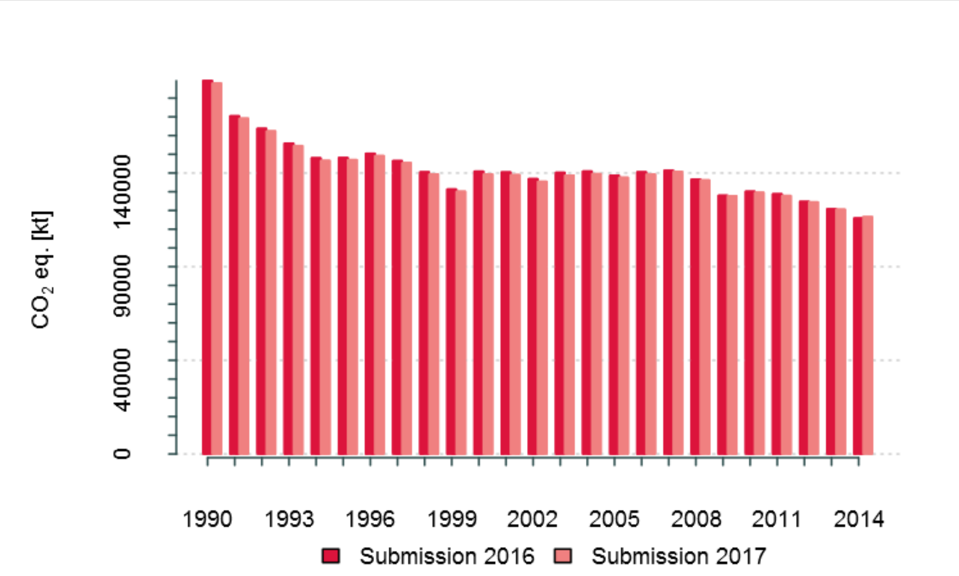



**Fig. 10-8 Difference in trends of total emissions excluding LULUCF in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)**

## 10.4 Planned improvements, including in response to the review process

Each year, the Czech inventory team analyses the findings of ERT (the Expert Review Team) and attempts to improve the quality of the inventory by implementation of the relevant recommendations.

An overview of previous findings and the relevant follow up by the Czech Republic was given in the previous NIRs (CHMI, 2012, 2013, 2014, 2015). In this report, attention is focused on the two last reviews.

In September 2010, the Czech Republic was subjected to a centralised review in Bonn. However, the relevant draft of the ARR 2010 was submitted from UNFCCC rather late, only on 17 February 2011, at the time when this report (2011 submission) was being written. The final version was issued only on 28 March 2011. Therefore it was not possible to implement most of the ERT recommendations.

During the centralised review in September 2010, the Expert Review Team (ERT) identified a potential problem in the incomplete reporting of category 1.B.2.a.ii (Oil Production). In this subcategory, the Czech Republic reported only $CH_4$ emissions from oil production, while $CO_2$ emissions and emissions of $CO_2$, $CH_4$ and $N_2O$ from venting and flaring were not reported. Therefore, the Czech Republic prepared the resubmission of CRF (within 6 weeks) in order to respect this ERT finding. In addition, ERT highlighted the necessity for full implementation of the QA/QC plan, better harmonization of information given in NIR and in CRF, improvement of time series consistency (mainly in Energy and Waste) and correct use of the notation key in CRF Tables.

In September 2011 (ARR 2011), the Czech Republic was subjected to the In-country-review in Prague. During the review, ERT identified the following “potential problem” in Agriculture: emissions of $N_2O$ from Manure management – 4.B.1 (even though this category was not identified as a Key Category). ERT claimed that the default factor used causes underestimation of the reported $N_2O$ emission from Manure management. This potential problem was successfully resolved in time (during a 6 week period).

In addition, ERT reiterated some recommendations from previous reviews regarding e.g. updating and replenishment of the QA/QC plan including refinement of the existing archiving system, development of an improvement plan and increasing stress on implementation for higher Tier methods for Key Categories.

Work on an updated QA/QC plan has been completed (see Chapter 1); the improvement plan, which includes also gradual implementation of higher Tiers, is presented in this chapter, together with an overview of the main improvements implemented so far in comparison with the 2011 submission.

Sector Chapters 3 to 8 contain current suggestions for improvements in the individual sectors as well as detailed explanations of how the ERT recommendations are specifically taken into account.

In September 2012, the Czech Republic was subjected to the centralised review in Bonn. During the review ERT identified the “potential problem” regarding following categories:

1) $CO_2$ emissions from 1.A Stationary Combustion
4) $CO_2$, $CH_4$ and $N_2O$ emissions from 1.A.3.a Civil Aviation
5) $CH_4$ and $N_2O$ emissions from 1.A.4.b Residential
6) $CH_4$ emissions from 1.B.1.b Solid Fuel Transformation
7) $N_2O$ emissions from 4.D.1.3 N-fixing crops
8) $N_2O$ emissions from 4.D.1.4 Crop residue
9) $CH_4$ emissions from 6.A Solid Waste Disposal
10) $CH_4$ and $N_2O$ emissions from 6.C Waste Incineration.

Issues 1), 3) – 6) were fully accepted by the Czech team and recalculated according to ERT instructions in time (during a 6 week period). Brief description of these recalculations is given above (Reporting under 3.1(e)). After resubmission the national GHG emissions total was by 365.5 Gg (i.e. 0.27% of total GHG emissions) higher.

Other issues 2), 7), 8) were carefully considered and were solved (without recalculation) by the Czech team by more transparent and more detailed explanation of the adequacy of used methods. Finally, ERT considered the whole “potential problem” as resolved.

In September 2013, the Czech Republic was subjected to the centralised review in Bonn. During the review ERT identified following potential problems:

1) Relevant background information and a descriptive summary of the revisions made by the Czech Republic in its 2013 inventory submission, in particular in the year 2011 with respect to HFC, PFC and $SF_6$ emissions from consumption of halocarbons and $SF_6$ and $N_2O$ emissions from domestic and commercial wastewater handling (human sewage);
11) A complete resubmission of the 2013 CRF tables, reflecting the revised estimates;
12) Party’s revision of the calculation of the commitment period reserve, based on the recalculated emissions reported for 2011, if the calculation of the commitment period reserve is based on the inventory and not the assigned amount.

All issues were accepted and the revised estimates were submitted in time.

Unfortunately, the relevant draft of the ARR has not been made available before official submission of this report. Therefore, it was not possible to take into account in this submission (15 March 2014) possible finding of ERT except those mentioned in the Saturday paper.

Overview of all actual recalculations (compared with the April’s 2013 submission) are given above (Chapter 10.2)

In September 2014, the Czech Republic was subject to centralized review in Bonn. During the review ERT identified the “potential problem” regarding following issues:

- Relevant background information and a descriptive summary of the revisions made by the Czech Republic in its 2014 annual submission, in particular in the years 2008-2010 with respect to $N_2O$ emissions from petroleum refining (energy) and in the years 2008-2012 with respect to $CH_4$ emissions from manure management (agriculture)

These issues were fully accepted by the Czech Republic and recalculated according to ERT instructions. Brief description of these recalculations is given above.

Overview of all actual recalculations (compared with the April’s 2014 submission) is given above (Reporting under 7.1I). The ARR (FCCC/ARR/2014/CZE) from this review was received in April 2015. Under usual circumstances it wouldn’t be possible to include the findings into the reporting. However this year majority of the issues will be possible to implement since the whole reporting is delayed. This delay is caused by not working CRF Reporter software. Part of the findings from ARR are already solved (please see chapter 3 REPORTING UNDER ARTICLE 7.1I OF REGULATION (EU) NO 525/2013), furthermore the rest will be considered during preparation of March submission.

Since delay of CRF Software, no reviews were conducted in 2015. Thus the Czech Republic wasn’t subject of review in 2015.

In August 2016, the Czech Republic was subject to centralized review in Bonn. During the review ERT identified the “potential problem” regarding following issues:

- Relevant background information and a descriptive summary of the revisions made by the Party in its 2015 and/or 2016 annual submission, in particular in the base year (or period) and 2013 and 2014, with respect to any category recalculated
- A complete official resubmission of the CRF tables for 1990-2014, reflecting the revised estimates;
- Party’s revision of the calculation of the assigned amount for the second commitment period of the Kyoto Protocol or an indication that the assigned amount has not changed;
- An indication of whether land-use change and forestry constitute a net source of GHG emissions in the base year and the aggregate anthropogenic carbon dioxide equivalent emissions by sources minus removals by sinks in that the base year or period from conversion of forests (deforestation);
- Party’s revision of the calculation of the commitment period reserve or an indication that the commitment period reserve has not changed;
- The difference between the assigned amount for the second commitment period and average annual emissions for the first three years of the first commitment period, multiplied by eight, or an indication that this value has not changed;
- The quantity amounting to 3.5% of the base year GHG emissions, excluding LULUCF, or an indication that this value has not changed;

Further, Czech Republic obtained extensive list of potential problems, which were all solved and recalculated in the resubmission in October 2016.

### 10.4.1 Overview of implemented improvements in the 2016 submission

The following table summarises the main changes and that were performed in 2017 (2015) submissions in comparison with previous submissions.

Last review was held in August 2016, when the Czech Republic was subjected to the centralised review in Bonn. However, the relevant draft of the ARR 2016 was not submitted so far. Therefore possible improvements based on ARR 2016 will be addressed only in the 2017 submission (except findings formulated in "Saturday paper" as potential problems that were resolved in time – resubmission in October 2016).

For changes in methodological descriptions please see Tab. 10-9.

**Tab. 10-9 Table of implemented improvements in the 2016 submission**

| Topic/Category, gas | Description of the change | Reason (motive) of the change | Reference to NIR or CRF Table |
|---|---|---|---|
| **Sector: General issues** | | | |
| QA/QC | Improved and updated QA/QC plan | Improvement suggested by Party | NIR, chapter 1.5<br>NIR, chapters 3 – 8 |
| Improvement plan | Updated Improvement plan | ARR 2010, para 16, para 37a<br>ARR 2011,. para 32,33 | NIR, chapter 10.3.2 |
| Archiving | Revised archiving routines | ARR 2010, para 34, 38b<br>ARR 2011, para 48 | NIR, chapter 1.3.3 |
| Key category analysis | T2 key cateogry analysis included in reporting | Improvement suggested by Party | NIR, chapter 1.5 Annex 1 |
| Uncertainty analysis | Sectoral uncertainties updated | Improvement suggested by Party | NIR, chapter 1.6 Annex 2 |
| **Sector: Energy – emissions from combustion** | | | |
| 1.A.1<br>1.A.2<br>1.A.4 | Solid fuels – EF $N_2O$ | Change of emission factors after UNFCCC review (potential problem in Saturday paper) | NIR, chapter 3. |
| 1.A.1.a | Other fossil fuels – EF $CO_2$, $CH_4$, $N_2O$ | Change of emission factors after UNFCCC review (potential problem in Saturday paper) | NIR, chapter 3. |
| 1.A.1.b | Liquid – EF $N_2O$ | Change of emission factors after UNFCCC review (potential problem in Saturday paper) | NIR, chapter 3. |
| 1.A.1.f | Other fossil fuels – EF $CH_4$, $N_2O$ | Change of emission factors after UNFCCC review (potential problem in Saturday paper) | NIR, chapter 3. |
| 1.B.1.A.1.ii | Underground mines, Post-Mining Activities – default EF: $CH_4$ | Change of emission factors after UNFCCC review (potential problem in Saturday paper) | NIR, chapter 3. |
| 1.B.1.A.2.i | Surface mines, Mining Activities – default EF: $CH_4$ | Change of emission factors after UNFCCC review (potential problem in Saturday paper) | NIR, chapter 3. |
| 1.A.3. | New EFs for $N_2O$ gasoline passenger cars and morcycles according EIG 2016 | EU ESD review recommendation, June 2016 | NIR, chapter 3.2.17.5.1. |
| 1.A.3. | Updated descriprion of QA/QC plan | Improvement suggested by Party | NIR, chapter 3.2.17.3 |
| **Sector: Industrial processes and Other Product Use** | | | |
| 2.F.1 | Implementation of the new calculatiom model | Improvement suggested by Party | NIR, chapter 4.7.1 |
| 2.G.1 | Division of activity data into medium voltage and hight voltage equipment | Improvement suggested by Party | NIR, chapter 4.8.1 |
| 2.C | Updated activity data | Improvement suggested by Party | NIR, chapter 4.4 |
| **Sector: Agriculture** | | | |
| 3.B, $N_2O$ | Activity data (Nex values) were corected for swine and cattle population | TFRN, EU ESD team | NIR, chapter 5.2.2 |
| 3.B.2, $N_2O$ | The emission factor (EF) of Manure Manangement for catle was corrected | Implementation of 2006 IPCC Guidelines | NIR, chapter 5.2.2.2 |
| 3.B, $N_2O$ | The fractions ($Frac_{GasMS}$ and $Frac_{LossMS}$) of N loss from Manure management system were updated for $N_2O$ emissions from Manure Management and $N_2O$ emissions from managed soils. | Implementation of 2006 IPCC Guidelines | NIR, chapter 5.2.2.2 |
| 3.B, $N_2O$ | The leaching from managed soils is reported | Implementation of 2006 IPCC | NIR, chapter 5.2.2 |

| | | | |
|---|---|---|---|
| | under the 3D. | Guidelines | |
| 3.D, $N_2O$ | $Frac_{REMOVE}$ was changed from 0.5 to zero | ERT recommendation | NIR, chapter 5.4 |
| 3.D, $N_2O$ | Underestimation by factor 0.9 was cancelled in the input data of synthetic fertilizers | Implementation of 2006 IPCC Guidelines | NIR, chapter 5.4 |
| 3.D, $N_2O$ | New activity data for N mineralized in mineral soil | Implementation of 2006 IPCC Guidelines | NIR, chapter 5.2. |
| **Sector: LULUCF** | | | |
| 4.A | Corrections, revised emission factors for burning | Improvements suggested by Party | NIR, chapter 6.4.5 |
| 4.G | Corrected activity data for the most recent years | Improvements suggested by Party | NIR, chapter 6.10 |
| **Sector: Waste** | | | |
| 5.C | Country specific oxidation factor | Unbalanced IPCC default | NIR, chapter 7 |
| 5.D | Updated methodology for subsectors. | Country specific data | NIR, chapter 7 |
| 5.D.2 | Uncertainity assesment | Recalculation and new methodology | NIR, chapter 7 |

**Tab. 10-10 Methodological descriptions in submission 2016**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | DESCRIPTION OF METHODS | RECALCULATIONS | REFERENCE |
|---|---|---|---|
| Total (Net Emissions) | | | More detailed information for each recalculation is provided in Table 10-1 and in relevant Chapters of NIR |
| **1. Energy** | | | |
| **A. Fuel Combustion (Sectoral Approach)** | | √ | |
| **1. Energy Industries** | √ | √ | |
| **2. Manufacturing Industries and Construction** | √ | √ | |
| **3. Transport** | √ | √ | |
| **4. Other Sectors** | √ | √ | |
| **5. Other** | | | |
| **B. Fugitive Emissions from Fuels** | | √ | |
| **1. Solid Fuels** | | √ | |
| **2. Oil and Natural Gas and Other emissions from Energy Production** | | √ | |
| **C. $CO_2$ transport and storage** | | | |
| **2. Industrial Processes** | | **√** | |
| **A. Mineral Industry** | | √ | |
| **B. Chemical Industry** | | √ | |
| **C. Metal Industry** | √ | √ | |
| **D. Non-energy Products from Fuels and Solvent Use** | | | |
| **E. Electronics Industry** | | | |
| **F. Product Uses as Substitutes for ODS** | √ | √ | |
| **G. Other Product Manufacture and Use** | √ | √ | |
| **3. Agriculture** | **√** | **√** | |
| **A. Enteric Fermentation** | | | |
| **B. Manure Management** | √ | √ | |
| **C. Rice Cultivation** | NO | NO | |
| **D. Agricultural Soils** | √ | √ | |
| **E. Prescribed Burning of Savannas** | NO | NO | |
| **F. Field Burning of Agricultural Residues** | NO | NO | |
| **G. Liming** | | | |
| **H. Urea Application** | | √ | |
| **I. Other Carbon-containing Fertilizers** | NO | NO | |
| **J. Other** | NO | NO | |
| **4. Land Use, Land-Use Change and Forestry** | | | |
| **A. Forest Land** | | √ | |
| **B. Cropland** | | | |
| **C. Grassland** | | | |
| **D. Wetlands** | | | |
| **E. Settlements** | | | |
| **F. Other Land** | | | |
| **G. Harvested Wood Products** | √ | √ | |
| **H. Other** | | | |
| **5. Waste** | | **√** | |
| **A. Solid Waste Disposal** | | | |
| **B. Biological treatment of solid waste** | | √ | |
| **C. Incineration and open burning of waste** | | | |
| **D. Wastewater treatment and discharge** | √ | √ | |
| **E. Other** | | | |
| **6. Other (as specified in Summary** | **NO** | **NO** | |

| **1.A)** | | | |
|---|---|---|---|
| KP LULUCF | Not reported in this submission | Not reported in this submission | |
| Article 3.3 activities | | | |
| **Afforestation/reforestation** | | | |
| **Deforestation** | | | |
| Article 3.4 activities | | | |
| **Forest management** | | | |
| **Cropland management (if elected)** | | | |
| **Grazing land management (if elected)** | | | |
| **Revegetation (if elected)** | | | |
| **Wetland drainage and rewetting (if elected)** | | | |
| **HWP** | | | |
| Memo Items: | | | |
| International Bunkers | | | |
| **Aviation** | | | |
| **Marine** | | | |
| Multilateral Operations | | | |
| $CO_2$ Emissions from Biomass | | | |
| $CO_2$ Captured | | | |
| Long-term storage of C in waste disposal sites | | | |
| Indirect $N_2O$ | | | |
| NIR Chapter | **DESCRIPTION** | | **REFERENCE** |
| | **Please tick where the latest NIR includes major changes** | | **If ticked please provide some more detailed information** |
| Chapter 1.2 Institutional arrangements | | | |
| Chapter 1.6 QA/QC plan | √ | | |

## 10.4.2 Improvement plan

Provisional Improvement plan was included in the NIR already last year and in this submission was updated and supplemented. This plan is in accordance with the recommendation of the international Expert Review Team (ERT) and concentrates particularly on introduction the more sophisticated procedures of the higher Tiers. These procedures employ country-specific emission factors and other parameters required for determining greenhouse gas emissions. However, it is rather difficult to obtain the data required for these purposes, especially at the present time, when only limited funds are available for the national inventory. Thus, it is planned to introduce the procedures of the higher Tiers gradually, over a longer time interval. In accordance with the IPCC methodology, emphasis is simultaneously put on Key categories. The following table gives the anticipated timetable for introduction of these procedures. As announced in the last submission, the country-specific emission factor for estimating $CO_2$ emissions from combustion of Natural Gas has been determined (please see Annex 2). These factors were already employed in this submission (see Chapter 3).

In addition to the planned introduction of the procedures of the higher Tiers in the individual sectors, the Improvement plan also includes a more general aspect. For instance last year have been revised uncertainty estimates. A substantial improvement in this respect has already appeared in this submission (see Chapter 1).

Furthermore Improvement Plan also includes using of EU ETS data for the purposes of national inventory. Substantial effort is put into implementation of this issue. In this submission EU ETS data were used for emission estimates in some subcategories in 2.A Mineral Product (e.g. 2.A.1 Cement Production). EU ETS data would be useful tool for QA/QC procedures also in Energy sector.

With the implementation of this issue could help also MS assistance project (Assistance to MS with KP Reporting) which is now under operation. Issue of implementation of EU ETS data was raised by the Czech Republic. Another issues concerning Energy and IP sector were raised in this assistance project.

**Tab. 10-11 Plan of improvements for key categories**

| Sector | Key Categories (KC) | GHG | % *) GHG | Type of KC | Present situation | Planned improvement | For submission |
|---|---|---|---|---|---|---|---|
| **General** | Uncertainty estimates | | | | Research of uncertainties held in 2012 | Improvement of uncertainty estimates | 2018 |
| **1.A.1.a.i** | Public electricity and heat production | AD | | | Activity data reported under 1.A.1.a.i | Distribution of fuel consumption in each subsector of 1.A.1.a | 2018 |
| **1.A** | 1A.3.b Transport - Road Transportation | $CO_2$ | 14.00 | LA,TA | Activity data for PC and LDT are reported together | Split activity data for PC and LDT to their own categories | 2018 |
| **1.A.4.a** | Commertial/Institutional | AD | | | Activity data fluctuation in 1991 till 1995 | Detailed research of data at the beginning of 90s is planned for the future submissions | 2018 |
| **1.A** | Stationary combustion – Liquid fules | $CO_2$ | 16.64 | LA | Default Emission factors | Detailed research of carbon contained in liquid fuels and consequent development of country specific emission factors | 2018 |
| **1.A.1.a** | Stationary Combustion - Solid Fuels | $CH_4$ | 0.21 | TA | Defaul EF | Country specific emission factors (measurement of concentrations in the flues gases of significatn sources) | 2019-2020 |
| **1.A.1.a** | Stationary Combustion - Liquid Fuels | $N_2O$ | | | Defaul EF | Country specific emission factors | after 2020 |
| **2.C.1** | Iron and Steel Production | $CO_2$ | 5.67 | LA | Tier 2 | Tier 3 | 2018, 2019 |
| **2.B.8** | 2.B.8. Petrochemical and carbon black production | $CO_2$ | | LA | Tier 1 | Country specific EFs for steam cracking ethylene production for $CO_2$ emissions | 2018, 2019 |
| **2.F.1** | 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | AD | | | Tier 1 - AD obtained from Custom Authorities | New source of AD | 2018 |
| **2.F.1** | 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFCs and PFCs | 2.82 | LA, TA | Emission factors established by an expert judgement and Table 7.9, 2006 IPCC Gl., Vol. 3-2 | Improvement of country-specific emission factors | 2018 |
| **3** | 3.A Enteric Fermentation | $CH_4$ | 2.39 | LA,TA | Tier 2 | Update of initial zoo-technical data | 2018 |
| **3** | 3.D.1. Direct emissions from managed soils | $N_2O$ | 2.12 | LA,TA | Tier 1 | Collection of activity data | 2019 |
| **3** | 3.D.1 Agricultural Soils, Indirect Emissions | $N_2O$ | 2.12 | LA | Tier 1 | Revision of estimation in collaboration with Waste sector | 2019 |
| **4** | 4.A.1 Forest Land remaining Forest Land | $CO_2$ $N_2O$ $CH_4$ | 4.66 | LA,TA | Tier 3 | Further revision of EFs on carbon content in wood according to the latest scientific evidence | 2018 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **5** | 5.A Solid Waste Disposal | $CO_2$ $CH_4$ | 2.79 | LA, TA | Tier 1 | Review of factor F | 2018 |
| **5** | 5.C Incineration and Open Burning of Waste | $CO_2$ $N_2O$ $CH_4$ | | | Uncertainty assessment based on research from 2012 | Update of uncertainty assessment | 2018 |
| **5** | 5.D Wastewater Treatment and Discharge | $N_2O$ $CH_4$ | 0.71 | LA | Tier 1, CS, D | Review of biogas composition | 2019 |

# Part 2: Supplementary Information Required under Article 7, paragraph 1

# 11 KP LULUCF

This chapter includes information required under KP LULUCF reporting for NIR submission in 2017.

## 11.1 General Information

The information provided in this chapter follows the requirements set in “Guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol” (Annex to decision 15/CMP.1, FCCC/KP/CMP/2005/8/Add.2) and “Information on land use, land-use change and forestry activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol in annual greenhouse gas inventories” (Annex II to decision 2/CMP.8, FCCC/KP/CMP/2012/13/Add.1).

This is the ordinary annual report on KP LULUCF activities under the second commitment period of the Kyoto Protocol (further denoted as 2CP) including the years 2013 to 2015.

### 11.1.1 Definition of forest and any other criteria

For reporting LULUCF activities under Articles 3.3 and 3.4 of the Kyoto Protocol, forest is defined as land with tree crown cover over at least 30% (or equivalent stocking density) and an area of more than 0.05 hectares. Trees should reach a minimum height of 2 meters at maturity. Tree rows less than 20 meters wide are not considered to form a forest.

In the Czech Republic, forests are strongly affected by forest management and the long forestry tradition. Hence, most of the forests should be considered as planted forest, whereas natural forests correspond to only a small fraction of the forest area. This area is under a specific protection and conservation regime based on the categories of Act 114/1992 Col. These categories include forests of different degree of naturalness, ranging from near-natural, natural and virgin forests. Only the latter two categories can be considered as natural and covered 29.1 kha as of 2015 (MAF 2016). All other forest area in the country (ca. 2.67 Mha) is then covered by dominantly planted forest, which is to a various degree affected by forest management interventions.

### 11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

In addition to the mandatory activities of Afforestation/Reforestation (further denoted as AR) and Deforestation (D) under Article 3, paragraph 3, of the Kyoto Protocol, the Czech Republic elected the optional activity of Forest Management (FM) under Article 3.4 of the Kyoto Protocol to be included in the accounting for the first commitment period. For 2CP, these activities (AR, D and FM) are mandatory, while the remaining KP LULUCF activities are neither elected nor reported by the Czech Republic. The accounting for KP LULUCF activities will be performed for the entire 2CP at its end.

### 11.1.3 Implementation and application of activities and elected activities under Article 3.3 and Article 3.4

Due to the close links imposed between the emission inventory under the Convention and under the Kyoto Protocol, most of the methodological approaches are applicable identically for the emission estimates of KP LULUCF activities and for those reported for the LULUCF sector under the Convention. Hence, reference is frequently made to the corresponding methodologies described in Chapter 6 (LULUCF) of the NIR 2017 text, while additional and specific information related to KP LULUCF activities is highlighted here.

The conceptual linkage between the AR, D and FM activities and the reporting based on land use categories under the Convention is as follows:

- **AR activity may represent the following types of land-use conversions:**
  - 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

- **D activity may represent the following situations:**
  - 4.B.2.1. Forest land converted to Cropland
  - 4.C.2.1. Forest land converted to Grassland
  - 4.D.2.1. Forest land converted to Wetlands
  - 4.E.2.1. Forest land converted to Settlements
  - 4.F.2.1. Forest land converted to Other Land

- **FM activities relate to emissions and removals correspondingly as described in category 4.A.1 Forest land remaining Forest land**

In this way, AR activities generally always represent land-use conversion from a land-use category other than Forest Land to the land use category of Forest Land. Similarly, D is an activity when Forest Land is converted to other types of land-use, as shown above. These links are retained consistently for the entire reporting period, similarly as for the adopted methodology. This ensures consistent treatment of the activity data and methodologies across 2CP, as well as for the reporting period under the Convention, i.e., since 1990, and in some applicable instances since 1969. Other details can be found below.

### 11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently employed in determining how land was classified.

Since only one activity of the listed Article 3.4 activities is reported by the Czech Republic, no precedence conditions and/or hierarchy among Article 3.4 activities are applicable.

## 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

Land areas associated with LULUCF activities are identified within a geographic boundary encompassing units of land or land subject to multiple activities under article 3.3 and 3.4 activities (i.e. reporting method 1, IPCC 2014). Considering the small area of the country and its specific conditions, there is no applicable stratification that would justify reporting for smaller than a country-level unit. This is also supported by the attributes of the available activity data. However, the land-use representation and land-use change identification system developed for KP and UNFCCC reporting purposes permit a truly detailed spatial assessment and identification of AR and D activities at the level of the individual cadastral units. The system is exclusively based on the annually updated data on land use from the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz) at the level of approximately 13 thousand individual cadastral units (Fig. 11.1). For this submission, the land use representation and land use change identification system was further refined as described in Chapter 6.2. Specifically for 2015, the areas of AR and D were estimated at the level of 13 091 cadastral units. The mean area of these units that enter the analysis of land-use changes within each of them is 602 ha. The cadastral information on particular land-use categories has a resolution of $m^2$. The minimum assessment unit for land-use change detection is 0.05 ha. This is linked to the spatial parameters of the forest definition employed in the Czech Republic.

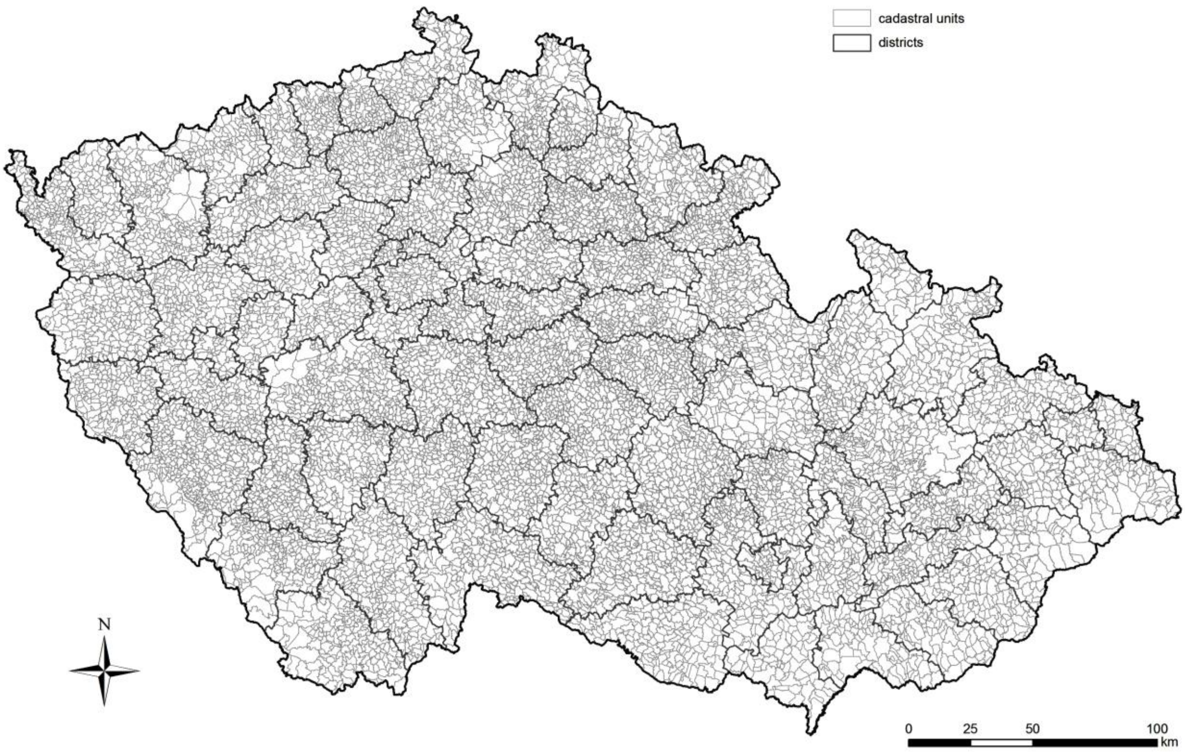



**Fig. 11.1: The spatial detail of the land use representation and land-use change identification system used for detecting land use change associated with ARD activities. In 2015, the areas of ARD were estimated at the level of 13 091 individual cadastral units.**

### 11.2.2 Methodology used to develop the land transition matrix

The land use representation and land-use change identification system was created in several steps, namely 1) source data assembly 2) linking land-use definitions 3) identification of land-use change 4) complementing time-series. These steps are described in detailed in Section 6.2 above. This results in a system of consistent representation of land areas, ranking as Reporting Method 1 of GPG for LULUCF (IPCC, 2014), having the attributes of both Approach 2 and Approach 3 and permitting accounting for all mandatory land-use transitions in annual time steps.

**Tab. 11-1 The identified land-use change from Cropland (C), Grassland (G), Wetlands (W), Settlements (S) and Other Land (O) to Forest Land (F), categorized as AR (kha/year) and land use change from F to land use categories C, G, W, S and O, which represent D (kha/year).**

| Year | Afforestation/Reforestation (AR, kha/year) | | | | | | Deforestation (D, kha/year) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C to F | G to F | W to F | S to F | O to F | Total | F to C | F to G | F to W | F to S | F to O | Total |
| **1990** | 0.50 | 0.36 | 0.00 | 0.02 | 0.00 | 0.88 | 0.03 | 0.08 | 0.01 | 0.28 | 0.00 | 0.40 |
| **1991** | 1.14 | 0.01 | 0.00 | 0.02 | 0.00 | 1.17 | 0.01 | 0.65 | 0.06 | 0.13 | 0.00 | 0.84 |
| **1992** | 0.15 | 0.05 | 0.01 | 0.02 | 0.00 | 0.23 | 0.03 | 0.20 | 0.02 | 0.21 | 0.00 | 0.47 |
| **1993** | 0.09 | 0.11 | 0.02 | 0.19 | 0.00 | 0.41 | 0.19 | 0.07 | 0.02 | 0.57 | 0.00 | 0.85 |
| **1994** | 0.26 | 0.29 | 0.12 | 0.90 | 0.00 | 1.56 | 0.13 | 0.08 | 0.01 | 0.40 | 0.00 | 0.62 |
| **1995** | 0.38 | 0.35 | 0.00 | 0.50 | 0.00 | 1.24 | 0.14 | 0.07 | 0.02 | 0.29 | 0.00 | 0.51 |
| **1996** | 0.74 | 0.41 | 0.03 | 0.59 | 0.00 | 1.77 | 0.18 | 0.32 | 0.02 | 0.38 | 0.00 | 0.90 |
| **1997** | 0.30 | 0.44 | 0.05 | 0.97 | 0.00 | 1.76 | 0.21 | 0.17 | 0.03 | 0.38 | 0.00 | 0.79 |
| **1998** | 0.46 | 0.67 | 0.09 | 2.28 | 0.00 | 3.51 | 0.38 | 0.39 | 0.05 | 0.56 | 0.00 | 1.38 |
| **1999** | 0.31 | 0.40 | 0.04 | 0.81 | 0.00 | 1.56 | 0.21 | 0.08 | 0.06 | 0.62 | 0.00 | 0.96 |
| **2000** | 0.51 | 0.54 | 0.08 | 2.40 | 0.00 | 3.52 | 0.13 | 0.14 | 0.06 | 0.39 | 0.00 | 0.72 |
| **2001** | 0.43 | 0.49 | 0.04 | 1.22 | 0.00 | 2.17 | 0.07 | 0.10 | 0.02 | 0.33 | 0.00 | 0.52 |
| **2002** | 0.34 | 0.77 | 0.04 | 3.55 | 0.00 | 4.71 | 0.04 | 0.07 | 0.08 | 0.33 | 0.00 | 0.52 |
| **2003** | 0.68 | 0.60 | 0.03 | 0.76 | 0.00 | 2.07 | 0.08 | 0.13 | 0.05 | 0.52 | 0.00 | 0.77 |
| **2004** | 0.66 | 0.80 | 0.07 | 0.52 | 0.26 | 2.30 | 0.10 | 0.07 | 0.02 | 0.51 | 0.02 | 0.72 |
| **2005** | 0.75 | 0.93 | 0.01 | 0.53 | 0.19 | 2.42 | 0.09 | 0.09 | 0.03 | 0.47 | 0.03 | 0.70 |
| **2006** | 1.03 | 0.62 | 0.04 | 0.39 | 0.18 | 2.25 | 0.07 | 0.04 | 0.03 | 0.36 | 0.01 | 0.52 |
| **2007** | 0.82 | 0.56 | 0.02 | 0.85 | 0.30 | 2.54 | 0.05 | 0.07 | 0.03 | 0.29 | 0.04 | 0.46 |
| **2008** | 0.67 | 0.49 | 0.08 | 0.87 | 0.22 | 2.33 | 0.11 | 0.05 | 0.03 | 0.29 | 0.02 | 0.50 |
| **2009** | 0.71 | 0.67 | 0.10 | 0.83 | 0.41 | 2.71 | 0.08 | 0.12 | 0.03 | 0.32 | 0.01 | 0.56 |
| **2010** | 1.01 | 0.63 | 0.14 | 0.71 | 0.45 | 2.94 | 0.11 | 0.09 | 0.06 | 0.36 | 0.02 | 0.63 |
| **2011** | 0.71 | 0.62 | 0.10 | 0.94 | 0.69 | 3.06 | 0.27 | 0.18 | 0.08 | 0.33 | 0.02 | 0.88 |
| **2012** | 0.74 | 0.70 | 0.05 | 0.78 | 0.35 | 2.62 | 0.07 | 0.11 | 0.04 | 0.26 | 0.04 | 0.51 |
| **2013** | 0.69 | 0.57 | 0.04 | 0.71 | 0.45 | 2.47 | 0.09 | 0.07 | 0.06 | 0.24 | 0.11 | 0.58 |
| **2014** | 0.67 | 0.43 | 0.05 | 1.84 | 0.28 | 3.27 | 0.08 | 0.09 | 0.04 | 0.35 | 0.02 | 0.57 |
| **2015** | 0.71 | 0.48 | 0.06 | 0.86 | 0.44 | 2.54 | 0.06 | 0.09 | 0.03 | 0.24 | 0.02 | 0.44 |

The identified annual land use changes among the major land use categories as defined in the Czech emission inventory are shown Tab. 11-1. The mean area of AR activities reached 2.2 kha per year during the 1990 to 2015 period, corresponding to a cumulative area of 58.0 kha. For the same period, the mean area of D reached 0.7 kha per year, which amounts to 17.3 kha for the entire period. The difference between AR and D corresponds to the net increment of cadastral forest land as shown in Fig. 6-4 above.

Although the system of land-use representation and land-use identification is basically identical for both KP-reporting and Convention reporting, there are some notable differences that have implications for the reported areas of KP activities (Tab. 11-2). These differences are imposed by the specific requirements for the reporting of LULUCF activities under the Kyoto protocol, namely:

i) AR activities that qualify under KP accounting are only those commenced since 1990

ii) AR land must be traced under KP reporting, i.e., it never enters the land registered under FM activity.

To handle this issue in the KP LULUCF reporting, two additional technical sub-categories were introduced for FM reporting. One is "Forest land remaining Forest land in KP reporting", while the second is "Residual afforested land from before 1990 (in conversion status)". The entire land qualified as the area under FM activity represents the sum of these two categories.

**Tab. 11-2: The forest areas of subcategories by four major tree species (Beech, Oak, Pine, Spruce) and the temporary unstocked areas (clearcut, CA), which altogether form the category 4A1 of the Convention reporting. Although not explicitly labelled in this table, until 2009 4A1 was identical with the category of Forest Land remaining Forest Land (FLRFL) used in the KP reporting of FM. 4A2 represents Land converted to Forest land, remaining in conversion status for a period of 20 years. 4A1 and 4A2 form the entire category 4A Forest Land used in the Convention reporting. Residual afforestation (RA) represents the fraction of AR areas afforested prior 1990, which forms part of the FM area (FM = FLRFL+RA), while the AR since 1990 (Art. 3.3) is treated separately and shown in Tab. 11-1 above**

| Year | Convention and KP LULUCF reporting categories and their areas (kha) since 1990 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Beech | Oak | Pine | Spruce | CA | 4A2 | 4A | FLRFL | RA | FM |
| **1990** | 380.9 | 156.0 | 466.2 | 1539.2 | 40.6 | 46.6 | 2629.5 | 2582.9 | 45.7 | 2628.6 |
| **1991** | 384.0 | 156.6 | 466.1 | 1535.0 | 40.7 | 46.9 | 2629.3 | 2582.4 | 44.8 | 2627.2 |
| **1992** | 387.4 | 157.7 | 464.7 | 1534.7 | 41.9 | 42.5 | 2629.1 | 2586.5 | 40.3 | 2626.8 |
| **1993** | 390.0 | 158.4 | 462.9 | 1533.9 | 41.4 | 41.9 | 2628.6 | 2586.7 | 39.2 | 2625.9 |
| **1994** | 393.9 | 158.6 | 461.5 | 1537.3 | 39.8 | 38.3 | 2629.5 | 2591.1 | 34.0 | 2625.1 |
| **1995** | 397.2 | 159.2 | 461.6 | 1537.7 | 38.9 | 35.4 | 2630.1 | 2594.6 | 29.9 | 2624.5 |
| **1996** | 399.9 | 160.9 | 460.8 | 1536.4 | 38.1 | 34.7 | 2631.0 | 2596.1 | 27.5 | 2623.6 |
| **1997** | 403.3 | 160.9 | 460.3 | 1537.3 | 36.0 | 33.8 | 2631.8 | 2597.8 | 24.8 | 2622.6 |
| **1998** | 409.9 | 161.3 | 462.9 | 1532.5 | 33.7 | 33.3 | 2633.8 | 2600.3 | 20.8 | 2621.0 |
| **1999** | 412.7 | 163.3 | 458.9 | 1537.6 | 32.2 | 29.5 | 2634.5 | 2604.7 | 15.4 | 2620.1 |
| **2000** | 417.0 | 165.3 | 457.5 | 1536.6 | 31.0 | 29.6 | 2637.3 | 2607.4 | 12.0 | 2619.4 |
| **2001** | 422.2 | 166.5 | 456.2 | 1535.7 | 29.8 | 28.5 | 2639.2 | 2610.4 | 8.7 | 2619.1 |
| **2002** | 428.1 | 168.0 | 454.1 | 1531.5 | 28.3 | 32.7 | 2643.1 | 2610.1 | 8.3 | 2618.3 |
| **2003** | 435.5 | 169.6 | 452.7 | 1525.2 | 27.0 | 33.9 | 2644.2 | 2610.0 | 7.4 | 2617.4 |
| **2004** | 441.1 | 170.4 | 450.3 | 1521.5 | 26.8 | 35.5 | 2645.7 | 2610.1 | 6.6 | 2616.7 |
| **2005** | 447.3 | 171.1 | 448.8 | 1517.5 | 26.3 | 36.3 | 2647.4 | 2610.9 | 5.0 | 2616.0 |
| **2006** | 451.7 | 173.0 | 446.8 | 1514.1 | 25.9 | 37.4 | 2649.1 | 2611.5 | 3.9 | 2615.5 |
| **2007** | 457.6 | 174.2 | 444.8 | 1509.9 | 26.1 | 38.6 | 2651.2 | 2612.5 | 2.5 | 2615.0 |
| **2008** | 464.6 | 176.6 | 442.9 | 1502.3 | 27.1 | 39.5 | 2653.0 | 2613.4 | 1.1 | 2614.5 |
| **2009** | 471.0 | 177.8 | 440.9 | 1496.7 | 27.6 | 41.1 | 2655.2 | 2613.9 | 0.0 | 2613.9 |
| **2010** | 475.2 | 179.7 | 439.4 | 1490.7 | 28.1 | 43.2 | 2657.4 | 2613.1 | 0.0 | 2613.1 |
| **2011** | 479.8 | 181.8 | 437.0 | 1484.8 | 29.1 | 45.0 | 2659.8 | 2612.6 | 0.0 | 2612.6 |
| **2012** | 485.6 | 183.4 | 435.4 | 1477.6 | 30.0 | 47.4 | 2661.9 | 2612.0 | 0.0 | 2612.0 |
| **2013** | 492.2 | 185.1 | 433.8 | 1469.9 | 30.5 | 49.5 | 2663.7 | 2611.4 | 0.0 | 2611.4 |
| **2014** | 500.4 | 185.1 | 431.0 | 1461.3 | 33.1 | 51.2 | 2666.4 | 2610.8 | 0.0 | 2610.8 |
| **2015** | 506.7 | 188.3 | 433.3 | 1450.6 | 31.4 | 52.5 | 2668.4 | 2610.4 | 0.0 | 2610.4 |

The Czech inventory system adopts the 20-year default period for preserving lands under conversion status as recommended by IPCC (2006). Therefore, the areas of the sub-category Forest land remaining Forest land in KP reporting are equal to the areas in the category 4A1 under Convention reporting until 2009. In KP reporting, the entire area of FM must additionally include the fraction of land afforested prior 1990, which is represented by the second introduced sub-category, i.e., "Residual afforested land from before 1990 (i.e., in conversion status)", which is abbreviated as RA in Tab. 11-2.

Since the reported year 2010, the area of FLRFL became equal to FM and the area of RA became zero. At the same time, the FM area became smaller than that reported under 4A1 under the Convention reporting (4A1 is not explicitly shown in Tab. 11-2, but it is equal to 4A - 4A2) and hence also the areas of the individual species groups differ under the Convention and KP reporting. This is due to the fact that forest area loss from FM due to D activities is not compensated by any residual areas of formerly (prior 1990) afforested land, and because AR, similarly to D, remain treated separately from FM even after 20 years.[9]

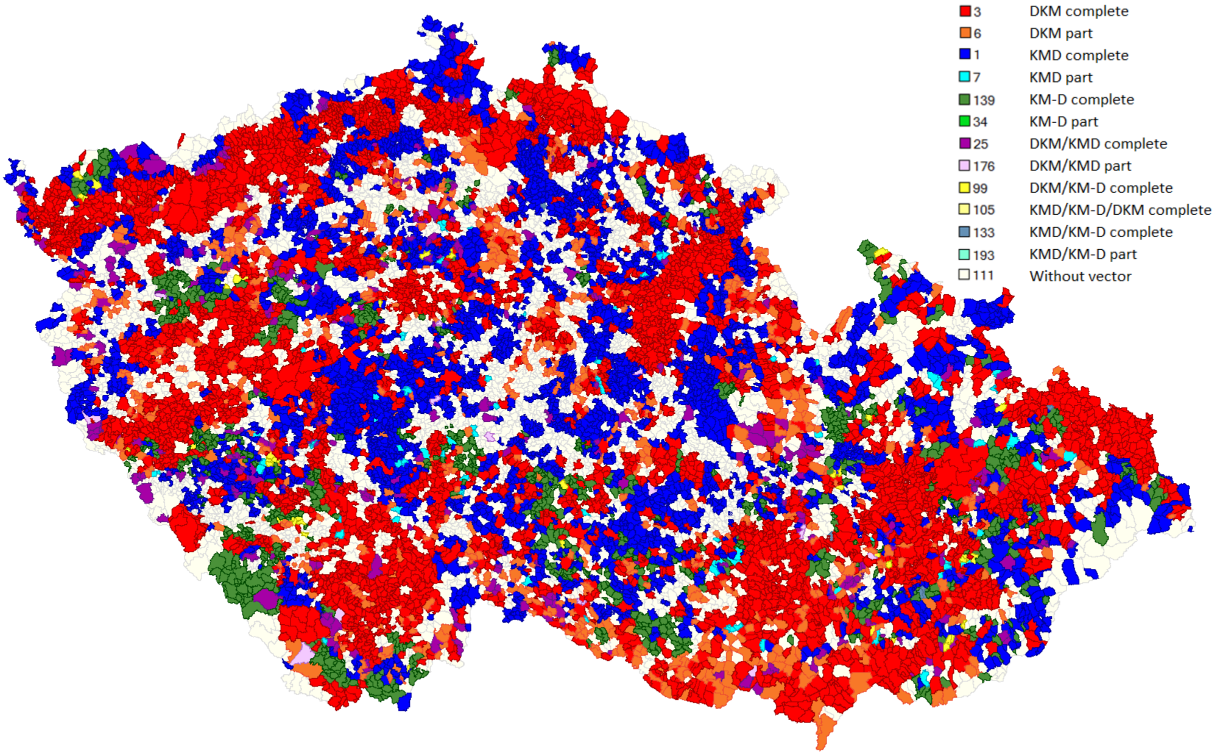



**Fig. 11.2: The ongoing digitalization of the Czech cadastral land use information with units identified by categories of source map origin, coordination system and scale (DKM, KMD, KM-D and their combination) and completeness labelled by individual colours. Based on the information of COSMC as of 2013.**

The system of land use, land-use representation and land-use change identification as currently implemented in this inventory represents the most advanced approach achievable within the conditions in the country. It should be understood that it is basically a bottom-up system using detailed information at the level of individual cadastral units (n=13 091 as of 2015). The information as reported in the CRF tables represents sum-up values of the individual cadastral units, involving 10 land use types of the original categorization and the time span from 1969 to 2015. It should also be noted the reconciled official land use information of COSMC undergoes continuous updating and accuracy improvement due to the progressing digitalization of the original maps. The resulting digital maps are distinguished by the source information and its coordination system. As also noted in section 6.2 of the NIR text (see also Footnote 3), the LULUCF inventory consults the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz) on the issues related to the information on land areas in the Czech Republic. To illustrate the process of ongoing digitalization of cadastral maps in the county, we include the map of the

[9] *It should be stressed that although fully solved in the Czech LULUCF and KP LULUCF inventory, the seemingly similar but different treatment of forest land areas under Convention and KP reporting is unfortunate and unnecessarily complex.*

recent (as of 2013) state of the art in this process (Fig. 11.2, based on COSMC). It gives an overview of the national cadastral system under the process of digitalization, with different categories by source map origin, coordination system, scale and completeness labelled by individual colours. Evidently, this gradual digitalization leads to rectified area information on individual cadastral parcels, units and therefore also on the entire country. This also explains the nature of the ongoing area rectifications in the official reports on areas of land and land use categories in the country. In early 2017, on a request of the inventory team, COSMC provided a new statement commenting the current digitalization progress and commenting issues linked to area rectification and origin of the land use changes that are officially reported by COSMC on behalf of the country.

### 11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

The KP LULUCF reporting of the Czech Republic is based on the annually updated data from the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz) at the level of about 13 thousands individual cadastral units (Fig. 11-1), which represent the Czech cadastral system. At that level, land use change is identifiable, using the standard identification codes and names of the Czech cadastral system and COSMC.

The spatial resolution of the adopted land-use representation and land-use change identification system is depicted in Figs. 11-3 and 11-4, which show the identified units with AR and D activities, respectively, in 2015.

