

# NATIONAL GREENHOUSE GAS INVENTORY REPORT OF THE CZECH REPUBLIC

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*SUBMISSION UNDER THE UNFCCC AND UNDER THE KYOTO PROTOCOL*

*REPORTED INVENTORIES 1990-2015*



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Ministry of the Environment of the  
Czech Republic

Elaborated by institutions involved in National Inventory System:

KONEKO, CDV, CHMI, IFER, CUEC  
with contribution of MoE and OTE

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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<sup>th</sup> March to European Commission and by 15<sup>th</sup> 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<sub>2</sub> contributing 81.63% to total national GHG emissions and removals expressed in CO<sub>2</sub> eq., followed by CH<sub>4</sub> 10.77% and N<sub>2</sub>O 4.81%. PFCs, HFCs, SF<sub>6</sub> and NF<sub>3</sub> 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 <sub>2</sub> eq.]		%		
CO <sub>2</sub> emissions without net CO <sub>2</sub> from LULUCF	161649.59	103769.75	82.55	81.63	-35.81
CO <sub>2</sub> emissions with net CO <sub>2</sub> from LULUCF	155024.01	97034.34	81.88	80.54	-37.41
CH <sub>4</sub> emissions without CH <sub>4</sub> from LULUCF	23450.87	13694.48	11.98	10.77	-41.60
CH <sub>4</sub> emissions with CH <sub>4</sub> from LULUCF	23568.21	13776.39	12.45	11.43	-41.55
N <sub>2</sub> O emissions without N <sub>2</sub> O from LULUCF	10642.52	6112.73	5.43	4.81	-42.56
N <sub>2</sub> O emissions with N <sub>2</sub> O from LULUCF	10663.05	6125.54	5.63	5.08	-42.55
F-gases	84.10	3549.88	0.04	2.79	
<b>Total (without LULUCF)</b>	<b>195827.08</b>	<b>127126.83</b>			<b>-35.08</b>
<b>Total (with LULUCF)</b>	<b>189339.37</b>	<b>120486.14</b>			<b>-36.36</b>
<b>Total (without LULUCF, with indirect)</b>	<b>197948.82</b>	<b>127925.53</b>			<b>-35.37</b>
<b>Total (with LULUCF, with indirect)</b>	<b>191461.11</b>	<b>121284.84</b>			<b>-36.65</b>

Over the period 1990 - 2015 CO<sub>2</sub> emissions and removals decreased by 37.41%, CH<sub>4</sub> emissions decreased by 41.55% during the same period mainly due to lower emissions from 1 Energy, 3 Agriculture and 5 Waste; N<sub>2</sub>O 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<sub>6</sub> emissions kept steady trend over the whole period.

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

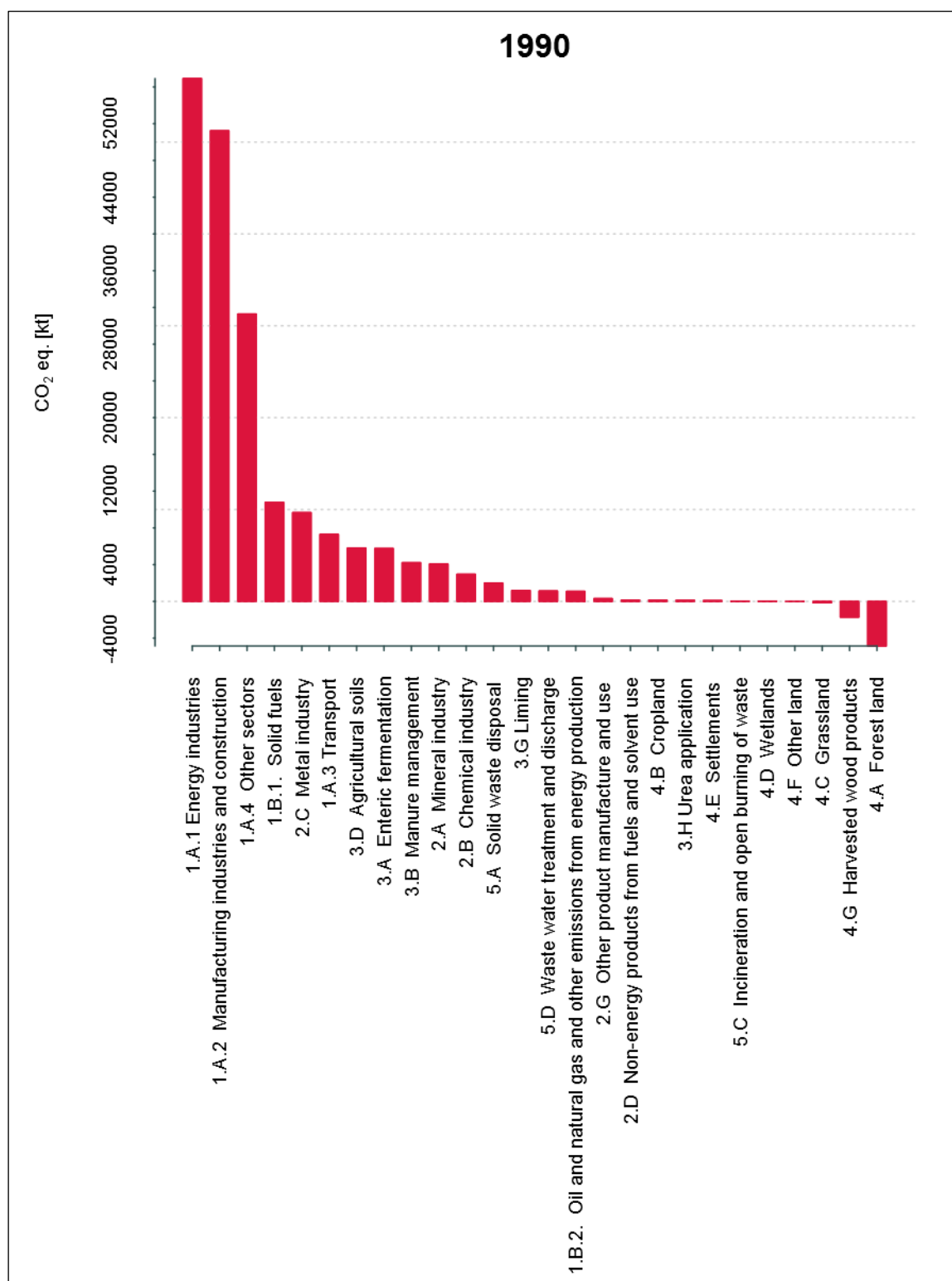


Fig. ES 1 Sources and sinks of greenhouse gases in 1990 (kt CO<sub>2</sub> eq.)

## 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 <sub>2</sub> eq.	kt CO <sub>2</sub> eq.	Total share [%]	Sectoral share [%]	%
<b>1. Energy</b>	<b>158569.9</b>	<b>97973.6</b>	<b>81.32</b>	<b>100</b>	<b>-38.21</b>
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 <sub>2</sub> transport and storage	NO	NO	NO	NO	0
<b>2. Industrial Processes</b>	<b>17080.368</b>	<b>15413.84</b>	<b>12.79</b>	<b>100</b>	<b>-9.76</b>
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
<b>3. Agriculture</b>	<b>17049.98</b>	<b>8482.99</b>	<b>7.04</b>	<b>100</b>	<b>-50.25</b>
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
<b>4. Land use, land-use change and forestry</b>	<b>-6487.71</b>	<b>-6640.69</b>	<b>-5.51</b>	<b>100</b>	<b>2.36</b>
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
<b>5. Waste</b>	<b>3126.83</b>	<b>5256.41</b>	<b>4.36</b>	<b>100</b>	<b>68.11</b>
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		
<b>Total CO<sub>2</sub> equivalent emissions without land use, land-use change and forestry</b>	<b>195827.08</b>	<b>127126.834</b>	<b>-</b>	<b>-</b>	<b>-35.08</b>
<b>Total CO<sub>2</sub> equivalent emissions with land use, land-use change and forestry</b>	<b>189339.37</b>	<b>120486.141</b>	<b>100</b>		<b>-36.36</b>
<b>Total CO<sub>2</sub> equivalent emissions, including indirect CO<sub>2</sub>, without land use, land-use change and forestry</b>	<b>197948.82</b>	<b>127925.53</b>	<b>-</b>	<b>-</b>	<b>-35.37</b>
<b>Total CO<sub>2</sub> equivalent emissions, including indirect CO<sub>2</sub>, with land use, land-use change and forestry</b>	<b>191461.11</b>	<b>121284.838</b>	<b>-</b>	<b>-</b>	<b>-36.65</b>



In 2015, 97 973.60 kt CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> eq.

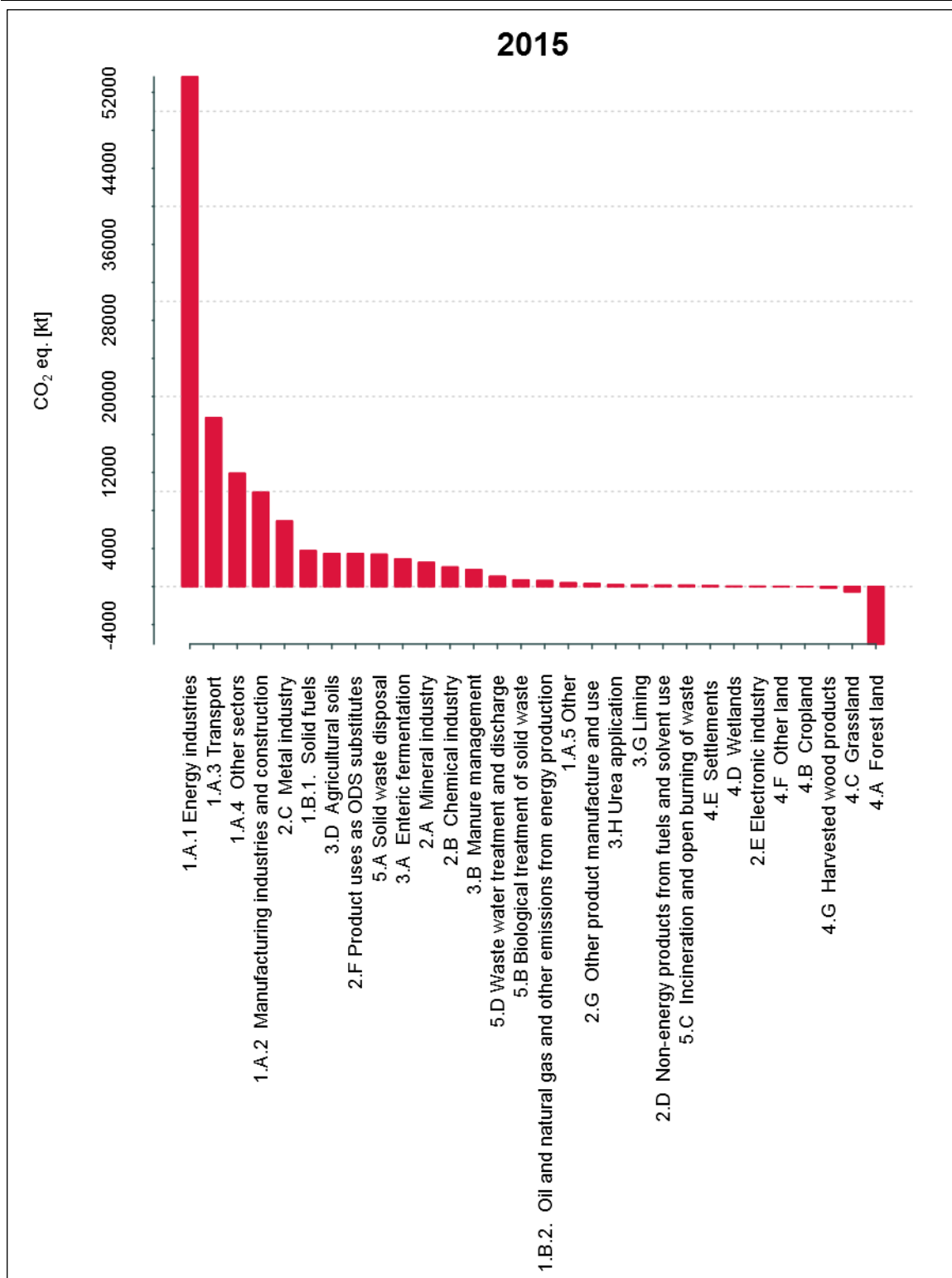


Fig. ES 2 Sources and sinks of greenhouse gases in 2015 (kt CO<sub>2</sub> eq.)

## 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 to 5.

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

A. Article 3.3 activities	Unit	2013	2014	2015
<i>A.1. Afforestation and Reforestation</i>				
CO <sub>2</sub> emissions/removals	Gg	-492.61	-549.75	-589.37
CH <sub>4</sub>	Gg	NO	NO	NO
N <sub>2</sub> O	Gg	NO	NO	NO
Net CO <sub>2</sub> equivalent emissions/removals	Gg CO <sub>2</sub> eq.	-492.61	-549.75	-589.37
<i>A.2. Deforestation</i>				
CO <sub>2</sub> emissions/removals	Gg	233.89	230.86	179.43
CH <sub>4</sub>	Gg	NO	NO	NO
N <sub>2</sub> O	Gg	0.00	0.00	0.00
Net CO <sub>2</sub> equivalent emissions/removals	Gg CO <sub>2</sub> 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
<i>B.1. Forest Management</i>				
CO <sub>2</sub> emissions/removals	Gg	-6 341.43	-6 264.90	-4 998.51
CH <sub>4</sub>	Gg	2.59	2.89	3.22
N <sub>2</sub> O	Gg	0.02	0.02	0.02
Net CO <sub>2</sub> equivalent emissions/removals	Gg CO <sub>2</sub> 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
<i>HWP contribution</i>				
CO <sub>2</sub> emissions/removals	Gg	-133.95	-94.13	-164.15
CH <sub>4</sub>	Gg	NO	NO	NO
N <sub>2</sub> O	Gg	NO	NO	NO
Net CO <sub>2</sub> equivalent emissions/removals	Gg CO <sub>2</sub> 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<sub>2</sub>

Emission estimates of indirect GHGs and SO<sub>2</sub> for the period from 1990 to 2015 are presented in Tab. ES 6.

Tab. ES 6 Indirect GHGs and SO<sub>2</sub> for 1990 to 2015 [kt]

	NO <sub>x</sub>	CO	NMVOC	SO <sub>x</sub> (as SO <sub>2</sub> )
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 [%]	<b>-72.31%</b>	<b>-44.03%</b>	<b>-49.81%</b>	<b>-93.41%</b>
NEC	<b>286</b>	<b>-</b>	<b>220</b>	<b>265</b>

<sup>1</sup>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<sub>x</sub> by 72.31%, for CO by 44.03%, for NMVOC by 49.81% and for SO<sub>2</sub> by 93.41%. The most important emission source for indirect greenhouse gases and SO<sub>2</sub> 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<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) 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<sub>2</sub> have increased by 40%, primarily from fossil fuels emissions and secondarily from net land use change emissions. CH<sub>4</sub> concentrations increased by 150% and N<sub>2</sub>O 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<sub>4</sub>, N<sub>2</sub>O) 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<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFC, PFC, SF<sub>6</sub>, NF<sub>3</sub> and indirect greenhouse gases NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>. 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<sub>3</sub>) 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<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>, HFCs, PFCs, SF<sub>6</sub> and NF<sub>3</sub> are calculated as CO<sub>2</sub> equivalents and added together to produce a total. Together with the direct greenhouse gases, also the emissions of NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> 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. All 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 6<sup>th</sup> *National Communication* (MoE, 2014).

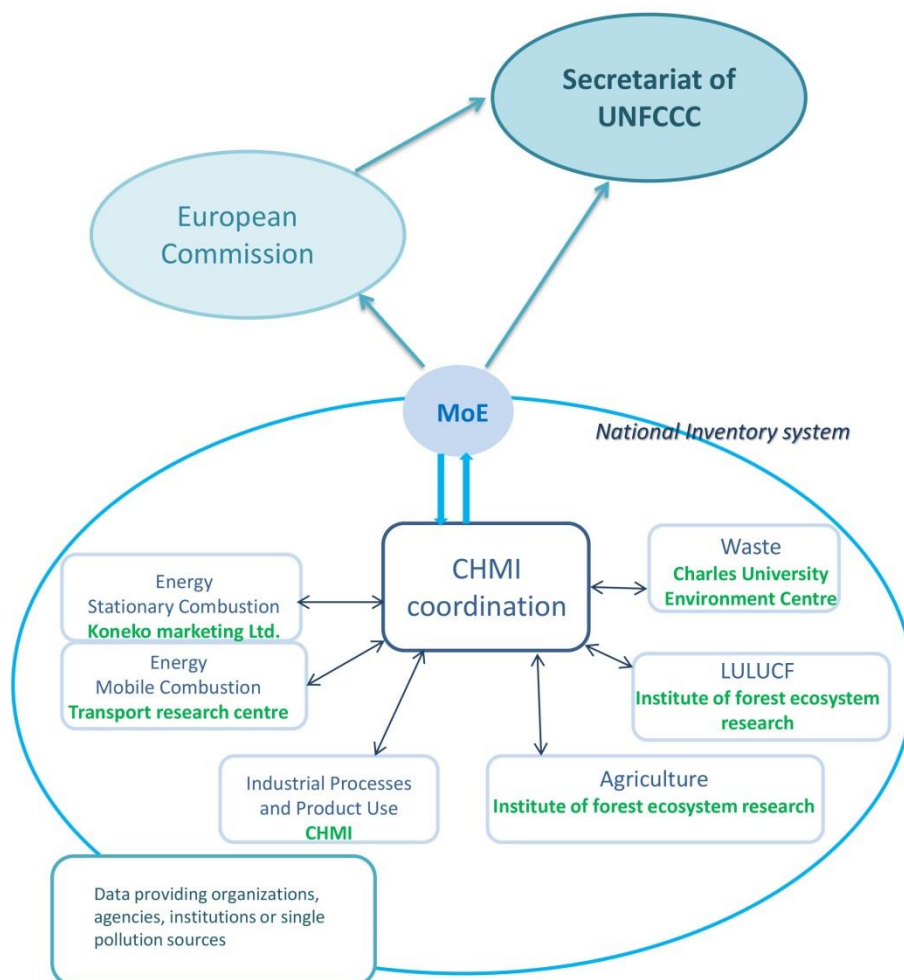


Fig. 1-1 Institutional arrangements of National Inventory System in the Czech Republic

### 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
<b>Mr. Stanislav Roman, Mrs. Denitsa Svobodová</b>	Coordinator of all QA/QC activities carried out within NIS and QA/QC guarantor of "General and crosscutting issues"
<b>Ms. Eva Krtková</b>	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.

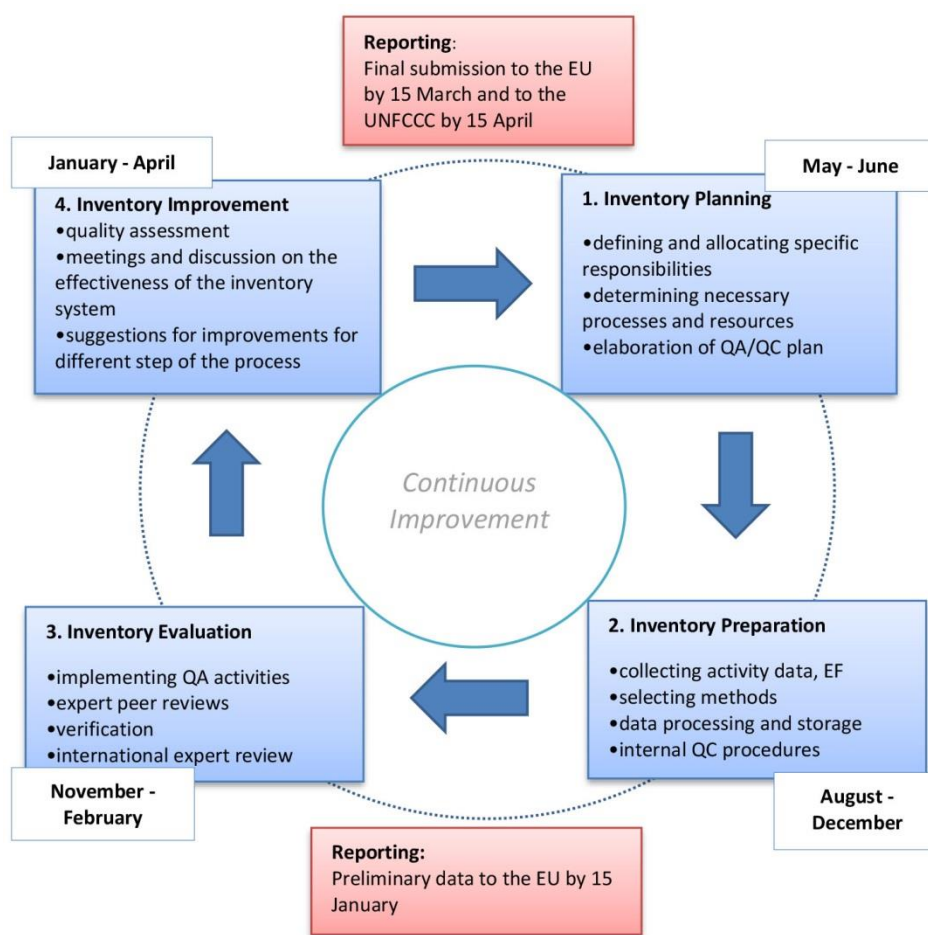


Fig. 1-2 Timeschedule of submissions and QA/QC prodedures

### 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.

Specifically, QC procedures in the sectors are organised as described below:

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
<b>15–20 November</b>	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
<b>21–25 November</b>	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
<b>26–30 November</b>	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
<b>1–5 December</b>	Finalization of the QC control of the data output and completion of the control form for the given category	Sectoral QA/QC guarantor
<b>6–10 December</b>	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
<b>10–15 December</b>	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)
<b>16–20 December</b>	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)
<b>up to 31 December</b>	CRF Tables submission to MoE for the approval	MoE and Sector coordinating group



<b>Up to 15 January</b>	CRF Tables submitted to the European Commission within the MoE reporting procedure pursuant to Article 7 of the Decision No. 525/2013/EC
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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 be 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 of 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

The QC procedures at the Tier 1 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.

QC procedures at the Tier 2 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. Vladimír 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, Mr. Vladimír Neužil	Control of the correct uploading of data from calculation sheets to the respective module of CRF Reporter
External KONEKO employees (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 expert. 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 (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 (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. Vladimír 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 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 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 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 Agrobiolgy, 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 Emission estimation in Agriculture sector (1st step of QC procedure, auto-control) 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 Emission estimation in LULUCF sector, 1st step of QC procedure (auto-control) 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. 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 “*check-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<sub>2</sub> (1 for CO<sub>2</sub>, 25 for CH<sub>4</sub> and 298 for N<sub>2</sub>O). The total amount of F-gases is relatively small compared to CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O; 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<sub>2</sub> 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<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>, 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<sup>th</sup> 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 <sub>2</sub>	38.97	24.03	LA, TA
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	40.85	78.45	LA, TA
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	52.46	46.10	LA, TA
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	62.33	58.46	LA, TA
2.C.1 Iron and Steel Production	CO <sub>2</sub>	67.41	98.67	LA
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	71.93	83.84	LA, TA
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	75.27	89.16	LA, TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	78.51	66.46	LA, TA
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	81.19	83.96	LA, TA
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	83.77	89.05	LA, TA
3.A Enteric Fermentation	CH <sub>4</sub>	86.07	82.90	LA, TA
2.A.1 Cement Production	CO <sub>2</sub>	87.12	94.24	LA
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	88.02	93.52	LA
3.B Manure Management	N <sub>2</sub> O	88.89	89.77	LA, TA
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	89.59	93.29	LA
3.B Manure Management	CH <sub>4</sub>	90.25	89.77	TA
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	90.91	95.92	LA
4.G Harvested wood products	CO <sub>2</sub>	98.23	81.41	TA
3.G Liming	CO <sub>2</sub>	98.40	84.36	TA
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	96.07	86.81	TA
5.B Biological treatment of solid waste	CH <sub>4</sub>	92.84	88.79	TA
2.B.2 Nitric Acid Production	N <sub>2</sub> O	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 <sub>2</sub>	41.44	23.59	LA, TA
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	43.43	72.06	LA, TA
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	55.77	43.14	LA, TA
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	66.27	53.94	LA, TA
2.C.1 Iron and Steel Production	CO <sub>2</sub>	71.67	99.02	LA
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	75.23	81.77	LA, TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	78.67	61.08	LA, TA
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	81.52	77.19	LA, TA
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	84.26	88.96	LA, TA
3.A Enteric Fermentation	CH <sub>4</sub>	86.71	83.23	LA, TA
2.A.1 Cement Production	CO <sub>2</sub>	87.82	94.80	LA
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	88.78	93.03	LA
3.B Manure Management	N <sub>2</sub> O	89.70	85.68	LA, TA
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	90.45	84.64	LA
3.G Liming	CO <sub>2</sub>	98.73	84.57	TA
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	96.90	86.85	TA
5.B Biological treatment of solid waste	CH <sub>4</sub>	93.90	88.61	TA
3.B Manure Management	CH <sub>4</sub>	91.15	89.65	TA
2.B.2 Nitric Acid Production	N <sub>2</sub> O	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 <sub>2</sub>	41.92	23.09	LA,TA
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	43.93	67.53	LA, TA
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	56.57	44.33	LA, TA
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	67.30	56.19	LA, TA
2.C.1 Iron and Steel Production	CO <sub>2</sub>	72.41	97.57	LA
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	76.61	91.26	LA, TA
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	79.28	72.40	LA, TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	81.83	77.96	LA, TA
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	84.35	84.95	LA, TA
3.A Enteric Fermentation	CH <sub>4</sub>	86.50	86.20	LA, TA
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	88.41	92.07	LA, TA
2.A.1 Cement Production	CO <sub>2</sub>	89.57	94.96	LA, TA
3.B Manure Management	N <sub>2</sub> O	90.32	87.11	LA, TA
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	90.98	94.33	LA, TA
5.D Wastewater treatment and discharge	CH <sub>4</sub>	91.62	96.20	LA
3.B Manure Management	CH <sub>4</sub>	92.19	90.10	LA, TA
2.B.1 Ammonia Production	CO <sub>2</sub>	92.74	99.29	LA
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	93.28	95.72	LA
5.B Biological treatment of solid waste	CH <sub>4</sub>	93.75	100.00	LA
2.A.2 Lime Production	CO <sub>2</sub>	94.20	93.09	LA, TA
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	94.65	95.38	LA
4.G Harvested wood products	CO <sub>2</sub>	98.73	81.50	TA
3.G Liming	CO <sub>2</sub>	98.85	88.06	TA
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	97.50	88.91	TA
2.B.2 Nitric Acid Production	N <sub>2</sub> O	96.33	89.54	TA
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	95.86	91.89	TA
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	95.10	92.70	TA
2.A.2 Lime Production	CO <sub>2</sub>	94.20	93.09	LA, TA
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	96.94	93.53	TA
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	96.12	93.95	TA
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	95.57	94.13	TA
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	98.18	94.66	TA
1.A.3.c Transport - Railways	CO <sub>2</sub>	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 <sub>2</sub>	44.31	26.04	LA,TA
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	46.43	71.56	LA,TA
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	59.79	47.69	LA,TA
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	71.13	59.60	LA,TA
2.C.1 Iron and Steel Production	CO <sub>2</sub>	76.53	99.66	LA
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	79.20	85.98	LA,TA
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	82.01	76.77	LA,TA
3.A Enteric Fermentation	CH <sub>4</sub>	84.29	87.38	LA,TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	86.98	82.48	LA,TA
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	89.00	91.82	LA,TA
2.A.1 Cement Production	CO <sub>2</sub>	90.22	94.94	LA,TA
3.B Manure Management	N <sub>2</sub> O	91.01	88.36	LA,TA
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	91.58	96.99	LA
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	92.28	94.65	LA,TA
3.B Manure Management	CH <sub>4</sub>	92.88	90.87	LA,TA
5.D Wastewater treatment and discharge	CH <sub>4</sub>	93.56	96.47	LA
2.B.1 Ammonia Production	CO <sub>2</sub>	94.14	98.46	LA
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	94.25	94.83	LA,TA
2.A.2 Lime Production	CO <sub>2</sub>	94.73	93.53	LA,TA
3.G Liming	CO <sub>2</sub>	98.94	89.37	TA
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	98.81	90.26	TA
2.B.2 Nitric Acid Production	N <sub>2</sub> O	97.60	91.54	TA
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	96.96	92.46	TA
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	96.46	93.10	TA

1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	97.38	93.98	TA
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	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
<b>Key categories (KC) with LULUCF</b>	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
<b>Key Categories (KC) without LULUCF:</b>	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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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<sub>2</sub> eq.]

	CO <sub>2</sub> <sup>1</sup>	CH <sub>4</sub> <sup>3</sup>	N <sub>2</sub> O <sup>3</sup>	HFCs	PFCs	NF <sub>3</sub>	SF <sub>6</sub>	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
% <sup>2)</sup>	-35.81	-41.55	-42.55				7.67	-35.37	-36.65
Note: Global warming potentials (GWPs) used (100 years time horizon): CO <sub>2</sub> = 1; CH <sub>4</sub> = 25; N <sub>2</sub> O = 298; SF <sub>6</sub> = 22 800; NF <sub>3</sub> = 17 200; HFCs and PFCs consist of different substances, therefore GWPs have to be calculated individually depending on substances									
<sup>1</sup> GHG emissions excluding emissions/removals from LULUCF									
<sup>2</sup> relative to base year									
<sup>3</sup> 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<sub>2</sub> 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<sub>2</sub> eq. resulting in total emissions of 121 284.84 kt CO<sub>2</sub> eq. The decrease was caused by CO<sub>2</sub>, PFCs emissions and SF<sub>6</sub> 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.

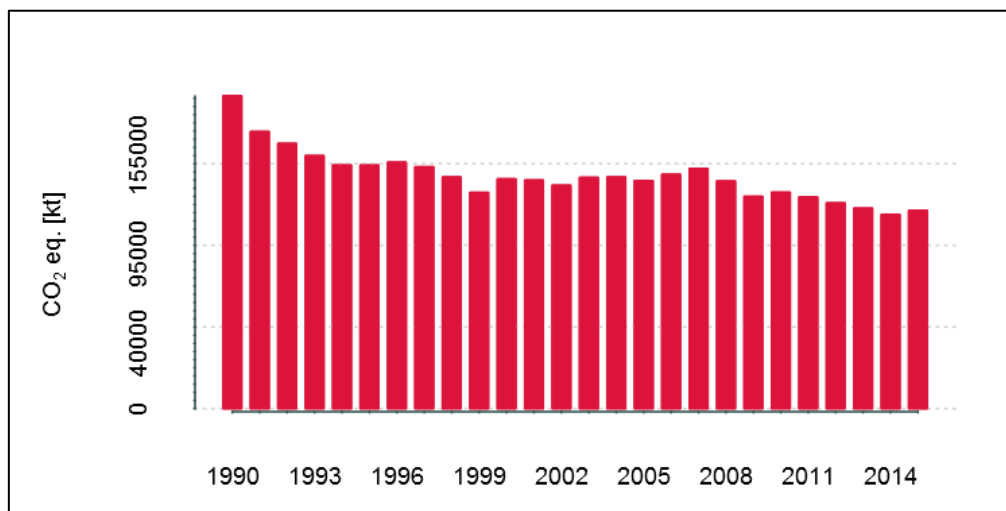


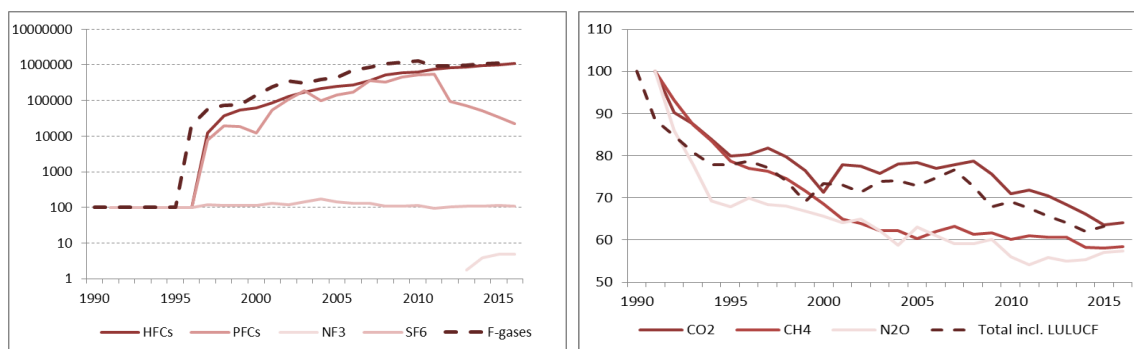
Fig. 2-1 Total trend of GHG emissions, [kt CO<sub>2</sub> eq.]

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

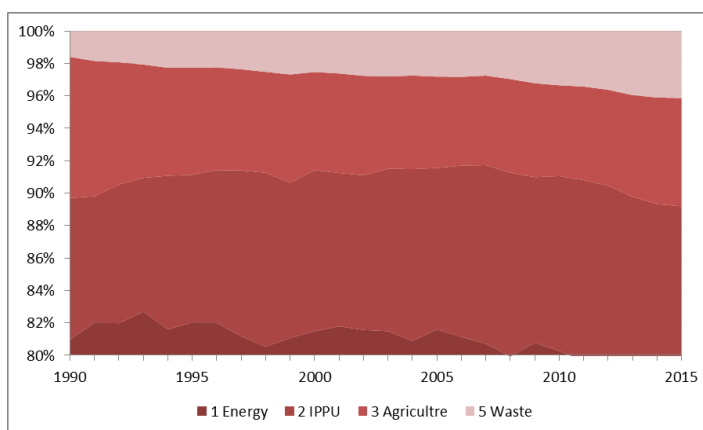


**Fig. 2-2** Trend in CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions 1990 - 2015 in index form (base year = 100%) and Trend in HFCs, PFCs (1995 – 2015) and SF<sub>6</sub> (1990 – 2015) actual emissions in index form (base year = 100%)

The major greenhouse gas in the Czech Republic is CO<sub>2</sub>, 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<sub>4</sub> (11.43% in 2015, 12.45% in the base year), N<sub>2</sub>O (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<sub>2</sub>

CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions and removals decreased from 161 649.59 to 103 769.75 kt CO<sub>2</sub> 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<sub>2</sub> share is hidden)

The main source of CO<sub>2</sub> 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<sub>2</sub> emissions increased remarkably between 1990 and 2015 from the 1.A.3 Transport category from 7 031.87 to 17 343.68 kt CO<sub>2</sub> eq.

#### CH<sub>4</sub>

CH<sub>4</sub> 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<sub>4</sub> 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<sub>4</sub> 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<sub>2</sub>O**

N<sub>2</sub>O emissions strongly decreased from 1990 to 1994 by 32.11% over this period and then shows slow decreasing trend with inter-annual fluctuation. N<sub>2</sub>O emissions decreased between 1990 and 2015 from 10 642.52 to 6 112.73 kt CO<sub>2</sub> eq. In 2014 N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub> 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<sub>2</sub> 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<sub>6</sub>**

SF<sub>6</sub> actual emissions in 1995 accounted for 88.47 kt CO<sub>2</sub> eq. Between 1995 and 2015 they inter-annually fluctuated with maximum of 144.19 kt CO<sub>2</sub> eq. in 2003 and minimum of 80.23 kt CO<sub>2</sub> eq. in 2010. In 2015 SF<sub>6</sub> reached amount of 90.55 kt, the level was 1.02% higher the base year (1995).

The main sources of SF<sub>6</sub> emissions is 2.G Other product manufacture and use.

## **NF<sub>3</sub>**

With the technological progress a new gas was included in the previous submission. NF<sub>3</sub> 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<sub>3</sub> equalled to 2.29 kt CO<sub>2</sub> 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<sub>2</sub> eq. which represents share of 5.52% of all GHG emissions.

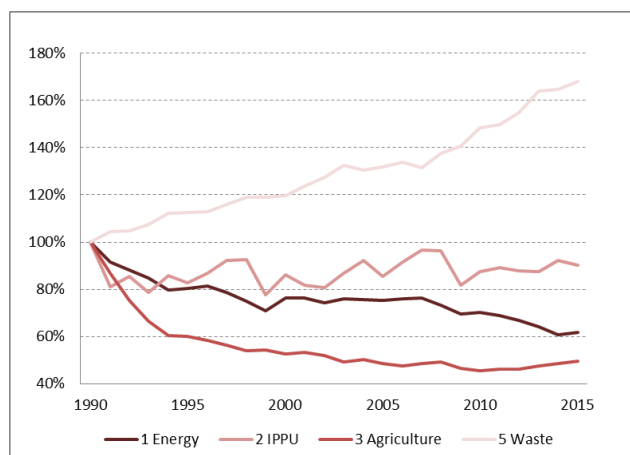


Fig. 2-4 Emission trends in 1990-2015 by categories in index form (base year = 100)

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).

Tab. 2-2 Summary of GHG emissions by category 1990-2015 [kt CO<sub>2</sub> eq.]

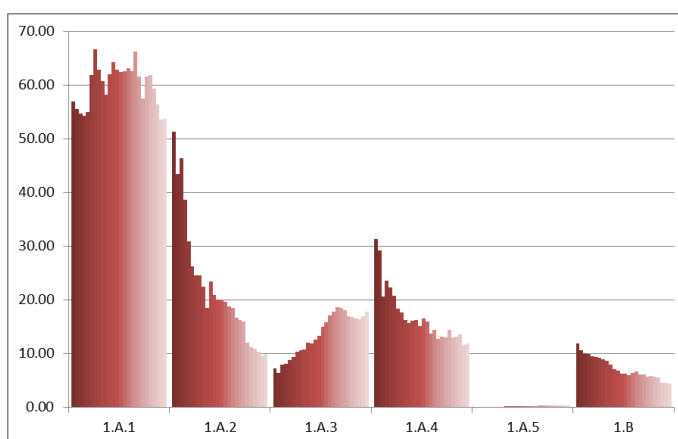
	1 Energy	2 IPPU	3 Agriculture	4 LULUCF	5 Waste
1990	158569.90	17080.37	17049.98	-6487.71	3126.83
1991	145280.83	13822.62	14776.05	-9608.86	3269.57
1992	139704.28	14587.97	12837.41	-10096.28	3279.01
1993	134456.29	13429.78	11358.39	-9692.70	3361.17
1994	126411.72	14667.86	10315.36	-7569.01	3509.75
1995	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
<sup>1</sup> %	1.40%	-2.37%	2.44%	-14.87%	2.04%
<sup>2</sup> %	-38.21%	-9.76%	-50.25%	2.36%	68.11%
<sup>1</sup> Difference relative to previous year					
<sup>2</sup> Difference relative to base year					

Tab. 2-3 Overview of trends in categories and subcategories (kt CO<sub>2</sub> eq.)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2005	2010	2014	2015
<b>Total (net emissions)</b>	<b>189339.37</b>	<b>147261.15</b>	<b>139419.53</b>	<b>138395.08</b>	<b>131425.78</b>	<b>118037.53</b>	<b>120486.14</b>
<b>1. Energy</b>	<b>158569.90</b>	<b>127386.59</b>	<b>120785.21</b>	<b>119563.18</b>	<b>111261.56</b>	<b>96618.86</b>	<b>97973.60</b>
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
<b>2. Industrial Processes</b>	<b>17080.37</b>	<b>14157.41</b>	<b>14720.47</b>	<b>14591.83</b>	<b>14965.30</b>	<b>15787.85</b>	<b>15413.84</b>
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
<b>3. Agriculture</b>	<b>17049.98</b>	<b>10245.64</b>	<b>8975.75</b>	<b>8257.49</b>	<b>7761.98</b>	<b>8280.62</b>	<b>8482.99</b>
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
<b>4. Land use, land-use change and forestry</b>	<b>-6487.71</b>	<b>-8046.44</b>	<b>-8805.07</b>	<b>-8134.59</b>	<b>-7200.07</b>	<b>-7801.09</b>	<b>-6640.69</b>
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
<b>5. Waste</b>	<b>3126.83</b>	<b>3517.95</b>	<b>3743.17</b>	<b>4117.16</b>	<b>4637.01</b>	<b>5151.31</b>	<b>5256.41</b>
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 <sub>2</sub> 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 <sub>2</sub> O	1307.45	629.48	499.88	475.63	391.22	318.85	308.79
Indirect CO <sub>2</sub>	2121.74	1745.19	1155.54	1083.21	967.43	777.69	798.70
<b>Total CO<sub>2</sub> equivalent emissions without land use, land-use change and forestry</b>	<b>195827.08</b>	<b>155307.59</b>	<b>148224.60</b>	<b>146529.67</b>	<b>138625.85</b>	<b>125838.63</b>	<b>127126.83</b>
<b>Total CO<sub>2</sub> equivalent emissions with land use, land-use change and forestry</b>	<b>189339.37</b>	<b>147261.15</b>	<b>139419.53</b>	<b>138395.08</b>	<b>131425.78</b>	<b>118037.53</b>	<b>120486.14</b>
<b>Total CO<sub>2</sub> equivalent emissions, including indirect CO<sub>2</sub>, without land use, land-use change and forestry</b>	<b>197948.82</b>	<b>157052.78</b>	<b>149380.15</b>	<b>147612.88</b>	<b>139593.28</b>	<b>126616.31</b>	<b>127925.53</b>
<b>Total CO<sub>2</sub> equivalent emissions, including indirect CO<sub>2</sub>, with land use, land-use change and forestry</b>	<b>191461.11</b>	<b>149006.34</b>	<b>140575.08</b>	<b>139478.29</b>	<b>132393.21</b>	<b>118815.22</b>	<b>121284.84</b>

### 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<sub>2</sub> eq. Total decrease between 1990 and 2015 is 38.21%. Between 2014 to 2015 emissions from category 1 Energy slightly increased by 1.40%.



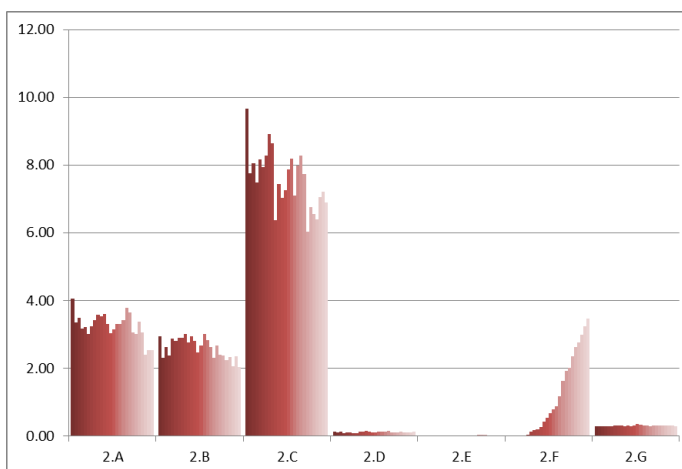
**Fig. 2-5 Trends in Energy by categories 1990-2015 (Tg CO<sub>2</sub> eq.)**

From the total 97 973.60kt CO<sub>2</sub> 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<sub>4</sub>, which represented 30.62% of all CH<sub>4</sub> emissions in 2015. 37.22% of all CH<sub>4</sub> emissions in 2015 originated from Energy category.

CO<sub>2</sub> 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<sub>2</sub> emissions (excl. LULUCF). CO<sub>2</sub> from category 1 Energy contributes for 73.62% to total GHG emissions, CH<sub>4</sub> for 6.60% and N<sub>2</sub>O 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> eq. in 2015 which corresponds to 6.67% of national total emissions (excluding LULUCF). The most important sub-category 3.D Agricultural Soils (N<sub>2</sub>O emissions) contributed by 40.76% to sectoral total in 2015, followed by the 3.A Enteric Fermentation (CH<sub>4</sub> emissions, 34.14%).

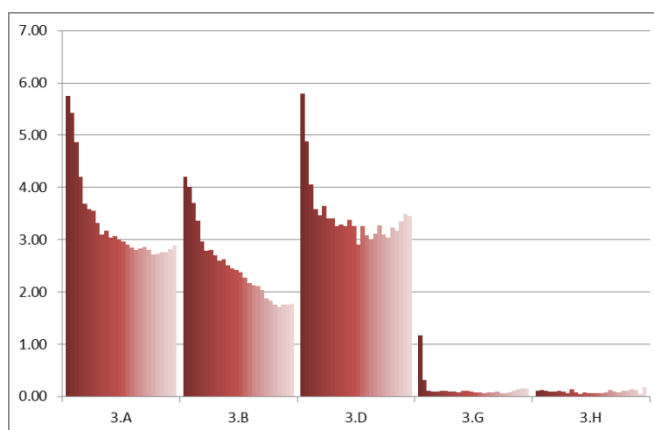


Fig. 2-7 Trends in Agriculture by categories 1990-2015 (Tg CO<sub>2</sub> eq.)

3 Agriculture is the largest source for N<sub>2</sub>O and second largest source for CH<sub>4</sub> emissions (73.05% of total emissions of N<sub>2</sub>O and 26.78% of total emissions of CH<sub>4</sub>, excluding LULUCF). However its 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 -10 096.28 kt CO<sub>2</sub> eq. in 1992 and maximum -3 759.54 kt CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>. Net CO<sub>2</sub> removals from this category amounted to -6 735.41 kt CO<sub>2</sub> eq. in 2015. CH<sub>4</sub> emissions amounted to 81.91 kt CO<sub>2</sub> eq., N<sub>2</sub>O to 12.81 kt CO<sub>2</sub> eq. Trends of the sub-categories in LULUCF sector are presented in Fig. 2-8.

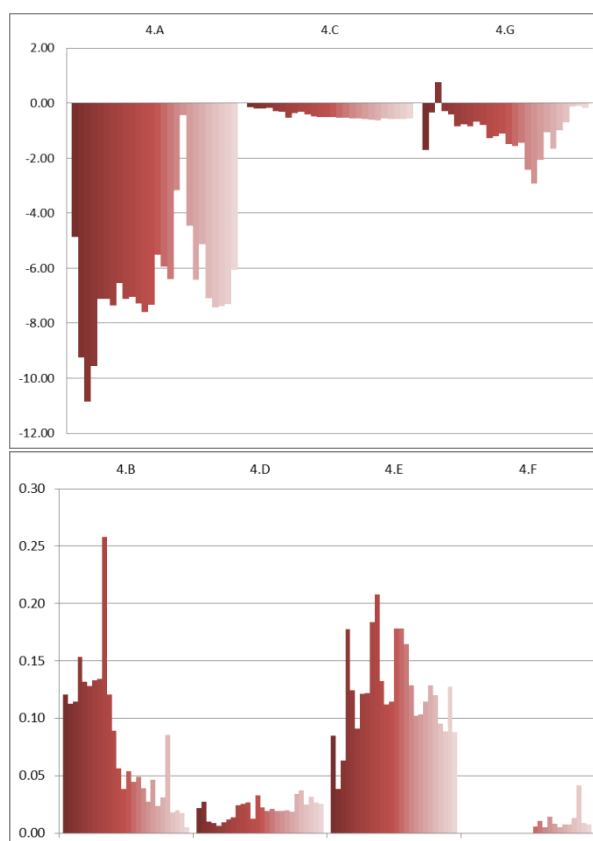


Fig. 2-8 Trends in LULUCF by separate source and sink categories 1990 – 2015 (Tg CO<sub>2</sub> eq.)

### 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<sub>2</sub> eq., which is 68.11% above the base year level. The increase of emissions is mainly due to higher emissions of CH<sub>4</sub> from 5.A Solid Waste Disposal and due to higher emissions in 5.C Incineration and open burning of waste. As a result of CH<sub>4</sub> 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.

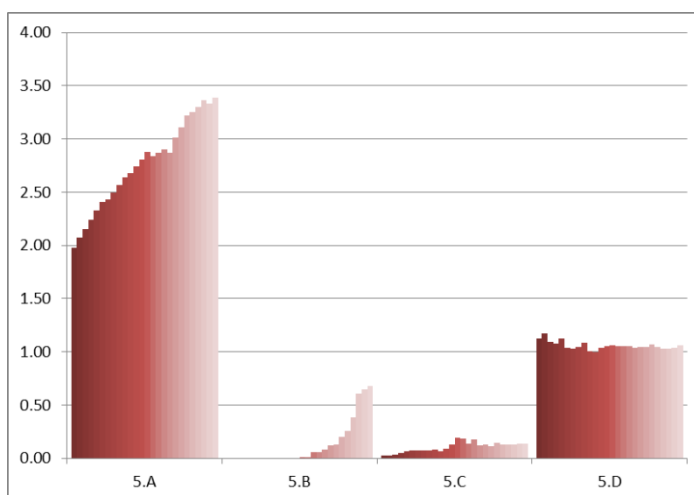


Fig. 2-9 Trends in Waste by categories 1990-2015 (Tg CO<sub>2</sub> eq.)

The main source is solid 5.A Solid Waste Disposal, which accounted for 69.37% of sectoral CH<sub>4</sub> 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<sub>4</sub> emissions; CO<sub>2</sub> contributes by 2.52% and N<sub>2</sub>O by 4.65%.

### 2.2.3 Description and interpretation of emission trends of indirect greenhouse gases and SO<sub>2</sub>

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<sub>2</sub> eq.]

Year	Article 3.3 activities		Article 3.4 activities		HWP HWP contribution
	Afforestation and Reforestation	Deforestation	Forest Management	Other Art. 3.4 activities	
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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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 incl. A1 LULUCF	KC excl. A1 LULUCF	KC incl. A2 LULUCF	KC excl. A2 LULUCF	% of total GHG incl. LULUCF	% of total GHG excl. LULUCF
1.A Stationary Combustion - Solid Fuels	CO <sub>2</sub>	LA,TA	LA, TA	yes	yes	yes	yes	44.04	46.45
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	LA,TA	LA, TA	yes	yes	yes	yes	2.11	2.22
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	LA,TA	LA, TA	yes	yes	yes	yes	13.28	14.00
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	LA,TA	LA, TA	yes	yes	yes	yes	11.27	11.89
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	LA,TA	LA, TA	yes	yes	yes	yes	2.80	2.95
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	LA	LA	yes	no	yes	yes	0.48	0.50
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	TA	TA	yes	yes	yes	yes	0.19	0.21
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	TA		yes	yes			0.30	0.32
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	TA		yes	yes			0.47	0.49
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	TA		yes	yes			0.21	0.22
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	TA		yes	yes			0.27	0.29
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	TA		yes	yes			0.11	0.12
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	TA		yes	no			0.17	0.18
1.A.3.c Transport - Railways	CO <sub>2</sub>	TA		yes	no			0.21	0.22

KC: key category

### 3.1.2 Emissions Trends

CO<sub>2</sub> emissions from the 1.A sector decreased by 36.33% from 144 Mt CO<sub>2</sub> in 1990 to 92 Tg CO<sub>2</sub> in 2015. Furthermore CO<sub>2</sub> emissions from the 1.B sector decreased by 55.7% from 458 kt in 1990 to 194 kt in 2015, as well as CH<sub>4</sub> 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<sub>2</sub> and CH<sub>4</sub> 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.