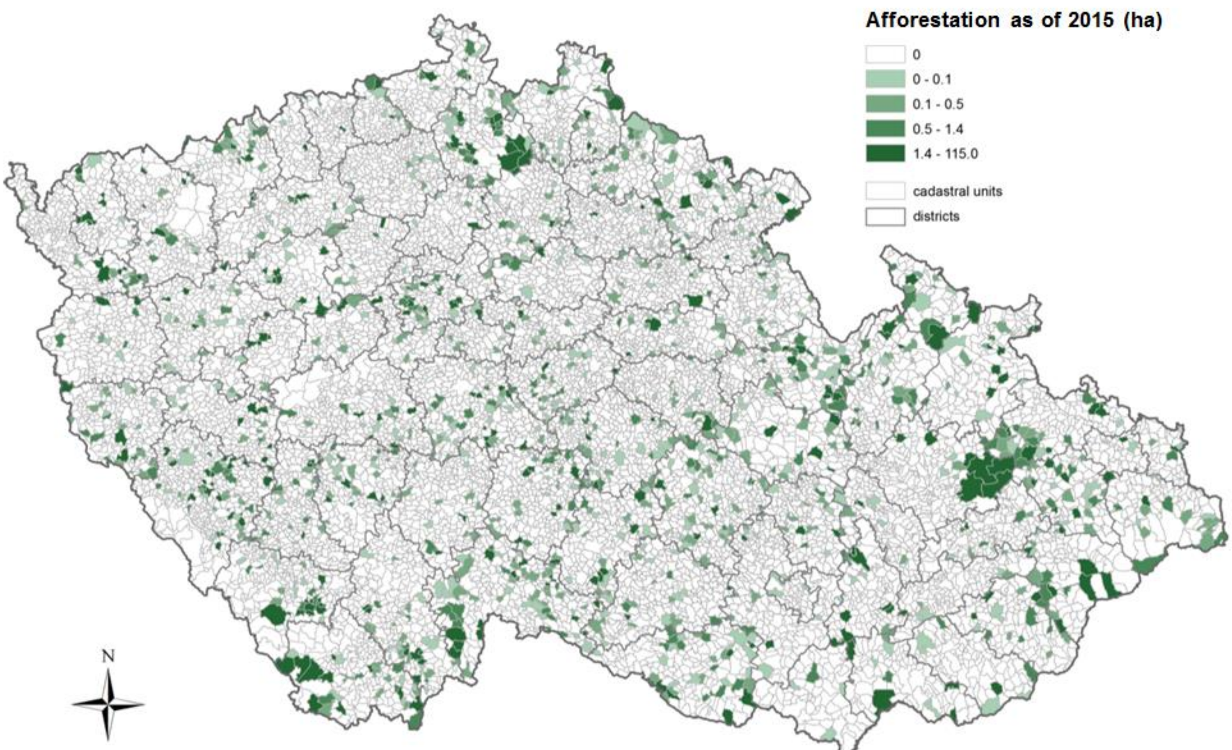



**Fig. 11-3: The cadastral units with identified afforestation (AR) activities in 2015.**

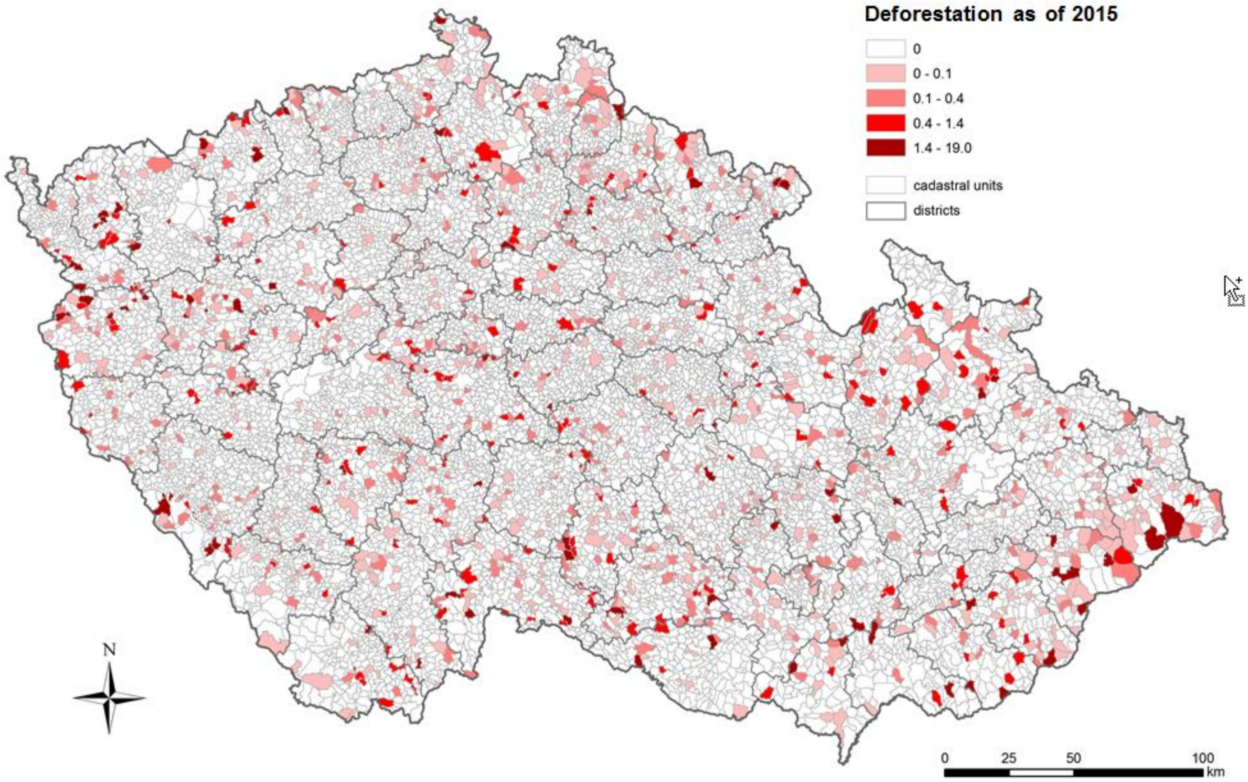



**Fig. 11. 4: The cadastral units with identified deforestation (D) activities in 2015.**

## 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*

Due to efforts to link the emission inventory under the Convention and that under the Kyoto Protocol, most of the methodological approaches are applicable identically for the KP LULUCF activities and the relevant LULUCF categories under the Convention reporting. These are described in detail in Chapter 6 (LULUCF) of the 2017 NIR submission. Hence, reference is often made to these methodologies, while additional and specific information related to Kyoto Protocol LULUCF activities is highlighted here.

For AR activities, the applicable methodology of IPCC (2006) for estimating emissions and removals is given in Section 4.3. Correspondingly, the emissions due to D were estimated based on the guidance given in Chapters 5.3, 6.3, 7.3, 8.3 and 9.3. For specific details on the approaches employed, country-specific activity data and factors, Chapter 6 of the NIR 2017 submission should be consulted.

In the KP LULUCF reporting., the emissions and/or removals of $CO_2$ are quantified for changes in five ecosystem carbon pools, namely above-ground biomass, below-ground biomass, dead wood, litter and soil organic matter. Additionally, the $CO_2$ emission contribution is estimated for Harvested wood Products (HWP), which may also concern AR and D activities.

Changes in above-ground biomass carbon pool were estimated primarily on the basis of forest taxation data in Forest Management Plans (further denoted as FMP), disaggregated in line with the country-specific approaches at the level of the four major tree species groups, namely beech, oak, pine and spruce (Chapter 6.4 of NIR 2017).

Since the estimates of biomass carbon stock change on Forest Land under the Convention involve one default coefficient for the root/shoot ratio (*R*; 0.20) and the equations of the default method involving multiplicative members, the attributing of carbon stock change to the below- and above-ground components, required for the reporting under Kyoto Protocol, was determined solely by *R*.

The carbon stock change in dead organic matter, i.e., deadwood and litter carbon pools for AR and D activities, was estimated similarly as described for the corresponding LULUCF categories in Chapters 6.4.2.2 and 6.5.2.2 of NIR 2017. This method uses the latest activity data obtained from the statistical inventory programs available in the country. The only difference between the LULUCF and KP LULUCF approaches is the different area associated with these carbon stock changes under the two reporting bodies. Mineral soil carbon stock estimation follows the methodology of soil carbon stock change estimation resulting from land use change among the land use categories of Forest Land, Cropland and Grassland, based on the interpreted soil carbon stock maps (Section 6.4.2.2, NIR 2017). Complementarily, for sub-categories involving Wetland, Settlements and Other Land, “NA” was entered in association with the soil carbon pool, as no adopted applicable methodology is listed for this pool in IPCC (2006) for the symmetric types of land-use conversion events.

For the FM activity, which resembles category 4A1 Forest Land remaining Forest Land, the Tier 1 methodology assumption of the IPCC Guidelines (IPCC, 2006) of no significant change in the deadwood carbon pool was adopted under UNFCCC Reporting. Since Tier 1 methodology does not meet the requirements of KP LULUCF reporting, justification for using this assumption under FM activity reporting is provided in Section 11.3.1.2. Note also that there is a common misunderstanding of what Tier 1 reporting means in terms of using the appropriate notation keys. In our case, the notation key “R” is used in order to distinguish a deliberate consideration of Tier 1 assumption as compared to “NE” (not estimated). NE inherently implies that the Tier 1 assumption cannot be considered and a carbon pool under this notation may actually represent a significant source or sink of emissions, which is not the case in this inventory. More information on the deadwood carbon pool considerations under FM is therefore provided in Section 11.3.1.2, which justifies our inexplicit reporting of the deadwood carbon pool. It should also be noted that the assumptions for carbon stock change of deadwood for FM activity will probably be revised using Tier 2 or Tier 3 methodology estimation based on the results of the recently conducted CzechTerra statistical landscape inventory in the Czech Republic.

In contrast, the carbon stock change of the soil carbon pool under FM was not estimated and the “NE” notation key is used. This implicitly also applies to the litter carbon pool, which is included in the soil carbon pool for the reasons noted above in the section on AR and D reporting, as well as due to the YASSO soil model concept, which is used for justification when omitting these carbon pools in Section 11.3.1.2 below.

Additional greenhouse gases ($CO_2$, $CH_4$ and $N_2O$) are reported from biomass burning. Burning is explicitly confined to the activity of FM and thus matches the corresponding estimates under the Convention for the land-use category 4A1 Forest Land remaining Forest Land. The emissions are estimated identically as described in Section 6.4.2.1 of the NIR 2017 text.

There are no $N_2O$ emissions from N-fertilization and soil drainage, which are therefore not applicable for the reporting period. On the contrary, $N_2O$ emissions are reported for deforestation of Forest land that is converted to Cropland. This estimation is identical to that reported under the Convention and described in NIR 2016, Section 6.5.2.2 for land use category 4.B.2.1.

The estimates for the emission contribution from changes in Harvested Wood Products (HWP) are also included in this inventory submission. The methodology and activity data are basically identical to those employed for HWP estimates under the Convention, which is described in Chapter 6.10. The adopted approach also includes information on emissions to HWP changes attributable to areas of D, which are methodologically treated differently (instant oxidation) compared to HWP attributable to FM (first order decay by product sub-categories; Approach B1).

### *11.3.1.2 Justification for omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4*

First, justification is provided for the deadwood carbon pool under FM, which is currently reported using the Tier 1 assumption that the time average values of this pool will remain constant with inputs balanced by outputs (IPCC 2006). As this is inadequate under KP LULUCF reporting, we use the following argumentation supporting the assumption that the deadwood carbon pool does not represent a source of emissions. We use both reasoning based on sound knowledge of probable system responses and empirical data.

The reasoning is based on the long term trend of increasing growing stock in our country, which is also demonstrated for the reporting period under the Convention (cf. Chapter 6 of NIR text). On large temporal and spatial scales, the amount of deadwood is roughly proportional to the growing stock. Since the growing stock has been steadily increasing during the reporting period in the forests of this country, there is basically the same trend as for deadwood volume. An increasing pool of deadwood volume basically means removals of emissions (fixing carbon). In other words, this pool is not a source of emissions.

The statistically representative empirical data that were recently acquired in the Czech Republic offer additional support for this trend. Specifically, information on the dead wood pool is available from two independent statistical inventories. One is the National Forest Inventory (NFI), whose first cycle was performed during 2001-2004. This inventory included about several thousand sample plots covering the entire forest area in the country. The results of this inventory campaign were published by the Forest Management Institute, Brandýs n. Labem (FMI), in 2007 and also included information on deadwood (FMI 2007). The second data source is the ongoing project of the National landscape inventory (CzechTerra - adaptation of landscape carbon reservoirs in the context of global change), a project funded by the Ministry of the Environment (SP/2d1/93/07). CzechTerra conducted its first field sampling during 2008 and 2009 (www.czechterra.cz). This project also contains a statistically representative assessment of the deadwood pool in forests applicable at a country level. Since both NFI and CzechTerra use an identical assessment method for lying deadwood volume, a straightforward comparison can be performed to assess the trend of lying dead wood pool change in Czech forests during very recent years. It can be assumed that NFI sampling represents the year 2003, while CzechTerra sampling represents the year 2009. Lying deadwood volume is estimated for four classes of decay stages, which are summarized in Table 11-3 below.

**Tab. 11-3 Mean volume of lying deadwood on forest land by decay classes as estimated by the NFI and CzechTerra inventory programs. The unit is mil. $m^3$ and the parentheses show the 95% confidence interval.**

| Campaign<br>Decay stage | NFI – ref. year 2003 | CzechTerra – ref. year 2009 |
|---|---|---|
| **Wood is hard** | 7.47 (7.02 - 7.93) | 9.54 (7.58 – 11.5) |
| **Soft periphery, centre hard** | 3.75 (3.48 - 4.02) | 5.10 (2.81 – 7.38) |
| **Hard periphery, centre soft** | 0.82 (0.73 - 0.90) | 1.28 (0.72 – 1.85) |
| **Totally soft/rotten** | 6.28 (5.98 - 6.59) | 4.79 (3.84 – 5.74) |

The volume of deadwood estimated by the CzechTerra campaign, representing the situation as of 2009, is larger for most of the decay stage classes compared to the estimates by NFI conducted for 2003. To envisage this trend more clearly, deadwood volume can be converted into biomass and carbon quantities as the product of the wood volume, density weighted by the mean growing stock volume of major tree species, reduction coefficients applicable to individual decomposition categories and wood carbon fraction as given in Section 11.3.1.1 above. The result of this recalculation is shown in Table 11-4.

**Tab. 11-4 Carbon stock held in lying deadwood on forest land by decay classes as estimated by the NFI and CzechTerra inventory programs. The unit is mil. t C.**

| Campaign<br>Decay stage | NFI – ref. year 2003 | CzechTerra – ref. year 2009 |
|---|---|---|
| **Wood is hard** | 1.29 | 1.65 |
| **Soft periphery, centre hard** | 0.65 | 0.88 |
| **Hard periphery, centre soft** | 0.09 | 0.14 |
| **Totally soft/rotten** | 0.27 | 0.21 |
| **Total quantity** | 2.30 | 2.88 |

To interpret the estimates shown in Table 11-4, we see that the total carbon content held in deadwood increased from 2.30 mil. t C in 2003 to 2.88 mil. t C in 2009. The difference is 0.58 mil. t C accumulated during the period of 6 years. Thus, the annual accumulation of carbon held in deadwood was 0.096 mil. t C, which represents a $CO_2$ sink of -0.35 mil. t $CO_2$/year.

To conclude, the above quantitative assessment from the two country-level statistical inventory programs (with identical methodology to obtain deadwood volume estimates by decay classes) demonstrates that the deadwood carbon pool is currently not a source of emissions under the conditions in the Czech Republic. However, it is planned that both the data and the underlying assumptions for deadwood carbon pool estimation will be further examined to explore the possibility of its specific accounting also under FM activity. This is scheduled for the next, i.e., 2018 NIR inventory submission.

Secondly, we provide justification for omitting the soil carbon pool (and inherently the litter carbon pool) from the reporting under FM activity. Here it is also assumed that, under the conditions of current forestry practices at the country level, forest soils do not represent a net source of $CO_2$ emissions. Justification for this approach is based on the targeted peer-reviewed modelling analysis performed for the actual circumstances of FM in the country (Cienciala et al., 2008b). It uses the well-established YASSO soil model (Liski et al., 2003, 2005) in combination with the similarly well-known and established EFISCEN forest scenario model (e.g., Karjalainen et al., 2002) and the actual data for forest biomass, growth performance and growing conditions in the country. The analysis shows that, under the adopted sustainable forest management practices implemented in the Czech Republic, the forest soil carbon pool (including litter) does not decrease, i.e., it is not a net source of emissions. The study contains further details on the country-specific model application, definition of scenarios and results related to both biomass and soil carbon pools, including the probable effect of changing climatic conditions. It also contains a discussion that elucidates the aspect of the YASSO model concept of litter input and aggregated output for litter/organic and mineral soil layers and its justification, as well as the reasoning with respect to the Kyoto protocol LULUCF reporting requirements. There is a wealth of literature on YASSO model applications that can be further consulted (www.environment.fi/syke/yasso).

To conclude, the forest soil carbon pool and inherently the litter carbon pool under current forest management practices and growth trends can be assumed not to be a source of emissions. The underlying assumptions will be further verified.

#### *11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out*

The indirect and natural GHG emissions and removals were not factored out.

#### *11.3.1.4 Changes in data and methods since the previous submission (recalculations)*

This inventory includes changes in activity data in areas, which were further improved for this inventory. Also, new activity data were used for litter and deadwood carbon stock estimates for AR and D activities. Finally, the emission contribution of HWP is newly included. All these changes required recalculation of emission estimates for the entire reporting period and the currently reported estimates are herewith revised compared to those in the previous submission.

#### 11.3.1.5 Uncertainty estimates

The uncertainty estimates were prepared following the methodological guidance of GPG for LULUCF (IPCC, 2003) and IPCC (2006), which is described in Chapter 6.4.3. It includes the noted issue of combining uncertainties that is considered questionable when uncertainties associated with removals and emissions are to be combined, which may result in a denominator close to or equal to zero (which is not admissible). Since the last revision introduced in the NIR 2012, no other changes have been implemented for the uncertainty estimation in the follow-up NIR submissions.

In 2015, the estimated overall uncertainty for AR activities was 39.6%. The overall uncertainty for D was 58.8%. For FM the overall uncertainty equalled 22.0%.

#### 11.3.1.6 Information on other methodological aspects

Despite efforts to make the reporting of KP LULUCF activities correspond to that under the Convention, there are some aspects that make direct comparison difficult. Specifically for FM, a direct comparison with the emission estimates of related category 4.A.1 under the Convention reporting will reveal some differences. There are several aspects to be considered when comparing the quantitative estimates of these categories, which relate to different treatment of land areas, i.e., differences in land-based and activity reporting (see Chapter 11.2.2 above).

#### 11.3.1.7 The year of the onset of an activity, if after 2013

Not applicable.

## 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 directly human-induced

The annually updated cadastral information from the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz) refers exclusively to intentional, i.e., human-induced interventions into land use. These interventions are thereby reflected in the corresponding records, including the time attribute, collected and summarized at the level of cadastral units and individual years.

### 11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

Since no remote sensing technology is directly involved in the Czech KP LULUCF emission inventory, there is no issue related to distinguishing harvesting or forest disturbance from deforestation. Harvesting and forest disturbance always occur on Forest Land, while deforestation is a permanent cadastral change of land use from Forest Land to other categories of land use.

### 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.

Any deforestation in terms of land use change requires an official administrative decision. Hence, no permanent loss of forest cover may occur prior this approval, which is reflected in cadastral land use. The above also implies that there is no afforestation occurring on previously deforested land through an administrative decision. A temporary loss of forest cover up to an area of 1 ha may occur as part of forest management operations on Forest land (units of land subject to *FM*), which is, however, not qualified as deforestation in terms of Art. 3.3. KP LULUCF activity.

### 11.4.4 Information related to natural disturbances provision under Art. 3.3

The Czech emission inventory of KP LULUCF activities does not employ any provision for natural disturbances for the accounting in 2CP and therefore no additional specific information on this issue is provided.

### 11.4.5 Information on Harvested wood products under Art. 3.3

As requested by paragraph 26 of Annex to 2/CMP.7, carbon stock changes in the HWP pool are reported and accounted for in the Czech emission inventory. The methodology of estimation is described in Section 11.5.3.5.

However, the estimates of HWP emission contribution also relate to Activities under Art. 3.3. Specifically for Deforestation (D), the emission estimation discerns the contribution of D to the total HWP produced and consumed domestically in order to apply direct oxidation for the associated emissions (IPCC 2014). The share of HWP originating from D is estimated on the basis of an area-based share of land under D and FM for the individual reporting years. This share reached 0.02% in both 1990 and 2014, with a maximum of 0.05% in 1998. The mean value for the entire reporting period was 0.03%, hence 99.98% of HWP products employed for first order decay estimation of HWP emission contribution originates from the areas under FM.

As for Afforestation/Reforestation (AR), due to inadequate tree age it may safely be assumed in the conditions of the country that no harvest has originated from AR activities yet. However, the empirical evidence (data) for this statement are lacking and hence it is formally impossible to separate harvest between AR and FM. Therefore, carbon stock changes in HWP are reported solely under FM (besides the separated and excluded harvest from D as described above) following the recommendation of IPCC 2013 KP Supplement (IPCC 2014), p. 2.118, namely “In case it is not possible to differentiate between the harvest from AR and FM, it is conservative and in line with good practice to assume that all HWP entering the accounting framework originate from FM”.

### 11.4.6 Information on estimated emissions and removals of activities under Art. 3.3

In 2015, the estimated removals from AR activities reached -589 Gg $CO_2$ eq. The estimated emissions from D equalled 180 Gg $CO_2$ eq. The details can be found in the corresponding CRF Tables of KP LULUCF.

## 11.5 Article 3.4

### 11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

The Czech Republic adopted the broad definition (FCCC/CP/2001/13/Add.1; IPCC 2014) of FM. It reads "Forest management is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner." This decision implies that the entire forest area in the country is subject to FM interventions, as guided by the Forestry Act (No. 289/1995 Coll.).

### 11.5.2 Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year

Not applicable for the Czech Republic.

### 11.5.3 Information relating to Forest Management

As noted in Section 11.5.1 above, the practice of *FM* is generally guided by the Forestry Act (No. 289/1995 Coll.).

#### *11.5.3.1 Conversion of natural forest to planted forest*

The extent of natural forest in the Czech Republic was 29.1 kha as of 2015 (MAF 2016), representing about 0.001% of the forest area in the country. The remnants of natural forest in the country are extremely valuable and under the most strict conservation and protection regime. Hence, no conversion of natural forest to planted forest is permitted and has not occurred under the conditions of the country during the reporting period since 1990.

#### *11.5.3.2 Forest Management Reference Level (FMRL)*

FMRL applicable for the Czech Republic was prepared by the Joint Research Centre of the European Commission (JRC), based on elaboration of the results of independent EU modeling groups, coordinated by the International Institute for Applied Systems Analysis (IIASA), assisted by the JRC and funded by the European Commission Directorate General of Climate Action (DG CLIM). The adopted value of FMRL with emissions/removals from HWP using the first order decay functions is 4 686 Gg $CO_2$ eq. A detailed description of the FMRL can be found on https://unfccc.int/bodies/awg-kp/items/5896.php (revised submission of the Czech Republic from 13 September 2011).

#### *11.5.3.3 Technical Corrections of FMRL*

No technical correction has been applied to FMRL applicable for the Czech Republic.

#### *11.5.3.4 Information related to the natural disturbance provision under Art. 3.4*

The Czech emission inventory of KP LULUCF activities does not apply any provision for natural disturbances for the accounting in 2CP and therefore no additional specific information on this issue is provided here.

#### *11.5.3.5 Information on Harvested Wood Products under Art. 3.4*

The estimates of the HWP emission contribution are predominantly related to activity of FM under Art. 3.4. The contribution of Art. 3.3 activities to HWP is discerned on the basis of the area-based share of land under D and FM for individual reporting years as described in Chapter 11.4.5. The share applicable to FM represents 99.98%, for which the first order decay estimation of the HWP emission contribution is used in accordance with IPCC (2014). The specific methodological details related to HWP under FM are described in Chapter 11.5.5 below.

### 11.5.4 Information on estimated emissions and removals of Forest Management activity under Art. 3.4

In 2015, the estimated removals from *FM* (without HWP contribution) reached -4 911 Gg $CO_2$ eq. The details can be found in the corresponding CRF Tables of KP LULUCF.

### 11.5.5 Information on methodology and estimated emission contribution from HWP

The activity and methodology data applicable to estimation of emission contribution from HWP are described in Chapter 6.10 of the current NIR submission. Estimation of the HWP contribution is treated identically under the Convention and KP LULUCF; therefore all details, including source category description, methodological issues, uncertainties and time series consistency, QA/QC and verification as described in Chapter 6.10 of NIR are also fully applicable for KP reporting. Other details can be found in the corresponding CRF tables.

In 2015, the estimated emission contribution from HWP reached -164 Gg $CO_2$ eq. The estimates for the entire reporting period since 1990 can be found in the corresponding CRF Tables of KP LULUCF.

## 11.6 Other information

### 11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

As stated in CRF KP-LULUCF table “NIR-3”, one key category was identified among the KP LULUCF activities, namely FM. Similarly to its associated LULUCF category 4.A.1 Forest land remaining Forest land, it was identified by level assessment. No other activity was identified as key in this NIR submission.

## 11.7 Information relating to Article 6

No LULUCF joint implementation project under Art. 6 concerns the Czech Republic.

# 12 Information on accounting of Kyoto units

## 12.1 Background information

The information from the national registry on the issue, acquisition, holding, transfer, cancellation, withdrawal and carryover of assigned amount units, removal units, emission reduction units and certified emission reductions in the period from 1st of January 2016 to 31st of December 2016 is provided in standard electronic format in Annex A5.7.

## 12.2 Summary of information reported in the SEF tables

In its true-up period report submission, the Czech Republic requested to carry over 48,272,014 AAUs to the second commitment period of the Kyoto Protocol. All other units in the national registry for the first commitment period have been retired.

At the end of the year 2016 no units valid for the second commitment period were in the national registry.

## 12.3 Discrepancies and notifications

No CDM notifications and non-replacements occurred in 2016.

No invalid units exist as at 31 December 2016.

No discrepant transactions occurred in 2016.

## 12.4 Publicly accessible information

Non-confidential information in accordance with decision 13/CMP.1, annex, chapter II.E, paragraphs 44–48, is provided in the Public Reports section of the registry website at:

https://ets-registry.webgate.ec.europa.eu/euregistry/CZ/public/reports/publicReports.xhtml

## 12.5 Calculation of the commitment period reserve (CPR)

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 calculations of the commitment period reserve for the Czech Republic are as follows.

Method 1: 90 % of assigned amount results in:

0.90 x 520,515,203 = 495,463,683 tonnes of $CO_2$eq.

Method 2: 100 % of most recently reviewed inventory, taken the 2016 submission as the most recently reviewed inventory, multiplied by 8 results in:

8 x 127,925,530 = 1 023,404,242 tonnes $CO_2$ eq.

The commitment period reserve consequently amount to **495,463,683** tonnes of carbon dioxide equivalent.

# 13 Information on changes in National System

Since 2014 the National Inventory Team obtained higher funding from Ministry of Environment, which is further improving the cooperation with sectoral experts and sectoral institutions. Since 2015 the contracts with relevant sectoral institution were signed for four years. Since previous years the contracts were signed only for one year this step means significant strengthening of National System.

The Czech National Inventory Team has undergone staffing changes:

- Beata Ondrusova has been hired as new sectoral expert to support inventory in Industrial processes and product use sector. Martin Beck is not official part of the inventory team any more, however he is supporting the team on QA procedures for IPPU.
- Stanislav Roman has been hired for purposes of ensuring proper QA/QC process (QA/QC manager) and QC of Waste sector. Denitsa Troeva Svobodova is currently external expert for purposes of ensuring proper QA/QC process (QA/QC manager) and QC of Waste sector.
- Jana Beranova has been hired as sectoral expert to support inventory in Agriculture sector. Zuzana Exnerova is no longer part of the inventory team, however she will serve as QA expert in future submission.

No other significant changes were made and the main pillars of the national inventory system declared in the Czech Republic's Initial Report under the Kyoto Protocol are operational and running.

# 14 Information on Changes in National Registry

## 14.1 Previous Review Recommendations

In document FCCC/ARR/2014/CZE ERT requested the Party to include non-confidential up-to-date holding and transaction information in its publicly available information. The non-confidential holding and transaction information was made available at the registry website:

https://ets-registry.webgate.ec.europa.eu/euregistry/CZ/public/reports/publicReports.xhtml

In August 2016, the Czech Republic was subject to centralized review in Bonn. The Annual Inventory Review Report has not been published by the date of the inventory submission. However no significant issues relating to functionality of the national registry have been identified during the centralized review.

## 14.2 Changes to National Registry

The following changes to the national registry of the Czech Republic have therefore occurred in 2016:

| Reporting Item | Description |
|---|---|
| 15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact | Change of main contact person for the national registry administrator to Mr. Martin Standera (mstandera@ote-cr.cz). |
| 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 | New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality.<br><br>Versions of the CSEUR released after 6.7.3 (the production version at the time of the last Chapter 14 submission) introduced other minor changes in the structure of the database.<br><br>These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model, including the new tables, is provided in Annex A. |
| 15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards | Changes introduced since version 6.7.3 of the national registry are listed in Annex B.<br>Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). Annex H testing was completed in January 2017 and the test report will be provided at a later date.<br>No other change in the registry's conformance to the technical standards occurred for the reported period. |

| Reporting Item | Description |
|---|---|
| 15/CMP.1 annex II.E paragraph 32.(e)<br>Change to discrepancies procedures | No change of discrepancies procedures occurred during the reported period. |
| 15/CMP.1 annex II.E paragraph 32.(f)<br>Change regarding security | The mandatory use of hard tokens for authentication and signature was introduced for registry administrators. |
| 15/CMP.1 annex II.E paragraph 32.(g)<br>Change to list of publicly available information | No change to the list of publicly available information occurred during the reporting period. |
| 15/CMP.1 annex II.E paragraph 32.(h)<br>Change of Internet address | No change of the registry internet address occurred during the reporting period. |
| 15/CMP.1 annex II.E paragraph 32.(i)<br>Change regarding data integrity measures | No change of data integrity measures occurred during the reporting period. |
| 15/CMP.1 annex II.E paragraph 32.(j)<br>Change regarding test results | Changes introduced since version 6.7.3 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; the report is attached as Annex B.<br>Annex H testing was carried out in January 2017 and the test report is attached as Annex H. |

# 15 Information on Minimization of Adverse Impact in Accordance with Art. 3, para 14

The Czech Republic strives to implement its Kyoto commitments in a way, which minimizes adverse impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention. The impact of mitigation actions on overall objectives of sustainable development is also given due consideration. As there is no common methodology for reporting of possible adverse impacts on developing country Parties, the information provided is based on the expert judgment of the Ministry of the Environment of the Czech Republic. More information on EU wide policies is available in chapter 15 of the Annual European Union greenhouse gas inventory 1990–2014 and inventory report 2016 and will be updated in the European Union submission for the year 2017. The table below summarizes how the Party gives priority to selected actions, identified in paragraph 24 of the Annex to Decision 15/CMP.1.

**Tab 15-1 Actions implementation by party as identified in paragraph 24 of the Annex to Decision 15/CMP.1**

| Action | Implementation by the Party |
|---|---|
| (a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities. | The ongoing liberalization of energy market is in line with EU policies and directives. No significant market distortions have been identified. Consumption taxes for electricity and fossil fuels were harmonized recently. The main instrument addressing externalities is the emission trading under the EU ETS. Introduction of new instruments is subject to economic modelling and regulatory impact assessment. The introduction of carbon tax was proposed and discussed but the government decided to wait for the outcome of proposal for EU wide harmonisation. The government has requested a feasibility and impact analysis to be submitted by the end of 2018. |
| (b) Removing subsidies associated with the use of environmentally unsound and unsafe technologies. | No subsidies for environmentally unsound and unsafe technologies have been identified. |
| (c) Cooperating in the technological development of non-energy uses of fossil fuels and supporting developing country Parties to this end. | The Czech Republic does not take part in any such activity. |
| (d) Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort. | There is currently no ongoing or CCS programme or demonstration project in the Czech Republic. On 31st March 2014 the first open call for applications to fund individual projects within the Programme CZ08 "Pilot Studies and Surveys on CCS Technology (Carbon Capture and Storage)" under the so called Norway Grants. In 2015 4 projects were approved in the first call of the the Programme CZ08. These projects focus on pilot CCS technologies for coal fired power plants, sharing of knowledge and experience, research of high temperature CO2 sorption from flue gas using carbonate loop and finally preparation of a pilot CCS project in the Czech Republic. The results of these 4 projects should be published during the year 2017. |
| (e) Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities. | The Czech Republic supports technology and capacity development through development assistance. Example of such activities is a project for modernization of powering and control of power plant block connected with establishment of a technical training centre at the University in Ulan Bator, Mongolia. |
| (f) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies. | The Czech Republic is cooperating in several bilateral development assistance projects focusing on reduction of fossil fuels dependence and development of renewable energy sources, inter alia:<br>- Developing sustainable, market-driven biogas and solar energy solutions for |

| | |
|---|---|
| | rural communities in Cambodia<br>- Developing biogas digesters in Cuba<br>- Supporting small enterprises in producing wood biomass fuel, developing geothermal energy and increasing energy efficiency of hospitals in Bosnia and Herzegovina<br>- Modernization of a central district heating system with possible use of alternative heat source in Serbia<br>Some of these projects build on projects successfully implemented in the period 2011 – 2014 described in the previous inventory report. |

# 16 Other Information

No other information submitted in 2015.

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# Abbreviations

| | |
|---|---|
| AACLC | Aggregate areas of cadastral land categories |
| APL | Association of Industrial Distilleries (Asociace průmyslových lihovarů) |
| ARR | Annual Review Report |
| AVNH | Association of Coatings Producers (Asociace výrobců nátěrových hmot) |
| AWMS | Animal Waste Management System |
| BOD | Biochemical Oxygen Demand |
| CCA | Czech Cement Association |
| CDV | Transport Research Centre (Centrum dopravního výzkumu) |
| CNG | Compressed Natural Gas |
| COD | Chemical Oxygen Demand |
| COP | Conference of Parties |
| COSMC | Czech Office for Surveying, Mapping and Cadastre |
| CUEC | Charles University Environment Center |
| CULS | Czech University of Life Sciences |
| CzechTerra | Czech Landscape Inventory |
| ČPS | Czech Gas Association (Český plynárenský svaz) |
| DOC | Degradable Organic Carbon |
| EEA | European Environmental Agency |
| EIG | Emission Inventory Guidebook |
| ERT | Expert Review Team |
| ETS | Emission Trading Scheme |
| FAO | Food and Agriculture Organization |
| FMI | Forest Management Institute, Brandýs nad Labem |
| FMP | Forest Management Plans |
| FOD (model) | First Order Decay (model) |
| GHG | Greenhouse Gas |
| HDV | Heavy Duty Vehicle |
| HWP | Harwested Wood Products |
| CHMI | Czech Hydrometeorological Institute |
| IEA | International Energy Agency |
| IFER | Institute of Forest Ecosystem Research (Ústav pro výzkum lesních ekosystémů) |
| IGU | International Gas Union |
| IPCC | Intergovernmental Panel of Climate Change |
| IPR | Integrated Pollution Register |
| ISPOP | Integrated system of mandatory reporting (Integrovaný systém plnění ohlašovacích povinností) |
| KP LULUCF | LULUCF activities under Kyoto Protocol |
| ISOH/VISOH | Information system of waste management/Public information system of waste management |
| LDV | Light Duty Vehicle |
| LPG | Liquid Petroleum Gas |
| LPIS | Land Parcel Identification System, |
| LTO | Landing/Taking-off |
| LULUCF | Land Use, Land-Use Change and Forestry |
| MA | Ministry of Agriculture |
| MCF | Methane Correction Factor |

| | |
|---|---|
| MIT | Ministry of Industry and Trade |
| MoE | Ministry of Environment |
| MSW | Municipal Solid Waste |
| NACE | Nomenclature Classification of Economic Activities |
| NIR | National Inventory Report |
| NIS | National Inventory System (National system under Kyoto protocol, Art. 5) |
| OKD, a.s. | Ostrava – Karvina Mines (Ostravsko karvinské doly, a.s.) |
| OTE | Electricity Market Operator (Operátor trhu s elektřinou, a.s.) |
| PC | Passenger Car |
| QA/QC | Quality Assurance/Quality Control |
| RA | Reference Approach |
| REZZO | Register of Emissions and Sources of Air Pollution (Registr emisí a zdrojů znečišťování ovzduší) |
| SA | Sectoral Approach |
| SWDS | Solid Waste Disposal Sites |
| UNECE | United Nations Economic Commission for Europe |
| UNFCCC | United Nation Framework Convention on Climate Change |
| ÚVVP | Institute for Research and Use of Fuels (Ústav pro výzkum a využití paliv) |
| VŠCHT | University of Chemistry and Technology Prague (Vysoká škola chemicko technologická) |
| NEC | National Emission Ceilings |

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# Annexes to the National Inventory Report

# Annex 1 Key Categories

Key Categories were estimated using IPCC 2006 Gl. approach 1 including and excluding LULUCF. Tables A1-1 till A1-4 followed the approach in Tables 4.2 and 4.3 of the IPCC 2006 Gl.

**Tab. A1- 1 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2015 – Level Assessment including LULUCF**

| IPCC Source Categories | GHG | Latest Year Emission or Removal Estimate (Gg) | ABS Latest Year Emission or Removal Estimate (Gg) | LA,% | Cumulative Total (LA,%) |
|---|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 56332.49 | 56332.49 | 41.92 | 41.92 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 2693.43 | 2693.43 | 2.00 | 43.93 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 16985.57 | 16985.57 | 12.64 | 56.57 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 14417.54 | 14417.54 | 10.73 | 67.30 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 6872.80 | 6872.80 | 5.11 | 72.41 |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | -5649.87 | 5649.87 | 4.20 | 76.61 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 3581.30 | 3581.30 | 2.67 | 79.28 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 3422.33 | 3422.33 | 2.55 | 81.83 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 3385.21 | 3385.21 | 2.52 | 84.35 |
| 3.A Enteric Fermentation | $CH_4$ | 2895.96 | 2895.96 | 2.16 | 86.50 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 2569.13 | 2569.13 | 1.91 | 88.41 |
| 2.A.1 Cement Production | $CO_2$ | 1549.54 | 1549.54 | 1.15 | 89.57 |
| 3.B Manure Management | $N_2O$ | 1007.81 | 1007.81 | 0.75 | 90.32 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 888.63 | 888.63 | 0.66 | 90.98 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 860.56 | 860.56 | 0.64 | 91.62 |
| 3.B Manure Management | $CH_4$ | 771.47 | 771.47 | 0.57 | 92.19 |
| 2.B.1 Ammonia Production | $CO_2$ | 741.66 | 741.66 | 0.55 | 92.74 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 715.16 | 715.16 | 0.53 | 93.28 |
| 5.B Biological treatment of solid waste | $CH_4$ | 633.99 | 633.99 | 0.47 | 93.75 |
| 2.A.2 Lime Production | $CO_2$ | 609.75 | 609.75 | 0.45 | 94.20 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 608.01 | 608.01 | 0.45 | 94.65 |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 599.44 | 599.44 | 0.45 | 95.10 |
| 4.A.2 Land converted to Forest Land | $CO_2$ | -491.59 | 491.59 | 0.37 | 95.47 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 140.54 | 140.54 | 0.10 | 95.57 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 387.19 | 387.19 | 0.29 | 95.86 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 347.53 | 347.53 | 0.26 | 96.12 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 280.12 | 280.12 | 0.21 | 96.33 |
| 4.C.1 Grassland remaining Grassland | $CO_2$ | -276.20 | 276.20 | 0.21 | 96.53 |
| 4.C.2 Land converted to Grassland | $CO_2$ | -274.15 | 274.15 | 0.20 | 96.73 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 269.78 | 269.78 | 0.20 | 96.94 |
| 1.A.3.c Transport - Railways | $CO_2$ | 264.11 | 264.11 | 0.20 | 97.13 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 249.15 | 249.15 | 0.19 | 97.32 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 248.99 | 248.99 | 0.19 | 97.50 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 246.32 | 246.32 | 0.18 | 97.69 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 223.50 | 223.50 | 0.17 | 97.85 |
| 2.B.10 Other | $CO_2$ | 222.81 | 222.81 | 0.17 | 98.02 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 218.43 | 218.43 | 0.16 | 98.18 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 197.23 | 197.23 | 0.15 | 98.33 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 188.53 | 188.53 | 0.14 | 98.47 |
| 3.H Urea application | $CO_2$ | 187.10 | 187.10 | 0.14 | 98.61 |
| 4.G Harvested wood products | $CO_2$ | -164.15 | 164.15 | 0.12 | 98.73 |
| 3.G Liming | $CO_2$ | 162.89 | 162.89 | 0.12 | 98.85 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 146.44 | 146.44 | 0.11 | 98.96 |
| 5.C Incineration and open burning of waste | $CO_2$ | 132.43 | 132.43 | 0.10 | 99.06 |
| 2.A.3 Glass Production | $CO_2$ | 125.47 | 125.47 | 0.09 | 99.15 |
| 2.D.1 Lubricant Use | $CO_2$ | 115.54 | 115.54 | 0.09 | 99.24 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 99.07 | 99.07 | 0.07 | 99.31 |
| 4.E.2 Land converted to Settlements | $CO_2$ | 88.12 | 88.12 | 0.07 | 99.38 |

| IPCC Source Categories | GHG | Latest Year Emission or Removal Estimate (Gg) | ABS Latest Year Emission or Removal Estimate (Gg) | LA,% | Cumulative Total (LA,%) |
|---|---|---|---|---|---|
| 4.B.1 Cropland remaining Cropland | $CO_2$ | -84.24 | 84.24 | 0.06 | 99.44 |
| 4.B.2 Land converted to Cropland | $CO_2$ | 83.93 | 83.93 | 0.06 | 99.50 |
| 4.A.1 Forest Land remaining Forest Land | $CH_4$ | 81.91 | 81.91 | 0.06 | 99.56 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 74.50 | 74.50 | 0.06 | 99.62 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 71.08 | 71.08 | 0.05 | 99.67 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 71.04 | 71.04 | 0.05 | 99.72 |
| 5.B Biological treatment of solid waste | $N_2O$ | 44.59 | 44.59 | 0.03 | 99.76 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 36.81 | 36.81 | 0.03 | 99.78 |
| 1.A.3.c Transport - Railways | $N_2O$ | 30.38 | 30.38 | 0.02 | 99.81 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 25.29 | 25.29 | 0.02 | 99.83 |
| 4.D.2. Land converted to Wetlands | $CO_2$ | 25.18 | 25.18 | 0.02 | 99.84 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 0.18 | 0.18 | 0.00 | 99.85 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 22.73 | 22.73 | 0.02 | 99.86 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 15.11 | 15.11 | 0.01 | 99.87 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 18.11 | 18.11 | 0.01 | 99.89 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $SF_6$ | 16.25 | 16.25 | 0.01 | 99.90 |
| 1.A.3.d Transport - Domestic navigation | $CO_2$ | 12.73 | 12.73 | 0.01 | 99.91 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 10.23 | 10.23 | 0.01 | 99.92 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 9.72 | 9.72 | 0.01 | 99.92 |
| 2.C.5 Lead Production | $CO_2$ | 8.81 | 8.81 | 0.01 | 99.93 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6.44 | 6.44 | 0.00 | 99.93 |
| 4.F.2 Land converted to Other Land | $CO_2$ | 7.55 | 7.55 | 0.01 | 99.94 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 6.72 | 6.72 | 0.00 | 99.95 |
| 4.A.1 Forest Land remaining Forest Land | $N_2O$ | 6.71 | 6.71 | 0.00 | 99.95 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 6.66 | 6.66 | 0.00 | 99.96 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 5.89 | 5.89 | 0.00 | 99.96 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 5.47 | 5.47 | 0.00 | 99.96 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 5.39 | 5.39 | 0.00 | 99.97 |
| 4.B.2. Land converted to Cropland | $N_2O$ | 4.98 | 4.98 | 0.00 | 99.97 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 4.50 | 4.50 | 0.00 | 99.97 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 4.24 | 4.24 | 0.00 | 99.98 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 3.67 | 3.67 | 0.00 | 99.98 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 3.44 | 3.44 | 0.00 | 99.98 |
| 2.G.2 SF6 and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 3.22 | 3.22 | 0.00 | 99.99 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 2.84 | 2.84 | 0.00 | 99.99 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 2.57 | 2.57 | 0.00 | 99.99 |
| 5.C Incineration and open burning of waste | $N_2O$ | 2.40 | 2.40 | 0.00 | 99.99 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $NF_3$ | 2.29 | 2.29 | 0.00 | 99.99 |
| 1.A.3 Transport - Biomass | $N_2O$ | 2.22 | 2.22 | 0.00 | 99.99 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 1.79 | 1.79 | 0.00 | 100.00 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 1.49 | 1.49 | 0.00 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0.78 | 0.78 | 0.00 | 100.00 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0.59 | 0.59 | 0.00 | 100.00 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0.53 | 0.53 | 0.00 | 100.00 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0.51 | 0.51 | 0.00 | 100.00 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0.50 | 0.50 | 0.00 | 100.00 |
| 2.C.6 Zinc Production | $CO_2$ | 0.41 | 0.41 | 0.00 | 100.00 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0.37 | 0.37 | 0.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $N_2O$ | 0.10 | 0.10 | 0.00 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 0.09 | 0.09 | 0.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0.04 | 0.04 | 0.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0.04 | 0.04 | 0.00 | 100.00 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0.03 | 0.03 | 0.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $CH_4$ | 0.03 | 0.03 | 0.00 | 100.00 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0.02 | 0.02 | 0.00 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0 | 0.00 | 0.00 | 100 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0 | 0 | 0 | 100 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0 | 0 | 0 | 100 |
| | | | | | |
| | **Total** | **120 496** | **134 376** | | |

**Tab. A1- 2 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2015 – Trend Assessment including LULUCF**

| IPCC Source Categories | GHG | Base Year Estimate | Current Year Estimate | Trend Assessment | % contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 110822.55 | 56332.49 | 0.07 | 23.09 | 23.09 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 6176.54 | 16985.57 | 0.07 | 21.24 | 44.33 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 11201.04 | 14417.54 | 0.04 | 11.86 | 56.19 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 15193.50 | 2693.43 | 0.04 | 11.35 | 67.53 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 10322.40 | 3581.30 | 0.02 | 4.86 | 72.40 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 0.00 | 3422.33 | 0.02 | 5.57 | 77.96 |
| 4.G Harvested wood products | $CO_2$ | -1712.95 | -164.15 | 0.01 | 3.53 | 81.50 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 1979.27 | 3385.21 | 0.01 | 3.46 | 84.95 |
| 3.A Enteric Fermentation | $CH_4$ | 5754.89 | 2895.96 | 0.00 | 1.25 | 86.20 |
| 3.B Manure Management | $N_2O$ | 2459.33 | 1007.81 | 0.00 | 0.91 | 87.11 |
| 3.G Liming | $CO_2$ | 1177.82 | 162.89 | 0.00 | 0.95 | 88.06 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 1212.44 | 248.99 | 0.00 | 0.85 | 88.91 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 1050.29 | 280.12 | 0.00 | 0.63 | 89.54 |
| 3.B Manure Management | $CH_4$ | 1752.07 | 771.47 | 0.00 | 0.56 | 90.10 |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | -4664.35 | -5649.87 | 0.00 | 1.16 | 91.26 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 0.00 | 387.19 | 0.00 | 0.63 | 91.89 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 4210.37 | 2569.13 | 0.00 | 0.18 | 92.07 |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 335.00 | 599.44 | 0.00 | 0.63 | 92.70 |
| 2.A.2 Lime Production | $CO_2$ | 1336.65 | 609.75 | 0.00 | 0.39 | 93.09 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 0.00 | 269.78 | 0.00 | 0.44 | 93.53 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 136.73 | 347.53 | 0.00 | 0.42 | 93.95 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 48.67 | 140.54 | 0.00 | 0.18 | 94.13 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 1586.96 | 888.63 | 0.00 | 0.20 | 94.33 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 24.04 | 218.43 | 0.00 | 0.33 | 94.66 |
| 1.A.3.c Transport - Railways | $CO_2$ | 653.86 | 264.11 | 0.00 | 0.25 | 94.90 |
| 2.A.1 Cement Production | $CO_2$ | 2489.18 | 1549.54 | 0.00 | 0.06 | 94.96 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 109.15 | 249.15 | 0.00 | 0.29 | 95.25 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 1079.91 | 608.01 | 0.00 | 0.13 | 95.38 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 792.47 | 715.16 | 0.00 | 0.34 | 95.72 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 889.80 | 860.56 | 0.00 | 0.48 | 96.20 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 456.24 | 188.53 | 0.00 | 0.17 | 96.37 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 9642.54 | 6872.80 | 0.00 | 1.20 | 97.57 |
| 5.C Incineration and open burning of waste | $CO_2$ | 23.15 | 132.43 | 0.00 | 0.19 | 97.76 |
| 3.H Urea application | $CO_2$ | 108.53 | 187.10 | 0.00 | 0.19 | 97.95 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 68.58 | 146.44 | 0.00 | 0.17 | 98.12 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 0.00 | 99.07 | 0.00 | 0.16 | 98.28 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 482.97 | 246.32 | 0.00 | 0.10 | 98.38 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 139.44 | 10.23 | 0.00 | 0.13 | 98.51 |
| 4.C.2 Land converted to Grassland | $CO_2$ | -145.34 | -274.15 | 0.00 | 0.12 | 98.63 |
| 4.B.1 Cropland remaining Cropland | $CO_2$ | -2.28 | -84.24 | 0.00 | 0.13 | 98.76 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 206.22 | 223.50 | 0.00 | 0.15 | 98.91 |
| 4.A.2 Land converted to Forest Land | $CO_2$ | -321.25 | -491.59 | 0.00 | 0.09 | 99.00 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 5.42 | 71.04 | 0.00 | 0.11 | 99.11 |
| 2.B.1 Ammonia Production | $CO_2$ | 990.80 | 741.66 | 0.00 | 0.18 | 99.29 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 234.18 | 197.23 | 0.00 | 0.08 | 99.37 |
| 2.A.3 Glass Production | $CO_2$ | 123.66 | 125.47 | 0.00 | 0.08 | 99.44 |
| 2.D.1 Lubricant Use | $CO_2$ | 116.13 | 115.54 | 0.00 | 0.07 | 99.51 |
| 4.E.2 Land converted to Settlements | $CO_2$ | 85.09 | 88.12 | 0.00 | 0.06 | 99.57 |
| 1.A.3.d Transport - Domestic navigation | $CO_2$ | 56.61 | 12.73 | 0.00 | 0.04 | 99.60 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 0.00 | 22.73 | 0.00 | 0.04 | 99.64 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 74.50 | 74.50 | 0.00 | 0.04 | 99.69 |
| 1.A.3.c Transport - Railways | $N_2O$ | 75.21 | 30.38 | 0.00 | 0.03 | 99.71 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 21.58 | 0.18 | 0.00 | 0.02 | 99.74 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 0.00 | 18.11 | 0.00 | 0.03 | 99.77 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 84.10 | 71.08 | 0.00 | 0.03 | 99.79 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 36.17 | 36.81 | 0.00 | 0.02 | 99.82 |
| 4.D.2. Land converted to Wetlands | $CO_2$ | 21.51 | 25.18 | 0.00 | 0.02 | 99.83 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 12.79 | 15.11 | 0.00 | 0.01 | 99.85 |
| 4.F.2 Land converted to Other Land | $CO_2$ | 0.00 | 7.55 | 0.00 | 0.01 | 99.86 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 0.00 | 6.72 | 0.00 | 0.01 | 99.87 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 0.00 | 6.66 | 0.00 | 0.01 | 99.88 |
| 4.B.2. Land converted to Cropland | $N_2O$ | 8.91 | 4.98 | 0.00 | 0.00 | 99.88 |

| IPCC Source Categories | GHG | Base Year Estimate | Current Year Estimate | Trend Assessment | % contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 2.C.5 Lead Production | $CO_2$ | 4.04 | 8.81 | 0.00 | 0.01 | 99.89 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 0.00 | 5.47 | 0.00 | 0.01 | 99.90 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 0.00 | 4.24 | 0.00 | 0.01 | 99.91 |
| 4.B.2 Land converted to Cropland | $CO_2$ | 113.99 | 83.93 | 0.00 | 0.02 | 99.93 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 0.75 | 4.50 | 0.00 | 0.01 | 99.93 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 2.20 | 5.39 | 0.00 | 0.01 | 99.94 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 0.18 | 3.67 | 0.00 | 0.01 | 99.94 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6.12 | 6.44 | 0.00 | 0.00 | 99.95 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 0.00 | 3.44 | 0.00 | 0.01 | 99.95 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 0.31 | 2.84 | 0.00 | 0.00 | 99.96 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 0.00 | 2.57 | 0.00 | 0.00 | 99.96 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | NF3 | 0.00 | 2.29 | 0.00 | 0.00 | 99.97 |
| 1.A.3 Transport - Biomass | $N_2O$ | 0.00 | 2.22 | 0.00 | 0.00 | 99.97 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 0.00 | 1.49 | 0.00 | 0.00 | 99.97 |
| 5.C Incineration and open burning of waste | $N_2O$ | 0.42 | 2.40 | 0.00 | 0.00 | 99.98 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 0.20 | 1.79 | 0.00 | 0.00 | 99.98 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 37.50 | 25.29 | 0.00 | 0.00 | 99.98 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 1.19 | 0.09 | 0.00 | 0.00 | 99.98 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 9.43 | 5.89 | 0.00 | 0.00 | 99.98 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 14.84 | 9.72 | 0.00 | 0.00 | 99.98 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0.00 | 0.59 | 0.00 | 0.00 | 99.98 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0.03 | 0.53 | 0.00 | 0.00 | 99.98 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0.00 | 0.51 | 0.00 | 0.00 | 99.99 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0.00 | 0.50 | 0.00 | 0.00 | 99.99 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0.92 | 0.37 | 0.00 | 0.00 | 99.99 |
| 4.A.1 Forest Land remaining Forest Land | $CH_4$ | 117.35 | 81.91 | 0.00 | 0.01 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $N_2O$ | 0.46 | 0.10 | 0.00 | 0.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $CH_4$ | 0.13 | 0.03 | 0.00 | 0.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0.00 | 0.04 | 0.00 | 0.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0.00 | 0.04 | 0.00 | 0.00 | 100.00 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0.00 | 0.03 | 0.00 | 0.00 | 100.00 |
| 4.A.1 Forest Land remaining Forest Land | $N_2O$ | 9.62 | 6.71 | 0.00 | 0.00 | 100.00 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0.01 | 0.02 | 0.00 | 0.00 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0.02 | 0.00 | 0.00 | 0.00 | 100.00 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.B.10 Other | $CO_2$ | 0.00 | 222.81 | 0.00 | 0.00 | 100.00 |
| 2.C.6 Zinc Production | $CO_2$ | 0.00 | 0.41 | 0.00 | 0.00 | 100.00 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $SF_6$ | 0.00 | 16.25 | 0.00 | 0.00 | 100.00 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0.00 | 0.78 | 0.00 | 0.00 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.G.2 SF6 and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 0.00 | 3.22 | 0.00 | 0.00 | 100.00 |
| 4.C.1 Grassland remaining Grassland | $CO_2$ | 0 | -276.1982751 | 0 | 0 | 100 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0 | 633.9866491 | 0 | 0 | 100 |
| 5.B Biological treatment of solid waste | $N_2O$ | 0 | 44.58524301 | 0 | 0 | 100 |
| | **Total** | **189342.79** | **120496.00** | **0.3246** | **100.00** | |

**Tab. A1- 3 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2015 – Level Assessment excluding LULUCF**

| IPCC Source Categories | GHG | Latest Year Emission or Removal Estimate (Gg) | ABS Latest Year Emission or Removal Estimate (Gg) | LA,% | Cumulative Total (LA) |
|---|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 56332.49 | 56332.49 | 44.31 | 44.31 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 2693.43 | 2693.43 | 2.12 | 46.43 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 16985.57 | 16985.57 | 13.36 | 59.79 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 14417.54 | 14417.54 | 11.34 | 71.13 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 6872.80 | 6872.80 | 5.41 | 76.53 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 3385.21 | 3385.21 | 2.66 | 79.20 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 3581.30 | 3581.30 | 2.82 | 82.01 |
| 3.A Enteric Fermentation | $CH_4$ | 2895.96 | 2895.96 | 2.28 | 84.29 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 3422.33 | 3422.33 | 2.69 | 86.98 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 2569.13 | 2569.13 | 2.02 | 89.00 |
| 2.A.1 Cement Production | $CO_2$ | 1549.54 | 1549.54 | 1.22 | 90.22 |
| 3.B Manure Management | $N_2O$ | 1007.81 | 1007.81 | 0.79 | 91.01 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 715.16 | 715.16 | 0.56 | 91.58 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 888.63 | 888.63 | 0.70 | 92.28 |
| 3.B Manure Management | $CH_4$ | 771.47 | 771.47 | 0.61 | 92.88 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 860.56 | 860.56 | 0.68 | 93.56 |
| 2.B.1 Ammonia Production | $CO_2$ | 741.66 | 741.66 | 0.58 | 94.14 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 140.54 | 140.54 | 0.11 | 94.25 |
| 2.A.2 Lime Production | $CO_2$ | 609.75 | 609.75 | 0.48 | 94.73 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 608.01 | 608.01 | 0.48 | 95.21 |
| 5.B Biological treatment of solid waste | $CH_4$ | 633.99 | 633.99 | 0.50 | 95.71 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 347.53 | 347.53 | 0.27 | 95.98 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 3.67 | 3.67 | 0.00 | 95.99 |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 599.44 | 599.44 | 0.47 | 96.46 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 249.15 | 249.15 | 0.20 | 96.65 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 387.19 | 387.19 | 0.30 | 96.96 |
| 1.A.3.c Transport - Railways | $CO_2$ | 264.11 | 264.11 | 0.21 | 97.17 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 269.78 | 269.78 | 0.21 | 97.38 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 280.12 | 280.12 | 0.22 | 97.60 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 246.32 | 246.32 | 0.19 | 97.79 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 223.50 | 223.50 | 0.18 | 97.97 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 218.43 | 218.43 | 0.17 | 98.14 |
| 2.B.10 Other | $CO_2$ | 222.81 | 222.81 | 0.18 | 98.31 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 197.23 | 197.23 | 0.16 | 98.47 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 188.53 | 188.53 | 0.15 | 98.62 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 248.99 | 248.99 | 0.20 | 98.81 |
| 3.G Liming | $CO_2$ | 162.89 | 162.89 | 0.13 | 98.94 |
| 5.C Incineration and open burning of waste | $CO_2$ | 132.43 | 132.43 | 0.10 | 99.05 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 146.44 | 146.44 | 0.12 | 99.16 |
| 2.A.3 Glass Production | $CO_2$ | 125.47 | 125.47 | 0.10 | 99.26 |
| 2.D.1 Lubricant Use | $CO_2$ | 115.54 | 115.54 | 0.09 | 99.35 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 71.04 | 71.04 | 0.06 | 99.41 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 71.08 | 71.08 | 0.06 | 99.46 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 74.50 | 74.50 | 0.06 | 99.52 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 99.07 | 99.07 | 0.08 | 99.60 |
| 3.H Urea application | $CO_2$ | 187.10 | 187.10 | 0.15 | 99.75 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0.53 | 0.53 | 0.00 | 99.75 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 36.81 | 36.81 | 0.03 | 99.78 |
| 5.B Biological treatment of solid waste | $N_2O$ | 44.59 | 44.59 | 0.04 | 99.81 |
| 1.A.3.c Transport - Railways | $N_2O$ | 30.38 | 30.38 | 0.02 | 99.83 |
| 2.C.5 Lead Production | $CO_2$ | 8.81 | 8.81 | 0.01 | 99.84 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 25.29 | 25.29 | 0.02 | 99.86 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 0.18 | 0.18 | 0.00 | 99.86 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 22.73 | 22.73 | 0.02 | 99.88 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 15.11 | 15.11 | 0.01 | 99.89 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $SF_6$ | 16.25 | 16.25 | 0.01 | 99.90 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 18.11 | 18.11 | 0.01 | 99.92 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 9.72 | 9.72 | 0.01 | 99.93 |
| 1.A.3.d Transport - Domestic navigation | $CO_2$ | 12.73 | 12.73 | 0.01 | 99.94 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 6.66 | 6.66 | 0.01 | 99.94 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6.44 | 6.44 | 0.01 | 99.95 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 5.89 | 5.89 | 0.00 | 99.95 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 10.23 | 10.23 | 0.01 | 99.96 |

| IPCC Source Categories | GHG | Latest Year Emission or Removal Estimate (Gg) | ABS Latest Year Emission or Removal Estimate (Gg) | LA,% | Cumulative Total (LA) |
|---|---|---|---|---|---|
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 6.72 | 6.72 | 0.01 | 99.96 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 4.50 | 4.50 | 0.00 | 99.97 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 1.49 | 1.49 | 0.00 | 99.97 |
| 2.G.2 SF6 and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 3.22 | 3.22 | 0.00 | 99.97 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 4.24 | 4.24 | 0.00 | 99.97 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 2.84 | 2.84 | 0.00 | 99.98 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 2.57 | 2.57 | 0.00 | 99.98 |
| 5.C Incineration and open burning of waste | $N_2O$ | 2.40 | 2.40 | 0.00 | 99.98 |
| 1.A.3 Transport - Biomass | $N_2O$ | 2.22 | 2.22 | 0.00 | 99.98 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | NF3 | 2.29 | 2.29 | 0.00 | 99.98 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0.78 | 0.78 | 0.00 | 99.99 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 1.79 | 1.79 | 0.00 | 99.99 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 5.47 | 5.47 | 0.00 | 99.99 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 3.44 | 3.44 | 0.00 | 99.99 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0.59 | 0.59 | 0.00 | 99.99 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0.51 | 0.51 | 0.00 | 99.99 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0.37 | 0.37 | 0.00 | 99.99 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0.50 | 0.50 | 0.00 | 100.00 |
| 2.C.6 Zinc Production | $CO_2$ | 0.41 | 0.41 | 0.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $N_2O$ | 0.10 | 0.10 | 0.00 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 0.09 | 0.09 | 0.00 | 100.00 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 5.39 | 5.39 | 0.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0.04 | 0.04 | 0.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0.04 | 0.04 | 0.00 | 100.00 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0.03 | 0.03 | 0.00 | 100.00 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0.02 | 0.02 | 0.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $CH_4$ | 0.03 | 0.03 | 0.00 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| | **Total** | **127 137** | **127 137** | **100.00** | |

**Tab. A1- 4 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2015 – Trend Assessment excluding LULUCF**

| IPCC Source Categories | GHG | Base Year Estimate | Current Year Estimate | Trend Assessment | % contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 110822.55 | 56332.49 | 0.08 | 26.04 | 26.04 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 6176.54 | 16985.57 | 0.07 | 21.64 | 47.69 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 11201.04 | 14417.54 | 0.04 | 11.92 | 59.60 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 15193.50 | 2693.43 | 0.04 | 11.96 | 71.56 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 10322.40 | 3581.30 | 0.02 | 5.20 | 76.77 |
| 2.F.1 Refrigeration and Air Conditioning Equipment (CO2 eq.) | HFC | 0.00 | 3422.33 | 0.02 | 5.71 | 82.48 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 1979.27 | 3385.21 | 0.01 | 3.50 | 85.98 |
| 3.A Enteric Fermentation | $CH_4$ | 5754.89 | 2895.96 | 0.00 | 1.40 | 87.38 |
| 3.B Manure Management | $N_2O$ | 2459.33 | 1007.81 | 0.00 | 0.98 | 88.36 |
| 3.G Liming | $CO_2$ | 1177.82 | 162.89 | 0.00 | 1.00 | 89.37 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 1212.44 | 248.99 | 0.00 | 0.90 | 90.26 |
| 3.B Manure Management | $CH_4$ | 1752.07 | 771.47 | 0.00 | 0.61 | 90.87 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 1050.29 | 280.12 | 0.00 | 0.67 | 91.54 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 4210.37 | 2569.13 | 0.00 | 0.27 | 91.82 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 0.00 | 387.19 | 0.00 | 0.65 | 92.46 |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 335.00 | 599.44 | 0.00 | 0.64 | 93.10 |
| 2.A.2 Lime Production | $CO_2$ | 1336.65 | 609.75 | 0.00 | 0.43 | 93.53 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 0.00 | 269.78 | 0.00 | 0.45 | 93.98 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 136.73 | 347.53 | 0.00 | 0.43 | 94.41 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 1586.96 | 888.63 | 0.00 | 0.24 | 94.65 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 48.67 | 140.54 | 0.00 | 0.18 | 94.83 |
| 2.A.1 Cement Production | $CO_2$ | 2489.18 | 1549.54 | 0.00 | 0.11 | 94.94 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 24.04 | 218.43 | 0.00 | 0.34 | 95.28 |
| 1.A.3.c Transport - Railways | $CO_2$ | 653.86 | 264.11 | 0.00 | 0.27 | 95.55 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 109.15 | 249.15 | 0.00 | 0.30 | 95.84 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 1079.91 | 608.01 | 0.00 | 0.16 | 96.00 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 889.80 | 860.56 | 0.00 | 0.47 | 96.47 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 456.24 | 188.53 | 0.00 | 0.18 | 96.65 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 792.47 | 715.16 | 0.00 | 0.33 | 96.99 |
| 5.C Incineration and open burning of waste | $CO_2$ | 23.15 | 132.43 | 0.00 | 0.20 | 97.18 |
| 3.H Urea application | $CO_2$ | 108.53 | 187.10 | 0.00 | 0.19 | 97.38 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 68.58 | 146.44 | 0.00 | 0.17 | 97.55 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 0.00 | 99.07 | 0.00 | 0.17 | 97.71 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 482.97 | 246.32 | 0.00 | 0.11 | 97.82 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 139.44 | 10.23 | 0.00 | 0.13 | 97.96 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 206.22 | 223.50 | 0.00 | 0.15 | 98.11 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 5.42 | 71.04 | 0.00 | 0.11 | 98.22 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 234.18 | 197.23 | 0.00 | 0.08 | 98.29 |
| 2.B.1 Ammonia Production | $CO_2$ | 990.80 | 741.66 | 0.00 | 0.16 | 98.46 |
| 2.A.3 Glass Production | $CO_2$ | 123.66 | 125.47 | 0.00 | 0.08 | 98.53 |
| 2.D.1 Lubricant Use | $CO_2$ | 116.13 | 115.54 | 0.00 | 0.07 | 98.60 |
| 1.A.3.d Transport - Domestic navigation | $CO_2$ | 56.61 | 12.73 | 0.00 | 0.04 | 98.64 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 9642.54 | 6872.80 | 0.00 | 1.02 | 99.66 |
| 1.A.3.c Transport - Railways | $N_2O$ | 75.21 | 30.38 | 0.00 | 0.03 | 99.69 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 0.00 | 22.73 | 0.00 | 0.04 | 99.73 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 74.50 | 74.50 | 0.00 | 0.04 | 99.77 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 21.58 | 0.18 | 0.00 | 0.02 | 99.80 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 0.00 | 18.11 | 0.00 | 0.03 | 99.83 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 84.10 | 71.08 | 0.00 | 0.03 | 99.86 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 36.17 | 36.81 | 0.00 | 0.02 | 99.88 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 12.79 | 15.11 | 0.00 | 0.01 | 99.89 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 0.00 | 6.72 | 0.00 | 0.01 | 99.90 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 0.00 | 6.66 | 0.00 | 0.01 | 99.91 |
| 2.C.5 Lead Production | $CO_2$ | 4.04 | 8.81 | 0.00 | 0.01 | 99.92 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 0.00 | 5.47 | 0.00 | 0.01 | 99.93 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 0.00 | 4.24 | 0.00 | 0.01 | 99.94 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 0.75 | 4.50 | 0.00 | 0.01 | 99.94 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 2.20 | 5.39 | 0.00 | 0.01 | 99.95 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 0.18 | 3.67 | 0.00 | 0.01 | 99.96 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 0.00 | 3.44 | 0.00 | 0.01 | 99.96 |

| IPCC Source Categories | GHG | Base Year Estimate | Current Year Estimate | Trend Assessment | % contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6.12 | 6.44 | 0.00 | 0.00 | 99.97 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 0.31 | 2.84 | 0.00 | 0.00 | 99.97 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 0.00 | 2.57 | 0.00 | 0.00 | 99.98 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | NF3 | 0.00 | 2.29 | 0.00 | 0.00 | 99.98 |
| 1.A.3 Transport - Biomass | $N_2O$ | 0.00 | 2.22 | 0.00 | 0.00 | 99.98 |
| 2.F.1 Refrigeration and Air Conditioning Equipment (CO2 eq.) | PFC | 0.00 | 1.49 | 0.00 | 0.00 | 99.99 |
| 5.C Incineration and open burning of waste | $N_2O$ | 0.42 | 2.40 | 0.00 | 0.00 | 99.99 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 0.20 | 1.79 | 0.00 | 0.00 | 99.99 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 37.50 | 25.29 | 0.00 | 0.00 | 99.99 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 14.84 | 9.72 | 0.00 | 0.00 | 99.99 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 9.43 | 5.89 | 0.00 | 0.00 | 99.99 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 1.19 | 0.09 | 0.00 | 0.00 | 100.00 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0.00 | 0.59 | 0.00 | 0.00 | 100.00 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0.03 | 0.53 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0.00 | 0.51 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0.00 | 0.50 | 0.00 | 0.00 | 100.00 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0.92 | 0.37 | 0.00 | 0.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $N_2O$ | 0.46 | 0.10 | 0.00 | 0.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $CH_4$ | 0.13 | 0.03 | 0.00 | 0.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0.00 | 0.04 | 0.00 | 0.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0.00 | 0.04 | 0.00 | 0.00 | 100.00 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0.00 | 0.03 | 0.00 | 0.00 | 100.00 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0.01 | 0.02 | 0.00 | 0.00 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0.02 | 0.00 | 0.00 | 0.00 | 100.00 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.B.10 Other | $CO_2$ | 0.00 | 222.81 | 0.00 | 0.00 | 100.00 |
| 2.C.6 Zinc Production | $CO_2$ | 0.00 | 0.41 | 0.00 | 0.00 | 100.00 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $SF_6$ | 0.00 | 16.25 | 0.00 | 0.00 | 100.00 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0.00 | 0.78 | 0.00 | 0.00 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.G.2 SF6 and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 0.00 | 3.22 | 0.00 | 0.00 | 100.00 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0.00 | 633.99 | 0.00 | 0.00 | 100.00 |
| 5.B Biological treatment of solid waste | $N_2O$ | 0.00 | 44.59 | 0.00 | 0.00 | 100.00 |
| | **Total** | **195832.51** | **127137.81** | **0.31** | **100.00** | |

**Tab. A1- 5 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 1990 – Level Assessment including LULUCF**

| IPCC Source Categories | GHG | Base Year Estimate | Base Year Estimate (Abs) | Level Assessment | Cumulative Total (LA) |
|---|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 110822.55 | 110822.55 | 54.58 | 54.58 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 15193.50 | 15193.50 | 7.48 | 62.07 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 11201.04 | 11201.04 | 5.52 | 67.58 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 9642.54 | 9642.54 | 4.75 | 72.33 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 10322.40 | 10322.40 | 5.08 | 77.42 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 6176.54 | 6176.54 | 3.04 | 80.46 |
| 3.A Enteric Fermentation | $CH_4$ | 5754.89 | 5754.89 | 2.83 | 83.29 |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | -4664.35 | 4664.35 | 2.30 | 85.59 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 4210.37 | 4210.37 | 2.07 | 87.66 |
| 3.B Manure Management | $N_2O$ | 2459.33 | 2459.33 | 1.21 | 88.88 |
| 2.A.1 Cement Production | $CO_2$ | 2489.18 | 2489.18 | 1.23 | 90.10 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 1979.27 | 1979.27 | 0.97 | 91.08 |
| 3.B Manure Management | $CH_4$ | 1752.07 | 1752.07 | 0.86 | 91.94 |
| 4.G Harvested wood products | $CO_2$ | -1712.95 | 1712.95 | 0.84 | 92.78 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 1586.96 | 1586.96 | 0.78 | 93.56 |
| 2.A.2 Lime Production | $CO_2$ | 1336.65 | 1336.65 | 0.66 | 94.22 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 1212.44 | 1212.44 | 0.60 | 94.82 |
| 3.G Liming | $CO_2$ | 1177.82 | 1177.82 | 0.58 | 95.40 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 889.80 | 889.80 | 0.44 | 95.84 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 1079.91 | 1079.91 | 0.53 | 96.37 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 1050.29 | 1050.29 | 0.52 | 96.89 |
| 2.B.1 Ammonia Production | $CO_2$ | 990.80 | 990.80 | 0.49 | 97.38 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 792.47 | 792.47 | 0.39 | 97.77 |
| 1.A.3.c Transport - Railways | $CO_2$ | 653.86 | 653.86 | 0.32 | 98.09 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 456.24 | 456.24 | 0.22 | 98.31 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 482.97 | 482.97 | 0.24 | 98.55 |
| 4.A.2 Land converted to Forest Land | $CO_2$ | -321.25 | 321.25 | 0.16 | 98.71 |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 335.00 | 335.00 | 0.16 | 98.87 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 48.67 | 48.67 | 0.02 | 98.90 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 234.18 | 234.18 | 0.12 | 99.01 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 206.22 | 206.22 | 0.10 | 99.11 |
| 4.C.2 Land converted to Grassland | $CO_2$ | -145.34 | 145.34 | 0.07 | 99.19 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 139.44 | 139.44 | 0.07 | 99.25 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 136.73 | 136.73 | 0.07 | 99.32 |
| 2.A.3 Glass Production | $CO_2$ | 123.66 | 123.66 | 0.06 | 99.38 |
| 4.A.1 Forest Land remaining Forest Land | $CH_4$ | 117.35 | 117.35 | 0.06 | 99.44 |
| 2.D.1 Lubricant Use | $CO_2$ | 116.13 | 116.13 | 0.06 | 99.50 |
| 4.B.2 Land converted to Cropland | $CO_2$ | 113.99 | 113.99 | 0.06 | 99.55 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 109.15 | 109.15 | 0.05 | 99.61 |
| 3.H Urea application | $CO_2$ | 108.53 | 108.53 | 0.05 | 99.66 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 84.10 | 84.10 | 0.04 | 99.70 |
| 4.E.2 Land converted to Settlements | $CO_2$ | 85.09 | 85.09 | 0.04 | 99.74 |
| 1.A.3.c Transport - Railways | $N_2O$ | 75.21 | 75.21 | 0.04 | 99.78 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 74.50 | 74.50 | 0.04 | 99.82 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 21.58 | 21.58 | 0.01 | 99.83 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 68.58 | 68.58 | 0.03 | 99.86 |
| 1.A.3.d Transport - Domestic navigation | $CO_2$ | 56.61 | 56.61 | 0.03 | 99.89 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 37.50 | 37.50 | 0.02 | 99.91 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 36.17 | 36.17 | 0.02 | 99.93 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 24.04 | 24.04 | 0.01 | 99.94 |
| 5.C Incineration and open burning of waste | $CO_2$ | 23.15 | 23.15 | 0.01 | 99.95 |
| 4.D.2. Land converted to Wetlands | $CO_2$ | 21.51 | 21.51 | 0.01 | 99.96 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 14.84 | 14.84 | 0.01 | 99.97 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 12.79 | 12.79 | 0.01 | 99.97 |
| 2.C.5 Lead Production | $CO_2$ | 4.04 | 4.04 | 0.00 | 99.98 |
| 4.A.1 Forest Land remaining Forest Land | $N_2O$ | 9.62 | 9.62 | 0.00 | 99.98 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 9.43 | 9.43 | 0.00 | 99.99 |
| 4.B.2. Land converted to Cropland | $N_2O$ | 8.91 | 8.91 | 0.00 | 99.99 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6.12 | 6.12 | 0.00 | 99.99 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 5.42 | 5.42 | 0.00 | 100.00 |
| 4.B.1 Cropland remaining Cropland | $CO_2$ | -2.28 | 2.28 | 0.00 | 100.00 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 2.20 | 2.20 | 0.00 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 1.19 | 1.19 | 0.00 | 100.00 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0.92 | 0.92 | 0.00 | 100.00 |

| IPCC Source Categories | GHG | Base Year Estimate | Base Year Estimate (Abs) | Level Assessment | Cumulative Total (LA) |
|---|---|---|---|---|---|
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 0.75 | 0.75 | 0.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $N_2O$ | 0.46 | 0.46 | 0.00 | 100.00 |
| 5.C Incineration and open burning of waste | $N_2O$ | 0.42 | 0.42 | 0.00 | 100.00 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 0.31 | 0.31 | 0.00 | 100.00 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 0.20 | 0.20 | 0.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $CH_4$ | 0.13 | 0.13 | 0.00 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0.02 | 0.02 | 0.00 | 100.00 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0.01 | 0.01 | 0.00 | 100.00 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 0.18 | 0.18 | 0.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0.03 | 0.03 | 0.00 | 100.00 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.B.10 Other | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.C.6 Zinc Production | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $SF_6$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | NF3 | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.G.2 SF6 and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 4.C.1 Grassland remaining Grassland | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 4.F.2 Land converted to Other Land | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 5.B Biological treatment of solid waste | $N_2O$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0 | 0 | 0 | 100 |
| 1.A.3 Transport - Biomass | $N_2O$ | 0 | 0 | 0 | 100 |
| | **Total** | **189342** | **203035** | **100.00** | |

**Tab. A1- 6 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 1990 – Level Assessment excluding LULUCF**

| IPCC Source Categories | GHG | Base Year Estimate | Base Year Estimate (Abs) | LA,% | Cumulative Total (LA) |
|---|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 110822.55 | 110822.55 | 56.59 | 56.59 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 15193.50 | 15193.50 | 7.76 | 64.35 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 11201.04 | 11201.04 | 5.72 | 70.07 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 9642.54 | 9642.54 | 4.92 | 74.99 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 10322.40 | 10322.40 | 5.27 | 80.26 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 6176.54 | 6176.54 | 3.15 | 83.42 |
| 3.A Enteric Fermentation | $CH_4$ | 5754.89 | 5754.89 | 2.94 | 86.36 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 4210.37 | 4210.37 | 2.15 | 88.51 |
| 3.B Manure Management | $N_2O$ | 2459.33 | 2459.33 | 1.26 | 89.76 |
| 2.A.1 Cement Production | $CO_2$ | 2489.18 | 2489.18 | 1.27 | 91.03 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 1979.27 | 1979.27 | 1.01 | 92.04 |
| 3.B Manure Management | $CH_4$ | 1752.07 | 1752.07 | 0.89 | 92.94 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 1586.96 | 1586.96 | 0.81 | 93.75 |
| 2.A.2 Lime Production | $CO_2$ | 1336.65 | 1336.65 | 0.68 | 94.43 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 1212.44 | 1212.44 | 0.62 | 95.05 |
| 3.G Liming | $CO_2$ | 1177.82 | 1177.82 | 0.60 | 95.65 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 889.80 | 889.80 | 0.45 | 96.11 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 1079.91 | 1079.91 | 0.55 | 96.66 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 1050.29 | 1050.29 | 0.54 | 97.19 |
| 2.B.1 Ammonia Production | $CO_2$ | 990.80 | 990.80 | 0.51 | 97.70 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 792.47 | 792.47 | 0.40 | 98.10 |
| 1.A.3.c Transport - Railways | $CO_2$ | 653.86 | 653.86 | 0.33 | 98.44 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 456.24 | 456.24 | 0.23 | 98.67 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 482.97 | 482.97 | 0.25 | 98.92 |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 335.00 | 335.00 | 0.17 | 99.09 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 48.67 | 48.67 | 0.02 | 99.11 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 234.18 | 234.18 | 0.12 | 99.23 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 206.22 | 206.22 | 0.11 | 99.34 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 139.44 | 139.44 | 0.07 | 99.41 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 136.73 | 136.73 | 0.07 | 99.48 |
| 2.A.3 Glass Production | $CO_2$ | 123.66 | 123.66 | 0.06 | 99.54 |
| 2.D.1 Lubricant Use | $CO_2$ | 116.13 | 116.13 | 0.06 | 99.60 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 109.15 | 109.15 | 0.06 | 99.66 |
| 3.H Urea application | $CO_2$ | 108.53 | 108.53 | 0.06 | 99.71 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 84.10 | 84.10 | 0.04 | 99.76 |
| 1.A.3.c Transport - Railways | $N_2O$ | 75.21 | 75.21 | 0.04 | 99.79 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 74.50 | 74.50 | 0.04 | 99.83 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 21.58 | 21.58 | 0.01 | 99.84 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 68.58 | 68.58 | 0.04 | 99.88 |
| 1.A.3.d Transport - Domestic navigation | $CO_2$ | 56.61 | 56.61 | 0.03 | 99.91 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 37.50 | 37.50 | 0.02 | 99.93 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 36.17 | 36.17 | 0.02 | 99.95 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 24.04 | 24.04 | 0.01 | 99.96 |
| 5.C Incineration and open burning of waste | $CO_2$ | 23.15 | 23.15 | 0.01 | 99.97 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 14.84 | 14.84 | 0.01 | 99.98 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 12.79 | 12.79 | 0.01 | 99.98 |
| 2.C.5 Lead Production | $CO_2$ | 4.04 | 4.04 | 0.00 | 99.99 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 9.43 | 9.43 | 0.00 | 99.99 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6.12 | 6.12 | 0.00 | 99.99 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 5.42 | 5.42 | 0.00 | 100.00 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 2.20 | 2.20 | 0.00 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 1.19 | 1.19 | 0.00 | 100.00 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0.92 | 0.92 | 0.00 | 100.00 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 0.75 | 0.75 | 0.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $N_2O$ | 0.46 | 0.46 | 0.00 | 100.00 |
| 5.C Incineration and open burning of waste | $N_2O$ | 0.42 | 0.42 | 0.00 | 100.00 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 0.31 | 0.31 | 0.00 | 100.00 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 0.20 | 0.20 | 0.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $CH_4$ | 0.13 | 0.13 | 0.00 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0.02 | 0.02 | 0.00 | 100.00 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0.01 | 0.01 | 0.00 | 100.00 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 0.18 | 0.18 | 0.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0.00 | 0.00 | 0.00 | 100.00 |

| IPCC Source Categories | GHG | Base Year Estimate | Base Year Estimate (Abs) | LA,% | Cumulative Total (LA) |
|---|---|---|---|---|---|
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0.03 | 0.03 | 0.00 | 100.00 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.B.10 Other | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.C.6 Zinc Production | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $SF_6$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | NF3 | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 0.00 | 100.00 |
| 2.G.2 SF6 and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 5.B Biological treatment of solid waste | $N_2O$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0.00 | 0.00 | 0.00 | 100.00 |
| 1.A.3 Transport - Biomass | $N_2O$ | 0.00 | 0.00 | 0.00 | 100.00 |
| | **Total** | **195832** | **195832** | **100.00** | |

**Tab. A1- 7 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2015 – Level Assessment including LULUCF**

| IPCC Source Categories | GHG | Latest Year Estimate | Latest Year Estimate (Abs) | Combined Uncertainty | LA for category | L*U (unc. amount) | LA_A2 | Cumulative fraction of total emissions | Cumulative fraction of uncertainty | Cumulative Total (LA) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 56332.49 | 56332.49 | 5.00 | 41.92 | 2816.62 | 38.97 | 42.00 | 0.09 | 38.97 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 2693.43 | 2693.43 | 5.83 | 2.00 | 157.05 | 1.88 | 2.01 | 0.11 | 40.85 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 16985.57 | 16985.57 | 3.72 | 12.64 | 631.48 | 11.61 | 12.66 | 0.07 | 52.46 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 14417.54 | 14417.54 | 3.91 | 10.73 | 563.02 | 9.87 | 10.75 | 0.07 | 62.33 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 6872.80 | 6872.80 | 12.21 | 5.11 | 838.93 | 5.08 | 5.12 | 0.23 | 67.41 |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | -5649.87 | 5649.87 | 21.38 | 4.20 | 1207.82 | 4.52 | 4.21 | 0.40 | 71.93 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 3385.21 | 3385.21 | 50.00 | 2.52 | 1692.60 | 3.35 | 2.52 | 0.95 | 75.27 |
| 2.F.1 Refrigeration and Air Conditioning Equipment (CO2 eq.) | HFC | 3422.33 | 3422.33 | 43.57 | 2.55 | 1490.97 | 3.24 | 2.55 | 0.83 | 78.51 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 3581.30 | 3581.30 | 13.60 | 2.67 | 487.11 | 2.68 | 2.67 | 0.26 | 81.19 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 2569.13 | 2569.13 | 52.20 | 1.91 | 1341.13 | 2.58 | 1.92 | 0.99 | 83.77 |
| 3.A Enteric Fermentation | $CH_4$ | 2895.96 | 2895.96 | 20.62 | 2.16 | 597.02 | 2.30 | 2.16 | 0.39 | 86.07 |
| 2.A.1 Cement Production | $CO_2$ | 1549.54 | 1549.54 | 2.83 | 1.15 | 43.83 | 1.05 | 1.16 | 0.05 | 87.12 |
| 3.D.2 Agricultural Soils, Indirect N2O emissions | $N_2O$ | 888.63 | 888.63 | 53.85 | 0.66 | 478.54 | 0.90 | 0.66 | 1.02 | 88.02 |
| 3.B Manure Management | $N_2O$ | 1007.81 | 1007.81 | 30.41 | 0.75 | 306.51 | 0.87 | 0.75 | 0.58 | 88.89 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 608.01 | 608.01 | 75.33 | 0.45 | 457.99 | 0.70 | 0.45 | 1.43 | 89.59 |
| 3.B Manure Management | $CH_4$ | 771 | 771 | 30 | 1 | 235 | 0.66 | 0.58 | 0.58 | 90.25 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 715 | 715 | 40 | 1 | 288 | 0.66 | 0.53 | 0.76 | 90.91 |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 599 | 599 | 51 | 0 | 304 | 0.59 | 0.45 | 0.96 | 91.51 |
| 2.B.1 Ammonia Production | $CO_2$ | 742 | 742 | 9 | 1 | 64 | 0.53 | 0.55 | 0.16 | 92.04 |
| 5.B Biological treatment of solid waste | $CH_4$ | 634 | 634 | 91 | 0 | 579 | 0.80 | 0.47 | 1.73 | 92.84 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 348 | 348 | 141 | 0 | 488 | 0.55 | 0.26 | 2.66 | 93.39 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 861 | 861 | 58 | 1 | 502 | 0.90 | 0.64 | 1.11 | 94.29 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 141 | 141 | 60 | 0 | 85 | 0.15 | 0.10 | 1.14 | 94.43 |
| 4.A.2 Land converted to Forest Land | $CO_2$ | -492 | 492 | 29 | 0 | 143 | 0.42 | 0.37 | 0.55 | 94.85 |
| 2.A.2 Lime Production | $CO_2$ | 610 | 610 | 3 | 0 | 17 | 0.41 | 0.45 | 0.05 | 95.27 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 387 | 387 | 18 | 0 | 70 | 0.30 | 0.29 | 0.34 | 95.57 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 246 | 246 | 60 | 0 | 148 | 0.26 | 0.18 | 1.14 | 95.83 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 249 | 249 | 50 | 0 | 125 | 0.25 | 0.19 | 0.95 | 96.07 |
| 4.C.2 Land converted to Grassland | $CO_2$ | -274 | 274 | 21 | 0 | 59 | 0.22 | 0.20 | 0.40 | 96.29 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 280 | 280 | 16 | 0 | 43 | 0.21 | 0.21 | 0.29 | 96.51 |
| 4.C.1 Grassland remaining Grassland | $CO_2$ | -276 | 276 | 17 | 0 | 47 | 0.21 | 0.21 | 0.32 | 96.72 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 197 | 197 | 56 | 0 | 111 | 0.20 | 0.15 | 1.07 | 96.92 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 224 | 224 | 40 | 0 | 90 | 0.21 | 0.17 | 0.76 | 97.13 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 270 | 270 | 8 | 0 | 21 | 0.19 | 0.20 | 0.14 | 97.32 |
| 3.H Urea application | $CO_2$ | 187 | 187 | 54 | 0 | 101 | 0.19 | 0.14 | 1.02 | 97.51 |
| 1.A Stationary Combustion - Other | $CO_2$ | 218 | 218 | 28 | 0 | 62 | 0.18 | 0.16 | 0.54 | 97.69 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| fuels - MSW | | | | | | | | | | |
| 1.A.3.c Transport - Railways | $CO_2$ | 264 | 264 | 5 | 0 | 14 | 0.18 | 0.20 | 0.10 | 97.88 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 249 | 249 | 11 | 0 | 28 | 0.18 | 0.19 | 0.21 | 98.06 |
| 4.G Harvested wood products | $CO_2$ | -164 | 164 | 62 | 0 | 102 | 0.18 | 0.12 | 1.17 | 98.23 |
| 3.G Liming | $CO_2$ | 163 | 163 | 54 | 0 | 88 | 0.17 | 0.12 | 1.02 | 98.40 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 146 | 146 | 61 | 0 | 89 | 0.15 | 0.11 | 1.15 | 98.55 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 189 | 189 | 25 | 0 | 48 | 0.16 | 0.14 | 0.48 | 98.71 |
| 4.E.2 Land converted to Settlements | $CO_2$ | 88 | 88 | 101 | 0 | 89 | 0.12 | 0.07 | 1.92 | 98.83 |
| 2.D.1 Lubricant Use | $CO_2$ | 116 | 116 | 50 | 0 | 58 | 0.11 | 0.09 | 0.95 | 98.94 |
| 5.C Incineration and open burning of waste | $CO_2$ | 132 | 132 | 16 | 0 | 21 | 0.10 | 0.10 | 0.30 | 99.04 |
| 2.A.3 Glass Production | $CO_2$ | 125 | 125 | 11 | 0 | 14 | 0.09 | 0.09 | 0.21 | 99.13 |
| 4.B.1 Cropland remaining Cropland | $CO_2$ | -84 | 84 | 51 | 0 | 43 | 0.08 | 0.06 | 0.97 | 99.22 |
| 4.A.1 Forest Land remaining Forest Land | $CH_4$ | 82 | 82 | 50 | 0 | 41 | 0.08 | 0.06 | 0.95 | 99.30 |
| 4.B.2 Land converted to Cropland | $CO_2$ | 84 | 84 | 35 | 0 | 29 | 0.07 | 0.06 | 0.65 | 99.37 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 99 | 99 | 8 | 0 | 8 | 0.07 | 0.07 | 0.14 | 99.44 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 75 | 75 | 40 | 0 | 30 | 0.07 | 0.06 | 0.76 | 99.51 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 71 | 71 | 16 | 0 | 11 | 0.05 | 0.05 | 0.30 | 99.57 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 71 | 71 | 5 | 0 | 4 | 0.05 | 0.05 | 0.09 | 99.62 |
| 1.A.3.c Transport - Railways | $N_2O$ | 30 | 30 | 137 | 0 | 42 | 0.05 | 0.02 | 2.60 | 99.66 |
| 5.B Biological treatment of solid waste | $N_2O$ | 45 | 45 | 5 | 0 | 2 | 0.03 | 0.03 | 0.10 | 99.69 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 37 | 37 | 40 | 0 | 15 | 0.03 | 0.03 | 0.76 | 99.73 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 25 | 25 | 303 | 0 | 77 | 0.07 | 0.02 | 5.73 | 99.80 |
| 4.D.2. Land converted to Wetlands | $CO_2$ | 25 | 25 | 64 | 0 | 16 | 0.03 | 0.02 | 1.21 | 99.82 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 0 | 0 | 50 | 0 | 0 | 0.00 | 0.00 | 0.95 | 99.82 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 23 | 23 | 44 | 0 | 10 | 0.02 | 0.02 | 0.83 | 99.84 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 15 | 15 | 50 | 0 | 8 | 0.01 | 0.01 | 0.95 | 99.86 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $SF_6$ | 16 | 16 | 21 | 0 | 3 | 0.01 | 0.01 | 0.40 | 99.87 |
| 1.A.3.d Transport - Domestic navigation | $CO_2$ | 13 | 13 | 5 | 0 | 1 | 0.01 | 0.01 | 0.10 | 99.88 |
| 2.C.5 Lead Production | $CO_2$ | 9 | 9 | 51 | 0 | 4 | 0.01 | 0.01 | 0.97 | 99.89 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 10 | 10 | 31 | 0 | 3 | 0.01 | 0.01 | 0.58 | 99.90 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6 | 6 | 60 | 0 | 4 | 0.01 | 0.00 | 1.14 | 99.91 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 10 | 10 | 6 | 0 | 1 | 0.01 | 0.01 | 0.10 | 99.91 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 7 | 7 | 60 | 0 | 4 | 0.01 | 0.01 | 1.14 | 99.92 |
| 4.A.1 Forest Land remaining Forest Land | $N_2O$ | 7 | 7 | 50 | 0 | 3 | 0.01 | 0.01 | 0.95 | 99.93 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 7 | 7 | 44 | 0 | 3 | 0.01 | 0.00 | 0.83 | 99.93 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 5 | 5 | 75 | 0 | 4 | 0.01 | 0.00 | 1.43 | 99.94 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 6 | 6 | 50 | 0 | 3 | 0.01 | 0.00 | 0.95 | 99.94 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 5 | 5 | 61 | 0 | 3 | 0.01 | 0.00 | 1.15 | 99.95 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 5 | 5 | 64 | 0 | 3 | 0.00 | 0.00 | 1.21 | 99.95 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 4 | 4 | 60 | 0 | 3 | 0.00 | 0.00 | 1.14 | 99.96 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 3 | 3 | 51 | 0 | 2 | 0.00 | 0.00 | 0.97 | 99.96 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 3 | 3 | 73 | 0 | 2 | 0.00 | 0.00 | 1.38 | 99.97 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 4 | 4 | 25 | 0 | 1 | 0.00 | 0.00 | 0.48 | 99.97 |
| 5.C Incineration and open burning | $N_2O$ | 2 | 2 | 73 | 0 | 2 | 0.00 | 0.00 | 1.38 | 99.97 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| of waste | | | | | | | | | | |
| 2.G.2 SF6 and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 3 | 3 | 22 | 0 | 1 | 0.00 | 0.00 | 0.42 | 99.97 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 3 | 3 | 44 | 0 | 1 | 0.00 | 0.00 | 0.83 | 99.98 |
| 1.A.3 Transport - Biomass | $N_2O$ | 2 | 2 | 61 | 0 | 1 | 0.00 | 0.00 | 1.15 | 99.98 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 1 | 1 | 44 | 0 | 1 | 0.00 | 0.00 | 0.83 | 99.98 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $NF_3$ | 2 | 2 | 21 | 0 | 0 | 0.00 | 0.00 | 0.40 | 99.98 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 2 | 2 | 54 | 0 | 1 | 0.00 | 0.00 | 1.02 | 99.98 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 1 | 1 | 44 | 0 | 0 | 0.00 | 0.00 | 0.83 | 99.98 |
| 1.A.3 Transport - Biomass | $CH_4$ | 1 | 1 | 51 | 0 | 0 | 0.00 | 0.00 | 0.96 | 99.99 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 1 | 1 | 50 | 0 | 0 | 0.00 | 0.00 | 0.96 | 99.99 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0 | 0 | 50 | 0 | 0 | 0.00 | 0.00 | 0.96 | 99.99 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0 | 0 | 158 | 0 | 1 | 0.00 | 0.00 | 2.98 | 99.99 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 1 | 1 | 25 | 0 | 0 | 0.00 | 0.00 | 0.48 | 99.99 |
| 2.C.6 Zinc Production | $CO_2$ | 0 | 0 | 51 | 0 | 0 | 0.00 | 0.00 | 0.97 | 99.99 |
| 1.A.3.d Transport - Domestic navigation | $N_2O$ | 0 | 0 | 137 | 0 | 0 | 0.00 | 0.00 | 2.60 | 99.99 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 0 | 0 | 110 | 0 | 0 | 0.00 | 0.00 | 2.08 | 99.99 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0 | 0 | 60 | 0 | 0 | 0.00 | 0.00 | 1.14 | 99.99 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0 | 0 | 50 | 0 | 0 | 0.00 | 0.00 | 0.95 | 99.99 |
| 1.A.3.d Transport - Domestic navigation | $CH_4$ | 0 | 0 | 158 | 0 | 0 | 0.00 | 0.00 | 2.98 | 99.99 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0.00 | 0.00 | 0.83 | 99.99 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0 | 0 | 75 | 0 | 0 | 0.00 | 0.00 | 1.43 | 99.99 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0 | 0 | 79 | 0 | 0 | 0.00 | 0.00 | 1.49 | 99.99 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0 | 0 | 82 | 0 | 0 | 0.00 | 0.00 | 1.56 | 99.99 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0.00 | 0.00 | 0.83 | 99.99 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0.00 | 0.00 | 0.83 | 99.99 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0.00 | 0.00 | 0.83 | 99.99 |
| 4.B.2. Land converted to Cropland | $N_2O$ | 5 | 5 | 250 | 0 | 12 | 0.01 | 0.00 | 4.73 | 100.00 |
| | Total= | 120248 | 134128 | 5280 | | | | | | |