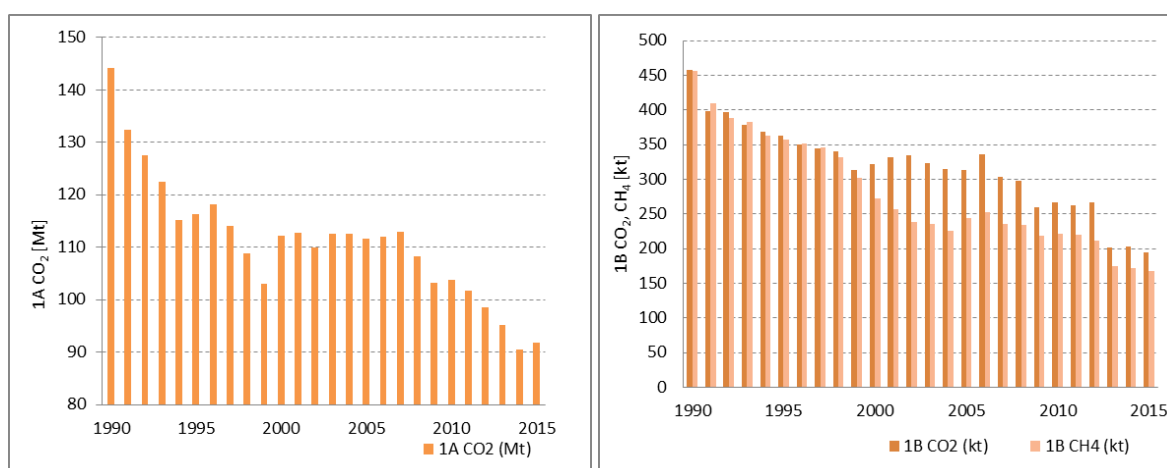


Fig. 3-1 Trend total CO<sub>2</sub> (Sectoral Approach) in 1.A and trend of CO<sub>2</sub> and CH<sub>4</sub> from 1.B sector in period 1990 – 2015

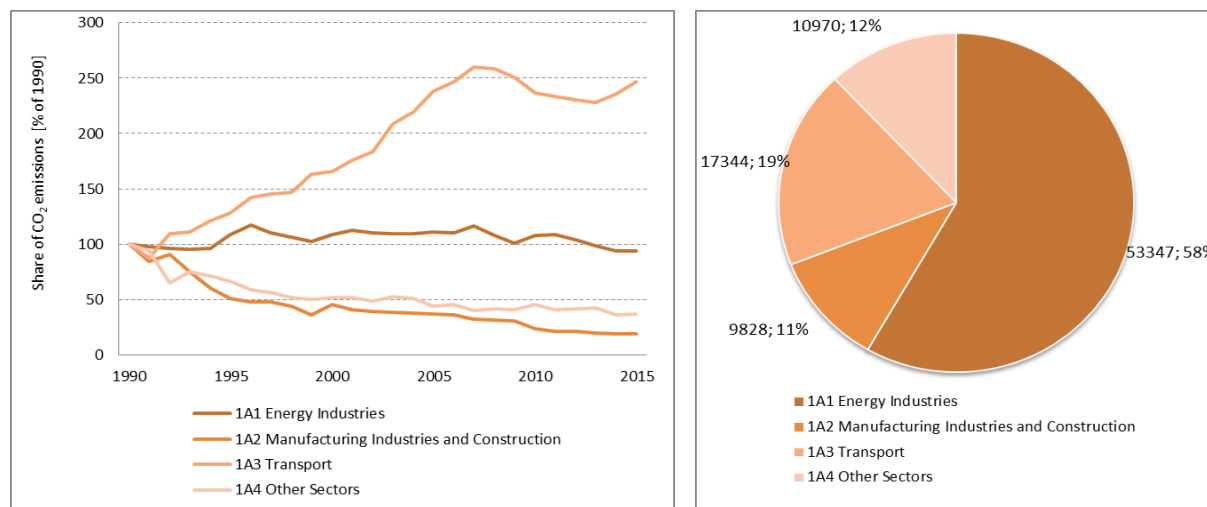
Tab. 3-2 Emissions of greenhouse gases and their trend from 1990 – 2015 from IPCC Category 1 Energy

	CO <sub>2</sub> [kt]	CH <sub>4</sub> [kt]	N <sub>2</sub> O [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<sub>2</sub> emissions and the share of CO<sub>2</sub> 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<sub>2</sub> in 1990 to 18.3 Tg in 2007. A slight decrease has been apparent since 2008, while between 2014 and 2015

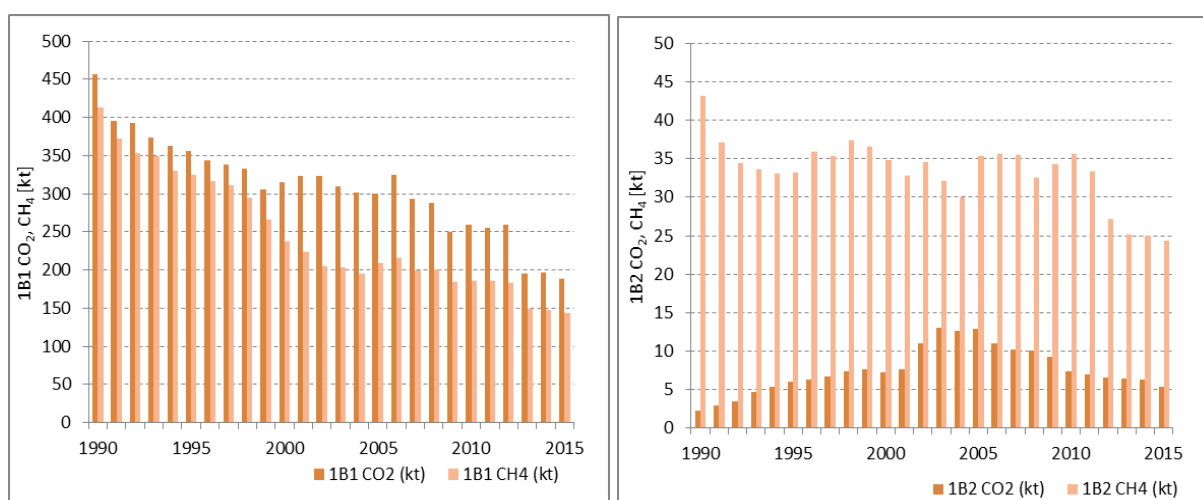


**Fig. 3-2 Share and development of CO<sub>2</sub> emissions from 1990 - 2015 in individual sub-sectors; share of CO<sub>2</sub> emissions in individual subsectors in 2015 [kt]**

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<sub>2</sub> in 1990 to 11 and 9.8 Tg CO<sub>2</sub> in 2015, respectively.

The fugitive emissions from Solid fuels also indicate substantial decrease in the whole time-series, i.e. 58.7% for CO<sub>2</sub> emission and 65.2% for CH<sub>4</sub> emissions. Fugitive CH<sub>4</sub> emissions from Oil and Natural Gas also indicate decrease for 43.7% in the time series. Fugitive CO<sub>2</sub> 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<sub>2</sub> and CH<sub>4</sub> 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<sub>2</sub> 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
<b>Total Trend 1990 - 2015</b>	<b>-38%</b>	<b>-36%</b>	<b>-5,8%</b>	<b>-81%</b>	<b>144%</b>	<b>-62%</b>	<b>121%<sup>1)</sup></b>	<b>-63%</b>	<b>-65%</b>	<b>-43%</b>

<sup>1)</sup>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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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)**

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

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 (%)
<b>1990</b>	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	
	<b>Total</b>	<b>1893.5</b>	<b>158.5</b>	<b>1735.1</b>	<b>1655.7</b>	<b>4.8</b>
<b>1995</b>	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	
	<b>Total</b>	<b>1533.7</b>	<b>168.0</b>	<b>1365.7</b>	<b>1380.2</b>	<b>-1.1</b>
<b>2000</b>	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	
	<b>Total</b>	<b>1527.7</b>	<b>153.9</b>	<b>1373.8</b>	<b>1355.0</b>	<b>1.4</b>
<b>2005</b>	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	
	<b>Total</b>	<b>1557.6</b>	<b>186.8</b>	<b>1370.8</b>	<b>1371.3</b>	<b>0.0</b>
<b>2010</b>	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	
	<b>Total</b>	<b>1489.4</b>	<b>174.9</b>	<b>1314.5</b>	<b>1280.1</b>	<b>2.7</b>
<b>2011</b>	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	
	<b>Total</b>	<b>1410.2</b>	<b>167.4</b>	<b>1242.8</b>	<b>1241.5</b>	<b>0.1</b>
<b>2012</b>	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	
	<b>Total</b>	<b>1362.0</b>	<b>170.2</b>	<b>1191.8</b>	<b>1207.2</b>	<b>-1.3</b>
<b>2013</b>	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	
	<b>Total</b>	<b>1348.7</b>	<b>167.7</b>	<b>1181.0</b>	<b>1173.7</b>	<b>0.6</b>
<b>2014</b>	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	
	<b>Total</b>	<b>1287.1</b>	<b>180.3</b>	<b>1106.8</b>	<b>1111.5</b>	<b>-0.4</b>
<b>2015</b>	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	
	<b>Total</b>	<b>1311.3</b>	<b>160.5</b>	<b>1150.9</b>	<b>1134.1</b>	<b>1.5</b>

**Tab. 3-6 Results for CO<sub>2</sub> emissions (kt) according to reference approach and comparison with sectoral approach**

Year	Type of fossil fuels	Apparent Consumption (kt CO <sub>2</sub> )	Carbon excluded (kt CO <sub>2</sub> )	RA (kt CO <sub>2</sub> )	SA (kt CO <sub>2</sub> )	(RA-SA)/SA (%)
<b>1990</b>	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	
	<b>Total</b>	<b>165 438</b>	<b>14 672</b>	<b>150 766</b>	<b>144 268</b>	<b>4.5</b>
<b>1995</b>	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	
	<b>Total</b>	<b>129 012</b>	<b>14 797</b>	<b>114 215</b>	<b>116 317</b>	<b>-1.8</b>
<b>2000</b>	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	
	<b>Total</b>	<b>127 286</b>	<b>13 574</b>	<b>113 711</b>	<b>112 210</b>	<b>1.3</b>
<b>2005</b>	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	
	<b>Total</b>	<b>127 788</b>	<b>16 032</b>	<b>111 756</b>	<b>111 606</b>	<b>0.1</b>
<b>2010</b>	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	
	<b>Total</b>	<b>121 116</b>	<b>14 900</b>	<b>106 216</b>	<b>103 777</b>	<b>2.4</b>
<b>2011</b>	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	
	<b>Total</b>	<b>116 350</b>	<b>14 342</b>	<b>102 009</b>	<b>101 638</b>	<b>0.4</b>
<b>2012</b>	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	
	<b>Total</b>	<b>111 574</b>	<b>14 512</b>	<b>97 062</b>	<b>98 568</b>	<b>-1.5</b>
<b>2013</b>	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	
	<b>Total</b>	<b>109 962</b>	<b>14 393</b>	<b>95 569</b>	<b>95 187</b>	<b>0.4</b>
<b>2014</b>	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	
	<b>Total</b>	<b>105 383</b>	<b>15 311</b>	<b>90 072</b>	<b>90 419</b>	<b>-0.4</b>
<b>2015</b>	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	
	<b>Total</b>	<b>107 360</b>	<b>13 828</b>	<b>93 532</b>	<b>91 858</b>	<b>1.8</b>

**Tab. 3-7 Apparent consumption in energy units (PJ) used in reference and sectoral approach for all fossil fuels and corresponding results for CO<sub>2</sub> emissions (kt)**

Year	Appar. cons. (PJ)	Carbon excluded (PJ)	Reference approach (PJ)	Sectoral approach (PJ)	(RA-SA)/SA (%)	Activity data (kt CO <sub>2</sub> )	Carbon excluded (kt CO <sub>2</sub> )	Reference approach (kt CO <sub>2</sub> )	Sectoral approach (kt CO <sub>2</sub> )	(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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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 GIs., from Solvent Use (2.D.3) there is no CO<sub>2</sub> 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<sub>2</sub> (Stored carbon), in the case of lubricants use, annually a part is oxidized to

CO<sub>2</sub> (Reported in 2.D.1) Consequently, CO<sub>2</sub> reported in Table 1.A(d) under Lubricants is the CO<sub>2</sub> 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<sub>2</sub> reported in Table 1.A(d) under Coke Oven Coke is the CO<sub>2</sub> 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. Subchapter "CO<sub>2</sub> 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 <sub>2</sub> /TJ]
LPG	45 945	65.86 <sup>1)</sup>
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 <sup>1)</sup>
Coke Oven Coke	28 775 <sup>2)</sup>	107.0

<sup>1)</sup> country-specific value

<sup>2)</sup> 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 calorific 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<sup>3</sup> and the consumption in TJ is also tabulated; however, in this case it is calculated using the gross calorific 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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 from 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<sup>3</sup> and in TJ; however, the data in TJ is determined using the gross caloric value. Volume reported by CzSO in thousand m<sup>3</sup> 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 precisely described by linear dependence

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

where NCV and GCV are expressed in MJ/m<sup>3</sup> 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  $NCV = 34.424 \text{ MJ/m}^3$  given in the Tab. 3-10 it corresponds the ratio  $NCV/GCV=0.9019$  calculated from the equation above. This equation was used for calculation of NCV from GCV for all time period.

For calculation of CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>4</sub> and N<sub>2</sub>O emissions from fuel combustion from stationary sources are not among the key categories. Thus contrary to CO<sub>2</sub> emission factors, for CH<sub>4</sub> and N<sub>2</sub>O emission factors are used always default values from IPCC 2006 Guidelines (IPCC, 2006). CH<sub>4</sub> and N<sub>2</sub>O emission factors are listed in the specific subchapters for specific subcategories.

General CO<sub>2</sub> emission factors and NCV are provided in Tab. 3- 10.

**Tab. 3-10 Net calorific values (NCV), CO<sub>2</sub> emission factors and oxidation factors used in the Czech GHG inventory – 2015**

Fuel (IPCC 2006 Guidelines definitions)	NCV [TJ/kt]	CO <sub>2</sub> EF <sup>a)</sup> [t CO <sub>2</sub> /TJ]	Oxidation factor	CO <sub>2</sub> EF <sup>b)</sup> [t CO <sub>2</sub> /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 <sup>d)</sup>	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 <sup>d)</sup>	29.536	93.53	1	93.53
Other Bituminous Coal <sup>d)</sup>	21.990	95.23	0.9707	92.44
Lignite (Brown Coal) <sup>d)</sup>	11.979	100.79	0.9846	99.24
Brown Coal Briquettes	19.793	97.50	0.9846 <sup>d)</sup>	96.00
Coke Oven Coke	28.750	107.00	1	107.00
Coke Oven Gas (TJ/mill. m <sup>3</sup> )	16.064 <sup>c)</sup>	44.40	1	44.40
Natural Gas (TJ/Gg) <sup>d)</sup>	48.756	55.42	1	55.42
Natural Gas (TJ/mill. m <sup>3</sup> ) <sup>d)</sup>	34.575	55.42	1	55.42

a) Emission factor without oxidation factor

b) Resulting emission factor with oxidation factor

c) TJ/mill. m<sup>3</sup>, t = 15 °C, p = 101.3 kPa

d) Country specific values of CO<sub>2</sub> 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 calculations 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 <sub>2</sub>	1.A Stationary combustion – Solid Fuels	4	3	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CO <sub>2</sub>	1.A Stationary combustion – Gaseous Fuels	3	2.5	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CO <sub>2</sub>	1.A Stationary combustion– Liquid Fuels	5	3	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CO <sub>2</sub>	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 <sub>2</sub>	1.A.3.e Other Transportation	4	3	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CO <sub>2</sub>	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 <sub>4</sub>	1.A Stationary combustion – Solid Fuels	5	50	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CH <sub>4</sub>	1.A Stationary combustion – Gaseous Fuels	4	50	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CH <sub>4</sub>	1.A Stationary combustion – Liquid Fuels	5	50	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines

CH <sub>4</sub>	1.A Stationary combustion – Biomass	8	50	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CH <sub>4</sub>	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 <sub>4</sub>	1.A.3.e Other Transportation	4	50	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N <sub>2</sub> O	1.A Stationary combustion – Solid Fuels	5	60	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N <sub>2</sub> O	1.A Stationary combustion – Gaseous Fuels	4	60	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N <sub>2</sub> O	1.A Stationary combustion – Liquid Fuels	5	60	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N <sub>2</sub> O	1.A Stationary combustion – Biomass	8	60	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N <sub>2</sub> O	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 <sub>2</sub> O	1.A.3.e Other Transportation	4	60	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N <sub>2</sub> O	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, Vladimír 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 (Vladimír 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 <sub>2</sub>			CH <sub>4</sub>		N <sub>2</sub> O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]	[-]	[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/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
<b>Total year 2015</b>	<b>518 222.6</b>			<b>49 064.8</b>		<b>1.2201</b>		<b>0.77256</b>
<b>Total year 2014</b>	<b>515 377.4</b>			<b>48 840.4</b>		<b>1.1525</b>		<b>0.76627</b>
<b>Index 2015/2014</b>	<b>1.01</b>			<b>1.00</b>		<b>1.06</b>		<b>1.01</b>
<b>Total year 1990</b>	<b>569 994.5</b>			<b>54 685.8</b>		<b>0.6212</b>		<b>0.81216</b>
<b>Index 2015/1990</b>	<b>0.91</b>			<b>0.90</b>		<b>1.96</b>		<b>0.95</b>

\*) 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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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<sub>2</sub> 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<sub>2</sub> emissions in subsector 1.A.1.a equalled 87.4% of total CO<sub>2</sub> 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
<b>Total capacity</b>	<b>19 990</b>	<b>MWe</b>

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.

<b>Electricity production (GWh)</b>	<b>51 063</b>
Main activity producer electricity plants	8 649
Main activity producer CHP plants	33 778
Autoproducer electricity plants	70
Autoproducer CHP plants	8 566
<b>Heat production (TJ)</b>	<b>118 467</b>
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<sub>2</sub> emissions in source category 1.A.1.a.

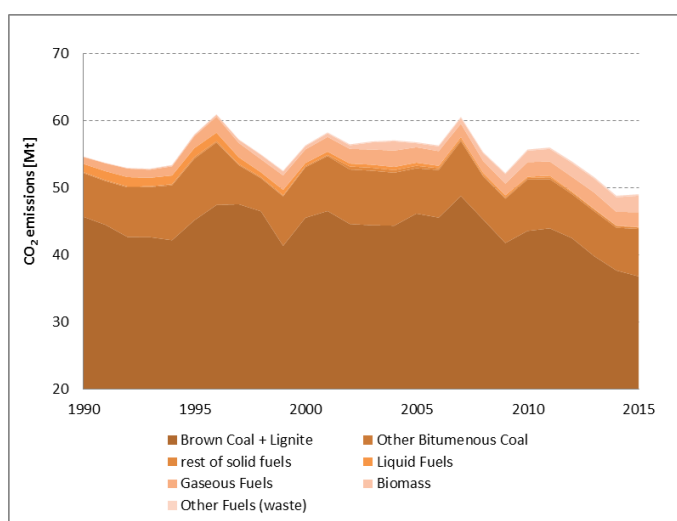


Fig. 3-4 Development of CO<sub>2</sub> emissions in 1.A.1.a category

CO<sub>2</sub> 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<sub>2</sub>/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<sub>2</sub>/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<sub>2</sub> 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

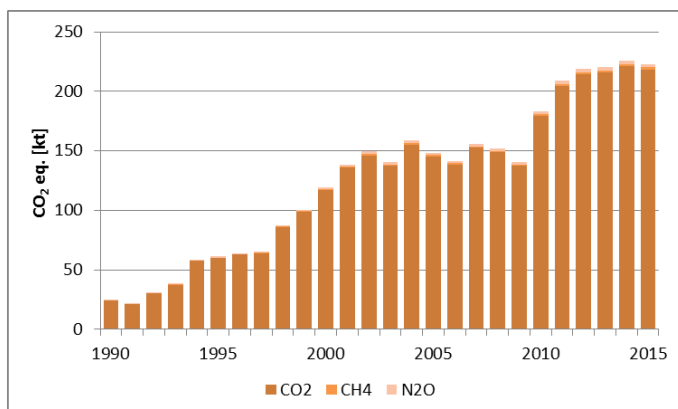


Fig. 3-5 trend of GHG emissions from waste incineration for energy purposes

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<sub>2</sub> from incinerated fossil carbon in MSW and emissions of methane and N<sub>2</sub>O 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

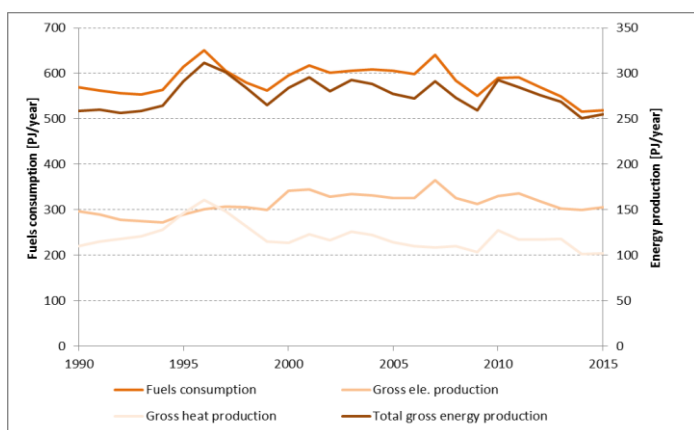
Incinerator (city)	Capacity (kt) 2015
TERMIZO (Liberec)	96
Pražské služby a.s. (Praha)	310
SAKO a.s. (Brno)	224

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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 recalculations 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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<sub>2</sub>O emission factor, original EF 1.4 to updated estimated 1.5 kg N<sub>2</sub>O/TJ.

This recalculation caused increase in N<sub>2</sub>O emission by 7.14%.

## Solid fuels

Tab. 3-16 Recalculations caused by change in N<sub>2</sub>O emission factor for solid fuels in submission 2017

N <sub>2</sub> O 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<sub>2</sub>/TJ (original value 139.33 kg CO<sub>2</sub>/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	3 319	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	5 715	6 724	8 315	10 937	13 379	15 842	17 336	19 270	19 459	20 425	
Difference	TJ	509	2 793	2 396	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 <sub>2</sub> 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> O 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<sub>2</sub>/TJ (original value 145.1 kg CO<sub>2</sub>/TJ), 30 kg CH<sub>4</sub>/TJ (original value 0.0208 kg CH<sub>4</sub>/TJ), 4 kg N<sub>2</sub>O/TJ (original value 5.208 kg N<sub>2</sub>O/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<sub>2</sub> emission after recalculation

CO <sub>2</sub> 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 <sub>2</sub> 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<sub>4</sub> emission after recalculation

CH <sub>4</sub> 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 <sub>4</sub> 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<sub>2</sub>O emission after recalculation

N <sub>2</sub> O 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 <sub>2</sub> O 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 <sub>2</sub>	CH <sub>4</sub>		N <sub>2</sub> O			
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O /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
<b>Total year 2015</b>	<b>13 882.2</b>			<b>830.6</b>		<b>0.02098</b>		<b>0.00316</b>
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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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<sub>4</sub> emissions are included in category 1.B.2.a Fugitive Emissions from Fuels - Oil.

The fraction of CO<sub>2</sub> emissions in subsector 1.A.1.b in CO<sub>2</sub> emissions in sector 1.A.1 equalled 1.6% in 2015. It contributed 0.9% to CO<sub>2</sub> 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.

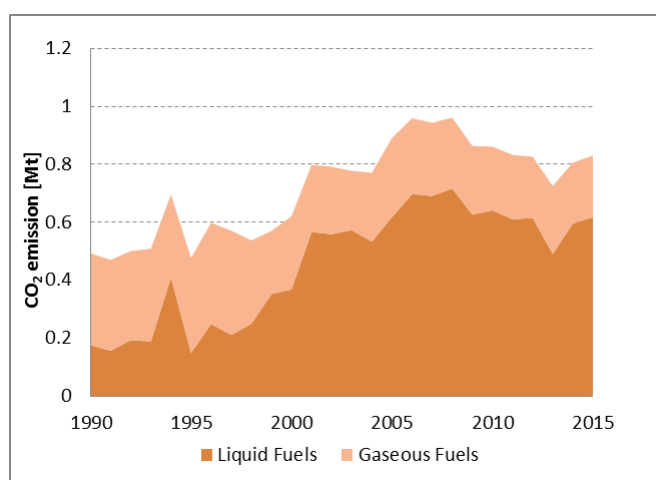


Fig. 3-7 Development of CO<sub>2</sub> emissions in 1.A.1.b category

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<sub>2</sub> occurred in 2008, followed by a value of 697 kt CO<sub>2</sub> in 2006. Thereafter, production decreased to the resulting level of 595 kt CO<sub>2</sub> in 2014, resp. 618 kt CO<sub>2</sub> in 2015.

The second greatest role is played by Natural Gas, with emissions in the range between 205 kt CO<sub>2</sub> in 2003 and 360 kt CO<sub>2</sub> in 1997 and resulting with 213 kt CO<sub>2</sub> 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)

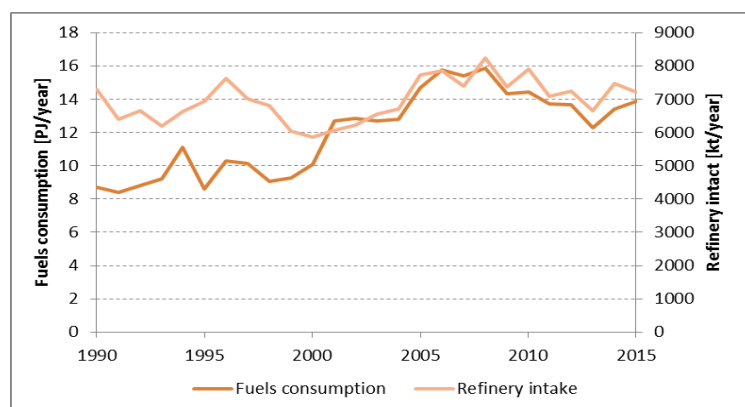


Fig. 3-8 Comparison of fuel consumption in the sector 1.A.1.b and amount of crude oil processed

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<sub>2</sub>O emission factor for refinery gas was updated to 0.1 kt N<sub>2</sub>O/TJ (original value 0.6 kg N<sub>2</sub>O/TJ). Details of the change please see in the table.

Tab. 3-22 Change in N<sub>2</sub>O emissions in 1.A.1.b in submission 2017

N <sub>2</sub> O 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 <sub>2</sub> O 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 <sub>2</sub> O 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 <sub>2</sub> emission		2013
Submission 2016	kt	211.3
Submission 2017	kt	234.8
Difference	kt	23.5
	%	11.1
CH <sub>4</sub> emission		2013
Submission 2016	kt	0.00382
Submission 2017	kt	0.00425
Difference	kt	0.00042
	%	11.1
N <sub>2</sub> O 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 <sub>2</sub>		CH <sub>4</sub>		N <sub>2</sub> O		
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/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
<b>Total year 2015</b>	<b>63 105.6</b>			<b>5 905.7</b>		<b>0.0645</b>		<b>0.06124</b>
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<sub>2</sub> 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<sub>2</sub>O 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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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”).

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.

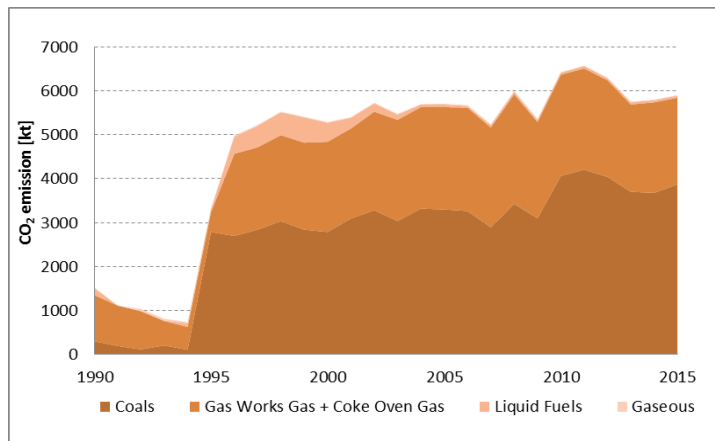


Fig. 3-9 Development of CO<sub>2</sub> emissions in 1.A.1.c.ii category

The fraction of CO<sub>2</sub> emissions in subsector 1.A.1.c in CO<sub>2</sub> emissions in sector 1.A.1 equalled 11% in 2015. It contributed only 6% to CO<sub>2</sub> 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 ( $\text{CO}_2$  and  $\text{H}_2\text{S}$ ) 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  $\text{CO}_2$  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  $\text{CO}_2$  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.

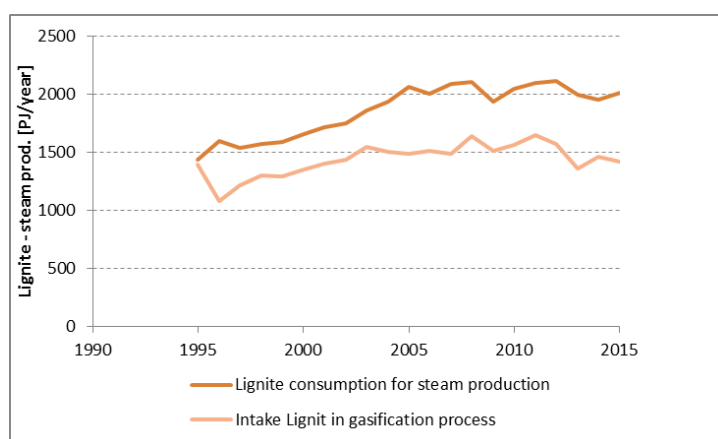


Fig. 3-10 Comparison of lignite consumption for steam production and gasification

### 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 <sub>2</sub> 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 <sub>4</sub> emission		2010	N <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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<sub>2</sub>O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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<sub>2</sub>O emission factor was updated to 1.5 kg N<sub>2</sub>O/TJ for solid fuels, which caused increase in N<sub>2</sub>O 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<sub>2</sub>O emission factor is 0.1 kg N<sub>2</sub>O/TJ.

Tab. 3-28 Changes after update of N<sub>2</sub>O emission factor in 1.A.1.c.ii

N <sub>2</sub> O 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 <sub>2</sub> O 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 <sub>2</sub> O 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	CO <sub>2</sub>			CH <sub>4</sub>		N <sub>2</sub> O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/TJ]	[kt]
Anthracite	911.2	98.3		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		999.0	10	0.0934	1.5	0.01400
Coke Oven Gas	5 385.4	44.4		239.1	1	0.0054	0.1	0.00054
Natural Gas	8 988.34	55.4*)		498.1	1	0.0090	0.1	0.00090
Wood/Wood Waste	4.2	112.0		0.5	30	0.0001	4.0	0.00002
<b>Total year 2015</b>	<b>25 722.9</b>			<b>1 928.3</b>		<b>0.1279</b>		<b>0.01847</b>
<b>Total year 2014</b>	<b>26 499.5</b>			<b>1 976.7</b>		<b>0.1313</b>		<b>0.01893</b>
<b>Index 2015/2014</b>	<b>0.97</b>			<b>0.98</b>		<b>0.97</b>		<b>0.98</b>
<b>Total year 1990</b>	<b>155 319.2</b>			<b>14 860.7</b>		<b>1.3950</b>		<b>0.20941</b>
<b>Index 2015/1990</b>	<b>0.17</b>			<b>0.13</b>		<b>0.09</b>		<b>0.09</b>

\*) 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 shown in details in the following outline.

2015							
Structure of Fuels	Source of Activity data	Emission factors			Method used		
		CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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.

The fraction of CO<sub>2</sub> emissions in subsector 1.A.2.a in CO<sub>2</sub> emissions in sector 1.A.2 equalled 19.6% in 2015. It contributed only 2% to CO<sub>2</sub> emissions in the whole Energy sector.

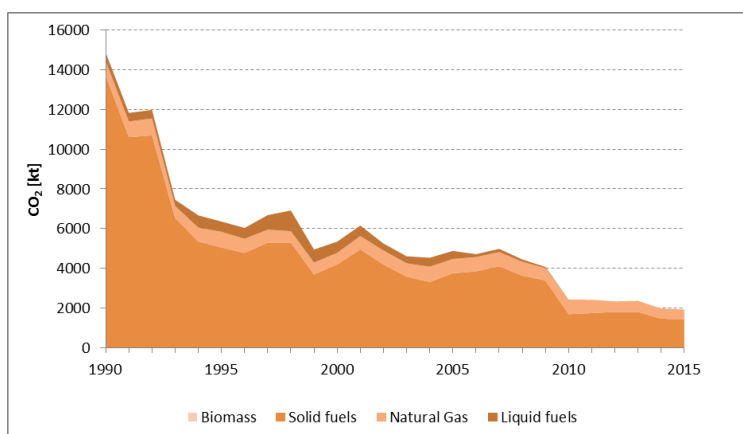


Fig. 3-11 Development of CO<sub>2</sub> emissions in source category 1.A.2.a

Important facility belongs to this

category is ArcelorMittal Ostrava, a.s. and Třinecké železářny 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions coming from metallurgical coke under 2.C.1. As a consequence of such approach we do not calculate any CO<sub>2</sub> 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

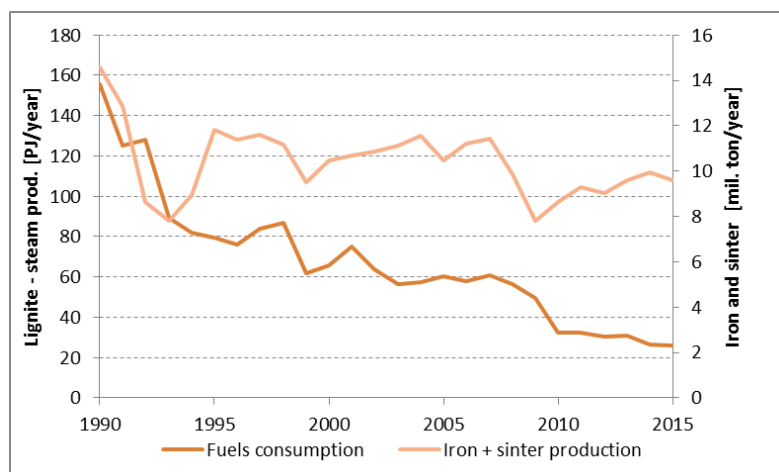


Fig. 3-12 The trend in the manufacture of agglomerates of iron ore and iron, in comparison with the development of fuel consumption in the sector 1.A.2.a

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.

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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O emission <sup>*)</sup>		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<sub>2</sub>O 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 <sub>2</sub> 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 <sub>4</sub> 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
<b>N<sub>2</sub>O emission</b>		<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
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<sub>2</sub>O emission factor was updated to 1.5 kg N<sub>2</sub>O/TJ for solid fuels, which caused increase in N<sub>2</sub>O emissions by 7.14%. The whole impact is smaller, since in 1.A.2.a is apparent share of coal gases, which N<sub>2</sub>O emission factor is 0.1 kg N<sub>2</sub>O/TJ.

Tab. 3-32 Changes after update of N<sub>2</sub>O emission factor in 1.A.2.a

<b>N<sub>2</sub>O emission</b>		<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>
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
<b>N<sub>2</sub>O emission</b>		<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>
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
<b>N<sub>2</sub>O emission</b>		<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>					
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 <sub>2</sub>		CH <sub>4</sub>		N <sub>2</sub> O		
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O /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
<b>Total year 2015</b>	<b>1 801.3</b>			<b>106.2</b>		<b>0.00294</b>		<b>0.00036</b>
<b>Total year 2014</b>	<b>1 617.3</b>			<b>95.7</b>		<b>0.00273</b>		<b>0.00033</b>
<b>Index 2015/2014</b>	<b>1.11</b>			<b>1.11</b>		<b>1.08</b>		<b>1.07</b>
<b>Total year 1990</b>	<b>1 476.3</b>			<b>102.0</b>		<b>0.00572</b>		<b>0.00081</b>
<b>Index 2015/1990</b>	<b>1.22</b>			<b>1.04</b>		<b>0.51</b>		<b>0.44</b>

\*) 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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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

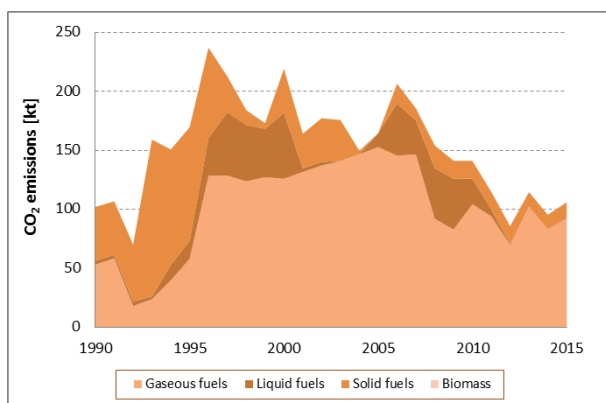
There are embodied the fuels of economic part according to NACE Rev. 2

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

Important facility belongs to this category is Kovohutě Příbram. The fraction of CO<sub>2</sub> emissions in subsector 1.A.2.b in CO<sub>2</sub> emissions in sector 1.A.2 equalled 1% in 2015. It contributed only 0.1% to CO<sub>2</sub> 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<sub>2</sub> emissions in the various sub-source categories in 1.A.2.b.



**Fig. 3-13 Development of CO<sub>2</sub> emissions in source category 1.A.2.b**

The trend of CO<sub>2</sub> 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O emission <sup>*)</sup>		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<sub>2</sub>O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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<sub>2</sub>O emission factor was updated to 1.5 kg N<sub>2</sub>O/TJ for solid fuels, which caused increase in N<sub>2</sub>O emissions by 7.14%. The whole impact is smaller, since in 1.A.2.a is apparent share of coal gases, which N<sub>2</sub>O emission factor is 0.1 kg N<sub>2</sub>O/TJ.

Tab. 3-36 Changes after update of N<sub>2</sub>O emission factor in 1.A.2.b

N <sub>2</sub> O 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 <sub>2</sub> O 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 <sub>2</sub> O 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 <sub>2</sub>			CH <sub>4</sub>		N <sub>2</sub> O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/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
<b>Total year 2015</b>	<b>22 246.1</b>			<b>1 601.9</b>		<b>0.09860</b>		<b>0.01439</b>
<b>Total year 2014</b>	<b>23 184.0</b>			<b>1 691.0</b>		<b>0.10703</b>		<b>0.01578</b>
<b>Index 2015/2014</b>	<b>0.96</b>			<b>0.95</b>		<b>0.92</b>		<b>0.91</b>
<b>Total year 1990</b>	<b>33 576.7</b>			<b>2 996.4</b>		<b>0.26480</b>		<b>0.03975</b>
<b>Index 2015/1990</b>	<b>0.66</b>			<b>0.53</b>		<b>0.37</b>		<b>0.36</b>

\*) 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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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:

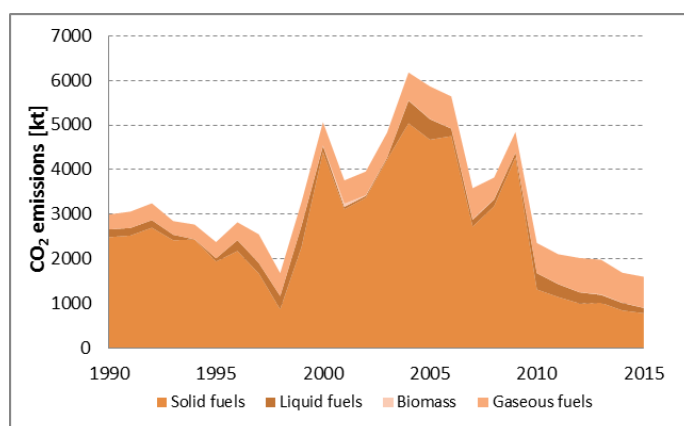


Fig. 3-14 Development of CO<sub>2</sub> emissions in source category 1.A.2.c

### Chemical (including Petrochemical)

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

Chemicals: NACE Division 20

The fraction of CO<sub>2</sub> emissions in subsector 1.A.2.c in CO<sub>2</sub> emissions in sector 1.A.2 equalled 16.3% in 2015. It contributed 1.7% to CO<sub>2</sub> emissions in the whole Energy sector.

The following figure (Fig. 3-14) provides an overview of CO<sub>2</sub> emissions in the sub-category in 1.A.2.c.

The course of CO<sub>2</sub> 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O emission <sup>*)</sup>		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

<sup>\*)</sup>combination of change in activity data and change in N<sub>2</sub>O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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<sub>2</sub>O emission factor was updated to 1.5 kg N<sub>2</sub>O/TJ for solid fuels, which caused increase in N<sub>2</sub>O emissions by 7.14%.

Tab. 3-40 Changes after update of N<sub>2</sub>O emission factor in 1.A.2.c

N <sub>2</sub> O 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 <sub>2</sub>		CH <sub>4</sub>		N <sub>2</sub> O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/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
<b>Total year 2015</b>	<b>33 050.3</b>			<b>2 851.9</b>		<b>0.54007</b>		<b>0.07179</b>
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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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 Větrník, 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

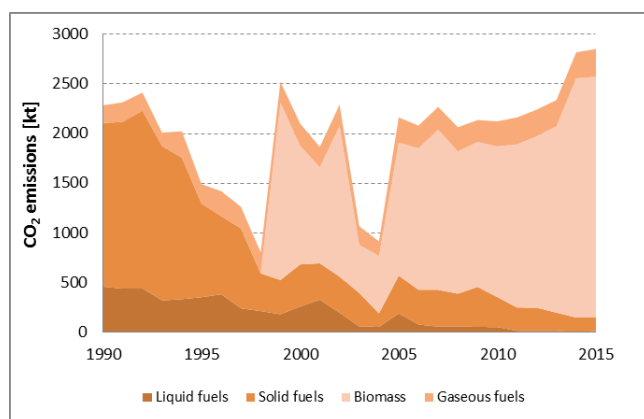


Fig. 3-15 Development of CO<sub>2</sub> emissions in source category 1.A.2.d

The fraction of CO<sub>2</sub> emissions in subsector 1.A.2.d in CO<sub>2</sub> emissions in sector 1.A.2 equalled 4% in 2015. It contributed 0.5% to CO<sub>2</sub> 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<sub>2</sub>, which is included in the balance of greenhouse gases. In Fig. 3-15 is shown the development of CO<sub>2</sub> 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O emission <sup>*)</sup>		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

<sup>\*)</sup>combination of change in activity data and change in N<sub>2</sub>O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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<sub>2</sub>O emission factor was updated to 1.5 kg N<sub>2</sub>O/TJ for solid fuels, which caused increase in N<sub>2</sub>O emissions by 7.14%.

Tab. 3-44 Changes after update of N<sub>2</sub>O emission factor in 1.A.2.d

N <sub>2</sub> O 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 <sub>2</sub>			CH <sub>4</sub>		N <sub>2</sub> O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/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
<b>Total year 2015</b>	<b>26 254.6</b>			<b>1 582.42</b>		<b>0.06526</b>		<b>0.00835</b>
<b>Total year 2014</b>	<b>26 787.6</b>			<b>1 570.30</b>		<b>0.04964</b>		<b>0.00615</b>

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

<sup>a)</sup> 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.

Structure of Fuels	Source of Activity data	2015 Emission factors			Method used		
		CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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

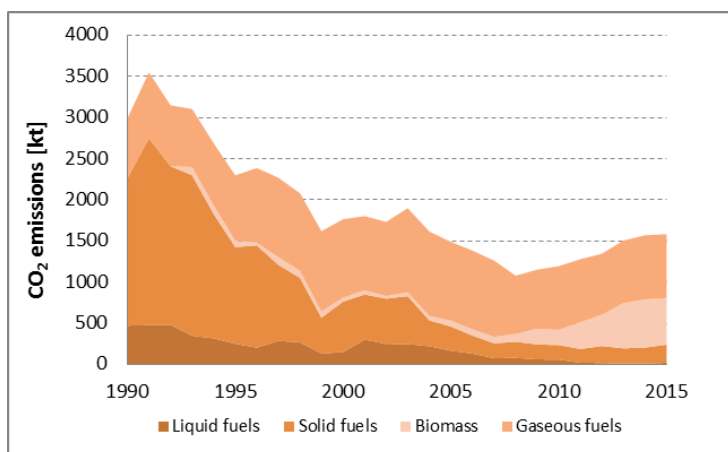


Fig. 3-16 Development of CO<sub>2</sub> emissions from fossil fuels combustion in source category 1.A.2.e

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.

The fraction of CO<sub>2</sub> emissions in subsector 1.A.2.e in CO<sub>2</sub> emissions in sector 1.A.2 equalled 10% in 2015. It contributed 1.1% to CO<sub>2</sub> 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

Biofuel consumption has a beneficial effect on the production of CO<sub>2</sub>, which is included in the balance of greenhouse gases. Fig. 3-16 shows the development of CO<sub>2</sub> 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O emission <sup>*)</sup>		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<sub>2</sub>O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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<sub>2</sub>O emission factor was updated to 1.5 kg N<sub>2</sub>O/TJ for solid fuels, which caused increase in N<sub>2</sub>O emissions by 7.14%.

Tab. 3-48 Changes after update of N<sub>2</sub>O emission factor in 1.A.2.e

N <sub>2</sub> O 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 <sub>2</sub>		CH <sub>4</sub>		N <sub>2</sub> O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
		[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/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
Coke 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
<b>Total year 2015</b>	<b>35 447.1</b>			<b>2360.20</b>		<b>0.23256</b>		<b>0.03144</b>
<b>Total year 2014</b>	<b>33 313.6</b>			<b>2227.45</b>		<b>0.19726</b>		<b>0.02687</b>
<b>Index 2015/2014</b>	<b>1.06</b>			<b>1.06</b>		<b>1.18</b>		<b>1.17</b>
<b>Total year 1990</b>	<b>59 962.4</b>			<b>4 527.12</b>		<b>0.29373</b>		<b>0.04487</b>
<b>Index 2015/1990</b>	<b>0.59</b>			<b>0.52</b>		<b>0.79</b>		<b>0.70</b>

\*) 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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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

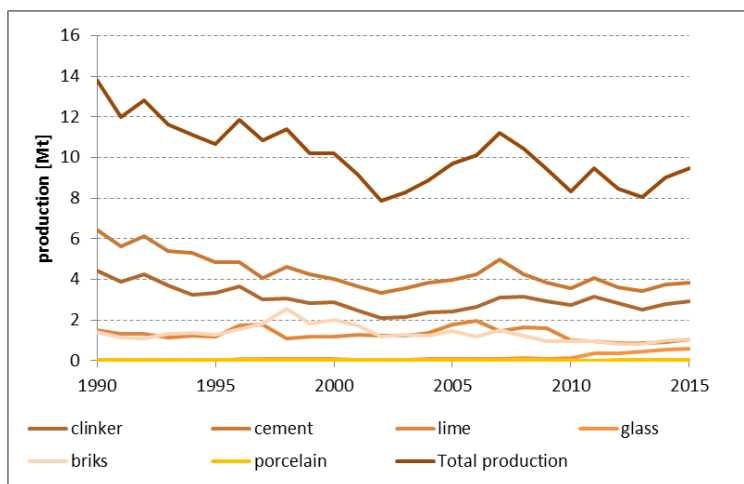


Fig. 3-17 Production of the most important mineral products

The fraction of CO<sub>2</sub> emissions in subsector 1.A.2.f in CO<sub>2</sub> emissions in sector 1.A.2 equalled 22.6% in 2015. It contributed 2.5% to CO<sub>2</sub> 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.

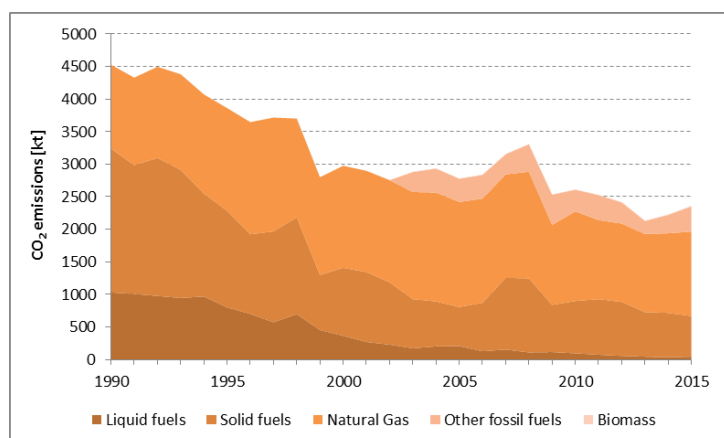


Fig. 3-18 Development of CO<sub>2</sub> emissions in source category 1.A.2.f

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.

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<sub>2</sub> emissions in the sub-category in 1.A.2.f.

The graph shows the evolution of CO<sub>2</sub> 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

### 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](http://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
<b>Solid fuels</b>	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
<b>Liquid fuels</b>	1 266	1 156	589	1 014	240	557	682	708	661	394	1 181	18	1 017
<b>Total</b>	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<sub>2</sub> 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<sub>2</sub> emission factors used in the consumption of alternative fuels in sector 1.A.2.f

[t CO <sub>2</sub> /TJ]	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
<b>Solid fuels</b>	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
<b>Liquid fuels</b>	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<sub>4</sub> and N<sub>2</sub>O 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<sub>4</sub> and N<sub>2</sub>O emissions used in the consumption of alternative fuels sector 1.A.2.f

EF [kg/TJ]	CH <sub>4</sub>	N <sub>2</sub> O
<b>Solid fuels</b>	30	4
<b>Liquid fuels</b>	30	4

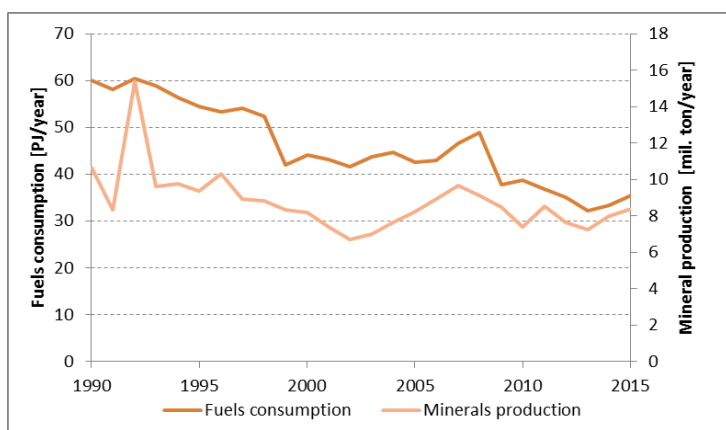


Fig. 3-19 Trends in production of mineral products compared with the development of fuel consumption in the sector 1.A.2.f

### 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O emission <sup>*)</sup>		2009	2010	2011	2012	2013	2014
Submission 2016	kt	0.0108	0.0122	0.0155	0.0143	0.0123	0.0103



<b>Submission 2017</b>	kt	0.0115	0.0127	0.0138	0.0134	0.0111	0.0111
<b>Difference</b>	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<sub>2</sub>O 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
<b>Submission 2016</b>	TJ	24 058	21 612	22 364	22 160	22 391
<b>Submission 2017</b>	TJ	24 884	21 985	21 788	21 727	22 092
<b>Difference</b>	TJ	826.4	373.4	-575.8	-432.5	-298.3
	%	3.44	1.7	-2.6	-2.0	-1.3
CO <sub>2</sub> emission		2010	2011	2012	2013	2014
<b>Submission 2016</b>	kt	1 330.1	1 194.3	1 234.5	1 225.5	1 239.4
<b>Submission 2017</b>	kt	1 375.8	1 214.9	1 202.7	1 201.6	1 222.9
<b>Difference</b>	kt	45.7	20.6	-31.8	-23.9	-16.5
	%	3.44	1.7	-2.6	-2.0	-1.3
CH <sub>4</sub> emission		2010	2011	2012	2013	2014
<b>Submission 2016</b>	kt	0.0241	0.0216	0.0224	0.0222	0.0224
<b>Submission 2017</b>	kt	0.0249	0.0220	0.0218	0.0217	0.0221
<b>Difference</b>	kt	0.0008	0.0004	-0.0006	-0.0004	-0.0003
	%	3.44	1.7	-2.6	-2.0	-1.3
N <sub>2</sub> O emission		2010	2011	2012	2013	2014
<b>Submission 2016</b>	kt	0.00241	0.00216	0.00224	0.00222	0.00224
<b>Submission 2017</b>	kt	0.00249	0.00220	0.00218	0.00217	0.00221
<b>Difference</b>	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<sub>2</sub>O emission factor was updated to 1.5 kg N<sub>2</sub>O/TJ for solid fuels, which caused increase in N<sub>2</sub>O emissions by 7.14%.