**Tab. A1- 8 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2015 – Level Assessment excluding LULUCF**

| IPCC Source Categories | GHG | Latest Year Estimate | Latest Year Estimate (Abs) | Combined Uncertainty | LA for category | L*U (unc.amount) | LA_A2 | Cumulative fraction of total emissions | Cumulative fraction of uncertainty | Cumulative Total (LA) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 56332 | 56332 | 5 | 42 | 2817 | 41 | 44.39 | 0.11 | 41.44 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 2693 | 2693 | 6 | 2 | 157 | 2 | 2.12 | 0.13 | 43.43 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 16986 | 16986 | 4 | 13 | 631 | 12 | 13.39 | 0.08 | 55.77 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 14418 | 14418 | 4 | 11 | 563 | 10 | 11.36 | 0.09 | 66.27 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 6873 | 6873 | 12 | 5 | 839 | 5 | 5.42 | 0.27 | 71.67 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 3385 | 3385 | 50 | 3 | 1693 | 4 | 2.67 | 1.10 | 75.23 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 3422 | 3422 | 44 | 3 | 1491 | 3 | 2.70 | 0.96 | 78.67 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 3581 | 3581 | 14 | 3 | 487 | 3 | 2.82 | 0.30 | 81.52 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 2569 | 2569 | 52 | 2 | 1341 | 3 | 2.02 | 1.15 | 84.26 |
| 3.A Enteric Fermentation | $CH_4$ | 2896 | 2896 | 21 | 2 | 597 | 2 | 2.28 | 0.46 | 86.71 |
| 2.A.1 Cement Production | $CO_2$ | 1550 | 1550 | 3 | 1 | 44 | 1 | 1.22 | 0.06 | 87.82 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 889 | 889 | 54 | 1 | 479 | 1 | 0.70 | 1.19 | 88.78 |
| 3.B Manure Management | $N_2O$ | 1008 | 1008 | 30 | 1 | 307 | 1 | 0.79 | 0.67 | 89.70 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 608 | 608 | 75 | 0 | 458 | 1 | 0.48 | 1.66 | 90.45 |
| 3.B Manure Management | $CH_4$ | 771 | 771 | 30 | 1 | 235 | 1 | 0.61 | 0.67 | 91.15 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 715 | 715 | 40 | 1 | 288 | 1 | 0.56 | 0.89 | 91.85 |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 599 | 599 | 51 | 0 | 304 | 1 | 0.47 | 1.12 | 92.49 |
| 2.B.1 Ammonia Production | $CO_2$ | 742 | 742 | 9 | 1 | 64 | 1 | 0.58 | 0.19 | 93.05 |
| 5.B Biological treatment of solid waste | $CH_4$ | 634 | 634 | 91 | 0 | 579 | 1 | 0.50 | 2.02 | 93.90 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 348 | 348 | 141 | 0 | 488 | 1 | 0.27 | 3.10 | 94.49 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 861 | 861 | 58 | 1 | 502 | 1 | 0.68 | 1.29 | 95.44 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 141 | 141 | 60 | 0 | 85 | 0 | 0.11 | 1.33 | 95.60 |
| 2.A.2 Lime Production | $CO_2$ | 610 | 610 | 3 | 0 | 17 | 0 | 0.48 | 0.06 | 96.04 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 387 | 387 | 18 | 0 | 70 | 0 | 0.31 | 0.40 | 96.36 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 246 | 246 | 60 | 0 | 148 | 0 | 0.19 | 1.33 | 96.64 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 249 | 249 | 50 | 0 | 125 | 0 | 0.20 | 1.11 | 96.90 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 280 | 280 | 16 | 0 | 43 | 0 | 0.22 | 0.34 | 97.12 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 197 | 197 | 56 | 0 | 111 | 0 | 0.16 | 1.24 | 97.34 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 224 | 224 | 40 | 0 | 90 | 0 | 0.18 | 0.89 | 97.56 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 270 | 270 | 8 | 0 | 21 | 0 | 0.21 | 0.17 | 97.76 |
| 3.H Urea application | $CO_2$ | 187 | 187 | 54 | 0 | 101 | 0 | 0.15 | 1.19 | 97.96 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 218 | 218 | 28 | 0 | 62 | 0 | 0.17 | 0.62 | 98.16 |
| 1.A.3.c Transport - Railways | $CO_2$ | 264 | 264 | 5 | 0 | 14 | 0 | 0.21 | 0.12 | 98.36 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.A.4 Other process uses of carbonates | $CO_2$ | 249 | 249 | 11 | 0 | 28 | 0 | 0.20 | 0.25 | 98.55 |
| 3.G Liming | $CO_2$ | 163 | 163 | 54 | 0 | 88 | 0 | 0.13 | 1.19 | 98.73 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 146 | 146 | 61 | 0 | 89 | 0 | 0.12 | 1.34 | 98.89 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 189 | 189 | 25 | 0 | 48 | 0 | 0.15 | 0.56 | 99.06 |
| 2.D.1 Lubricant Use | $CO_2$ | 116 | 116 | 50 | 0 | 58 | 0 | 0.09 | 1.11 | 99.18 |
| 5.C Incineration and open burning of waste | $CO_2$ | 132 | 132 | 16 | 0 | 21 | 0 | 0.10 | 0.35 | 99.28 |
| 2.A.3 Glass Production | $CO_2$ | 125 | 125 | 11 | 0 | 14 | 0 | 0.10 | 0.25 | 99.38 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 99 | 99 | 8 | 0 | 8 | 0 | 0.08 | 0.17 | 99.46 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 75 | 75 | 40 | 0 | 30 | 0 | 0.06 | 0.89 | 99.53 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 71 | 71 | 16 | 0 | 11 | 0 | 0.06 | 0.35 | 99.59 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 71 | 71 | 5 | 0 | 4 | 0 | 0.06 | 0.11 | 99.64 |
| 1.A.3.c Transport - Railways | $N_2O$ | 30 | 30 | 137 | 0 | 42 | 0 | 0.02 | 3.03 | 99.69 |
| 5.B Biological treatment of solid waste | $N_2O$ | 45 | 45 | 5 | 0 | 2 | 0 | 0.04 | 0.11 | 99.72 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 37 | 37 | 40 | 0 | 15 | 0 | 0.03 | 0.89 | 99.76 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 25 | 25 | 303 | 0 | 77 | 0 | 0.02 | 6.68 | 99.83 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 0 | 0 | 50 | 0 | 0 | 0 | 0.00 | 1.11 | 99.83 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 23 | 23 | 44 | 0 | 10 | 0 | 0.02 | 0.96 | 99.85 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 15 | 15 | 50 | 0 | 8 | 0 | 0.01 | 1.11 | 99.87 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $SF_6$ | 16 | 16 | 21 | 0 | 3 | 0 | 0.01 | 0.47 | 99.88 |
| 1.A.3.d Transport - Domestic navigation | $CO_2$ | 13 | 13 | 5 | 0 | 1 | 0 | 0.01 | 0.12 | 99.89 |
| 2.C.5 Lead Production | $CO_2$ | 9 | 9 | 51 | 0 | 4 | 0 | 0.01 | 1.13 | 99.90 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 10 | 10 | 31 | 0 | 3 | 0 | 0.01 | 0.68 | 99.91 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6 | 6 | 60 | 0 | 4 | 0 | 0.01 | 1.33 | 99.92 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 10 | 10 | 6 | 0 | 1 | 0 | 0.01 | 0.12 | 99.93 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 7 | 7 | 60 | 0 | 4 | 0 | 0.01 | 1.33 | 99.93 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 7 | 7 | 44 | 0 | 3 | 0 | 0.01 | 0.96 | 99.94 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 5 | 5 | 75 | 0 | 4 | 0 | 0.00 | 1.66 | 99.95 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 6 | 6 | 50 | 0 | 3 | 0 | 0.00 | 1.11 | 99.95 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 5 | 5 | 61 | 0 | 3 | 0 | 0.00 | 1.34 | 99.96 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 5 | 5 | 64 | 0 | 3 | 0 | 0.00 | 1.41 | 99.96 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 4 | 4 | 60 | 0 | 3 | 0 | 0.00 | 1.33 | 99.97 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 3 | 3 | 51 | 0 | 2 | 0 | 0.00 | 1.13 | 99.97 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 3 | 3 | 73 | 0 | 2 | 0 | 0.00 | 1.61 | 99.98 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 4 | 4 | 25 | 0 | 1 | 0 | 0.00 | 0.56 | 99.98 |
| 5.C Incineration and open burning of waste | $N_2O$ | 2 | 2 | 73 | 0 | 2 | 0 | 0.00 | 1.61 | 99.98 |
| 2.G.2 $SF_6$ and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 3 | 3 | 22 | 0 | 1 | 0 | 0.00 | 0.49 | 99.99 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 3 | 3 | 44 | 0 | 1 | 0 | 0.00 | 0.96 | 99.99 |
| 1.A.3 Transport - Biomass | $N_2O$ | 2 | 2 | 61 | 0 | 1 | 0 | 0.00 | 1.34 | 99.99 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 1 | 1 | 44 | 0 | 1 | 0 | 0.00 | 0.96 | 99.99 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $NF_3$ | 2 | 2 | 21 | 0 | 0 | 0 | 0.00 | 0.47 | 99.99 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 2 | 2 | 54 | 0 | 1 | 0 | 0.00 | 1.19 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 1 | 1 | 44 | 0 | 0 | 0 | 0.00 | 0.96 | 100.00 |
| 1.A.3 Transport - Biomass | $CH_4$ | 1 | 1 | 51 | 0 | 0 | 0 | 0.00 | 1.12 | 100.00 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 1 | 1 | 50 | 0 | 0 | 0 | 0.00 | 1.11 | 100.00 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0 | 0 | 50 | 0 | 0 | 0 | 0.00 | 1.11 | 100.00 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0 | 0 | 158 | 0 | 1 | 0 | 0.00 | 3.48 | 100.00 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 1 | 1 | 25 | 0 | 0 | 0 | 0.00 | 0.56 | 100.00 |
| 2.C.6 Zinc Production | $CO_2$ | 0 | 0 | 51 | 0 | 0 | 0 | 0.00 | 1.13 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $N_2O$ | 0 | 0 | 137 | 0 | 0 | 0 | 0.00 | 3.03 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 0 | 0 | 110 | 0 | 0 | 0 | 0.00 | 2.43 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0 | 0 | 60 | 0 | 0 | 0 | 0.00 | 1.33 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0 | 0 | 50 | 0 | 0 | 0 | 0.00 | 1.11 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $CH_4$ | 0 | 0 | 158 | 0 | 0 | 0 | 0.00 | 3.48 | 100.00 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0 | 0.00 | 0.96 | 100.00 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0 | 0 | 75 | 0 | 0 | 0 | 0.00 | 1.66 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0 | 0 | 79 | 0 | 0 | 0 | 0.00 | 1.74 | 100.00 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0 | 0 | 82 | 0 | 0 | 0 | 0.00 | 1.82 | 100.00 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0 | 0.00 | 0.96 | 100.00 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0 | 0.00 | 0.96 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0 | 0.00 | 0.96 | 100.00 |

**Tab. A1- 9 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2015 – Trend Assessment including LULUCF**

| IPCC Source Categories | GHG | Base Year Estimate (Abs) | Current Year Estimate (Abs) | Combined Uncertainty | TA_A1 | Uncertain ammount BY | Uncertain ammount CY | BY uncertain total | CY uncertain total | Level A 2 assessment | Trend A2 Assessment | % contribution to Trend | Cumulative fraction of uncertainty (BY) | Cumulative Total (TA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 110823 | 56332 | 5 | 23 | 5541 | 2817 | 116364 | 59149 | 44 | 17 | 24 | 19.50 | 24.03 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 6177 | 16986 | 4 | 21 | 230 | 631 | 6406 | 17617 | 13 | 16 | 22 | 23.87 | 46.10 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 11201 | 14418 | 4 | 12 | 437 | 563 | 11638 | 14981 | 11 | 9 | 12 | 27.77 | 58.46 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 0 | 3422 | 44 | 6 | 0 | 1491 | 0 | 4913 | 4 | 6 | 8 | 38.10 | 66.46 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 15194 | 2693 | 6 | 11 | 886 | 157 | 16079 | 2850 | 2 | 9 | 12 | 39.18 | 78.45 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 10322 | 3581 | 14 | 5 | 1404 | 487 | 11726 | 4068 | 3 | 4 | 6 | 42.56 | 83.96 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 1979 | 3385 | 50 | 3 | 990 | 1693 | 2969 | 5078 | 4 | 4 | 5 | 54.28 | 89.16 |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | -4664 | -5650 | 21 | 1 | -997 | -1208 | -5661 | -6858 | -5 | -4 | -5 | 45.91 | 83.84 |
| 4.G Harvested wood products | $CO_2$ | -1713 | -164 | 62 | 4 | -1062 | -102 | -2775 | -266 | 0 | -2 | -2 | 45.21 | 81.41 |
| 3.A Enteric Fermentation | $CH_4$ | 5755 | 2896 | 21 | 1 | 1186 | 597 | 6941 | 3493 | 3 | 1 | 1 | 49.34 | 82.90 |
| 3.G Liming | $CO_2$ | 1178 | 163 | 54 | 1 | 634 | 88 | 1812 | 251 | 0 | 1 | 1 | 49.95 | 84.36 |
| 3.B Manure Management | $N_2O$ | 2459 | 1008 | 30 | 1 | 748 | 307 | 3207 | 1314 | 1 | 1 | 1 | 52.07 | 85.54 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 1212 | 249 | 50 | 1 | 608 | 125 | 1821 | 374 | 0 | 1 | 1 | 52.94 | 86.81 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0 | 634 | 91 | 0 | 0 | 579 | 0 | 1213 | 1 | 1 | 2 | 56.94 | 88.79 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 4210 | 2569 | 52 | 0 | 2198 | 1341 | 6408 | 3910 | 3 | 0 | 0 | 66.23 | 89.05 |
| 3.B Manure Management | $CH_4$ | 1752 | 771 | 30 | 1 | 533 | 235 | 2285 | 1006 | 1 | 1 | 1 | 67.85 | 89.77 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 1050 | 280 | 16 | 1 | 163 | 43 | 1213 | 324 | 0 | 1 | 1 | 68.15 | 90.50 |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 335 | 599 | 51 | 1 | 170 | 304 | 505 | 903 | 1 | 1 | 1 | 70.26 | 91.45 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 137 | 348 | 141 | 0 | 192 | 488 | 329 | 836 | 1 | 1 | 1 | 73.64 | 92.47 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 0 | 387 | 18 | 1 | 0 | 70 | 0 | 457 | 0 | 1 | 1 | 74.12 | 93.22 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 1587 | 889 | 54 | 0 | 855 | 479 | 2442 | 1367 | 1 | 0 | 0 | 77.43 | 93.52 |
| 2.A.2 Lime Production | $CO_2$ | 1337 | 610 | 3 | 0 | 38 | 17 | 1374 | 627 | 0 | 0 | 0 | 77.55 | 93.92 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 49 | 141 | 60 | 0 | 29 | 85 | 78 | 225 | 0 | 0 | 0 | 78.14 | 94.20 |
| 4.A.2 Land converted to Forest Land | $CO_2$ | -321 | -492 | 29 | 0 | -93 | -143 | -414 | -634 | 0 | 0 | -1 | 77.15 | 93.60 |
| 4.C.1 Grassland remaining Grassland | $CO_2$ | 0 | -276 | 17 | 0 | 0 | -47 | 0 | -323 | 0 | 0 | -1 | 76.83 | 93.07 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 1080 | 608 | 75 | 0 | 813 | 458 | 1893 | 1066 | 1 | 0 | 0 | 80.00 | 93.29 |
| 1.A.5.b Mobile | $CO_2$ | 0 | 270 | 8 | 0 | 0 | 21 | 0 | 290 | 0 | 0 | 0 | 80.14 | 93.77 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| sources in Agriculture and Forestry | | | | | | | | | | | | | | |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 24 | 218 | 28 | 0 | 7 | 62 | 31 | 280 | 0 | 0 | 0 | 80.57 | 94.19 |
| 2.A.1 Cement Production | $CO_2$ | 2489 | 1550 | 3 | 0 | 70 | 44 | 2560 | 1593 | 1 | 0 | 0 | 80.87 | 94.24 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 890 | 861 | 58 | 0 | 519 | 502 | 1409 | 1363 | 1 | 1 | 1 | 84.35 | 95.01 |
| 1.A.3.c Transport - Railways | $CO_2$ | 654 | 264 | 5 | 0 | 34 | 14 | 688 | 278 | 0 | 0 | 0 | 84.45 | 95.27 |
| 4.C.2 Land converted to Grassland | $CO_2$ | -145 | -274 | 21 | 0 | -31 | -59 | -176 | -333 | 0 | 0 | 0 | 84.04 | 94.91 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 109 | 249 | 11 | 0 | 12 | 28 | 121 | 277 | 0 | 0 | 0 | 84.23 | 95.23 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 456 | 189 | 25 | 0 | 116 | 48 | 572 | 236 | 0 | 0 | 0 | 84.56 | 95.44 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 792 | 715 | 40 | 0 | 319 | 288 | 1112 | 1003 | 1 | 0 | 0 | 86.56 | 95.92 |
| 3.H Urea application | $CO_2$ | 109 | 187 | 54 | 0 | 58 | 101 | 167 | 288 | 0 | 0 | 0 | 87.26 | 96.22 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 483 | 246 | 60 | 0 | 290 | 148 | 773 | 394 | 0 | 0 | 0 | 88.28 | 96.38 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 69 | 146 | 61 | 0 | 42 | 89 | 110 | 235 | 0 | 0 | 0 | 88.90 | 96.65 |
| 5.C Incineration and open burning of waste | $CO_2$ | 23 | 132 | 16 | 0 | 4 | 21 | 27 | 153 | 0 | 0 | 0 | 89.04 | 96.87 |
| 4.B.1 Cropland remaining Cropland | $CO_2$ | -2 | -84 | 51 | 0 | -1 | -43 | -3 | -127 | 0 | 0 | 0 | 88.74 | 96.66 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 0 | 99 | 8 | 0 | 0 | 8 | 0 | 107 | 0 | 0 | 0 | 88.80 | 96.84 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 206 | 224 | 40 | 0 | 83 | 90 | 289 | 314 | 0 | 0 | 0 | 89.42 | 97.05 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 139 | 10 | 6 | 0 | 8 | 1 | 147 | 11 | 0 | 0 | 0 | 89.42 | 97.18 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 5 | 71 | 5 | 0 | 0 | 4 | 6 | 75 | 0 | 0 | 0 | 89.45 | 97.30 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 9643 | 6873 | 12 | 1 | 1177 | 839 | 10820 | 7712 | 6 | 1 | 1 | 95.26 | 98.67 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 234 | 197 | 56 | 0 | 132 | 111 | 366 | 308 | 0 | 0 | 0 | 96.03 | 98.79 |
| 4.E.2 Land converted to Settlements | $CO_2$ | 85 | 88 | 101 | 0 | 86 | 89 | 171 | 178 | 0 | 0 | 0 | 96.65 | 98.90 |
| 5.B Biological treatment of solid waste | $N_2O$ | 0 | 45 | 5 | 0 | 0 | 2 | 0 | 47 | 0 | 0 | 0 | 96.66 | 98.98 |
| 2.D.1 Lubricant Use | $CO_2$ | 116 | 116 | 50 | 0 | 58 | 58 | 174 | 174 | 0 | 0 | 0 | 97.06 | 99.08 |
| 1.A.3.c Transport - Railways | $N_2O$ | 75 | 30 | 137 | 0 | 103 | 42 | 178 | 72 | 0 | 0 | 0 | 97.35 | 99.15 |
| 2.A.3 Glass Production | $CO_2$ | 124 | 125 | 11 | 0 | 14 | 14 | 137 | 139 | 0 | 0 | 0 | 97.45 | 99.23 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 0 | 23 | 44 | 0 | 0 | 10 | 0 | 33 | 0 | 0 | 0 | 97.52 | 99.29 |
| 2.B.1 Ammonia Production | $CO_2$ | 991 | 742 | 9 | 0 | 85 | 64 | 1076 | 805 | 1 | 0 | 0 | 97.96 | 99.49 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 22 | 0 | 50 | 0 | 11 | 0 | 32 | 0 | 0 | 0 | 0 | 97.96 | 99.52 |
| 1.A.3.d Transport - Domestic navigation | $CO_2$ | 57 | 13 | 5 | 0 | 3 | 1 | 60 | 13 | 0 | 0 | 0 | 97.97 | 99.56 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 75 | 75 | 40 | 0 | 30 | 30 | 105 | 105 | 0 | 0 | 0 | 98.17 | 99.62 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | SF6 | 0 | 16 | 21 | 0 | 0 | 3 | 0 | 20 | 0 | 0 | 0 | 98.20 | 99.65 |
| 4.D.2. Land converted to Wetlands | $CO_2$ | 22 | 25 | 64 | 0 | 14 | 16 | 35 | 41 | 0 | 0 | 0 | 98.31 | 99.68 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 36 | 37 | 40 | 0 | 15 | 15 | 51 | 52 | 0 | 0 | 0 | 98.41 | 99.72 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 13 | 15 | 50 | 0 | 6 | 8 | 19 | 23 | 0 | 0 | 0 | 98.46 | 99.73 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | SF6 | 84 | 71 | 16 | 0 | 13 | 11 | 97 | 82 | 0 | 0 | 0 | 98.54 | 99.77 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 0 | 7 | 60 | 0 | 0 | 4 | 0 | 11 | 0 | 0 | 0 | 98.57 | 99.78 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 0 | 7 | 44 | 0 | 0 | 3 | 0 | 10 | 0 | 0 | 0 | 98.59 | 99.80 |
| 2.C.5 Lead Production | $CO_2$ | 4 | 9 | 51 | 0 | 2 | 4 | 6 | 13 | 0 | 0 | 0 | 98.62 | 99.81 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 0 | 5 | 61 | 0 | 0 | 3 | 0 | 9 | 0 | 0 | 0 | 98.64 | 99.83 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 0 | 4 | 60 | 0 | 0 | 3 | 0 | 7 | 0 | 0 | 0 | 98.66 | 99.84 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 2 | 5 | 75 | 0 | 2 | 4 | 4 | 9 | 0 | 0 | 0 | 98.69 | 99.85 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 1 | 5 | 64 | 0 | 0 | 3 | 1 | 7 | 0 | 0 | 0 | 98.71 | 99.86 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6 | 6 | 60 | 0 | 4 | 4 | 10 | 10 | 0 | 0 | 0 | 98.74 | 99.87 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 0 | 3 | 51 | 0 | 0 | 2 | 0 | 5 | 0 | 0 | 0 | 98.75 | 99.88 |
| 4.B.2. Land converted to Cropland | $N_2O$ | 9 | 5 | 250 | 0 | 22 | 12 | 31 | 17 | 0 | 0 | 0 | 98.83 | 99.88 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 0 | 3 | 73 | 0 | 0 | 2 | 1 | 5 | 0 | 0 | 0 | 98.85 | 99.89 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 0 | 4 | 25 | 0 | 0 | 1 | 0 | 5 | 0 | 0 | 0 | 98.86 | 99.90 |
| 2.G.2 $SF_6$ and PFC from other product use ($CO_2$ eq.) | SF6 | 0 | 3 | 22 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 98.86 | 99.90 |
| 4.A.1 Forest Land remaining Forest Land | $CH_4$ | 117 | 82 | 50 | 0 | 59 | 41 | 176 | 123 | 0 | 0 | 0 | 99.14 | 99.92 |
| 2.F.2 Foam Blowing (CO2 eq.) | HFC | 0 | 3 | 44 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 99.15 | 99.93 |
| 5.C Incineration and open burning of waste | $N_2O$ | 0 | 2 | 73 | 0 | 0 | 2 | 1 | 4 | 0 | 0 | 0 | 99.16 | 99.93 |
| 1.A.3 Transport - Biomass | $N_2O$ | 0 | 2 | 61 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 99.17 | 99.94 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 38 | 25 | 303 | 0 | 113 | 77 | 151 | 102 | 0 | 0 | 0 | 99.70 | 99.95 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 0 | 1 | 44 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 99.71 | 99.95 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | NF3 | 0 | 2 | 21 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 99.71 | 99.96 |
| 4.B.2 Land converted to Cropland | $CO_2$ | 114 | 84 | 35 | 0 | 39 | 29 | 153 | 113 | 0 | 0 | 0 | 99.91 | 99.98 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 0 | 2 | 54 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 99.92 | 99.99 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 9 | 6 | 50 | 0 | 5 | 3 | 14 | 9 | 0 | 0 | 0 | 99.94 | 99.99 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 15 | 10 | 31 | 0 | 5 | 3 | 19 | 13 | 0 | 0 | 0 | 99.96 | 99.99 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0 | 1 | 44 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 99.96 | 99.99 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 1 | 0 | 110 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 99.96 | 99.99 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0 | 1 | 51 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 99.96 | 99.99 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0 | 1 | 50 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 99.97 | 99.99 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 99.97 | 99.99 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0 | 1 | 25 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 99.97 | 100.00 |
| 2.C.6 Zinc Production | $CO_2$ | 0 | 0 | 51 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 99.97 | 100.00 |
| 1.A.3.c Transport - Railways | $CH_4$ | 1 | 0 | 158 | 0 | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 99.97 | 100.00 |
| 1.A.3.d Transport - | $N_2O$ | 0 | 0 | 137 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 99.98 | 100.00 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic navigation | | | | | | | | | | | | | | |
| 4.A.1 Forest Land remaining Forest Land | $N_2O$ | 10 | 7 | 50 | 0 | 5 | 3 | 14 | 10 | 0 | 0 | 0 | 100.00 | 100.00 |
| 1.A.3.d Transport - Domestic navigation | $CH_4$ | 0 | 0 | 158 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0 | 0 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00 | 100.00 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00 | 100.00 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00 | 100.00 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0 | 0 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00 | 100.00 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0 | 0 | 79 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00 | 100.00 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0 | 0 | 82 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00 | 100.00 |
| 2.F.2 Foam Blowing (CO2 eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00 | 100.00 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00 | 100.00 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0 | 0 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.00 | 100.00 |
| | Total= | 196616 | 138045 | | | 19599 | 15639.93 | 216215.3 | 153685.2 | 100 | 62.68758 | 0.319846 | | |

**Tab. A1- 10 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2015 – Trend Assessment excluding LULUCF**

| IPCC Source ategories | GHG | Base Year Estimate (Abs) | Current Year Estimate (Abs) | Combined Uncertainty | TA_A1 | Uncertain ammount BY | Uncertain ammount CY | BY uncertain total | CY uncertain total | Level A 2 assessment | Trend A2 Assessment | % contribution to Trend | Cumulative fraction of uncertainty (BY) | Cumulative Total (TA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 110822.5 | 56332.49 | 5 | 23.09087 | 5541.127 | 2816.625 | 116363.7 | 59149.12 | 41.43572 | 17.57092 | 23.59482 | 17.76805 | 23.59482 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 6176.538 | 16985.57 | 3.717752 | 21.23782 | 229.6284 | 631.4815 | 6406.167 | 17617.06 | 12.34127 | 14.55785 | 19.54877 | 21.7516 | 43.14359 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 11201.04 | 14417.54 | 3.905125 | 11.85831 | 437.4144 | 563.0228 | 11638.45 | 14980.56 | 10.49433 | 8.042198 | 10.79933 | 25.30331 | 53.94292 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 0 | 3422.333 | 43.56604 | 5.567486 | 0 | 1490.975 | 0 | 4913.307 | 3.441919 | 5.31171 | 7.132743 | 34.70879 | 61.07567 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 15193.5 | 2693.432 | 5.830952 | 11.34793 | 885.9258 | 157.0527 | 16079.43 | 2850.484 | 1.996849 | 8.1825 | 10.98774 | 35.69952 | 72.0634 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 10322.4 | 3581.301 | 13.60147 | 4.860547 | 1403.998 | 487.1095 | 11726.39 | 4068.41 | 2.850043 | 3.816387 | 5.124772 | 38.77234 | 77.18817 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 1979.275 | 3385.207 | 50 | 3.457972 | 989.6373 | 1692.604 | 2968.912 | 5077.811 | 3.557158 | 3.409741 | 4.578714 | 49.44975 | 81.76689 |
| 3.A Enteric Fermentation | $CH_4$ | 5754.891 | 2895.958 | 20.61553 | 1.246789 | 1186.401 | 597.0171 | 6941.292 | 3492.975 | 2.446934 | 1.086374 | 1.458819 | 53.2159 | 83.22571 |
| 3.G Liming | $CO_2$ | 1177.817 | 162.8932 | 53.85165 | 0.954382 | 634.2737 | 87.72067 | 1812.09 | 250.6139 | 0.175562 | 0.998488 | 1.340803 | 53.76927 | 84.56651 |
| 3.B Manure Management | $N_2O$ | 2459.334 | 1007.814 | 30.41381 | 0.906594 | 747.9772 | 306.5148 | 3207.311 | 1314.329 | 0.920727 | 0.825914 | 1.109065 | 55.70285 | 85.67558 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 1212.438 | 248.9893 | 50.15974 | 0.850163 | 608.1557 | 124.8924 | 1820.593 | 373.8818 | 0.261915 | 0.871182 | 1.169852 | 56.4907 | 86.84543 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0 | 633.9866 | 91.28738 | 0 | 0 | 578.7498 | 0 | 1212.736 | 0.849558 | 1.311073 | 1.760553 | 60.14162 | 88.60598 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 4210.368 | 2569.13 | 52.20153 | 0.179451 | 2197.877 | 1341.125 | 6408.244 | 3910.256 | 2.739251 | 0.261842 | 0.35161 | 68.6018 | 88.95759 |
| 3.B Manure Management | $CH_4$ | 1752.071 | 771.4666 | 30.41381 | 0.558866 | 532.8715 | 234.6324 | 2284.942 | 1006.099 | 0.704802 | 0.51299 | 0.68886 | 70.08193 | 89.64645 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 1050.292 | 280.12 | 15.52417 | 0.631652 | 163.0492 | 43.48632 | 1213.341 | 323.6063 | 0.226696 | 0.500135 | 0.671599 | 70.35625 | 90.31805 |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 335.0035 | 599.439 | 50.63596 | 0.628349 | 169.6322 | 303.5317 | 504.6357 | 902.9707 | 0.632558 | 0.622677 | 0.836152 | 72.27102 | 91.1542 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 136.7253 | 347.534 | 140.5418 | 0.423822 | 192.1562 | 488.4306 | 328.8814 | 835.9647 | 0.585618 | 0.673359 | 0.904209 | 75.35217 | 92.05841 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 0 | 387.1912 | 18.02776 | 0.629887 | 0 | 69.80188 | 0 | 456.993 | 0.320137 | 0.494049 | 0.663426 | 75.7925 | 92.72184 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 1586.963 | 888.6303 | 53.85165 | 0.197329 | 854.6056 | 478.5421 | 2441.568 | 1367.172 | 0.957745 | 0.23236 | 0.312021 | 78.81128 | 93.03386 |
| 2.A.2 Lime Production | $CO_2$ | 1336.645 | 609.7481 | 2.828427 | 0.391867 | 37.80604 | 17.24628 | 1374.452 | 626.9944 | 0.439228 | 0.285009 | 0.38272 | 78.92007 | 93.41658 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 48.67369 | 140.5436 | 60.20797 | 0.178246 | 29.30544 | 84.61844 | 77.97913 | 225.162 | 0.157733 | 0.188793 | 0.253517 | 79.45387 | 93.67009 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 1079.906 | 608.0136 | 75.32596 | 0.12889 | 813.4494 | 457.992 | 1893.355 | 1066.006 | 0.746769 | 0.173908 | 0.233529 | 82.34301 | 93.90362 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 0 | 269.7826 | 7.615773 | 0.438885 | 0 | 20.54603 | 0 | 290.3286 | 0.203384 | 0.31387 | 0.421476 | 82.47262 | 94.3251 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 24.04374 | 218.4295 | 28.28427 | 0.330451 | 6.800597 | 61.78118 | 30.84434 | 280.2106 | 0.196296 | 0.281325 | 0.377772 | 82.86235 | 94.70287 |
| 2.A.1 Cement Production | $CO_2$ | 2489.184 | 1549.543 | 2.828427 | 0.056208 | 70.40476 | 43.82769 | 2559.589 | 1593.371 | 1.116204 | 0.070497 | 0.094666 | 83.13883 | 94.79754 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 889.8047 | 860.5591 | 58.38352 | 0.478763 | 519.4993 | 502.4247 | 1409.304 | 1362.984 | 0.954811 | 0.486244 | 0.652945 | 86.30826 | 95.45048 |
| 1.A.3.c Transport - Railways | $CO_2$ | 653.8584 | 264.1123 | 5.220153 | 0.24727 | 34.13241 | 13.78707 | 687.9908 | 277.8994 | 0.194677 | 0.181525 | 0.243758 | 86.39523 | 95.69424 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 109.1494 | 249.1497 | 11.18034 | 0.292318 | 12.20327 | 27.85579 | 121.3526 | 277.0055 | 0.194051 | 0.214456 | 0.287978 | 86.57096 | 95.98222 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 456.242 | 188.5283 | 25.31798 | 0.165642 | 115.5112 | 47.73154 | 571.7532 | 236.2598 | 0.165507 | 0.145113 | 0.194862 | 86.87206 | 96.17708 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 792.465 | 715.1609 | 40.31129 | 0.343002 | 319.4529 | 288.2906 | 1111.918 | 1003.451 | 0.702948 | 0.305886 | 0.410754 | 88.69068 | 96.58783 |
| 3.H Urea application | $CO_2$ | 108.5333 | 187.099 | 53.85165 | 0.192011 | 58.44699 | 100.7559 | 166.9803 | 287.8549 | 0.201651 | 0.194221 | 0.260807 | 89.32627 | 96.84864 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 482.9722 | 246.3181 | 60.13319 | 0.099302 | 290.4266 | 148.1189 | 773.3988 | 394.4371 | 0.276315 | 0.115368 | 0.154921 | 90.26065 | 97.00356 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 68.58059 | 146.4366 | 60.53098 | 0.167224 | 41.5125 | 88.63954 | 110.0931 | 235.0762 | 0.164678 | 0.177014 | 0.237701 | 90.81981 | 97.24126 |
| 5.C Incineration and open burning of waste | $CO_2$ | 23.14868 | 132.428 | 15.81139 | 0.19147 | 3.660127 | 20.93871 | 26.8088 | 153.3668 | 0.107438 | 0.147022 | 0.197427 | 90.9519 | 97.43869 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 0 | 99.0704 | 7.615773 | 0.161169 | 0 | 7.544977 | 0 | 106.6154 | 0.074687 | 0.11526 | 0.154776 | 90.99949 | 97.59346 |
| 2.G.3 N2O from product uses | $N_2O$ | 206.216 | 223.5 | 40.31129 | 0.150099 | 83.12833 | 90.09573 | 289.3443 | 313.5957 | 0.219683 | 0.13633 | 0.183068 | 91.56784 | 97.77653 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 139.4389 | 10.22729 | 5.5389 | 0.127721 | 7.723382 | 0.566479 | 147.1623 | 10.79377 | 0.007561 | 0.091423 | 0.122765 | 91.57141 | 97.8993 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 5.423796 | 71.03647 | 5 | 0.109948 | 0.27119 | 3.551824 | 5.694986 | 74.5883 | 0.052251 | 0.076647 | 0.102924 | 91.59382 | 98.00222 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 9642.538 | 6872.795 | 12.20656 | 1.19794 | 1177.022 | 838.9316 | 10819.56 | 7711.727 | 5.402295 | 0.757619 | 1.017356 | 96.88603 | 99.01958 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 234.1806 | 197.2348 | 56.35601 | 0.078419 | 131.9748 | 111.1537 | 366.1554 | 308.3885 | 0.216035 | 0.076892 | 0.103253 | 97.58722 | 99.12283 |
| 5.B Biological treatment of solid waste | $N_2O$ | 0 | 44.58524 | 5.035871 | 0 | 0 | 2.245255 | 0 | 46.8305 | 0.032806 | 0.050628 | 0.067985 | 97.60138 | 99.19081 |
| 2.D.1 Lubricant Use | $CO_2$ | 116.131 | 115.5415 | 50.24938 | 0.067735 | 58.35509 | 58.05887 | 174.4861 | 173.6004 | 0.121612 | 0.065444 | 0.087881 | 97.96764 | 99.2787 |
| 1.A.3.c Transport - Railways | $N_2O$ | 75.20519 | 30.37755 | 137.2911 | 0.02844 | 103.25 | 41.70567 | 178.4552 | 72.08322 | 0.050496 | 0.047085 | 0.063227 | 98.23073 | 99.34192 |
| 2.A.3 Glass Production | $CO_2$ | 123.6581 | 125.4664 | 11.18034 | 0.076088 | 13.8254 | 14.02757 | 137.4835 | 139.494 | 0.09772 | 0.054494 | 0.073176 | 98.31922 | 99.4151 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 0 | 22.73036 | 43.56604 | 0.036978 | 0 | 9.902719 | 0 | 32.63308 | 0.02286 | 0.035279 | 0.047374 | 98.38168 | 99.46247 |
| 2.B.1 Ammonia Production | $CO_2$ | 990.8021 | 741.6618 | 8.602325 | 0.180778 | 85.23202 | 63.80016 | 1076.034 | 805.462 | 0.56425 | 0.11698 | 0.157085 | 98.78415 | 99.61956 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 21.57847 | 0.182157 | 50.24938 | 0.022044 | 10.84304 | 0.091533 | 32.42151 | 0.27369 | 0.000192 | 0.022416 | 0.030101 | 98.78473 | 99.64966 |
| 1.A.3.d Transport - Domestic navigation | $CO_2$ | 56.6124 | 12.72831 | 5.220153 | 0.037904 | 2.955254 | 0.664437 | 59.56765 | 13.39274 | 0.009382 | 0.02725 | 0.036592 | 98.78892 | 99.68625 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 74.5 | 74.5 | 40.31129 | 0.044068 | 30.03191 | 30.03191 | 104.5319 | 104.5319 | 0.073228 | 0.03978 | 0.053418 | 98.97837 | 99.73967 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $SF_6$ | 0 | 16.245 | 21.2132 | 0 | 0 | 3.446085 | 0 | 19.69108 | 0.013794 | 0.021288 | 0.028586 | 99.00011 | 99.76826 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 36.16907 | 36.81298 | 40.31129 | 0.022442 | 14.58022 | 14.83979 | 50.74929 | 51.65277 | 0.036184 | 0.02029 | 0.027246 | 99.09372 | 99.7955 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 12.791 | 15.11326 | 50.08992 | 0.011344 | 6.407004 | 7.570219 | 19.19801 | 22.68348 | 0.01589 | 0.011074 | 0.014871 | 99.14148 | 99.81037 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 84.10263 | 71.0829 | 15.81139 | 0.028568 | 13.29779 | 11.23919 | 97.40043 | 82.32209 | 0.057669 | 0.020765 | 0.027884 | 99.21238 | 99.83826 |
| 1.A.5.b Mobile sources in | $N_2O$ | 0 | 6.718556 | 60.40695 | 0.01093 | 0 | 4.058475 | 0 | 10.77703 | 0.00755 | 0.011651 | 0.015645 | 99.23798 | 99.8539 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture and Forestry | | | | | | | | | | | | | | |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 0 | 6.6638 | 43.56604 | 0.010841 | 0 | 2.903154 | 0 | 9.566954 | 0.006702 | 0.010343 | 0.013889 | 99.2563 | 99.86779 |
| 2.C.5 Lead Production | $CO_2$ | 4.0366 | 8.809 | 50.9902 | 0.010152 | 2.05827 | 4.491726 | 6.09487 | 13.30073 | 0.009318 | 0.01011 | 0.013576 | 99.28463 | 99.88137 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 0 | 5.474448 | 60.82763 | 0.008906 | 0 | 3.329977 | 0 | 8.804426 | 0.006168 | 0.009518 | 0.012782 | 99.30564 | 99.89415 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 0 | 4.236444 | 60.40695 | 0.006892 | 0 | 2.559107 | 0 | 6.795551 | 0.00476 | 0.007347 | 0.009865 | 99.32178 | 99.90401 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 2.202202 | 5.391638 | 75.32596 | 0.006491 | 1.65883 | 4.061303 | 3.861032 | 9.45294 | 0.006622 | 0.007515 | 0.010091 | 99.3474 | 99.9141 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 0.75 | 4.5 | 64.03124 | 0.006544 | 0.480234 | 2.881406 | 1.230234 | 7.381406 | 0.005171 | 0.007118 | 0.009558 | 99.36558 | 99.92366 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6.121901 | 6.435245 | 60.07495 | 0.004131 | 3.677729 | 3.865971 | 9.79963 | 10.30122 | 0.007216 | 0.004272 | 0.005736 | 99.38996 | 99.9294 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 0 | 3.444494 | 50.9902 | 0.005604 | 0 | 1.756354 | 0 | 5.200848 | 0.003643 | 0.005623 | 0.00755 | 99.40104 | 99.93695 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 0.312542 | 2.839345 | 72.8011 | 0.004296 | 0.227534 | 2.067074 | 0.540077 | 4.906419 | 0.003437 | 0.004926 | 0.006615 | 99.41408 | 99.94356 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 0.181731 | 3.672115 | 25.4951 | 0.005786 | 0.046332 | 0.936209 | 0.228063 | 4.608325 | 0.003228 | 0.004822 | 0.006475 | 99.41999 | 99.95004 |
| 2.G.2 SF6 and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 0 | 3.22392 | 22.36068 | 0 | 0 | 0.72089 | 0 | 3.94481 | 0.002763 | 0.004265 | 0.005727 | 99.42454 | 99.95576 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 0 | 2.571108 | 43.56604 | 0.004183 | 0 | 1.12013 | 0 | 3.691238 | 0.002586 | 0.003991 | 0.005359 | 99.4316 | 99.96112 |
| 5.C Incineration and open burning of waste | $N_2O$ | 0.42018 | 2.403749 | 72.8011 | 0.003475 | 0.305896 | 1.749956 | 0.726076 | 4.153705 | 0.00291 | 0.003982 | 0.005347 | 99.44264 | 99.96647 |
| 1.A.3 Transport - Biomass | $N_2O$ | 0 | 2.219623 | 60.53098 | 0.003611 | 0 | 1.34356 | 0 | 3.563183 | 0.002496 | 0.003852 | 0.005173 | 99.45112 | 99.97164 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 37.5032 | 25.2886 | 302.5779 | 0.002313 | 113.4764 | 76.51772 | 150.9796 | 101.8063 | 0.071318 | 0.004296 | 0.005768 | 99.93381 | 99.97741 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 0 | 1.486205 | 43.56604 | 0.002418 | 0 | 0.647481 | 0 | 2.133686 | 0.001495 | 0.002307 | 0.003098 | 99.9379 | 99.98051 |
| 2.E.1 Integrated Circuit or Semiconductor ($CO_2$ eq.) | $NF_3$ | 0 | 2.2876 | 21.2132 | 0.003721 | 0 | 0.485273 | 0 | 2.772873 | 0.001942 | 0.002998 | 0.004025 | 99.94096 | 99.98453 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 0.19665 | 1.7865 | 53.85165 | 0.002703 | 0.105899 | 0.96206 | 0.302549 | 2.74856 | 0.001925 | 0.002759 | 0.003706 | 99.94703 | 99.98824 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 9.431957 | 5.894973 | 50.24938 | 0.000175 | 4.7395 | 2.962187 | 14.17146 | 8.857161 | 0.006205 | 0.000352 | 0.000473 | 99.96571 | 99.98871 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 14.83844 | 9.723477 | 30.80584 | 0.000456 | 4.571106 | 2.995399 | 19.40954 | 12.71888 | 0.00891 | 0.000153 | 0.000206 | 99.98461 | 99.98892 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0 | 0.7828 | 43.56604 | 0 | 0 | 0.341035 | 0 | 1.123835 | 0.000787 | 0.001215 | 0.001631 | 99.98676 | 99.99055 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 1.18708 | 0.086991 | 110.0727 | 0.001087 | 1.306651 | 0.095753 | 2.493731 | 0.182745 | 0.000128 | 0.001549 | 0.002081 | 99.98737 | 99.99263 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0 | 0.59445 | 50.63596 | 0.000967 | 0 | 0.301005 | 0 | 0.895455 | 0.000627 | 0.000968 | 0.0013 | 99.98926 | 99.99393 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0 | 0.508734 | 50.48762 | 0.000828 | 0 | 0.256848 | 0 | 0.765582 | 0.000536 | 0.000828 | 0.001111 | 99.99088 | 99.99504 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0 | 0.498262 | 50.48762 | 0.000811 | 0 | 0.251561 | 0 | 0.749822 | 0.000525 | 0.000811 | 0.001089 | 99.99247 | 99.99613 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0.02625 | 0.530417 | 25.4951 | 0.000836 | 0.006692 | 0.13523 | 0.032942 | 0.665647 | 0.000466 | 0.000697 | 0.000935 | 99.99332 | 99.99707 |
| 2.C.6 Zinc Production | $CO_2$ | 0 | 0.4128 | 50.9902 | 0 | 0 | 0.210488 | 0 | 0.623288 | 0.000437 | 0.000674 | 0.000905 | 99.99465 | 99.99797 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0.91549 | 0.369793 | 157.5793 | 0.000346 | 1.442623 | 0.582717 | 2.358113 | 0.95251 | 0.000667 | 0.000622 | 0.000835 | 99.99833 | 99.99881 |
| 1.A.3.d Transport - Domestic navigation | $N_2O$ | 0.455344 | 0.102376 | 137.2911 | 0.000305 | 0.625147 | 0.140553 | 1.080491 | 0.242929 | 0.00017 | 0.000494 | 0.000664 | 99.99921 | 99.99947 |
| 1.A.3.d Transport - | $CH_4$ | 0.1337 | 0.0300 | 157.57 | 8.95E- | 0.2106 | 0.0473 | 0.3443 | 0.0774 | 5.42E- | 0.0001 | 0.0002 | 99.999 | 99.999 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic navigation | | | 6 | 93 | 05 | 84 | 69 | 84 | 29 | 05 | 58 | 12 | 51 | 68 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0.002964 | 0.042346 | 60.13319 | 6.58E-05 | 0.001783 | 0.025464 | 0.004747 | 0.06781 | 4.75E-05 | 7E-05 | 9.4E-05 | 99.99967 | 99.99978 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0.002487 | 0.035525 | 50.15974 | 5.52E-05 | 0.001247 | 0.017819 | 0.003734 | 0.053344 | 3.74E-05 | 5.51E-05 | 7.39E-05 | 99.99979 | 99.99985 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0 | 0.031451 | 43.56604 | 5.12E-05 | 0 | 0.013702 | 0 | 0.045153 | 3.16E-05 | 4.88E-05 | 6.55E-05 | 99.99987 | 99.99992 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0.009067 | 0.023629 | 75.32596 | 2.91E-05 | 0.006829 | 0.017799 | 0.015896 | 0.041429 | 2.9E-05 | 3.37E-05 | 4.52E-05 | 99.99999 | 99.99996 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0.024895 | 0.001822 | 78.60184 | 2.28E-05 | 0.019568 | 0.001432 | 0.044462 | 0.003255 | 2.28E-06 | 2.76E-05 | 3.71E-05 | 99.99999 | 100 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0.000197 | 0.001129 | 82.46211 | 1.63E-06 | 0.000163 | 0.000931 | 0.00036 | 0.002061 | 1.44E-06 | 1.98E-06 | 2.65E-06 | 100 | 100 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0 | 0 | 43.56604 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0 | 0 | 43.56604 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0 | 0 | 43.56604 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |

# Annex 2 Assessment of uncertainty

**Tab. A2 - 1 Uncertainty analysis (Tier 1), first part of Table 3.3 of IPCC 2006 Gl. incl. LULUCF**

| Input DATA | | | | | |
|---|---|---|---|---|---|
| **IPCC Source Category** | **Gas** | **Base year emissions (1990) abs** | **Year t emissions (2015) abs** | **Activity data uncertainty** | **Emission factor uncertainty** |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 265.05 | 417.63 | 8 | 50 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 58.65 | 113.88 | 8 | 60 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 11195.61 | 13719.29 | 3 | 3 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 12.79 | 17.72 | 3 | 50 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6.12 | 7.39 | 3 | 60 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 22219.95 | 19121.96 | 5 | 3 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 60.16 | 22.54 | 5 | 50 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 262.57 | 673.47 | 5 | 60 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 0.00 | 301.59 | 10 | 15 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 0.00 | 0.81 | 10 | 50 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 0.00 | 1.35 | 10 | 60 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 24.04 | 221.01 | 20 | 20 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 0.20 | 1.81 | 20 | 50 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 0.31 | 2.87 | 20 | 70 |
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 110822.55 | 55609.34 | 4 | 3 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 1212.44 | 186.20 | 4 | 50 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 450.92 | 226.17 | 4 | 60 |
| 1.A.3.a Transport - Civil Aviation | $CO_2$ | 139.44 | 7.02 | 4 | 4 |
| 1.A.3.a Transport - Civil Aviation | $CH_4$ | 0.02 | 0.00 | 4 | 21 |
| 1.A.3.a Transport - Civil Aviation | $N_2O$ | 1.19 | 0.06 | 4 | 40 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 6176.54 | 16117.13 | 3 | 2 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 37.50 | 23.33 | 3 | 100 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 136.73 | 610.49 | 3 | 100 |
| 1.A.3.c Transport - Railways | $CO_2$ | 653.86 | 273.78 | 5 | 1 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0.92 | 0.38 | 5 | 100 |
| 1.A.3.c Transport - Railways | $N_2O$ | 75.21 | 31.49 | 5 | 100 |
| 1.A.3.d Transport - Navigation | $CO_2$ | 56.61 | 9.55 | 5 | 2 |
| 1.A.3.d Transport - Navigation | $CH_4$ | 0.13 | 0.02 | 5 | 50 |
| 1.A.3.d Transport - Navigation | $N_2O$ | 0.46 | 0.08 | 5 | 90 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 5.42 | 83.72 | 4 | 3 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0.00 | 0.04 | 4 | 50 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0.00 | 0.05 | 4 | 60 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 0.00 | 71.21 | 7 | 3 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0.00 | 0.36 | 7 | 50 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 0.00 | 3.04 | 7 | 60 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 0.00 | 260.37 | 7 | 3 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0.00 | 0.49 | 7 | 50 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 0.00 | 6.72 | 7 | 60 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 456.24 | 196.83 | 4 | 25 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 9119.12 | 3129.84 | 4 | 13 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 0.75 | 4.93 | 40 | 50 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 2.20 | 0.05 | 7 | 75 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 1079.91 | 625.48 | 7 | 75 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0.01 | 0.03 | 7 | 75 |
| 2.A.1 Cement Production | $CO_2$ | 2489.18 | 1482.00 | 2 | 2 |
| 2.A.2 Lime Production | $CO_2$ | 1336.65 | 629.04 | 2 | 2 |
| 2.A.3 Glass Production | $CO_2$ | 123.66 | 111.93 | 5 | 10 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 109.15 | 320.51 | 5 | 10 |
| 2.B.1 Ammonia Production | $CO_2$ | 990.80 | 689.05 | 5 | 7 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 1050.29 | 255.62 | 4 | 15 |

| Input DATA | | | | | |
|---|---|---|---|---|---|
| IPCC Source Category | Gas | Base year emissions (1990) abs | Year t emissions (2015) abs | Activity data uncertainty | Emission factor uncertainty |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 74.50 | 74.50 | 5 | 40 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 792.47 | 1080.92 | 5 | 40 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 36.17 | 53.22 | 5 | 40 |
| 2.B.10 Other | $CO_2$ | 0.00 | 219.52 | 3 | 3 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 9642.54 | 6498.79 | 7 | 10 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 14.84 | 10.09 | 7 | 30 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 0.00 | 56.72 | 5 | 25 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0.01 | 502.72 | 5 | 25 |
| 2.C.5 Lead Production | $CH_4$ | 10.40 | 24.10 | 10 | 50 |
| 2.C.6 Zinc Production | $CO_2$ | 0.00 | 0.29 | 10 | 50 |
| 2.D.1 Lubricant Use | $CO_2$ | 116.13 | 92.55 | 5 | 50 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 9.43 | 7.07 | 5 | 50 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 0.00 | 17.02 | 5 | 5 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $CO_2$ | 0.00 | 17.20 | 15 | 15 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $SF_6$ | 0.00 | 2.35 | 15 | 15 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | $NF_3$ | 0.21 | 2796.90 | 37 | 23 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 0.00 | 4.85 | 37 | 23 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0.00 | 2.64 | 37 | 23 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 37 | 23 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0.00 | 20.88 | 37 | 23 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 0.00 | 0.03 | 37 | 23 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0.00 | 8.11 | 37 | 23 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 37 | 23 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0.00 | 1.86 | 37 | 23 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0.00 | 0.00 | 37 | 23 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | PFC | 85.22 | 75.56 | 5 | 15 |
| 2.G.2 $SF_6$ and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 0.00 | 3.26 | 10 | 20 |
| 2.G.3 $N_2O$ from product uses | $SF_6$ | 206.22 | 223.50 | 5 | 40 |
| 3.A Enteric Fermentation | $N_2O$ | 5754.89 | 2817.27 | 5 | 20 |
| 3.B Manure Management | $CH_4$ | 1772.43 | 768.19 | 5 | 30 |
| 3.B Manure Management | $CH_4$ | 3309.60 | 1312.02 | 5 | 30 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 3991.85 | 2397.43 | 15 | 50 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 1500.79 | 784.92 | 20 | 50 |
| 3.G Liming | $N_2O$ | 1177.82 | 150.29 | 20 | 50 |
| 3.H Urea application | $CO_2$ | 108.53 | 57.03 | 20 | 50 |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | -4644.62 | -6907.74 | 0 | 18 |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | 117.30 | 73.31 | 0 | 50 |
| 4.A.1 Forest Land remaining Forest Land | $CH_4$ | 9.61 | 6.01 | 0 | 50 |
| 4.A.2 Land converted to Forest Land | $N_2O$ | -321.25 | -482.21 | 0 | 29 |
| 4.B.1 Cropland remaining Cropland | $CO_2$ | -2.28 | -76.00 | 0 | 52 |
| 4.B.2 Land converted to Cropland | $CO_2$ | 113.99 | 88.11 | 0 | 38 |
| 4.B.2. Land converted to Cropland | $CO_2$ | 8.91 | 0.00 | 0 | 250 |
| 4.C.1 Grassland remaining Grassland | $N_2O$ | 0.00 | -273.92 | 0 | 17 |
| 4.C.2 Land converted to Grassland | $CO_2$ | -145.34 | -295.18 | 0 | 20 |
| 4.D.2. Land converted to Wetlands | $CO_2$ | 21.51 | 26.76 | 0 | 66 |
| 4.E.2 Land converted to Settlements | $CO_2$ | 85.09 | 127.60 | 0 | 101 |
| 4.F.2 Land converted to Other Land | $CO_2$ | 0.00 | 8.55 | 0 | 101 |
| 4.G Harvested wood products | $CO_2$ | -1712.95 | -94.13 | 0 | 62 |
| 5.A Solid Waste Disposal on Land | $CO_2$ | 1979.27 | 3330.79 | 30 | 40 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0.00 | 617.79 | 20 | 10 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0.00 | 36.50 | 20 | 1 |
| 5.C Incineration and open burning of waste | $N_2O$ | 23.15 | 131.74 | 20 | 5 |
| 5.C Incineration and open burning of waste | $CO_2$ | 0.00 | 0.00 | 20 | 50 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0.42 | 2.39 | 20 | 70 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 1138.23 | 731.05 | 21 | 50 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 234.18 | 204.00 | 26 | 50 |
| 1.A.3 Transport - Biomass | $N_2O$ | 0.00 | 0.63 | 8 | 50 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0.00 | 2.37 | 8 | 60 |
| | | | | | |
| | **Total** | **196142.60** | **132929.89** | | |

**Tab. A2 - 2 Uncertainty analysis (Tier 1), second part of Table 3.3 of IPCC 2006 Gl. incl. LULUCF**

| Uncertainty of Emissions | | | | |
|---|---|---|---|---|
| **IPCC Source Category** | **Gas** | **Combined uncertainty** | **Uncertain amount** | **Combined uncertainty as% of total national emissions in year t** |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 50.64 | 211.47 | 0.1591 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 60.53 | 68.93 | 0.0519 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 3.91 | 535.76 | 0.4030 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 50.09 | 8.87 | 0.0067 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 60.07 | 4.44 | 0.0033 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 5.83 | 1114.99 | 0.8388 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 50.25 | 11.33 | 0.0085 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 60.21 | 405.48 | 0.3050 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 18.03 | 54.37 | 0.0409 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 50.99 | 0.41 | 0.0003 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 60.83 | 0.82 | 0.0006 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 28.28 | 62.51 | 0.0470 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 53.85 | 0.97 | 0.0007 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 72.80 | 2.09 | 0.0016 |
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 5.00 | 2780.47 | 2.0917 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 50.16 | 93.40 | 0.0703 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 60.13 | 136.00 | 0.1023 |
| 1.A.3.a Transport - Civil Aviation | $CO_2$ | 5.47 | 0.38 | 0.0003 |
| 1.A.3.a Transport - Civil Aviation | $CH_4$ | 21.38 | 0.00 | 0.0000 |
| 1.A.3.a Transport - Civil Aviation | $N_2O$ | 40.20 | 0.03 | 0.0000 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 3.82 | 615.19 | 0.4628 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 100.04 | 23.34 | 0.0176 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 100.04 | 610.76 | 0.4595 |
| 1.A.3.c Transport - Railways | $CO_2$ | 5.21 | 14.28 | 0.0107 |
| 1.A.3.c Transport - Railways | $CH_4$ | 100.12 | 0.38 | 0.0003 |
| 1.A.3.c Transport - Railways | $N_2O$ | 100.12 | 31.53 | 0.0237 |
| 1.A.3.d Transport - Navigation | $CO_2$ | 5.22 | 0.50 | 0.0004 |
| 1.A.3.d Transport - Navigation | $CH_4$ | 50.25 | 0.01 | 0.0000 |
| 1.A.3.d Transport - Navigation | $N_2O$ | 90.14 | 0.07 | 0.0001 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 5.00 | 4.19 | 0.0031 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 50.16 | 0.02 | 0.0000 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 60.13 | 0.03 | 0.0000 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 7.62 | 5.42 | 0.0041 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 50.49 | 0.18 | 0.0001 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 60.41 | 1.84 | 0.0014 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 7.62 | 19.83 | 0.0149 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 50.49 | 0.25 | 0.0002 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 60.41 | 4.06 | 0.0031 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 25.32 | 49.83 | 0.0375 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 13.60 | 425.70 | 0.3202 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 64.03 | 3.15 | 0.0024 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 75.33 | 0.04 | 0.0000 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 75.33 | 471.15 | 0.3544 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 75.33 | 0.02 | 0.0000 |
| 2.A.1 Cement Production | $CO_2$ | 2.83 | 41.92 | 0.0315 |
| 2.A.2 Lime Production | $CO_2$ | 2.83 | 17.79 | 0.0134 |
| 2.A.3 Glass Production | $CO_2$ | 11.18 | 12.51 | 0.0094 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 11.18 | 35.83 | 0.0270 |
| 2.B.1 Ammonia Production | $CO_2$ | 8.60 | 59.27 | 0.0446 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 15.52 | 39.68 | 0.0299 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 40.31 | 30.03 | 0.0226 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 40.31 | 435.73 | 0.3278 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 40.31 | 21.45 | 0.0161 |
| 2.B.10 Other | $CO_2$ | 3.91 | 8.57 | 0.0064 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 12.21 | 793.28 | 0.5968 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 30.81 | 3.11 | 0.0023 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 25.50 | 14.46 | 0.0109 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 25.50 | 128.17 | 0.0964 |
| 2.C.5 Lead Production | $CH_4$ | 50.99 | 12.29 | 0.0092 |

| Uncertainty of Emissions | | | | |
|---|---|---|---|---|
| **IPCC Source Category** | **Gas** | **Combined uncertainty** | **Uncertain amount** | **Combined uncertainty as% of total national emissions in year t** |
| 2.C.6 Zinc Production | $CO_2$ | 50.99 | 0.15 | 0.0001 |
| 2.D.1 Lubricant Use | $CO_2$ | 50.25 | 46.51 | 0.0350 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 50.25 | 3.55 | 0.0027 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 7.07 | 1.20 | 0.0009 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $CO_2$ | 21.21 | 3.65 | 0.0027 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $SF_6$ | 21.21 | 0.50 | 0.0004 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | $NF_3$ | 43.57 | 1218.50 | 0.9166 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 43.57 | 2.12 | 0.0016 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 43.57 | 1.15 | 0.0009 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 43.57 | 0.00 | 0.0000 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 43.57 | 9.10 | 0.0068 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 43.57 | 0.01 | 0.0000 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 43.57 | 3.53 | 0.0027 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 43.57 | 0.00 | 0.0000 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 43.57 | 0.81 | 0.0006 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 43.57 | 0.00 | 0.0000 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | PFC | 15.81 | 11.95 | 0.0090 |
| 2.G.2 $SF_6$ and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 22.36 | 0.73 | 0.0005 |
| 2.G.3 $N_2O$ from product uses | $SF_6$ | 40.31 | 90.10 | 0.0678 |
| 3.A Enteric Fermentation | $N_2O$ | 20.62 | 580.80 | 0.4369 |
| 3.B Manure Management | $CH_4$ | 30.41 | 233.64 | 0.1758 |
| 3.B Manure Management | $CH_4$ | 30.41 | 399.04 | 0.3002 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 52.20 | 1251.50 | 0.9415 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 53.85 | 422.69 | 0.3180 |
| 3.G Liming | $N_2O$ | 53.85 | 80.93 | 0.0609 |
| 3.H Urea application | $CO_2$ | 53.85 | 30.71 | 0.0231 |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | 18.41 | -1271.82 | -0.9568 |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | 50.00 | 36.65 | 0.0276 |
| 4.A.1 Forest Land remaining Forest Land | $CH_4$ | 50.00 | 3.00 | 0.0023 |
| 4.A.2 Land converted to Forest Land | $N_2O$ | 28.97 | -139.68 | -0.1051 |
| 4.B.1 Cropland remaining Cropland | $CO_2$ | 52.31 | -39.76 | -0.0299 |
| 4.B.2 Land converted to Cropland | $CO_2$ | 38.10 | 33.57 | 0.0253 |
| 4.B.2. Land converted to Cropland | $CO_2$ | 250.00 | 0.00 | 0.0000 |
| 4.C.1 Grassland remaining Grassland | $N_2O$ | 16.94 | -46.41 | -0.0349 |
| 4.C.2 Land converted to Grassland | $CO_2$ | 19.69 | -58.13 | -0.0437 |
| 4.D.2. Land converted to Wetlands | $CO_2$ | 65.90 | 17.64 | 0.0133 |
| 4.E.2 Land converted to Settlements | $CO_2$ | 101.47 | 129.48 | 0.0974 |
| 4.F.2 Land converted to Other Land | $CO_2$ | 101.47 | 8.67 | 0.0065 |
| 4.G Harvested wood products | $CO_2$ | 62.00 | -58.36 | -0.0439 |
| 5.A Solid Waste Disposal on Land | $CO_2$ | 50.00 | 1665.39 | 1.2528 |
| 5.B Biological treatment of solid waste | $CH_4$ | 22.36 | 138.14 | 0.1039 |
| 5.B Biological treatment of solid waste | $CH_4$ | 20.01 | 7.30 | 0.0055 |
| 5.C Incineration and open burning of waste | $N_2O$ | 20.62 | 27.16 | 0.0204 |
| 5.C Incineration and open burning of waste | $CO_2$ | 53.85 | 0.00 | 0.0000 |
| 5.C Incineration and open burning of waste | $CH_4$ | 72.80 | 1.74 | 0.0013 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 54.23 | 396.45 | 0.2982 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 56.36 | 114.97 | 0.0865 |
| 1.A.3 Transport - Biomass | $N_2O$ | 50.64 | 0.32 | 0.0002 |
| 1.A.3 Transport - Biomass | $CH_4$ | 60.53 | 1.44 | 0.0011 |
| | | | | |
| | | **Level uncertainty =** | **14789.24** | **3.36** |

**Tab. A2 - 3 Uncertainty analysis (Tier 1), third part of Table 3.3 of IPCC 2006 Gl. incl. LULUCF**

| Uncertainty of Trend | | | | | | |
|---|---|---|---|---|---|---|
| **IPCC Source Category** | **Gas** | **Type A sensitivity** | **Type B sensitivity** | **Uncertainty in trend in national emissions introduced by EF uncertainty** | **Uncertainty in trend in national emissions introduced by AD uncertainty** | **Uncertainty introduced into the trend in total national emissions** |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 0.0012 | 0.0021 | 0.0607 | 0.0241 | 0.0653 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 0.0004 | 0.0006 | 0.0227 | 0.0066 | 0.0236 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 0.0312 | 0.0699 | 0.0781 | 0.2968 | 0.3069 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 0.0000 | 0.0001 | 0.0023 | 0.0004 | 0.0023 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 0.0000 | 0.0000 | 0.0010 | 0.0002 | 0.0010 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 0.0207 | 0.0975 | 0.0621 | 0.6894 | 0.6921 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | -0.0001 | 0.0001 | -0.0046 | 0.0008 | 0.0047 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 0.0025 | 0.0034 | 0.1516 | 0.0243 | 0.1535 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 0.0015 | 0.0015 | 0.0231 | 0.0217 | 0.0317 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 0.0000 | 0.0000 | 0.0002 | 0.0001 | 0.0002 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 0.0000 | 0.0000 | 0.0004 | 0.0001 | 0.0004 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 0.0010 | 0.0011 | 0.0209 | 0.0319 | 0.0381 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 0.0000 | 0.0000 | 0.0004 | 0.0003 | 0.0005 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 0.0000 | 0.0000 | 0.0009 | 0.0004 | 0.0010 |
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | -0.0988 | 0.2835 | -0.2965 | 1.6038 | 1.6310 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | -0.0032 | 0.0009 | -0.1620 | 0.0054 | 0.1621 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | -0.0004 | 0.0012 | -0.0243 | 0.0065 | 0.0252 |
| 1.A.3.a Transport - Civil Aviation | $CO_2$ | -0.0004 | 0.0000 | -0.0017 | 0.0002 | 0.0017 |
| 1.A.3.a Transport - Civil Aviation | $CH_4$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.A.3.a Transport - Civil Aviation | $N_2O$ | 0.0000 | 0.0000 | -0.0002 | 0.0000 | 0.0002 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 0.0608 | 0.0822 | 0.1435 | 0.3486 | 0.3770 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 0.0000 | 0.0001 | -0.0011 | 0.0005 | 0.0012 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 0.0026 | 0.0031 | 0.2640 | 0.0132 | 0.2643 |
| 1.A.3.c Transport - Railways | $CO_2$ | -0.0009 | 0.0014 | -0.0013 | 0.0099 | 0.0100 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0.0000 | 0.0000 | -0.0001 | 0.0000 | 0.0001 |
| 1.A.3.c Transport - Railways | $N_2O$ | -0.0001 | 0.0002 | -0.0099 | 0.0011 | 0.0100 |
| 1.A.3.d Transport - Navigation | $CO_2$ | -0.0001 | 0.0000 | -0.0002 | 0.0003 | 0.0004 |
| 1.A.3.d Transport - Navigation | $CH_4$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.A.3.d Transport - Navigation | $N_2O$ | 0.0000 | 0.0000 | -0.0001 | 0.0000 | 0.0001 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 0.0004 | 0.0004 | 0.0012 | 0.0024 | 0.0027 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 0.0004 | 0.0004 | 0.0011 | 0.0036 | 0.0038 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0001 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 0.0000 | 0.0000 | 0.0009 | 0.0002 | 0.0009 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 0.0013 | 0.0013 | 0.0040 | 0.0131 | 0.0137 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0001 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 0.0000 | 0.0000 | 0.0021 | 0.0003 | 0.0021 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | -0.0006 | 0.0010 | -0.0143 | 0.0057 | 0.0154 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | -0.0155 | 0.0160 | -0.2021 | 0.0903 | 0.2213 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 0.0000 | 0.0000 | 0.0011 | 0.0014 | 0.0018 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 0.0000 | 0.0000 | -0.0006 | 0.0000 | 0.0006 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | -0.0005 | 0.0032 | -0.0407 | 0.0316 | 0.0515 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.A.1 Cement Production | $CO_2$ | -0.0010 | 0.0076 | -0.0021 | 0.0214 | 0.0215 |
| 2.A.2 Lime Production | $CO_2$ | -0.0014 | 0.0032 | -0.0028 | 0.0091 | 0.0095 |
| 2.A.3 Glass Production | $CO_2$ | 0.0001 | 0.0006 | 0.0014 | 0.0040 | 0.0043 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 0.0013 | 0.0016 | 0.0126 | 0.0116 | 0.0171 |
| 2.B.1 Ammonia Production | $CO_2$ | 0.0001 | 0.0035 | 0.0006 | 0.0248 | 0.0248 |
| 2.B.2 Nitric Acid Production | $N_2O$ | -0.0023 | 0.0013 | -0.0349 | 0.0074 | 0.0357 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 0.0001 | 0.0004 | 0.0049 | 0.0027 | 0.0056 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 0.0028 | 0.0055 | 0.1109 | 0.0390 | 0.1176 |

| Uncertainty of Trend | | | | | | |
|---|---|---|---|---|---|---|
| **IPCC Source Category** | **Gas** | **Type A sensitivity** | **Type B sensitivity** | **Uncertainty in trend in national emissions introduced by EF uncertainty** | **Uncertainty in trend in national emissions introduced by AD uncertainty** | **Uncertainty introduced into the trend in total national emissions** |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 0.0001 | 0.0003 | 0.0059 | 0.0019 | 0.0062 |
| 2.B.10 Other | $CO_2$ | 0.0011 | 0.0011 | 0.0028 | 0.0047 | 0.0055 |
| 2.C.1 Iron and Steel Production | $CH_4$ | -0.0002 | 0.0331 | -0.0018 | 0.3280 | 0.3280 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 0.0000 | 0.0001 | 0.0000 | 0.0005 | 0.0005 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 0.0003 | 0.0003 | 0.0072 | 0.0020 | 0.0075 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0.0026 | 0.0026 | 0.0641 | 0.0181 | 0.0666 |
| 2.C.5 Lead Production | $CH_4$ | 0.0001 | 0.0001 | 0.0043 | 0.0017 | 0.0047 |
| 2.C.6 Zinc Production | $CO_2$ | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0001 |
| 2.D.1 Lubricant Use | $CO_2$ | 0.0001 | 0.0005 | 0.0035 | 0.0033 | 0.0049 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0003 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 0.0001 | 0.0001 | 0.0004 | 0.0006 | 0.0008 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $CO_2$ | 0.0001 | 0.0001 | 0.0013 | 0.0019 | 0.0023 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $SF_6$ | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0003 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | $NF_3$ | 0.0143 | 0.0143 | 0.3280 | 0.7461 | 0.8150 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 0.0000 | 0.0000 | 0.0006 | 0.0013 | 0.0014 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0.0000 | 0.0000 | 0.0003 | 0.0007 | 0.0008 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0.0001 | 0.0001 | 0.0024 | 0.0056 | 0.0061 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0.0000 | 0.0000 | 0.0010 | 0.0022 | 0.0024 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0.0000 | 0.0000 | 0.0002 | 0.0005 | 0.0005 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | PFC | 0.0001 | 0.0004 | 0.0014 | 0.0027 | 0.0030 |
| 2.G.2 $SF_6$ and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 0.0000 | 0.0000 | 0.0003 | 0.0002 | 0.0004 |
| 2.G.3 $N_2O$ from product uses | $SF_6$ | 0.0004 | 0.0011 | 0.0171 | 0.0081 | 0.0189 |
| 3.A Enteric Fermentation | $N_2O$ | -0.0055 | 0.0144 | -0.1104 | 0.1016 | 0.1500 |
| 3.B Manure Management | $CH_4$ | -0.0022 | 0.0039 | -0.0662 | 0.0277 | 0.0718 |
| 3.B Manure Management | $CH_4$ | -0.0047 | 0.0067 | -0.1424 | 0.0473 | 0.1500 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | -0.0016 | 0.0122 | -0.0785 | 0.2593 | 0.2709 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | -0.0012 | 0.0040 | -0.0592 | 0.1132 | 0.1277 |
| 3.G Liming | $N_2O$ | -0.0033 | 0.0008 | -0.1652 | 0.0217 | 0.1666 |
| 3.H Urea application | $CO_2$ | -0.0001 | 0.0003 | -0.0042 | 0.0082 | 0.0092 |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | -0.0192 | -0.0352 | -0.3530 | 0.0000 | 0.3530 |
| 4.A.1 Forest Land remaining Forest Land | $CO_2$ | 0.0000 | 0.0004 | -0.0016 | 0.0000 | 0.0016 |
| 4.A.1 Forest Land remaining Forest Land | $CH_4$ | 0.0000 | 0.0000 | -0.0001 | 0.0000 | 0.0001 |
| 4.A.2 Land converted to Forest Land | $N_2O$ | -0.0013 | -0.0025 | -0.0391 | 0.0000 | 0.0391 |
| 4.B.1 Cropland remaining Cropland | $CO_2$ | -0.0004 | -0.0004 | -0.0199 | 0.0000 | 0.0199 |
| 4.B.2 Land converted to Cropland | $CO_2$ | 0.0001 | 0.0004 | 0.0021 | 0.0000 | 0.0021 |
| 4.B.2. Land converted to Cropland | $CO_2$ | 0.0000 | 0.0000 | -0.0077 | 0.0000 | 0.0077 |
| 4.C.1 Grassland remaining Grassland | $N_2O$ | -0.0014 | -0.0014 | -0.0237 | 0.0000 | 0.0237 |
| 4.C.2 Land converted to Grassland | $CO_2$ | -0.0010 | -0.0015 | -0.0197 | 0.0000 | 0.0197 |
| 4.D.2. Land converted to Wetlands | $CO_2$ | 0.0001 | 0.0001 | 0.0041 | 0.0000 | 0.0041 |
| 4.E.2 Land converted to Settlements | $CO_2$ | 0.0004 | 0.0007 | 0.0362 | 0.0000 | 0.0362 |
| 4.F.2 Land converted to Other Land | $CO_2$ | 0.0000 | 0.0000 | 0.0044 | 0.0000 | 0.0044 |
| 4.G Harvested wood products | $CO_2$ | 0.0054 | -0.0005 | 0.3372 | 0.0000 | 0.3372 |
| 5.A Solid Waste Disposal on Land | $CO_2$ | 0.0101 | 0.0170 | 0.4057 | 0.7205 | 0.8268 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0.0031 | 0.0031 | 0.0315 | 0.0891 | 0.0945 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0.0002 | 0.0002 | 0.0001 | 0.0053 | 0.0053 |
| 5.C Incineration and open burning of waste | $N_2O$ | 0.0006 | 0.0007 | 0.0030 | 0.0190 | 0.0192 |
| 5.C Incineration and open burning of waste | $CO_2$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0.0000 | 0.0000 | 0.0008 | 0.0003 | 0.0008 |
| 5.D Wastewater treatment and discharge | $N_2O$ | -0.0002 | 0.0037 | -0.0103 | 0.1107 | 0.1112 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 0.0002 | 0.0010 | 0.0115 | 0.0382 | 0.0399 |
| 1.A.3 Transport - Biomass | $N_2O$ | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0002 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0.0000 | 0.0000 | 0.0007 | 0.0001 | 0.0007 |
| | | | | | **Trend** | **2.34** |

**Tab. A2 - 4 Uncertainty analysis (Tier 1), first part of Table 3.3 of IPCC 2006 Gl. excl. LULUCF**

| Input DATA | | | | | |
|---|---|---|---|---|---|
| **IPCC Source Category** | **Gas** | **Base year emissions (1990) abs** | **Year t emissions (2015) abs** | **Activity data uncertainty** | **Emission factor uncertainty** |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 335.00 | 599.44 | 8 | 50 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 68.58 | 146.44 | 8 | 60 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 11201.04 | 14417.54 | 3 | 3 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 12.79 | 15.11 | 3 | 50 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 6.12 | 6.44 | 3 | 60 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 15193.50 | 2693.43 | 5 | 3 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 21.58 | 0.18 | 5 | 50 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 48.67 | 140.54 | 5 | 60 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 0.00 | 387.19 | 10 | 15 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 0.00 | 3.44 | 10 | 50 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 0.00 | 5.47 | 10 | 60 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 24.04 | 218.43 | 20 | 20 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 0.20 | 1.79 | 20 | 50 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 0.31 | 2.84 | 20 | 70 |
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 110822.55 | 56332.49 | 4 | 3 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 1212.44 | 248.99 | 4 | 50 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 482.97 | 246.32 | 4 | 60 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 139.44 | 10.23 | 4 | 4 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0.02 | 0.00 | 4 | 79 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 1.19 | 0.09 | 4 | 110 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 6176.54 | 16985.57 | 3 | 2 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 37.50 | 25.29 | 3 | 303 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 136.73 | 347.53 | 3 | 141 |
| 1.A.3.c Transport - Railways | $CO_2$ | 653.86 | 264.11 | 5 | 2 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0.92 | 0.37 | 5 | 158 |
| 1.A.3.c Transport - Railways | $N_2O$ | 75.21 | 30.38 | 5 | 137 |
| 1.A.3.d Transport - Domestic Navigation | $CO_2$ | 56.61 | 12.73 | 5 | 2 |
| 1.A.3.d Transport - Domestic Navigation | $CH_4$ | 0.13 | 0.03 | 5 | 158 |
| 1.A.3.d Transport - Domestic Navigation | $N_2O$ | 0.46 | 0.10 | 5 | 137 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 5.42 | 71.04 | 4 | 3 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0.00 | 0.04 | 4 | 50 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0.00 | 0.04 | 4 | 60 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 0.00 | 99.07 | 7 | 3 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0.00 | 0.50 | 7 | 50 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 0.00 | 4.24 | 7 | 60 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 0.00 | 269.78 | 7 | 3 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0.00 | 0.51 | 7 | 50 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 0.00 | 6.72 | 7 | 60 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 456.24 | 188.53 | 4 | 25 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 10322.40 | 3581.30 | 4 | 13 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 0.75 | 4.50 | 40 | 50 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 2.20 | 5.39 | 7 | 75 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 1079.91 | 608.01 | 7 | 75 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0.01 | 0.02 | 7 | 75 |
| 2.A.1 Cement Production | $CO_2$ | 2489.18 | 1549.54 | 2 | 2 |
| 2.A.2 Lime Production | $CO_2$ | 1336.65 | 609.75 | 2 | 2 |
| 2.A.3 Glass Production | $CO_2$ | 123.66 | 125.47 | 5 | 10 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 109.15 | 249.15 | 5 | 10 |
| 2.B.1 Ammonia Production | $CO_2$ | 990.80 | 741.66 | 5 | 7 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 1050.29 | 280.12 | 4 | 15 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 74.50 | 74.50 | 5 | 40 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 792.47 | 715.16 | 5 | 40 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 36.17 | 36.81 | 5 | 40 |
| 2.B.10 Other | $CO_2$ | 0.00 | 222.81 | 3 | 3 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 9642.54 | 6872.80 | 7 | 10 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 14.84 | 9.72 | 7 | 30 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0.03 | 0.53 | 5 | 25 |

| | | | | | |
|---|---|---|---|---|---|
| 2.C.2 Ferroalloys Production | $CH_4$ | 0.18 | 3.67 | 5 | 25 |
| 2.C.5 Lead Production | $CO_2$ | 4.04 | 8.81 | 10 | 50 |
| 2.C.6 Zinc Production | $CO_2$ | 0.00 | 0.41 | 10 | 50 |
| 2.D.1 Lubricant Use | $CO_2$ | 116.13 | 115.54 | 5 | 50 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 9.43 | 5.89 | 5 | 50 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 0.00 | 18.11 | 5 | 5 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $SF_6$ | 0.00 | 16.25 | 15 | 15 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $NF_3$ | 0.00 | 2.29 | 15 | 15 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 0.00 | 3422.33 | 37 | 23 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 0.00 | 1.49 | 37 | 23 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 0.00 | 2.57 | 37 | 23 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 37 | 23 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 0.00 | 22.73 | 37 | 23 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0.00 | 0.03 | 37 | 23 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 0.00 | 6.66 | 37 | 23 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 37 | 23 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0.00 | 0.78 | 37 | 23 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0.00 | 0.00 | 37 | 23 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 84.10 | 71.08 | 5 | 15 |
| 2.G.2 $SF_6$ and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 0.00 | 3.22 | 10 | 20 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 206.22 | 223.50 | 5 | 40 |
| 3.A Enteric Fermentation | $CH_4$ | 5754.89 | 2895.96 | 5 | 20 |
| 3.B Manure Management | $CH_4$ | 1752.07 | 771.47 | 5 | 30 |
| 3.B Manure Management | $N_2O$ | 2459.33 | 1007.81 | 5 | 30 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 4210.37 | 2569.13 | 15 | 50 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 1586.96 | 888.63 | 20 | 50 |
| 3.G Liming | $CO_2$ | 1177.82 | 162.89 | 20 | 50 |
| 3.H Urea application | $CO_2$ | 108.53 | 187.10 | 20 | 50 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 1979.27 | 3385.21 | 30 | 40 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0.00 | 633.99 | 5 | 91 |
| 5.B Biological treatment of solid waste | $N_2O$ | 0.00 | 44.59 | 5 | 1 |
| 5.C Incineration and open burning of waste | $CO_2$ | 23.15 | 132.43 | 15 | 5 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0.00 | 0.00 | 20 | 80 |
| 5.C Incineration and open burning of waste | $N_2O$ | 0.42 | 2.40 | 20 | 70 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 889.80 | 860.56 | 30 | 50 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 234.18 | 197.23 | 26 | 50 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0.00 | 0.59 | 8 | 50 |
| 1.A.3 Transport - Biomass | $N_2O$ | 0.00 | 2.22 | 8 | 60 |
| | | | | | |
| | **Total** | **195832.51** | **127135.00** | | |

**Tab. A2 - 5 Uncertainty analysis (Tier 1), second part of Table 3.3 of IPCC 2006 Gl. excl. LULUCF**

| | | Uncertainty of Emissions | | |
|---|---|---|---|---|
| **IPCC Source Category** | **Gas** | **Combined uncertainty** | **Uncertain ammount** | **Combined uncertainty as % of total national emissions in year t** |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 50.64 | 303.53 | 0.2387 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 60.53 | 88.64 | 0.0697 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 3.91 | 563.02 | 0.4429 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 50.09 | 7.57 | 0.0060 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 60.07 | 3.87 | 0.0030 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | 5.83 | 157.05 | 0.1235 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | 50.25 | 0.09 | 0.0001 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 60.21 | 84.62 | 0.0666 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 18.03 | 69.80 | 0.0549 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 50.99 | 1.76 | 0.0014 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 60.83 | 3.33 | 0.0026 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 28.28 | 61.78 | 0.0486 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 53.85 | 0.96 | 0.0008 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 72.80 | 2.07 | 0.0016 |
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | 5.00 | 2816.62 | 2.2155 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | 50.16 | 124.89 | 0.0982 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | 60.13 | 148.12 | 0.1165 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | 5.54 | 0.57 | 0.0004 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 78.60 | 0.00 | 0.0000 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 110.07 | 0.10 | 0.0001 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 3.72 | 631.48 | 0.4967 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 302.58 | 76.52 | 0.0602 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 140.54 | 488.43 | 0.3842 |
| 1.A.3.c Transport - Railways | $CO_2$ | 5.22 | 13.79 | 0.0108 |
| 1.A.3.c Transport - Railways | $CH_4$ | 157.58 | 0.58 | 0.0005 |
| 1.A.3.c Transport - Railways | $N_2O$ | 137.29 | 41.71 | 0.0328 |
| 1.A.3.d Transport - Domestic Navigation | $CO_2$ | 5.22 | 0.66 | 0.0005 |
| 1.A.3.d Transport - Domestic Navigation | $CH_4$ | 157.58 | 0.05 | 0.0000 |
| 1.A.3.d Transport - Domestic Navigation | $N_2O$ | 137.29 | 0.14 | 0.0001 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 5.00 | 3.55 | 0.0028 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 50.16 | 0.02 | 0.0000 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 60.13 | 0.03 | 0.0000 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 7.62 | 7.54 | 0.0059 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 50.49 | 0.25 | 0.0002 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 60.41 | 2.56 | 0.0020 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 7.62 | 20.55 | 0.0162 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 50.49 | 0.26 | 0.0002 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 60.41 | 4.06 | 0.0032 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | 25.32 | 47.73 | 0.0375 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | 13.60 | 487.11 | 0.3831 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 64.03 | 2.88 | 0.0023 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 75.33 | 4.06 | 0.0032 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | 75.33 | 457.99 | 0.3602 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 75.33 | 0.02 | 0.0000 |
| 2.A.1 Cement Production | $CO_2$ | 2.83 | 43.83 | 0.0345 |
| 2.A.2 Lime Production | $CO_2$ | 2.83 | 17.25 | 0.0136 |
| 2.A.3 Glass Production | $CO_2$ | 11.18 | 14.03 | 0.0110 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 11.18 | 27.86 | 0.0219 |
| 2.B.1 Ammonia Production | $CO_2$ | 8.60 | 63.80 | 0.0502 |
| 2.B.2 Nitric Acid Production | $N_2O$ | 15.52 | 43.49 | 0.0342 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 40.31 | 30.03 | 0.0236 |
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 40.31 | 288.29 | 0.2268 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 40.31 | 14.84 | 0.0117 |
| 2.B.10 Other | $CO_2$ | 3.91 | 8.70 | 0.0068 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 12.21 | 838.93 | 0.6599 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 30.81 | 3.00 | 0.0024 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 25.50 | 0.14 | 0.0001 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 25.50 | 0.94 | 0.0007 |
| 2.C.5 Lead Production | $CO_2$ | 50.99 | 4.49 | 0.0035 |

| | | | | |
|---|---|---|---|---|
| 2.C.6 Zinc Production | $CO_2$ | 50.99 | 0.21 | 0.0002 |
| 2.D.1 Lubricant Use | $CO_2$ | 50.25 | 58.06 | 0.0457 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 50.25 | 2.96 | 0.0023 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 7.07 | 1.28 | 0.0010 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $SF_6$ | 21.21 | 3.45 | 0.0027 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $NF_3$ | 21.21 | 0.49 | 0.0004 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 43.57 | 1490.97 | 1.1727 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 43.57 | 0.65 | 0.0005 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 43.57 | 1.12 | 0.0009 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 43.57 | 0.00 | 0.0000 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 43.57 | 9.90 | 0.0078 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 43.57 | 0.01 | 0.0000 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 43.57 | 2.90 | 0.0023 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 43.57 | 0.00 | 0.0000 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 43.57 | 0.34 | 0.0003 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 43.57 | 0.00 | 0.0000 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 15.81 | 11.24 | 0.0088 |
| 2.G.2 $SF_6$ and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 22.36 | 0.72 | 0.0006 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 40.31 | 90.10 | 0.0709 |
| 3.A Enteric Fermentation | $CH_4$ | 20.62 | 597.02 | 0.4696 |
| 3.B Manure Management | $CH_4$ | 30.41 | 234.63 | 0.1846 |
| 3.B Manure Management | $N_2O$ | 30.41 | 306.51 | 0.2411 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | 52.20 | 1341.13 | 1.0549 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | 53.85 | 478.54 | 0.3764 |
| 3.G Liming | $CO_2$ | 53.85 | 87.72 | 0.0690 |
| 3.H Urea application | $CO_2$ | 53.85 | 100.76 | 0.0793 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 50.00 | 1692.60 | 1.3313 |
| 5.B Biological treatment of solid waste | $CH_4$ | 91.29 | 578.75 | 0.4552 |
| 5.B Biological treatment of solid waste | $N_2O$ | 5.04 | 2.25 | 0.0018 |
| 5.C Incineration and open burning of waste | $CO_2$ | 15.81 | 20.94 | 0.0165 |
| 5.C Incineration and open burning of waste | $CH_4$ | 82.46 | 0.00 | 0.0000 |
| 5.C Incineration and open burning of waste | $N_2O$ | 72.80 | 1.75 | 0.0014 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 58.38 | 502.42 | 0.3952 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 56.36 | 111.15 | 0.0874 |
| 1.A.3 Transport - Biomass | $CH_4$ | 50.64 | 0.30 | 0.0002 |
| 1.A.3 Transport - Biomass | $N_2O$ | 60.53 | 1.34 | 0.0011 |
| | | | | 12.4753 |
| | | **Level uncertainty =** | **15860.53** | **3.39** |

**Tab. A2 - 6 Uncertainty analysis (Tier 1), third part of Table 3.3 of IPCC 2006 Gl. excl. LULUCF**

| | | Uncertainty of Trend | | | | |
|---|---|---|---|---|---|---|
| **IPCC Source Category** | **Gas** | **Type A sensitivity** | **Type B sensitivity** | **Uncertainty in trend in national emissions introduced by EF uncertainty** | **Uncertainty in trend in national emissions introduced by AD uncertainty** | **Uncertainty introduced into the trend in total national emissions** |
| 1.A Stationary Combustion - Biomass | $CH_4$ | 0.0020 | 0.0031 | 0.0975 | 0.0346 | 0.1035 |
| 1.A Stationary Combustion - Biomass | $N_2O$ | 0.0005 | 0.0007 | 0.0312 | 0.0085 | 0.0324 |
| 1.A Stationary Combustion - Gaseous Fuels | $CO_2$ | 0.0365 | 0.0736 | 0.0912 | 0.3124 | 0.3254 |
| 1.A Stationary Combustion - Gaseous Fuels | $CH_4$ | 0.0000 | 0.0001 | 0.0017 | 0.0003 | 0.0018 |
| 1.A Stationary Combustion - Gaseous Fuels | $N_2O$ | 0.0000 | 0.0000 | 0.0008 | 0.0001 | 0.0008 |
| 1.A Stationary Combustion - Liquid Fuels | $CO_2$ | -0.0366 | 0.0138 | -0.1098 | 0.0973 | 0.1466 |
| 1.A Stationary Combustion - Liquid Fuels | $CH_4$ | -0.0001 | 0.0000 | -0.0035 | 0.0000 | 0.0035 |
| 1.A Stationary Combustion - Liquid Fuels | $N_2O$ | 0.0006 | 0.0007 | 0.0334 | 0.0051 | 0.0338 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CO_2$ | 0.0020 | 0.0020 | 0.0297 | 0.0280 | 0.0408 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $CH_4$ | 0.0000 | 0.0000 | 0.0009 | 0.0002 | 0.0009 |
| 1.A Stationary Combustion - Other fuels - 1A2 | $N_2O$ | 0.0000 | 0.0000 | 0.0017 | 0.0004 | 0.0017 |
| 1.A Stationary Combustion - Other fuels - MSW | $CO_2$ | 0.0010 | 0.0011 | 0.0207 | 0.0315 | 0.0377 |
| 1.A Stationary Combustion - Other fuels - MSW | $CH_4$ | 0.0000 | 0.0000 | 0.0004 | 0.0003 | 0.0005 |
| 1.A Stationary Combustion - Other fuels - MSW | $N_2O$ | 0.0000 | 0.0000 | 0.0009 | 0.0004 | 0.0010 |
| 1.A Stationary Combustion - Solid Fuels | $CO_2$ | -0.0793 | 0.2877 | -0.2378 | 1.6272 | 1.6445 |
| 1.A Stationary Combustion - Solid Fuels | $CH_4$ | -0.0027 | 0.0013 | -0.1374 | 0.0072 | 0.1376 |
| 1.A Stationary Combustion - Solid Fuels | $N_2O$ | -0.0003 | 0.0013 | -0.0206 | 0.0071 | 0.0218 |
| 1.A.3.a Transport - Domestic Aviation | $CO_2$ | -0.0004 | 0.0001 | -0.0016 | 0.0003 | 0.0016 |
| 1.A.3.a Transport - Domestic Aviation | $CH_4$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.A.3.a Transport - Domestic Aviation | $N_2O$ | 0.0000 | 0.0000 | -0.0004 | 0.0000 | 0.0004 |
| 1.A.3.b Transport - Road Transportation | $CO_2$ | 0.0662 | 0.0867 | 0.1454 | 0.3680 | 0.3957 |
| 1.A.3.b Transport - Road Transportation | $CH_4$ | 0.0000 | 0.0001 | 0.0015 | 0.0005 | 0.0016 |
| 1.A.3.b Transport - Road Transportation | $N_2O$ | 0.0013 | 0.0018 | 0.1857 | 0.0075 | 0.1858 |
| 1.A.3.c Transport - Railways | $CO_2$ | -0.0008 | 0.0013 | -0.0012 | 0.0095 | 0.0096 |
| 1.A.3.c Transport - Railways | $CH_4$ | 0.0000 | 0.0000 | -0.0002 | 0.0000 | 0.0002 |
| 1.A.3.c Transport - Railways | $N_2O$ | -0.0001 | 0.0002 | -0.0129 | 0.0011 | 0.0130 |
| 1.A.3.d Transport - Domestic Navigation | $CO_2$ | -0.0001 | 0.0001 | -0.0002 | 0.0005 | 0.0005 |
| 1.A.3.d Transport - Domestic Navigation | $CH_4$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.A.3.d Transport - Domestic Navigation | $N_2O$ | 0.0000 | 0.0000 | -0.0001 | 0.0000 | 0.0001 |
| 1.A.3.e Transport - Other Transportation | $CO_2$ | 0.0003 | 0.0004 | 0.0010 | 0.0021 | 0.0023 |
| 1.A.3.e Transport - Other Transportation | $CH_4$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.A.3.e Transport - Other Transportation | $N_2O$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.A.5.b Other mobile sources not included elsewhere | $CO_2$ | 0.0005 | 0.0005 | 0.0015 | 0.0050 | 0.0052 |
| 1.A.5.b Other mobile sources not included elsewhere | $CH_4$ | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0001 |
| 1.A.5.b Other mobile sources not included elsewhere | $N_2O$ | 0.0000 | 0.0000 | 0.0013 | 0.0002 | 0.0013 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CO_2$ | 0.0014 | 0.0014 | 0.0041 | 0.0136 | 0.0143 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $CH_4$ | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0001 |
| 1.A.5.b Mobile sources in Agriculture and Forestry | $N_2O$ | 0.0000 | 0.0000 | 0.0021 | 0.0003 | 0.0021 |
| 1.B.1.a Coal Mining and Handling | $CO_2$ | -0.0005 | 0.0010 | -0.0137 | 0.0054 | 0.0148 |
| 1.B.1.a Coal Mining and Handling | $CH_4$ | -0.0159 | 0.0183 | -0.2070 | 0.1035 | 0.2314 |
| 1.B.1.b. Solid Fuel Transformation | $CH_4$ | 0.0000 | 0.0000 | 0.0010 | 0.0013 | 0.0017 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CO_2$ | 0.0000 | 0.0000 | 0.0015 | 0.0003 | 0.0015 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $CH_4$ | -0.0005 | 0.0031 | -0.0356 | 0.0307 | 0.0471 |
| 1.B.2 Fugitive Emission from Oil, Natural Gas | $N_2O$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.A.1 Cement Production | $CO_2$ | -0.0003 | 0.0079 | -0.0007 | 0.0224 | 0.0224 |
| 2.A.2 Lime Production | $CO_2$ | -0.0013 | 0.0031 | -0.0026 | 0.0088 | 0.0092 |
| 2.A.3 Glass Production | $CO_2$ | 0.0002 | 0.0006 | 0.0023 | 0.0045 | 0.0051 |
| 2.A.4 Other process uses of carbonates | $CO_2$ | 0.0009 | 0.0013 | 0.0091 | 0.0090 | 0.0128 |
| 2.B.1 Ammonia Production | $CO_2$ | 0.0005 | 0.0038 | 0.0035 | 0.0268 | 0.0270 |
| 2.B.2 Nitric Acid Production | $N_2O$ | -0.0021 | 0.0014 | -0.0308 | 0.0081 | 0.0318 |
| 2.B.4 Caprolactam, glyoxal and glyoxylic acid production | $N_2O$ | 0.0001 | 0.0004 | 0.0053 | 0.0027 | 0.0060 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.B.8 Petrochemical and carbon black production | $CO_2$ | 0.0010 | 0.0037 | 0.0410 | 0.0258 | 0.0484 |
| 2.B.8 Petrochemical and carbon black production | $CH_4$ | 0.0001 | 0.0002 | 0.0027 | 0.0013 | 0.0030 |
| 2.B.10 Other | $CO_2$ | 0.0011 | 0.0011 | 0.0028 | 0.0048 | 0.0056 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 0.0031 | 0.0351 | 0.0313 | 0.3474 | 0.3488 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.0000 | 0.0000 | 0.0000 | 0.0005 | 0.0005 |
| 2.C.2 Ferroalloys Production | $CO_2$ | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0001 |
| 2.C.2 Ferroalloys Production | $CH_4$ | 0.0000 | 0.0000 | 0.0005 | 0.0001 | 0.0005 |
| 2.C.5 Lead Production | $CO_2$ | 0.0000 | 0.0000 | 0.0016 | 0.0006 | 0.0017 |
| 2.C.6 Zinc Production | $CO_2$ | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0001 |
| 2.D.1 Lubricant Use | $CO_2$ | 0.0002 | 0.0006 | 0.0103 | 0.0042 | 0.0111 |
| 2.D.2 Paraffin Wax Use | $CO_2$ | 0.0000 | 0.0000 | -0.0001 | 0.0002 | 0.0002 |
| 2.D.3 Urea used as catalyst | $CO_2$ | 0.0001 | 0.0001 | 0.0005 | 0.0007 | 0.0008 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $SF_6$ | 0.0001 | 0.0001 | 0.0012 | 0.0018 | 0.0022 |
| 2.E.1 Integrated circuit or semiconductor ($CO_2$ eq.) | $NF_3$ | 0.0000 | 0.0000 | 0.0002 | 0.0002 | 0.0003 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | HFC | 0.0175 | 0.0175 | 0.4019 | 0.9144 | 0.9989 |
| 2.F.1 Refrigeration and Air Conditioning Equipment ($CO_2$ eq.) | PFC | 0.0000 | 0.0000 | 0.0002 | 0.0004 | 0.0004 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | HFC | 0.0000 | 0.0000 | 0.0003 | 0.0007 | 0.0008 |
| 2.F.2 Foam Blowing ($CO_2$ eq.) | PFC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | HFC | 0.0001 | 0.0001 | 0.0027 | 0.0061 | 0.0066 |
| 2.F.3 Fire Protection ($CO_2$ eq.) | PFC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.F.4 Aerosols ($CO_2$ eq.) | HFC | 0.0000 | 0.0000 | 0.0008 | 0.0018 | 0.0019 |
| 2.F.4 Aerosols ($CO_2$ eq.) | PFC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.F.5 Solvents ($CO_2$ eq.) | HFC | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0002 |
| 2.F.5 Solvents ($CO_2$ eq.) | PFC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.G.1 Electrical Equipment ($CO_2$ eq.) | $SF_6$ | 0.0001 | 0.0004 | 0.0013 | 0.0026 | 0.0029 |
| 2.G.2 $SF_6$ and PFC from other product use ($CO_2$ eq.) | $SF_6$ | 0.0000 | 0.0000 | 0.0003 | 0.0002 | 0.0004 |
| 2.G.3 $N_2O$ from product uses | $N_2O$ | 0.0005 | 0.0011 | 0.0183 | 0.0081 | 0.0200 |
| 3.A Enteric Fermentation | $CH_4$ | -0.0043 | 0.0148 | -0.0858 | 0.1046 | 0.1352 |
| 3.B Manure Management | $CH_4$ | -0.0019 | 0.0039 | -0.0561 | 0.0279 | 0.0626 |
| 3.B Manure Management | $N_2O$ | -0.0030 | 0.0051 | -0.0902 | 0.0364 | 0.0973 |
| 3.D.1 Agricultural Soils, Direct $N_2O$ emissions | $N_2O$ | -0.0008 | 0.0131 | -0.0419 | 0.2783 | 0.2814 |
| 3.D.2 Agricultural Soils, Indirect $N_2O$ emissions | $N_2O$ | -0.0007 | 0.0045 | -0.0362 | 0.1283 | 0.1333 |
| 3.G Liming | $CO_2$ | -0.0031 | 0.0008 | -0.1536 | 0.0235 | 0.1554 |
| 3.H Urea application | $CO_2$ | 0.0006 | 0.0010 | 0.0298 | 0.0270 | 0.0402 |
| 5.A Solid Waste Disposal on Land | $CH_4$ | 0.0107 | 0.0173 | 0.4289 | 0.7334 | 0.8496 |
| 5.B Biological treatment of solid waste | $CH_4$ | 0.0032 | 0.0032 | 0.2951 | 0.0229 | 0.2960 |
| 5.B Biological treatment of solid waste | $N_2O$ | 0.0002 | 0.0002 | 0.0001 | 0.0016 | 0.0016 |
| 5.C Incineration and open burning of waste | $CO_2$ | 0.0006 | 0.0007 | 0.0030 | 0.0143 | 0.0147 |
| 5.C Incineration and open burning of waste | $CH_4$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5.C Incineration and open burning of waste | $N_2O$ | 0.0000 | 0.0000 | 0.0008 | 0.0003 | 0.0008 |
| 5.D Wastewater treatment and discharge | $CH_4$ | 0.0014 | 0.0044 | 0.0722 | 0.1873 | 0.2008 |
| 5.D Wastewater treatment and discharge | $N_2O$ | 0.0002 | 0.0010 | 0.0115 | 0.0370 | 0.0388 |
| 1.A.3 Transport - Biomass | $CH_4$ | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0002 |
| 1.A.3 Transport - Biomass | $N_2O$ | 0.0000 | 0.0000 | 0.0007 | 0.0001 | 0.0007 |
| | | | | | | |
| | | | | | **Trend uncertainty =** | **2.29** |

# Annex 3 Detailed methodological descriptions for individual sources or sink categories

## A3. 1 Updates of the country specific emission and oxidation factors for determination of $CO_2$ emissions from combustion of bituminous coal and lignite (brown coal) in the Czech Republic

### 1. Introduction

Emissions of $CO_2$, produced during the combustion of solid fuels, have in the Czech Republic a very significant contribution to the overall emissions of greenhouse gases. Emissions of $CO_2$ are according to the IPCC methodology determined as a product of the consumption of fuels, expressed as amount of energy contained in the fuels determined on the basis of net calorific value (TJ), emission factor for $CO_2$ (t $CO_2$/TJ) and oxidation factor. In the met

hodology for GHG inventory, IPCC provides default emission factors for $CO_2$, for the individual types of fuels (IPCC,1997 and 2006).