Tab. 3-55 Changes after update of N<sub>2</sub>O emission factor in 1.A.2.f

N <sub>2</sub> O emission		1990	1995	2000	2005	2010	2011	2012	2013	2014
<b>Submission 2016</b>	kt	0.0322	0.0192	0.0151	0.0087	0.0122	0.0155	0.0143	0.0123	0.0103
<b>Submission 2017</b>	kt	0.0345	0.0205	0.0162	0.0094	0.0127	0.0138	0.0134	0.0111	0.0111
<b>Difference</b>	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<sub>2</sub>/TJ, for solid fossil fuels 86.03 t CO<sub>2</sub>/TJ for 2014.

Tab. 3-56 Change of CO<sub>2</sub> from Other fossil fuels for 2014

CO <sub>2</sub> emission		2014
<b>Submission 2016</b>	kt	301.6
<b>Submission 2017</b>	kt	279.5
<b>Difference</b>	kt	-22.1
	%	-7.32

After a recommendation of ERT CH<sub>4</sub> and N<sub>2</sub>O emission factors for Other fossil fuels were also changed. For CH<sub>4</sub> updated emission factors is 30 kg CH<sub>4</sub>/TJ for both liquid and solid other fossil fuels. For N<sub>2</sub>O updated emission factors is 4 kg N<sub>2</sub>O/TJ for both liquid and solid other fossil fuels.

Tab. 3-57 Change of CH<sub>4</sub> from Other fossil fuels

CH <sub>4</sub> 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<sub>2</sub>O from Other fossil fuels

N <sub>2</sub> O 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 <sub>2</sub>			CH <sub>4</sub>		N <sub>2</sub> O		
	data	EF	OxF	Emission	EF	Emission	EF	Emission	
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/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	
Coke 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	
<b>Total year 2015</b>	<b>50 004.3</b>			<b>3 534.22</b>		<b>0.36467</b>		<b>0.04930</b>	
<b>Total year 2014</b>	<b>46 300.7</b>			<b>3 253.57</b>		<b>0.32708</b>		<b>0.04412</b>	
<b>Index 2015/2014</b>	<b>1.08</b>			<b>1.09</b>		<b>1.11</b>		<b>1.12</b>	
<b>Total year 1990</b>	<b>301 656.3</b>			<b>24 730.77</b>		<b>1.97324</b>		<b>0.29944</b>	
<b>Index 2015/1990</b>	<b>0.17</b>			<b>0.14</b>		<b>0.18</b>		<b>0.16</b>	

\*) 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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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)

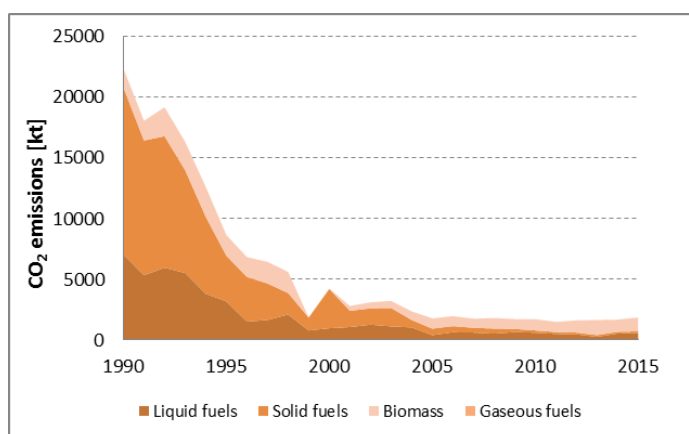


Fig. 3-20 Development of CO<sub>2</sub> emissions in source category 1.A.2.g

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<sub>2</sub> emissions in subsector 1.A.2.f in CO<sub>2</sub> emissions in sector 1.A.2 equalled 24.4% in 2015. It contributed 2.6% to CO<sub>2</sub> 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<sub>2</sub> emissions (and other greenhouse gases). This is the category with the largest relative decrease in CO<sub>2</sub> 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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
<b>N<sub>2</sub>O emission<sup>*)</sup></b>		<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
<b>Submission 2016</b>	kt	0.0033	0.0025	0.0022	0.0020	0.0022	0.0019
<b>Submission 2017</b>	kt	0.0036	0.0027	0.0021	0.0021	0.0021	0.0021
<b>Difference</b>	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<sub>2</sub>O emission factor (ERT recommendation 2016)

Tab. 3-61 Changes after recalculation in 1.A.2.g for Natural Gas

<b>Fuel consumption</b>		<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
<b>Submission 2016</b>	TJ	35 611.7	32 054.4	31 303.8	33 824.9	29 384.5
<b>Submission 2017</b>	TJ	36 835.1	32 608.3	33 520.6	32 799.5	28 146.5
<b>Difference</b>	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
<b>CO<sub>2</sub> emission</b>		<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
<b>Submission 2016</b>	kt	1 968.9	1 771.3	1 728.0	1 870.6	1 626.5
<b>Submission 2017</b>	kt	2 036.5	1 801.9	1 850.3	1 813.9	1 558.0
<b>Difference</b>	kt	67.6	30.6	122.4	-56.7	-68.5
	%	3.4	1.7	7.1	-3.0	-4.2
<b>CH<sub>4</sub> emission</b>		<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
<b>Submission 2016</b>	kt	0.0356	0.0321	0.0313	0.0338	0.0294
<b>Submission 2017</b>	kt	0.0368	0.0326	0.0335	0.0328	0.0281
<b>Difference</b>	kt	0.0012	0.0006	0.0022	-0.0010	-0.0012
	%	3.4	1.7	7.1	-3.0	-4.2
<b>N<sub>2</sub>O emission</b>		<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
<b>Submission 2016</b>	kt	0.0036	0.0032	0.0031	0.0034	0.0029
<b>Submission 2017</b>	kt	0.0037	0.0033	0.0034	0.0033	0.0028
<b>Difference</b>	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<sub>2</sub>O emission factor was updated to 1.5 kg N<sub>2</sub>O/TJ for solid fuels, which caused increase in N<sub>2</sub>O 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<sub>2</sub>O/TJ.

Tab. 3-62 Changes after update of N<sub>2</sub>O emission factor in 1.A.2.g

<b>N<sub>2</sub>O emission</b>		<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>
<b>Submission 2016</b>	kt	0.171	0.133	0.123	0.117	0.087	0.051	0.052	0.043	0.025	0.015
<b>Submission 2017</b>	kt	0.183	0.143	0.132	0.126	0.093	0.055	0.056	0.046	0.027	0.016
<b>Difference</b>	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
<b>N<sub>2</sub>O emission</b>		<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>
<b>Submission 2016</b>	kt	0.0464	0.0192	0.0193	0.0216	0.0084	0.0072	0.0068	0.0051	0.0054	0.0033
<b>Submission 2017</b>	kt	0.0497	0.0206	0.0206	0.0231	0.0090	0.0077	0.0073	0.0055	0.0058	0.0036
<b>Difference</b>	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
<b>N<sub>2</sub>O emission</b>		<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>					
<b>Submission 2016</b>	kt	0.0025	0.0022	0.0020	0.0022	0.0019					
<b>Submission 2017</b>	kt	0.0027	0.0021	0.0021	0.0021	0.0021					
<b>Difference</b>	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<sub>2</sub> and N<sub>2</sub>O), and also those with country-specific character



(CH<sub>4</sub>). 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<sup>-1</sup>] of fuel because the country-specific measured data are listed in this unit.

Tab. 3-64 Emission factors of CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> from road transport in 2015 in [g.kg<sup>-1</sup>] of fuel

Vehicle type	Fuel type	European emission standard	EF CO <sub>2</sub> [g.kg <sup>-1</sup> ]	EF N <sub>2</sub> O [g.kg <sup>-1</sup> ]	EF CH <sub>4</sub> [g.kg <sup>-1</sup> ]
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<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> from non-road transport in 2015 in [g.kg<sup>-1</sup>] of fuel

Transport type	Fuel type	EF CO <sub>2</sub> [g.kg <sup>-1</sup> ]	EF N <sub>2</sub> O [g.kg <sup>-1</sup> ]	EF CH <sub>4</sub> [g.kg <sup>-1</sup> ]
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<sub>2</sub> 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<sub>2</sub> 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 contribution of transport to total CO<sub>2</sub> 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<sub>2</sub> emissions.

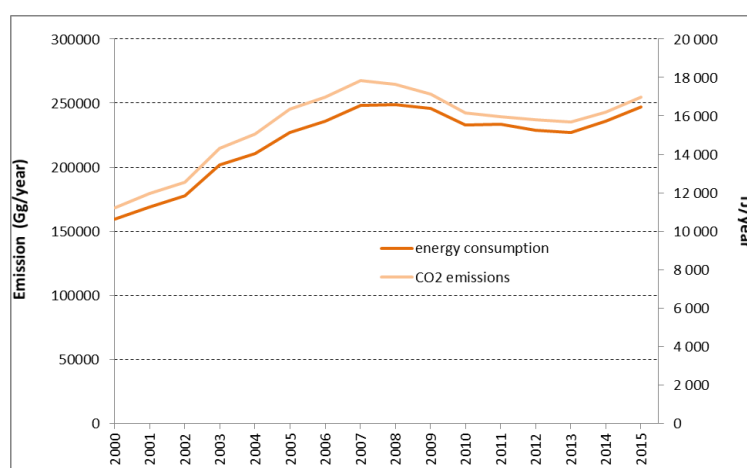
Mobile sources used for purposes other than transport (gasoline-powered lawn mowers, chain saws, construction machinery, etc.) make a smaller contribution to the increasing consumption of gasoline and diesel oil.

In relation to CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions calculation from mobile sources in 1990 – 2015 [kt CO<sub>2</sub>]

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<sub>2</sub> emissions from road transport

According to Fig. 3-22 the emissions of CO<sub>2</sub> from road transportation follow the trend in energy consumption. There are no disproportions. CO<sub>2</sub> 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<sub>4</sub> 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<sub>4</sub> emissions was observed in 2014 and 2015. This was caused mainly by the acquisition 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<sub>4</sub> emissions calculation from mobile sources [Mg] of CH<sub>4</sub> 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
<b>1990</b>	0.996	1 500	37	5.35	0.10	0.13	1 544
<b>1991</b>	0.273	1 354	33	5.31	0.17	0.12	1 393
<b>1992</b>	0.278	1 757	28	5.18	0.24	0.11	1 791
<b>1993</b>	0.169	1 683	23	5.13	0.31	0.10	1 712
<b>1994</b>	0.156	1 814	19	5.05	0.38	0.10	1 839
<b>1995</b>	0.095	1 826	19	5.22	0.66	0.09	1 851
<b>1996</b>	0.108	1 924	18	4.34	1.59	0.08	1 948
<b>1997</b>	0.071	1 851	16	3.64	1.37	0.09	1 872
<b>1998</b>	0.069	1 771	20	3.57	1.06	0.10	1 796
<b>1999</b>	0.090	1 834	19	2.09	1.13	0.10	1 856
<b>2000</b>	0.077	1 703	18	1.49	1.05	0.13	1 724
<b>2001</b>	0.056	1 701	17	2.35	1.08	0.13	1 722
<b>2002</b>	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<sub>4</sub> 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<sub>4</sub>. This trend changed in 2014 when CH<sub>4</sub> 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.

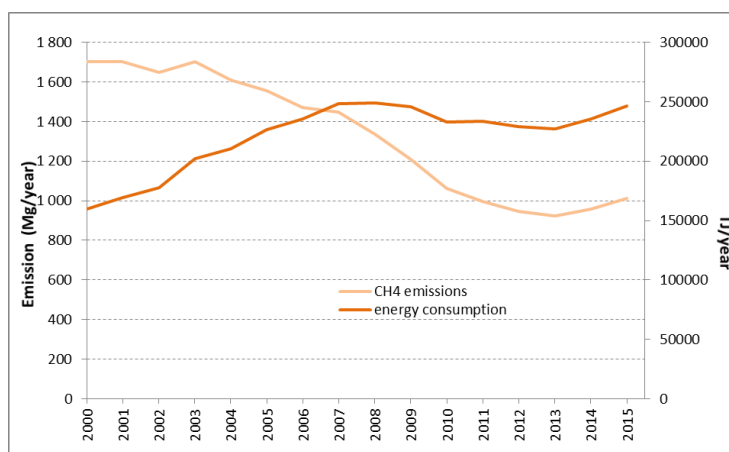


Fig. 3-22 Comparison of energy consumption and CH<sub>4</sub> emissions from road transport

### N<sub>2</sub>O 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<sub>x</sub> emissions but not N<sub>2</sub>O emissions. However, this effect is suppressed in new vehicles as a consequence of the lower fuel consumption. Between 2008 and 2013, the N<sub>2</sub>O 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<sub>2</sub>O emissions over the past 5 years, as the share of vehicles with high N<sub>2</sub>O emissions has been increasing in this period. Consequently, N<sub>2</sub>O emissions from mobile sources represent a somewhat more important contribution than CH<sub>4</sub> emissions. In calculation of N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O emission factors from mobile sources approach the recommended IPCC values. The N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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 IPCC 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<sub>2</sub>O 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<sub>2</sub>O are given in Tab. 3-24.

EFs described higher were used until the year 1999. In next years the CS EFs, based on the recommendation 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<sub>2</sub>O emissions calculation from mobile sources in 1990 – 2015 [Mg N<sub>2</sub>O]**

	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<sub>2</sub>O 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<sub>2</sub>O 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<sub>x</sub>. Consequently and because of the impact of last economic crisis (decrease in transport of goods) a decrease in N<sub>2</sub>O emissions was observed in the following years, which is more intense than the decrease in energy consumption.

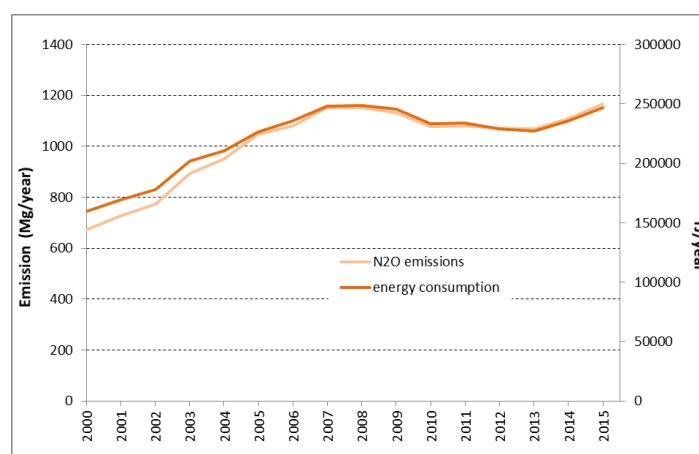


Fig. 3-23 Comparison of energy consumption and N<sub>2</sub>O emissions from road transport

### Other Transportation (CRF1.A.3.e )

Country specific CO<sub>2</sub> emission factor is used in this category. For detailed information please see Annex 3.

Default emission factors are used for CH<sub>4</sub> and N<sub>2</sub>O 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 <sub>2</sub>	138.1	9.2	4.0	3.9	5.6
1A3aii Civil Aviation-Jet Kerosene	CO <sub>2</sub>	1.4	1.0	4.0	3.2	5.1
1A3bi PC+LDV-Gasoline	CO <sub>2</sub>	3468.7	4478.6	3.0	4.0	5.0
1A3bi PC+LDV-Diesel Oil	CO <sub>2</sub>	1548.9	5300.2	3.0	1.5	3.3
1A3bi PC+LDV-LPG	CO <sub>2</sub>	0.0	296.7	3.0	3.2	4.4
1A3bi PC+LDV Gaseous Fuels	CO <sub>2</sub>	0.0	57.9	3.0	3.2	4.4
1A3bi PC+LDV Biomass	CO <sub>2</sub>	0.0	489.0	3.0	2.5	3.9
1A3biii HDV-Diesel Oil	CO <sub>2</sub>	7344.6	6788.6	3.0	1.5	3.3
1A3biii HDV-Gaseous Fuels	CO <sub>2</sub>	0.0	25.7	3.0	3.2	4.4
1A3biii HDV-Biomass	CO <sub>2</sub>	0.0	388.4	3.0	1.5	3.3
1A3biv Motorcycles-Gasoline	CO <sub>2</sub>	18.4	37.9	3.0	4.0	5.0
1A3biv Motorcycles-Biomass	CO <sub>2</sub>	0.0	1.6	3.0	4.0	5.0
1A3c Railways-Diesel Oil	CO <sub>2</sub>	653.9	264.1	5.0	1.5	5.2
1A3dii National navigation-Diesel Oil	CO <sub>2</sub>	56.6	12.7	5.0	1.5	5.2
1D1a International Aviation-Jet Kerosene	CO <sub>2</sub>	523.7	887.5	4.0	3.2	5.1
1A3aii Civil Aviation-Aviation Gasoline	CH <sub>4</sub>	0.0	0.0	4.0	78.5	78.7
1A3aii Civil Aviation-Jet Kerosene	CH <sub>4</sub>	0.0	0.0	4.0	78.5	78.6
1A3bi PC+LDV-Gasoline	CH <sub>4</sub>	26.0	5.6	3.0	157.5	157.5
1A3bi PC+LDV-Diesel Oil	CH <sub>4</sub>	1.0	3.5	3.0	101.3	101.3
1A3bi PC+LDV-LPG	CH <sub>4</sub>	0.0	2.5	3.0	809.8	809.8
1A3bi PC+LDV Gaseous Fuels	CH <sub>4</sub>	0.0	2.4	3.0	809.8	809.8
1A3bi PC+LDV Biomass	CH <sub>4</sub>	0.0	0.4	3.0	123.2	123.2
1A3biii HDV-Diesel Oil	CH <sub>4</sub>	35.0	8.4	3.0	157.5	157.5
1A3biii HDV-Gaseous Fuels	CH <sub>4</sub>	0.0	1.1	3.0	809.8	809.8
1A3biii HDV-Biomass	CH <sub>4</sub>	0.0	0.2	3.0	101.3	101.3
1A3biv Motorcycles-Gasoline	CH <sub>4</sub>	0.6	1.3	3.0	151.7	151.7
1A3biv Motorcycles-Biomass	CH <sub>4</sub>	0.0	0.0	3.0	151.7	151.7
1A3c Railways-Diesel Oil	CH <sub>4</sub>	0.9	0.4	5.0	157.5	157.5
1A3dii National navigation-Diesel Oil	CH <sub>4</sub>	0.1	0.0	5.0	157.5	157.5
1D1a International Aviation-Jet Kerosene	CH <sub>4</sub>	0.1	0.2	4.0	78.5	78.6
1A3aii Civil Aviation-Aviation Gasoline	N <sub>2</sub> O	1.2	0.0	4.0	110.0	110.1
1A3aii Civil Aviation-Jet Kerosene	N <sub>2</sub> O	0.0	0.0	4.0	110.0	110.1
1A3bi PC+LDV-Gasoline	N <sub>2</sub> O	106.7	7.5	3.0	133.8	133.8
1A3bi PC+LDV-Diesel Oil	N <sub>2</sub> O	14.7	10.2	3.0	137.2	137.2
1A3bi PC+LDV-LPG	N <sub>2</sub> O	0.0	0.0	3.0	1266.7	1266.7
1A3bi PC+LDV Gaseous Fuels	N <sub>2</sub> O	0.0	0.1	3.0	1266.7	1266.7
1A3bi PC+LDV Biomass	N <sub>2</sub> O	0.0	0.1	3.0	135.8	135.9
1A3biii HDV-Diesel Oil	N <sub>2</sub> O	84.3	132.7	3.0	137.2	137.2
1A3biii HDV-Gaseous Fuels	N <sub>2</sub> O	0.0	0.4	3.0	1266.7	1266.7
1A3biii HDV-Biomass	N <sub>2</sub> O	0.0	1.0	3.0	97.9	97.9
1A3biv Motorcycles-Gasoline	N <sub>2</sub> O	0.1	0.2	3.0	156.9	156.9
1A3biv Motorcycles-Biomass	N <sub>2</sub> O	0.0	0.0	3.0	156.9	156.9
1A3c Railways-Diesel Oil	N <sub>2</sub> O	75.2	30.4	5.0	137.2	137.3
1A3dii National navigation-Diesel Oil	N <sub>2</sub> O	0.5	0.1	5.0	137.2	137.3
1D1a International Aviation-Jet Kerosene	N <sub>2</sub> O	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 <sub>2</sub> (kt)			CH <sub>4</sub> (t)			N <sub>2</sub> O (t)		
	Original estimate data	Updated 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

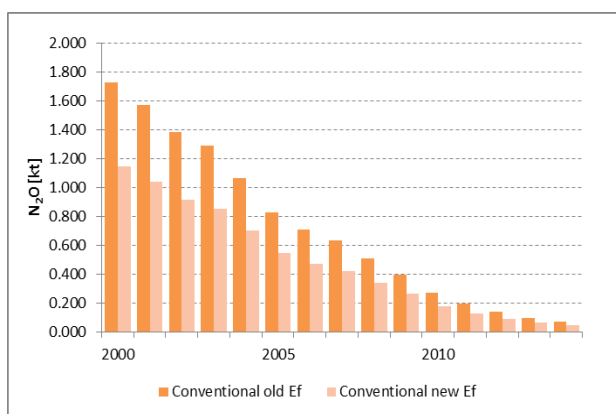
The emission factors of N<sub>2</sub>O for gasoline PCs and gasoline motorcycles for 2000 – 2014 were changed on the basis of the ESD review held in June 2016,. On the basis of the recommendations, the original country specific EFs were replaced by Tier 1 EFs given in the EMEP/EEA emission inventory guidebook 2016, page 23, table 3-7. See the differences in in tables and figures below.

Tab. 3-72 EFs N<sub>2</sub>O 2000 – 2014 before recalculation

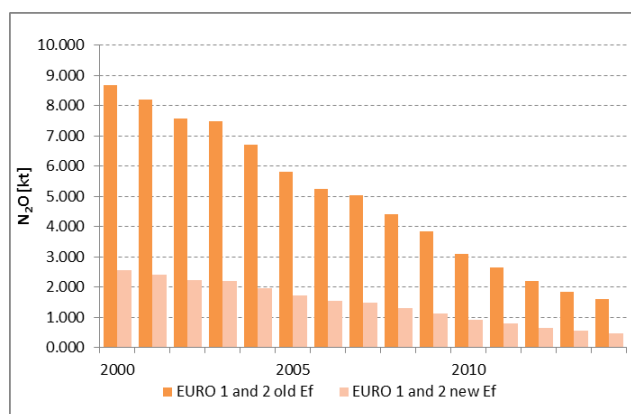
Year	Old EFs N <sub>2</sub> O (g/kg)			
	1.A.3.b.i Gasoline			1.A.3.b.iv Gasoline
	conventional	EURO 1 and 2	EURO 3 and higher	all
2000	0.31	0.7	1.1	0.0587
2001	0.31	0.7	1.1	0.0587
2002	0.31	0.7	1.1	0.0587
2003	0.31	0.7	1.07	0.0587
2004	0.31	0.7	1.03	0.0587
2005	0.31	0.7	1.01	0.0587
2006	0.31	0.7	0.98	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<sub>2</sub>O 2000 – 2014 after recalculation

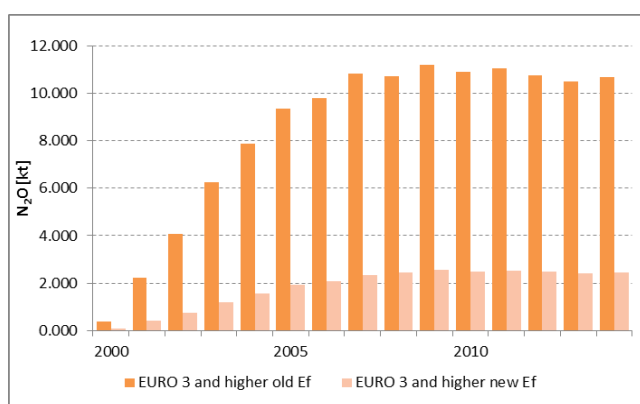
Year	New EFs N <sub>2</sub> O (g/kg)			
	1.A.3.b.i Gasoline			1.A.3.b.iv Gasoline
	conventional	EURO 1 and 2	EURO 3 and higher	all
2000	0.206	0.206	0.206	0.059
2001	0.206	0.206	0.206	0.059
2002	0.206	0.206	0.206	0.059
2003	0.206	0.206	0.206	0.059
2004	0.206	0.206	0.206	0.059
2005	0.206	0.206	0.206	0.059
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



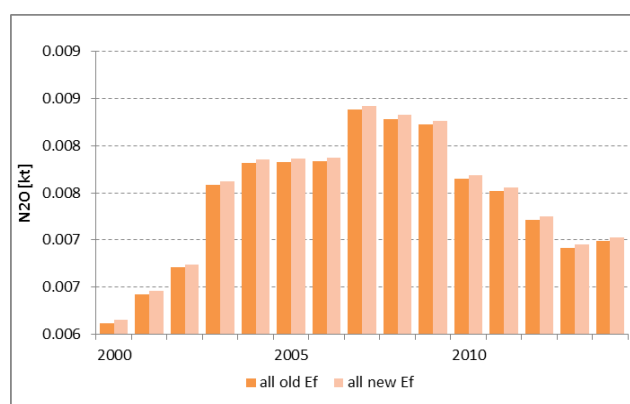
**Fig. 3-27 Comparison of N<sub>2</sub>O emissions 2000 – 2014, 1.A.3.b.i Gasoline before and after recalculation for conventional PCs**



**Fig. 3-27 Comparison of N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O emissions 2000 – 2014, 1.A.3.b.iv Gasoline before and after recalculation for gasoline motorcycles**

### 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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 <sub>2</sub> (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 <sub>4</sub> (kt)			Emissions N <sub>2</sub> O (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)		
	Gaseous 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 <sub>2</sub> Gasoline (t/TJ)	69.12	69.30
CO <sub>2</sub> Diesel oil(t/TJ)	74.05	74.05
CH <sub>4</sub> Gaseous fuels(kg/TJ)	91.83	92.00
N <sub>2</sub> O 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<sub>2</sub> and N<sub>2</sub>O 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	CO <sub>2</sub>		CH <sub>4</sub>		N <sub>2</sub> O		
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/TJ]	[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
<b>Total year 2015</b>	<b>47 038.2</b>			<b>2 700.87</b>		<b>0.4375</b>		<b>0.00895</b>
<b>Total year 2014</b>	<b>46 983.7</b>			<b>2 687.93</b>		<b>0.3965</b>		<b>0.00844</b>
<b>Index 2015/2014</b>	<b>1.00</b>			<b>1.00</b>		<b>1.10</b>		<b>1.06</b>
<b>Total year 1990</b>	<b>121 435.7</b>			<b>10 023.61</b>		<b>1.0166</b>		<b>0.10207</b>
<b>Index 2015/1990</b>	<b>0.39</b>			<b>0.27</b>		<b>0.43</b>		<b>0.09</b>

\*) 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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions produced in category 1.A.4.a represent in 2015 24% of whole 1.A.4, which is 3% of CO<sub>2</sub> 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)

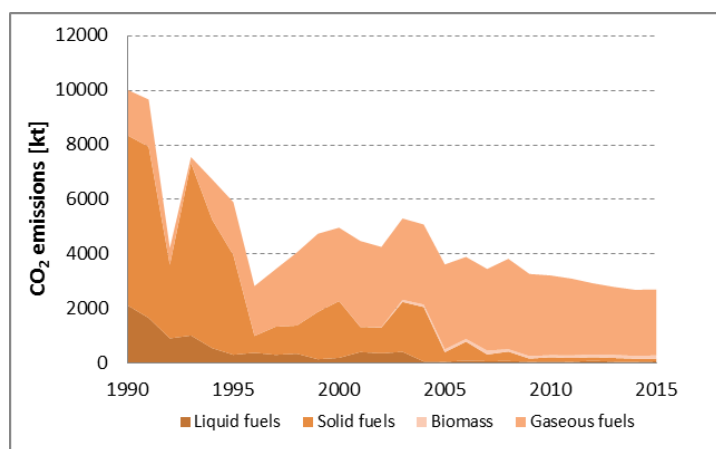


Fig. 3-28 Development of CO<sub>2</sub> emissions in source category 1.A.4.a

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<sub>2</sub> 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O emission <sup>*)</sup>		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<sub>2</sub>O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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<sub>2</sub>O emission factor was updated to 1.5 kg N<sub>2</sub>O/TJ for solid fuels, which caused increase in N<sub>2</sub>O emissions by 7.14%.

Tab. 3-83 Changes after update of N<sub>2</sub>O emission factor in 1.A.4.a

N <sub>2</sub> O 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 <sub>2</sub>			CH <sub>4</sub>		N <sub>2</sub> O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/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
<b>Total year 2015</b>	<b>181 245.4</b>			<b>15497.7</b>		<b>31.5690</b>		<b>0.3471</b>
<b>Total year 2014</b>	<b>173 761.5</b>			<b>15012.5</b>		<b>31.1133</b>		<b>0.3416</b>
<b>Index 2015/2014</b>	<b>1.04</b>			<b>1.03</b>		<b>1.01</b>		<b>1.02</b>
<b>Total year 1990</b>	<b>222 730.7</b>			<b>20 682.1</b>		<b>51.8513</b>		<b>0.3710</b>
<b>Index 2015/1990</b>	<b>0.81</b>			<b>0.75</b>		<b>0.61</b>		<b>0.94</b>

\*) 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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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<sub>2</sub> emissions in subsector 1.A.4.b in CO<sub>2</sub> emissions in sector 1.A.4 equalled 66% in 2014. It contributed 8% to CO<sub>2</sub> 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.

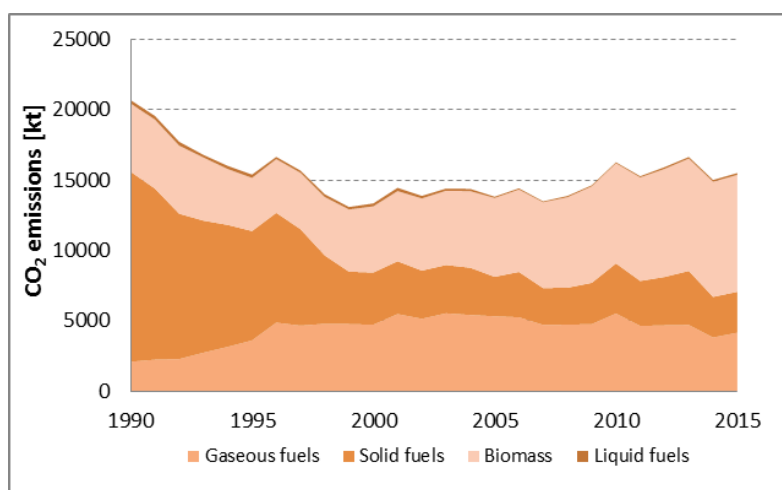


Fig. 3-29 Development of CO<sub>2</sub> emissions in source category 1.A.4.b

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<sub>2</sub> emissions, which are included in total greenhouse gas emissions. While the total fuel consumption declines in this subsector generally slightly (only about 20%), CO<sub>2</sub> 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O emission <sup>*)</sup>		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<sub>2</sub>O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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<sub>2</sub>O emission factor was updated to 1.5 kg N<sub>2</sub>O/TJ for solid fuels, which caused increase in N<sub>2</sub>O emissions by 7.14%.

Tab. 3-87 Changes after update of N<sub>2</sub>O emission factor in 1.A.4.b

N <sub>2</sub> O 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	CO <sub>2</sub>			CH <sub>4</sub>		N <sub>2</sub> O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/TJ]	[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
<b>Total year 2015</b>	<b>21 708.5</b>			<b>1 495.24</b>		<b>0.3176</b>		<b>0.07489</b>
<b>Total year 2014</b>	<b>22 316.8</b>			<b>1 536.44</b>		<b>0.3218</b>		<b>0.07677</b>
<b>Index 2015/2014</b>	<b>0.97</b>			<b>0.97</b>		<b>0.99</b>		<b>0.98</b>
<b>Total year 1990</b>	<b>47 622.9</b>			<b>3 790.22</b>		<b>5.4137</b>		<b>0.08558</b>
<b>Index 2015/1990</b>	<b>0.46</b>			<b>0.39</b>		<b>0.06</b>		<b>0.88</b>

\*) Country specific data

The high emissions of CH<sub>4</sub> 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<sub>4</sub>/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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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

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.

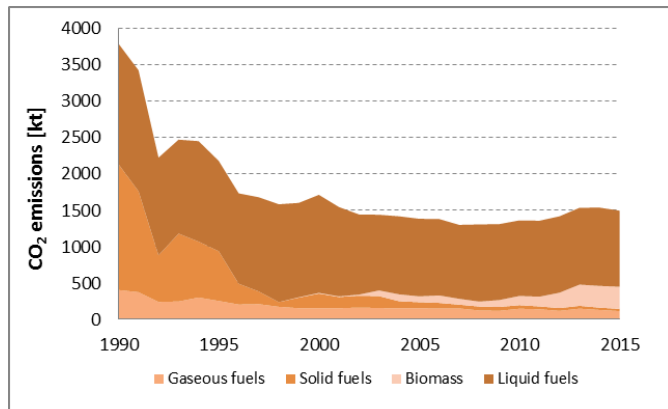


Fig. 3-30 Development of CO<sub>2</sub> emissions in source category 1.A.4.c

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

Agriculture/Forestry/Fisheries: NACE Divisions 01 – 03.

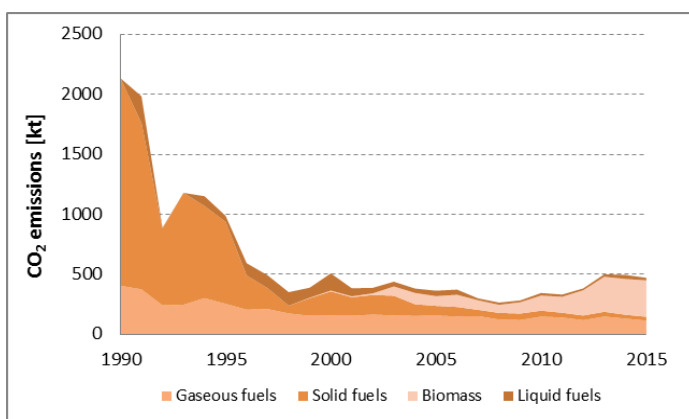


Fig. 3-31 Development of CO<sub>2</sub> emissions in source category 1.A.4.c.i

The fraction of CO<sub>2</sub> emissions in subsector 1.A.4.c in CO<sub>2</sub> emissions in sector 1.A.4 equalled 10% in 2015. It contributed 1.3% to CO<sub>2</sub> emissions in the whole Energy sector.

Development of fuel consumption and the corresponding CO<sub>2</sub> 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.

In the next chart is shown the fuel consumption and the corresponding CO<sub>2</sub> 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.

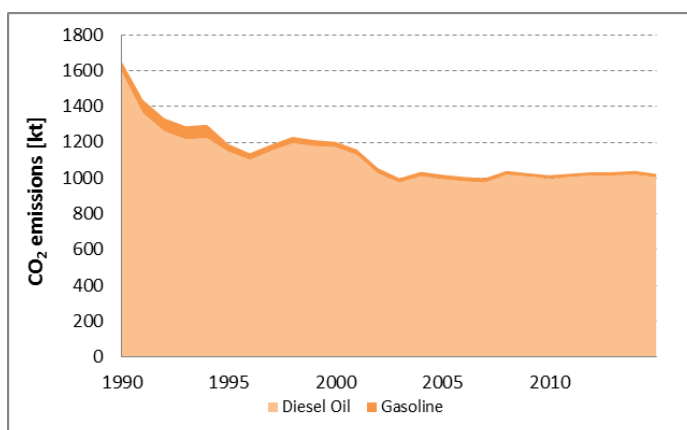


Fig. 3-32 Development of CO<sub>2</sub> emissions in source category 1.A.4.c.ii

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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O 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 <sub>2</sub> 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 <sub>4</sub> 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 <sub>2</sub> O emission <sup>*)</sup>		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

<sup>\*)</sup>combination of change in activity data and change in N<sub>2</sub>O emission factor (ERT recommendation 2016)

Tab. 3-90 Changes after recalculation in 1.A.4.c for Natural Gas

Fuel consumption		2012	CH <sub>4</sub> 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 <sub>2</sub> emission		2012	N <sub>2</sub> O emission		2012
Submission 2016	kt	117.0	Submission 2016	kt	0.000212
Submission 2017	kt	118.5	Submission 2017	kt	0.000215

<b>Difference</b>	kt	1.5	<b>Difference</b>	kt	0.000003
	%	1.3		%	1.3

Further, following the recommendation of ERT N<sub>2</sub>O emission factor was updated to 1.5 kg N<sub>2</sub>O/TJ for solid fuels, which caused increase in N<sub>2</sub>O emissions by 7.14%.

Tab. 3-91 Changes after update of N<sub>2</sub>O emission factor in 1.A.4.c

N <sub>2</sub> O emission		1990	1995	2000	2005	2010	2011	2012	2013	2014
<b>Submission 2016</b>	kt	0.02451	0.009453	0.002851	0.001144	0.000739	0.000631	0.00061	0.000631	0.000456
<b>Submission 2017</b>	kt	0.02626	0.010127	0.003055	0.001226	0.000751	0.000596	0.000592	0.000607	0.000488
<b>Difference</b>	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 <sub>2</sub>			CH <sub>4</sub>		N <sub>2</sub> O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO <sub>2</sub> /TJ]		[kt]	[kg CH <sub>4</sub> /TJ]	[kt]	[kg N <sub>2</sub> O/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
<b>Total year 2015</b>	<b>5 046.6</b>			<b>368.85</b>		<b>0.0403</b>		<b>0.0368</b>
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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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<sub>2</sub> emissions in subsector 1.A.5 in 2015 contributed 0.3% to CO<sub>2</sub> emissions in the whole Energy sector 1.A.

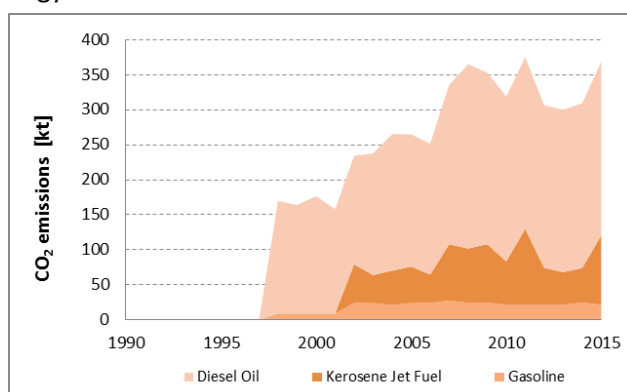


Fig. 3-33 Development of CO<sub>2</sub> emissions in source category 1.A.5.b.

Development of fuel consumption and the corresponding CO<sub>2</sub> 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 apparent 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<sub>4</sub> 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<sub>4</sub> 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.

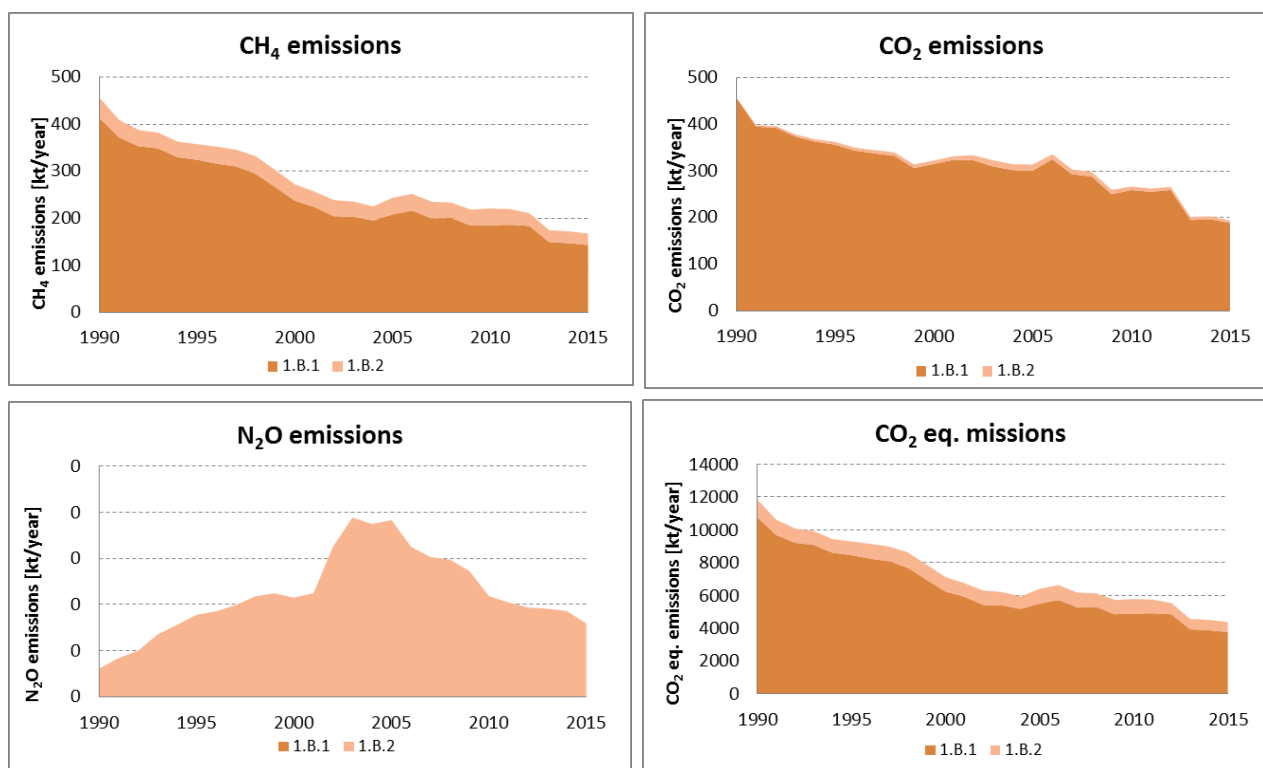


Fig. 3-34 GHG emissions trends from Fugitive emissions from fuels [kt/year]

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<sub>2</sub> 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<sub>2</sub> emissions). N<sub>2</sub>O 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<sub>2</sub> equivalent, is visible from Fig. 3-35.

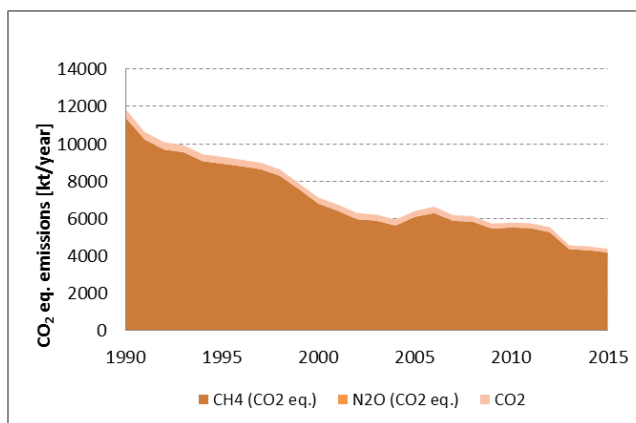


Fig. 3-35 The share of individual GHG emissions from the total emissions, expressed as CO<sub>2</sub> eq. (1.B.)

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.a.1.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	CH <sub>4</sub>	CO <sub>2</sub>		N <sub>2</sub> O	
		data	EF	Emission	EF	Emission	Emission
		[Gg]	[kg CH <sub>4</sub> /t]	[kt]	[t CO <sub>2</sub> /t]	[kt]	[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
1.B.1.a.1.ii	Post-mining activ.		1.675	13.93	NA	NA	NA
1.B.1.a.1.iii	Abandoned mines	+) )		2.96		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
1.B.1.a.2.ii	Post-mining activ.		0.067	2.55	NA	NA	NA
1.B.1.b	Solid fuel transformation	6,00	30	0.18	NO	NE	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 <sub>4</sub>	CO <sub>2</sub>	N <sub>2</sub> O	CH <sub>4</sub>	CO <sub>2</sub> N <sub>2</sub> O
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 <sup>+) )</sup>	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.

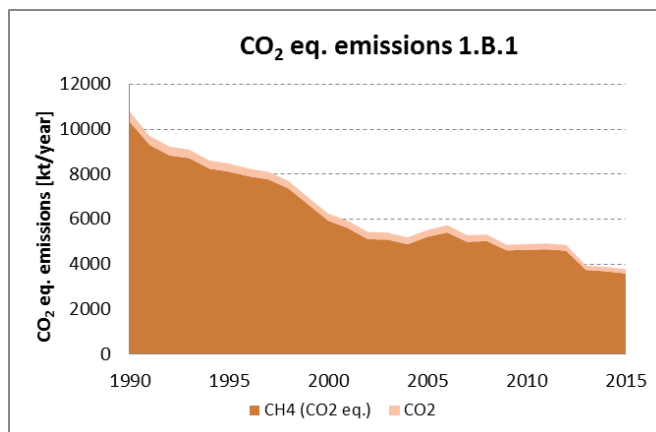


Fig. 3-37 The trend of GHG emissions and the relationship between emissions of CO<sub>2</sub> and CH<sub>4</sub> (1.B.1)

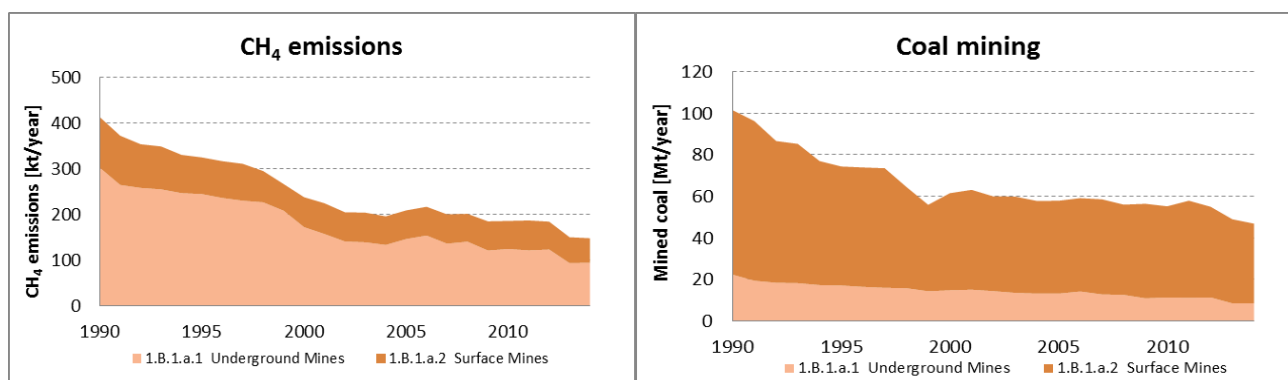


Fig. 3-36 The ratio of methane emissions from Underground mines and Surface mines and the corresponding development of mining of Hard Coal and Lignite (1.B.1)

Besides methane, during mining of coal mass a certain amount of carbon dioxide is released, that accompanies methane in the firedamp. CO<sub>2</sub> 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<sub>2</sub> emissions in the total GHG emissions, which on average makes about 6%.

The contribution of the individual subsectors to the total emissions of CH<sub>4</sub>, 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<sub>4</sub> 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<sub>4</sub> 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<sub>4</sub>. 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<sup>3</sup> CH<sub>4</sub>. 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<sup>3</sup> CH<sub>4</sub> 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<sub>4</sub> 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<sub>2</sub> emissions from the actual production of briquettes are included in subcategory 1.A.2.g.

#### *Production of charcoal*

CH<sub>4</sub> emissions from charcoal production were estimated by using EF provided by the Revised 1996 Guidelines (IPCC, 1997); the value of 1000 kg CH<sub>4</sub>/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<sub>4</sub> 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<sub>4</sub> emissions from charcoal production

1.B.1.b Solid Fuel Transformation			
	Production	Production	CH <sub>4</sub> 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<sub>2</sub> emissions are not estimated or are negligible and no known method is available for their determination in this category (notation key NE). Fugitive N<sub>2</sub>O 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<sub>4</sub> emissions in the Ostrava - Karvina coal-mining area**

	Coal mining [mil. t/year]	CH <sub>4</sub> emissions [mil. m <sup>3</sup> /year]	Emission factors [m <sup>3</sup> /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
<b>Total</b>	<b>167.31</b>	<b>3 375.3</b>	<b>20.2</b>
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<sup>3</sup>/t was recalculated to 12.261 kg/t using a density of methane of 0.67 m<sup>3</sup>/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<sub>4</sub>/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 <sup>3</sup> CH <sub>4</sub> * year <sup>-1</sup>					
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 <sub>4</sub> emissions	EF
	[kt/year]	[t/year]	[t CH <sub>4</sub> /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<sub>2</sub> emission factor for underground hard coal mining. Monthly data on the concentrations and amounts of CO<sub>2</sub> 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<sub>2</sub>/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<sub>2</sub>/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<sub>2</sub> 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 <sub>2</sub>
	[kt/year]	[t CO <sub>2</sub> /kt]	[kt CO <sub>2</sub> /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<sub>4</sub>/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<sub>4</sub> emissions from underground coal mining – post mines operations in period 1990 - 2015**

year	production OKD [kt/year]	emission factor [t CH <sub>4</sub> /kt]	emission of CO <sub>2</sub> [kt CH <sub>4</sub> /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<sub>4</sub> on abandoned mines**

year	CH <sub>4</sub> emission in period [kt/year]				Calculated	Use of CH <sub>4</sub>	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<sub>4</sub> emissions from surface coal mining and post mines operations in period 1990 - 2015

year	Brown Coal production	Emission factors for activities		emission of
	[kt/year]	mines [t CH <sub>4</sub> /kt]	post-mines [t CH <sub>4</sub> /kt]	CH <sub>4</sub> [kt CH <sub>4</sub> /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<sub>4</sub> emissions from charcoal production were estimated by using EF provided by the Revised 1996 Guidelines (IPCC, 1997); the value of 1000 kg CH<sub>4</sub>/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<sub>2</sub> 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 <sub>2</sub>	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 <sub>4</sub>	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<sub>4</sub> 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<sub>4</sub>, 1.B.1.A.1.ii - Underground mines, Post-Mining Activities were updated (to 1.675 kg CH<sub>4</sub>/t coal). This recalculation yields to higher emissions.