The default emission factors, tabulated in IPCC methodology were determined as middle values on the basis of many calorimetric and analytical tests of individual types of fuels. It is necessary to remember that the used data for determination of this emission factors has predominantly American origin and further comes from the 80s. For the needs of current national inventory, where the nature of the various types of fuels may be different, the default emission factors are not necessary sufficiently satisfactory.

Hence, the new versions of the IPCC methodology (IPCC, 2000 and 2006) recommends to all countries, where emissions of $CO_2$ from combustion of solid fuels is a so called key category, to check and update the emission factors of $CO_2$ for calculation of emissions of $CO_2$ on the basis of national data. In the Czech Republic, where the main part of the $CO_2$ emissions from solid fuels comes from the combustion of lignite (brown coal) and bituminous coal, it is significant to determine country specific emission factors for these two types of fuels.

The default emission factors for lignite (brown coal) and bituminous coal, provided in the older and newer version of the IPCC methodology, practically do not differ. In the recommended values for oxidation factor, however a substantial change appeared: while the older version (IPCC, 1997) reported default value of oxidation factor 0.98, new version (IPCC, 2006) provides default value of 1, which is the maximum possible and considering the solid fuels, in practice unreachable. In the IPCC methodology this change was introduced, because the authors of the new version were aware that these values are for solid fuels so geographically and technologically specific, that it could be difficult to generalize them. Default value of 1 was chosen as a conservative estimate, preventing possible underestimation of emission determination. Therefore a country, which wants to prevent possible overestimation of the emissions of $CO_2$ from combustion of solid fuels, has to determine representative country specific values of oxidation factor for individual types of solid fuels, on the basis of local data.

For determination of the country specific emission factors it is necessary to obtain data about the carbon content in given type of fuel and its net calorific value.

The factor for the carbon content (CC) is for the individual types of solid fuels defined as the ratio of weight of the carbon and the amount of energy in this fuel of the mass m

$$CC = m \cdot \frac{w_c}{m} \cdot Q_i = \frac{w_c}{Q_i} \qquad \text{(A3-1)}$$

where wc is the fraction of mass of carbon in the fuel and $Q_i$ is its net calorific value. It is important to notice, that all variables in the equation (A3-1) are related to the fuel (carbon) with its current water content in the supplied fuel, i.e. in the state, when it is determined the quantity (i.e. mass): raw - index $^r$ .

As the calorific value is expressed in MJ/kg (=TJ/kt), carbon content in% mass ($C^r$ = 100*$w_C$) and CC in t C/TJ, it is possible to rewrite the previous equation to:

$$CC\left[t\frac{C}{TJ}\right] = \frac{10 \cdot C^r[\%]}{Q_i^r\left[\frac{MJ}{kg}\right]} \qquad \text{(A3-2)}$$

The emission factor for $CO_2$ (t $CO_2$/TJ) is obtained by multiplying by the ratio of the molar weight of carbon dioxide and carbon

$$EF(CO_2) = CC \cdot 3.664 \qquad \text{(A3-3)}$$

IPCC methodology provides the following default factors for carbon content CC:

Lignite (brown coal): 27.6 (t C/TJ)

Bituminous coal: 25.8 (t C/TJ)

In the Czech national inventory these emission factors were used until 2006. On the basis of the recommendation of international expert review team (ERT) of UNFCCC, during the review conducted in February 2007, it was decided to use for lignite (brown coal) and bituminous coal factors for CC values 25.43 and 27.27 (t C/TJ), which can be found in the national study from 1999 (Fott, 1999) and are pertaining to the state of the coal in the Czech Republic in the 90s. For determination of the oxidation factor the necessary data was not available, therefore for all solid fuels was used the default value of 0.98 from 1996 Guidelines, for the whole time series from 1990 to 2012 (2006 Guidelines come into force from the current year 2013).

In the last years related to the implementation of the emission trading within EU ETS, the operators of the bigger plants combusting coal began to systematically address the laboratory determined emission factors for different types of coal, combusted in these plants according to the prescribed requirements of the European Directive 82/2003 EC including the relevant guidelines, regarding the methodology of monitoring. Some operators gradually extended this assessment also by the determination of oxidation factors, whose values depend not only on the type of coal, but also on the nature of the combustion source.

Data from the coal analysis from 1999 naturally was not so extensive. Further the coal base in the beginning of the 90s in the Czech Republic largely changed - production in less efficient mines have been gradually phased out and the in the existing mines now often is extracted on different places for example, in deeper coal layers. For these reasons, the research team of the Czech national inventory decided in the frame of its improvement plan to revise the emission factors, used until now and to determine new oxidation factors. Detailed description of the used approach, input data and discussion of the reached results, can be found in the study of authors E. Krtková, P. Fott and V. Neužil, prepared for publication in scientific journal. In the further text of this Annex clarification of the principle of the used method is reported and the reached results from the above mentioned paper are presented.

## 2. Revision and updating of nationally specific emission factors

In the last years, lignite (brown coal) is extracted mostly in the North Bohemia (Mostecko), where is the most significant brown coal area in the Czech Republic, and to a lesser extent in the West Bohemian region (Sokolovsko). Bituminous coal is currently quarried only in Ostrava-Karvina district, in the large coalfield, whose greater part is situated in the neighboring country Poland. Lignite (brown coal) is in the Czech Republic extracted from the surface mines, while bituminous coal is extracted from the underground mines.

**Overview of data sets for updating emission factors**

Set “ČEZ“

The most extensive collection of data with the results of chemical analyzes, including calorific values, gained the national inventory team from the company ČEZ, which operates most of the coal-fired power plants in CR, burning in particular energy (pulverized) lignite (brown coal). The set contains 29 samples of bituminous energy (pulverized) coal and 146 samples of lignite (brown coal), mainly energy one and to a lesser extent also sorted one - 25 samples and this is mostly from North Bohemian region, and in to a lesser extent from West Bohemian region.

Set “Dalkia”

Except from the company ČEZ, the research team received extended set of relevant coal data from the company Dalkia, which operates particularly power and heat plants, combusting mostly bituminous energy coal in the east part of the Czech Republic and with a lesser extent lignite (brown coal). The set “Dalkia” contains analyzes mostly of bituminous coal (143 samples) and 36 samples of lignite (brown coal).

Combined set of aggregated data

In order to evaluate the parameters, required for determining of country specific emission factors, the primary data was aggregated as it follows: aggregated items from the above mentioned sets (“ČEZ” and “Dalkia”) were acquired as average of calorific value and the percentage of carbon content from six to twelve analyzed samples (i.e. analysis of monthly collected samples).

Combined set was extended by 3 aggregated items (yearly average for 2012) by lignite (brown coal) from West Bohemian region (Sokolovská uhelná).

The combined set included three major operators of combustion sources in the Czech Republic and contains of 37 aggregated items altogether, from which 19 from the set “ČEZ”, 15 from set “Dalkia”, three were obtained as described in the previous paragraph. This set contains 23 aggregated items of lignite (brown coal) (from which 4 from set “Dalkia”) and 14 for bituminous coal (3 items come from the set “ČEZ”, the rest 11 items are from the set “Dalkia”). 18 aggregated items for lignite (brown coal) come from a larger North Bohemian region, 5 items of lignite (brown coal) – from smaller West Bohemian region.

The range of the net calorific value for lignite (brown coal) is, from this set, between 9.9 and 18.5 MJ/kg, while the range of the net calorific value for black coal is between (16.2 and 26.4 MJ/kg).

Set “ETS”

The set contains data from the ETS database created in CHMI, to which have been saved certified forms, filled by the operators of energy installations in the Czech Republic under the ETS. These forms, containing data for 2011, were provided to CHMI from the Ministry of Environment. For the processing there were taken into account only those installations whose annual emissions exceeded 50 kt $CO_2$ and which, in accordance with monitoring guidelines of EU, determined emission factors from the laboratory data. In this way there were processed 34 sources, combusting lignite (brown coal) and 13 – combusting bituminous coal.

The range of net calorific value for lignite (brown coal) was in this case between 10.4 and 18.8 MJ/kg, while for bituminous coal - was between 17.1 and 26.8 MJ/kg.

**The procedure for evaluating of the emission factors**

In the above mentioned article from 1999 (Fott, 1999) it was demonstrated linear correlation between the carbon content $C^r$ [%] in the coal and its calorific value $Q_i^r$ [MJ/kg].

$$C^r = a \cdot Q_i^r + b \qquad \text{(A3-4)}$$

with a correlation coefficient $r^2$ higher than 0.99. This correlation equation fits for bituminous and lignite (brown coal), therefore both types of coal can be described by one equation (i.e. a single pair of parameters a, b).

Taking into account the equation (A3-2), dependence between the carbon content CC (t C/TJ) and the calorific value $Q_i^r$ [MJ/kg] is obtained.

$$CC = 10 \cdot \left(a + \frac{b}{Q_i^r}\right) \qquad \text{(A3-5)}$$

In this way a country specific parameters a, b were evaluated in equation (A3-4), (A3-5) instead of two separate values of country specific factor for lignite (brown coal) and for bituminous coal.

This procedure was applied also on current data. For the process there were used the two most representative sets: combined set of aggregated data, hereinafter referred as “Comb” and “ETS”.

On Fig. A3 1 it can be seen, that for the combined data set “Comb” a correlation between carbon content and net calorific value can be described for both types of coal with a regression line (see equation (A3-4)) with parameters a = 2.4142 and b = 4.0291, while the correlation coefficient value $r^2$ = 0.997 is close to one.

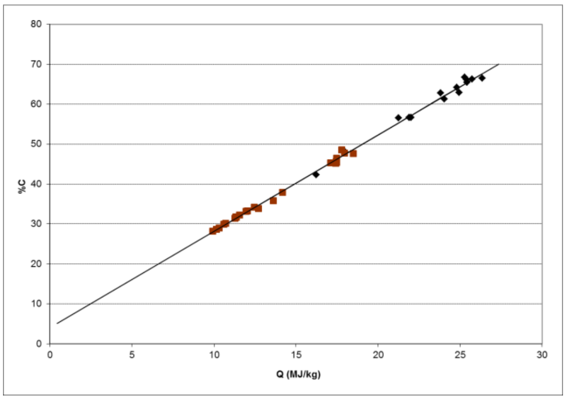



**Fig. A3 1 Combined set of aggregated data “Comb”. Correlation between carbon content (%C) and net calorific value for lignite (brown coal) (indicated with brown squares) and bituminous coal (indicated with black squares)**

In terms of the uncertainty of emission determination, it is necessary to assess the extent to which the carbon content factor values differ from the values determined by the curve (5). This is graphically illustrated on Fig. A3 2. Numerically, the difference between the individual points from the calculated curve can be characterized with the mean relative error, which is 1.14% for lignite (brown coal) and 1.30% for bituminous coal. Nevertheless, the mean relative error of any kind of coal does not exceed 3%. Therefore, the uncertainty of the carbon content factors and thus the uncertainty of $CO_2$ emission factors can be considered as acceptable.

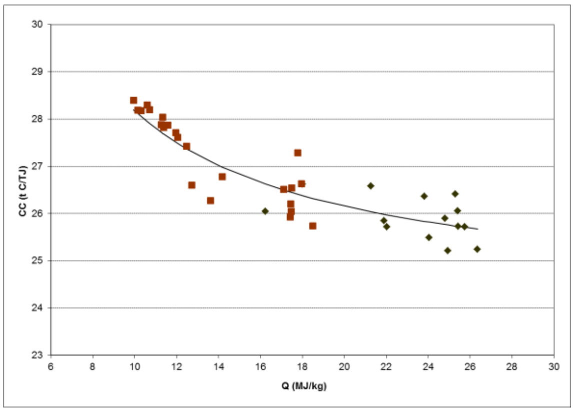



**Fig. A3 2 Combined set of aggregated data "Comb". Correlation between the factor of carbon content CC and net calorific value for brown coal (indicated as brown squares) and black coal (indicated as black squares), found through the eq. A3-5.**

In the set "ETS" values $Q_i^r$ and factors for CC were available, but the carbon content in percentages was not given. Therefore the parameters a, b were assessed with non-liner regression, using the equation (A3-5). In this way the parameters a = 2.4211 and b = 3.9539 were determined. In this case the mean relative error for lignite (brown coal) was equal to 1.59% and for bituminous coal was equal to 1.73%.

The parameters a, b, evaluated from the both sets are very similar. However, statistical indicators characterizing uncertainty are in the case of set "ETS" somewhat higher, than for the combined set.

### 3. Determination of country specific oxidation factors

**Formula for calculation of oxidation factor from analytical data**

Oxidation factor from analytical data is calculated using the following formula.

$$OF = 1 - \frac{A}{C \cdot \left(\frac{1}{C,out - 1}\right)} = 1 - \frac{A \cdot C,out}{C \cdot (1 - C,out)}$$

where OF is oxidation factor (with value somewhat lower than 1), A is the mass fraction of ash, C is the mass fraction of carbon and C,out is the mass fraction of carbon on the exit of the combustion device (the mass fractions are values in the interval between 0 and 1, e.g. 40% corresponds to mass fraction of 0.4). In case, that on the exit both forms of ash are present (slag and dry ash), C,out is calculated as weighted average of the fraction of non-combusted carbon in both forms of ash.

**Sets of data used for determination of oxidation factors and their processing**

<u>Set "ČEZ"</u>

This is the set "ČEZ", which is described above, containing 146 samples of lignite (brown coal) and 29 samples of bituminous coal. This set contains also all data occurring in the resulting equation (A3-6), used for the calculation of oxidation factor.

Results from the processed data from the set "ČEZ" are these values of oxidation factors:

OF for lignite (brown coal): 0.9857

OF for bituminous coal: 0.9696

<u>Set "Dalkia"</u>

As a matter of fact the set "Dalkia" is that described above. The set contains analysis of mostly bituminous coal (143 samples). Representative value in case of the bituminous coal from the set "Dalkia" is 0.9719.

OF for lignite (brown coal) was possible to be obtained from the set "Dalkia", using only the part of the samples, combusted at not so important combustion installations (i.e. with relatively low emissions). From these was calculated average (0.979) considered only as approximate value for comparison purposes.

<u>Set "ETS"</u>

The set contains data from the ETS database, created in CHMI (see above), into which have been saved proven forms, provided by the energy operators, falling under ETS. For processing there were taken into account only these plants (installations), whose emissions exceeded 50 kt and where the indicated oxidation factors were identified based on chemical analysis. In this way were processed 10 sources combusting bituminous coal and 18 sources, combusting lignite (brown coal). From the set "ETS" were calculated the following representative values of OF for bituminous and lignite (brown coal).

Resulting values of OF from set "ETS" are:

OF for lignite (brown coal): 0.9835

OF for bituminous coal: 0.9708

**For lignite (brown coal)** was taken as the most representative current country value for OF, the value of **OF = 0.9846** determined as average of the two average values from sets "ČEZ" and "ETS":

$$OF = \frac{0.9857 + 0.9835}{2} = 0.9846$$

**For bituminous coal** was taken as the most representative current country value for OF, the value of **OF = 0.9707** determined as average of the three average values from sets "ČEZ", "Dalkia" and "ETS":

$$OF = \frac{0.9696 + 0.9719 + 0.9708}{3} = 0.9707$$

**4. The method of determining carbon dioxide emissions, using country specific parameters**

Carbon dioxide emissions for specific category sources is determined as a product of consumed fuel, expressed as the amount of energy contained in the fuel defined on the basis of calorific value (TJ), emission factor for $CO_2$ (t $CO_2$/TJ) and oxidation factor. CzSO provides annual fuel consumption for each category of sources, both in weight units and in energy units determined using the net calorific value. The national inventory research team uses this data as an input activity data.

For determination of the $CO_2$ emission factor it is necessary to define appropriate emission and oxidation factor for individual categories and for the whole time series. Regarding the updating of the country specific emission factors, the research team decided to determine them as an average of two values: emission factor, calculated using the eq. A3-5, using the parameters **a = 2.4142** and **b = 4.0291**, determined from the combined file "Comb" and emission factor calculated using the parameters **a =2.4211** and **b = 3.9539**, calculated from the file "ETS". The reason for this decision is the very good correspondence of the relevant curves calculated from equation (A3-5) of these two representative sets.

In the case of the oxidation factors the research team decided to use till 2010 so far used oxidation factor of 0.98 and from year 2011 the newly determined country specific oxidation factor presented in section 3. The reason for this decision is the fact that the current values were determined, based on data recorded between 2011 and 2012, while the data for the previous years was not available. However, the newly established oxidation factors suggest that so far used value 0.98 corresponds better to reality than the default value of 1 pursuant to 2006 Guidelines.

**Examples of setting of $CO_2$ emission factors, 2013**

a) Lignite (brown coal)

In tab. 3-11, chapter "Energy" is provided average calorific value of 13.409 MJ/kg, CC factor is calculated as:

$$\frac{10 \cdot \left(\frac{2.4142 + 4.0291}{13.409}\right) + 10 \cdot \left(\frac{2.4211 + 3.9539}{13.409}\right)}{2} = \frac{27.147 + 27.160}{2} = 27.153 \ \frac{t\ C}{TJ}$$

To this corresponds emission factor for $CO_2$

$$27.153 \cdot 3.664 = 99.489 \ \frac{t\ CO_2}{TJ}$$

27.153 • 3.664= 99.489 t $CO_2$/TJ. Resultant emission factor for $CO_2$ including the oxidation factor has a value of.

$$99.489 \cdot 0.9846 = 97.957 \frac{t\ CO_2}{TJ}$$

b) Bituminous coal

In tab. 3-11, chapter "Energy" is provided average calorific value of 25.502 MJ/kg, CC factor is calculated as:

$$\frac{10 \cdot \left(\frac{2.4142 + 4.0291}{25.502}\right) + 10 \cdot \left(\frac{2.4211 + 3.9539}{25.502}\right)}{2} = \frac{25.722 + 25.761}{2} = 25.742 \ \frac{t\ C}{TJ}$$

To this corresponds emission factor for $CO_2$

$$25.742 \cdot 3.664 = 94.317\ \frac{t\ CO_2}{TJ}$$

Resultant emission factor for $CO_2$ including the oxidation factor has a value of

$$94.317 \cdot 0.9707 = 91.554 \frac{t\ CO_2}{TJ}$$

## A3. 2 Country specific $CO_2$ emission factor for LPG

In order to enhance the accuracy of emission estimates from Energy sector the research with aim to develop country specific emission factor for LPG was carried out last year. LPG is the mixture of propane and butane and other C2 – C5 hydrocarbons and is available in two versions – summer and winter mixture. The basic qualitative parameters are available in the official Czech Standard ČSN EN ISO 4256. These parameters are given in Tab. A3 - 1.

**Tab. A3 - 1 Qualitative parameters of LPG – summer and winter mixture**

| PARAMETER*) | summer mixture | winter mixture |
|---|---|---|
| C2-hydrocarbons and inerts -%, max. | 7 | 7 |
| C3- hydrocarbons -%, min. | 30 | 55 |
| C4- hydrocarbons -% | 30 - 60 | 15 - 40 |
| C5-and higher hydrocarbons -%, max. | 3 | 2 |
| Unsaturated hydrocarbons -%, max. | 60 | 65 |
| Hydrogen sulfide - mg.kg$^{-1}$, max. | 0.2 | 0.2 |
| Content of sulphur - mg.kg$^{-1}$, max. | 200 | 200 |

**)% in the table mean mass percents*

For the determination of country specific emission factor is necessary to obtain data about composition of LPG, which is distributed in the territory of the Czech Republic. These data were obtained from the Česká rafinérská, a.s., which is the major distributor of the LPG in the CR. The quality of distributed LPG is based on the above mentioned official standard (ČSN EN ISO 4256) and so also the data provided by Česká rafinérská, a.s. are in line with this standard. The specific composition is listed in Tab. A3 - 2.

**Tab. A3 - 2 Composition of LPG distributed in the Czech Republic (in mass percents)**

| Composition | summer mixture | winter mixture |
|---|---|---|
| C2+inerts | 0.2 | 0.1 |
| propane | 38.5 | 58.7 |
| propylene | 7.2 | 4.5 |
| iso-butane | 25.6 | 27.9 |
| n-butane | 15.7 | 5.9 |
| sum of butens | 12.2 | 2.8 |
| C5 and higher | 0.6 | 0.1 |
| Ratio of the production of summer : winter mixture = circa 1 : 1.1 | | |

This elementary composition of LPG (given in Tab. A2-2) was used for the calculations of country specific emission factor (based on the carbon content in each component). At first carbon emission factors related to the mass of LPG (kg C/kg LPG) were computed. For the summer mixture is the carbon emission factor equal to 0.8287 kg C/kg; for winter mixture 0.8232 kg C/kg. Final value computed using weighted average taking in consideration the summer : winter mixture ratio is equal to 0.8258 kg C/kg.

The net calorific value related to the mass (MJ/kg) was computed using equation A2-2. For the summer mixture is net calorific value equal to 45.853 MJ/kg; for the winter mixture to 46.029 MJ/kg. Final value computed using weighted average taking in consideration the summer : winter mixture ratio is equal to 45.945 MJ/kg. This net calorific value was also used for the conversion of activity data from kilotons to TJ.

Final emission factor was determined using equation A3-7

$$\frac{1000 \cdot 0.8258}{45.945} = 17.974\ \frac{t\ C}{TJ} \qquad \text{(A3-6)}$$

This value is in very good agreement with the value 17.9 t C/TJ determined in Harmelen and Koch (2002); corresponded net calorific value is 45.5 MJ/kg (Harmelen and Koch, 2002), which is also in a good agreement with the value determined as Czech country specific.

Tab. A3 – 3 indicates comparison of the newly developed country specific $CO_2$ emission factor and the default one provided either in Revised 1996 Guidelines (IPCC, 1997) or in 2006 Guidelines (IPCC, 2006). It is necessary to keep in mind, that 2006 Guidelines states the range of default emission factors, which for LPG is 16.8 – 17.9 t C/TJ. It is apparent that default emission factors slightly underestimate the emission estimates. The country specific emission factor does not fit into the default interval, which also supports this conclusion. Since country specific emission factor was evaluated based on the specific composition of LPG distributed in the Czech Republic, the newly developed emission factor will evaluate the emission estimates more accurate than the default emission factor.

**Tab. A3 - 3 Comparison of country specific $CO_2$ and default emission factors for LPG**

| | [t C/TJ] | [t $CO_2$/TJ] |
|---|---|---|
| Revised 1996 Guidelines | 17.2 | 63.07 |
| 2006 Guidelines | 17.2 | 63.1 |
| $CO_2$ country specific emission factor for CR | 17.97 | 65.90 |

Based on the composition of LPG was also net calorific value computed, which agreed better to the specific conditions of CR then the net calorific value presented in CzSO questionnaire. The updated net calorific value was used for the computation of fuel consumption in TJ; the value 45 945 kJ/kg was used (conversion from kt to TJ).

## A3. 3 Country specific $CO_2$ emission factor for Refinery Gas

Another improvement concerning emission factor from combustion of Refinery Gas was accomplished in 2013. Refinery gas is defined as non-condensable gas obtained during distillation of crude oil or treatment id oil products in refineries. It consists mainly of hydrogen, methane, ethane and olefins (IPCC, 2006).

Refinery Gas in CR is also used mainly by Česká rafinérská, a.s. This company is also included in the EU ETS and in terms of this obligation also carries out the analyses of molar composition of Refinery Gas. These analyses were provided to the inventory team for the purposes of the development of country specific $CO_2$ emission factor from combustion of Refinery Gas. These analyses obtain the information about content of hydrogen, content of $CO_2$, content of CO, content of methane, ethane, propane, iso-butane, n-butane, butenes, iso-pentanes, n-pentanes, ethylene, propylene, C6 and higher hydrocarbons, content of oxygen, nitrogen, hydrogen sulphide and water in the Refinery Gas. The analyses are available for the 2008 – 2012 in the time step 3 – 4 days.

It is apparent that the available analyses are sufficiently detailed, so it allowed the inventory to team to develop country specific emission factor for the Czech Republic. The approach of 'carbon content in the fuel', which was fully attested in case of determination of country specific emission factor from combustion of Natural Gas (Krtková et al., 2014), was also used for determination of Refinery Gas emission factor. Based on the molar composition of the gas mixture the country specific emission factors for years 2008 – 2012 were determined. For the years before the average value of the 2008 – 2012 values was used. The table below shows the used values.

**Tab. A3 - 4 Country specific carbon emission factors from combustion of Refinery Gas (t C/TJ)**

| 1990 - 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| 15.03 | 15.06 | 14.93 | 14.58 | 15.24 | 15.34 |

All values in the table lies within the default range 13.1 – 18.8 t C/TJ specified in the 2006 Guidelines and further more are close to the default value 15.7 t C/TJ (IPCC, 2006). However, the previously used default value provided by the 1996 Guidelines (IPCC, 1997) was somewhat higher, 18. 2 t C/TJ.

Also net calorific value of Refinery Gas was computed based on the available analyses of the molar composition. CzSO has updated this value based on the request of the inventory team. The updated value is 46.023 MJ/kg. This value was used for the whole time series.

## A3. 4 Country specific $CO_2$ emission factor for Natural Gas combustion

Extensive research was carried out in 2012 with aim to develop the country-specific emission factor for Natural Gas combustion (CHMI, 2012b). This research was part of a project of The Technical Assistance of the Green Savings programme. Final evaluation of the $CO_2$ emission factor for Natural Gas combustion is based on its correlation with the net calorific value. Detailed description of the research is given in the following paragraphs.

Complete description of this research will be published in Greenhouse Gas Measurement & Management journal, the manuscript is entitled Carbon dioxide emissions from natural gas combustion – country specific emission factors for the Czech Republic (Krtková et al., 2014).

The net calorific value of Natural Gas can be computed on the basis of the molar composition according to:

$$Qm = \sum wi \bullet Qmi \quad \text{(A3-8)}$$

$$Qv = Qm \bullet d \quad \text{(A3-9)}$$

where $Q_m$ [MJ/kg] is the net calorific value of Natural Gas related to its mass, w [kg/kg] is the mass fraction, $Q_{mi}$ [MJ/kg] is the net calorific value of different components of Natural Gas related to their mass, $Q_v$ [MJ/$m^3$] is the net calorific values of Natural Gas related to its volume and d [kg/$m^3$] is its density.

Tab. A3 - 5 lists the net calorific values of the basic components of Natural Gas.

**Tab. A3 - 5 Net calorific values of the basic components of Natural Gas (ČSN EN ISO 6976, 2006)**

| Net calorific values of basic components of Natural Gas [MJ/kg] | |
|---|---|
| methane | 50.035 |
| ethane | 47.52 |
| propane | 46.34 |
| iso-butane | 45.57 |
| n-butane | 45.72 |
| iso-pentane | 45.25 |
| n-pentane | 45.35 |
| sum C>6 (like heptane) | 44.93 |

The carbon emission factor for Natural Gas related to its energy content ($CEF_{TJ}$ [t C/TJ]) is computed according to

$$CEFTJ = CEF_m/Q_m \quad \text{(A3-10)}$$

where $CEF_m$ is carbon emission factor related to the mass.

Carbon dioxide emission factor (EF ($CO_2$) [t $CO_2$/TJ]) is then calculated

$$EF\ (CO_2) = CEFTJ \bullet M_{CO2}/M_C \quad \text{(A3-11)}$$

where $M_{CO2}$ and $M_C$ are the molecular weight of carbon dioxide and atomic weight of carbon, respectively.

A similar method (to the one described here) of computing EF ($CO_2$) and $Q_v$ for 10 characteristic samples of Natural Gas was used in the article (Čapla and Havlát, 2006). Samples 1 – 4 were chosen based on their place of origin: sample 1 – Natural Gas from Russian gas fields distributed in Czech Republic in 2001; sample 2 – Natural Gas from Norwegian gas fields in the North Sea; sample 3 – Natural Gas coming from Dutch gas fields; sample 4 – Natural Gas mined in Southern Moravia. Samples 5 – 10 represented the composition of the Natural Gas distributed in the Czech Republic in 2005 – 2006.

This rather representative dataset was used to determine the regression curve, which was similar to the line

$$EF\ (CO_2) = 0.269 \bullet (Qv/3.6)^2 - 2.988 \bullet (Qv/3.6) + 59.212 \quad \text{(A3-12)}$$

which was tightly fit to all 10 points (correlation coefficient $R^2$ = 0.999). In this correlation expression $Q_v$ represents the net calorific value related to the volume under “trade conditions” (101.3 kPa, 15° C).

The calculations of the regression curve for the samples 5 – 10 indicated in particularly close range of Qv: 34.11 – 34.27 MJ/m$^3$. The lowest net calorific value (31.31 MJ/m$^3$) was determined for sample number 3 (Dutch field) and the highest (38.28 MJ/m$^3$) for Norwegian gas type. The low net calorific value of Dutch Natural Gas is caused by relatively high content of nitrogen; the high net calorific value of the Norwegian Natural Gas is a result of the higher content of C2, C3 and C4 hydrocarbons (especially ethane).

The above-described methodology was tested on a relatively small dataset. To obtain sufficiently reliable correlation, this methodology had to be tested on a dataset which would provide composition of Natural Gas in sufficient time series. In cooperation with CzSO a dataset comprising analyses of Natural Gas composition was obtained. These analyses are continuously evaluated in the laboratory of NET4GAS, Ltd. Daily average values on the Natural Gas composition from the first day in the month were available for evaluation of the $CO_2$ emission factor. The dataset of these analyses began on 1$^{st}$ January 2007 and the last data are from 1$^{st}$ September 2011. Furthermore data for 1$^{st}$ February 2012 were also available. The report on each analysis contains data on the molar composition of the Natural Gas, physical characteristics and conditions during which the analysis was performed. Overall, 58 analyses were available. Fig. A3 3 depicts the trend of net calorific values in time.

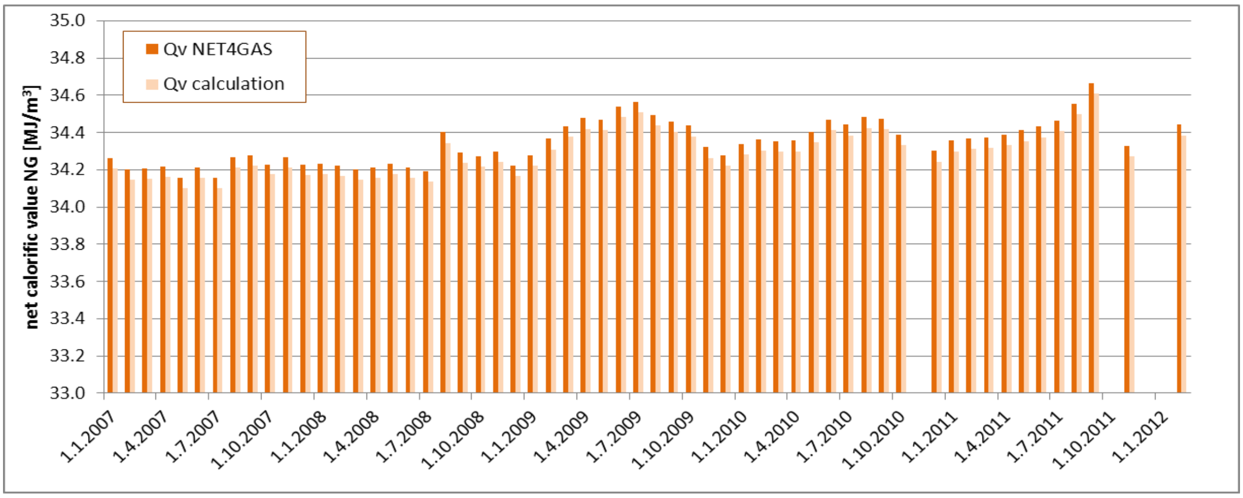



**Fig. A3 3 Net calorific values given in NET4GAS Ltd. reports and net calorific values calculated on the basis of composition of Natural Gas in 1.1.2007 – 1.2.2012 (both values are given at 15°C)**

The figure indicates a good match between the two depicted values; the deviation is almost constant and reaches an average value of 0.16%. The deviation is probably caused by the fact that the measured values correspond to the non-state gas behaviour; however the calculation is based on the assumption of ideal gas behaviour. For this reason, the net calorific values from the NET4GAS Ltd. reports were used for calculation of the emission factor. The reports contain data related to the reference temperature 20° C; thus, it was necessary to recalculate net calorific values and densities for 15° C.

The results of the calculations are depicted in Fig.A2- 2. This figure also contains computation of the correlation

$$EF\ (CO_2) = 0.787 \bullet Qv + 28.21 \quad \text{(A3-13)}$$

where $Q_v$ [MJ/m$^3$] is the net calorific value of Natural Gas at “trade conditions”: temperature 15°C and pressure of 101.3 kPa.

These findings were compared with the results obtained during preparation of this research. First, the data about analyses of Natural Gas obtained from RWE Transgas were used for comparison. This dataset contains data from 2003, 2004 and 2009 and evaluation of these data resulted in the correlation

$$EF\ (CO_2) = 0.6876 \bullet Qv + 31.619 \quad \text{(A3-14)}$$

The second source for comparison is the paper of Čapla and Havlát (2006), where the correlation resulted in equation (A3-13).

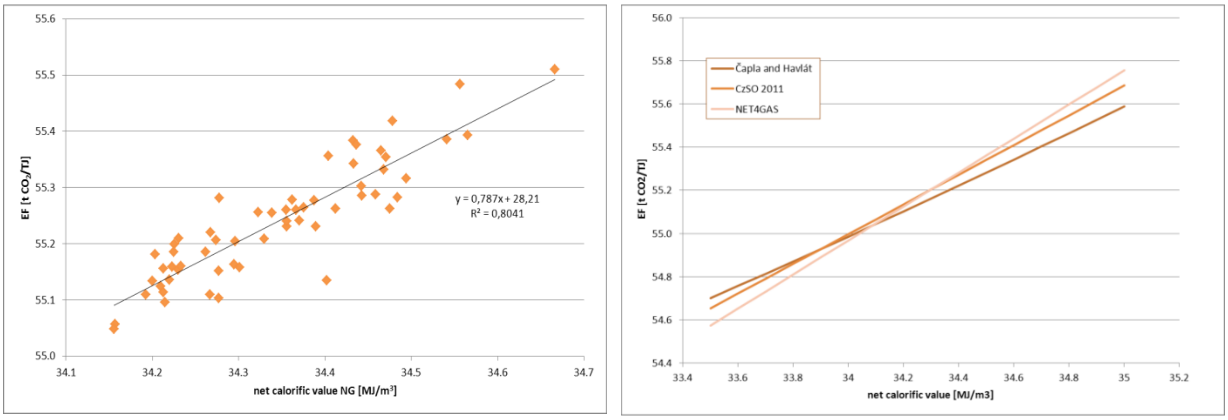



**Fig. A3 4 Correlation of EF [t $CO_2$/TJ] and net calorific value of Natural Gas and Comparison of three approaches used for calculation**

Fig. A3- 4 indicates good correlation between all three approaches in the region of 34.1 – 34.3 MJ/m$^3$, where the deviation between the results is 0.3% in maximum.

Each year in its energy balance, the Czech Statistical Office reports the average value of net calorific value of Natural Gas. Fig. A3- 4 indicates the trend of these calorific values. It is apparent that NCV is continuously slightly increasing.

The dark line in Fig. A2- 4 indicates the lowest net calorific value determined in the dataset provided by NET4GAS Ltd in 2007 - 2012. For the period of 2007 towards all the net calorific values are lower than 34.1 MJ/m$^3$. For this reason, it is more accurate to use the correlation obtained from the dataset representing the data before this year, i.e. the correlation evaluated by Čapla and Havlát (2006).

Fig. A3- 5 depicts the correlation curve combined on the basis of both correlations. It is given for the whole range of net calorific values, which was identified in Natural Gas in the Czech Republic in the 1990 - 2010 period. The value 34.1 MJ/m$^3$ is depicted by the dashed line.

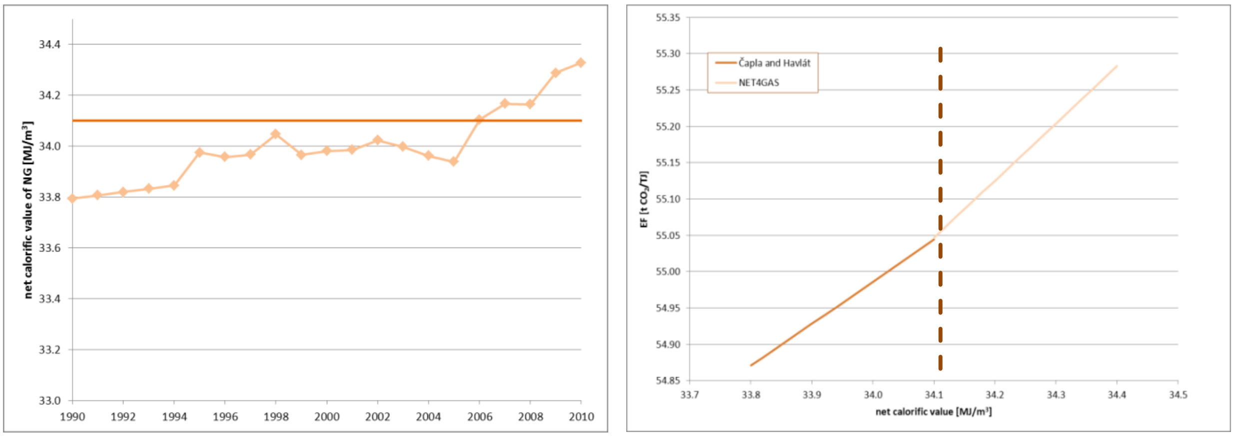



**Fig. A3 5 Trend in Natural Gas NCV 1990 – 2010 and Correlation between NCV and EF combined from two approaches – Čapla and Havlát (NCV lower than 34.1 MJ/m$^3$) and computed correlation on the basis of NET4GAS dataset (NCV higher than 34.1 MJ/m$^3$)**

Evaluation of $CO_2$ emission factors for Natural Gas combustion is based on the computational approach described above. There are two correlation relations; each of them is used for a different range of net calorific values. As depicted in Fig. A2- 5, both correlations follow each other closely. Tab A3 - 6 lists all the calculated emission factors for both correlations; the recommended values are in bold.

**Tab. A3 - 6 Comparison of both recommended correlations**

| year | Average net calorific value of NG reported by CzSO | EF $CO_2$ calculated on the basis of Čapla and Havlát correlation (eq. A2-5) | EF $CO_2$ calculated on the basis of NET4GAS, Ltd. dataset correlation (eq. A2-6) |
|---|---|---|---|
| | [MJ/m$^3$] | [t $CO_2$/TJ] | [t $CO_2$/TJ] |
| **1990** | 33.794 | **54.87** | *54.81* |
| **1991** | 33.807 | **54.87** | *54.82* |
| **1992** | 33.820 | **54.88** | *54.83* |
| **1993** | 33.832 | **54.89** | *54.84* |
| **1994** | 33.845 | **54.90** | *54.85* |
| **1995** | 33.975 | **54.97** | *54.95* |
| **1996** | 33.957 | **54.96** | *54.93* |
| **1997** | 33.966 | **54.97** | *54.94* |
| **1998** | 34.046 | **55.01** | *55.00* |
| **1999** | 33.965 | **54.97** | *54.94* |
| **2000** | 33.980 | **54.97** | *54.95* |
| **2001** | 33.986 | **54.98** | *54.96* |
| **2002** | 34.023 | **55.00** | *54.99* |
| **2003** | 33.997 | **54.98** | *54.97* |
| **2004** | 33.962 | **54.96** | *54.94* |
| **2005** | 33.938 | **54.95** | *54.92* |
| **2006** | 34.105 | *55.05* | **55.05** |
| **2007** | 34.167 | *55.08* | **55.10** |
| **2008** | 34.164 | *55.08* | **55.10** |
| **2009** | 34.288 | *55.16* | **55.19** |
| **2010** | 34.328 | *55.18* | **55.23** |

The deviations between the two calculations are less than 0.15%. The values written in bold were used for recalculation of $CO_2$ emissions from Natural Gas combustion for the 1990 – 2010 time series (held in 2013 submission). Former submissions employed the default emission factor 56.1 t $CO_2$/TJ, which overestimated the $CO_2$ emissions from Natural Gas combustion, especially at the beginning of the nineteen nineties (about 2.4% in 1990).

For years 2011 and 2012 the correlation relation based on the NET4GAS, Ltd. dataset was used (eq. A3-13):

$$EF\ (CO_2) = 0.787 \bullet Qv + 28.21 \qquad \text{(A3-15)}$$

The availability of analyses of the Natural Gas composition should be ensured in the coming years. The validity of equation (A2-7) will be continuously tested using new data, and if necessary, the correlation equation will be modified to fit the new data as best as possible.

Starting with submission 2013 updated emission factors are be used for all categories in 1A Energy for the whole time series.

For other detailed discussion of methodology and data for estimating $CO_2$ emissions from fossil fuel combustion please see the discussion of methodology in Chapter 3.4 and in the Annex 4.

## A3. 5 Methodology for Road Transport (1.A.3.b)

The Methodology of determination of air polluting emissions from transport in the Czech Republic is used for transport emission calculations on a national and regional level. The results are reported not only to UNFCCC, but also to CLRTAP and other international bodies. The methodology was adopted by the Ministry of Transport, Ministry of Environment and Czech Hydrometeorological Institute in 2002 and was updated in 2006. The methodology includes only emissions from transport and does not include emissions from electricity production used by electric vehicles. It also does not include emissions from the engines of off-road machines and vehicles used, for example, in agriculture, the building industry, the army or households.

The underlying principles of the methodology are:

- categorization of vehicles
- measured emission factors
- distribution of fuel consumption between individual transport modes
- annual mileages in selected vehicle categories

The methodology is based on the classification of vehicles in 23 categories using the following criteria: transport mode, fuel type, weight of vehicles (in road freight traffic) and equipment with effective catalytic converter systems (cars). Every category has associated emission factors for $CO_2$, CO, $NO_X$, $N_2O$, $CH_4$, NMVOC, $SO_2$, Pb and PM, based on the available measurements. Emission factors are expressed in $g.kg^{-1}$ of fuel and are processed in the MS Access database.

Two parallel approaches are used for classification of fuel consumption. The first one is "top - down", i.e. allocating total fuel consumption according to transport performances and numbers of vehicles, and the second one is "bottom - up", i.e. from annual mileages and average consumption in $1.100km^{-1}$. This consumption is classified in 5 categories (motorcycles, gasoline passenger cars with or without catalytic converter systems, diesel light duty vehicles, diesel heavy duty vehicles), taken from the 23 categories mentioned above, which exhibit the largest differences in annual mileages ($km.year^{-1}$).

Mileages are reported in a manner such that the sum of the fuel consumptions in the first three categories (motorcycles, gasoline passenger cars with or without catalytic convert systems) calculated using the "bottom - up" method is identical with the fuel consumption in the individual transport categories calculated using the "top - down" method. A similar approach is employed for road freight transport. The relationship of the mileages employed must be in line with the relationships of the above mentioned categories in real situations. These are derived from the transport census. This is based on the total fuel consumption in the appropriate transport modes. Transport performances are used to derive the relative fuel consumption for the individual transport modes.

The categorization of vehicles enables separate calculation of the $N_2O$ production from the total amount of $NO_X$. VOCs are separated into $CH_4$ (which contributes to the greenhouse effect) and nonmethane VOCs. Every category has associated emission factors according to the available measurements in the Czech Republic and the recommended values from international statistics (IPCC, Emission Inventory Guidebook). Emission factors are given in $g.kg^{-1}$ of fuel and are processed in the MS Access database.

*Reference:*

*DUFEK, J., HUZLÍK, J., ADAMEC, V. Methodology of determination of air pollution emissions from transport in the Czech Republic. Brno: CDV, 2006, 26 s.(in Czech). http://www.cdv.cz/metodiky/*

## A3. 6 Country specific $CO_2$ emission factor for Lime Production

Emissions of GHG from lime production are classified into two different categories. The first category relates to the combustion processes, ongoing in the production of lime, and emissions from it are reported in sector "Energy" in the Czech National Inventory Report. In the second category are included emissions from decomposition of carbonates, of decomposition of organic carbon, contained in the raw material, used for the production of lime. These emissions are described in sector "Industrial processes", in subsector 'Mineral industry'. The following calculations apply only to the second category of emissions.

Production of lime is based on heating limestone, during which decomposition (calcination) of carbonates, contained in limestone, occurs and carbon dioxide is released. In limestone mainly calcium carbonate and magnesium carbonate mixture is present in range of 75.0 to 98.5% of weight, of which the magnesium carbonate is 0.5 to 15.0% of weight. Detailed chemical composition and the division into classes of limestone, according to the national standards are shown in Tab. A3 - 7 (ČSN, 1992).

**Tab. A3 - 7 Division of limestone, according to chemical composition**

| Chemical composition in% weight | | Quality class | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII |
| **$CaCO_3$ + $MgCO_3$** | min | 98.5 | 97.5 | 96.0 | 95.0 | 93.0 | 85.0 | 80.0 | 75.0 |
| **from which $MgCO_3$** | min | 0.5 | 0.8 | 2.0 | 4.0 | 6.0 | 10.0 | 15.0 | |
| **$SiO_2$** | max | 0.3 | 0.8 | 1.5 | 3.0 | 4.5 | 6.0 | 8.0 | 18.0 |
| **$Al_2O_3$ + $Fe_2O_3$** | max | 0.2 | 0.4 | 0.8 | 2.0 | 3.5 | 5.0 | 6.0 | 6.0 |
| **from which $Fe_2O_3$** | max | 0.03 | 0.1 | 0.03 | 1.0 | 2.0 | 2.5 | 2.5 | |
| **MnO** | max | 0.01 | 0.03 | 0.03 | 0.03 | | | | |
| **$SO_3$** | max | 0.08 | 0.1 | 0.2 | 0.2 | 0.3 | 0.5 | 0.5 | 2.0 |

The composition of limestone is closely associated with the emission factor. As calcium carbonate and magnesium carbonate have a different emission factors, the ratio between the two emission factors is reflected in the resulting emission factor. Emission factor derived from $CaCO_3$ or $MgCO_3$ is defined as emission factor of method A. This method is based on the input materials in the process of lime production. Further emission factor can be determined for outgoing materials or for CaO and MgO in lime. This procedure is called method B. Emission factors from method A and B are described in Tab. A3-8 (Commission Regulation (EU) № 601/2012).

**Tab. A3 - 8 Emission factors for method A and B**

| Method | Material | EF [t $CO_2$/ t material] |
|---|---|---|
| **A (input)** | $CaCO_3$ | 0.440 |
| | $MgCO_3$ | 0.522 |
| **B (output)** | CaO | 0.785 |
| | MgO | 1.092 |

Additional ingredients (other carbonates and organic carbon), which occur in limestone in very small quantities, may also be a source of emissions. These small amounts will affect to a minor extent the total emission factor; therefore for the inventory of GHG can be considered as negligible.

Thus the most significant impact on the emission factor has the composition of the input material, which subsequently is reflected in the composition of lime. Therefore we can affirm that, it is inessential, if we calculate from the composition of the input material (Method A) or the composition of the output material (Method B), both ways would lead to the same emission factor for the given process.

The best way to do that is to observe the relation between the emission factor and mass in% of $MgCO_3$ in the input material (Method A). This dependence can be observed on Fig. A3-6.

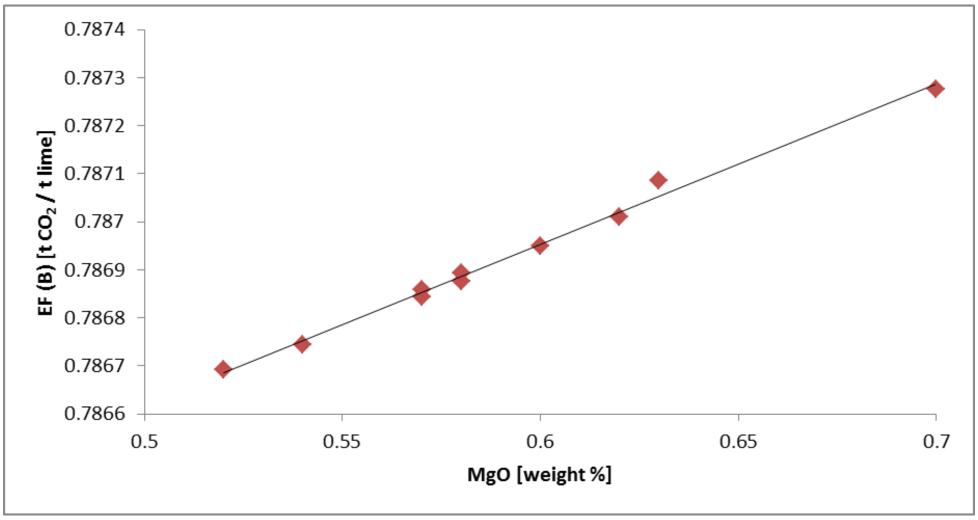



**Fig. A3 6 Correlation between emission factor and mass representation of $MgCO_3$ in input material**

Dependence between emission factor and output material (weight% MgO) occurs naturally, even when using method B, as you can see on Fig. A3 - 7.

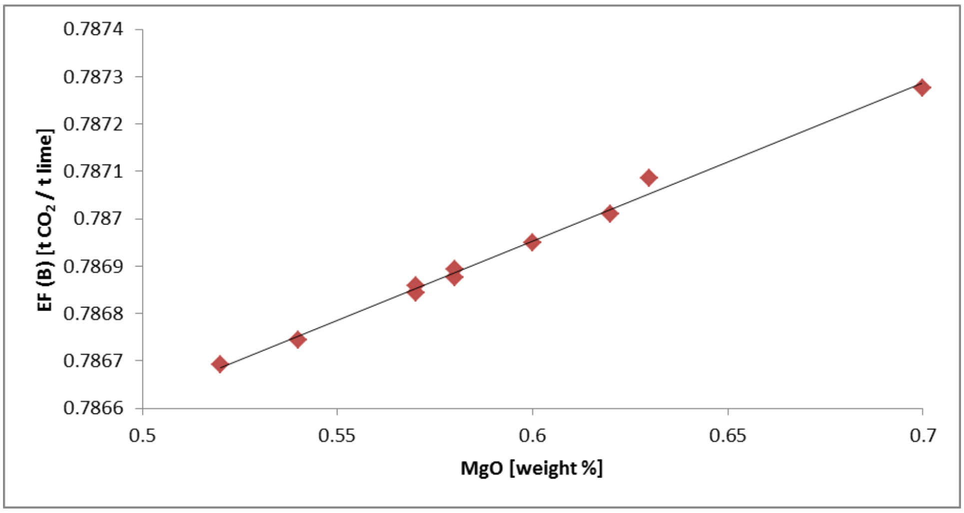



**Fig. A3 7 Correlation of emission factor in mass representation of MgO in output material**

As Fig. A3 - 6 and A3 - 7 shows, the emission factor varies with the amount of MgCO3 or MgO only very slightly. Limestone, which is processed in the Czech Republic, is supplied to the lime plants from the same source and the composition of it for the individual sources does not change much with time. These facts reveal that, similarly, the emission factor for lime production will move only within a narrow range, which will have a small impact on the calculation of the emissions. As it is evident from Fig. A3 – 6 the emissions calculated, using Tier 1 approach, which adopts country specific emission factor (Vacha, 2004), are only very slightly overestimated compared to emissions from the ETS, which are obtained by measuring or Tier 3 approach.


**Fig. A3 8 Development of emissions of $CO_2$ from production of lime in CR for period 1990 – 2014**

Figure A3 - 7 shows oscillating weighted total emission factor derived from the ETS which fluctuates near the country specific emission factor values. From figure 4 it is observed that there could be a slight decrease in the emission factor since 2009, but it will be rather an incidental drop. For the period 1990 - 2004, for which ETS data are not available, the emission factors could be calculated as the average of the available data from the ETS. The average of these values is 0.7885 t $CO_2$/t lime and it differs from the country specific emission factor only by one ten-thousandth. For this reason, for this time period it is considered to keep the country specific emission factor.

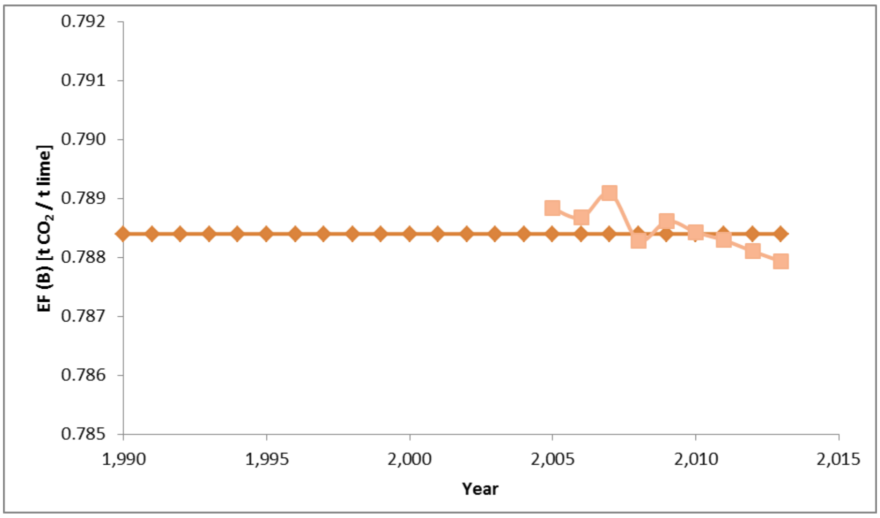



**Fig. A3 9 Development of EF for production of lime in CR for period 1990 - 2014 (method B)**

Since the composition of limestone from 1990 to the present has not changed significantly, the emission factor does not undergo any major change. Therefore for the period 1990 - 2004 the country specific emission factor (0.7884 t $CO_2$/t lime; Vacha, 2004) can be used and for the remaining period will be applied emission factors derived from the ETS.

Due to the very small variation of $MgCO_3$ content in limestone, the emission factor changes slightly over time. We can use as an emission factor for the period 1990-2004 the proposed country specific, which is equal to 0.7884 t $CO_2$/t lime (Method B) and activity data for emission calculations utilize the Czech Statistical Office and Czech Lime Association. Since 2005 it is possible to use ETS data that have greater accuracy than the country specific EF together with data from the CSO and CLA.

# Annex 4 The national energy balance for the most recent inventory year

Following tables present energy balance for the Czech Republic for 2015.

**Tab. A4 - 1 Energy balance for solid fuels 2015**

| SOLID FUELS | Coking Coal [kt/year] | Sub Bituminous Coal [kt/year] | Lignite/Brown Coal [kt/year] | Coke Oven Coke [kt/year] | Coal Tar [kt/year] |
|---|---|---|---|---|---|
| Indigenous Production | 4088 | 4226 | 38105 | 2332 | 189 |
| Total Imports (Balance) | 1579 | 1483 | 1031 | 396 | 328 |
| Total Exports (Balance) | 1895 | 1666 | 885 | 516 | 5 |
| International Marine Bunkers | 0 | 0 | 0 | 0 | 0 |
| Stock Changes (National Territory) | -68 | -34 | -430 | 24 | 5 |
| Inland Consumption (Calculated) | 3704 | 4372 | 37821 | 2236 | 517 |
| Statistical Differences | 665 | -180 | -281 | -36 | -10 |
| Transformation Sector | 3039 | 3912 | 34774 | 1858 | 79 |
| Main Activity Producer Electricity Plants | 0 | 0 | 7268 | 0 | 0 |
| Main Activity Producer CHP Plants | 0 | 3545 | 23651 | 0 | 0 |
| Main Activity Producer Heat Plants | 0 | 7 | 150 | 0 | 1 |
| Autoproducer Electricity Plants | 0 | 0 | 0 | 0 | 0 |
| Autoproducer CHP Plants | 0 | 60 | 2279 | 0 | 5 |
| Autoproducer Heat Plants | 0 | 0 | 11 | 0 | 0 |
| Patent Fuel Plants (Transformation) | 0 | 0 | 0 | 0 | 0 |
| Coke Ovens (Transformation) | 3039 | 0 | 0 | 78 | 0 |
| BKB Plants (Transformation) | 0 | 0 | 0 | 0 | 0 |
| Gas Works (Transformation) | 0 | 0 | 1415 | 0 | 73 |
| Blast Furnaces (Transformation) | 0 | 300 | 0 | 1780 | 0 |
| Coal Liquefaction Plants (Transformation) | 0 | 0 | 0 | 0 | 0 |
| Non-specified (Transformation) | 0 | 0 | 0 | 0 | 0 |
| Energy Sector | 0 | 0 | 859 | 0 | 0 |
| Own Use in Electricity, CHP and Heat Plants | 0 | 0 | 1 | 0 | 0 |
| Coal Mines | 0 | 0 | 858 | 0 | 0 |
| Patent Fuel Plants (Energy) | 0 | 0 | 0 | 0 | 0 |
| Coke Ovens (Energy) | 0 | 0 | 0 | 0 | 0 |
| BKB Plants (Energy) | 0 | 0 | 0 | 0 | 0 |
| Gas Works (Energy) | 0 | 0 | 0 | 0 | 0 |
| Blast Furnaces (Energy) | 0 | 0 | 0 | 0 | 0 |
| Petroleum Refineries | 0 | 0 | 0 | 0 | 0 |
| Coal Liquefaction Plants (Energy) | 0 | 0 | 0 | 0 | 0 |
| Non-specified (Energy) | 0 | 0 | 0 | 0 | 0 |
| Distribution Losses | 0 | 42 | 0 | 0 | 0 |
| Total Final Consumption | 0 | 598 | 2469 | 414 | 448 |
| Total Non-Energy Use | 0 | 1 | 210 | 0 | 428 |
| Final Energy Consumption | 0 | 597 | 2259 | 414 | 20 |
| Industry Sector | 0 | 248 | 776 | 376 | 20 |
| Iron and Steel | 0 | 28 | 16 | 326 | 0 |
| Chemical (including Petrochemical) | 0 | 41 | 497 | 0 | 0 |
| Non-Ferrous Metals | 0 | 0 | 0 | 4 | 0 |
| Non-Metallic Minerals | 0 | 155 | 14 | 29 | 20 |
| Transport Equipment | 0 | 0 | 19 | 0 | 0 |
| Machinery | 0 | 0 | 16 | 8 | 0 |
| Mining and Quarrying | 0 | 0 | 0 | 0 | 0 |
| Food, Beverages and Tobacco | 0 | 24 | 91 | 9 | 0 |
| Paper, Pulp and Printing | 0 | 0 | 103 | 0 | 0 |
| Wood and Wood Products | 0 | 0 | 3 | 0 | 0 |
| Construction | 0 | 0 | 6 | 0 | 0 |
| Textiles and Leather | 0 | 0 | 7 | 0 | 0 |
| Non-specified (Industry) | 0 | 0 | 4 | 0 | 0 |
| Transport Sector | 0 | 1 | 1 | 0 | 0 |
| Other Sectors | 0 | 348 | 1482 | 38 | 0 |
| Commercial and Public Services | 0 | 2 | 36 | 4 | 0 |
| Residential | 0 | 344 | 1427 | 32 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| Agriculture/Forestry | 0 | 2 | 19 | 1 | 0 |
| Fishing | 0 | 0 | 0 | 0 | 0 |
| Non-specified (Other) | 0 | 0 | 0 | 1 | 0 |

**Tab. A4 - 2 Energy balance for solid fuels 2015**

| SOLID FUELS | BKB-PB [kt/year] | Gas Works Gas [TJ/year] | Coke Oven Gas [TJ/year] | Blast Furnace Gas [TJ/year] | Other Recovered Gases [TJ/year] |
|---|---|---|---|---|---|
| Indigenous Production | 0 | 17024 | 18946 | 19473 | 6068 |
| Total Imports (Balance) | 141 | 0 | 0 | 0 | 0 |
| Total Exports (Balance) | 3 | 0 | 0 | 0 | 0 |
| International Marine Bunkers | 0 | 0 | 0 | 0 | 0 |
| Stock Changes (National Territory) | 1 | 0 | 0 | 0 | 0 |
| Inland Consumption (Calculated) | 139 | 17024 | 18946 | 19473 | 6068 |
| Statistical Differences | 0 | 111 | -290 | -29 | 263 |
| Transformation Sector | 0 | 16474 | 5278 | 7840 | 1108 |
| Main Activity Producer Electricity Plants | 0 | 0 | 0 | 0 | 0 |
| Main Activity Producer CHP Plants | 0 | 0 | 5278 | 7840 | 523 |
| Main Activity Producer Heat Plants | 0 | 0 | 0 | 0 | 0 |
| Autoproducer Electricity Plants | 0 | 0 | 0 | 0 | 0 |
| Autoproducer CHP Plants | 0 | 16474 | 0 | 0 | 585 |
| Autoproducer Heat Plants | 0 | 0 | 0 | 0 | 0 |
| Patent Fuel Plants (Transformation) | 0 | 0 | 0 | 0 | 0 |
| Coke Ovens (Transformation) | 0 | 0 | 0 | 0 | 0 |
| BKB Plants (Transformation) | 0 | 0 | 0 | 0 | 0 |
| Gas Works (Transformation) | 0 | 0 | 0 | 0 | 0 |
| Blast Furnaces (Transformation) | 0 | 0 | 0 | 0 | 0 |
| Coal Liquefaction Plants (Transformation) | 0 | 0 | 0 | 0 | 0 |
| Non-specified (Transformation) | 0 | 0 | 0 | 0 | 0 |
| Energy Sector | 0 | 439 | 7472 | 5823 | 1131 |
| Own Use in Electricity, CHP and Heat Plants | 0 | 0 | 274 | 0 | 79 |
| Coal Mines | 0 | 439 | 0 | 0 | 1052 |
| Patent Fuel Plants (Energy) | 0 | 0 | 0 | 0 | 0 |
| Coke Ovens (Energy) | 0 | 0 | 7198 | 2088 | 0 |
| BKB Plants (Energy) | 0 | 0 | 0 | 0 | 0 |
| Gas Works (Energy) | 0 | 0 | 0 | 0 | 0 |
| Blast Furnaces (Energy) | 0 | 0 | 0 | 3735 | 0 |
| Petroleum Refineries | 0 | 0 | 0 | 0 | 0 |
| Coal Liquefaction Plants (Energy) | 0 | 0 | 0 | 0 | 0 |
| Non-specified (Energy) | 0 | 0 | 0 | 0 | 0 |
| Distribution Losses | 0 | 0 | 321 | 937 | 64 |
| Total Final Consumption | 139 | 0 | 6165 | 4902 | 3502 |
| Total Non-Energy Use | 0 | 0 | 0 | 0 | 793 |
| Final Energy Consumption | 139 | 0 | 6165 | 4902 | 2709 |
| Industry Sector | 0 | 0 | 6165 | 4902 | 2709 |
| Iron and Steel | 0 | 0 | 6056 | 4902 | 1244 |
| Chemical (including Petrochemical) | 0 | 0 | 0 | 0 | 1408 |
| Non-Ferrous Metals | 0 | 0 | 0 | 0 | 0 |
| Non-Metallic Minerals | 0 | 0 | 73 | 0 | 57 |
| Transport Equipment | 0 | 0 | 0 | 0 | 0 |
| Machinery | 0 | 0 | 36 | 0 | 0 |
| Mining and Quarrying | 0 | 0 | 0 | 0 | 0 |
| Food, Beverages and Tobacco | 0 | 0 | 0 | 0 | 0 |
| Paper, Pulp and Printing | 0 | 0 | 0 | 0 | 0 |
| Wood and Wood Products | 0 | 0 | 0 | 0 | 0 |
| Construction | 0 | 0 | 0 | 0 | 0 |
| Textiles and Leather | 0 | 0 | 0 | 0 | 0 |
| Non-specified (Industry) | 0 | 0 | 0 | 0 | 0 |
| Transport Sector | 0 | 0 | 0 | 0 | 0 |
| Other Sectors | 139 | 0 | 0 | 0 | 0 |
| Commercial and Public Services | 16 | 0 | 0 | 0 | 0 |
| Residential | 123 | 0 | 0 | 0 | 0 |
| Agriculture/Forestry | 0 | 0 | 0 | 0 | 0 |
| Fishing | 0 | 0 | 0 | 0 | 0 |
| Non-specified (Other) | 0 | 0 | 0 | 0 | 0 |

**Tab. A4 - 3 Energy balance for Crude Oil, Refinery Gas and Additives/Oxygenates for 2015**

| LIQUID FUELS | Crude Oil [kt/year] | Refinery Feedstocks [kt/year] | Additives Oxygenates [kt/year] |
|---|---|---|---|
| Indigenous Production | 128 | | 81 |
| From Other Sources | | | 404 |
| From Other Sources - Solid fuels | | | |
| From Other Sources - Natural Gas | | | |
| From Other Sources - Renewables | | | 404 |
| Backflows | | 68 | 0 |
| Primary Product Receipts | | | 0 |
| Refinery Gross Output | | | 0 |
| Inputs of Recycled Products | | | 0 |
| Refinery Fuel | | | 0 |
| Total Imports (Balance) | | | 22 |
| Total Exports (Balance) | 7132 | 3 | |
| International Marine Bunkers | 28 | 0 | |
| Interproduct Transfers | | | |
| Products Transferred | | 134 | |
| Direct Use | | | 397 |
| Stock Changes (National Territory) | | 4 | 0 |
| Refinery Intake (Calculated) | -16 | 209 | 110 |
| Gross Inland Deliveries (Calculated) | 7216 | | |
| Statistical Differences | 0 | 0 | 0 |
| Gross Inland Deliveries (Observed) | -7 | 0 | |
| Refinery Intake (Observed) | 0 | 209 | 110 |

**Tab. A4 - 4 Energy balance for liquid fuels 2015**

| LIQUID FUELS | Refinery Gas [kt/year] | | LPG [kt/year] | | Naphtha [kt/year] | | Motor Gasoline [kt/year] | | Biogasoline [kt/year] | | Aviation Gasoline [kt/year] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Refinery Gross Output | 156 | | 220 | | 657 | | 1533 | | 120 | | 0 | |
| Refinery Fuel | 141 | | 0 | | 0 | | 0 | | 0 | | 0 | |
| Total Imports (Balance) | 0 | | 176 | | 88 | | 511 | | 7 | | 3 | |
| Total Exports (Balance) | 0 | | 140 | | 90 | | 563 | | 30 | | 0 | |
| International Marine Bunkers | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | |
| Stock Changes (National Territory) | 0 | | 2 | | -4 | | -3 | | 0 | | 0 | |
| Gross Inland Deliveries (Calculated) | 15 | | 286 | | 651 | | 1478 | | 97 | | 3 | |
| Statistical Differences | 0 | | 0 | | 0 | | 0 | | -1 | | 0 | |
| Gross Inland Deliveries (Observed) | 15 | | 286 | | 651 | | 1478 | | 98 | | 3 | |
| Refinery Intake (Observed) | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | |
| Non-energy use in Petrochemical industry | 0 | | 105 | | 651 | | 0 | | 0 | | 0 | |
| | Energy Use | Non Energy Use | Energy Use | Non Energy Use | Energy Use | Non Energy Use | Energy Use | Non Energy Use | Energy Use | Non Energy Use | Energy Use | Non Energy Use |
| Transformation Sector | 15 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Main Activity Producer Electricity Plants | | | | | | | | | | | | |
| Autoproducer Electricity Plants | | | | | | | | | | | | |
| Main Activity Producer CHP Plants | 15 | | 7 | | | | | | | | | |
| Autoproducer CHP Plants | | | | | | | | | | | | |
| Main Activity Producer Heat Plants | | | | | | | | | | | | |
| Autoproducer Heat Plants | | | | | | | | | | | | |
| Gas Works (Transformation) | | | | | | | | | | | | |
| For Blended Natural Gas | | | | | | | | | | | | |
| Coke Ovens (Transformation) | | | | | | | | | | | | |
| Blast Furnaces (Transformation) | | | | | | | | | | | | |
| Petrochemical Industry | | | | | | | | | | | | |
| Patent Fuel Plants (Transformation) | | | | | | | | | | | | |
| Non-specified (Transformation) | | | | | | | | | | | | |
| Energy Sector | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coal Mines | | | | | | | | | | | | |
| Oil and Gas Extraction | | | | | | | | | | | | |
| Coke Ovens (Energy) | | | | | | | | | | | | |
| Blast Furnaces (Energy) | | | | | | | | | | | | |
| Gas Works (Energy) | | | | | | | | | | | | |
| Own Use in Electricity, CHP and Heat Plants | | | | | | | | | | | | |
| Non-specified (Energy) | | | | | | | | | | | | |
| Distribution Losses | | | | | | | | | | | | |
| Total Final Consumption | 0 | 0 | 174 | 105 | 0 | 651 | 1478 | 0 | 98 | 0 | 3 | 0 |
| Transport Sector | 0 | 0 | 98 | 0 | 0 | 0 | 1478 | 0 | 98 | 0 | 3 | 0 |
| International Aviation | | | | | | | | | | | | |
| Domestic Aviation | | | | | | | | | | | 3 | |
| Road | | | 98 | | | | 1478 | | 98 | | | |
| Rail | | | | | | | | | | | | |
| Domestic Navigation | | | | | | | | | | | | |
| Pipeline Transport | | | | | | | | | | | | |
| Non-specified (Transport) | | | | | | | | | | | | |
| Industry Sector | 0 | 0 | 23 | 105 | 0 | 651 | 0 | 0 | 0 | 0 | 0 | 0 |
| Iron and Steel | | | | | | | | | | | | |
| Chemical (including Petrochemical) | | | 2 | 105 | | 651 | | | | | | |
| Non-Ferrous Metals | | | | | | | | | | | | |
| Non-Metallic Minerals | | | 2 | | | | | | | | | |
| Transport Equipment | | | 1 | | | | | | | | | |
| Machinery | | | 3 | | | | | | | | | |
| Mining and Quarrying | | | | | | | | | | | | |
| Food, Beverages and Tobacco | | | 2 | | | | | | | | | |
| Paper, Pulp and Printing | | | 1 | | | | | | | | | |
| Wood and Wood Products | | | | | | | | | | | | |
| Construction | | | 3 | | | | | | | | | |
| Textiles and Leather | | | 1 | | | | | | | | | |
| Non-specified (Industry) | | | 8 | | | | | | | | | |
| Other Sectors | 0 | 0 | 53 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Commercial and Public Services | | | 6 | | | | | | | | | |
| Residential | | | 43 | | | | | | | | | |
| Agriculture/Forestry | | | 4 | | | | | | | | | |
| Fishing | | | | | | | | | | | | |
| Non-specified (Other) | | | | | | | | | | | | |

**Tab. A4 - 5 Energy balance for liquid fuels 2015**

| LIQUID FUELS | Kerosene Type Jet Fuel [kt/year] | | Other Kerosene [kt/year] | | Transport Diesel [kt/year] | | Biodiesel [kt/year] | | Heating and Other Gasoil [kt/year] | | Residual Fuel Oil [kt/year] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Refinery Gross Output | 186 | | 0 | | 3037 | | 0 | | 137 | | 169 | |
| Refinery Fuel | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | |
| Total Imports (Balance) | 140 | | 3 | | 2191 | | 43 | | 21 | | 2 | |
| Total Exports (Balance) | 0 | | 0 | | 1043 | | 55 | | 50 | | 132 | |
| International Marine Bunkers | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | |
| Stock Changes (National Territory) | -7 | | 0 | | -1 | | -1 | | 0 | | -3 | |
| Gross Inland Deliveries (Calculated) | 319 | | 3 | | 4457 | | 264 | | 112 | | 52 | |
| Statistical Differences | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | |
| Gross Inland Deliveries (Observed) | 319 | | 3 | | 4457 | | 264 | | 112 | | 52 | |
| Refinery Intake (Observed) | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | |
| Non-energy use in Petrochemical industry | 0 | | 0 | | 0 | | 0 | | 5 | | 0 | |
| | Energy Use | Non Energy Use | Energy Use | Non Energy Use | Energy Use | Non Energy Use | Energy Use | Non Energy Use | Energy Use | Non Energy Use | Energy Use | Non Energy Use |
| Transformation Sector | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 23 | 0 |
| Main Activity Producer Electricity Plants | 0 | 0 | | | | | | | | | 5 | 0 |
| Autoproducer Electricity Plants | 0 | 0 | | | | | | | | | 0 | 0 |
| Main Activity Producer CHP Plants | 0 | 0 | | | | | | | 2 | | 10 | 0 |
| Autoproducer CHP Plants | 0 | 0 | | | | | | | 2 | | 2 | 0 |
| Main Activity Producer Heat Plants | 0 | 0 | | | | | | | | | 6 | 0 |
| Autoproducer Heat Plants | 0 | 0 | | | | | | | | | 0 | 0 |
| Gas Works (Transformation) | 0 | 0 | | | | | | | | | 0 | 0 |
| For Blended Natural Gas | 0 | 0 | | | | | | | | | 0 | 0 |
| Coke Ovens (Transformation) | 0 | 0 | | | | | | | | | 0 | 0 |
| Blast Furnaces (Transformation) | 0 | 0 | | | | | | | | | 0 | 0 |
| Petrochemical Industry | 0 | 0 | | | | | | | | | 0 | 0 |
| Patent Fuel Plants (Transformation) | 0 | 0 | | | | | | | | | 0 | 0 |
| Non-specified (Transformation) | 0 | 0 | | | | | | | | | 0 | 0 |
| Energy Sector | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coal Mines | 0 | 0 | | | 16 | | | | | | 0 | 0 |
| Oil and Gas Extraction | 0 | 0 | | | | | | | | | 0 | 0 |
| Coke Ovens (Energy) | 0 | 0 | | | | | | | | | 0 | 0 |
| Blast Furnaces (Energy) | 0 | 0 | | | | | | | | | 0 | 0 |
| Gas Works (Energy) | 0 | 0 | | | | | | | | | 0 | 0 |
| Own Use in Electricity, CHP and Heat Plants | 0 | 0 | | | | | | | | | 0 | 0 |
| Non-specified (Energy) | 0 | 0 | | | | | | | | | 0 | 0 |
| Distribution Losses | 0 | 0 | | | | | | | | | 0 | 0 |
| Total Final Consumption | 319 | 319 | 3 | 0 | 4441 | 0 | 264 | 0 | 103 | 5 | 29 | 6 |
| Transport Sector | 319 | 319 | 0 | 0 | 4061 | 0 | 264 | 0 | 84 | 0 | 0 | 0 |
| International Aviation | 285 | 285 | | | | | | | | | 0 | 0 |
| Domestic Aviation | 34 | 34 | | | | | | | | | 0 | 0 |
| Road | 0 | 0 | | | 4058 | | 264 | | | | 0 | 0 |
| Rail | 0 | 0 | | | | | | | 84 | | 0 | 0 |
| Domestic Navigation | 0 | 0 | | | 3 | | | | | | 0 | 0 |
| Pipeline Transport | 0 | 0 | | | | | | | | | 0 | 0 |
| Non-specified (Transport) | 0 | 0 | | | | | | | | | 0 | 0 |
| Industry Sector | 0 | 0 | 0 | 0 | 47 | 0 | 0 | 0 | 11 | 5 | 17 | 6 |
| Iron and Steel | 0 | 0 | | | | | | | | | 0 | 0 |
| Chemical (including Petrochemical) | 0 | 0 | | | | | | | | 5 | 2 | 6 |
| Non-Ferrous Metals | 0 | 0 | | | | | | | | | 0 | 0 |
| Non-Metallic Minerals | 0 | 0 | | | | | | | 2 | | 5 | 0 |
| Transport Equipment | 0 | 0 | | | | | | | 1 | | 0 | 0 |
| Machinery | 0 | 0 | | | | | | | 1 | | 1 | 0 |
| Mining and Quarrying | 0 | 0 | | | | | | | | | 0 | 0 |
| Food, Beverages and Tobacco | 0 | 0 | | | | | | | 1 | | 2 | 0 |
| Paper, Pulp and Printing | 0 | 0 | | | | | | | 2 | | 1 | 0 |
| Wood and Wood Products | 0 | 0 | | | | | | | 1 | | 2 | 0 |
| Construction | 0 | 0 | | | 44 | | | | 2 | | 0 | 0 |
| Textiles and Leather | 0 | 0 | | | | | | | | | 0 | 0 |
| Non-specified (Industry) | 0 | 0 | | | 3 | | | | 1 | | 4 | 0 |
| Other Sectors | 0 | 0 | 3 | 0 | 333 | 0 | 0 | 0 | 8 | 0 | 12 | 0 |
| Commercial and Public Services | 0 | 0 | | | 9 | | | | 3 | | 9 | 0 |
| Residential | 0 | 0 | | | | | | | | | 0 | 0 |
| Agriculture/Forestry | 0 | 0 | | | 316 | | | | 5 | | 3 | 0 |
| Fishing | 0 | 0 | | | | | | | | | 0 | 0 |
| Non-specified (Other) | 0 | 0 | 3 | | 8 | | | | | | 0 | 0 |

**Tab. A4 - 6 Energy balance for liquid fuels 2015**

| LIQUID FUELS | White Spirit SBP [kt/year] | Lubricants [kt/year] | Bitumen [kt/year] | Paraffin Wax [kt/year] | Petroleum Coke [kt/year] | Other Products [kt/year] |
|---|---|---|---|---|---|---|
| Refinery Gross Output | 0 | 92 | 440 | 10 | 90 | 781 |
| Refinery Fuel | 0 | 0 | 0 | 0 | 90 | 0 |
| Total Imports (Balance) | 19 | 187 | 352 | 11 | 9 | 180 |
| Total Exports (Balance) | 0 | 77 | 242 | 11 | 2 | 85 |
| International Marine Bunkers | 0 | 0 | 0 | 0 | 0 | 0 |
| Stock Changes (National Territory) | -1 | 6 | -5 | 0 | 0 | -28 |
| Gross Inland Deliveries (Calculated) | 18 | 196 | 545 | 10 | 7 | 726 |
| Statistical Differences | 0 | 0 | 0 | 0 | 0 | 0 |
| Gross Inland Deliveries (Observed) | 18 | 196 | 545 | 10 | 7 | 726 |
| Refinery Intake (Observed) | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-energy use in Petrochemical industry | 0 | 0 | 0 | 0 | 0 | 333 |

| LIQUID FUELS | White Spirit SBP Energy Use | White Spirit SBP Non Energy Use | Lubricants Energy Use | Lubricants Non Energy Use | Bitumen Energy Use | Bitumen Non Energy Use | Paraffin Wax Energy Use | Paraffin Wax Non Energy Use | Petroleum Coke Energy Use | Petroleum Coke Non Energy Use | Other Products Energy Use | Other Products Non Energy Use |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transformation Sector | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 68 |
| Main Activity Producer Electricity Plants | | | | | | | | | | | | |
| Autoproducer Electricity Plants | | | | | | | | | | | | |
| Main Activity Producer CHP Plants | | | | | | | | | | | | |
| Autoproducer CHP Plants | | | | | | | | | | | | |
| Main Activity Producer Heat Plants | | | | | | | | | | | | |
| Autoproducer Heat Plants | | | | | | | | | | | | |
| Gas Works (Transformation) | | | | | | | | | | | | |
| For Blended Natural Gas | | | | | | | | | | | | |
| Coke Ovens (Transformation) | | | | | | | | | | | | |
| Blast Furnaces (Transformation) | | | | | | | | | | | | |
| Petrochemical Industry | | | | | | | | | | | | 68 |
| Patent Fuel Plants (Transformation) | | | | | | | | | | | | |
| Non-specified (Transformation) | | | | | | | | | | | | |
| Energy Sector | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coal Mines | | | | | | | | | | | | |
| Oil and Gas Extraction | | | | | | | | | | | | |
| Coke Ovens (Energy) | | | | | | | | | | | | |
| Blast Furnaces (Energy) | | | | | | | | | | | | |
| Gas Works (Energy) | | | | | | | | | | | | |
| Own Use in Electricity, CHP and Heat Plants | | | | | | | | | | | | |
| Non-specified (Energy) | | | | | | | | | | | | |
| Distribution Losses | | | | | | | | | | | | |
| Total Final Consumption | 0 | 18 | 0 | 196 | 2 | 543 | 0 | 10 | 0 | 7 | 220 | 438 |
| Transport Sector | 0 | 0 | 0 | 157 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| International Aviation | | | | | | | | | | | | |
| Domestic Aviation | | | | | | | | | | | | |
| Road | | | | 149 | | | | | | | | |
| Rail | | | | 8 | | | | | | | | |
| Domestic Navigation | | | | | | | | | | | | |
| Pipeline Transport | | | | | | | | | | | | |
| Non-specified (Transport) | | | | | | | | | | | | |
| Industry Sector | 0 | 18 | 0 | 39 | 0 | 543 | 0 | 10 | 0 | 7 | 220 | 438 |
| Iron and Steel | | | | | | | | | | 3 | | |
| Chemical (including Petrochemical) | | 3 | | | | | | | | | 39 | 333 |
| Non-Ferrous Metals | | | | | | | | | | | | |
| Non-Metallic Minerals | | | | | | | | | | | 5 | |
| Transport Equipment | | | | | | | | | | | | |
| Machinery | | | | | | | | | | 3 | | |
| Mining and Quarrying | | | | | | | | | | | | |
| Food, Beverages and Tobacco | | | | | | | | | | | 2 | |
| Paper, Pulp and Printing | | | | | | | | | | | | |
| Wood and Wood Products | | | | | | | | | | | | |
| Construction | | | | | | 543 | | | | | 3 | |
| Textiles and Leather | | | | | | | | | | | | |
| Non-specified (Industry) | | 15 | | 39 | | | | 10 | | 1 | 171 | 105 |
| Other Sectors | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Commercial and Public Services | | | | | | | | | | | | |
| Residential | | | | | | | | | | | | |
| Agriculture/Forestry | | | | | | | | | | | | |
| Fishing | | | | | | | | | | | | |
| Non-specified (Other) | | | | | 2 | | | | | | | |

**Tab. A4 - 7 Energy balance for Natural Gas 2014 [TJ] in GCV**

| | |
|---|---|
| Indigenous Production | 9529 |
| Associated Gas | 5742 |
| Non-Associated Gas | 0 |
| Colliery Gas | 3787 |
| From Other Sources | 0 |
| Total Imports (Balance) | 286770 |
| Total Exports (Balance) | 3 |
| International Marine Bunkers | 0 |
| Stock Changes (National Territory) | 5282 |
| Inland Consumption (Calculated) | 301578 |
| Statistical Differences | 0 |
| Inland Consumption (Observed) | 301578 |
| Recoverable Gas | |
| Opening Stock Level (National Territory) | 82956 |
| Closing Stock Level (National Territory) | 77674 |
| Opening stock level (Held abroad) | 11374 |
| Closing stock level (Held abroad) | 14893 |
| Memo: | |
| Gas Vented | 0 |
| Gas Flared | 0 |
| Memo: Cushion Gas | |
| Cushion Gas Closing Stock Level | 42737 |
| Memo: From other sources | |
| From Other Sources - Oil | 0 |
| From Other Sources - Coal | 0 |
| From Other Sources - Renewables | 0 |

| | |
|---|---|
| Transformation Sector | 53620 |
| Main Activity Producer Electricity Plants | 4866 |
| Autoproducer Electricity Plants | 6 |
| Main Activity Producer CHP Plants | 21420 |
| Autoproducer CHP Plants | 1932 |
| Main Activity Producer Heat Plants | 17925 |
| Autoproducer Heat Plants | 7471 |
| Gas Works (Transformation) | 0 |
| Coke Ovens (Transformation) | 0 |
| Blast Furnaces (Transformation) | 0 |
| Gas-to-Liquids (GTL) Plants (Transformation) | 0 |
| Non-specified (Transformation) | 0 |
| Energy Sector | 4400 |
| Coal Mines | 0 |
| Oil and Gas Extraction | 139 |
| Petroleum Refineries | 4261 |
| Coke Ovens (Energy) | 0 |
| Blast Furnaces (Energy) | 0 |
| Gas Works (Energy) | 0 |
| Own Use in Electricity, CHP and Heat Plants | 0 |
| Liquefaction (LNG)/Regasification Plants | 0 |
| Gas-to-Liquids (GTL) Plants (Energy) | 0 |
| Non-specified (Energy) | 0 |
| Distribution Losses | 5371 |
| Transport Sector | 3088 |
| Road | 1667 |
| of which Biogas | 0 |
| Pipeline Transport | 1421 |
| Non-specified (Transport) | 0 |
| Industry Sector | 96678 |
| Iron and Steel | 9082 |
| Chemical (including Petrochemical) | 12694 |
| Non-Ferrous Metals | 1687 |
| Non-Metallic Minerals | 23640 |
| Transport Equipment | 6221 |
| Machinery | 12201 |
| Mining and Quarrying | 2450 |
| Food, Beverages and Tobacco | 14108 |
| Paper, Pulp and Printing | 5098 |
| Wood and Wood Products | 976 |
| Construction | 3923 |
| Textiles and Leather | 2377 |
| Non-specified (Industry) | 2221 |
| Other Sectors | 133959 |
| Commercial and Public Services | 45687 |
| Residential | 83243 |
| Agriculture/Forestry | 2300 |
| Fishing | 5 |
| Non-specified (Other) | 2724 |

# Annex 5 Any additional information, as applicable

Information provided in A5.1 – A5.2 are related to emission estimation in Energy sector.

## A5.1 Improved ratio NCV/GCV for Natural Gas

Default ratio NCV/GCV for natural gas according to the IPCC methodology (IPCC 2006) is equal to 0.9

For more accurate determination of the ratio, data set NET4GAS was used. This data set contains, among other values, NCV and GCV in MJ/m$^3$ for reference temperature of 20˚C, for each month and for the time period of 5 years (1997 to 2011). All monthly values for NCV and GCV were recalculated for temperature of 15 ˚C (i.e. trading conditions), and further it was determined annual average of the monthly values for NCV and GCV and their ratio NCV/GCV, see Tab. A5-1.

**Tab. A5 1 Annual average NCV, GCV and their ratio (determined and calculated using correlation)**

| MJ/m$^3$ | 2007 | 2008 | 2009 | 2010 | 2011 | Average | Standard deviation | %Standard deviation |
|---|---|---|---|---|---|---|---|---|
| NCV, 15 ˚C | 34.2236 | 34.2498 | 34.4267 | 34.3921 | 34.4469 | 34.3478 | 0.0927 | 0.27% |
| GCV, 15 ˚C | 37.9572 | 37.9841 | 38.1724 | 38.1363 | 38.1942 | 38.0888 | 0.0986 | 0.26% |
| Ratio NCV/GCV | 0.90164 | 0.90169 | 0.90187 | 0.90182 | 0.90189 | 0.90178 | 0.0001 | 0.01% |
| 0.001011*GCV + 0.863274 [a)] | 0.90165 | 0.90168 | 0.90187 | 0.90183 | 0.90189 | | | |

[a)] *Precise calculation of the ratio NCV/GCV*

As CzSO reports mainly yearly gross calorific values for natural gas (GCV), while data expressing net calorific value (NCV) is needed, correlation for the calculation of NCV from known values for GCV, reported every year from CzSO, was determined by linear regression, see. Fig. A5-1

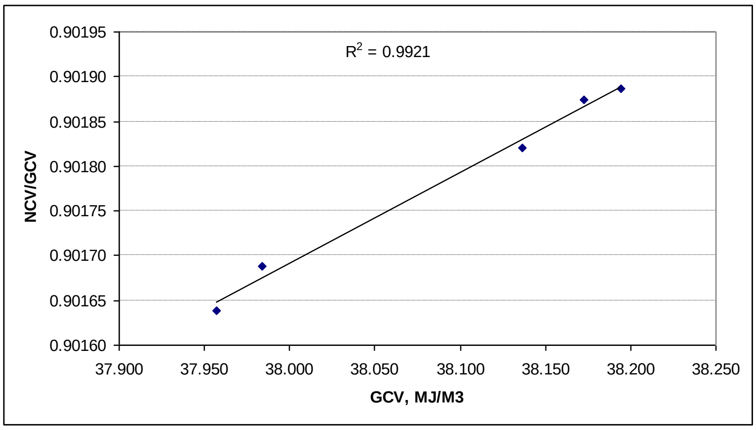



**Fig. A5 1 Regression line corresponds with the data shown in Tab. A5-1.**

The resulting equation for exact calculation of NCV from known values for GCV is:

NCV = (0.001011 * GCV + 0.863274) * GCV (A5 – 1)

where NCV and GCV are expressed in MJ/m$^3$ in the reference temperatures of 15 ˚C (i.e. trading conditions)

## A5.2 Improved ratio NCV/GCV for coke oven gas

Recommended ratio NCV/GCV for coke oven gas according to the CzSO is equal to 0.9

For more accurate determination of the ratio, the data set obtained from the one of the significant coke producer in the Czech Republic, was mostly used. This data set uses calculation sheets developed by CHMI for determination of emission factors for $CO_2$, density and NCV for gaseous fuels, calculated from its composition, etc.

This calculation sheet uses for calculation of NCV and GCV for fuels in gaseous state, calorific value and GCV, based on the weight of the individual components that are listed in regulation ČSN 38 5509 (DIN 1872), so it enables also the calculation of the ratio NCV/GCV.

Unlike in natural gas, in industrially produced fuels NCV and GCV are usually provided in reference temperature of 0˚C (273.15 K), i.e. in “normal conditions”. The same is used in the above mentioned data set. Default ratio NCV/GCV does not depend on the reference temperature, because recalculation coefficients for different reference temperatures in the ratio NCV/GCV are canceled out. The ratio NCV/GCV is calculated for each month in 2010, i.e. 12 times, from which the ratio, standard deviation and its relative value are calculated.

Results are presented in Tab. A5-2.

**Tab. A5 2 Annual averages of NCV, GCV under normal condition (i.e. 0˚C) and their ratio**

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| NCV. MJ/Nm$^3$ | 16.935 | 17.108 | 16.847 | 16.040 | 16.459 | 17.210 | 17.162 | |
| GCV, MJ/NM$^3$ | 19.053 | 19.251 | 18.953 | 18.059 | 18.530 | 19.342 | 19.270 | |
| NCV/GCV | 0.8888 | 0.8886 | 0.8889 | 0.8882 | 0.8883 | 0.8898 | 0.8906 | |
| | | | | | | | | |
| Month | 8 | 9 | 10 | 11 | 12 | Average | Standard deviation | % |
| NVC. MJ/Nm$^3$ | 17.177 | 16.832 | 17.056 | 17.218 | 17.312 | 16.946 | 0.353 | 2.1% |
| GCV, MJ/NM$^3$ | 19.309 | 18.925 | 19.183 | 19.357 | 19.443 | 19.056 | 0.386 | 2.0% |
| NCV/GCV | 0.8896 | 0.8894 | 0.8891 | 0.8895 | 0.8904 | 0.8893 | 0.0007 | 0.1% |

Average value of the ratio NCV/GCV is **0.8893** (precisely 0.88926).

In addition to this, a control calculation was conducted, based on the data obtained from another significant coke producer. Due to the incompleteness of the data in comparison with the dataset mentioned above, the ratio NCV/GCV was determined from the average of 4 values (January, April, July, October) and the value is 0.8861, which is relatively close to the more precisely identified value above.

## A5.3 Net calorific values of individual types of fuels in the period 1990-2014

Net Calorific Values (NCV) of each individual fossil fuel in the period 1990-2014 used in the Energy sector were taken from the standard CzSO Questionnaires (IEA/OECD, Eurostat, UN Questionnaires). For liquid fuels, CzSO provides for each year one net calorific value for all sectors, while for solid fuels, generally indicates three values: for 1A1, 1A2 and 1A4 which were used in the sectoral approach. In Table A5- 3 are shown for clarity aggregated values, calculated as a weighted average of these three values.

In case of solid and liquid fuels are calorific values expressed in kJ/kg. For natural gas CzSO presents primarily Gross Calorific Values (GCV) in kJ/m$^3$ (volume related to the trading conditions: 15 ° C and 101.3 kPa). Conversion GCV to NCV, derived in the Czech Hydrometeorological Institute in cooperation with KONEKO, is shown in this Annex above. For the COG (Coke Oven Gas) CzSO presents activity data directly in energy units TJ related to GCV (marked as $TJ_{Gross}$), but without GCV values for individual years. Conversion to TJ related to NCV (marked as $TJ_{Net}$), which is required for the calculation of emissions with respect to the definition of emission factors, also appears in this Annex. It is visible that the ratio NCV/GCV = 0.8893 is equal to the ratio $TJ_{Net}/TJ_{Gross.}$

In Table A5-3 are shown the net calorific values of solid and liquid fuels in the period 1990 - 2014. The symbol "NO" means, as in CRF, that the fuel was not used, “NE” symbol indicates that the value of NCV has not been estimated. Table A5-3 provides definitions of fuels used by CzSO. In most cases, these definitions of fuel are identical to the definitions of IPCC (IPCC, 2006). It is noted, however, that fuels marked as "Fuel oil - high sulfur" and "Fuel oil - low sulfur" in the table, according to the terminology of CzSO, fall according to the IPCC under "Residual Fuel Oil". Similarly fuels marked as "Road diesel" and "Heating and other gas oil" are covered by the IPCC under " Gas/Diesel Oil ".