Tab. 3-101 Impact of recalculation after CH<sub>4</sub> EF change in 1.B.1.A.1.ii

CH <sub>4</sub> 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 <sub>4</sub> 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 <sub>4</sub> 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<sub>4</sub>, 1.B.1.A.2.i - Surface mines, Mining Activities (to 1.34 kg CH<sub>4</sub>/t coal from z 0.077 kg CH<sub>4</sub>/t coal) This recalculation represents increase for 73.9%.

Tab. 3-102 Impact of recalculation after CH<sub>4</sub> EF change in 1.B.1.A.2.i

CH <sub>4</sub> 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	CH <sub>4</sub> EF	Emission	CO <sub>2</sub> EF	Emission	N <sub>2</sub> O EF	Emission
		[PJ]	[t CH <sub>4</sub> /PJ]	[kt]	[t CO <sub>2</sub> /PJ]	[kt]	[kg N <sub>2</sub> O/PJ]	[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<sub>2</sub> 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			Method used		
			CH <sub>4</sub>	CO <sub>2</sub>	N <sub>2</sub> O	CH <sub>4</sub>	CO <sub>2</sub>	N <sub>2</sub> O
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.

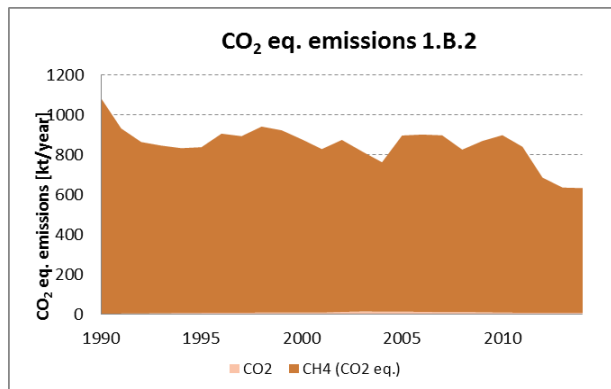


Fig. 3-38 The trend of GHG emissions and the relationship between CO<sub>2</sub> and CH<sub>4</sub> emissions (1.B.2)

The graph on Fig. 3-38 shows that the proportion of total CO<sub>2</sub> 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<sub>4</sub> emissions throughout the period in the category 1.B.2 is shown on Fig. 3-39.

As shown on Fig. 3-39 for the amount of CH<sub>4</sub> emissions in sector 1.B.2. Oil and Natural Gas are therefore crucial the emissions, produced in the gas industry.

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.

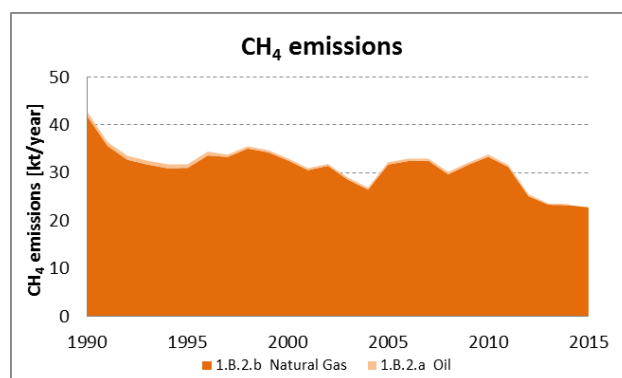


Fig. 3-39 The ratio of methane emissions from subsector Oil (1.B.2.a) and Natural Gas (1.B.2.b)

### 3.3.2.1.1 Oil (CRF 1.B.2.a)

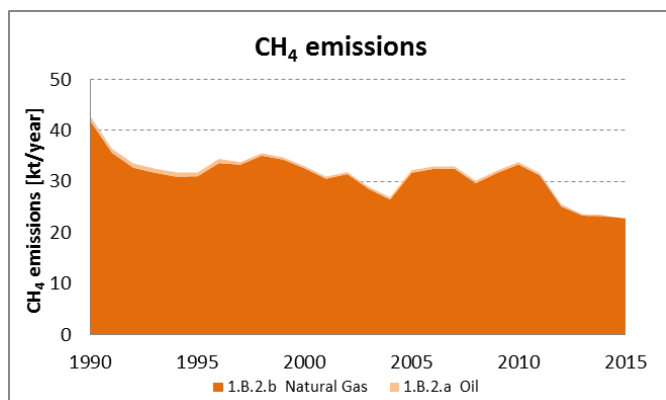


Fig. 3-40 Crude Oil production end import in the CR in 1990 – 2015

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.

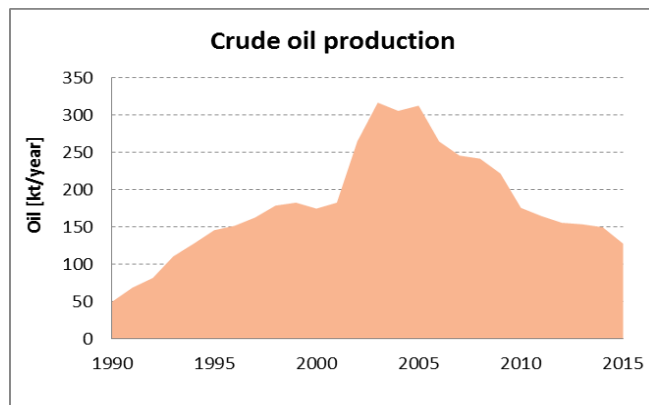
GHG emissions from Crude Oil transport and refining and from Crude Oil production, which is performed in the Czech Republic in combination with mining of Natural Gas, are reported in this category. CO<sub>2</sub> emissions from the refinery resulting from combustion

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)



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.

Fig. 3-41 Crude Oil production in the CR in 1990 – 2015

### 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<sub>4</sub> and CO<sub>2</sub> 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

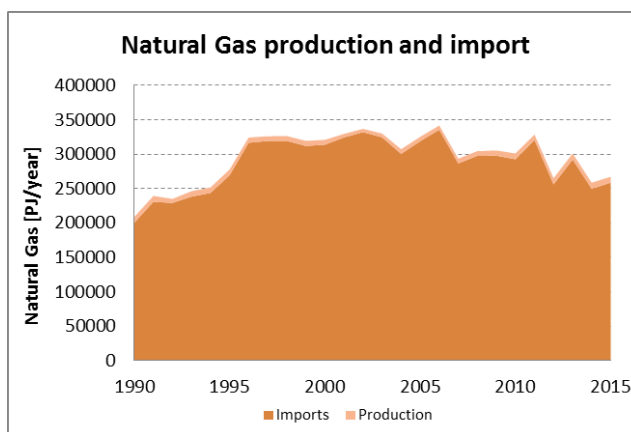


Fig. 3-42 Natural Gas production and import in the CR in 1990 – 2015

production and import of natural gas in the Czech Republic is shown on Fig. 3-42.

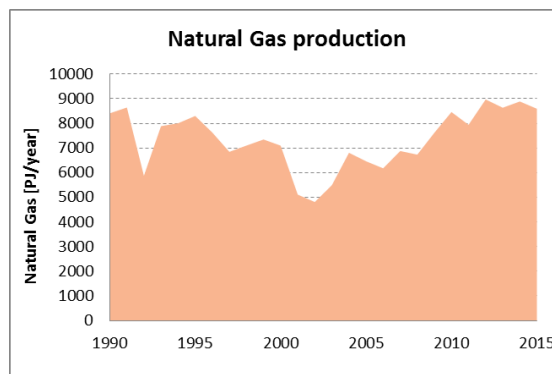
#### *Exploration (1.B.2.b.iii.1)*

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.

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.



**Fig. 3-43 Natural Gas production in the area of CR in 1990 – 2015**

#### *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<sup>3</sup> 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<sub>4</sub> and CO<sub>2</sub> emissions from Venting for domestic production (mining) of Crude Oil; N<sub>2</sub>O 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<sub>4</sub>, CO<sub>2</sub> and N<sub>2</sub>O 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<sub>4</sub>, CO<sub>2</sub> and N<sub>2</sub>O from Venting and Flaring in 1990 – 2015**

	Venting - emissions [t/year]		Flaring - emissions [t/year]		
	CH <sub>4</sub>	CO <sub>2</sub>	CH <sub>4</sub>	CO <sub>2</sub>	N <sub>2</sub> O
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<sub>4</sub> 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<sub>2</sub> 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<sub>2</sub> and CH<sub>4</sub> – notation key NO. N<sub>2</sub>O emissions: notation key NA: N<sub>2</sub>O emissions are practically not formed in exploratory work.

##### *Production and Upgrading (1.B.2.a.iii.2)*

Activity data for determining CH<sub>4</sub> and CO<sub>2</sub> emissions are taken from the CzSO – IEA questionnaires and controlled using data from the Mining Yearbook.

CH<sub>4</sub> 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<sub>2</sub> 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<sub>2</sub>: 2.8E-04 Gg per 10<sup>3</sup> m<sup>3</sup> total oil production = 7 576 kg/PJ

For the estimation of N<sub>2</sub>O 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<sub>4</sub> and CO<sub>2</sub> emissions.

EF CH<sub>4</sub>: 5.4E-06 Gg per 10<sup>3</sup> m<sup>3</sup> oil transported by pipeline = 146 kg/PJ

EF CO<sub>2</sub>: 4.9E-07 Gg per 10<sup>3</sup> m<sup>3</sup> 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<sub>2</sub>O 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<sub>4</sub>: 2.6x10<sup>-6</sup> to 41.0x10<sup>-6</sup> Gg per 10<sup>3</sup> m<sup>3</sup> oil refined = 585 kg/PJ (average)

The IPCC method does not give any EF for CO<sub>2</sub> or N<sub>2</sub>O. 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<sub>2</sub>, CH<sub>4</sub> or N<sub>2</sub>O – notation key – NA. The products which originate during oil processing cannot contain CO<sub>2</sub> or CH<sub>4</sub>. There isn't known process by which could arise fugitive CO<sub>2</sub> or CH<sub>4</sub> emissions during the distribution of oil products.

#### *Other (1.B.2.a.iii.6)*

Activity data: notation key: NO; CH<sub>4</sub>, CO<sub>2</sub> and N<sub>2</sub>O 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<sub>4</sub> emissions in the Natural Gas sector (2015)

	EF		Activity data		Losses of NG
	value	units	value	units	mil.m <sup>3</sup> /year
<b>production</b>	0.2	% vol.	247	mil. m <sup>3</sup>	0.49
<b>high pressure pipelines</b>	600	m <sup>3</sup> /km.year	13 028	km	7.60
<b>transmission pipelines<sup>*)</sup></b>					1.15
<b>compressors<sup>**)</sup></b>					0.20
<b>storage<sup>***)</sup></b>					1.10
<b>regulation stations</b>	1 000	m <sup>3</sup> /station	4 465	pcs	4.39
<b>distribution network</b>	300	m <sup>3</sup> /km.year	48 475	km	14.28
<b>final consumption</b>	2	m <sup>3</sup> /consumer	2 844 334	pcs	5.59
<b>Total</b>					<b>34.02</b>
<b>Emissions in Gg (0.67 kg/m<sup>3</sup>)</b>					<b>23.34</b>

<sup>\*)</sup> data from IRZ (Integrated Pollution Register of Czech Republic – Czech version of E-PRTR) - company NET4GAS

<sup>\*\*) data from operating records of leakage Natural Gas - company RWE</sup>

<sup>\*\*\*)</sup> 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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<sub>4</sub>: 8.7E-03 Gg per 10<sup>3</sup> m<sup>3</sup> total oil production

CO<sub>2</sub>: 1.8E-03 Gg per 10<sup>3</sup> m<sup>3</sup> total oil production

N<sub>2</sub>O: NA

#### Flaring (Default Weighted Total)

CH<sub>4</sub>: 2.1E-05 Gg per 10<sup>3</sup> m<sup>3</sup> total oil production

CO<sub>2</sub>: 3.4E-02 Gg per 10<sup>3</sup> m<sup>3</sup> total oil production

N<sub>2</sub>O: 5.4E-07 Gg per 10<sup>3</sup> m<sup>3</sup> 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<sub>4</sub>: 235 390 kg/PJ

CO<sub>2</sub>: 48 701 kg/PJ

#### Flaring

CH<sub>4</sub>: 568.2 kg/PJ

CO<sub>2</sub>: 919 913 kg/PJ

N<sub>2</sub>O: 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 <sub>2</sub>	1.B.2 Oil and Natural Gas	7	75	V. Neuzil, P. Fott, AD and EF unc. in line with 2006 Guidelines
CH <sub>4</sub>	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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>O 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 GHG LULUCF	% of total incl.	% of GHG LULUCF	% of total excl.
<b>2.C.1 Iron and Steel Production</b>	CO <sub>2</sub>	LA	LA	yes	yes	yes	yes	5.37		5.67	
<b>2.F.1 Refrigeration and Air Conditioning Equipment (CO<sub>2</sub> eq.)</b>	HFC	LA, TA	LA, TA	yes	yes	yes	yes	2.68		2.82	
<b>2.A.1 Cement Production</b>	CO <sub>2</sub>	LA, TA	LA	yes	yes	yes	yes	1.21		1.28	
<b>2.B.8 Petrochemical and carbon black production</b>	CO <sub>2</sub>	LA	LA	yes	yes	yes	no	0.56		0.59	
<b>2.B.2 Nitric Acid Production</b>	N <sub>2</sub> O	TA	TA	yes	yes	yes	yes	0.22		0.23	
<b>2.B.1 Ammonia Production</b>	CO <sub>2</sub>	LA		yes	yes			0.58		0.61	
<b>2.A.2 Lime Production</b>	CO <sub>2</sub>	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:

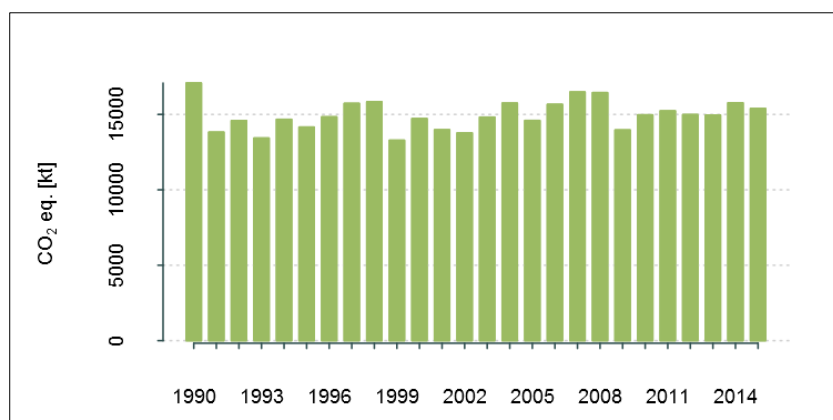


Fig. 4-1 Trend of emissions from IPPU [kt CO<sub>2</sub> eq.]

Trends in Greenhouse Gas emissions.

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<sub>2</sub> eq.

emissions have shown stable trend since 2010 with minor fluctuation.

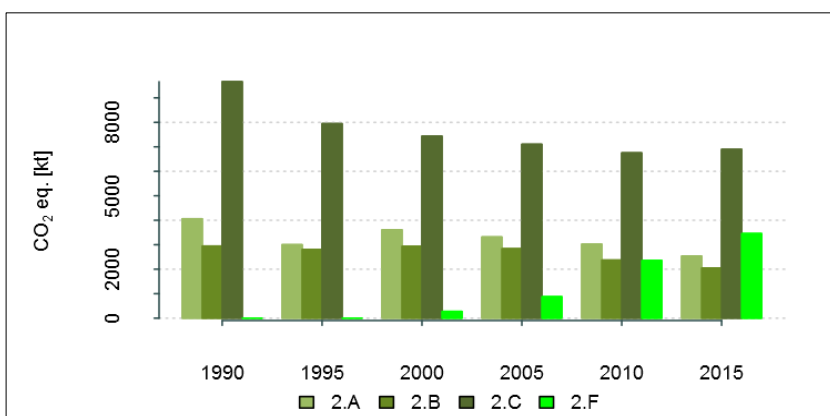


Fig. 4-2 Emissions from principal subcategories of IPPU [kt CO<sub>2</sub> eq.]

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

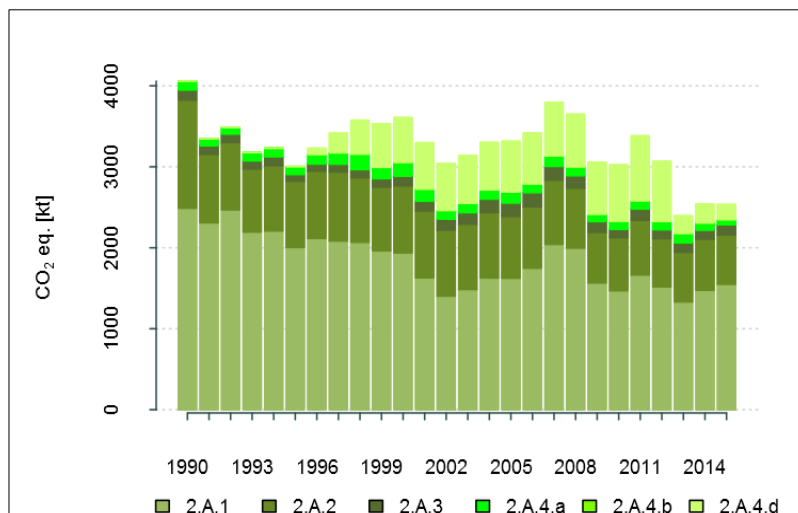
provided for all the categories in the following chapters.

Category 2.A Mineral Products includes practically only emissions of CO<sub>2</sub> as well as category 2.C Metal Production. CO<sub>2</sub> emissions from the 2.B Chemical Industry comes from 2.B.1 Ammonia Production, while N<sub>2</sub>O emissions originate from 2.B.2 Nitric Acid Production. Industrial CH<sub>4</sub> 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.



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.

Fig. 4-3 Trend of emissions from 2.A Mineral Industry and share of specific subcategories [kt CO<sub>2</sub>]

Tab. 4-2 lists the CO<sub>2</sub> emissions in the individual subcategories in 2.A Mineral Products in 2015.

Tab. 4-2 CO<sub>2</sub> emissions in individual subcategories in 2.A Mineral Products category in 1990 – 2015

	Category 2.A - CO <sub>2</sub> 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<sub>2</sub> emission factors and methodology used for computations of 2015 emissions in category 2.A**

	Emission factor CO <sub>2</sub>	Unit	Source or type of EF	Methodology
<b>2.A.1 Cement Production</b>	0.53	t CO <sub>2</sub> /t sinter	CS (EU ETS)	Tier 3
<b>2.A.2 Lime Production</b>	0.77	t CO <sub>2</sub> /t CaO	CS (EU ETS)	Tier 3
<b>2.A.3 Glass Production</b>	0.10	t CO <sub>2</sub> /t Glass	Default (IPCC, 2006)	Tier 1
<b>2.A.4.a Ceramics</b>	0.09	t CO <sub>2</sub> /tiles thousand m <sup>2</sup>	CS (EU ETS)	Tier 3
	0.04	t CO <sub>2</sub> /brick unit	CS (EU ETS)	Tier 3
	C	t CO <sub>2</sub> /roofing tiles	CS (EU ETS)	Tier 3
<b>2.A.4.b Other uses of Soda Ash</b>	0.42	t CO <sub>2</sub> /t soda ash	IEF	Tier 3
<b>2.A.4.d Other (Flue-gas desulfurisation)</b>	C	t CO <sub>2</sub> /t desulfurated flue-gas	CS (EU ETS)	Tier 3
<b>(Mineral wool production)</b>	0.25	t CO <sub>2</sub> /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<sub>2</sub> emissions from cement production have decreased since 1990 by 37.75%. Total CO<sub>2</sub> 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<sub>2</sub> is emitted during transformation of raw materials (mainly decarbonisation of limestone). Process-related CO<sub>2</sub> is emitted during the production of clinker (calcination process) when calcium carbonate (CaCO<sub>3</sub>) 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<sub>2</sub> 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<sub>3</sub>) and fossil carbon (C), which will also calcinate or oxidize in the process causing CO<sub>2</sub> emissions.

##### 4.2.1.2 Methodological issues

CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions and, therefore, substantial attention is devoted to their determination.

The methodology used for CO<sub>2</sub> 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<sub>2</sub> emissions and clinker production, varies from 0.527 to 0.553 t CO<sub>2</sub>/t clinker.

Tab. 4-4 introduces the activity data for clinker production, emission factor and CO<sub>2</sub> emissions for the whole time series.

**Tab. 4-4 Activity data, CO<sub>2</sub> emission factor and CO<sub>2</sub> emissions in 2.A.1 Cement Production category in 1990 - 2015**

	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<b>Clinker production</b>	kt	4 726	4 368	4 653	4 122	4 134	3 740	3 934	3 829	3 758	3 547
<b>EF CO<sub>2</sub></b>	t CO <sub>2</sub> /t clinker	0.527	0.529	0.531	0.532	0.534	0.536	0.538	0.544	0.550	0.553
<b>Emissions CO<sub>2</sub></b>	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
<b>Clinker production</b>	kt	3 537	2 954	2 549	2 725	3 017	3 045	3 288	3 837	3 759	2 923
<b>EF CO<sub>2</sub></b>	t CO <sub>2</sub> /t clinker	0.548	0.551	0.551	0.545	0.539	0.533	0.532	0.532	0.531	0.536
<b>Emissions CO<sub>2</sub></b>	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
<b>Clinker production</b>	kt	2 748	3 132	2 838	2 472	2 792	2 919
<b>EF CO<sub>2</sub></b>	t CO <sub>2</sub> /t clinker	0.535	0.531	0.535	0.539	0.529	0.531
<b>Emissions CO<sub>2</sub></b>	kt	1 469	1 665	1 517	1 332	1 477	1 550

### 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

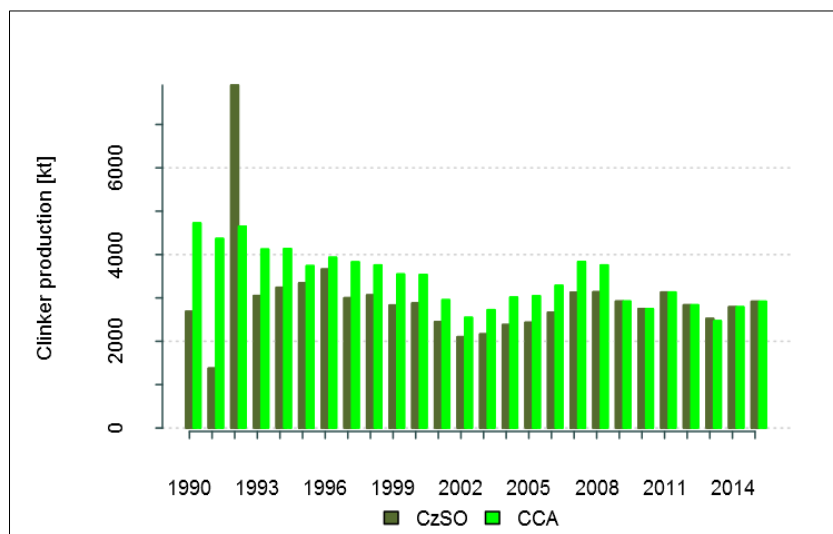


Fig. 4-4 Comparison of clinker production data provided by CzSO and CCA

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<sub>2</sub> emissions reported under category 2.A.1 Cement production for 2014. In the previous submission, the reported amount of CO<sub>2</sub> emissions was 1482.00 kt. This amount of CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> is released during calcination. During the production of lime, the limestone is heated up which leads to decomposition (i.e. calcination) of CaCO<sub>3</sub>/MgCO<sub>3</sub> to the lime (CaO, CaO·MgO) and CO<sub>2</sub> is being released into the atmosphere.

#### 4.2.2.2 Methodological issues

CO<sub>2</sub> emissions from 2.A.2 Lime Production are calculated according to the IPCC 2006 Guidelines (IPCC, 2006). CO<sub>2</sub> 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<sub>2</sub> emissions generated in the process of the calcination step of lime treatment are considered in this category. CO<sub>2</sub> 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<sub>2</sub>/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<sub>2</sub>/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<sub>2</sub> emissions for the whole time series.

**Tab. 4-5 Activity data, CO<sub>2</sub> emission factor and CO<sub>2</sub> emissions in 2.A.2 Lime Production category in 1990 - 2015**

	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<b>Lime production</b>	kt	1 823	1 152	1 134	1 062	1 100	1 115	1 133	1 163	1 087	1 074
<b>EF CO<sub>2</sub></b>	t CO <sub>2</sub> /t CaCO <sub>3</sub>	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733
<b>Emissions CO<sub>2</sub></b>	kt	1 337	845	831	779	807	818	831	853	797	787

	unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<b>Lime production</b>	kt	1 130	1 128	1 112	1 102	1 103	1 040	1 034	1 083	1 012	853
<b>EF CO<sub>2</sub></b>	t CO <sub>2</sub> /t CaCO <sub>3</sub>	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733
<b>Emissions CO<sub>2</sub></b>	kt	829	827	815	808	809	763	758	794	742	625

	unit	2010	2011	2012	2013	2014	2015
<b>Lime production</b>	kt	832	858	758	778	814	790
<b>EF CO<sub>2</sub></b>	t CO <sub>2</sub> /t CaCO <sub>3</sub>	0.788	0.788	0.788	0.788	0.772	0.772
<b>Emissions CO<sub>2</sub></b>	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.

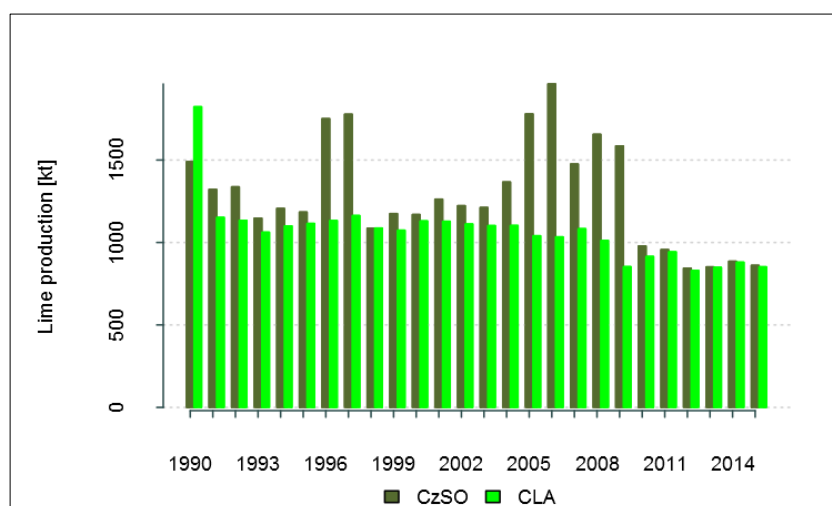


Fig. 4-5 Comparison of lime production data provided by CzSO and CLA

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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions from 2.A.3 Glass production equalled 125 kt CO<sub>2</sub> in 2015.

#### 4.2.3.1 Source category description

CO<sub>2</sub> 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<sub>2</sub>/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<sub>2</sub> emissions for the whole time series.

Tab. 4-6 Activity data, CO<sub>2</sub> emission factor and CO<sub>2</sub> 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 <sub>2</sub>	t CO <sub>2</sub> /t glass	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Emissions CO <sub>2</sub>	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 <sub>2</sub>	t CO <sub>2</sub> /t glass	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Emissions CO <sub>2</sub>	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 <sub>2</sub>	t CO <sub>2</sub> /t glass	0.10	0.10	0.10	0.10	0.10	0.10
Emissions CO <sub>2</sub>	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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions from 2.A.4.a Ceramics, 2.A.4.b Other uses of Soda Ash and from 2.A.4.d Other. CO<sub>2</sub> emissions from Other Process Uses of Carbonates have increased since 1990 by 128.26%.

CO<sub>2</sub> 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<sub>2</sub> emissions from 2.A.4.b Other uses of Soda Ash amounted to 1.01 kt CO<sub>2</sub> in 2015. CO<sub>2</sub> emissions from 2.A.4.d Other amounted to 184.20 kt CO<sub>2</sub> in 2015.

#### ***4.2.4.1 Source category description***

CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions from this category are small and insignificant (varied between 0.1 and 1.1 kt CO<sub>2</sub>) compared to the other categories.

CO<sub>2</sub> 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<sub>2</sub> is emitted, so that the mass of CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions in the individual subcategories in 2.A.4 Other Process Uses of Carbonates for time period 1990 - 2015.

**Tab. 4-7 CO<sub>2</sub> emissions in individual subcategories in 2.A.4 Other Process Uses of Carbonates category in 1990 - 2015**

Category 2.A.4 - CO <sub>2</sub> 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 <sub>2</sub> 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<sub>2</sub> 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.

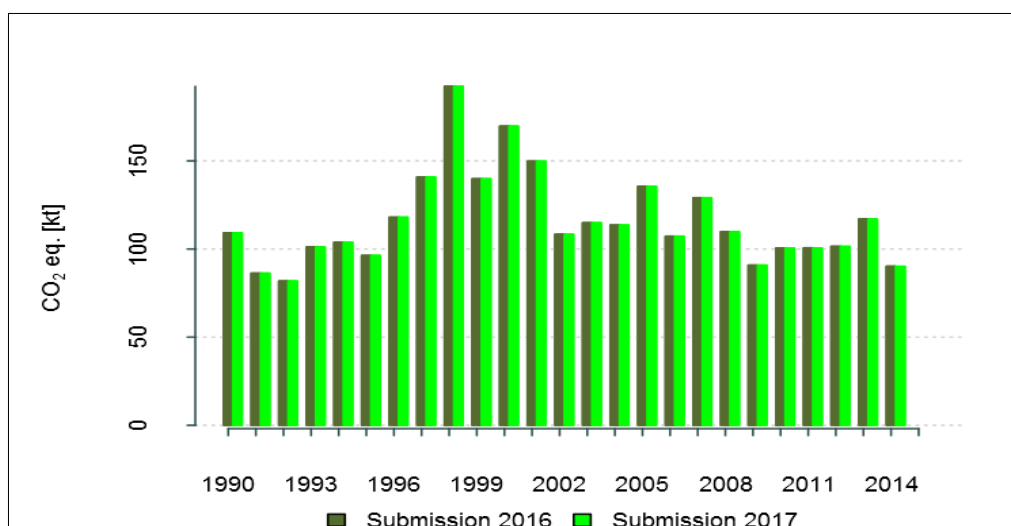


Fig. 4-6 Recalculation in category 2.A.4.a Ceramics due to double counting

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<sub>2</sub> 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.

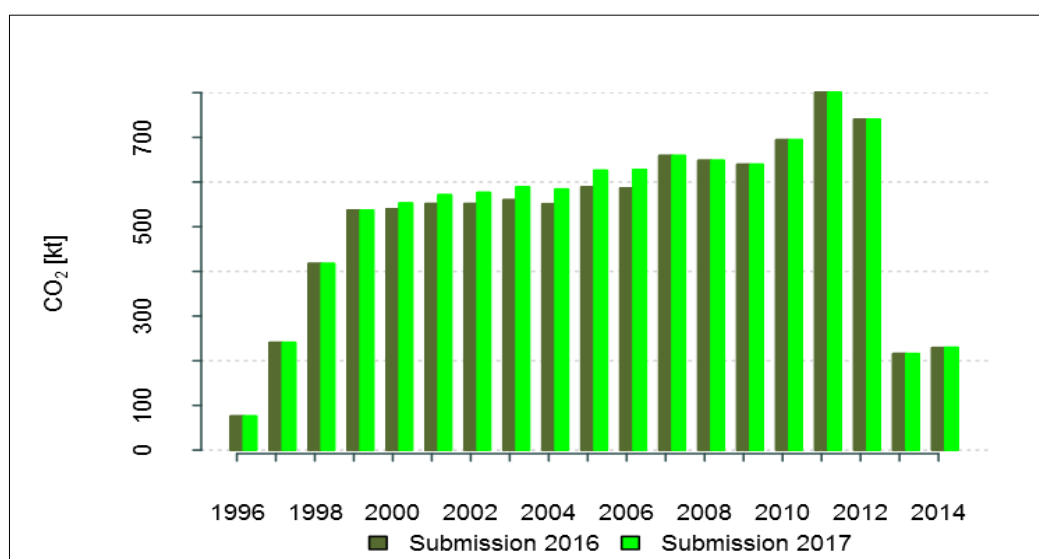


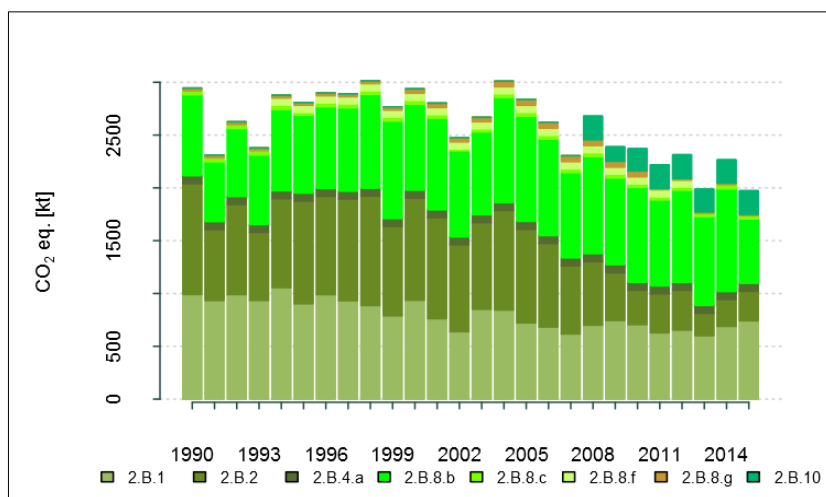
Fig. 4-7 Recalculation in category 2.A.4.d Other due to new activity data about mineral wool production and due to double counting

#### 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.



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<sub>2</sub> and CH<sub>4</sub> emissions in 2.B.8.f are reported as C (confidential) since 2013, similar to CO<sub>2</sub> emissions in 2.B.8.g since 2011. The emission trend for the category 2.B Chemical Industry is depicted in Fig. 4-8.

Fig. 4-8 Trend of emissions from 2.B Chemical Industry and share of specific subcategories [kt CO<sub>2</sub> eq.]

Tab. 4-8 lists the exact amount of CO<sub>2</sub> eq. emissions from the individual subcategories in 2.B Chemical Industry for time period 1990 - 2015.

Tab. 4-8 CO<sub>2</sub> eq. emissions in individual subcategories in 2.B Chemical industry category in 1990–2015

	Category 2.B - CO <sub>2</sub> 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 <sub>2</sub> 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 <sub>2</sub> /kt NH <sub>3</sub>	CS	Tier 1
2.B.2 Nitric Acid Production	1.67	kg N <sub>2</sub> O / t HNO <sub>3</sub>	IEF	Tier 1
2.B.4 Caprolactam, Glyoxal and Glyoxilic Acid Production	Constant value of N <sub>2</sub> O emissions reported for each year			
2.B.8 Petrochemical and Carbon Black production	1.90	t CO <sub>2</sub> /t ethylene	Default (IPCC, 2006)	Tier 1
	3.00	kg CH <sub>4</sub> /t ethylene	Default (IPCC, 2006)	Tier 1
	0.29	t CO <sub>2</sub> /t VCM	Default (IPCC, 2006)	Tier 1
	0.02	t CH <sub>4</sub> /t VCM	Default (IPCC, 2006)	Tier 1
	2.62	t CO <sub>2</sub> /t carbon black	Default (IPCC, 2006)	Tier 1
	0.06	kg CH <sub>4</sub> /t carbon black	Default (IPCC, 2006)	Tier 1
	C	t CO <sub>2</sub> /t styrene	CS	Tier 3
	0.004	t CH <sub>4</sub> /t styrene	Default (IPCC, 2006)	Tier 1
2.B.10 Other	2.70	t CO <sub>2</sub> /t Other	IEF	Tier 1

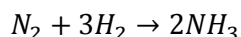
The column source or type of EF indicates the way how was the certain emission factor determined. Detailed information for each emission factor is given in the relevant chapters.

### 4.3.1 Ammonia Production (CRF 2.B.1)

The production of ammonia constitutes an important source of CO<sub>2</sub> derived from non-energy use of fuels in the chemical industry. CO<sub>2</sub> emissions from ammonia production in 2015 equalled to 741.66 kt of CO<sub>2</sub>, 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<sub>2</sub> 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:



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<sub>2</sub>/kt NH<sub>3</sub>. 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<sub>3</sub>. Total CO<sub>2</sub> emissions from ammonia production were lowered by CO<sub>2</sub> used in urea production, consequently / therefore the portion of CO<sub>2</sub> emissions to NH<sub>3</sub> 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<sub>2</sub> 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<sub>2</sub> emissions from ammonia production are reported in Table 1.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<sub>2</sub> emissions from ammonia production in 1990 – 2015

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Residual fuel oil used for NH <sub>3</sub> 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 <sub>2</sub> 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 <sub>2</sub> 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 <sub>3</sub> 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 <sub>2</sub> 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 <sub>2</sub> 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 <sub>3</sub> 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 <sub>2</sub> from 2.B.1 [kt]	705.45	628.05	653.79	601.13	689.05	741.66
CO <sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>O in the chemical industry. N<sub>2</sub>O emissions from production of nitric acid in 2015 equalled to 0.94 kt N<sub>2</sub>O, 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<sub>2</sub>O 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,  $\text{NO}_x$ , based on selective or non-selective catalytic reduction. Non-selective catalytic reduction also makes a substantial contribution to removal of  $\text{N}_2\text{O}$ . Since 2004, the technology to reduce  $\text{N}_2\text{O}$  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,  $\text{NO}_x$  (i.e.  $\text{NO}$  and  $\text{NO}_2$ ). In this country, the process of Selective Catalytic Reduction (SCR) is mostly used, which slightly increases the amount of  $\text{N}_2\text{O}$ , and also to a certain degree Non-Selective Catalytic Reduction (NSCR), which also removes  $\text{N}_2\text{O}$  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  $\text{DENO}_x$  technology) are in accord with the principles given in the above-cited IPCC methodology. The effect of the  $\text{NO}_x$  removal technology on the emission factor for  $\text{N}_2\text{O}$  was evaluated on the basis of the balance calculations presented in studies (Markvart and Bernauer, 2000, 2003).

Tab. 4-11 Emission factors for  $\text{N}_2\text{O}$  recommended by (Markvart and Bernauer, 2000) for 1990 - 2003

Pressure in $\text{HNO}_3$ production	0.1 MPa			0.4 MPa		
Technology $\text{DENO}_x$	--	SCR	NSCR	--	SCR	NSCR
Emission factors $\text{N}_2\text{O}$ [kg $\text{N}_2\text{O}/\text{t HNO}_3$ ]	9.05	9.20	1.80	5.43	5.58	1.09

Collection of activity data for  $\text{HNO}_3$  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  $\text{N}_2\text{O}$  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<sub>2</sub>O recommended by Markvart and Bernauer, for 2004 and thereafter**

Pressure in HNO <sub>3</sub> production	0.1 MPa	0.4 MPa	0.4 MPa	0.7 MPa
Technology DENO <sub>x</sub>	SCR	SCR	NSCR	SCR
Emission factors N <sub>2</sub> O [kg N <sub>2</sub> O/t HNO <sub>3</sub> ]	9.05	4.9	1.09	7.8 <sup>a)</sup>

<sup>a)</sup> EF without N<sub>2</sub>O mitigation. Cases of N<sub>2</sub>O mitigation in 2005 -2008 are shown in Tab. 4-11

In the last quarter of 2005, a new N<sub>2</sub>O mitigation unit based on catalytic decomposition of N<sub>2</sub>O 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<sub>2</sub>O/t HNO<sub>3</sub> (100%). Therefore, the mean value in 2005 for the 0.7 MPa technology was equal to 7.02 kg N<sub>2</sub>O/t HNO<sub>3</sub> (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<sub>2</sub>O mitigation unit and gradual improvement of the effectiveness is given in Tab. 4-13.

Two high temperature N<sub>2</sub>O 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<sub>2</sub>O was 3.10 kg N<sub>2</sub>O/ t HNO<sub>3</sub> (100%); in the July-November 2009 period, EF N<sub>2</sub>O was 3.30 kg N<sub>2</sub>O/ t HNO<sub>3</sub> (100%). The second system consisting of high temperature N<sub>2</sub>O decomposition catalyst developed by YARA company, decreased EF N<sub>2</sub>O in the November-December 2009 period to the value 0.95 kg N<sub>2</sub>O/ t HNO<sub>3</sub> (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<sub>2</sub>O and slow deactivation of the N<sub>2</sub>O decomposition catalyst. Thus, the mean value of EF N<sub>2</sub>O for this high pressure nitric acid technology in 2009 was assessed at a value of 2.85 kg N<sub>2</sub>O/ t HNO<sub>3</sub> (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<sub>2</sub>O decomposition catalyst (i.e. YARA catalyst) is employed, the EF N<sub>2</sub>O would be approximately close to 1.3 kg N<sub>2</sub>O/ t HNO<sub>3</sub> (100%).

YARA's catalyst, which was also used in 2012, exhibits excellent stability with respect to N<sub>2</sub>O 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<sub>2</sub>O mitigation unit**

	2004 <sup>a)</sup>	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EF, kg N <sub>2</sub> O/t HNO <sub>3</sub> (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

<sup>a)</sup> EF without N<sub>2</sub>O 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<sub>2</sub>O from HNO<sub>3</sub> production**

Production process	N <sub>2</sub> O Emission factor (kg N <sub>2</sub> O/t 100% HNO <sub>3</sub> )	Reference
Plants with NSCR (all processes)	2.00 ± 10%	(IPCC, 2006)
Plants with processed integrated or tailgas N <sub>2</sub> O destruction	2.50 ± 10%	
Atmospheric pressure plants (low pressure)	5.00 ± 10%	
Medium pressure combustion plants	7.00 ± 20%	
High pressure plants	9.00 ± 40%	
Czech Republic		(Markvart and Bernauer, 2009, 2010)
Atmospheric pressure plants	9.05	
Medium pressure plants with SCR	4.90	
Medium pressure plants with NSCR	1.09	
High pressure plants SCR (no N <sub>2</sub> O decomposition)	7.80	
High pressure plants SCR (with N <sub>2</sub> O decomposition)	4.82 – 1.29	

Tab. 4-15 gives the N<sub>2</sub>O emissions from production of nitric acid, including the production values.

**Tab. 4-15 Emission trends for HNO<sub>3</sub> production and N<sub>2</sub>O emissions in 1990-2015**

	Production of HNO <sub>3</sub> , [kt HNO <sub>3</sub> (100%)]	Emissions of N <sub>2</sub> O [kt N <sub>2</sub> O] from HNO <sub>3</sub> production	Implied Emission Factor IEF [Mg N <sub>2</sub> O/ kt HNO <sub>3</sub> ]
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<sub>3</sub>.

#### **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<sub>3</sub> 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub> 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 cyclohexanoneoxime, 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<sub>2</sub>O 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<sub>2</sub>O 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 to 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<sub>2</sub>O.

#### **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 to 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions from Petrochemical and Carbon Black Production are reported in Table 1.A(d) under Naphtha, which is the major feedstock used, as well (please see chapter 3.2.3. for details).

##### **CO<sub>2</sub> and CH<sub>4</sub> 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<sub>2</sub>/tonne ethylene produced (with correction factor 110% for countries of Eastern Europe) and 3 kg CH<sub>4</sub>/tonne ethylene produced as default emission factors. In the period 1990 – 2015, CO<sub>2</sub> emissions varied between 545 to 959 kt CO<sub>2</sub> and methane emissions varied between 0.9 and 1.5 kt CH<sub>4</sub>, detailed values for each year are available in Tab. 4-16.

Tab. 4-16 Emission trends from CO<sub>2</sub> and CH<sub>4</sub> emissions from production of ethylene in 1990-2015

	Category 2.B.8.b		
	Ethylene Production [kt]	CO <sub>2</sub> Emissions [kt]	CH <sub>4</sub> 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<sub>2</sub> and CH<sub>4</sub> 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<sub>2</sub>/tonne VCM produced and for methane 0.0226 kg CH<sub>4</sub>/tonne VCM produced as default emission factors. Carbon dioxide emissions varied in the period 1990 - 2015 between 16.7 kt CO<sub>2</sub> and 40.3 kt CO<sub>2</sub>. 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<sub>4</sub>, 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<sub>4</sub>.

### ***CO<sub>2</sub> and CH<sub>4</sub> 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<sub>2</sub> 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<sub>4</sub>/tonne carbon black produced and 2.62 t CO<sub>2</sub> /t carbon black produced. The highest value of methane emissions over the past few years is practically insignificant (0.00153 kt).

### ***CO<sub>2</sub> and CH<sub>4</sub> 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<sub>4</sub>/kt styrene. The emission factor for CO<sub>2</sub> emissions is 0.27 kt CO<sub>2</sub>/kt styrene (Bernauer and Markvart, 2015). Since 2011, activity data and CO<sub>2</sub> 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<sub>4</sub> and carbon dioxide emissions varied between 18.9 and 45.9 kt CO<sub>2</sub>.

#### ***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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>3</sub> 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<sub>2</sub>). Emissions from steam reforming of NG are somewhat more significant (about 200 kt of CO<sub>2</sub>)).

#### 4.3.10.2 Methodological issues

Subcategory 2.B.10 Other includes CO<sub>2</sub> 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<sub>2</sub> 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 (VŠCHT), 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<sub>2</sub> emissions from category 2.B.10 Other. Related CO<sub>2</sub> emissions from 2.B.10 are reported in Table 1.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
<b>Other non-energy use in chemical industry</b>	CO <sub>2</sub> emissions [kt]	208.34	123.08	195.74	206.72	210.01	201.27	204.75	206.97
<b>Non selective catalytic reduction</b>	CO <sub>2</sub> 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 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<sub>2</sub> 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<sub>2</sub> emissions from 2.C.1 Iron and Steel Production, 99.8% of CO<sub>2</sub> emissions arise from 2.C.1. CO<sub>2</sub> emissions from iron and steel are identified as a key category (by both level and trend assessments). A small amount of CH<sub>4</sub> 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<sub>2</sub> 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<sub>2</sub> 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.

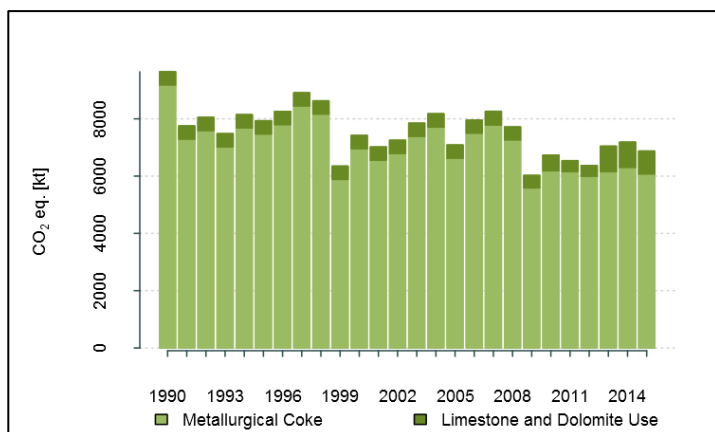


Fig. 4-9 Trend of CO<sub>2</sub> emissions in 2.C.1, 1990 – 2015 [kt CO<sub>2</sub>]

#### 4.4.1.2 Methodological issues

The CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions from 2.C.1 are reported in Table 1.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<sub>2</sub> emissions in 1990 – 2015

	Coke consumed in blast furnaces	Other Bituminous Coal	Coal Tar	Use of limestone and dolomite	CO <sub>2</sub> 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 <sub>2</sub> 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<sub>4</sub> from metal production is based on the IPCC 2006 Guidelines Tier 1 methodology. Default emission factors 0.1 g CH<sub>4</sub> per tonne of coke produced and 0.07 kg CH<sub>4</sub> 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<sub>2</sub>) 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

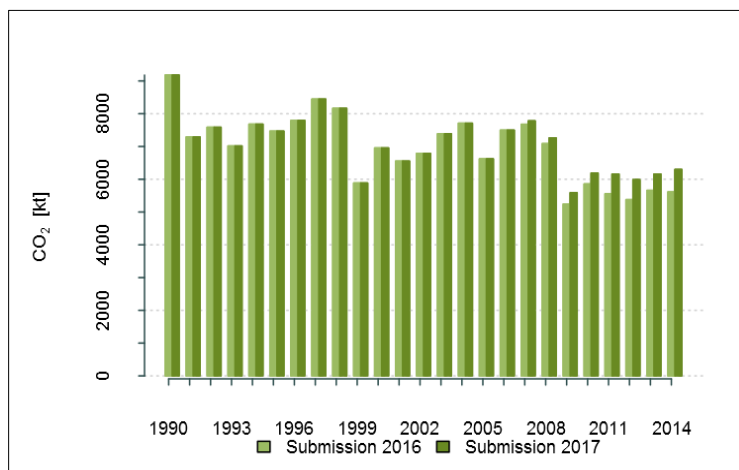
The sector-specific QA/QC plan follows from the overall plan described in Chapter 1. The greatest attention was focused on identifying gaps and imperfections using the new reporting software (CRF Reporter), specifically by observing trends in figures and by checking IEFs. Attention was also focused on checking sources from inter-sector boundaries (Energy, Industry) that they are neither omitted nor counted twice. CO<sub>2</sub> 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<sub>2</sub>, as well as for CH<sub>4</sub>. 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 <sub>2</sub> (1.5% od Si)	EF CH <sub>4</sub> (1.5% od Si)
Vanadium	75-85%	FeSi 45% Si	2.5	0.083333*)	
Aluminum	1.5% max	FeSi 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.