**Tab. A5 3a Net calorific values for fossil fuels**

| NCV [kJ/kg] | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Anthracite** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 32 000 |
| **Bituminous Coal** | 19 411 | 19 229 | 21 420 | 21 655 | 21 724 | 21 907 | 22 046 | 22 233 | 23 838 | 24 072 | 21 710 | 22 205 | 23 119 |
| **Coking Coal** | 28 413 | 27 178 | 28 419 | 28 467 | 28 467 | 28 466 | 28 464 | 28 608 | 28 608 | 28 537 | 28 392 | 28 596 | 28 752 |
| **Lignite** | 12 076 | 12 062 | 12 046 | 12 075 | 12 211 | 12 496 | 12 614 | 12 112 | 12 114 | 12 824 | 12 481 | 12 443 | 12 441 |
| **Coke Oven Coke** | 27 167 | 27 177 | 27 426 | 27 375 | 27 215 | 27 216 | 27 218 | 28 225 | 28 230 | 28 688 | 28 013 | 28 502 | 28 542 |
| **Coal Tar** | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | 37 148 |
| **BKB** | 22 868 | 23 058 | 21 854 | 22 922 | 23 136 | 22 941 | 22 918 | 22 924 | 24 080 | 24 620 | 24 912 | 24 243 | 23 803 |
| **Crude oil** | 41 646 | 41 646 | 41 650 | 41 652 | 41 652 | 41 652 | 41 650 | 41 650 | 41 622 | 41 628 | 41 543 | 41 889 | 41 483 |
| **Refinery gas** | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 |
| **LPG** | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 |
| **Naphtha** | 43 300 | 43 300 | 43 300 | 43 300 | 43 300 | 43 352 | 43 416 | 43 391 | 43 709 | 43 686 | 43 669 | 42 837 | 42 858 |
| **Motor gasoline** | 43 340 | 43 332 | 43 342 | 43 340 | 43 308 | 43 320 | 43 320 | 43 300 | 43 300 | 43 300 | 43 300 | 43 300 | 43 300 |
| **Aviation gasoline** | 43 836 | 43 836 | 43 836 | 43 836 | 43 836 | 43 836 | 43 836 | 43 800 | 43 800 | 43 800 | 43 800 | 43 800 | 43 800 |
| **Biogasoline** | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 |
| **Kerosene Jet Fuel** | 43 454 | 43 454 | 43 454 | 43 454 | 43 454 | 43 445 | 43 433 | 43 116 | 43 000 | 43 000 | 43 000 | 42 800 | 42 800 |
| **Other kerosene** | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 |
| **Road diesel** | 42 503 | 42 492 | 42 505 | 42 513 | 42 513 | 42 497 | 42 506 | 42 500 | 42 505 | 42 622 | 42 571 | 41 850 | 41 832 |
| **Heating and other gas oil** | 42 300 | 42 300 | 42 300 | 42 300 | 42 300 | 42 279 | 42 310 | 42 300 | 42 300 | 42 412 | 42 461 | 41 764 | 41 748 |
| **Biodiesel** | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 |
| **Fuel oil - low sulphur** | 38 850 | 38 850 | 38 850 | 38 850 | 38 850 | 38 825 | 37 041 | 38 784 | 38 890 | 39 639 | 39 694 | 39 286 | 39 313 |
| **Fuel oil - high sulphur** | 40 700 | 40 700 | 40 700 | 40 700 | 40 700 | 40 863 | 40 804 | 40 783 | 40 775 | 40 917 | 40 893 | 39 636 | 40 316 |
| **Residential Fuel Oil** | 40 576 | 40 589 | 40 619 | 40 626 | 40 635 | 40 738 | 40 258 | 40 595 | 40 538 | 40 544 | 40 659 | 39 511 | 39 670 |
| **Petroleum coke** | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 |
| **Lubricants** | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 |
| **Bitumen** | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 |
| **Other Oil*)** | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 41 497 | 39 398 | 39 411 | 38 503 | 39 348 | 39 474 | 40 717 | 40 693 |

**) The same values of NCV as for Other products are reported by CzSO also for White spirit and SPB, Paraffin waxes, Lubricants and Bitumen*

**Tab. A5 3b Net calorific values for fossil fuels**

| NCV [kJ/kg] | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Anthracite** | 32 000 | 32 000 | 32 000 | 30 941 | 30 000 | 30 000 | 30 000 | 30 000 | 29 809 | 28 170 | 28 944 | 28 756 | 28 476 |
| **Bituminous Coal** | 23 436 | 23 292 | 22 333 | 22 390 | 23 389 | 23 418 | 22 642 | 22 985 | 23 148 | 23 657 | 23 507 | 22 387 | 21 990 |
| **Coking Coal** | 28 971 | 28 745 | 28 818 | 29 148 | 29 279 | 29 326 | 29 381 | 29 385 | 29 207 | 29 373 | 29 244 | 29 468 | 29 536 |
| **Lignite** | 12 418 | 12 605 | 12 687 | 12 793 | 12 455 | 12 615 | 12 480 | 12 527 | 12 205 | 12 331 | 12 607 | 12 084 | 11 979 |
| **Coke Oven Coke** | 28 562 | 28 024 | 27 880 | 28 631 | 28 312 | 28 344 | 28 590 | 27 888 | 27 814 | 28 204 | 28 465 | 28 571 | 28 750 |
| **Coal Tar** | 36 944 | 36 686 | 37 336 | 36 301 | 37 000 | 37 000 | 37 161 | 36 936 | 36 995 | 37 829 | 37 754 | **36 738** | 36 801 |
| **BKB** | 25 505 | 24 025 | 22 948 | 23 638 | 23 525 | 22 098 | 22 253 | 20 779 | 21 437 | 21 933 | 20 809 | 21 149 | 19 793 |
| **Crude oil** | 41 991 | 41 980 | 41 980 | 41 986 | 42 259 | 42 357 | 42 353 | 42 400 | 42 370 | 42 392 | 42 400 | 42 400 | 42 400 |
| **Refinery gas** | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 | 46 023 |
| **LPG** | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 | 45 945 |
| **Naphtha** | 42 940 | 42 841 | 42 841 | 42 841 | 43 935 | 43 951 | 43 947 | 43 961 | 43 971 | 43 993 | 43 600 | 43 600 | 43 600 |
| **Motor gasoline** | 43 300 | 43 300 | 43 300 | 43 817 | 43 800 | 43 839 | 44 165 | 44 235 | 44 308 | 44 302 | 44 315 | 44 433 | 44 487 |
| **Aviation gasoline** | 43 793 | 43 790 | 43 790 | 43 790 | 43 790 | 43 790 | 43 790 | 43 790 | 43 790 | 43 790 | 43 790 | 43 790 | 43 790 |
| **Biogasoline** | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 | 27 000 |
| **Kerosene Jet Fuel** | 42 800 | 42 800 | 42 800 | 43 300 | 43 300 | 43 300 | 43 300 | 43 300 | 43 300 | 43 300 | 43 300 | 43 300 | 43 300 |
| **Other kerosene** | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 | 42 800 |
| **Road diesel** | 41 833 | 41 839 | 41 827 | 42 760 | 42 706 | 42 760 | 42 762 | 42 753 | 42 594 | 42 599 | 42 600 | 42 600 | 42 600 |
| **Heating and other gas oil** | 41 711 | 41 718 | 41 800 | 42 600 | 42 600 | 42 600 | 42 600 | 42 600 | 42 600 | 42 600 | 42 600 | 42 600 | 42 600 |
| **Biodiesel** | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 | 37 000 |
| **Fuel oil - low sulphur** | 40 000 | 39 584 | 39 538 | 39 599 | 41 484 | 39 718 | 39 700 | 39 696 | 39 522 | 39 436 | 39 439 | 39 500 | 39 500 |
| **Fuel oil - high sulphur** | 40 371 | 40 519 | 39 869 | 39 663 | 39 758 | 39 700 | 39 695 | 39 489 | 39 427 | 39 581 | 39 500 | 39 500 | 39 500 |
| **Residential Fuel Oil** | 40 182 | 39 997 | 39 686 | 39 628 | 40 594 | 39 710 | 39 698 | 39 603 | 39 482 | 39 509 | 39 475 | 39 500 | 39 500 |
| **Petroleum coke** | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 37 500 | 38 500 | 38 500 | 38 500 | 38 500 |
| **Lubricants** | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 |
| **Bitumen** | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 | 40 193 |
| **Other Oil*)** | 40 642 | 40 787 | 40 862 | 39 337 | 39 338 | 40 007 | 40 078 | 39 831 | 40 189 | 40 350 | 40 179 | 39 921 | 39 466 |

**) The same values of NCV as for Other products are reported by CzSO also for White spirit and SPB, Paraffin waxes, Lubricants and Bitumen*

**Tab. A5 4a Net calorific values for Natural Gas**

| NCV [kJ/m$^3$] | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural Gas**) | 33 436 | 33 431 | 33 458 | 33 908 | 33 962 | 34 037 | 34 008 | 34 020 | 34 104 | 34 021 | 34 035 | 34 041 | 34 079 |

***) 15 °C, 101.3 kPa*

**Tab. A5 4b Net calorific values for Natural Gas**

| NCV [kJ/m$^3$] | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural Gas**) | 34 052 | 34 015 | 34 029 | 34 165 | 34 234 | 34 228 | 34 263 | 34 405 | 34 371 | 34 295 | 34 424 | 34 489 | 34 427 |

***) 15 °C, 101.3 kPa*

## A5.4 Oxidation factor for waste incineration (CRF Sector 5.C)

In the sector 5C equation for CO2 estimation apply OFj – oxidation factor how much carbon from total carbon content is actually oxidized. Official methodology IPCC 2006 suggested new oxidation factor for waste incineration. Change of the factor in previous methodologies is shown in Tab. A5 5a.

**Tab. A5 5a Overview of oxidation factors in IPCC methodology**

| Methodology | IPCC 1996 | GPG 2000 | IPCC 2006 |
|---|---|---|---|
| **Name** | NA | EFi | OFj |
| **Value** | NA<br>(effectively 1) | MSW: 0.95<br>CW: 0.95<br>ISW: NA<br>HW: 0.995 | MSW: 1.00<br>CW: 1.00<br>ISW: 1.00<br>HW: 1.00 |

OF set to 1 (or 100%) actually means that all carbon in fuel is incinerated. This is safe assumption that might not lead to underestimation of emission from the source category, but it will make much harder to correctly estimate uncertainty however. We argue that using less than 100% as oxidation gives much better starting point should we do proper uncertainty assessment that is planned for next submission. Also there is an existence of various measurement showing unburned carbon in bottom ash of the waste incinerator.

**Tab. A5 5b Selected studies focusing of carbon in bottom ash**

| Study | Value of TOC in bottom ash | Note |
|---|---|---|
| **Rendek E. et al 2006a** | 3.74 – 0.88 (wt %) | 5 WI facilities |
| **Ferrari S. et al 2001** | 17.3 - 6.0 g/kg | 11 WI facilities |
| **Van Zomeren , A., Comans R.N.J., 2009** | 29.4- 19.8 g/kg | 3 WWI |
| **Rendek E. et al, 2006b** | 1.5 (wt %) | Sample mix |
| **Bjurström H., 2014** | 3.9 (wt %) | Multiple samples, averaged |
| **Straka P. et al., 2014** | 0.64 – 22.06 (wt %) | 10 facilites |

National studies are limited (only one focused on unburnt carbon from biomaterials), however all the studies show that OFj is less than 1. Overview of reviewed studies is in Tab A5 5b. Please note that studies in table did reviewed several facilities an/or samples from various places. They do show consistently, that oxidation of carbon in waste (fossil or organic) is not 100%. We argue that by using default factor methodology suggest we would overestimate real emission from waste incineration, hence are using factors presented in particular chapters in NIR to produce results that have managed uncertainty of estimate.

**Related references**

André van Zomeren, Rob N.J. Comans, Carbon speciation in municipal solid waste incinerator (MSWI) bottom ash in relation to facilitated metal leaching, Waste Management, Volume 29, Issue 7, July 2009, Pages 2059-2064, ISSN 0956-053X, http://dx.doi.org/10.1016/j.wasman.2009.01.005.

Eva Rendek, Gaëlle Ducom, Patrick Germain, Assessment of MSWI bottom ash organic carbon behavior: A biophysicochemical approach, Chemosphere, Volume 67, Issue 8, April 2007, Pages 1582-1587, ISSN 0045-6535, http://dx.doi.org/10.1016/j.chemosphere.2006.11.054.

Eva Rendek, Gaëlle Ducom, Patrick Germain, Carbon dioxide sequestration in municipal solid waste incinerator (MSWI) bottom ash, Journal of Hazardous Materials, Volume 128, Issue 1, 16 January 2006, Pages 73-79, ISSN 0304-3894, http://dx.doi.org/10.1016/j.jhazmat.2005.07.033.

H. Bjurström, B.B. Lind, A. Lagerkvist, Unburned carbon in combustion residues from solid biofuels, Fuel, Volume 117, Part A, 30 January 2014, Pages 890-899, ISSN 0016-2361, http://dx.doi.org/10.1016/j.fuel.2013.10.020.

Pavel Straka, Jana Náhunková, Margit Žaloudková, Analysis of unburned carbon in industrial ashes from biomass combustion by thermogravimetric method using Boudouard reaction, Thermochimica Acta, Volume 575, 10 January 2014, Pages 188-194, ISSN 0040-6031, http://dx.doi.org/10.1016/j.tca.2013.10.033.

Stefano Ferrari, Hasan Belevi, Peter Baccini, Chemical speciation of carbon in municipal solid waste incinerator residues, Waste Management, Volume 22, Issue 3, June 2002, Pages 303-314, ISSN 0956-053X, http://dx.doi.org/10.1016/S0956-053X(01)00049-6.

## A5. 5 General quality control protocol used in NIS

The following table shows general QC form for NIR, which is used for QC procedures in each specific sector. The QC form follows the guidance provided in IPCC 2006 Gl.

**Detailed checklist for Inventory Document**

**(NIR)**

Reviewed documents: (e.g. relevant chapter in NIR)

Responsible compiler of reviewed category: ...

Persons, who carried out the controls: autocontrol – ..., control – ...

Date of finalization of control:

**Instructions for filling**

This form should be fulfilled after finalizing the whole chapter of the NIR. This form should be fulfilled in line with QA/QC plan. In case when it is not clear how to solve founded discrepancies the worker responsible for control should problematic issues discuss with the sector compiler and if needed with other relevant experts.

The table should be fulfilled according to each listed item. In the form can be added additional issues which are characteristic for the relevant chapter.

**Checklist for Inventory Document**

| Activities | Task completed | |
|---|---|---|
| | Name | Date |
| **Tables and Figures** | | |
| All numbers in tables match numbers in spreadsheets | | |
| Check that all tables have correct number of significant digits | | |
| Check alignment in columns and labels | | |
| Check that table formatting is consistent | | |
| Check that all tables and figures are updated with new data and referenced in the text | | |
| Check table and figure titles for accuracy and consistency with content | | |
| Check that figure formatting is consistent | | |
| Check that coloring of figures is consistent | | |
| Other (specify) | | |
| **Equations** | | |
| Check for consistency in equation formatting | | |
| Check that variables used in equations are defined following the equation | | |
| Other (specify) | | |
| **References** | | |
| Check consistency of references | | |
| Check that in text citations and references match | | |
| Other (specify) | | |

| | | |
|---|---|---|
| **General Format** | | |
| All acronyms and abbreviations are spelled out first time and not subsequent times throughout each chapter | | |
| All headings, titles and subheadings are kept the same as the original structure | | |
| All fonts in the text are consistent | | |
| All highlighting, notes and comments are removed from the final document | | |
| Size, style and indenting of bullets are consistent | | |
| Spell check is complete | | |
| Check the consistency in names and numbering of CRF categories | | |
| Other (specify) | | |
| **Other Issues** | | |
| Check that each section is updated with current year (or most recent year that inventory report includes) | | |
| Check that the most recent relevant IPCC methodology is used | | |
| Check that all sections and subchapters follow the provided structure | | |
| Other (specify) | | |

Notes or comments:

....

The following table shows QC form for general technical control (Tier 1). The QC form follows the guidance provided in IPCC 2006 Gl.

---

**QC form for general technical control**

**QC (Tier 1)**

Source category/ removals: (e.g. 2A Mineral Products)

Reviewed documents: (e.g. CRF Reporter, computational spreadsheet for 2A, relevant chapter in NIR)

Responsible compiler of reviewed category: ...

Persons, who carried out the controls: autocontrol – ..., control – ...

Date of finalization of control:

**Instructions for filling**

This form should be completed for each source/sink category and provides a record of the checks which were carried out and possible consequent corrections. This form should be fulfilled in line with QA/QC plan. In case when it is not clear how to solve founded discrepancies the worker responsible for control should discuss the problematic issues with the sector compiler and if needed with other relevant experts.

The first part of the form summarizes results of the controls (once completed) and highlights all significant findings or actions. The second part should be fulfilled according to each listed item. Some explanations of items are given below the checklist. For particular categories not all checks (items) will be applicable - these items are then noted as not relevant (n.r.) or not available (n.a.). This way no check and no row should be left blank or deleted. On the contrary, rows for additional checks that are relevant to the source/sink category can be added to the form.

**Summary of control results**

Overview of findings and corrections:

*description of findings*

Suggested corrections, which should be realized in the next submission:

*description of suggested corrections*

Issues remaining after the corrections:

*description of remaining issues*

**QC form for general and technical control (QC, Tier 1)**

| Item | | Checked completed | | | Corrective action | | |
|---|---|---|---|---|---|---|---|
| | | Date | Individual (first initial, last name) | Errors (Y/N) | Date | Individual (first initial, last name) | Supporting documents |
| **Input data QC** | | | | | | | |
| 1 | Cross-check activity data from each category (either measurements or parameters used in calculations) for transcription error (errors between the source of data and spreadsheets). | | | | | | |
| 2 | Check that units are properly labelled in calculation sheets. | | | | | | |
| 3 | Check that units are correctly carried through from beginning to end of calculations. | | | | | | |
| 4 | Check that conversion factors are correct. | | | | | | |
| 5 | Check that temporal and spatial adjustment factors are used correctly. | | | | | | |
| 6 | Cross-check activity data between calculation spreadsheets and **CRF** tables (and if needed in **NIR**). | | | | | | |
| 7 | Other (please specify) | | | | | | |
| **Calculation** | | | | | | | |
| 8 | Reproduce a set of emissions and removals calculations. | | | | | | |
| 9 | Use a simple approximation method that gives similar results to the original and more complex calculation to ensure that there is no data input error or calculation error. | | | | | | |
| 10 | Identify parameters (e.g., activity data, constants) that are common to multiple categories and confirm that there is consistency in the values used for these parameters in the emission/removal calculations. | | | | | | |
| 11 | Check that emissions and removals data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries (also in **CRF** tables) | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12 | Check that emissions and removals data are correctly transcribed between different intermediate products, including calculation spreasheets, **CRF** tables and **NIR** | | | | | | |
| 13 | Other (please specify) | | | | | | |
| **Database files** | | | | | | | |
| 14 | Confirm that the appropriate data processing steps are correctly represented in the database. | | | | | | |
| 15 | Confirm that data relationships are correctly represented in the database. | | | | | | |
| 16 | Ensure that data fields are properly labelled and have the correct design specifications. | | | | | | |
| 17 | Ensure that adequate documentation of database and model structure and operation are archived. | | | | | | |
| 18 | Other (please specify) | | | | | | |
| **Consistency** | | | | | | | |
| 19 | Check for temporal consistency in time series input data for each category. | | | | | | |
| 20 | Check for consistency in the algorithm/method used for calculations throughout the time series. | | | | | | |
| 21 | Check methodological and data changes resulting in recalculations. | | | | | | |
| 22 | Check that the effects of mitigation activities have been appropriately reflected in time series calculations. | | | | | | |
| 23 | Other (please specify) | | | | | | |
| **Completeness** | | | | | | | |
| 24 | Confirm that estimates are reported for all categories and for all years from the appropriate base year to the period of the current inventory. | | | | | | |
| 25 | For subcategories, confirm that entire category is being covered. | | | | | | |
| 26 | Provide clear definition of 'Other' type categories (**NIR** and spreadsheets) | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 27 | Check that known data gaps that result in incomplete estimates are documented, including a qualitative evaluation of the importance of the estimate in relation to total emissions (e.g., subcategories classified as 'not estimated'). | | | | | | |
| 28 | Other (please specify) | | | | | | |
| **Trend QC** | | | | | | | |
| 29 | For each category, current inventory estimates should be compared to previous estimates, if available. | | | | | | |
| 30 | If there are significant changes from expected trends, re-check estimates and explain any differences. | | | | | | |
| 31 | Check value of implied emission factors (aggregate emissions divided by activity data) across time series. | | | | | | |
| 32 | Do any years show outliers that are not explained? | | | | | | |
| 33 | If they remain static across time series, are changes in emissions or removals being captured? | | | | | | |
| 34 | Check if there are any unusual and unexplained trends noticed for activity data or other parameters across the time series. | | | | | | |
| 35 | Other (please specify) | | | | | | |
| **Data documentation (NIR + DATA)** | | | | | | | |
| 36 | Check of data file (e.g. importing tables) from the view of completeness | | | | | | |
| 37 | Confirm that bibliographical data references are properly cited in the internal documentation | | | | | | |
| 38 | Check of the references on source of input data in the spreadsheets | | | | | | |
| 39 | Check that all references in spreadsheets are documented | | | | | | |
| 40 | Check of completeness of references on the sources of input data in the computational spreadsheets | | | | | | |
| 41 | Random check of referred materials, if they really contains referred data | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 42 | Check that assumptions and criteria for the selection of activity data, emission factors and other estimation parameters are properly recorded and archived. | | | | | | |
| 43 | Check that the changes in data or methodology (e.g. recalculations) are described and documented | | | | | | |
| 44 | Check that quotes are realized uniformly | | | | | | |
| 45 | Other (please specify) | | | | | | |

*Explanations of some items:*

*5. Spatial adjustment factors refer to factors used to adjust average data, obtained from one or more locations within the Member State to national average data.*

*22. Check that effects of actions/activities taken to avoid or minimize environmental damage are considered and reflected in time series.*

**General notes to controls**

*description*

**Notes for each parts and founded issues**

*notes which are needed to add in order to finish adequate control*

The following table shows QC form for category – specific technical control (QC Tier 2). The QC form follows the guidance provided in IPCC 2006 Gl.

**QC form for category-specific technical control**

**QC (Tier 2)**

Source category/ removals: (e.g. 2A Mineral Products)

Reviewed documents: (e.g. CRF Reporter, computational spreadsheet for 2A, relevant chapter in NIR)

Responsible compiler of reviewed category: ...

Persons, who carried out the controls: autocontrol – ..., control – ...

Date of finalization of control:

**Instructions for filling**

This form should be completed for key categories or categories where significant methodological and data revision have taken place and provides a record of the checks which were carried out and possible consequent corrections. This form should be fulfilled in line with QA/QC plan. In case when it is not clear how to solve founded discrepancies the worker responsible for control should problematic issues discuss with the sector compiler and if needed with other relevant experts.

The first part of the form summarizes results of the controls (once completed) and highlights all significant findings or actions. The second part should be fulfilled according to each listed item. Some explanations of items are given below the checklist. For particular categories not all checks (items) will be applicable - these items are then noted as not relevant (n.r.) or not available (n.a.). This way no check and no row should be left blank or deleted. On the contrary, rows for additional checks that are relevant to the source/sink category can be added to the form.

**Summary of control results**

Overview of findings and corrections:

*description of findings*

Suggested corrections, which should be realized in the next submission:

*description of suggested corrections*

Issues remaining after the corrections:

*description of remaining issues*

**QC form for category-specific and technical control (QC, Tier 2)**

| Item | | Checked completed | | | Corrective action | | |
|---|---|---|---|---|---|---|---|
| | | Date | Individual (first initial, last name) | Errors (Y/N) | Date | Individual (first initial, last name) | Supporting documents |
| **EMISSION DATA QUALITY CHECKS** | | | | | | | |
| 1 | Are emission comparisons for historical data source performed | | | | | | |
| 2 | Are emission comparisons for significant sub-source categories performed | | | | | | |
| 3 | If applicable, are checks against independent estimates or estimates based on alternative methods performed | | | | | | |
| 4 | Are reference calculations performed | | | | | | |
| 5 | Is completeness check performed | | | | | | |
| 6 | Other (detailed checks) | | | | | | |
| **EMISSION FACTOR QUALITY CHECKS** | | | | | | | |
| **IPCC default emission factors** | | | | | | | |
| 7 | Are the national conditions comparable to the context of the IPCC default emission factors study | | | | | | |
| 8 | Are default IPCC factors compared with site or plant-level factors | | | | | | |
| **Country-specific emission factors** | | | | | | | |
| ***QC on models*** | | | | | | | |
| 9 | Are the model assumptions appropriate and applicable to the GHG inventory methods and national circumstances | | | | | | |
| 10 | Are the extrapolations/interpolations appropriate and applicable to the GHG inventory methods and national circumstances | | | | | | |
| 11 | Are the calibration-based modifications appropriate and applicable to the GHG inventory methods and national circumstances | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12 | Are the data characteristics appropriate and applicable to the GHG inventory methods and national circumstances | | | | | | |
| 13 | Are the model documentation (including descriptions, assumptions, rationale, and scientific evidence and references supporting the approach and parameters used for modelling) available | | | | | | |
| 14 | Are model validation steps performed by model developers and data suppliers | | | | | | |
| 15 | Are QA/QC procedures performed by model developers and data suppliers | | | | | | |
| 16 | Are the responses to these results documented | | | | | | |
| 17 | Are plans to periodically evaluate and update or replace assumptions with appropriate new measurements prepared | | | | | | |
| 18 | Is there completeness in relation to the IPCC source/sink categories | | | | | | |
| | ***Comparisons*** | | | | | | |
| 19 | Are country-specific factors compared with IPCC default factors | | | | | | |
| 20 | Is comparison between countries, including historical trends, min and max value, base and most recent year value, IEF performed | | | | | | |
| 21 | If applicable, is comparison to plant-level emission factors performed | | | | | | |
| 22 | Other (detailed checks) | | | | | | |
| **ACTIVITY DATA QUALITY CHECKS** | | | | | | | |
| | **National level activity data** | | | | | | |
| 23 | Are alternative activity data sets based on independent data available | | | | | | |
| 24 | Were comparisons with independently compiled data sets performed | | | | | | |
| 25 | Were the national data compared with extrapolated samples or partial data at sub-national level | | | | | | |
| 26 | Was a historical trend check performed | | | | | | |
| 27 | Are any sharp increases/decreases detected and checked for calculation errors | | | | | | |
| 28 | Are any sharp increases/decreases explained and documented | | | | | | |
| | **Site-specific activity data** | | | | | | |
| 29 | Are there any inconsistencies between the sites | | | | | | |
| 30 | If yes, was a QC check performed to identify the cause of the inconsistency (errors, different measurement techniques or real differences in emissions, operating conditions or technology) | | | | | | |
| 31 | Are the activity data compared between different reference sources and geographic scales (national production statistics vs. aggregated activity data) | | | | | | |
| 32 | Are the differences explained | | | | | | |
| 33 | If applicable, is a comparison between bottom up (site-specific) and top down (national level) account balance performed | | | | | | |
| 34 | Are large differences explained | | | | | | |
| 35 | Other (please specify) | | | | | | |
| **CALCULATION RELATED QUALITY CHECKS** | | | | | | | |
| 36 | Are checks of the calculation algorithm (duplications, unit conversion, calculation errors) performed | | | | | | |
| 37 | Are the calculations reproducible | | | | | | |
| 38 | Are all calculation procedures recorded | | | | | | |
| 39 | Other (please specify) | | | | | | |

*Explanations of some items:*

*3. For example comparisons can be made to similar statistics prepared by FAO (for agriculture), IEA (for energy) etc.*

*8. Compare IPCC default emission factors with site or plant-level factor to determine their representativeness relative to actual sources in the country. This check is good practice even if data are only available for a small percentage of sites or plants.*

*18. If the model computes and comprises all data covered/required by the IPCC category.*

*19. Comparison should be made, taking into consideration the characteristics and properties on which the default factors are based. The intent is to determine whether country-specific factors are reasonable, given the similarities or differences between the national category and the "average" category, represented by the default.*

*25. For example, if national production data are being used to calculate the inventory, it may also be possible to obtain plant-specific production or capacity data for a subset of the total population of plants. The effectiveness of this check depends on how representative the sub-sample is of the national population, and how well the extrapolation technique captures the national population.*

**General notes to controls**

*description*

**Notes for each parts and founded issues**

*notes which are needed to add in order to finish adequate control*

## A5. 6Completeness check form used for controlling of data in CRF Reporter

Following table is presenting example of form used for completeness evaluation for all sectors. The table contain also comments by expert in case the completeness function is not working properly. Following shortcuts have been used:

| | |
|---|---|
| COMPLETED | C |
| PARTLY COMPLETED | P |
| INCOMPLETE | I |
| MISSING | M |

**Tab. A5 – 6 Completeness check for Waste sector (2015)**

| Waste | | 15 May check | 19 October check | Comment by expert |
|---|---|---|---|---|
| 5 | Waste | i | p | complete |
| 5.A | Solid waste disposal | c | p | complete |
| 5.A.1 | Managed waste disposal sites | c | p | complete |
| 5.A.1.a | Anaerobic | c | p | complete |
| 5.A.1.b | Semi-aerobic | c | c | |
| 5.A.2 | Unmanaged waste disposal sites | c | c | |
| 5.A.3 | Uncategorised waste disposal sites | c | c | |
| 5.B | Biological treatment of solid waste | c | p | complete |
| 5.B.1 | Composting | c | p | complete |
| 5.B.1.a | Municipal solid waste | c | c | |
| 5.B.1.b | Other | c | i | complete |
| 5.B.2 | Anaerobic digestion at biogas facilities | c | p | complete |
| 5.B.2.a | Municipal solid waste | c | p | complete |
| 5.B.2.b | Other | c | i | complete |
| 5.C | Incineration and open burning of waste | c | p | complete |
| 5.C.1 | Waste incineration | c | p | complete |
| 5.C.1.1 | Biogenic | c | p | complete |
| 5.C.1.1.a | Municipal solid waste | c | p | complete |
| 5.C.1.1.b | Other | c | i | complete |
| 5.C.1.2 | Non-biogenic | c | p | complete |
| 5.C.1.2.a | Municipal solid waste | c | p | complete |
| 5.C.1.2.b | Other | c | c | |
| | Hazardous waste | | c | |
| 5.C.2 | Open burning of waste | c | c | |
| 5.C.2.1 | Biogenic | c | c | |
| 5.C.2.1.a | Municipal solid waste | c | c | |
| 5.C.2.1.b | Other | c | i | complete |
| 5.C.2.2 | Non-biogenic | c | c | |
| 5.C.2.2.a | Municipal solid waste | c | c | |
| 5.C.2.2.b | Other | c | i | complete |
| 5.D | Wastewater treatment and discharge | i | p | complete |
| 5.D.1 | Domestic wastewater treatment and discharge | c | c | |
| 5.D.2 | Industrial waste water and discharge | c | p | complete |
| 5.D.3 | Other | i | i | complete |
| 5.E | Other | c | i | complete |
| 5.F | Memo Items | c | p | complete |
| 5.F.1 | Long-term Storage of C in Waste Disposal Sites | c | c | |
| 5.F.2 | Annual Change in Total Long-term C Storage | c | c | |
| 5.F.3 | Annual Change in Total Long-term C Storage in HWP Waste | c | p | complete |

The following tables shows categories that are not estimated (NE) including relevant explanations of the reasons. Categories that are included elsewhere (IE) are shown in similar way.

# A5. 7 Additional information to be considered as part of the annual inventory submission and the supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol or other useful reference information

Standard electronic format (SEF) tables

**SEF Table 1**

| | |
|---|---|
| Party | Czech Republic |
| Submission Year | 2017 |
| Reported Year | 2016 |
| Commitment Period | 2 |

**Table 1. Total quantities of Kyoto Protocol units by account type at beginning of reported year**

| | Account type | Unit type | | | | | |
|---|---|---|---|---|---|---|---|
| | | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
| 1 | Party holding accounts | NO | NO | NO | NO | NO | NO |
| 2 | Entity holding accounts | NO | NO | NO | NO | NO | NO |
| 3 | Retirement account | NO | NO | NO | NO | NO | NO |
| 4 | Previous period surplus reserve account | NO | | | | | |
| 5 | Article 3.3/3.4 net source cancellation accounts | NO | NO | NO | NO | | |
| 6 | Non-compliance cancellation account | NO | NO | NO | NO | | |
| 7 | Voluntary cancellation account | NO | NO | NO | NO | NO | NO |
| 8 | Cancellation account for remaining units after carry-over | NO | NO | NO | NO | NO | NO |
| 9 | Article 3.1 ter and quater ambition increase cancellation account | NO | | | | | |
| 10 | Article 3.7 ter cancellation account | NO | | | | | |
| 11 | tCER cancellation account for expiry | | | | | NO | |
| 12 | lCER cancellation account for expiry | | | | | | NO |
| 13 | lCER cancellation account for reversal of storage | | | | | | NO |
| 14 | lCER cancellation account for non-submission of certification report | | | | | | NO |
| 15 | tCER replacement account for expiry | NO | NO | NO | NO | NO | |
| 16 | lCER replacement account for expiry | NO | NO | NO | NO | | |
| 17 | lCER replacement account for reversal of storage | NO | NO | NO | NO | | NO |
| 18 | lCER replacement account for non-submission of certification report | NO | NO | NO | NO | | NO |
| 19 | Total | NO | NO | NO | NO | NO | NO |

### SEF Table 2A

| | |
|---|---|
| **Party** | Czech Republic |
| **Submission Year** | 2017 |
| **Reported Year** | 2016 |
| **Commitment Period** | 2 |

**Table 2a. Annual internal transactions**

| Transaction type | Additions | | | | | | Subtractions | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AAUs | ERUs | RMUs | CERs | tCERs | lCERs | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
| **Art6 issuance and conversion** | | | | | | | | | | | | |
| **Party verified projects** | | NO | | | | | NO | | NO | | | |
| **Independently verified projects** | | NO | | | | | NO | | NO | | | |
| **Art3.3 and 3.4 issuance or cancellation** | | | | | | | | | | | | |
| **3.3 Afforestation reforestation** | | | NO | | | | NO | NO | NO | NO | | |
| **3.3 Deforestation** | | | NO | | | | NO | NO | NO | NO | | |
| **3.4 Forest management** | | | NO | | | | NO | NO | NO | NO | | |
| **3.4 Cropland management** | | | NO | | | | NO | NO | NO | NO | | |
| **3.4 Grazing land management** | | | NO | | | | NO | NO | NO | NO | | |
| **3.4 Revegetation** | | | NO | | | | NO | NO | NO | NO | | |
| **3.4 Wetland drainage and rewetting** | | | NO | | | | NO | NO | NO | NO | | |
| **Art 12 afforestation and reforestation** | | | | | | | | | | | | |
| **Replacement of expired tCERs** | | | | | | | NO | NO | NO | NO | NO | |
| **Replacement of expired lCERs** | | | | | | | NO | NO | NO | NO | | |
| **Replacement for reversal of storage** | | | | | | | NO | NO | NO | NO | | NO |
| **Cancellation for reversal of storage** | | | | | | | | | | | | NO |
| **Replacement for non-submission of certification report** | | | | | | | NO | NO | NO | NO | | NO |
| **Cancellation for non submission of certification report** | | | | | | | | | | | | NO |
| **Other cancelation** | | | | | | | | | | | | |
| **Voluntary cancellation** | | | | | | | NO | NO | NO | NO | NO | NO |
| **Article 3.1 ter and quater ambition increase cancellation** | | | | | | | NO | | | | | |
| **Subtotal** | | NO | NO | | | | NO | NO | NO | NO | NO | NO |

| Transaction type | Retirement | | | | | |
|---|---|---|---|---|---|---|
| | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
| **Retirement** | NO | NO | NO | NO | NO | NO |
| **Retirement from PPSR** | NO | | | | | |
| **Total** | NO | NO | NO | NO | NO | NO |

### SEF Table 2BC

| | |
|---|---|
| **Party** | Czech Republic |
| **Submission Year** | 2017 |
| **Reported Year** | 2016 |
| **Commitment Period** | 2 |

**Table 2b. Annual external transactions**

| | Additions | | | | | | Subtractions | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total transfers and acquisitions** | **AAUs** | **ERUs** | **RMUs** | **CERs** | **tCERs** | **lCERs** | **AAUs** | **ERUs** | **RMUs** | **CERs** | **tCERs** | **lCERs** |
| **Subtotal** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

**Table 2c. Annual transactions between PPSR accounts**

| | AAUs | ERUs | RMUs | CERs | tCERs | lCERs | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Subtotal** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

**Table 2d. Share of proceeds transactions under decision 1/CMP.8, paragraph 21 - Adaptation Fund**

| | AAUs | ERUs | RMUs | CERs | tCERs | lCERs | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **First international transfers of AAUs** | NO | | | | | | NO | | | | | |
| **Issuance of ERU from Party-verified projects** | | NO | | | | | | NO | | | | |
| **Issuance of independently verified ERUs** | | NO | | | | | | NO | | | | |

**Table 2e. Total annual transactions**

| | AAUs | ERUs | RMUs | CERs | tCERs | lCERs | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total (Sum of sub-totals in table 2a and table 2b)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

## SEF Table 3

| | |
|---|---|
| Party | Czech Republic |
| Submission Year | 2017 |
| Reported Year | 2016 |
| Commitment Period | 2 |

**Table 3. Expiry, cancellation and replacement**

| Transaction or event type | Requirement to replace or cancel | | | Replacement | | | | | | Cancellation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transaction or event type | tCERs | lCERs | CERs | AAUs | ERUs | RMUs | CERs | tCERs | lCERs | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
| Temporary CERs | | | | | | | | | | | | | | | |
| Expired in retirement and replacement accounts | NO | | | NO | NO | NO | NO | NO | | | | | | | |
| Expired in holding accounts | NO | | | | | | | | | | | | | NO | |
| Long-term CERs | | | | | | | | | | | | | | | |
| Expired in retirement and replacement accounts | | NO | | NO | NO | NO | NO | | | | | | | | |
| Expired in holding accounts | | NO | | | | | | | | | | | | | NO |
| Subject to reversal of Storage | | NO | | NO | NO | NO | NO | | NO | | | | | | NO |
| Subject to non submission of certification Report | | NO | | NO | NO | NO | NO | | NO | | | | | | NO |
| Carbon Capture and Storage CERs | | | | | | | | | | | | | | | |
| Subject to net reversal of storage | | | NO | | | | | | | NO | NO | NO | NO | | |
| Subject to non submission of certification report | | | NO | | | | | | | NO | NO | NO | NO | | |
| Total | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

## SEF Table 4

| | |
|---|---|
| Party | Czech Republic |
| Submission Year | 2017 |
| Reported Year | 2016 |
| Commitment Period | 2 |

**Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year**

| Account type | Unit type | | | | | |
|---|---|---|---|---|---|---|
| | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
| Party holding accounts | NO | NO | NO | NO | NO | NO |
| Entity holding accounts | NO | NO | NO | NO | NO | NO |
| Retirement account | NO | NO | NO | NO | NO | NO |
| Previous period surplus reserve account | NO | | | | | |
| Article 3.3/3.4 net source cancellation accounts | NO | NO | NO | NO | | |
| Non-compliance cancellation account | NO | NO | NO | NO | | |
| Voluntary cancellation account | NO | NO | NO | NO | NO | NO |
| Cancellation account for remaining units after carry-over | NO | NO | NO | NO | NO | NO |
| Article 3.1 ter and quater ambition increase cancellation account | NO | | | | | |
| Article 3.7 ter cancellation account | NO | | | | | |
| tCER cancellation account for expiry | | | | | NO | |
| lCER cancellation account for expiry | | | | | | NO |
| lCER cancellation account for reversal of storage | | | | | | NO |
| lCER cancellation account for non-submission of certification report | | | | | | NO |
| tCER replacement account for expiry | NO | NO | NO | NO | NO | |
| lCER replacement account for expiry | NO | NO | NO | NO | | |
| lCER replacement account for reversal of storage | NO | NO | NO | NO | | NO |
| lCER replacement account for non-submission of certification report | NO | NO | NO | NO | | NO |
| Total | NO | NO | NO | NO | NO | NO |

## SEF Table 5ABCDE

| | |
|---|---|
| Party | Czech Republic |
| Submission Year | 2017 |
| Reported Year | 2016 |
| Commitment Period | 2 |

### Table 5a. Summary information on additions and subtractions

| | Additions | | | | | | Subtractions | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AAUs | ERUs | RMUs | CERs | tCERs | lCERs | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
| Assigned amount units issued | NO | | | | | | | | | | | |
| Article 3 Paragraph 7 ter cancellations | | | | | | | NO | | | | | |
| Cancellation following increase in ambition | | | | | | | NO | | | | | |
| Cancellation of remaining units after carry over | | | | | | | NO | NO | NO | NO | NO | NO |
| Non-compliance cancellation | | | | | | | NO | NO | NO | NO | | |
| Carry-over | | NO | | NO | | | | NO | | NO | | |
| Carry-over to PPSR | NO | | | | | | NO | | | | | |
| Total | NO | NO | | NO | | | NO | NO | NO | NO | NO | NO |

### Table 5b. Summary information on annual transactions

| | Additions | | | | | | Subtractions | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AAUs | ERUs | RMUs | CERs | tCERs | lCERs | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
| Year 1 (2013) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 2 (2014) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 3 (2015) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 4 (2016) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 5 (2017) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 6 (2018) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 7 (2019) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 8 (2020) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2021 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2022 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2023 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Total | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

### Table 5c. Summary information on annual transactions between PPSR accounts

| | Additions | | | | | | Subtractions | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AAUs | ERUs | RMUs | CERs | tCERs | lCERs | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
| Year 1 (2013) | NO | | | | | | NO | | | | | |
| Year 2 (2014) | NO | | | | | | NO | | | | | |
| Year 3 (2015) | NO | | | | | | NO | | | | | |
| Year 4 (2016) | NO | | | | | | NO | | | | | |
| Year 5 (2017) | NO | | | | | | NO | | | | | |
| Year 6 (2018) | NO | | | | | | NO | | | | | |
| Year 7 (2019) | NO | | | | | | NO | | | | | |
| Year 8 (2020) | NO | | | | | | NO | | | | | |
| 2021 | NO | | | | | | NO | | | | | |
| 2022 | NO | | | | | | NO | | | | | |
| 2023 | NO | | | | | | NO | | | | | |
| Total | NO | | | | | | NO | | | | | |

### Table 5d. Summary information on expiry, cancellation and replacement

| | Requirement to replace or cancel | | | Replacement | | | | | | Cancellation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | tCERs | lCERs | CERs | AAUs | ERUs | RMUs | CERs | tCERs | lCERs | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
| Year 1 (2013) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 2 (2014) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 3 (2015) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 4 (2016) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 5 (2017) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 6 (2018) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 7 (2019) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Year 8 (2020) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2021 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2022 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2023 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Total | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

### Table 5e. Summary information on retirement

| | AAUs | ERUs | RMUs | CERs | tCERs | lCERs |
|---|---|---|---|---|---|---|
| Year 1 (2013) | NO | NO | NO | NO | NO | NO |
| Year 2 (2014) | NO | NO | NO | NO | NO | NO |
| Year 3 (2015) | NO | NO | NO | NO | NO | NO |
| Year 4 (2016) | NO | NO | NO | NO | NO | NO |
| Year 5 (2017) | NO | NO | NO | NO | NO | NO |
| Year 6 (2018) | NO | NO | NO | NO | NO | NO |
| Year 7 (2019) | NO | NO | NO | NO | NO | NO |
| Year 8 (2020) | NO | NO | NO | NO | NO | NO |
| 2021 | NO | NO | NO | NO | NO | NO |
| 2022 | NO | NO | NO | NO | NO | NO |
| 2023 | NO | NO | NO | NO | NO | NO |
| Total | NO | NO | NO | NO | NO | NO |

**SEF Table 6ABC**

| | |
|---|---|
| **Party** | Czech Republic |
| **Submission Year** | 2017 |
| **Reported Year** | 2016 |
| **Commitment Period** | 2 |

**Table 6a. Memo item: corrective transactions relating to additions and subtractions**

| **Additions** | | | | | | **Subtractions** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **AAUs** | **ERUs** | **RMUs** | **CERs** | **tCERs** | **lCERs** | **AAUs** | **ERUs** | **RMUs** | **CERs** | **tCERs** | **lCERs** |

**Table 6b. Memo item: corrective transactions relating to replacement**

| **Expiry, cancellation and requirement to replace** | | **Replacement** | | | | | |
|---|---|---|---|---|---|---|---|
| **tCERs** | **lCERs** | **AAUs** | **ERUs** | **RMUs** | **CERs** | **tCERs** | **lCERs** |

**Table 6c. Memo item: corrective transactions relating to retirement**

| **Retirement** | | | | | |
|---|---|---|---|---|---|
| **AAUs** | **ERUs** | **RMUs** | **CERs** | **tCERs** | **lCERs** |

**Fig. A7 1 Annex A – CP2 SEF Tables**

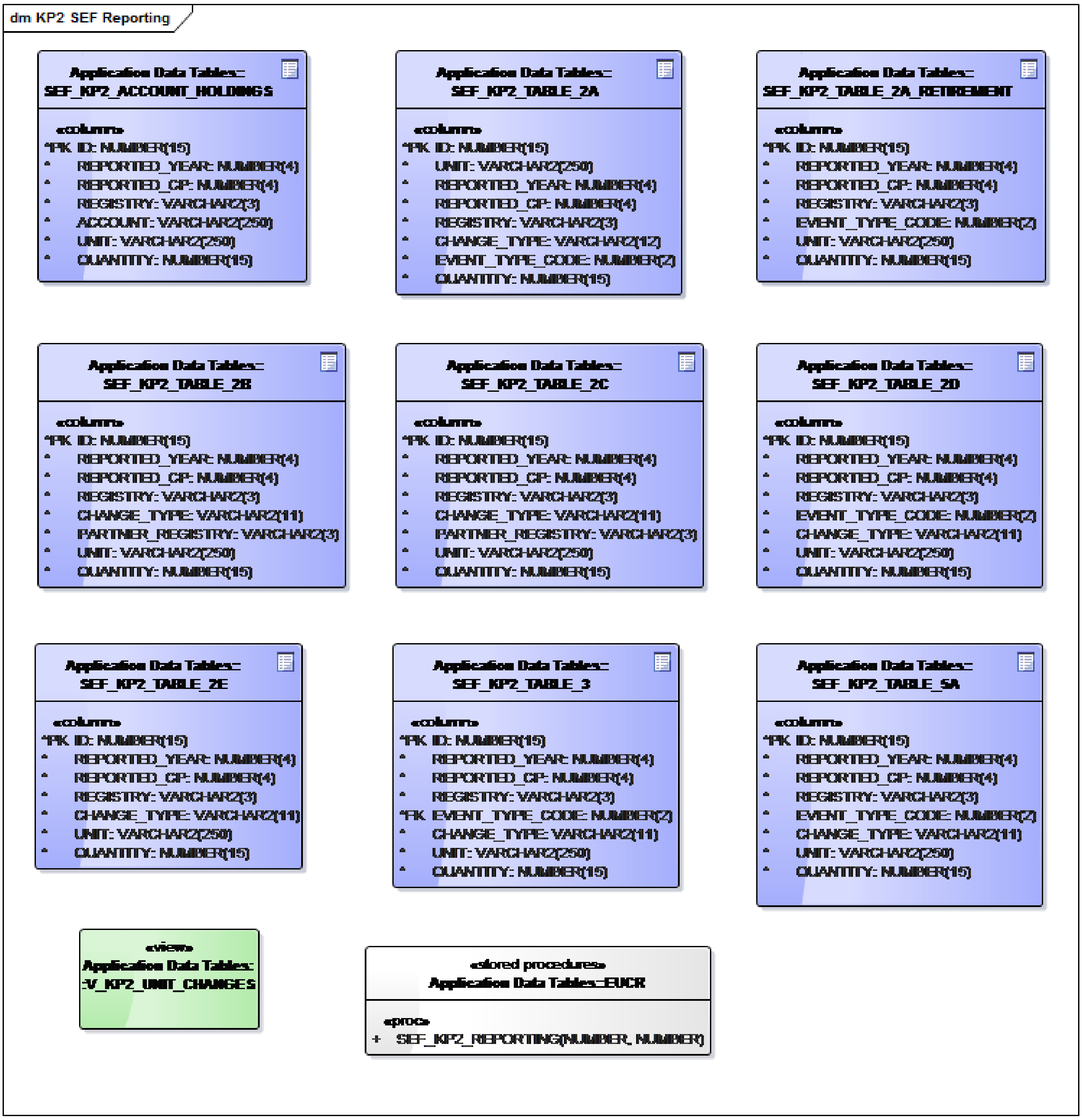
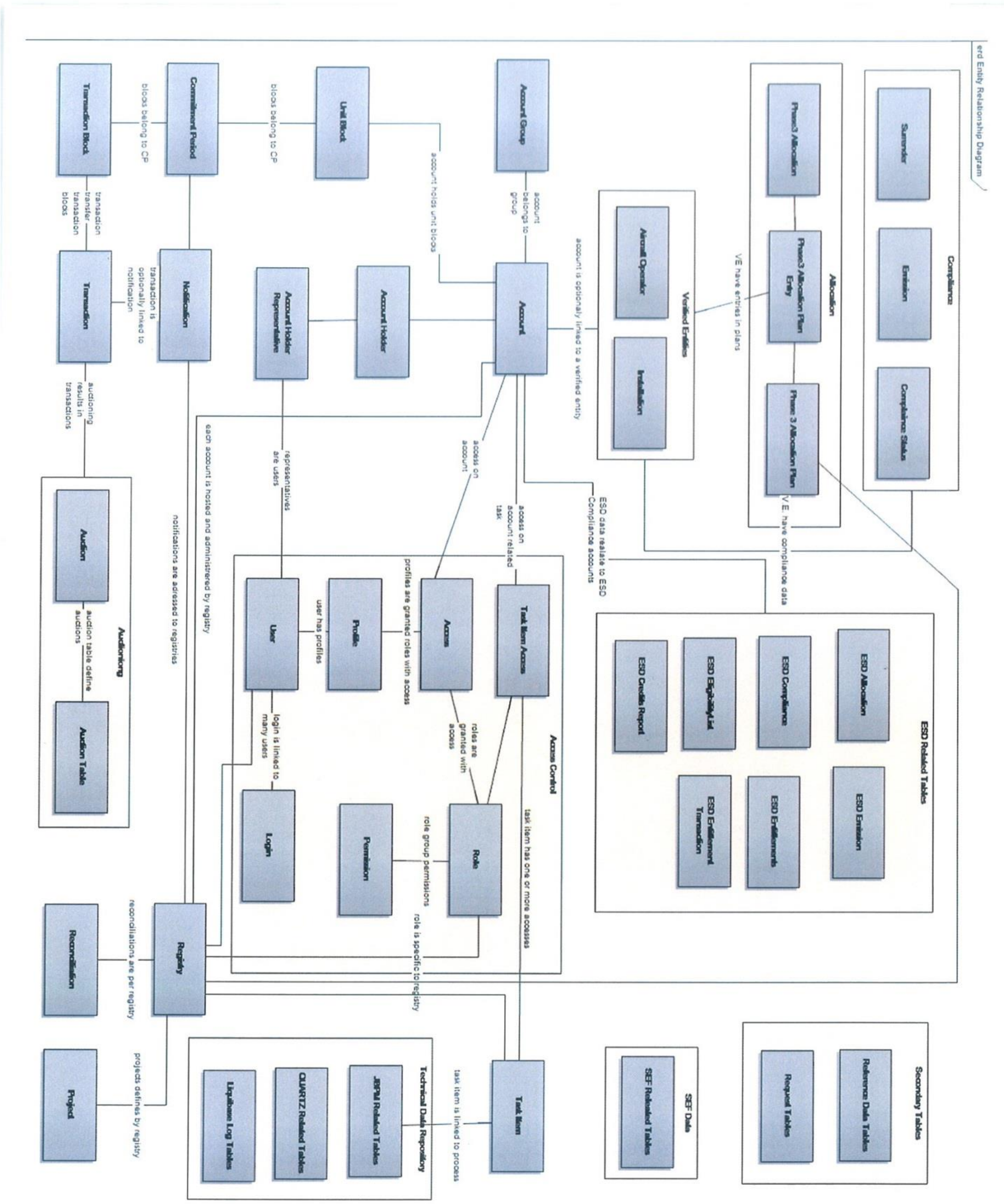


**Fig. A7 2 Annex A - CSEUR**



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