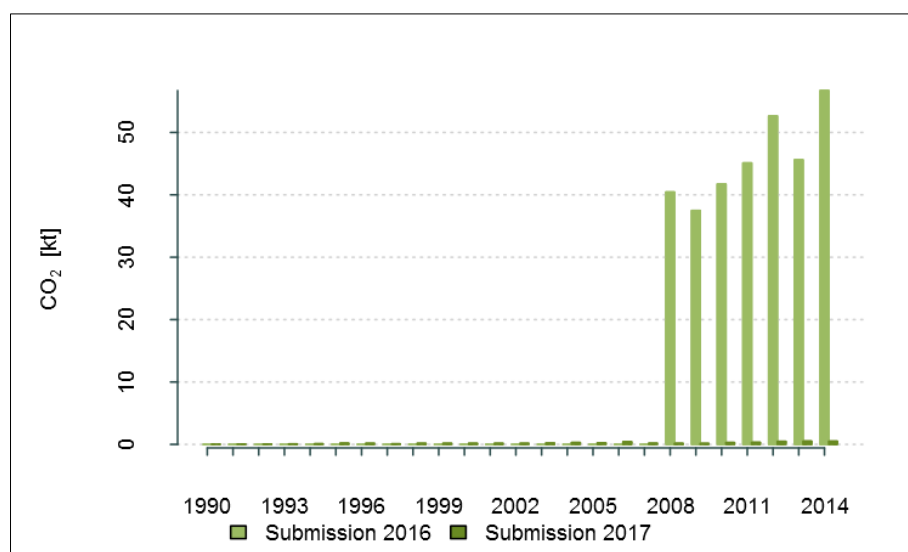


Fig. 4-11 Recalculation in 2.C.2

#### **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<sub>2</sub> emissions were estimated at the level of Tier 1 methodology based on the IPCC 2006 Guidelines (IPCC, 2006) using the default CO<sub>2</sub> emission factor 0.2 t CO<sub>2</sub>/t of lead. CO<sub>2</sub> 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.

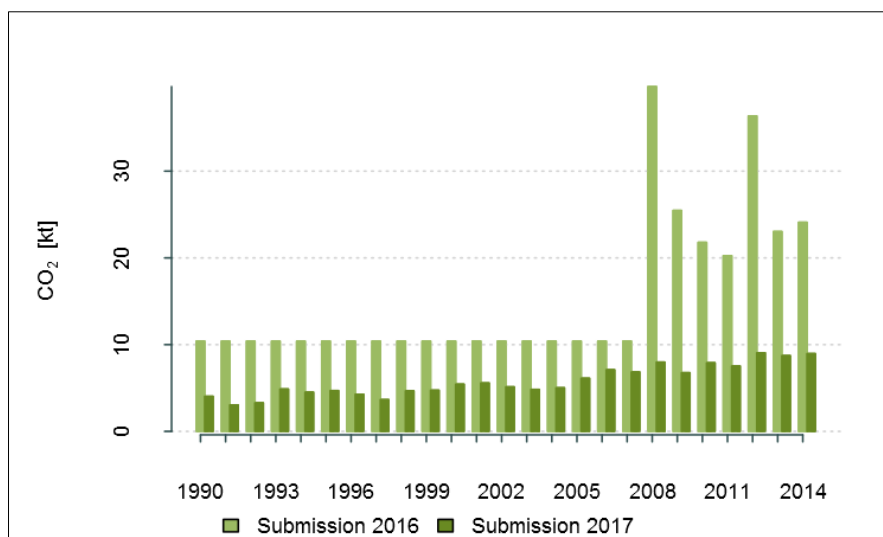


Fig. 4-12 Recalculation in 2.C.5

#### 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<sub>2</sub> emissions were estimated on the level Tier 1 methodology based on IPCC 2006 Guidelines (IPCC, 2006) using default CO<sub>2</sub> emission factor 1.72 t CO<sub>2</sub>/t of zinc. CO<sub>2</sub> 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.

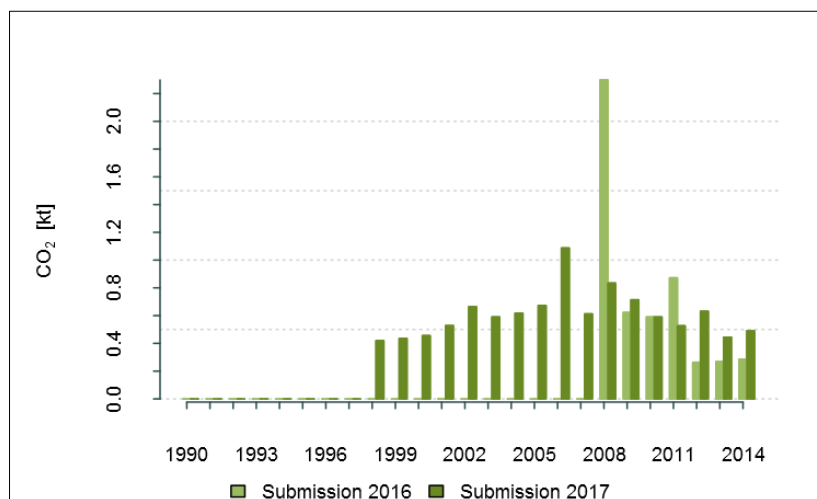


Fig. 4-13 Recalculation in 2.C.6

#### 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.

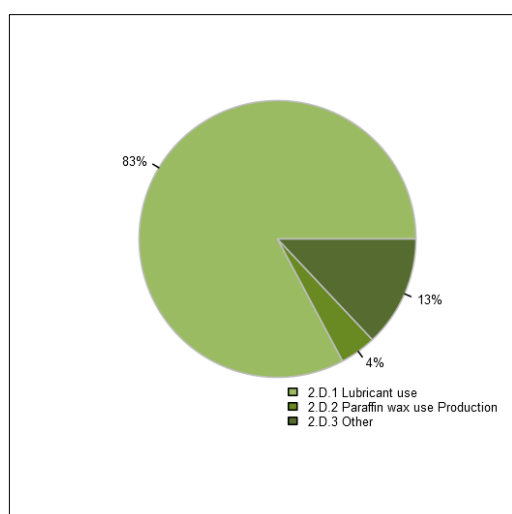


Fig. 4-14 The share of individual subcategories for CO<sub>2</sub> emissions in 2.D in 2015 [kt CO<sub>2</sub>]

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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions from this category in 2015 were equal to 115.5 kt CO<sub>2</sub>. Related CO<sub>2</sub> emissions from 2.D.1 are reported in Table 1.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 statistics, 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<sub>2</sub> emission estimation. Default emission factor 20 kg C/GJ was used, Oxidised During Use (ODU) factor was used default equal to 0.2. CO<sub>2</sub> emissions in 2015 from this category were equal to 5.9 kt CO<sub>2</sub>.

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

Since the activity data used are from official statistics, 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<sub>2</sub> 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<sub>2</sub> emissions (IPCC, 2006).

##### ***Urea used as catalyst***

IPCC 2006 Gl. incorporate this category as source of CO<sub>2</sub> emissions. However, based on methodology emissions 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. From the whole amount of non-energy use of Other oil products were extracted the Oil needed for NH<sub>3</sub> 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<sub>2</sub> emissions. CO<sub>2</sub> emissions in 2015 from this category were equal to 18.11 kt CO<sub>2</sub>.

#### **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<sub>2</sub>, CH<sub>4</sub> or N<sub>2</sub>O 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

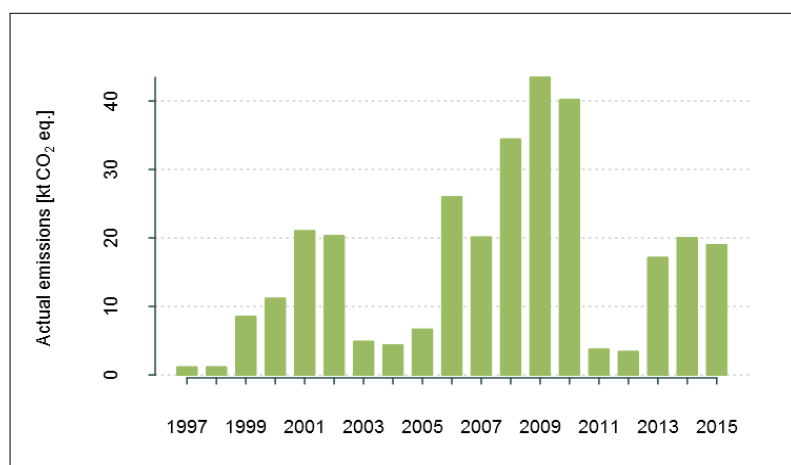
No improvements are planned in this category.

### 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<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>, SF<sub>6</sub> and NF<sub>3</sub>.



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<sub>4</sub> began to 2015. Emissions of F-gases equalled to 18.97 kt CO<sub>2</sub> eq. in 2015. Total emissions of F-gases from 2.E were lower in 2015 by 1.03 kt CO<sub>2</sub> eq. compared to previous year

Fig. 4-15 Trend of emissions from 2.E Electronics Industry [kt CO<sub>2</sub> eq.]

Tab. 4-20 lists the exact amount of CO<sub>2</sub> 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 <sub>2</sub> 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 <sub>2</sub> 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<sub>2</sub> 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 <sub>4</sub> , C <sub>2</sub> F <sub>6</sub> , SF <sub>6</sub> , NF <sub>3</sub>	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<sub>2</sub>F<sub>6</sub>, CF<sub>4</sub>, SF<sub>6</sub>, CHF<sub>3</sub> (HFC-23) and NF<sub>3</sub>. 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<sub>6</sub> and NF<sub>3</sub> are significant for semiconductor manufacturing. SF<sub>6</sub> is used in semiconductor industry for etching and melting Mg and Al. Huge energy companies are the main contributors to the SF<sub>6</sub> emissions. SF<sub>6</sub> consumption can be considered as stagnant in the last years. NF<sub>3</sub> is used for semiconductor manufacturing since year 2012. The consumption of NF<sub>3</sub> 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<sub>6</sub>.

##### 4.6.2 Methodological issues

Because of the lack of detailed information, the data about gases C<sub>2</sub>F<sub>6</sub>, CF<sub>4</sub>, SF<sub>6</sub>, CHF<sub>3</sub> (HFC-23) and NF<sub>3</sub> 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<sub>i</sub> and d<sub>i</sub>, which are considered by expert judgement to be negligible and further using equation 6.3 for estimation of by-product emissions of CF<sub>4</sub>. By-product emissions of CF<sub>4</sub> are reported together with regular CF<sub>4</sub> 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<sub>6</sub> 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<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>, SF<sub>6</sub> and NF<sub>3</sub> 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-U <sub>i</sub> )	B <sub>CF<sub>4</sub></sub>	B <sub>C<sub>2</sub>F<sub>6</sub></sub>	B <sub>C<sub>3</sub>F<sub>8</sub></sub>
HFC-23 (CHF <sub>3</sub> )	0.4	0.07	NA	NA
CF <sub>4</sub>	0.9	NA	NA	NA
C <sub>2</sub> F <sub>6</sub>	0.6	0.2	NA	NA
SF <sub>6</sub>	0.2	NA	NA	NA
NF <sub>3</sub>	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<sub>6</sub> or NF<sub>3</sub> 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.

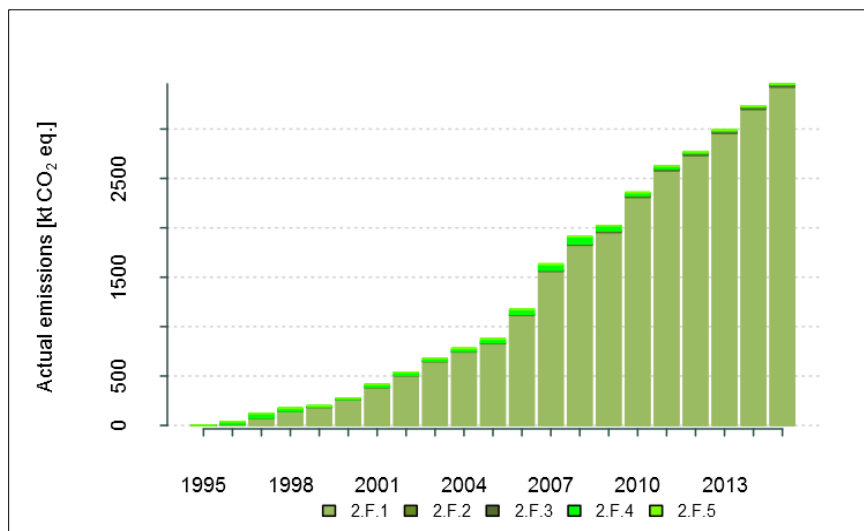


Fig. 4-16 Trend of emissions from 2.F Product Uses as Substitutes for Ozone Depleting Substances and share of specific subcategories [kt CO<sub>2</sub> eq.]

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<sub>2</sub> eq. in 1995 to 3456.60 kt CO<sub>2</sub> 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<sub>2</sub> eq.]

	Category 2.F - emissions of PFCs and HFCs [kt CO <sub>2</sub> 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<sub>6</sub>) 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
<b>2.F.1 Refrigeration and Air Conditioning</b>	HFCs, PFCs	CS and Default (IPCC, 2006)	Tier 2a
<b>2.F.2 Foam Blowing Agents</b>	HFCs	Default (IPCC, 2006)	Tier 1a
<b>2.F.3 Fire protection</b>	HFCs, PFCs	Default (IPCC, 2006)	Tier 1a
<b>2.F.4 Aerosols</b>	HFCs	Default (IPCC, 2006)	Tier 1a
<b>2.F.5 Solvents</b>	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.

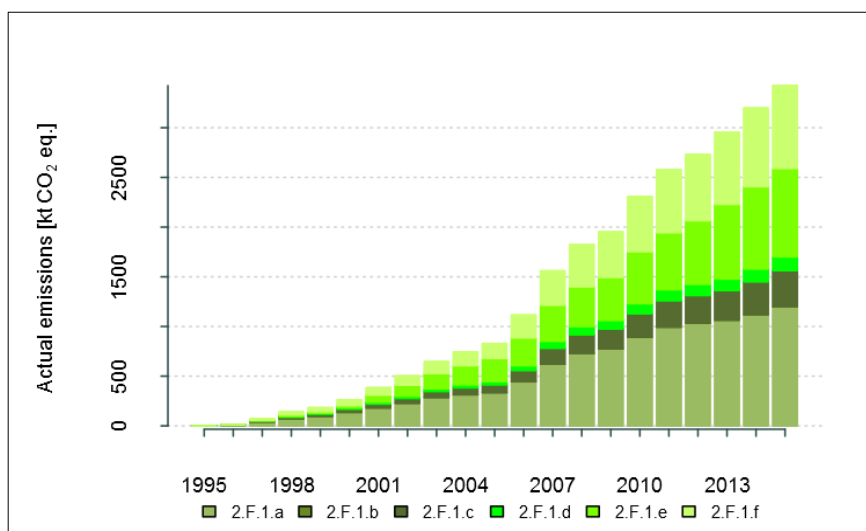


Fig. 4-17 Trend of emissions from 2.F.1 Refrigeration and Air conditioning and share of specific subcategories [kt CO<sub>2</sub> eq.]

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 <sub>6</sub> F <sub>14</sub> , C <sub>3</sub> F <sub>8</sub> , C <sub>2</sub> F <sub>6</sub>
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 <sub>6</sub> F <sub>14</sub>	100%	x	x	x	x
C <sub>3</sub> F <sub>8</sub>	100%	x	x	x	x
C <sub>2</sub> F <sub>6</sub>	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<sub>6</sub>. 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
<b>2.F.1.a Commercial Refrigeration</b>	HFC-134a	1996
	HFC-32	1998, 1999
<b>2.F.1.b Domestic Refrigeration</b>	HFC-134a	1996
<b>2.F.1.c Industrial Refrigeration</b>	HFC-32	1998, 1999
	HFC-134a	1996
<b>2.F.1.d Transport Refrigeration</b>	HFC-32	1998
	HFC-134a	1996
<b>2.F.1.e Mobile Air Conditioning</b>	HFC-134a	1998, 1999, 2000, 2001
<b>2.F.1.f Stationary Air Conditioning</b>	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<sub>3</sub>F<sub>8</sub> (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.

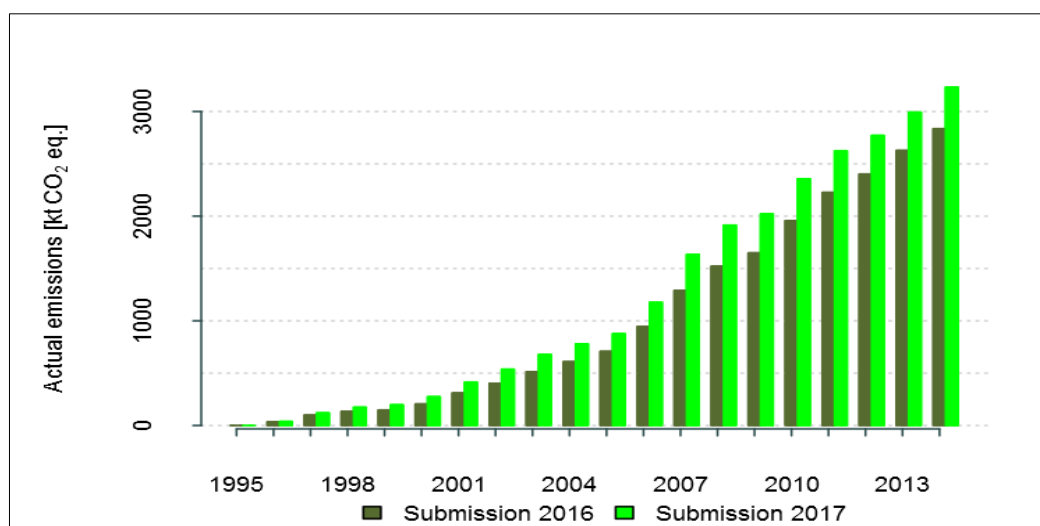


Fig. 4-18 Recalculation in 2.F category due to implementation of the new calculation model

#### 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

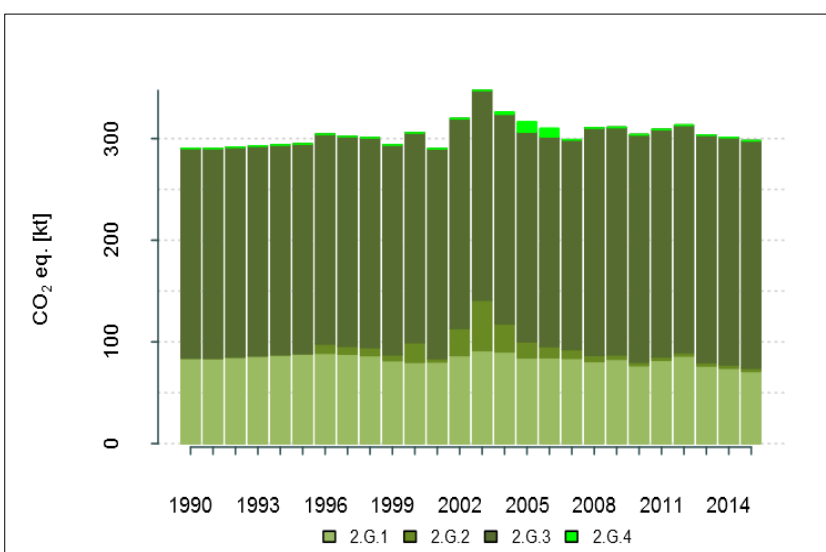


Fig. 4-19 Trend of emissions from 2.G Other Product Manufacture and Use and share of specific subcategories [kt CO<sub>2</sub> eq.]

SF<sub>6</sub> and PFCs from Other Product Use, 2.G.3 N<sub>2</sub>O from Product Uses and Category 2.G.4 Other. Under the 2.G. category are reported SF<sub>6</sub> and N<sub>2</sub>O emissions.

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<sub>2</sub> eq. in 2015 compared to the previous year.

Tab. 4-29 lists the exact amount of CO<sub>2</sub> emissions from the individual subcategories in 2.G. Other Product Manufacture and Use for the 1990 to 2015 period.

Tab. 4-29 CO<sub>2</sub> eq. emissions in individual subcategories in 2.G Other Product Manufacture and Use category in 1990-2015

	Category 2.G - emissions [kt CO <sub>2</sub> eq.]			
	2.G.1 Electrical Equipment	2.G.2 SF <sub>6</sub> and PFCs from Other Product Use	2.G.3 N <sub>2</sub> O 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 <sub>6</sub>	Default (IPCC, 2006)	T1
2.G.2 SF <sub>6</sub> and PFCs from Other Product Use	SF <sub>6</sub>	Default (IPCC, 2006)	D
2.G.3 N <sub>2</sub> O from Product Uses	N <sub>2</sub> O	Default (IPCC, 2006)	D



## 4.8.1 Electrical Equipment (2.G.1)

### 4.8.1.1 Source category description

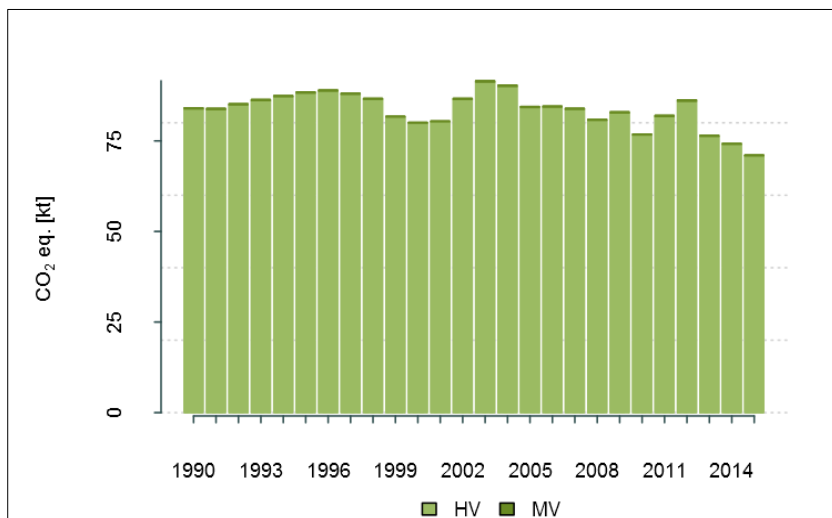


Fig. 4-20 Trend of emissions from 2.G.1 Electrical equipment and share of HV and MV equipment [kt CO<sub>2</sub> eq.]

Recently this subcategory was divided into Medium Voltage (MV) Electrical equipment (< 52 kV) and High Voltage (HV) Electrical Equipment (> 52 kV) containing SF<sub>6</sub>. 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<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> does not even require the operator to report SF<sub>6</sub> usage in ISPOP.

SF<sub>6</sub> 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 SF<sub>6</sub>. 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.

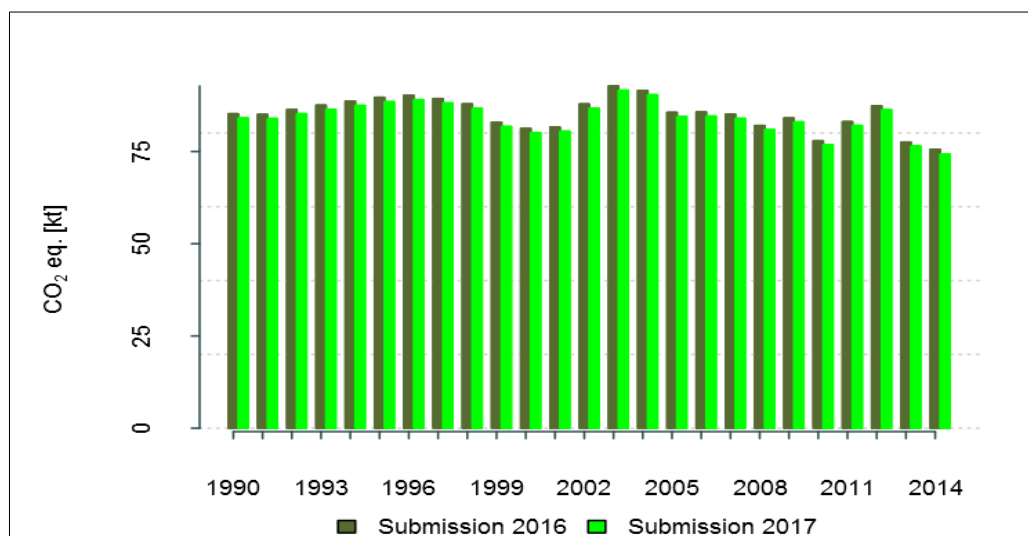


Fig. 4-21 Recalculation in category 2.G.1 due to division of activity data to MV and HV equipment

#### 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<sub>6</sub> 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<sub>6</sub> for manufacturing sound-proof windows is not used. Lifetime of

windows filled with SF<sub>6</sub> is assumed to be 25 years. SF<sub>6</sub> 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<sub>2</sub>O from Product Uses (CRF 2.G.3)**

#### **4.8.3.1 Source category description**

This category (2.G.3) includes N<sub>2</sub>O 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<sub>2</sub>O were derived from production in the Czech Republic (0.6 kt N<sub>2</sub>O) and from import of N<sub>2</sub>O (0.15 kt N<sub>2</sub>O), 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<sub>2</sub>O 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<sub>2</sub>O). 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<sub>2</sub>O 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<sub>6</sub> 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<sub>4</sub> emissions only), manure management (CH<sub>4</sub> and N<sub>2</sub>O emissions), agricultural soils (only N<sub>2</sub>O emissions), urea application and liming (only CO<sub>2</sub> 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 described 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
<b>3.D.1 Agricultural Soils, Direct N<sub>2</sub>O emissions</b>	N <sub>2</sub> O	LA, TA	LA, TA	yes	yes	yes	yes	2.01	2.12
<b>3.A Enteric Fermentation</b>	CH <sub>4</sub>	LA, TA	LA, TA	yes	yes	yes	yes	2.26	2.39
<b>3.D.2 Agricultural Soils, Indirect N<sub>2</sub>O emissions</b>	N <sub>2</sub> O	LA, TA	LA	yes	yes	yes	yes	0.69	0.73
<b>3.B Manure Management</b>	N <sub>2</sub> O	LA, TA	LA, TA	yes	yes	yes	yes	0.79	0.83
<b>3.B Manure Management</b>	CH <sub>4</sub>	LA, TA	TA	yes	yes	yes	yes	0.60	0.64
<b>3.G Liming</b>	CO <sub>2</sub>	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<sub>2</sub> 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 <sub>2</sub> 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

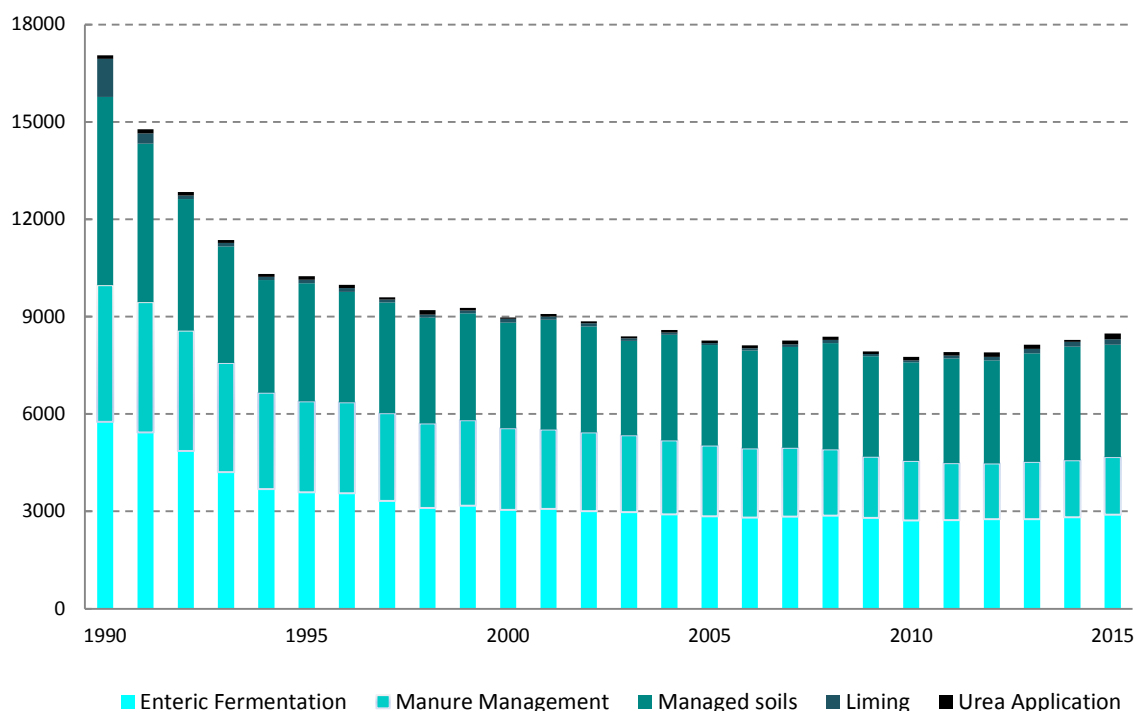


Fig. 5-1 The emission trend of agricultural sector in period 1990-2015 [Gg CO<sub>2</sub> eq.]

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<sub>2</sub>O 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<sub>GasMS</sub> and Frac<sub>LossMS</sub>) of N loss from Manure Management System (MMS) were updated to coordinate reporting for N<sub>2</sub>O emissions from Manure Management and N<sub>2</sub>O emissions from managed soils.
- According to ERT recommendation the value of Frac<sub>REMOVE</sub> (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 N<sub>2</sub>O emissions) to consider emitting NH<sub>3</sub> and NO<sub>x</sub>, 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<sub>2</sub>O 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 ( $F_{SOM}$ ), 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<sub>4</sub> and N<sub>2</sub>O 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
<b>Cattle</b>	3 506 222	3 359 979	2 949 576	2 511 754	2 161 429	2 029 826
<b>Pigs</b>	4 789 898	4 569 304	4 609 149	4 598 821	4 070 898	3 866 568
<b>Sheep</b>	429 714	429 106	342 069	254 301	196 030	165 345
<b>Poultry</b>	31 981 100	33 278 468	30 756 308	28 219 580	24 974 149	26 688 376

	1996	1997	1998	1999	2000	2001
<b>Cattle</b>	1 988 810	1 865 901	1 700 788	1 657 326	1 573 527	1 582 295
<b>Pigs</b>	4 016 246	4 079 590	4 012 943	4 000 720	3 687 967	3 469 802
<b>Sheep</b>	134 009	120 921	93 557	86 047	84 108	87 539
<b>Poultry</b>	27 875 356	27 572 714	29 035 455	30 222 187	30 784 432	28 864 561

	2002	2003	2004	2005 <sup>1)</sup>	2006	2007
<b>Cattle</b>	1 520 145	1 473 822	1 428 327	1 397 324	1 373 645	1 391 396
<b>Pigs</b>	3 440 925	3 362 801	3 126 539	2 876 834	2 840 375	2 830 415
<b>Sheep</b>	96 286	103 129	115 852	140 197	148 412	168 910
<b>Poultry</b>	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
<b>Cattle</b>	1 401 607	1 363 213	1 349 286	1 343 686	1 353 685	1 352 822	1 373 560	1 407 132
<b>Pigs</b>	2 432 984	1 971 417	1 909 232	1 749 092	1 578 827	1 586 627	1 617 061	1 559 648
<b>Sheep</b>	183 618	183 084	196 913	209 052	221 014	220 521	225 397	231 694
<b>Poultry</b>	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<sub>4</sub> emissions from Enteric Fermentation. In 2015, 2.4% of agricultural CH<sub>4</sub> 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<sub>4</sub> 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<sub>4</sub>.

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<sup>1</sup> of age (male and female)

<sup>1</sup> Since 2009 the age limit for “Calves” shifted up to 8 months.

- Young bulls and heifers (6-12 months of age<sup>2</sup>)
- 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
<b>Mature cows (dairy and suckler)</b>	520	540	580	585	590
<b>Heifers &gt; 2 years</b>	485	490	505	510	515
<b>Bulls and bullocks &gt; 2 years</b>	750	780	820	840	850
<b>Heifers 1-2 years</b>	380	385	395	395	390
<b>Bulls 1-2 years</b>	490	510	530	540	560
<b>Heifers 6-12 months</b>	275	280	285	285	290*
<b>Bulls 6-12 months</b>	325	330	335	340	350*
<b>Calves to 6 months</b>	128	132	133	135	135*

*Note: \* Since 2009 the age limit for “Calves” shifted up to 8 months.*

<sup>2</sup> 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, Trínáctý 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<sub>4</sub> 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<sub>4</sub> 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<sub>4</sub> (43%) and direct (43%) and indirect (14%) N<sub>2</sub>O emissions from animal manure management. Total emissions from Manure Management (CH<sub>4</sub> and N<sub>2</sub>O) equalled 1779 Gg CO<sub>2</sub> 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<sub>2</sub>O) and methane (CH<sub>4</sub>) 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<sub>2</sub>O 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<sub>2</sub> eq.)

	Total (CO <sub>2</sub> eq.)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (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<sub>4</sub> 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
<b>Dairy cows</b>	226.8	237.4	264.1	294.9	309.7	335.2
<b>Other cattle</b>	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 ( $B_0$ , 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
$B_0$	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:

$$CH_4 \text{ emissions} \left[ \frac{kt}{year} \right] = \sum \left( \frac{EF \cdot \text{cattle population} \left[ \frac{kg}{kt} \right]}{10^6} \right)$$

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):

$$EF = VS \cdot 365 \cdot B_0 \cdot 0.67 \cdot \sum (MCF \cdot MS)$$

**Tab. 5-12 Parameter VS, EF (kg CH<sub>4</sub>/h/yr) and methane emissions from Manure Management in period 1990-2015**

	Dairy cows		Other cattle	
	VS	EF	VS	EF
<b>1990</b>	4.18	13.91	2.35	8.22
<b>1991</b>	4.03	13.39	2.34	8.20
<b>1992</b>	4.10	13.65	2.30	8.10
<b>1993</b>	4.12	13.69	2.29	8.06
<b>1994</b>	4.21	13.66	2.29	8.07
<b>1995</b>	4.38	13.61	2.39	8.08
<b>1996</b>	4.45	10.55	2.40	8.15
<b>1997</b>	4.37	8.52	2.43	8.30
<b>1998</b>	4.57	8.90	2.44	8.35
<b>1999</b>	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<sub>4</sub> 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;  $0.173 = 1.13 \times 0.13 + 0.03 \times 0.87$ ).

### Nitrous oxide emissions (CRF 3.B.2)

N<sub>2</sub>O 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<sub>2</sub>O taking place before the manure is applied to soils are reported under Manure Management. The IPCC Guidelines method for estimating N<sub>2</sub>O 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  $X_{i,j}$  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  $X_{i,1} + X_{i,2} + \dots + X_{i,6} = 1$ . 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<sub>4</sub> 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<sub>2</sub>O 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<sub>2</sub>O 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 <sub>3</sub> )
	[kg N <sub>2</sub> O-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 NO<sub>x</sub>. 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  $\text{NH}_3$  and  $\text{NO}_x$  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  $\text{N}_2\text{O}$  emissions from Manure Management, the fraction of nitrogen losses due to volatilization and the default indirect factor  $\text{EF}_4$  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 ( $\text{Frac}_{\text{LeachMS}}$ ) 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  $\text{N}_2\text{O}$  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 "N<sub>2</sub>O emissions from Manure Management" category were not affected.

The  $\text{CH}_4$  emissions from Manure Management of cattle were recalculated in 2011. In line with IPCC, a higher-tier method to estimate the  $\text{CH}_4$  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  $\text{N}_2\text{O}$  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  $\text{N}_2\text{O}$  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. Kvapilík (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  $\text{CH}_4$  emissions equals to 20%; for estimation of

N<sub>2</sub>O emissions, this value equals to 30%. The combined uncertainty for CH<sub>4</sub> emissions equals to 20.6% and that for N<sub>2</sub>O 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 (N<sub>ex</sub>) for swine was changed based on the correction of average swine weight (originally calculated based on the slaughter weight).

The N<sub>2</sub>O 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<sub>GasMS</sub> and Frac<sub>LossMS</sub>) of N loss from Manure Management System (MMS) were updated to coordinate reporting for N<sub>2</sub>O emissions from Manure Management and N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O emissions from Agriculture originated from Agricultural Soils, while the rest originated from Manure Management (23%). The trend in N<sub>2</sub>O emissions from this category is during reporting period 1990-2015 decreasing. Tab. 5-19 presents the N<sub>2</sub>O emissions of Agricultural soils by the individual sub-categories.

**Tab. 5-19 N<sub>2</sub>O emissions come from Agricultural Soils in period 1990-2015 in kt N<sub>2</sub>O**

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<sub>2</sub>O 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<sub>2</sub>O emissions are shown in Tab. 5-20. The IPCC default fraction values are used to estimate N<sub>2</sub>O 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 <sub>1</sub> = 0.01 kg N <sub>2</sub> O-N/kg N
	Animal Waste	
	Sewage Sludge	
	N-crop residues	
	Mineralized N	
Pasture, range & paddock manure	Cattle, pigs, poultry	EF <sub>3</sub> = 0.02 kg N <sub>2</sub> O-N/kg N
	Sheep, others	EF <sub>3</sub> = 0.01 kg N <sub>2</sub> O-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<sub>2</sub>O 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 <sub>3</sub>
	[kg N <sub>2</sub> O-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 <sub>AG</sub>	calc	calc	calc	calc	calc	calc
AG <sub>DM</sub>	calc	calc	calc	calc	calc	calc
Frac <sub>Remove</sub>	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 <sub>BG-BIO</sub>	0.22	0.19	0.2	0.2	0.4	0.19
N <sub>BG</sub>	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)**

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

#### **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<sub>2</sub>O emissions from atmospheric deposition of N volatilized from managed soil are estimated using Equation 11.9, where F<sub>ON</sub> includes also sewage sludge inputs. The conversion of N<sub>2</sub>O-N emissions to N<sub>2</sub>O emissions for reporting purposes is performed by factor 44/28.

**EQUATION 11.9**  
**N<sub>2</sub>O FROM ATMOSPHERIC DEPOSITION OF N VOLATILISED FROM MANAGED SOILS (TIER 1)**

$$N_2O_{(ATD)}-N = [(F_{SN} \cdot \text{Frac}_{GASF}) + ((F_{ON} + F_{PRP}) \cdot \text{Frac}_{GASM})] \cdot EF_4$$

### Leaching/Runoff

The N<sub>2</sub>O emissions from leaching and runoff in regions, where leaching and runoff occurs, are estimated using Equation 11.10, where F<sub>ON</sub> includes also sewage sludge inputs. The conversion of N<sub>2</sub>O-N emissions to N<sub>2</sub>O emissions for reporting purposes is performed by factor 44/28.

**EQUATION 11.10**  
**N<sub>2</sub>O FROM N LEACHING/RUNOFF FROM MANAGED SOILS IN REGIONS WHERE LEACHING/RUNOFF OCCURS (TIER 1)**

$$N_2O_{(L)}-N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \cdot \text{Frac}_{LEACH-(H)} \cdot EF_5$$

### 5.4.3 Uncertainty and time-series consistency

In relation to the consistency of the emission series for N<sub>2</sub>O (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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O emissions and
2. Potatoes and sugar beet crops produced in the country were included in the estimations of N<sub>2</sub>O emissions from crop residues returned to soils.

On the basis of the recommendations of TERT and ERT the Direct N<sub>2</sub>O emissions from agricultural soils were recalculated and reported in the 2016 resubmission. This led to changes in N<sub>2</sub>O 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 N<sub>2</sub>O 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  $F_{\text{REMOVE}}$  (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 N<sub>2</sub>O emissions) to consider emitting NH<sub>3</sub> and NO<sub>x</sub>, 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<sub>2</sub>O 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 ( $F_{\text{SOM}}$ ) 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 ( $F_{\text{SOM}}$ ), 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<sub>2</sub> emissions as the carbonate lime dissolve and release bicarbonate, which evolves into CO<sub>2</sub> 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<sub>2</sub>, 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
<b>CL+GL</b>	2650	700	230	220	230	248	255	210	204	196	209	210	196
<b>FL</b>	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
<b>CL+GL</b>	172	158	143	160	174	203	145	135	182	263	308	342	353
<b>FL</b>	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<sub>3</sub>. To convert CO<sub>2</sub>-C emissions into CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>-C emissions, the product of the amount of urea is multiplied by the emission factor. CO<sub>2</sub>-C emissions are converted into CO<sub>2</sub> 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
<b>Urea (kt)</b>	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
<b>Urea (kt)</b>	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 9<sup>th</sup> Conference of the Parties (COP) to UNFCCC. The reporting guidelines were revised at the 19<sup>th</sup> 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<sub>2</sub> 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<sub>2</sub> emissions and removals, and emissions of non-CO<sub>2</sub> gases (CH<sub>4</sub>, N<sub>2</sub>O, NO<sub>x</sub> 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.

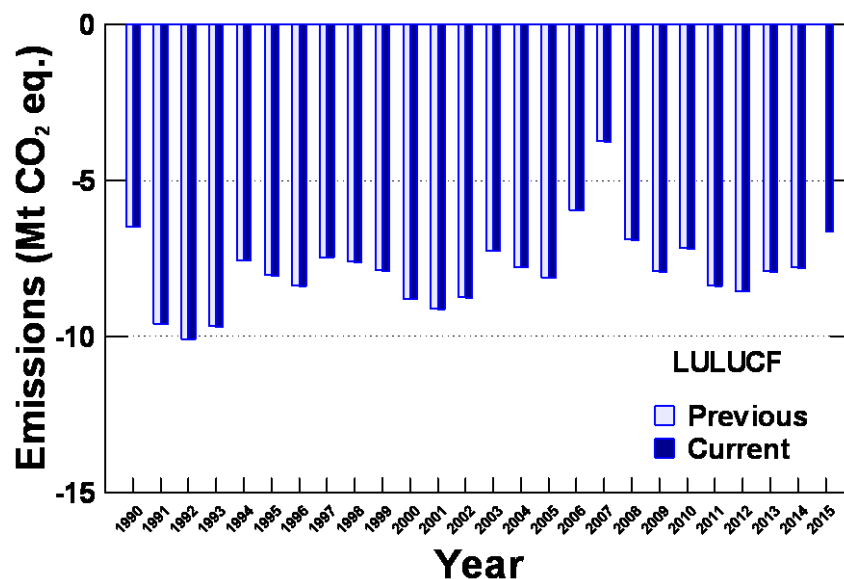


Fig. 6-1 The current and previously reported estimates of emissions for the LULUCF sector. The values are negative, hence correspond to net removals of green-house gases.

### 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 <sub>2</sub> eq.	Emissions 2015 kt CO <sub>2</sub> eq.
<b>4 Total LULUCF</b>	-6 488	-6 641
<b>4.A Forest Land</b>	-4 859	-6 053
4.A.1 Forest Land remaining Forest Land	-4 537	-5 561
4.A.2 Land converted to Forest Land	-321	-482
<b>4.B Cropland</b>	121	5
4.B.1 Cropland remaining Cropland	-2	-84
4.B.2 Land converted to Cropland	123	89
<b>4.C Grassland</b>	-145	-550
4.C.1 Grassland remaining Grassland	0	-276
4.C.2 Land converted to Grassland	-145	-274
<b>4.D Wetlands</b>	22	25
4.D.1 Wetlands remaining Wetlands	(0)	(0)
4.D.2 Land converted to Wetlands	22	25
<b>4.E Settlements</b>	85	88
4.E.1 Settlements remaining Settlements	(0)	(0)
4.E.2 Land converted to Settlements	85	88
<b>4.F Other Land</b>	(0)	8
<b>4.G Harvested Wood Products</b>	-1 713	-164

Note: Emissions of non-CO<sub>2</sub> gases (CH<sub>4</sub> and N<sub>2</sub>O) 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<sub>2</sub> 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<sub>2</sub> 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
<b>4.A.1 Forest Land remaining Forest Land</b>	CO <sub>2</sub>	LA, TA	LA, TA	yes	no	yes	no	4.42
<b>4.G Harvested wood products</b>	CO <sub>2</sub>	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](http://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” (AALC). The AALC 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” (AALC), 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. AALC 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 AALC 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.

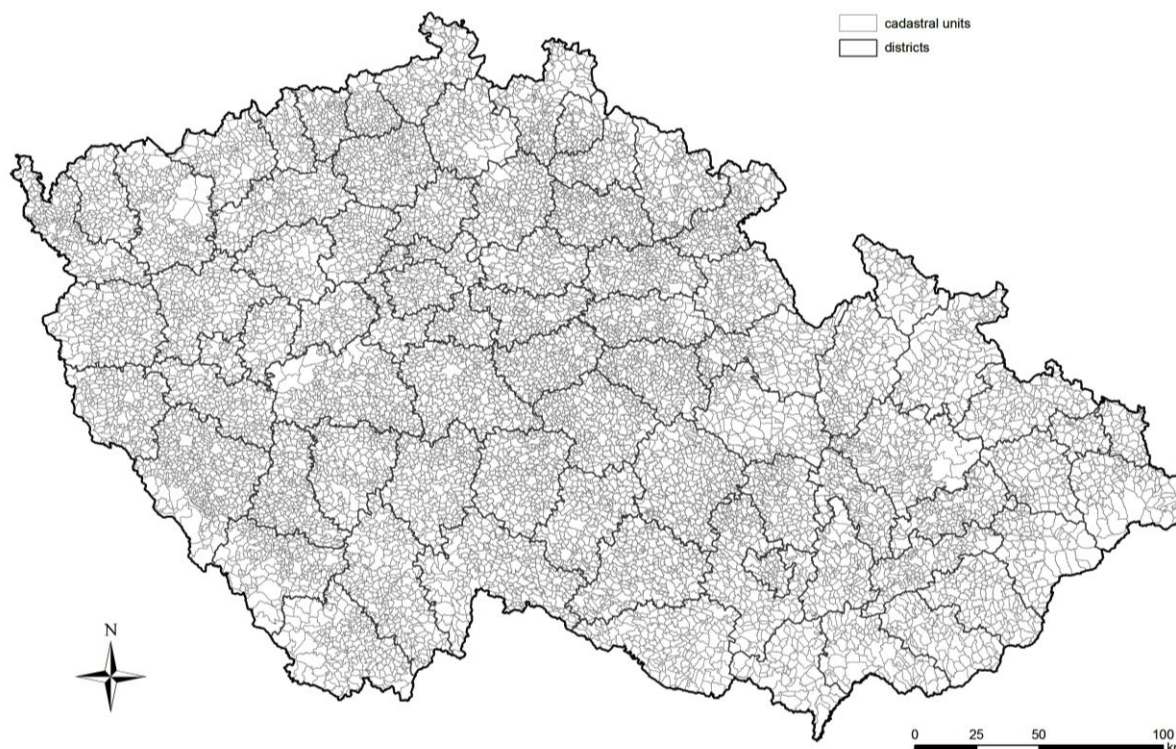


Fig. 6-2 Cadastral units (grey lines; n = 13 091) and districts (black lines; n=79), the basis of the Czech land use representation and land use change identification system.

### 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	Settlements	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
<b>Difference</b>		<b>-12913</b>	<b>5766</b>	<b>-4934</b>	<b>0</b>	<b>12082</b>	<b>1</b>	<b>2</b>
<b>Conversion type</b>		<b>Area (m<sup>2</sup>)</b>						
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<sup>2</sup>.

#### 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](http://www.cuzk.cz)), which administers the source information on land use used in the LULUCF emission inventory<sup>3</sup>. 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" (AACL), centrally collected and administered by COSMC, as described in detail in Section 6.2 above. The specific attribution and linking of cadastral land use

<sup>3</sup> The work of the Czech Office for Surveying, Mapping and Cadastre (COSMC; [www.cuzk.cz](http://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.

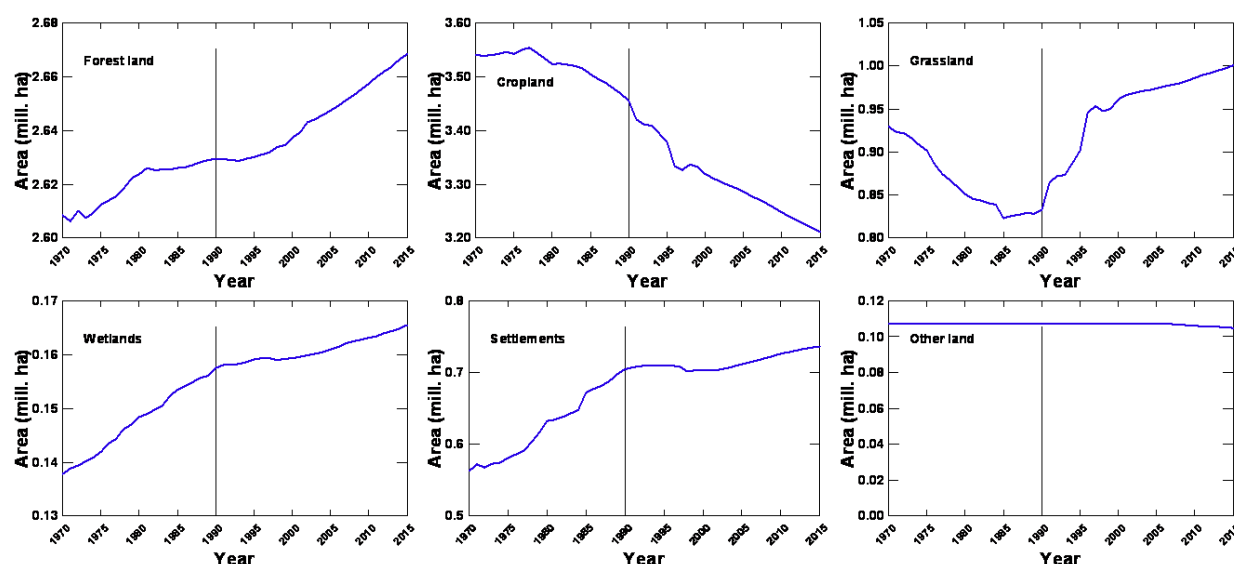


Fig. 6-4 Trends in areas of the six major land-use categories in the Czech Republic between 1970 and 2015 (based on information from the Czech Office for Surveying, Mapping and Cadastre).

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)

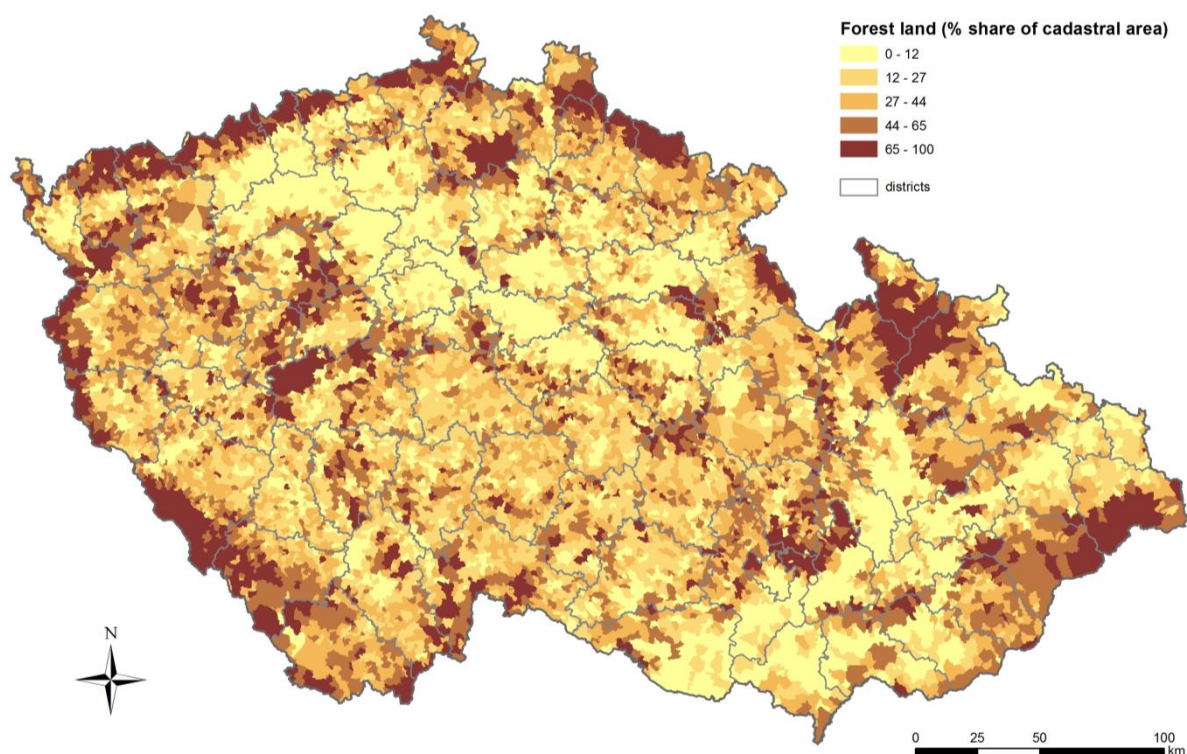


Fig. 6-5 Forest land in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2015).

### 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<sup>4</sup>. 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,

<sup>4</sup> 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<sup>3</sup> in 1990 to 693 mil. m<sup>3</sup> (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](http://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.

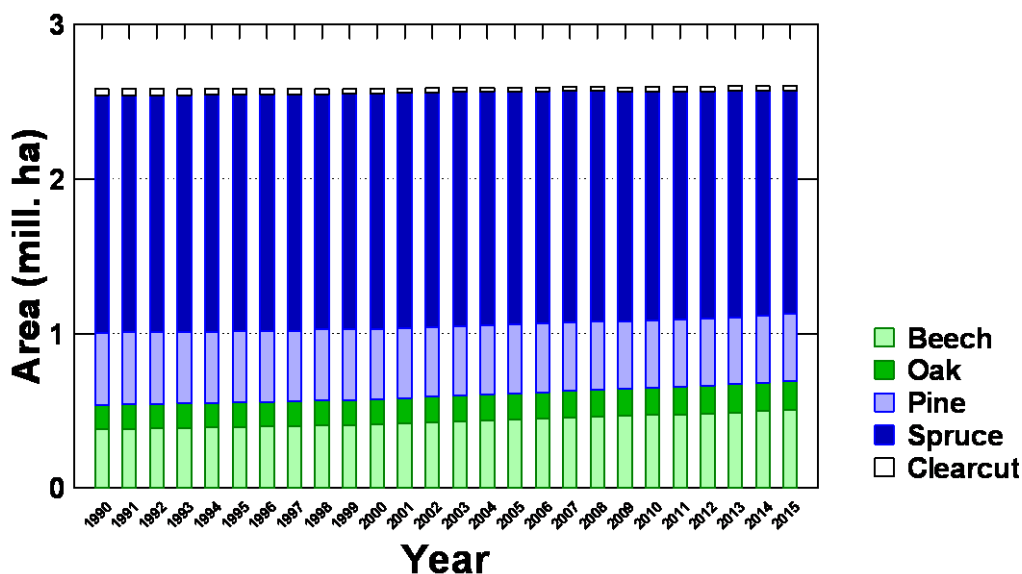


Fig. 6-6 Activity data – area for the four major groups of species and clearcut area during 1990 to 2015.

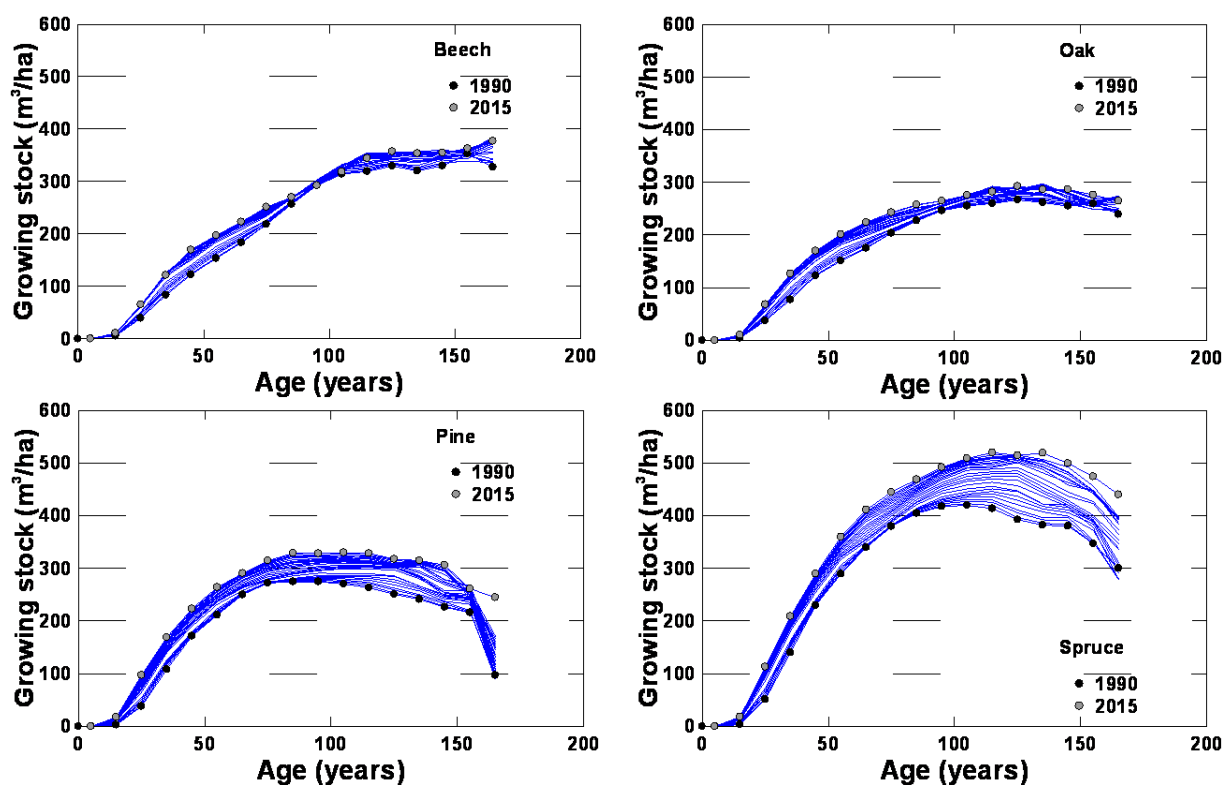


Fig. 6-7 Activity data – mean growing stock volume against stand age for the four major groups of species during 1990 to 2015; each line corresponds to an individual inventory year. The symbols identify only the situation in 1990 and 2015.

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<sup>3</sup> in 1990 to 16.2 mil. m<sup>3</sup> (under bark) in 2015, down from the all-time high of 18.5 mil. m<sup>3</sup> 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<sup>3</sup>, down from the maximum of nearly 21 mill. m<sup>3</sup> 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.

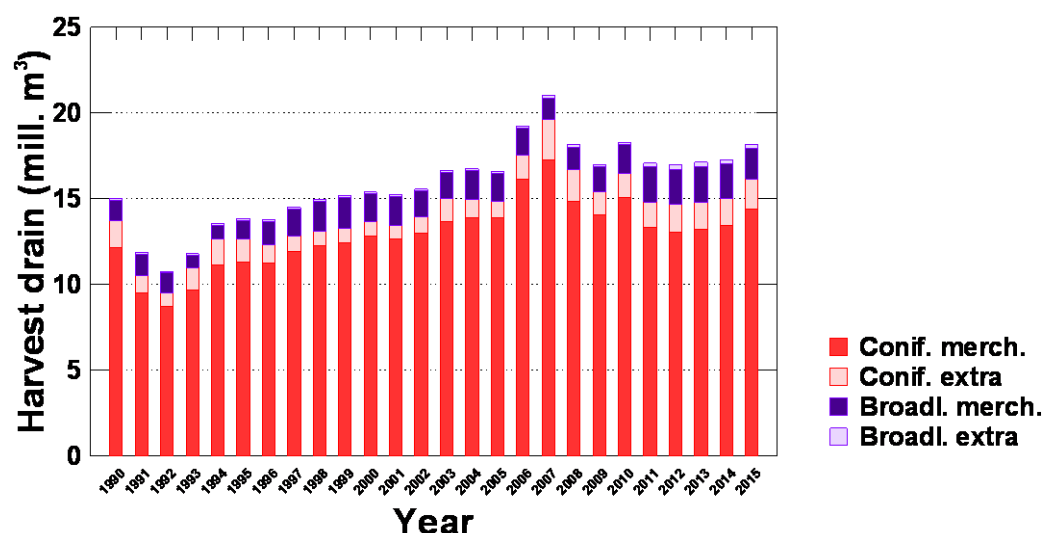


Fig. 6-8 The applicable total annual harvest drain for coniferous (Conif.) and broadleaved (Broadl.) tree species, which includes both the reported quantities of merchantable wood for the two categories (Conif. merch, Broadl. merch.) and the associated harvest loss (Conif. extra, Broadl. extra) for the 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 <sup>-3</sup>	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 <sup>-3</sup>	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<sub>2</sub> associated with forests and non-CO<sub>2</sub> 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<sup>5</sup> 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<sup>6</sup> (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).

<sup>5</sup> 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.

<sup>6</sup> 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.

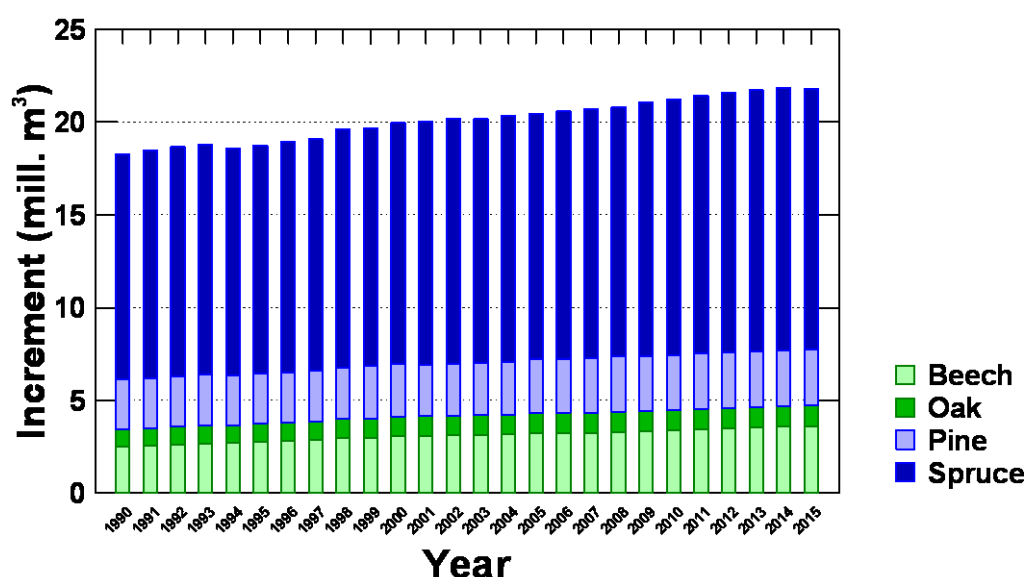


Fig. 6-9 Current annual increment (Increment, mill. m<sup>3</sup> underbark) by the individual tree species groups as used in the reporting period 1990 to 2015.

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 <sup>-3</sup>	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 <sup>3</sup> ha <sup>-1</sup>	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 ( $BCEF_v$ ) 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

$$L_{\text{wood removals}} = H * BCEF_h * (1 + R) * CF \quad (3)$$

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, Spruce	Oak,	Pine,	Beech, Oak, Pine, Spruce
Harvest drain volume ( $H$ , incl. $F_{HL}$ )	Mm <sup>3</sup>	0.95; 0.35; 1.49; 12.16			1.54; 0.46; 1.75; 14.41
Biomass expansion factor ( $BCEF_h$ )	Mg m <sup>-3</sup>	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  $\text{CO}_2$ , also other greenhouse gases ( $\text{CH}_4$ ,  $\text{CO}$ ,  $\text{N}_2\text{O}$  and  $\text{NO}_x$ ) 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- $\text{CO}_2$  gases ( $\text{CH}_4$ ,  $\text{CO}$ ,  $\text{N}_2\text{O}$  and  $\text{NO}_x$ ) 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- $\text{CO}_2$  gases can be found in the corresponding CRF Tables.

There are no direct  $\text{N}_2\text{O}$  emissions from N fertilization on Forest Land, as there is no practice of nitrogen fertilization of forest stands in the Czech Republic. Similarly, non- $\text{CO}_2$  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  $\text{CO}_2$ .

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- $\text{CO}_2$  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  $\text{N}_2\text{O}$  emissions from nitrogen fertilization, which is not carried out in this country on forest land.

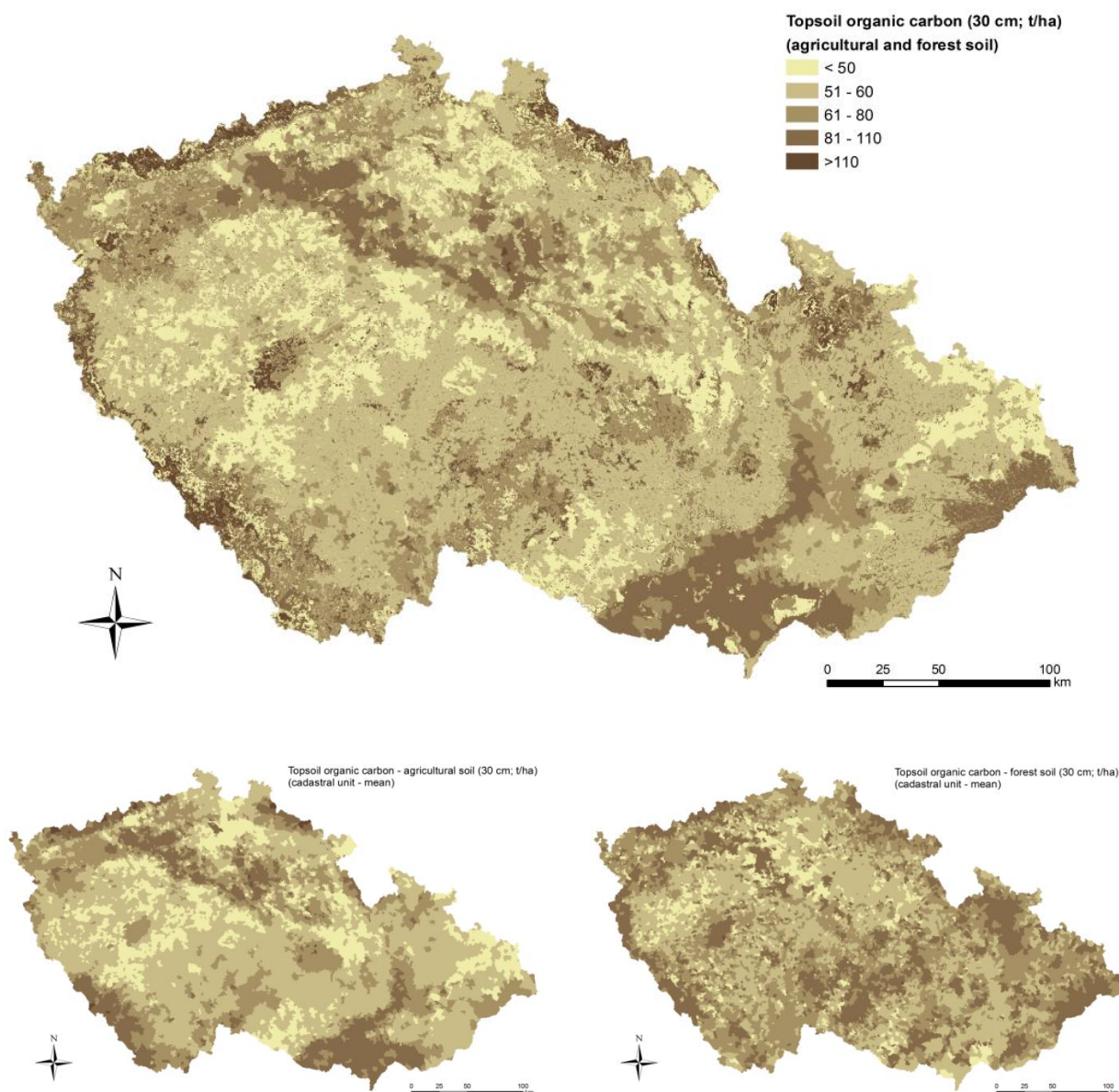


Fig. 6-10 Top - topsoil (30 cm) organic carbon content map adapted from Macků et al. (2007), Šefrna and Janderková (2007); bottom –topsoil carbon content for agricultural (left) and forest (right) soils estimated as cadastral unit means from the source maps. The unit (t/ha) and unit categories are identical 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:

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \dots + U_n^2} \quad (4)$$

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:

$$U_{total} = \frac{\sqrt{(U_1 * x_1)^2 + (U_2 * x_2)^2 + \dots + (U_n * x_n)^2}}{|x_1 + x_2 + \dots + x_n|} \quad (5)$$

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<sub>2</sub> or CO<sub>2</sub> 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.

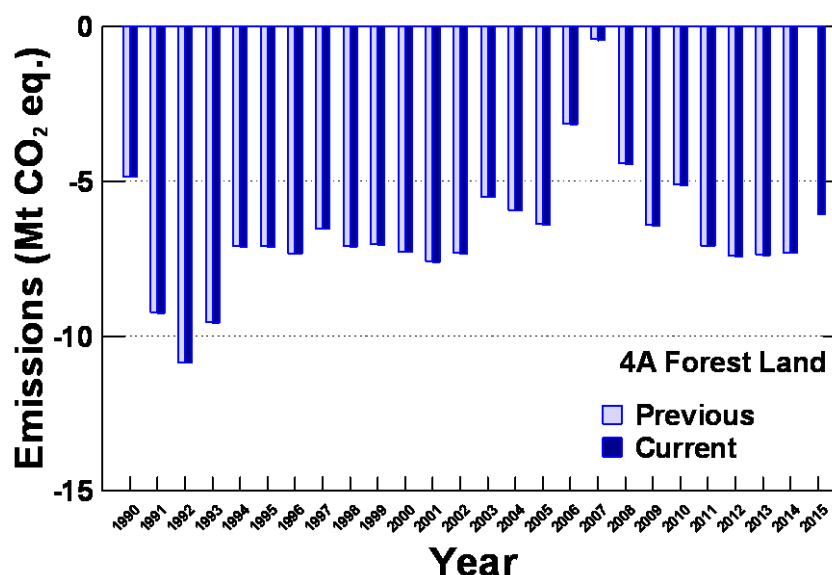


Fig. 6-11 Current and previously reported assessment of emissions for category 4.A Forest Land. The values are negative, hence representing net removals of green-house gases

#### 6.4.6 Source-specific planned improvements, including those in response to the review process

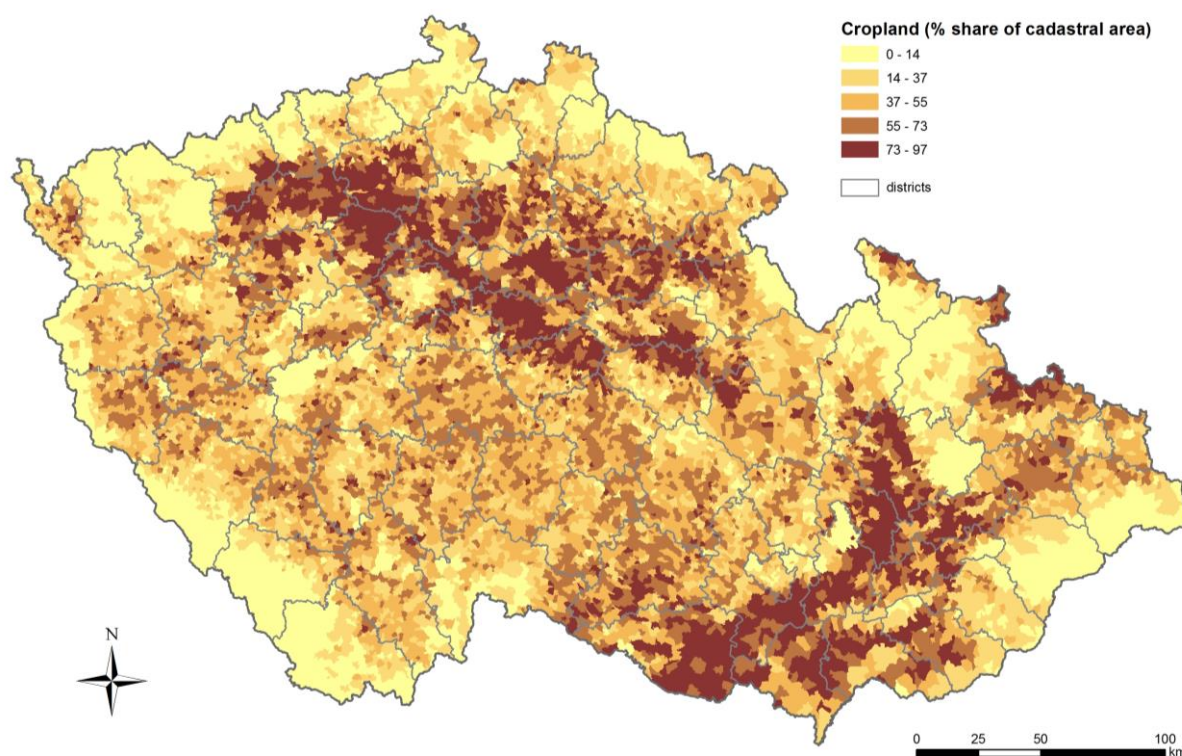
The current inventory report applicable for 4.A Forest Land used the rectified land area data for the entire data set required for the LULUCF inventory and improved emission estimates for the carbon stock

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<sub>2</sub>O 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<sub>2</sub> 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](http://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<sup>3</sup>), 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<sub>2</sub> gases, namely emissions of N<sub>2</sub>O due to mineralization. The estimation followed the Tier 1 approach of Eqs. 2.25 and 11.8 (IPCC 2006). Accordingly, direct N<sub>2</sub>O emissions were quantified on the basis of the detected changes in mineral soils employing a default emission factor of 0.01 kg N<sub>2</sub>O-N/kg N (EF1, IPCC 2006), and C:N ratio of 15. Linked to this, indirect N<sub>2</sub>O emissions from atmospheric deposition of N volatilized from managed soils were estimated using Eq. 11.10 and the emission factor 0.0075 (EF5, IPCC 2006).

Other non-CO<sub>2</sub> emissions may be related to those from burning. However, this is not a common practice in this country and no other non-CO<sub>2</sub> 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).

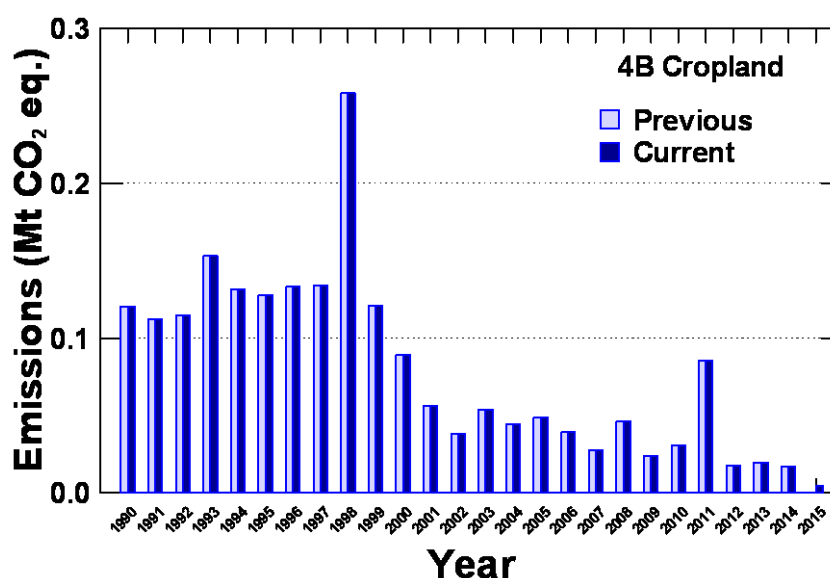


Fig. 6-13 Current and previously reported assessment of emissions for category 4.B Cropland



### 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” (AACLK), 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.

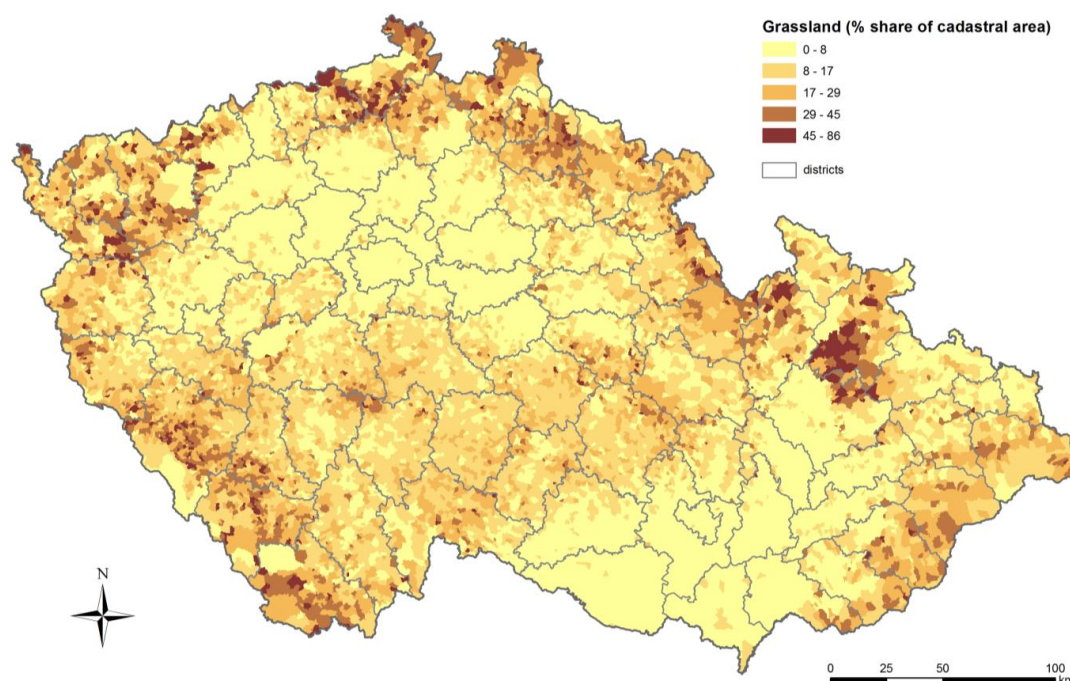


Fig. 6-14 Grassland in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2015).

## 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<sub>2</sub> 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).

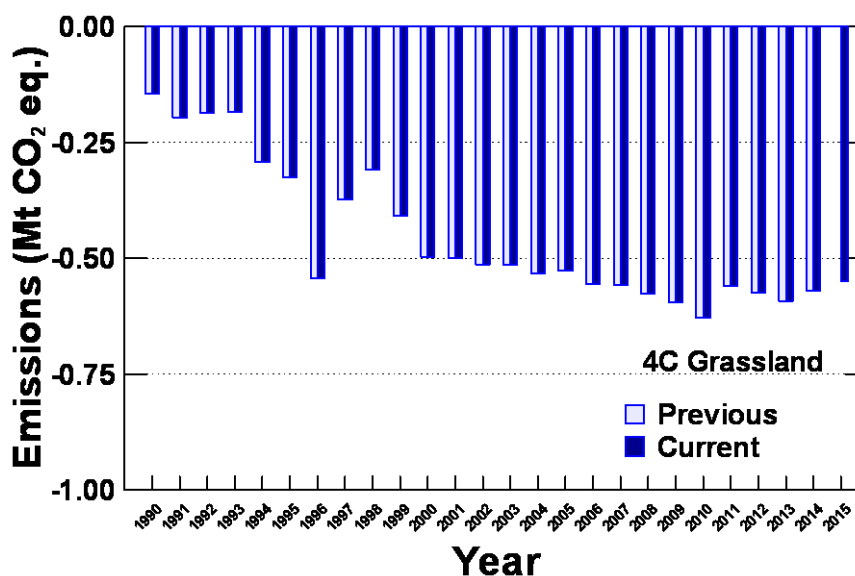


Fig. 6-15 Current and previously reported assessment of emissions for category 4.C Grassland. The values are negative, hence representing net removals of green-house gases.

#### 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<sup>7</sup>.

<sup>7</sup> 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 16<sup>th</sup> Century (Marek 2002)

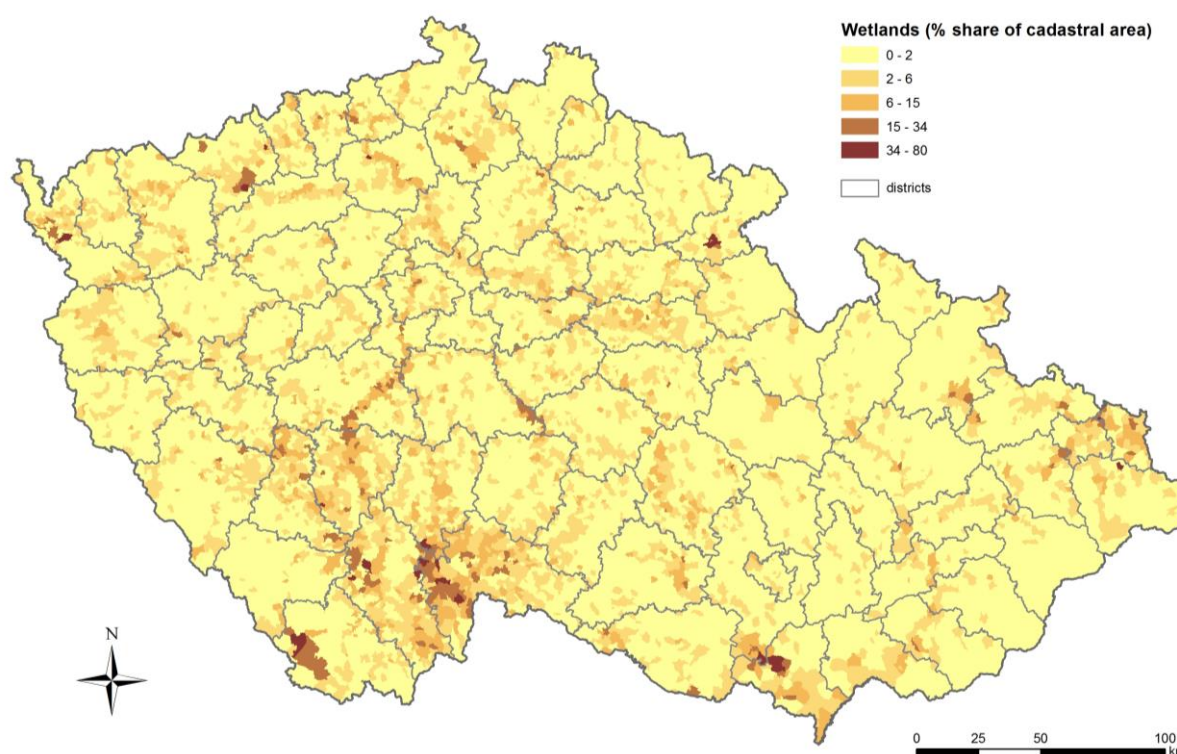


Fig. 6-16 Wetlands – distribution calculated as a spatial share of the category within individual cadastral units (as of 2015).

### 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).

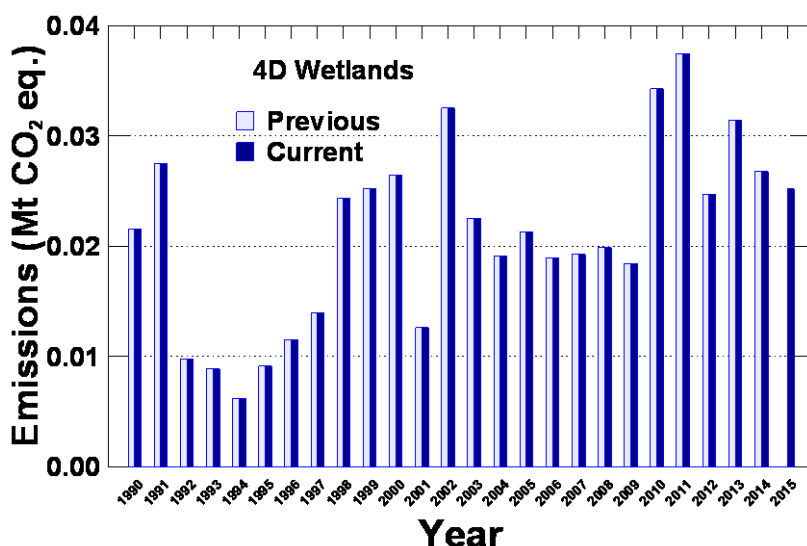


Fig. 6-17 Current and previously reported assessment of emissions for category 4.D Wetlands

#### 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)

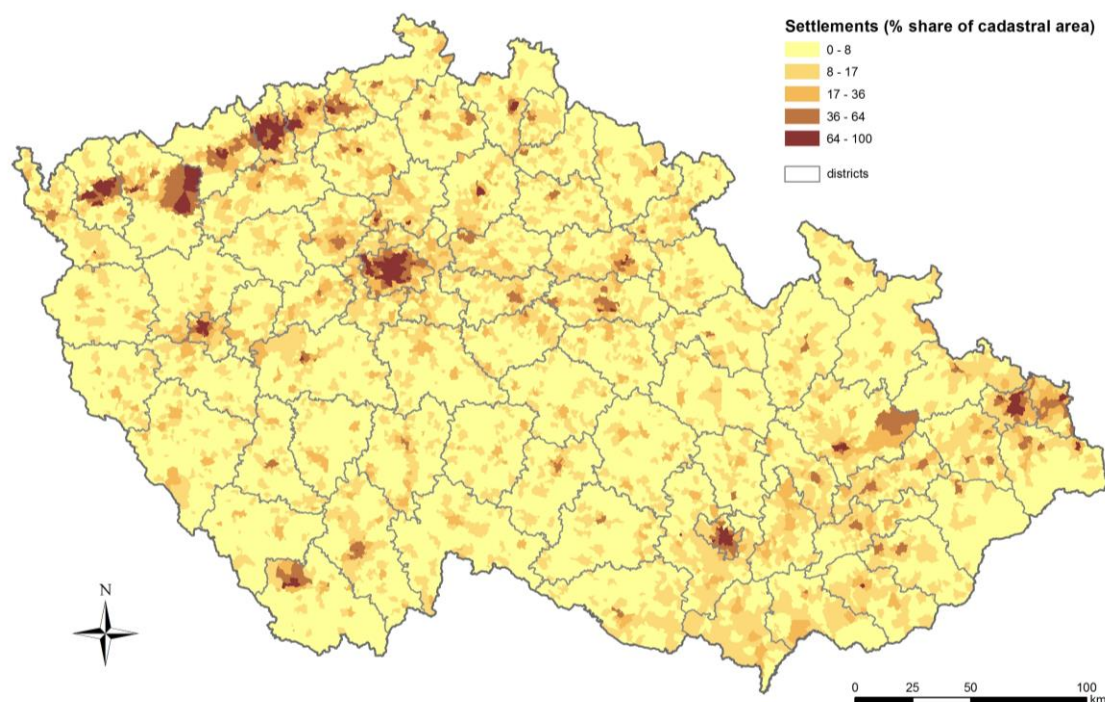


Fig. 6-18 Settlements – distribution calculated as a spatial share of the category within individual cadastral units (as of 2015).

### 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).



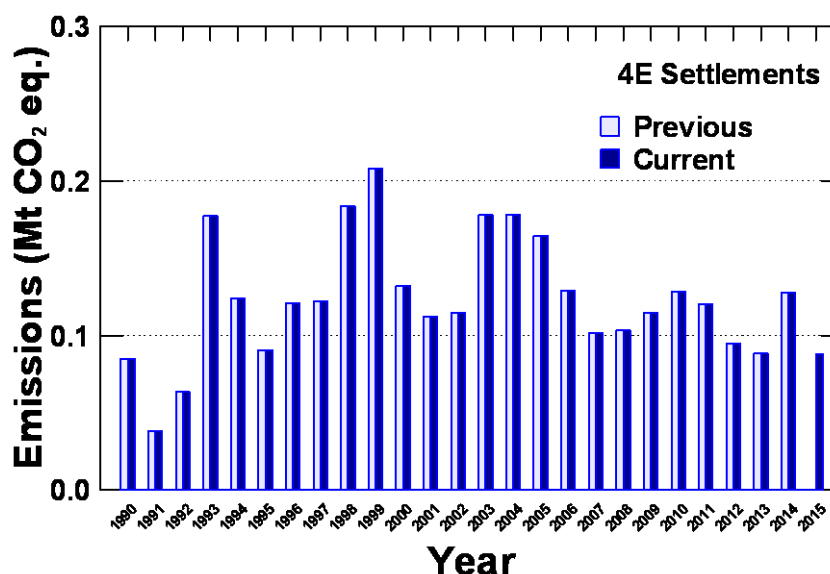


Fig. 6-19 Current and previously reported assessment of emissions for the category 4.E Settlements

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” (AALC), collected and administered by COSMC. It is part of the AALC “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<sub>2</sub> 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).

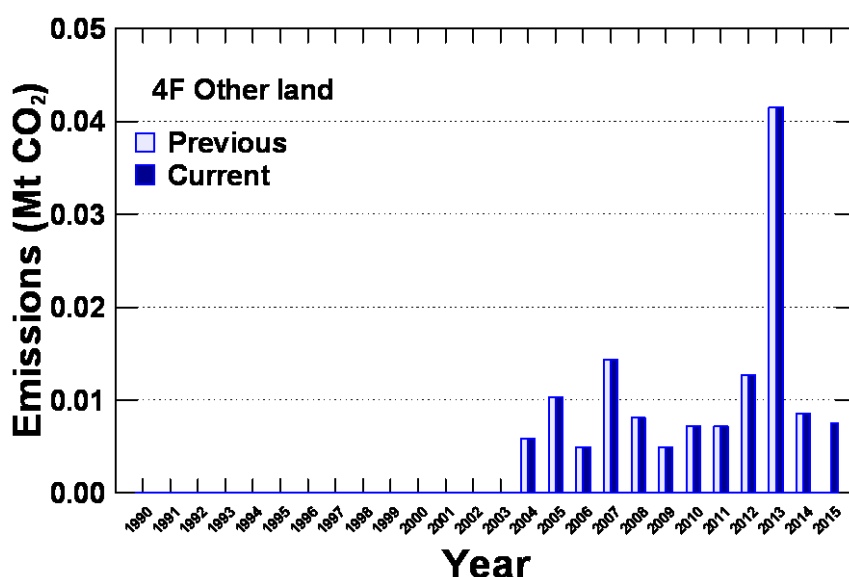


Fig. 6-20 Current and previously reported assessment of emissions for the category 4.F Other Land

### 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<sub>2</sub> 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

HWP category	Production		Import		Export	
	Country		Country		Country	
	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<sub>2</sub>/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).

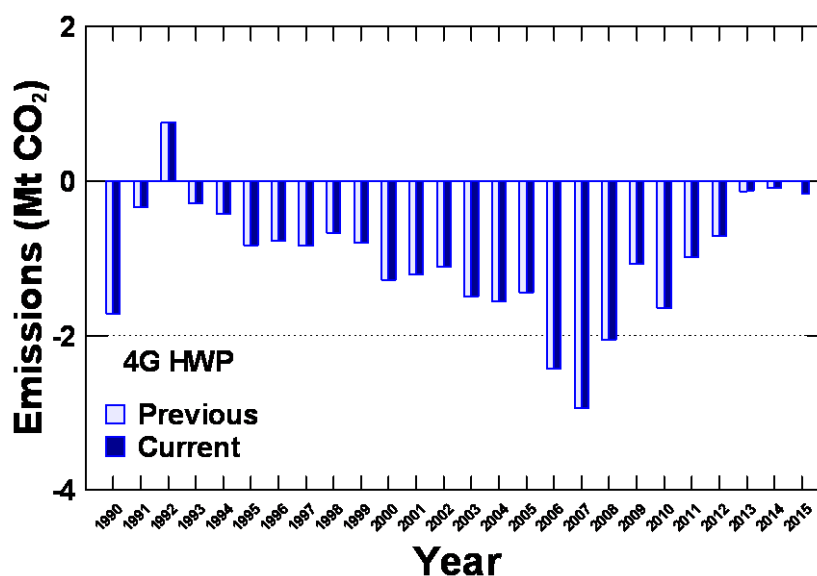


Fig. 6-21 The reported assessment of HWP contribution to emissions in the LULUCF sector for the category 4.G HWP

#### 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.

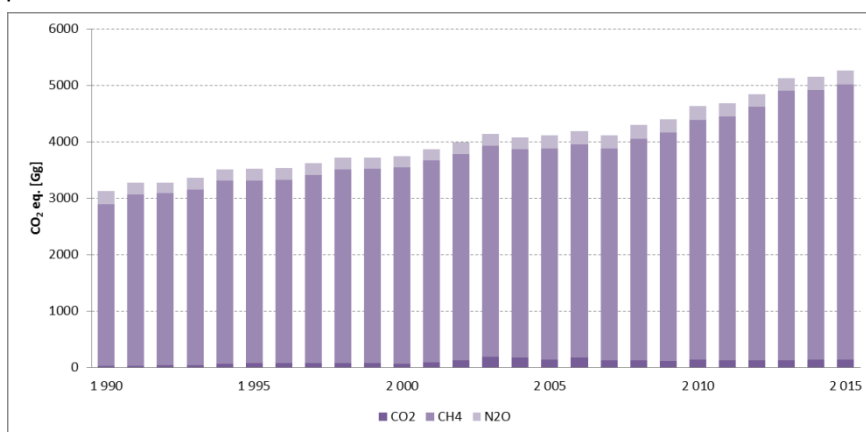


Fig. 7-1 Development of Waste sector by gasses, 1990-2015

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<sub>4</sub>, equalling 3385 Gg of CO<sub>2</sub> 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 <sub>4</sub>	LA, TA	LA, TA	yes	yes	yes	yes	2.65	2.79
5.B Biological treatment of solid waste	CH <sub>4</sub>	LA	TA	yes	no	yes	yes	0.50	0.52
5.D Wastewater treatment and discharge	CH <sub>4</sub>	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 ( $\text{CH}_4$ ). The decomposition of organic material, derived from biomass sources (e.g., crops, food, textile, wood), is the primary source of  $\text{CO}_2$ , released from waste. These  $\text{CO}_2$  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 ( $\text{N}_2\text{O}$ ), nitrogen oxides ( $\text{NO}_x$ ) and carbon monoxide ( $\text{CO}$ ). In line with the IPCC 2006 methodology, only  $\text{CH}_4$  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

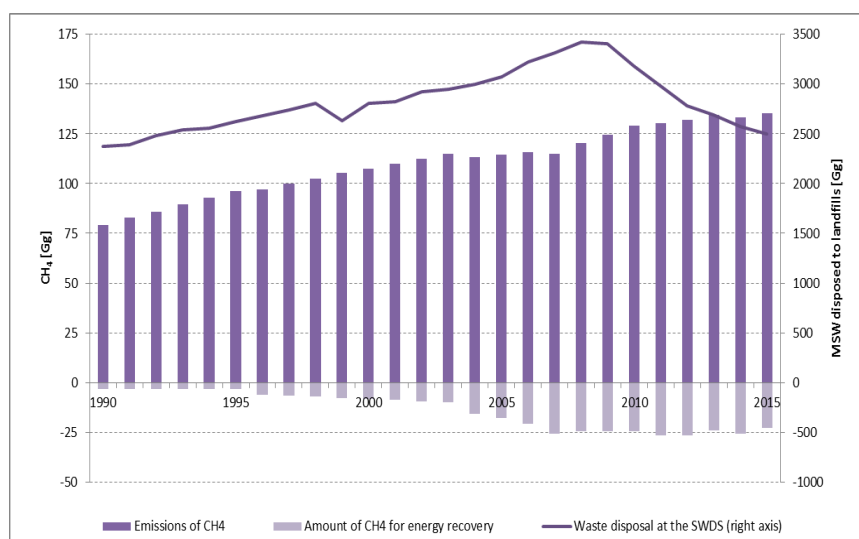


Fig. 7-2 Development of emissions from SWDS and total amount of waste disposed to SWDS, 1990-2015

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 interpolation 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.

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 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		

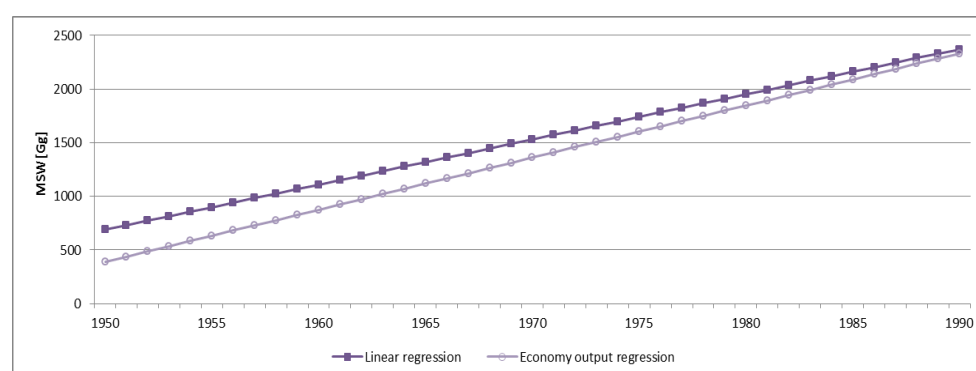


Fig. 7-3 MSW disposal in SWDS in the Czech Republic, 1950-1990

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 composition 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)
<b>k-rate</b>	0.06	0.185	0.06	0.03	
<b>DOC (default)</b>	0.4	0.15	0.24	0.43	
<b>Share of particular waste streams</b>					
<b>1990-1995</b>	0.22	0.30	0.05	0.08	0.176
<b>1996</b>	0.22	0.29	0.05	0.08	0.179
<b>1997</b>	0.23	0.28	0.06	0.08	0.181
<b>1998</b>	0.24	0.27	0.06	0.08	0.184
<b>1999</b>	0.25	0.26	0.07	0.08	0.187
<b>2000</b>	0.26	0.25	0.07	0.08	0.191
<b>2001</b>	0.27	0.23	0.08	0.08	0.195
<b>2002</b>	0.24	0.25	0.08	0.09	0.194
<b>2003</b>	0.22	0.27	0.07	0.11	0.193
<b>2004</b>	0.19	0.30	0.07	0.13	0.192
<b>2005</b>	0.16	0.32	0.07	0.14	0.191
<b>2006</b>	0.16	0.32	0.07	0.14	0.187
<b>2007</b>	0.17	0.32	0.08	0.13	0.193
<b>2008</b>	0.16	0.32	0.07	0.14	0.188
<b>2009-2015*</b>	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
<b>Unmanaged, shallow</b>	0.4
<b>Unmanaged, deep</b>	0.8
<b>Managed, anaerobic</b>	1.0
<b>Managed, semi-aerobic</b>	0.5
<b>Uncategorised</b>	0.6

**Tab. 7-5 MCF values employed, 1950-2015**

	MCF
<b>1950 – 1959</b>	0.6
<b>1960 – 1969</b>	0.6
<b>1970 – 1979</b>	0.8
<b>1980 – 1989</b>	0.9
<b>1990 – 2015</b>	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<sub>2</sub>. 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<sub>2</sub> and has biogenic origin is not considered to constitute a GHG emission and hence recovered methane (R) is subtracted 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<sub>4</sub> 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 <sub>4</sub> generation	CH <sub>4</sub> recovery	CH <sub>4</sub> oxidized	CH <sub>4</sub> 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 uncertainty 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 uncertainty [%]	EF uncertainty [%]	Origin of the parameters
CH <sub>4</sub>	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 distinguishable 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

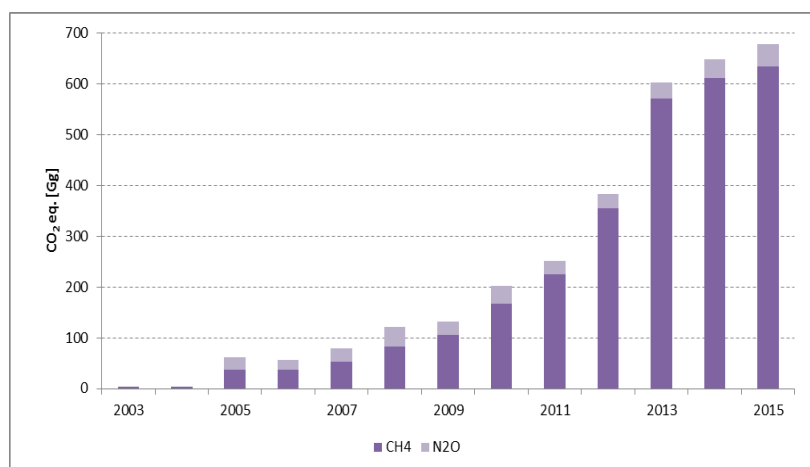


Fig. 7-4 Development of emissions from biological treatment of solid waste, 2003-2015

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.

### 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
<b>MSW [tons]</b>	48 760	61 475	79 801	114 437	134 601	144 136	181 914	153 500	202 832	303 110	373 985
<b>Other waste [tons]</b>	288 814	222 672	296 390	428 739	221 276	358 242	190 058	228 284	247 045	207 233	249 411
<b>Emission factor [kg CH<sub>4</sub>/ton]</b>	4										
<b>Emission factor [kg N<sub>2</sub>O/ton]</b>	0.24										
<b>Total Composting CH<sub>4</sub> [Gg]</b>	1.35	1.14	1.50	2.17	1.42	2.01	1.49	1.53	1.80	2.04	2.49
<b>Total Composting N<sub>2</sub>O [Gg]</b>	0.08	0.07	0.09	0.13	0.09	0.12	0.09	0.09	0.11	0.12	0.15
<b>Total composting GHG [Gg CO<sub>2</sub> eq.]</b>	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
Conversion [TJ/Gg]	50.009												
Activity data [Gg CH <sub>4</sub> ] - 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 <sub>4</sub> ]	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 uncertainty [%]	EF uncertainty [%]	Origin of the parameters
CH <sub>4</sub>	5.B.1 Composting	20	NA	AD Expert judgement M. Havránek; EF IPCC default, verification of AD Jiří Valta (CENIA)
N <sub>2</sub> O	5.B.1 Composting	20	NA	AD Expert judgement M. Havránek; EF IPCC default, verification of AD Jiří Valta (CENIA)
CH <sub>4</sub>	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<sub>4</sub>], 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O from these practices.

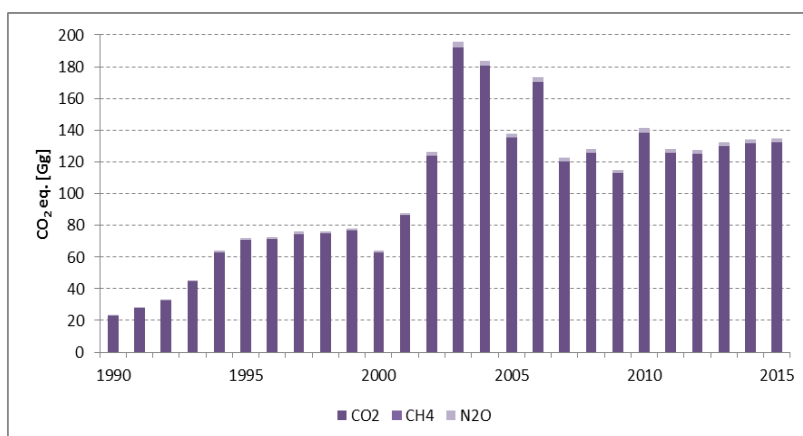


Fig. 7-5 Development of emissions from waste incineration, 1990-2015

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, that 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions are described as an information item and are not included in the national totals.

Estimation of CO<sub>2</sub> 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<sub>2</sub>. 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 <sub>2</sub> ratio	3.7									
Emission factor [Gg CH <sub>4</sub> /Gg]	5.6E-07									
Emission factor [Gg N <sub>2</sub> O/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 <sub>2</sub> [Gg CO <sub>2</sub> ] Fossil	23.1	70.7	63.0	135.2	138.6	125.8	125.2	130.1	131.7	132.4
Total CO <sub>2</sub> [Gg CO <sub>2</sub> ] Bio.	2.6	7.9	7.0	15.0	15.40	14.0	13.91	14.45	14.64	14.71
Total CH <sub>4</sub> [Gg CH <sub>4</sub> ]	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 <sub>2</sub> O [Gg N <sub>2</sub> O]	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<sub>2</sub>O per Gg of incinerated HW and 0.56 kg of methane per Gg of incinerated HW. The biogenic emissions of CO<sub>2</sub> 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 uncertainty [%]	EF uncertainty [%]	Origin of the parameters
CO <sub>2</sub>	5.C.1 Waste incineration	15	5	AD Expert judgement M. Havránek; EF IPCC default
N <sub>2</sub> O	5.C.1 Waste incineration	20	70	AD Expert judgement M. Havránek; EF IPCC default
CH <sub>4</sub>	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)

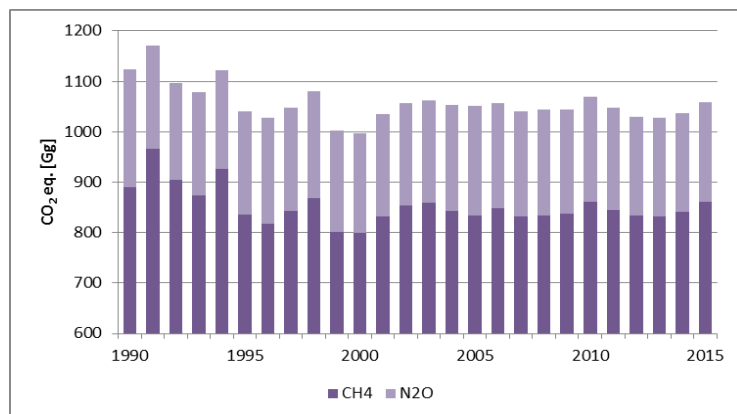


Fig. 7-6 Development of emissions from wastewater treatment and discharge, 1990-2015

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.

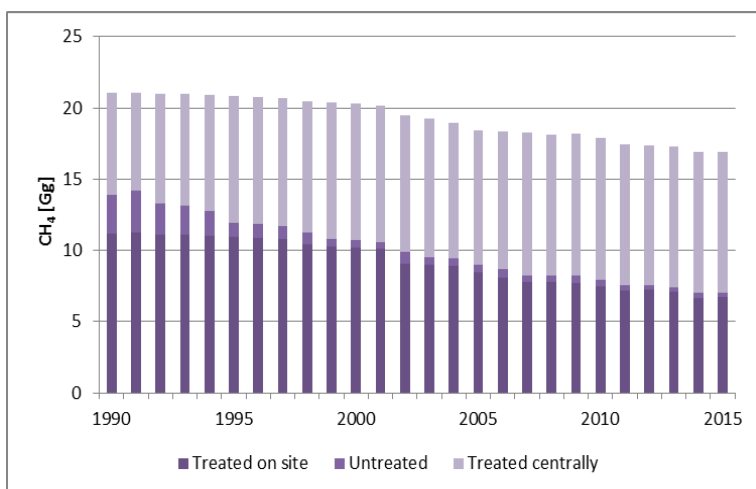


Fig. 7-7 Development of 5.D.1 emission of CH<sub>4</sub> by types of treatment

Wastewater treatment plants treat about 97% of all the collected water. Anaerobic technology is being increasingly used to produce biogas from sludge.

This category was recalculated 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<sub>5</sub> (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 biogas production from sludge treatment are used to reduce TOW (total organic waste). Outline of TOW flow is given in the following figure (Fig. 7-8).

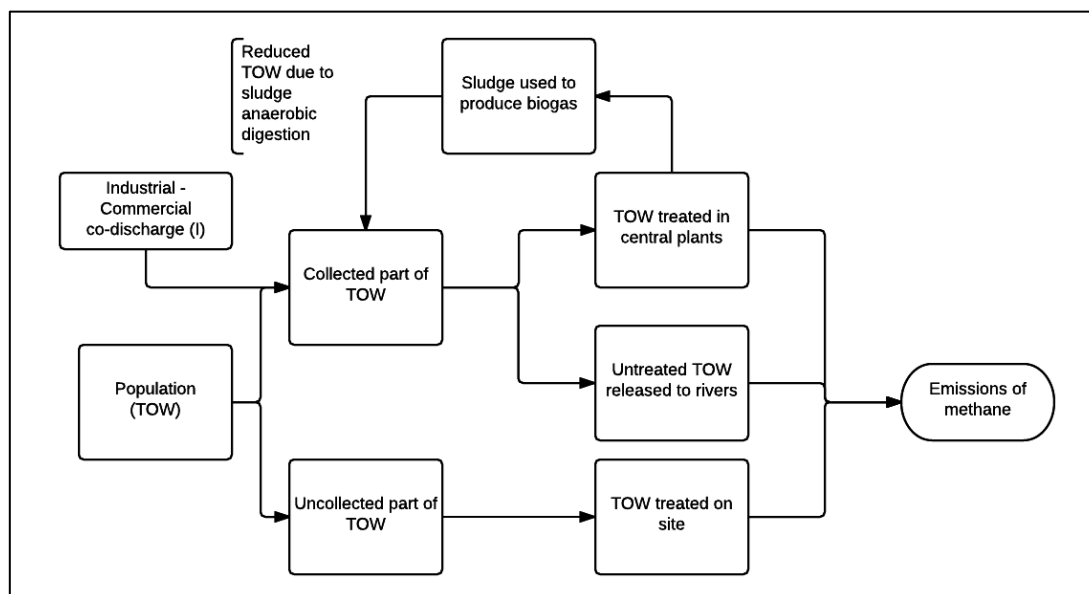


Fig. 7-8 Outline of total organic waste flow in 5D1

The basic activity data (and their sources) for determining emissions from this subcategory are as follows, tabular 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 GI 2006 resulting in methane emissions.
- Collected TOW is multiplied by the default co-discharge correction factor.
- Biogas produced by wastewater treatment plants is converted to the TOW required to produce this biogas and is subtracted 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 <sub>4</sub> /kg BOD]	TOW [g BOD/person/year]	Correction factor for industrial co- discharge	NCV of CH <sub>4</sub> [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 <sub>4</sub> ]	Untreated TOW emissions [Gg of CH <sub>4</sub> ]	Treated TOW emissions [Gg of CH <sub>4</sub> ]	Biogas reduction (fraction of treated TOW)	Total emissions [Gg of CH <sub>4</sub> ]
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<sub>2</sub>O 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<sub>2</sub>O [Gg] from 5.D.1 and 5.D.2, 1990-2015, Czech Republic**

	Proteins [g/capita/day <sup>8</sup> ]	Population [number, thous. pers.]	F <sub>npr</sub> [kg N/kg protein]	F <sub>nnon-noc</sub>	F <sub>ind-com</sub>	Nefluent [kg N/yr]	EF [kg N <sub>2</sub> O/kg N]	Emissions [Gg N <sub>2</sub> O]
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 F<sub>nnon-con</sub> 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<sub>2</sub>O is also not robust and varies significantly.

<sup>8</sup> The latest available data is used for 2014 and 2015; data for Czechoslovakia are used for 1990-1992.

Tab. 7-18 Uncertainty estimates for 5.D.1 category

Gas	Category	AD uncertainty [%]	EF uncertainty [%]	Origin of the parameters
CH <sub>4</sub>	5.D.1 Domestic wastewater	21	50	Combined uncertainty of quantification parameters Expert judgement M. Havránek
N <sub>2</sub> O	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<sub>4</sub>, N<sub>2</sub>O eq., 1990-2014

CH <sub>4</sub>	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 <sub>4</sub>	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 <sub>2</sub> O	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 <sub>2</sub> O	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 uncertainty range in a similar way as in category 5D2 using the upper and lower margins of the estimates to estimate the uncertainty 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

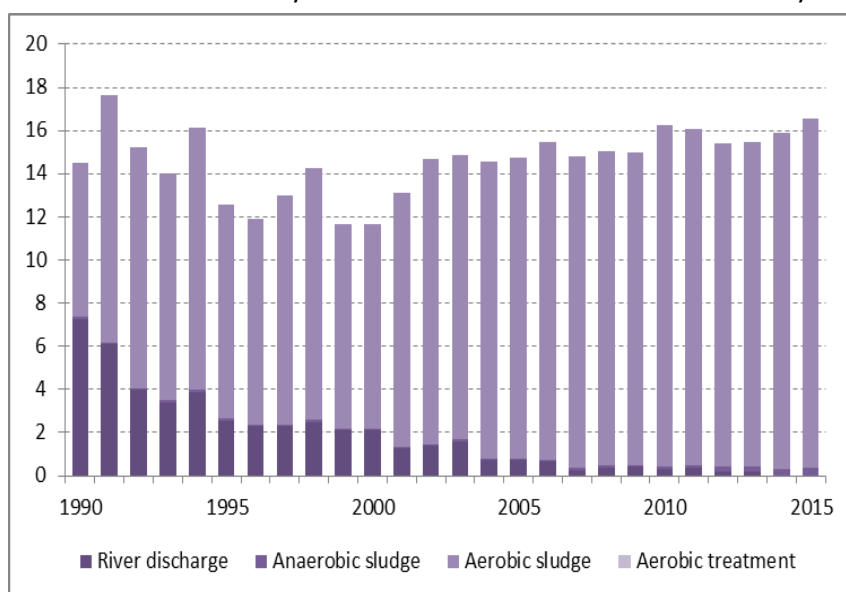


Fig. 7-9 Development of 5.D.2 by types of emission sources

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.

### 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<sup>3</sup>). 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.

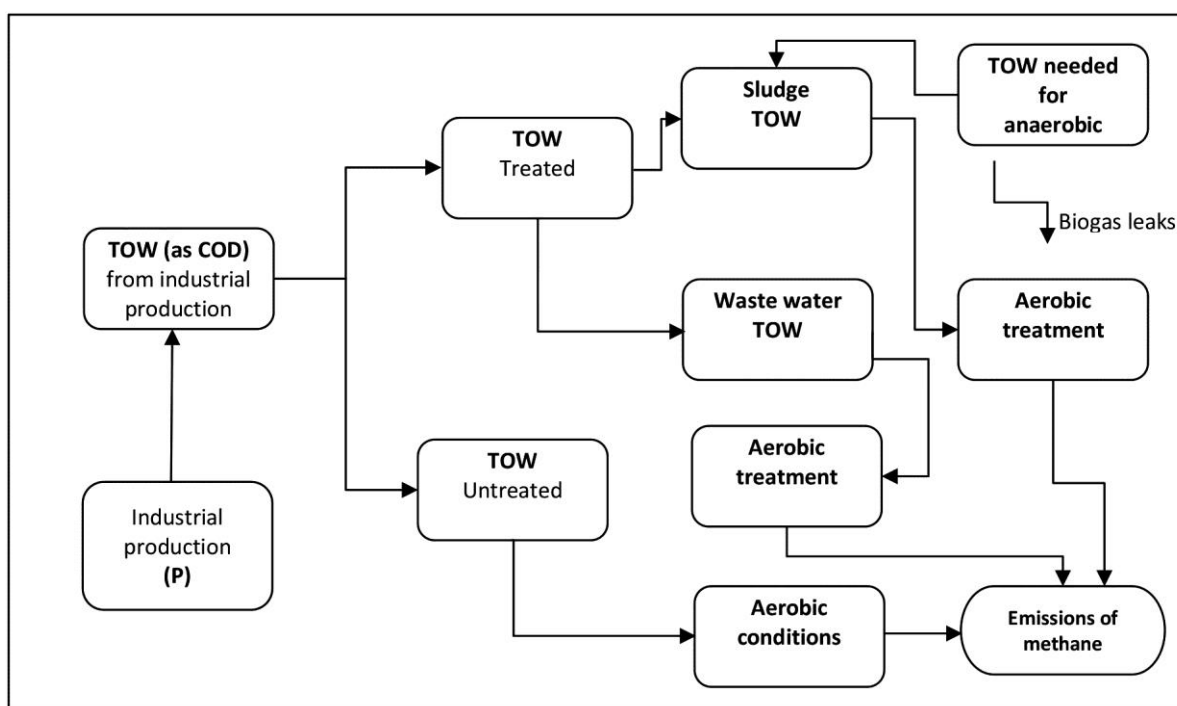


Fig. 7-10 Outline of total organic waste flow in 5.D.2

**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
<b>COD suggested [kg/m3]</b>	11	2.7	2.9	4.1	3	1	3.7	9	0.9	10	3.2	0.9	5	1.5
<b>Wastewater [m3/ton of product]</b>	24	7	6.3	13	67	0.6	0.6	162	3	9	11	3.1	20	23
<b>Industrial production [mil. tonnes]</b>														
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 Záborská (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<sub>4</sub> [Gg] from 5.D.2, 1990-2015, Czech Republic**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CH <sub>4</sub> 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 <sub>4</sub>	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 <sub>4</sub> 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 <sub>4</sub>	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 uncertainty 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 applicable) 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 uncertainty 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 uncertainty range.

**Tab. 7-23 Uncertainty estimates for 5.D.2 category**

Gas	Category	AD uncertainty [%]	EF uncertainty [%]	Origin of the parameters
CH <sub>4</sub>	5.D.2 Industrial wastewater	40	50	Combined uncertainty of quantification parameters + IPCC Default values, Expert judgement M. Havránek

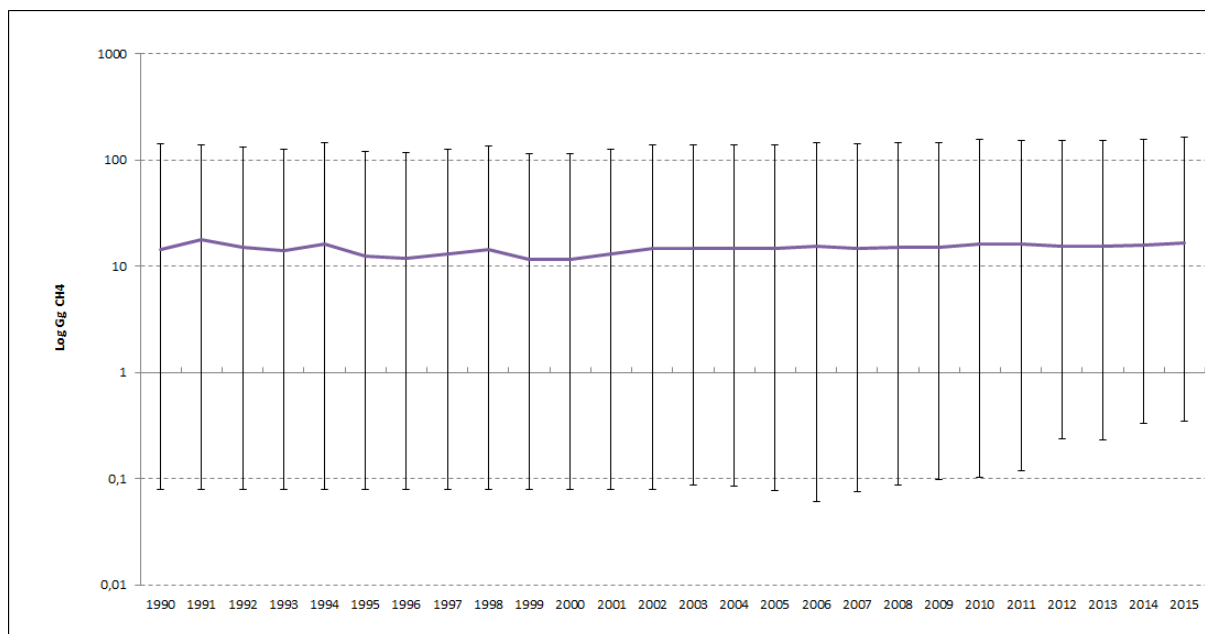


Fig. 7-11 Maximum uncertainty range for 5.D.2 (log scale), 1990-2015

#### 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.

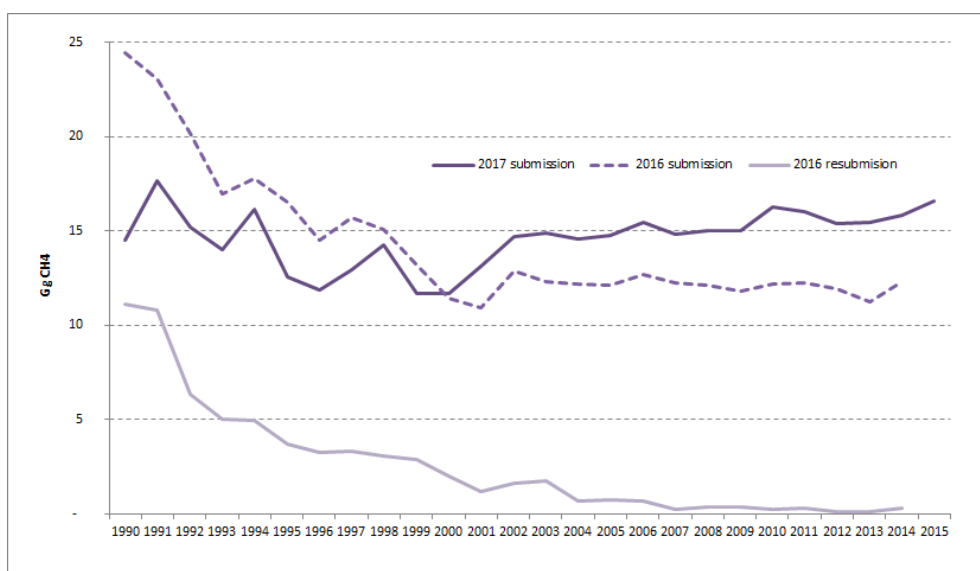


Fig. 7-12 Recalculation for 5.D.2, 1990-2015

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	2015
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<sub>2</sub> and nitrous oxide emissions

### 9.1 Description of sources of indirect emissions in GHG inventory

The estimation of indirect CO<sub>2</sub> and N<sub>2</sub>O emissions is based on the official Czech inventories for the precursor gases (CO, NMVOC, NH<sub>3</sub> and NO<sub>x</sub>) reported under the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the CH<sub>4</sub> 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<sub>x</sub> 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<sub>x</sub> by 72.31%. SO<sub>x</sub> (reported as SO<sub>2</sub>) emissions decreased by 93.41% compared to 1990 level. NH<sub>3</sub> 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 <sub>x</sub>	NO <sub>x</sub> w/o LULUCF	CO	CO w/o LULUCF	NMVOC	SO <sub>x</sub>	NH <sub>3</sub>
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

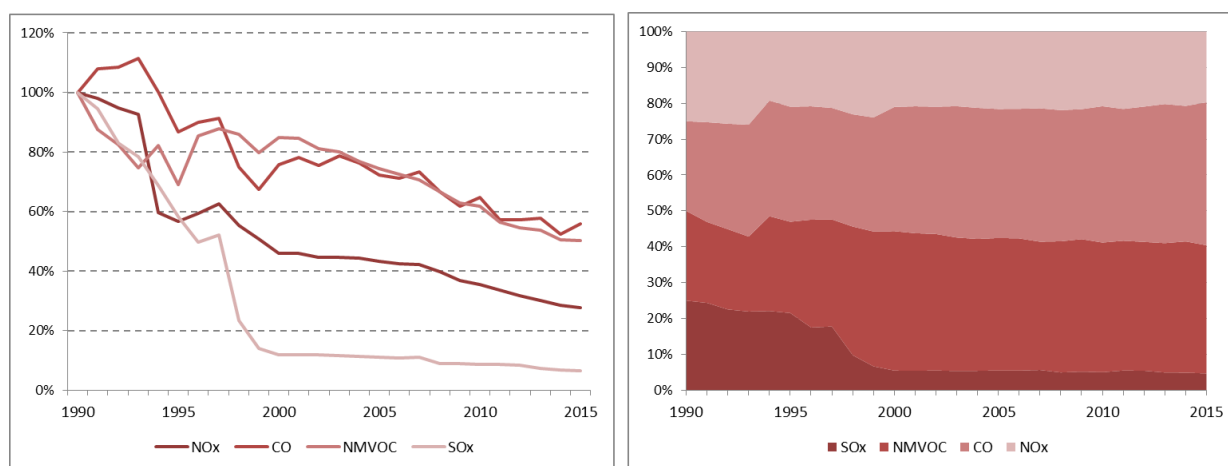


Fig. 9-1 Indexed emissions of precursor gases for 1990-2015 (1990 =100%), [%] (left); Overall trend in percentual share of precursor gases (right)

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<sub>x</sub> 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

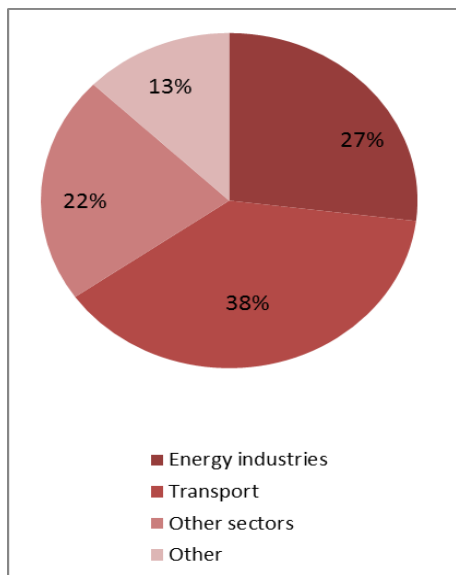
Transport, 1.A.4 Other sectors; for NMVOC are 1.A.3 Transport, 1.A.4 Other sectors and 2.D Non-energy products from fuels and solvent use; for SO<sub>x</sub> are 1.A.1 Energy industries, 1.A.2 Manufacturing industries and construction and 1.A.4 Other sectors. Total production from the main CRF categories can be seen on Tab. 9-2.

Tab. 9-2 Precursor GHG emissions in sectors of origin for 2015

	NO <sub>x</sub> [Gg]	CO [Gg]	NMVOC [Gg]	SO <sub>x</sub> [Gg]	NH <sub>3</sub> [Gg]
<b>Total emissions</b>	<b>204.47</b>	<b>598.07</b>	<b>150.92</b>	<b>123.29</b>	<b>4.52</b>
<b>1. Energy</b>	200.79	532.48	76.64	121.86	4.37
<b>1A Fuel combustion</b>	200.68	532.36	68.10	119.72	4.37
<b>1A1 Energy Industries</b>	55.09	10.12	5.19	78.55	0.01
<b>1A2 Manufacturing industries and construction</b>	22.22	108.58	1.57	19.30	0.15
<b>1A3 Transport</b>	78.33	132.70	31.72	0.27	4.20
<b>1A4 Other sectors</b>	44.84	280.81	29.61	21.60	0.01
<b>1A5 Other</b>	IE	IE	IE	IE	IE
<b>1B Fugitive emissions from fuels</b>	0.12	0.12	8.54	2.13	0.00
<b>2. Industrial processes and product use</b>	2.73	36.90	72.68	1.42	0.14
<b>2A Mineral industry</b>	0.23	0.01	0.08	0.09	0.04
<b>2B Chemical industry</b>	1.26	0.15	1.62	0.85	0.08
<b>2C Metal industry</b>	1.16	36.63	0.23	0.46	0.00
<b>2D Non-energy products from fuels and solvent use</b>	0.00	0.00	70.51	0.00	0.00
<b>2G Other product manufacture and use</b>	0.07	0.10	0.25	0.03	0.02
<b>3. Agriculture</b>	-	-	-	-	-
<b>4. LULUCF</b>	0.81	28.67	-	-	-
<b>5.Waste</b>	0.13	0.02	1.59	0.01	0.00

## 9.2 Production of indirect emissions from precursor gases

### 9.2.1 Indirect N<sub>2</sub>O emissions from nitrogen oxides



Emissions of NO<sub>x</sub> 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<sub>x</sub> emissions decreased from 739 to 204 kt during the period 1990 - 2015. In 2015, NO<sub>x</sub> emissions were 72.31% below the 1990 level. Slightly more than 98% of total NO<sub>x</sub> 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<sub>2</sub>O emissions correspondingly decreased from 3.53 to 0.97 kt in 2015.

Fig. 9-2 The share of sectors on NO<sub>x</sub> emissions in 2015

### 9.2.2 Indirect N<sub>2</sub>O from ammonia

Emissions of anthropogenic NH<sub>3</sub> 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<sub>3</sub> were 4.52 kt. The declining trend of the emissions is calculated based on the latest research of NH<sub>3</sub> emissions in the period between 1990 and 2000.

Total indirect N<sub>2</sub>O emissions from NH<sub>3</sub> for 2015 are 0.06 kt.

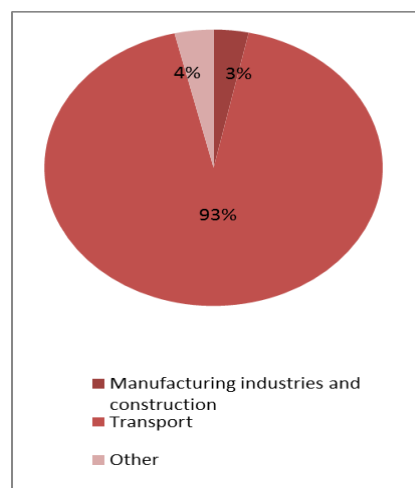


Fig. 9-3 The share of sectors on NH<sub>3</sub> emissions in 2015

### 9.2.3 Indirect CO<sub>2</sub> 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<sub>2</sub> emissions from CO in 2015 are 58.2 kt, which is 83.3% less than 1990.

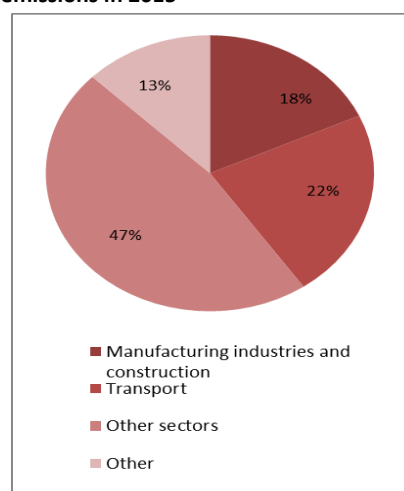


Fig. 9-4 The share of sectors on CO emissions in 2015

### 9.2.4 Indirect CO<sub>2</sub> 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.

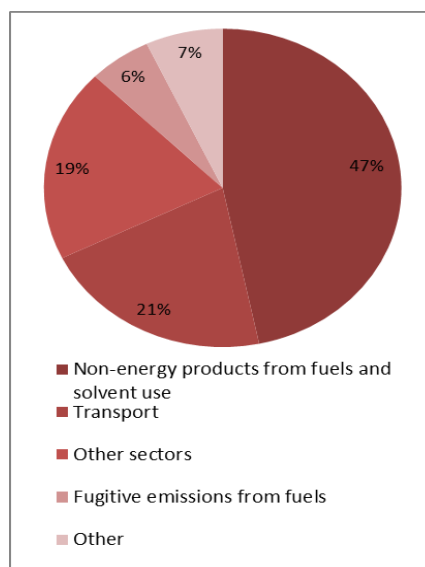


Fig. 9-5 The share of sectors on NMVOC emissions in 2015

### 9.2.5 Indirect CO<sub>2</sub> from methane

CH<sub>4</sub> emissions, used for the calculation of indirect emissions are mainly produced from categories 1.B.1 Solid fuels. For more information on CH<sub>4</sub> emissions, consult respective chapters. Total indirect CO<sub>2</sub> emissions from CH<sub>4</sub> produced in 2015 are 561.5 kt, which is 65.4% less than in 1990.

## 9.3 Production of indirect CO<sub>2</sub> and N<sub>2</sub>O emissions from source categories

Estimations of indirect CO<sub>2</sub> and N<sub>2</sub>O 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 <sub>2</sub> [kt]	N <sub>2</sub> O [kt]	CO <sub>2</sub> [kt]	N <sub>2</sub> O [kt]	CO <sub>2</sub> [kt]	N <sub>2</sub> O [kt]	CO <sub>2</sub> [kt]	N <sub>2</sub> O [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<sub>2</sub> and N<sub>2</sub>O between the examined sectors.

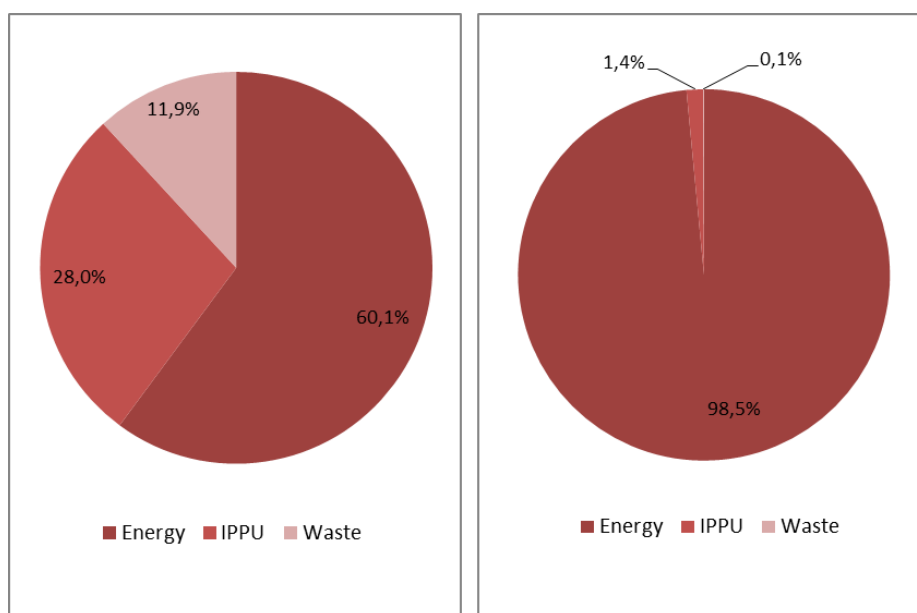


Fig. 9-6 Division of indirect emission of CO<sub>2</sub> (left) and N<sub>2</sub>O (right) between the producing sectors for 2015 (in %)

Energy sector covers 60.1% of the total production of indirect CO<sub>2</sub> and 98.5% of the total production of indirect N<sub>2</sub>O. 99.9% of the N<sub>2</sub>O 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>O 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<sub>2</sub> is 28.0% and concerning indirect N<sub>2</sub>O is 1.4%.

Sector Waste represents 11.9% from the total indirect CO<sub>2</sub> emissions and 0.06% from total N<sub>2</sub>O emissions. Almost 100% from the Waste production of indirect CO<sub>2</sub> emissions are emitted from category 5.D Wastewater treatment and discharge and 97.7% from the indirect production of N<sub>2</sub>O 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<sub>2</sub> emissions

Indirect emissions of CO<sub>2</sub> were calculated using the default IPCC Tier 1 method. The following equations were used for calculating the indirect emissions, respectively from CO, CH<sub>4</sub> and NMVOC.

$$Emissions_{CO_2} = Emissions_{CO} \cdot \frac{44}{28}$$

$$Emissions_{CO_2} = Emissions_{CH_4} \cdot \frac{44}{16}$$

$$Emissions_{CO_2} = Emissions_{NMVOC} \cdot \text{Percent carbon in NMVOC by mass} \cdot \frac{44}{12}$$

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<sub>2</sub>O emissions

The indirect N<sub>2</sub>O 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<sub>2</sub>O. The calculation method is the IPCC default Tier 1. Indirect N<sub>2</sub>O 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<sub>2</sub> and N<sub>2</sub>O 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<sub>2</sub> eq. reported in previous and current submissions can be observed on Fig. 9-7.

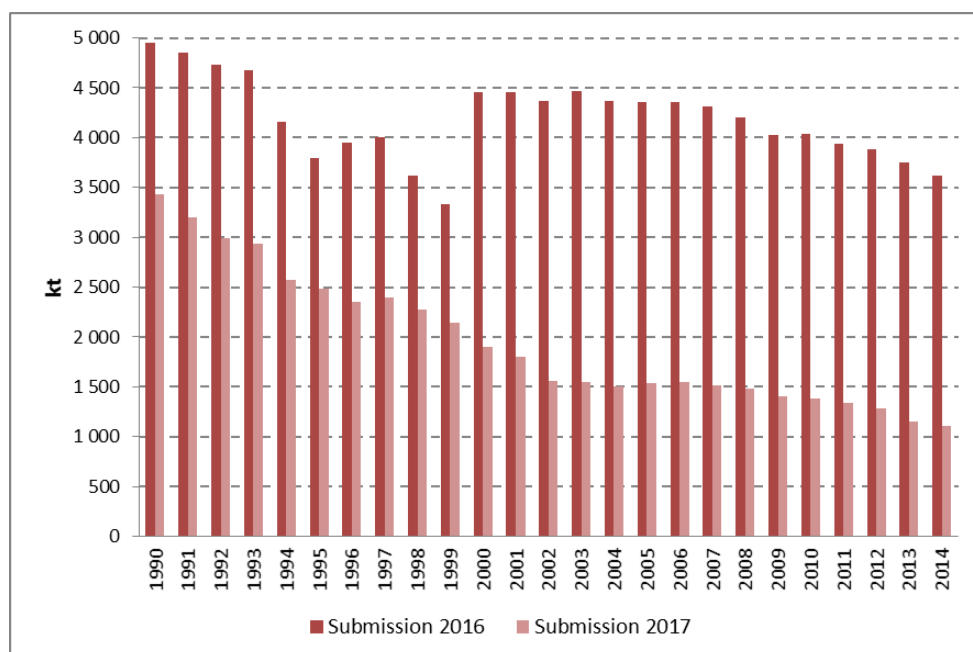


Fig. 9-7 Comparison of total indirect emissions in CO<sub>2</sub> eq. between previous and current submissions

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<sub>3</sub> emissions for the whole period. In the previous submission only data for NH<sub>3</sub>

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
<b>Submission 2016</b> [kt CO <sub>2</sub> eq.]	4952	4856	4728	4674	4157	3800	3953	4006	3621	3336	4451	4459	4369
<b>Submission 2017</b> [kt CO <sub>2</sub> eq.]	3427	3197	2994	2941	2574	2483	2350	2401	2273	2139	1904	1805	1556
<b>Decrease</b>	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	
<b>Submission 2016</b> [kt CO <sub>2</sub> eq.]	4467	4364	4358	4352	4314	4200	4031	4038	3938	3887	3756	3604	
<b>Submission 2017</b> [kt CO <sub>2</sub> eq.]	1547	1505	1539	1544	1520	1481	1410	1385	1334	1288	1155	1107	
<b>Decrease</b>	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<sub>2</sub> 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<sub>2</sub>O 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<sub>4</sub> and N<sub>2</sub>O 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions.

#### ***10.1.1.11 Recalculation in sector Other – Glass Production (2.A.7.1)***

For 2005 was found the error in reported CO<sub>2</sub> 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<sup>st</sup> 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<sub>2</sub> 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O emissions for the entire time series and

- 3) Potatoes and sugarbeet crops produced in the country were included in the estimations of N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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](http://www.zf.jcu.cz)), were used.

The equation used to estimate direct N<sub>2</sub>O emissions from Agricultural soils (N-fixing crops) has form

$$\text{FBN} = \text{Crop} * \text{FracDM} * \text{FracNCRBF}.$$

##### **Category 4.D.1.4**

N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O. 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emission factors***

In the current submission are used newly determined country specific emission factors for CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> and N<sub>2</sub>O emissions didn't significantly change. CH<sub>4</sub> 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<sub>2</sub>O 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<sub>4</sub> 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<sub>2</sub> 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<sub>2</sub>O Emissions from managed soils
- 3.C.5 Indirect N<sub>2</sub>O Emissions from managed soils
- 3.C.6 Indirect N<sub>2</sub>O 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<sub>2</sub>O 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<sub>4</sub> and N<sub>2</sub>O. 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<sub>4</sub> and N<sub>2</sub>O 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<sub>4</sub> and N<sub>2</sub>O 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<sub>4</sub> and N<sub>2</sub>O (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<sub>2</sub>O 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<sub>6</sub> and NF<sub>3</sub> 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<sub>4</sub> 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<sub>4</sub> for manure management for pigs recalculated the CH<sub>4</sub> 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<sub>4</sub> 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<sub>2</sub>O 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<sub>2</sub>O 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 N<sub>2</sub>O emissions

Updated estimates of Indirect emissions from atmospheric deposition of N volatilized 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<sub>2</sub>O and CH<sub>4</sub>.

##### ***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 N<sub>2</sub>O, 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<sub>2</sub>O. Czech Republic accepted proposed change and submitted updated values using default emission factor from IPCC 2006 Gls. 1.5 kg/TJ for N<sub>2</sub>O 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 in 1.A.1.a - Public Electricity and Heat Production for CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O. Default emission factors from IPCC 2006 Gls. were used in response, i.e. 30 kg/TJ for CH<sub>4</sub>, 91.7 t/TJ for CO<sub>2</sub> and 4 kg/TJ for N<sub>2</sub>O.



#### 10.1.4.1.3 Update of emission factor for N<sub>2</sub>O, 1.A.1.b - Petroleum Refining, Liquid fuels

During UNFCCC review was identified incorrect emission factor for N<sub>2</sub>O 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<sub>4</sub>, N<sub>2</sub>O, 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<sub>4</sub> and N<sub>2</sub>O. Default emission factors from IPCC 2006 Gls. were used in response, i.e. 30 kg/TJ for CH<sub>4</sub> and 4 kg/TJ for N<sub>2</sub>O.

#### 10.1.4.1.5 Update of emission factor for N<sub>2</sub>O, 1.A.3.b Road transport

In response to the EU ESD review held in June 2016 were changed emission factor for N<sub>2</sub>O 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 activity data

Due to updated activity data obtained from CzSO concerning LPG consumption in 1.A.3.b.i. Cars , the recalculation occurred.

#### 10.1.4.1.8 Update of emission factors for CH<sub>4</sub>, 1.B.1.A.1.ii – Underground mines, Post-Mining Activities

During UNFCCC review was identified incorrect emission factor for CH<sub>4</sub> 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<sub>4</sub>, 1.B.1.A.2.i – Surface mines, Mining Activities

During UNFCCC review was identified incorrect emission factor for CH<sub>4</sub> in 1.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 CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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 some 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>6</sub>. 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<sub>6</sub> 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<sub>2</sub>O 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<sub>LeachMS</sub> 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<sub>GasMS</sub> and Frac<sub>LossMS</sub>) of N loss from MMS were updated to coordinate reporting for N<sub>2</sub>O emissions from Manure Management and N<sub>2</sub>O emissions from managed soils.

##### 10.1.4.3.2 N<sub>2</sub>O emissions from managed soils (3.D)

According to ERT recommendation the Frac<sub>REMOVE</sub> 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<sub>3</sub> and NO<sub>x</sub>, 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<sub>SOM</sub>) 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 Harvested 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 stock changes in the harvested 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 <sub>2</sub>	Gg	3917.38	2233.05
	N <sub>2</sub> O	Gg	3.53	4.68
Submission 2017	CO <sub>2</sub>	Gg	2291.50	829.94
	N <sub>2</sub> O	Gg	57.65	4.68
Difference	CO <sub>2</sub>	%	-41.50	-62.85
	N <sub>2</sub> O	%	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<sub>3</sub> 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 <sub>2</sub> -eq, kt)	Latest submission (CO <sub>2</sub> -eq, kt)	Difference (CO <sub>2</sub> -eq, kt)	Difference %	Impact of recalculation on total emissions excl. LULUCF%	Impact of recalculation on total emissions incl. LULUCF %
<b>Total National Emissions and Removals</b>	112923.93	114707.90	1783.97	1.58%	1.46%	2%
<b>1. Energy</b>	95026.02	96618.86	1592.83	1.68%	1.30%	1%
<b>A. Fuel combustion activities</b>	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>B. Fugitive Emissions from Fuels</b>	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%
<b>C. CO<sub>2</sub> transport and storage</b>	NO	NO	NA	NA	NA	NA
<b>2. Industrial processes and product use</b>	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
<b>3. Agriculture</b>	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
<b>4. Land use, land-use change and forestry (net)</b>	-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
<b>5. Waste</b>	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 <sub>2</sub> emissions from biomass	13247.69	15726.25	2478.56	18.71%	2.02%	2%
CO <sub>2</sub> 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 <sub>2</sub> O	1395.60	1395.61	0.00	0.00%	0.00%	0%
Indirect CO <sub>2</sub>	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<sub>2</sub>

The influence of the recalculations for the emission trend of CO<sub>2</sub> are illustrated on Fig. 10-1. Both curves are following the same pattern. The CO<sub>2</sub> emissions are higher on average by 0.12%, through the whole time period.

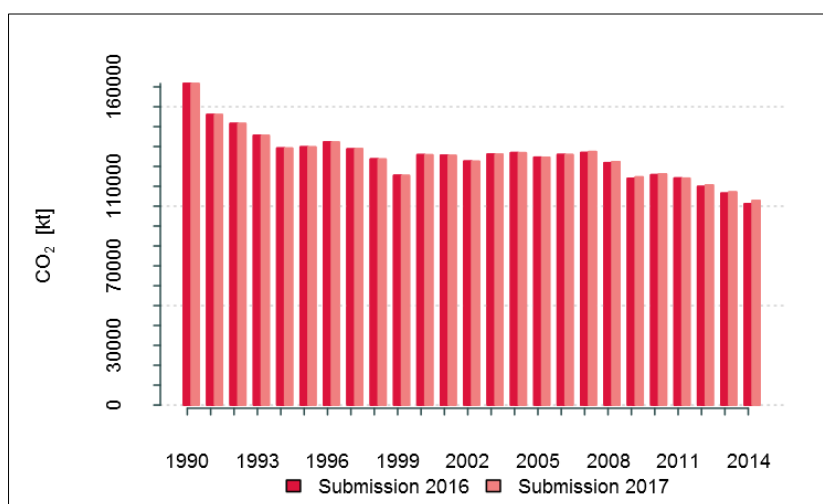


Fig. 10-1 Difference in trends of CO<sub>2</sub> emissions in index form, between the submissions 2016 and 2017, due to recalculations (1990 = 100%)

### 10.3.2 Implications for emission trend and time-series consistency of CH<sub>4</sub>

The influence of the recalculations for the emission trend of CH<sub>4</sub> are illustrated on Fig. 10-2. Both curves are following the same pattern. The CH<sub>4</sub> emission trend is higher on average by 0.37%, through the whole time period.



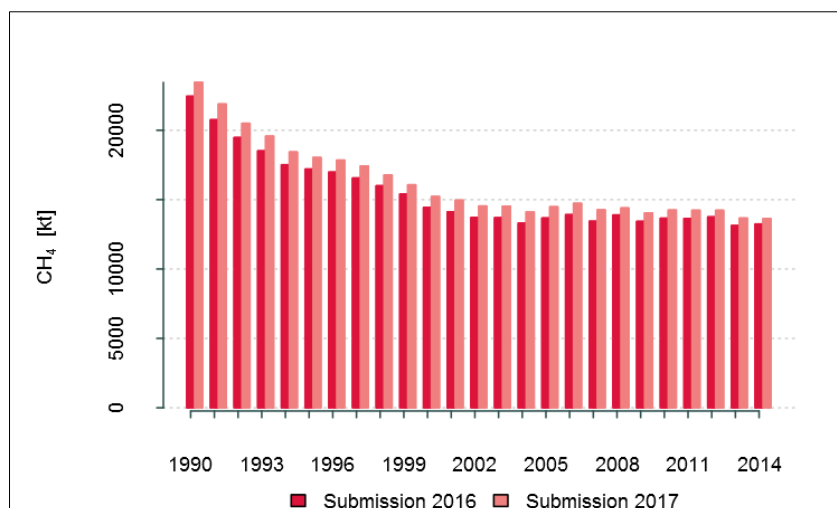


Fig. 10-2 Difference in trends of CH<sub>4</sub> emissions in index form, between the submissions 2016 and 2017, due to recalculations (1990 = 100%)

### 10.3.3 Implications for emission trend and time-series consistency of N<sub>2</sub>O

The influence of the recalculations for the emission trend of N<sub>2</sub>O are illustrated on Fig. 10-3. Both curves are following the same pattern. The N<sub>2</sub>O emission trend is lower on average 1.2%, through the whole time period.

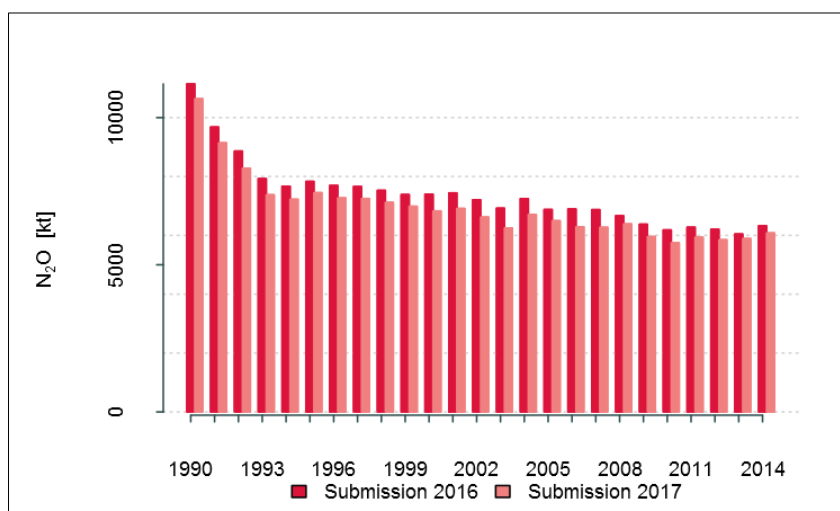


Fig. 10-3 Difference in trends of N<sub>2</sub>O emissions in index form, between the submissions 2016 and 2017, due to recalculations (1990 = 100%)

### 10.3.4 Implications for emission trends and time-series consistency of F-gases and SF<sub>6</sub>

The influence of the recalculations for the emission trend of HFCs are illustrated on Fig. 10-4. Both curves are following the same pattern.

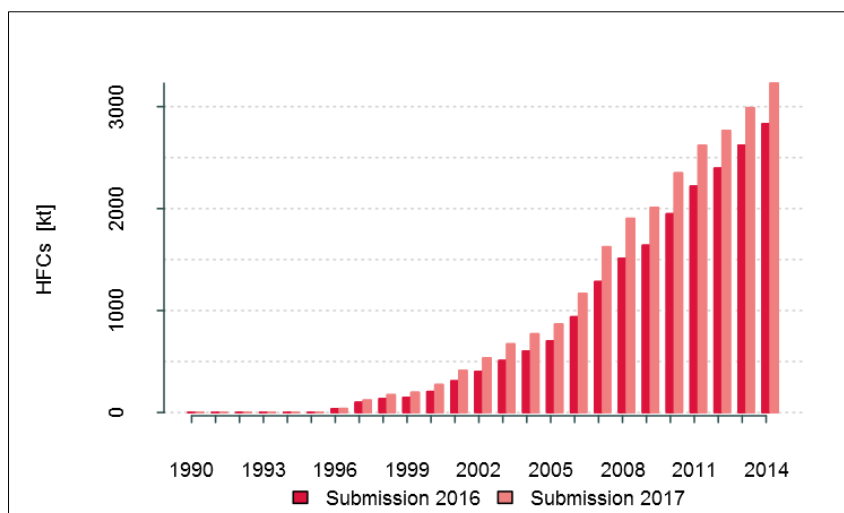


Fig. 10-4 Difference in trends of HFCs emissions in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)

The influence of the recalculations for the emission trend of PFCs are illustrated on Fig. 10-5. Both curves are following the same pattern.

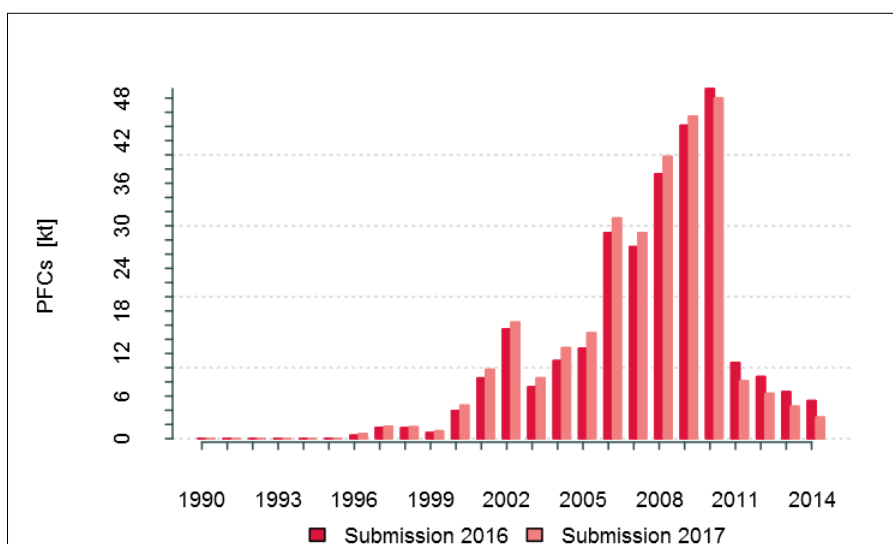


Fig. 10-5 Difference in trends of PFCs emissions in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)

The influence of the recalculations for the emission trend of SF<sub>6</sub> are illustrated on Fig. 10-6. Both curves are following the same pattern.

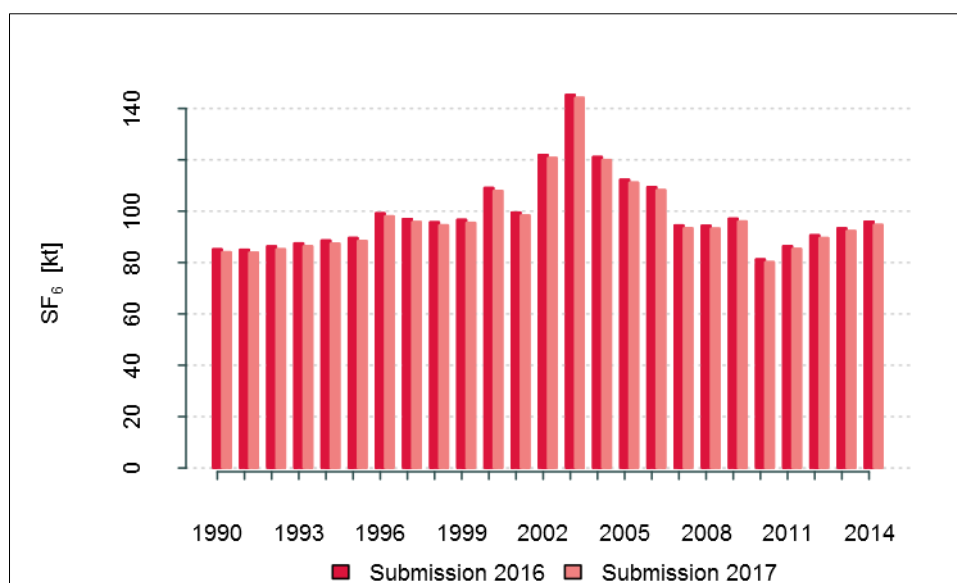


Fig. 10-6 Difference in trends of SF<sub>6</sub> emissions in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)

### 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.

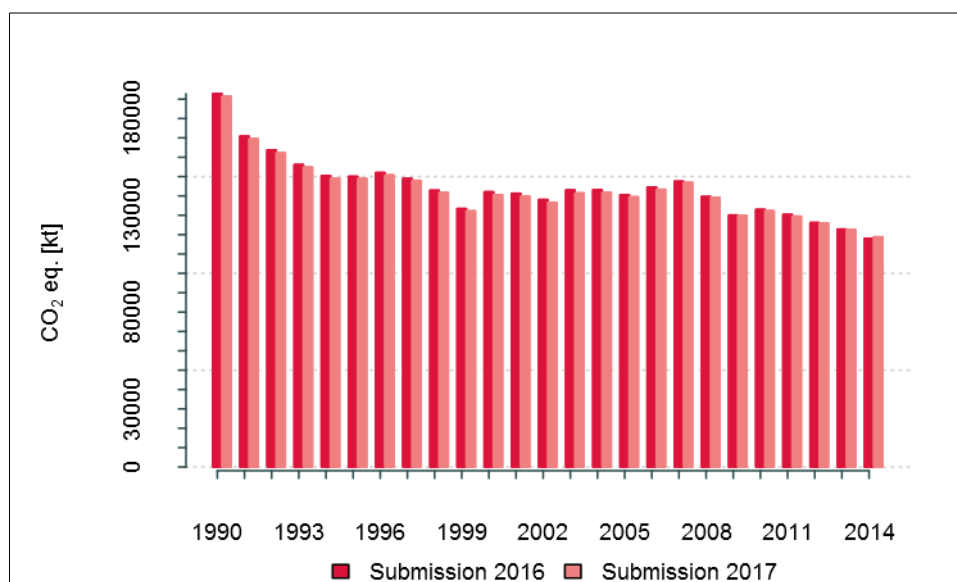


Fig. 10-7 Difference in trends of total emissions including LULUCF in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)

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.

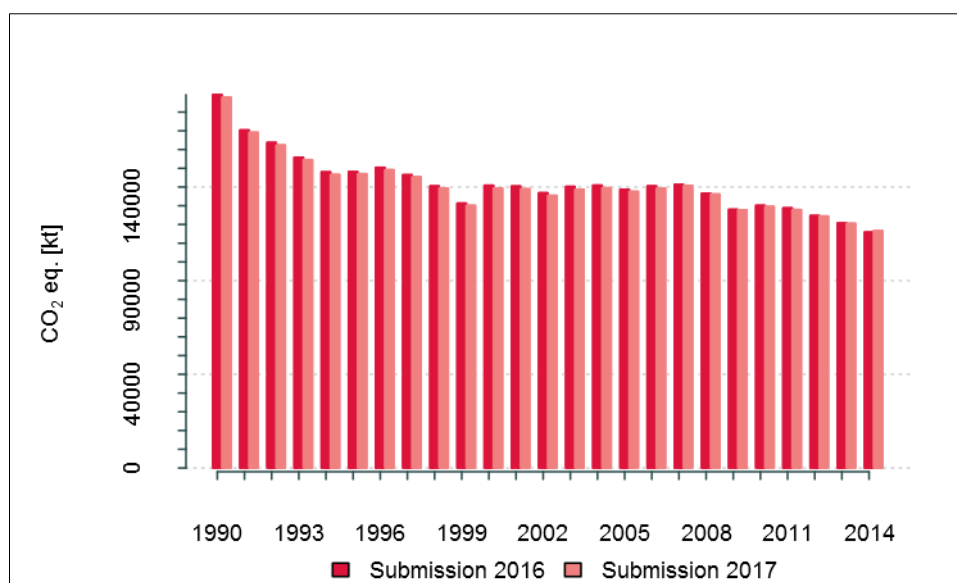


Fig. 10-8 Difference in trends of total emissions excluding LULUCF in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)

## 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<sub>4</sub> emissions from oil production, while CO<sub>2</sub> emissions and emissions of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub> emissions from 1.A Stationary Combustion
- 4) CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions from 1.A.3.a Civil Aviation
- 5) CH<sub>4</sub> and N<sub>2</sub>O emissions from 1.A.4.b Residential
- 6) CH<sub>4</sub> emissions from 1.B.1.b Solid Fuel Transformation
- 7) N<sub>2</sub>O emissions from 4.D.1.3 N-fixing crops
- 8) N<sub>2</sub>O emissions from 4.D.1.4 Crop residue
- 9) CH<sub>4</sub> emissions from 6.A Solid Waste Disposal
- 10) CH<sub>4</sub> and N<sub>2</sub>O 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<sub>6</sub> emissions from consumption of halocarbons and SF<sub>6</sub> and N<sub>2</sub>O 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<sub>2</sub>O emissions from petroleum refining (energy) and in the years 2008-2012 with respect to CH<sub>4</sub> 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
<b>Sector: General issues</b>			
QA/QC	Improved and updated QA/QC plan	Improvement suggested by Party	NIR, chapter 1.5 NIR, chapters 3 – 8
Improvement plan	Updated Improvement plan	ARR 2010, para 16, para 37a ARR 2011, para 32,33	NIR, chapter 10.3.2
Archiving	Revised archiving routines	ARR 2010, para 34, 38b ARR 2011, para 48	NIR, chapter 1.3.3
Key category analysis	T2 key category 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
<b>Sector: Energy – emissions from combustion</b>			
1.A.1	Solid fuels – EF N <sub>2</sub> O	Change of emission factors after UNFCCC review (potential problem in Saturday paper)	NIR, chapter 3.
1.A.2			
1.A.4			
1.A.1.a	Other fossil fuels – EF CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O	Change of emission factors after UNFCCC review (potential problem in Saturday paper)	NIR, chapter 3.
1.A.1.b	Liquid – EF N <sub>2</sub> O	Change of emission factors after UNFCCC review (potential problem in Saturday paper)	NIR, chapter 3.
1.A.1.f	Other fossil fuels – EF CH <sub>4</sub> , N <sub>2</sub> O	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 <sub>4</sub>	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 <sub>4</sub>	Change of emission factors after UNFCCC review (potential problem in Saturday paper)	NIR, chapter 3.
1.A.3.	New EFs for N <sub>2</sub> O gasoline passenger cars and motorcycles according EIG 2016	EU ESD review recommendation, June 2016	NIR, chapter 3.2.17.5.1.
1.A.3.	Updated description of QA/QC plan	Improvement suggested by Party	NIR, chapter 3.2.17.3
<b>Sector: Industrial processes and Other Product Use</b>			
2.F.1	Implementation of the new calculation model	Improvement suggested by Party	NIR, chapter 4.7.1
2.G.1	Division of activity data into medium voltage and high voltage equipment	Improvement suggested by Party	NIR, chapter 4.8.1
2.C	Updated activity data	Improvement suggested by Party	NIR, chapter 4.4
<b>Sector: Agriculture</b>			
3.B, N <sub>2</sub> O	Activity data (Nex values) were corrected for swine and cattle population	TFRN, EU ESD team	NIR, chapter 5.2.2
3.B.2, N <sub>2</sub> O	The emission factor (EF) of Manure Management for cattle was corrected	Implementation of 2006 IPCC Guidelines	NIR, chapter 5.2.2.2
3.B, N <sub>2</sub> O	The fractions (Frac <sub>GasMS</sub> and Frac <sub>LossMS</sub> ) of N loss from Manure management system were updated for N <sub>2</sub> O emissions from Manure Management and N <sub>2</sub> O emissions from managed soils.	Implementation of 2006 IPCC Guidelines	NIR, chapter 5.2.2.2
3.B, N <sub>2</sub> O	The leaching from managed soils is reported	Implementation of 2006 IPCC	NIR, chapter 5.2.2

	under the 3D.	Guidelines	
3.D, N <sub>2</sub> O	Frac <sub>REMOVE</sub> was changed from 0.5 to zero	ERT recommendation	NIR, chapter 5.4
3.D, N <sub>2</sub> O	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 <sub>2</sub> O	New activity data for N mineralized in mineral soil	Implementation of 2006 IPCC Guidelines	NIR, chapter 5.2.
<b>Sector: LULUCF</b>			
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
<b>Sector: Waste</b>			
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	Uncertainty 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 <sub>2</sub> 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	

<b>1.A)</b>		
KP LULUCF	Not reported in this submission	Not reported in this submission
Article 3.3 activities		
<b>Afforestation/reforestation</b>		
<b>Deforestation</b>		
Article 3.4 activities		
<b>Forest management</b>		
<b>Cropland management (if elected)</b>		
<b>Grazing land management (if elected)</b>		
<b>Revegetation (if elected)</b>		
<b>Wetland drainage and rewetting (if elected)</b>		
<b>HWP</b>		
Memo Items:		
International Bunkers		
<b>Aviation</b>		
<b>Marine</b>		
Multilateral Operations		
CO <sub>2</sub> Emissions from Biomass		
CO <sub>2</sub> Captured		
Long-term storage of C in waste disposal sites		
Indirect N <sub>2</sub> O		
NIR Chapter	<b>DESCRIPTION</b> Please tick where the latest NIR includes major changes	<b>REFERENCE</b> If ticked please provide some more detailed information
Chapter 1.2 Institutional arrangements		
Chapter 1.6 QA/QC plan	v	

## 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<sub>2</sub> 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
<b>General</b>	Uncertainty estimates				Research of uncertainties held in 2012	Improvement of uncertainty estimates	2018
<b>1.A.1.a.i</b>	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
<b>1.A</b>	1A.3.b Transport - Road Transportation	CO <sub>2</sub>	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
<b>1.A.4.a</b>	Commercial/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
<b>1.A</b>	Stationary combustion – Liquid fuels	CO <sub>2</sub>	16.64	LA	Default Emission factors	Detailed research of carbon contained in liquid fuels and consequent development of country specific emission factors	2018
<b>1.A.1.a</b>	Stationary Combustion - Solid Fuels	CH <sub>4</sub>	0.21	TA	Default EF	Country specific emission factors (measurement of concentrations in the flues gases of significant sources)	2019-2020
<b>1.A.1.a</b>	Stationary Combustion - Liquid Fuels	N <sub>2</sub> O			Default EF	Country specific emission factors	after 2020
<b>2.C.1</b>	Iron and Steel Production	CO <sub>2</sub>	5.67	LA	Tier 2	Tier 3	2018, 2019
<b>2.B.8</b>	2.B.8. Petrochemical and carbon black production	CO <sub>2</sub>		LA	Tier 1	Country specific EFs for steam cracking ethylene production for CO <sub>2</sub> emissions	2018, 2019
<b>2.F.1</b>	2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	AD			Tier 1 - AD obtained from Custom Authorities	New source of AD	2018
<b>2.F.1</b>	2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> 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
<b>3</b>	3.A Enteric Fermentation	CH <sub>4</sub>	2.39	LA,TA	Tier 2	Update of initial zoo-technical data	2018
<b>3</b>	3.D.1. Direct emissions from managed soils	N <sub>2</sub> O	2.12	LA,TA	Tier 1	Collection of activity data	2019
<b>3</b>	3.D.1 Agricultural Soils, Indirect Emissions	N <sub>2</sub> O	2.12	LA	Tier 1	Revision of estimation in collaboration with Waste sector	2019
<b>4</b>	4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub> N <sub>2</sub> O CH <sub>4</sub>	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 <sub>2</sub> CH <sub>4</sub>	2.79	LA, TA	Tier 1	Review of factor F	2018
5	5.C Incineration and Open Burning of Waste	CO <sub>2</sub> N <sub>2</sub> O CH <sub>4</sub>			Uncertainty assessment based on research from 2012	Update of uncertainty assessment	2018
5	5.D Wastewater Treatment and Discharge	N <sub>2</sub> O CH <sub>4</sub>	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.

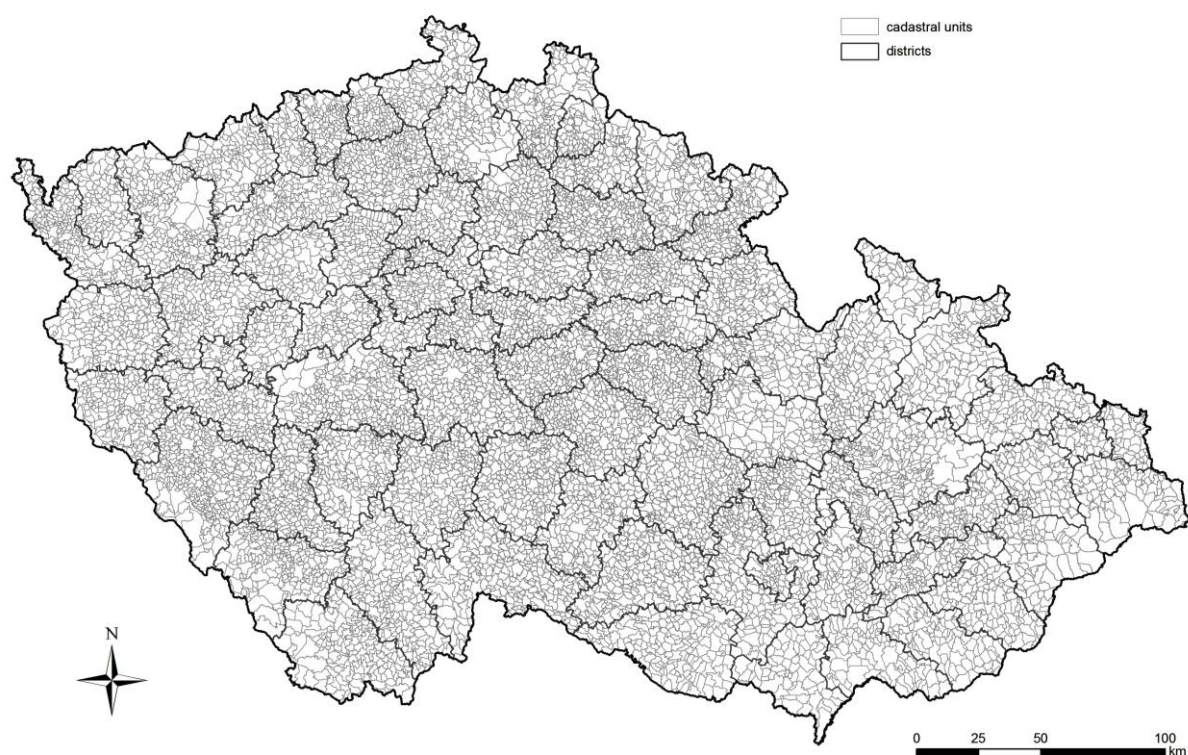
### 11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently employed in determining how land was classified.

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](http://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.

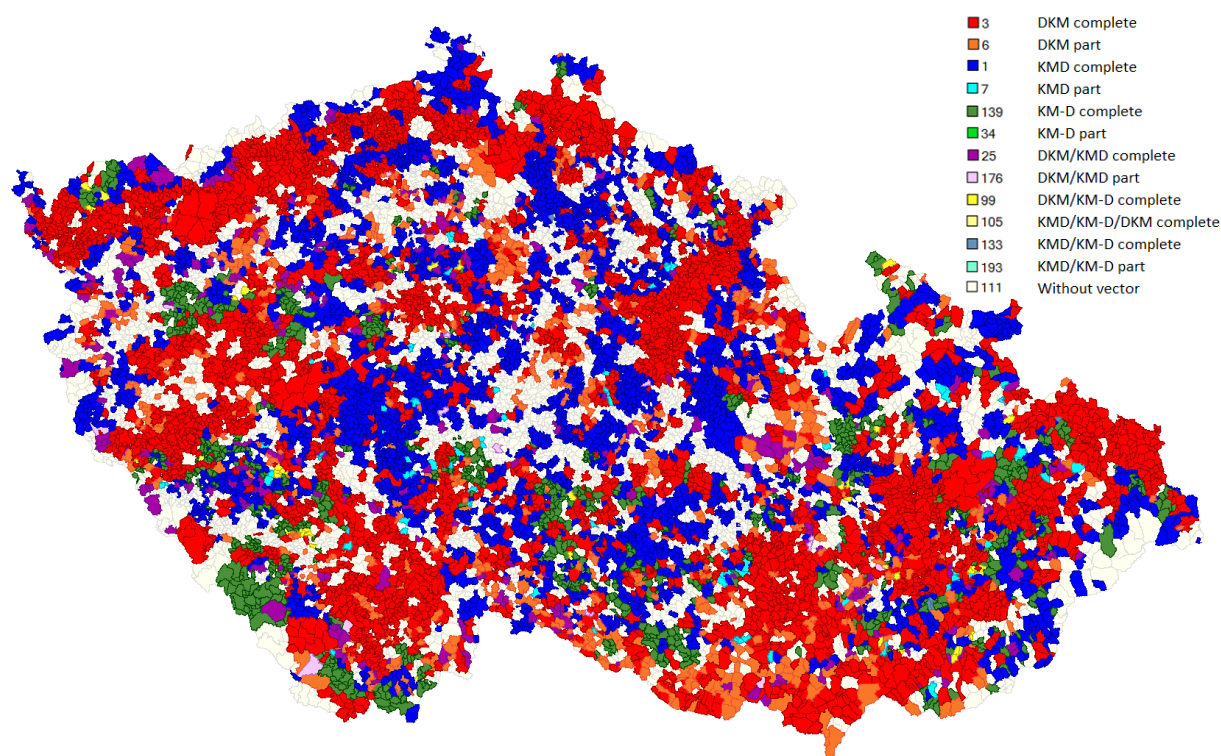
To handle this issue in the KP LULUCF reporting, two additional technical sub-categories were introduced for FM reporting. One is “Forest land remaining Forest land in KP reporting”, while the second is “Residual afforested land from before 1990 (in conversion status)”. The entire land qualified as the 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.<sup>9</sup>



**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](http://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

<sup>9</sup> 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](http://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.

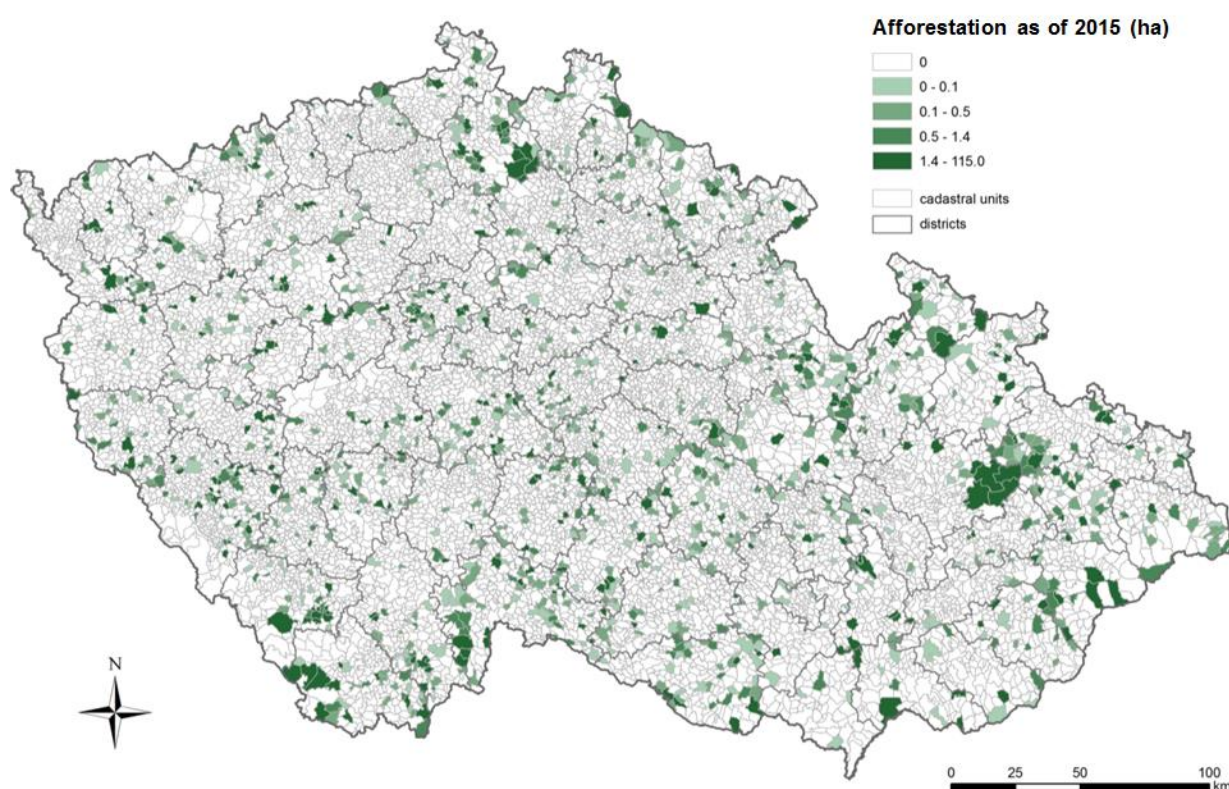


Fig. 11-3: The cadastral units with identified afforestation (AR) activities in 2015.



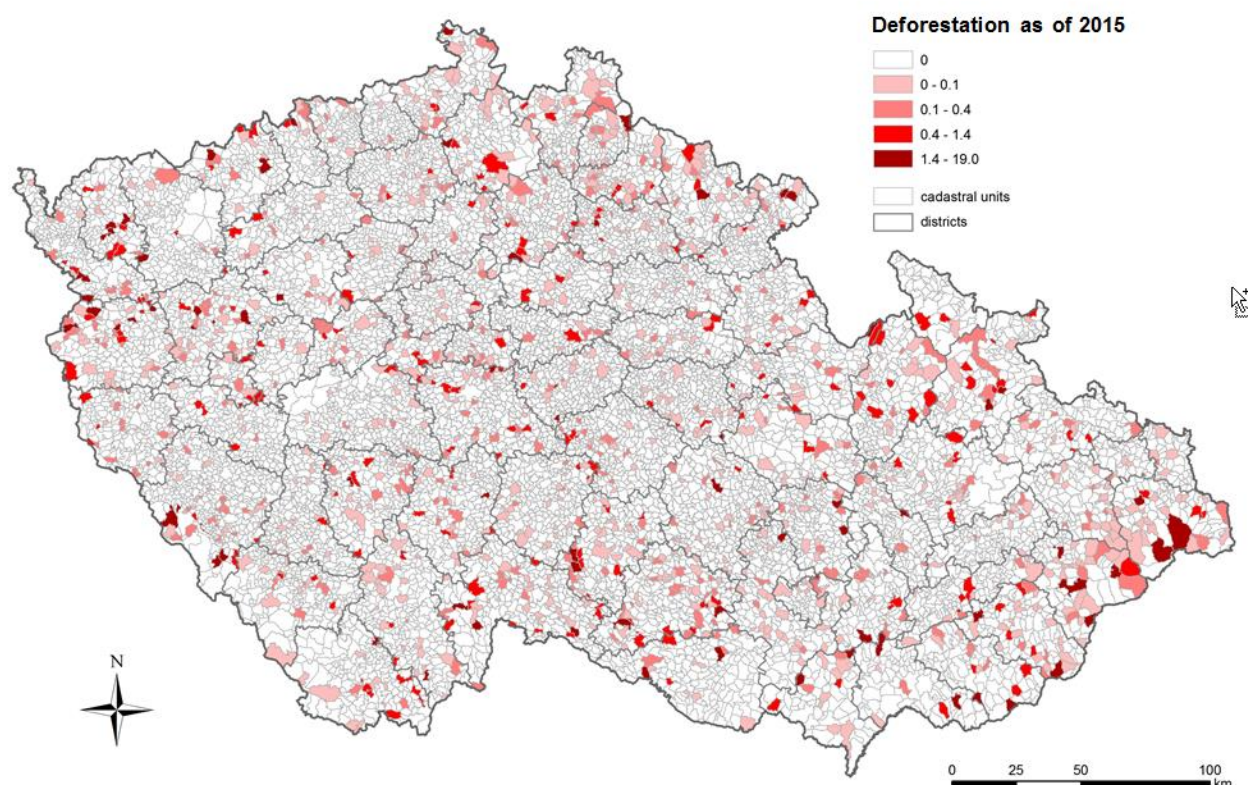


Fig. 11. 4: The cadastral units with identified deforestation (D) activities in 2015.

## 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<sub>2</sub> 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<sub>2</sub> 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 ( $\text{CO}_2$ ,  $\text{CH}_4$  and  $\text{N}_2\text{O}$ ) 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  $\text{N}_2\text{O}$  emissions from N-fertilization and soil drainage, which are therefore not applicable for the reporting period. On the contrary,  $\text{N}_2\text{O}$  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](http://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<sup>3</sup> and the parentheses show the 95% confidence interval.**

Campaign Decay stage	NFI – ref. year 2003	CzechTerra – ref. year 2009
<b>Wood is hard</b>	7.47 (7.02 - 7.93)	9.54 (7.58 – 11.5)
<b>Soft periphery, centre hard</b>	3.75 (3.48 - 4.02)	5.10 (2.81 – 7.38)
<b>Hard periphery, centre soft</b>	0.82 (0.73 - 0.90)	1.28 (0.72 – 1.85)
<b>Totally soft/rotten</b>	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 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<sub>2</sub> sink of -0.35 mil. t CO<sub>2</sub>/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<sub>2</sub> 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](http://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](http://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<sub>2</sub> eq. The estimated emissions from D equalled 180 Gg CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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 1<sup>st</sup> of January 2016 to 31<sup>st</sup> 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:

$$0.90 \times 520,515,203 = 495,463,683 \text{ tonnes of CO}_2\text{eq.}$$

Method 2: 100 % of most recently reviewed inventory, taken the 2016 submission as the most recently reviewed inventory, multiplied by 8 results in:

$$8 \times 127,925,530 = 1\,023,404,242 \text{ tonnes CO}_2 \text{ eq.}$$

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 ( <a href="mailto:mstandera@ote-cr.cz">mstandera@ote-cr.cz</a> ).
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	<p>New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality.</p> <p>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.</p> <p>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.</p>
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	<p>Changes introduced since version 6.7.3 of the national registry are listed in Annex B.</p> <p>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.</p> <p>No other change in the registry's conformance to the technical standards occurred for the reported period.</p>



Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The mandatory use of hard tokens for authentication and signature was introduced for registry administrators.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 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. 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 31 <sup>st</sup> 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 CO <sub>2</sub> 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: - Developing sustainable, market-driven biogas and solar energy solutions for

	<p>rural communities in Cambodia</p> <ul style="list-style-type: none"> <li>- Developing biogas digesters in Cuba</li> <li>- Supporting small enterprises in producing wood biomass fuel, developing geothermal energy and increasing energy efficiency of hospitals in Bosnia and Herzegovina</li> <li>- Modernization of a central district heating system with possible use of alternative heat source in Serbia</li> </ul> <p>Some of these projects build on projects successfully implemented in the period 2011 – 2014 described in the previous inventory report.</p>
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## 16 Other Information

No other information submitted in 2015.

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## Abbreviations

AALC	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	Harvested 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 <sub>2</sub>	56332.49	56332.49	41.92	41.92
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	2693.43	2693.43	2.00	43.93
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	16985.57	16985.57	12.64	56.57
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	14417.54	14417.54	10.73	67.30
2.C.1 Iron and Steel Production	CO <sub>2</sub>	6872.80	6872.80	5.11	72.41
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	-5649.87	5649.87	4.20	76.61
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	3581.30	3581.30	2.67	79.28
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	3422.33	3422.33	2.55	81.83
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	3385.21	3385.21	2.52	84.35
3.A Enteric Fermentation	CH <sub>4</sub>	2895.96	2895.96	2.16	86.50
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	2569.13	2569.13	1.91	88.41
2.A.1 Cement Production	CO <sub>2</sub>	1549.54	1549.54	1.15	89.57
3.B Manure Management	N <sub>2</sub> O	1007.81	1007.81	0.75	90.32
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	888.63	888.63	0.66	90.98
5.D Wastewater treatment and discharge	CH <sub>4</sub>	860.56	860.56	0.64	91.62
3.B Manure Management	CH <sub>4</sub>	771.47	771.47	0.57	92.19
2.B.1 Ammonia Production	CO <sub>2</sub>	741.66	741.66	0.55	92.74
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	715.16	715.16	0.53	93.28
5.B Biological treatment of solid waste	CH <sub>4</sub>	633.99	633.99	0.47	93.75
2.A.2 Lime Production	CO <sub>2</sub>	609.75	609.75	0.45	94.20
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	608.01	608.01	0.45	94.65
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	599.44	599.44	0.45	95.10
4.A.2 Land converted to Forest Land	CO <sub>2</sub>	-491.59	491.59	0.37	95.47
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	140.54	140.54	0.10	95.57
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	387.19	387.19	0.29	95.86
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	347.53	347.53	0.26	96.12
2.B.2 Nitric Acid Production	N <sub>2</sub> O	280.12	280.12	0.21	96.33
4.C.1 Grassland remaining Grassland	CO <sub>2</sub>	-276.20	276.20	0.21	96.53
4.C.2 Land converted to Grassland	CO <sub>2</sub>	-274.15	274.15	0.20	96.73
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	269.78	269.78	0.20	96.94
1.A.3.c Transport - Railways	CO <sub>2</sub>	264.11	264.11	0.20	97.13
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	249.15	249.15	0.19	97.32
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	248.99	248.99	0.19	97.50
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	246.32	246.32	0.18	97.69
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	223.50	223.50	0.17	97.85
2.B.10 Other	CO <sub>2</sub>	222.81	222.81	0.17	98.02
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	218.43	218.43	0.16	98.18
5.D Wastewater treatment and discharge	N <sub>2</sub> O	197.23	197.23	0.15	98.33
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	188.53	188.53	0.14	98.47
3.H Urea application	CO <sub>2</sub>	187.10	187.10	0.14	98.61
4.G Harvested wood products	CO <sub>2</sub>	-164.15	164.15	0.12	98.73
3.G Liming	CO <sub>2</sub>	162.89	162.89	0.12	98.85
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	146.44	146.44	0.11	98.96
5.C Incineration and open burning of waste	CO <sub>2</sub>	132.43	132.43	0.10	99.06
2.A.3 Glass Production	CO <sub>2</sub>	125.47	125.47	0.09	99.15
2.D.1 Lubricant Use	CO <sub>2</sub>	115.54	115.54	0.09	99.24
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	99.07	99.07	0.07	99.31
4.E.2 Land converted to Settlements	CO <sub>2</sub>	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 <sub>2</sub>	-84.24	84.24	0.06	99.44
4.B.2 Land converted to Cropland	CO <sub>2</sub>	83.93	83.93	0.06	99.50
4.A.1 Forest Land remaining Forest Land	CH <sub>4</sub>	81.91	81.91	0.06	99.56
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	74.50	74.50	0.06	99.62
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	71.08	71.08	0.05	99.67
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	71.04	71.04	0.05	99.72
5.B Biological treatment of solid waste	N <sub>2</sub> O	44.59	44.59	0.03	99.76
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	36.81	36.81	0.03	99.78
1.A.3.c Transport - Railways	N <sub>2</sub> O	30.38	30.38	0.02	99.81
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	25.29	25.29	0.02	99.83
4.D.2. Land converted to Wetlands	CO <sub>2</sub>	25.18	25.18	0.02	99.84
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	0.18	0.18	0.00	99.85
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	22.73	22.73	0.02	99.86
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	15.11	15.11	0.01	99.87
2.D.3 Urea used as catalyst	CO <sub>2</sub>	18.11	18.11	0.01	99.89
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	16.25	16.25	0.01	99.90
1.A.3.d Transport - Domestic navigation	CO <sub>2</sub>	12.73	12.73	0.01	99.91
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	10.23	10.23	0.01	99.92
2.C.1 Iron and Steel Production	CH <sub>4</sub>	9.72	9.72	0.01	99.92
2.C.5 Lead Production	CO <sub>2</sub>	8.81	8.81	0.01	99.93
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	6.44	6.44	0.00	99.93
4.F.2 Land converted to Other Land	CO <sub>2</sub>	7.55	7.55	0.01	99.94
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	6.72	6.72	0.00	99.95
4.A.1 Forest Land remaining Forest Land	N <sub>2</sub> O	6.71	6.71	0.00	99.95
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	6.66	6.66	0.00	99.96
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	5.89	5.89	0.00	99.96
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	5.47	5.47	0.00	99.96
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	5.39	5.39	0.00	99.97
4.B.2. Land converted to Cropland	N <sub>2</sub> O	4.98	4.98	0.00	99.97
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	4.50	4.50	0.00	99.97
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	4.24	4.24	0.00	99.98
2.C.2 Ferroalloys Production	CH <sub>4</sub>	3.67	3.67	0.00	99.98
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	3.44	3.44	0.00	99.98
2.G.2 SF6 and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	3.22	3.22	0.00	99.99
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	2.84	2.84	0.00	99.99
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	2.57	2.57	0.00	99.99
5.C Incineration and open burning of waste	N <sub>2</sub> O	2.40	2.40	0.00	99.99
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	NF <sub>3</sub>	2.29	2.29	0.00	99.99
1.A.3 Transport - Biomass	N <sub>2</sub> O	2.22	2.22	0.00	99.99
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	1.79	1.79	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	PFC	1.49	1.49	0.00	100.00
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	0.78	0.78	0.00	100.00
1.A.3 Transport - Biomass	CH <sub>4</sub>	0.59	0.59	0.00	100.00
2.C.2 Ferroalloys Production	CO <sub>2</sub>	0.53	0.53	0.00	100.00
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	0.51	0.51	0.00	100.00
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0.50	0.50	0.00	100.00
2.C.6 Zinc Production	CO <sub>2</sub>	0.41	0.41	0.00	100.00
1.A.3.c Transport - Railways	CH <sub>4</sub>	0.37	0.37	0.00	100.00
1.A.3.d Transport - Domestic navigation	N <sub>2</sub> O	0.10	0.10	0.00	100.00
1.A.3.a Transport - Domestic Aviation	N <sub>2</sub> O	0.09	0.09	0.00	100.00
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0.04	0.04	0.00	100.00
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0.04	0.04	0.00	100.00
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	0.03	0.03	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH <sub>4</sub>	0.03	0.03	0.00	100.00
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	0.02	0.02	0.00	100.00
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	0.00	0.00	0.00	100.00
5.C Incineration and open burning of waste	CH <sub>4</sub>	0.00	0.00	0.00	100.00
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0	0.00	0.00	100
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0	0	0	100
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	0	0	0	100
	<b>Total</b>	<b>120 496</b>	<b>134 376</b>		

Tab. A1- 2 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2015 – Trend Assessment including LULUCF

IPCC Source Categories	GHG	Base Year Estimate	Current Estimate	Year	Trend Assessment	% contribution to Trend	Cumulative total of contribution to trend
1.A Stationary Combustion - Solid Fuels	CO <sub>2</sub>	110822.55	56332.49		0.07	23.09	23.09
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	6176.54	16985.57		0.07	21.24	44.33
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	11201.04	14417.54		0.04	11.86	56.19
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	15193.50	2693.43		0.04	11.35	67.53
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	10322.40	3581.30		0.02	4.86	72.40
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	0.00	3422.33		0.02	5.57	77.96
4.G Harvested wood products	CO <sub>2</sub>	-1712.95	-164.15		0.01	3.53	81.50
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	1979.27	3385.21		0.01	3.46	84.95
3.A Enteric Fermentation	CH <sub>4</sub>	5754.89	2895.96		0.00	1.25	86.20
3.B Manure Management	N <sub>2</sub> O	2459.33	1007.81		0.00	0.91	87.11
3.G Liming	CO <sub>2</sub>	1177.82	162.89		0.00	0.95	88.06
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	1212.44	248.99		0.00	0.85	88.91
2.B.2 Nitric Acid Production	N <sub>2</sub> O	1050.29	280.12		0.00	0.63	89.54
3.B Manure Management	CH <sub>4</sub>	1752.07	771.47		0.00	0.56	90.10
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	-4664.35	-5649.87		0.00	1.16	91.26
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	0.00	387.19		0.00	0.63	91.89
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	4210.37	2569.13		0.00	0.18	92.07
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	335.00	599.44		0.00	0.63	92.70
2.A.2 Lime Production	CO <sub>2</sub>	1336.65	609.75		0.00	0.39	93.09
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	0.00	269.78		0.00	0.44	93.53
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	136.73	347.53		0.00	0.42	93.95
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	48.67	140.54		0.00	0.18	94.13
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	1586.96	888.63		0.00	0.20	94.33
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	24.04	218.43		0.00	0.33	94.66
1.A.3.c Transport - Railways	CO <sub>2</sub>	653.86	264.11		0.00	0.25	94.90
2.A.1 Cement Production	CO <sub>2</sub>	2489.18	1549.54		0.00	0.06	94.96
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	109.15	249.15		0.00	0.29	95.25
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	1079.91	608.01		0.00	0.13	95.38
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	792.47	715.16		0.00	0.34	95.72
5.D Wastewater treatment and discharge	CH <sub>4</sub>	889.80	860.56		0.00	0.48	96.20
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	456.24	188.53		0.00	0.17	96.37
2.C.1 Iron and Steel Production	CO <sub>2</sub>	9642.54	6872.80		0.00	1.20	97.57
5.C Incineration and open burning of waste	CO <sub>2</sub>	23.15	132.43		0.00	0.19	97.76
3.H Urea application	CO <sub>2</sub>	108.53	187.10		0.00	0.19	97.95
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	68.58	146.44		0.00	0.17	98.12
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	0.00	99.07		0.00	0.16	98.28
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	482.97	246.32		0.00	0.10	98.38
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	139.44	10.23		0.00	0.13	98.51
4.C.2 Land converted to Grassland	CO <sub>2</sub>	-145.34	-274.15		0.00	0.12	98.63
4.B.1 Cropland remaining Cropland	CO <sub>2</sub>	-2.28	-84.24		0.00	0.13	98.76
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	206.22	223.50		0.00	0.15	98.91
4.A.2 Land converted to Forest Land	CO <sub>2</sub>	-321.25	-491.59		0.00	0.09	99.00
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	5.42	71.04		0.00	0.11	99.11
2.B.1 Ammonia Production	CO <sub>2</sub>	990.80	741.66		0.00	0.18	99.29
5.D Wastewater treatment and discharge	N <sub>2</sub> O	234.18	197.23		0.00	0.08	99.37
2.A.3 Glass Production	CO <sub>2</sub>	123.66	125.47		0.00	0.08	99.44
2.D.1 Lubricant Use	CO <sub>2</sub>	116.13	115.54		0.00	0.07	99.51
4.E.2 Land converted to Settlements	CO <sub>2</sub>	85.09	88.12		0.00	0.06	99.57
1.A.3.d Transport - Domestic navigation	CO <sub>2</sub>	56.61	12.73		0.00	0.04	99.60
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	0.00	22.73		0.00	0.04	99.64
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	74.50	74.50		0.00	0.04	99.69
1.A.3.c Transport - Railways	N <sub>2</sub> O	75.21	30.38		0.00	0.03	99.71
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	21.58	0.18		0.00	0.02	99.74
2.D.3 Urea used as catalyst	CO <sub>2</sub>	0.00	18.11		0.00	0.03	99.77
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	84.10	71.08		0.00	0.03	99.79
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	36.17	36.81		0.00	0.02	99.82
4.D.2. Land converted to Wetlands	CO <sub>2</sub>	21.51	25.18		0.00	0.02	99.83
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	12.79	15.11		0.00	0.01	99.85
4.F.2 Land converted to Other Land	CO <sub>2</sub>	0.00	7.55		0.00	0.01	99.86
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	0.00	6.72		0.00	0.01	99.87
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	0.00	6.66		0.00	0.01	99.88
4.B.2. Land converted to Cropland	N <sub>2</sub> O	8.91	4.98		0.00	0.00	99.88

IPCC Source Categories	GHG	Base Year Estimate	Current Estimate	Year	Trend Assessment	% contribution to Trend	Cumulative total of contribution to trend
2.C.5 Lead Production	CO <sub>2</sub>	4.04	8.81		0.00	0.01	99.89
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	0.00	5.47		0.00	0.01	99.90
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	0.00	4.24		0.00	0.01	99.91
4.B.2 Land converted to Cropland	CO <sub>2</sub>	113.99	83.93		0.00	0.02	99.93
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	0.75	4.50		0.00	0.01	99.93
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	2.20	5.39		0.00	0.01	99.94
2.C.2 Ferroalloys Production	CH <sub>4</sub>	0.18	3.67		0.00	0.01	99.94
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	6.12	6.44		0.00	0.00	99.95
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	0.00	3.44		0.00	0.01	99.95
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	0.31	2.84		0.00	0.00	99.96
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	0.00	2.57		0.00	0.00	99.96
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	NF <sub>3</sub>	0.00	2.29		0.00	0.00	99.97
1.A.3 Transport - Biomass	N <sub>2</sub> O	0.00	2.22		0.00	0.00	99.97
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	PFC	0.00	1.49		0.00	0.00	99.97
5.C Incineration and open burning of waste	N <sub>2</sub> O	0.42	2.40		0.00	0.00	99.98
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	0.20	1.79		0.00	0.00	99.98
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	37.50	25.29		0.00	0.00	99.98
1.A.3.a Transport - Domestic Aviation	N <sub>2</sub> O	1.19	0.09		0.00	0.00	99.98
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	9.43	5.89		0.00	0.00	99.98
2.C.1 Iron and Steel Production	CH <sub>4</sub>	14.84	9.72		0.00	0.00	99.98
1.A.3 Transport - Biomass	CH <sub>4</sub>	0.00	0.59		0.00	0.00	99.98
2.C.2 Ferroalloys Production	CO <sub>2</sub>	0.03	0.53		0.00	0.00	99.98
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	0.00	0.51		0.00	0.00	99.99
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0.00	0.50		0.00	0.00	99.99
1.A.3.c Transport - Railways	CH <sub>4</sub>	0.92	0.37		0.00	0.00	99.99
4.A.1 Forest Land remaining Forest Land	CH <sub>4</sub>	117.35	81.91		0.00	0.01	100.00
1.A.3.d Transport - Domestic navigation	N <sub>2</sub> O	0.46	0.10		0.00	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH <sub>4</sub>	0.13	0.03		0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0.00	0.04		0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0.00	0.04		0.00	0.00	100.00
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	0.00	0.03		0.00	0.00	100.00
4.A.1 Forest Land remaining Forest Land	N <sub>2</sub> O	9.62	6.71		0.00	0.00	100.00
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	0.01	0.02		0.00	0.00	100.00
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	0.02	0.00		0.00	0.00	100.00
5.C Incineration and open burning of waste	CH <sub>4</sub>	0.00	0.00		0.00	0.00	100.00
2.B.10 Other	CO <sub>2</sub>	0.00	222.81		0.00	0.00	100.00
2.C.6 Zinc Production	CO <sub>2</sub>	0.00	0.41		0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	16.25		0.00	0.00	100.00
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0.00	0.00		0.00	0.00	100.00
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0.00	0.00		0.00	0.00	100.00
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	0.00	0.78		0.00	0.00	100.00
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	0.00	0.00		0.00	0.00	100.00
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	3.22		0.00	0.00	100.00
4.C.1 Grassland remaining Grassland	CO <sub>2</sub>	0	-276.1982751		0	0	100
5.B Biological treatment of solid waste	CH <sub>4</sub>	0	633.9866491		0	0	100
5.B Biological treatment of solid waste	N <sub>2</sub> O	0	44.58524301		0	0	100
<b>Total</b>		<b>189342.79</b>	<b>120496.00</b>		<b>0.3246</b>	<b>100.00</b>	

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 <sub>2</sub>	56332.49	56332.49	44.31	44.31
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	2693.43	2693.43	2.12	46.43
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	16985.57	16985.57	13.36	59.79
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	14417.54	14417.54	11.34	71.13
2.C.1 Iron and Steel Production	CO <sub>2</sub>	6872.80	6872.80	5.41	76.53
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	3385.21	3385.21	2.66	79.20
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	3581.30	3581.30	2.82	82.01
3.A Enteric Fermentation	CH <sub>4</sub>	2895.96	2895.96	2.28	84.29
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	3422.33	3422.33	2.69	86.98
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	2569.13	2569.13	2.02	89.00
2.A.1 Cement Production	CO <sub>2</sub>	1549.54	1549.54	1.22	90.22
3.B Manure Management	N <sub>2</sub> O	1007.81	1007.81	0.79	91.01
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	715.16	715.16	0.56	91.58
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	888.63	888.63	0.70	92.28
3.B Manure Management	CH <sub>4</sub>	771.47	771.47	0.61	92.88
5.D Wastewater treatment and discharge	CH <sub>4</sub>	860.56	860.56	0.68	93.56
2.B.1 Ammonia Production	CO <sub>2</sub>	741.66	741.66	0.58	94.14
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	140.54	140.54	0.11	94.25
2.A.2 Lime Production	CO <sub>2</sub>	609.75	609.75	0.48	94.73
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	608.01	608.01	0.48	95.21
5.B Biological treatment of solid waste	CH <sub>4</sub>	633.99	633.99	0.50	95.71
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	347.53	347.53	0.27	95.98
2.C.2 Ferroalloys Production	CH <sub>4</sub>	3.67	3.67	0.00	95.99
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	599.44	599.44	0.47	96.46
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	249.15	249.15	0.20	96.65
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	387.19	387.19	0.30	96.96
1.A.3.c Transport - Railways	CO <sub>2</sub>	264.11	264.11	0.21	97.17
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	269.78	269.78	0.21	97.38
2.B.2 Nitric Acid Production	N <sub>2</sub> O	280.12	280.12	0.22	97.60
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	246.32	246.32	0.19	97.79
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	223.50	223.50	0.18	97.97
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	218.43	218.43	0.17	98.14
2.B.10 Other	CO <sub>2</sub>	222.81	222.81	0.18	98.31
5.D Wastewater treatment and discharge	N <sub>2</sub> O	197.23	197.23	0.16	98.47
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	188.53	188.53	0.15	98.62
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	248.99	248.99	0.20	98.81
3.G Liming	CO <sub>2</sub>	162.89	162.89	0.13	98.94
5.C Incineration and open burning of waste	CO <sub>2</sub>	132.43	132.43	0.10	99.05
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	146.44	146.44	0.12	99.16
2.A.3 Glass Production	CO <sub>2</sub>	125.47	125.47	0.10	99.26
2.D.1 Lubricant Use	CO <sub>2</sub>	115.54	115.54	0.09	99.35
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	71.04	71.04	0.06	99.41
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	71.08	71.08	0.06	99.46
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	74.50	74.50	0.06	99.52
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	99.07	99.07	0.08	99.60
3.H Urea application	CO <sub>2</sub>	187.10	187.10	0.15	99.75
2.C.2 Ferroalloys Production	CO <sub>2</sub>	0.53	0.53	0.00	99.75
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	36.81	36.81	0.03	99.78
5.B Biological treatment of solid waste	N <sub>2</sub> O	44.59	44.59	0.04	99.81
1.A.3.c Transport - Railways	N <sub>2</sub> O	30.38	30.38	0.02	99.83
2.C.5 Lead Production	CO <sub>2</sub>	8.81	8.81	0.01	99.84
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	25.29	25.29	0.02	99.86
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	0.18	0.18	0.00	99.86
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	22.73	22.73	0.02	99.88
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	15.11	15.11	0.01	99.89
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	16.25	16.25	0.01	99.90
2.D.3 Urea used as catalyst	CO <sub>2</sub>	18.11	18.11	0.01	99.92
2.C.1 Iron and Steel Production	CH <sub>4</sub>	9.72	9.72	0.01	99.93
1.A.3.d Transport - Domestic navigation	CO <sub>2</sub>	12.73	12.73	0.01	99.94
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	6.66	6.66	0.01	99.94
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	6.44	6.44	0.01	99.95
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	5.89	5.89	0.00	99.95
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	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 <sub>2</sub> O	6.72	6.72	0.01	99.96
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	4.50	4.50	0.00	99.97
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	PFC	1.49	1.49	0.00	99.97
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	3.22	3.22	0.00	99.97
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	4.24	4.24	0.00	99.97
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	2.84	2.84	0.00	99.98
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	2.57	2.57	0.00	99.98
5.C Incineration and open burning of waste	N <sub>2</sub> O	2.40	2.40	0.00	99.98
1.A.3 Transport - Biomass	N <sub>2</sub> O	2.22	2.22	0.00	99.98
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	NF <sub>3</sub>	2.29	2.29	0.00	99.98
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	0.78	0.78	0.00	99.99
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	1.79	1.79	0.00	99.99
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	5.47	5.47	0.00	99.99
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	3.44	3.44	0.00	99.99
1.A.3 Transport - Biomass	CH <sub>4</sub>	0.59	0.59	0.00	99.99
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	0.51	0.51	0.00	99.99
1.A.3.c Transport - Railways	CH <sub>4</sub>	0.37	0.37	0.00	99.99
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0.50	0.50	0.00	100.00
2.C.6 Zinc Production	CO <sub>2</sub>	0.41	0.41	0.00	100.00
1.A.3.d Transport - Domestic navigation	N <sub>2</sub> O	0.10	0.10	0.00	100.00
1.A.3.a Transport - Domestic Aviation	N <sub>2</sub> O	0.09	0.09	0.00	100.00
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	5.39	5.39	0.00	100.00
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0.04	0.04	0.00	100.00
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0.04	0.04	0.00	100.00
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	0.03	0.03	0.00	100.00
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	0.02	0.02	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH <sub>4</sub>	0.03	0.03	0.00	100.00
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	0.00	0.00	0.00	100.00
5.C Incineration and open burning of waste	CH <sub>4</sub>	0.00	0.00	0.00	100.00
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
<b>Total</b>		<b>127 137</b>	<b>127 137</b>	<b>100.00</b>	



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 <sub>2</sub>	110822.55	56332.49	0.08	26.04	26.04
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	6176.54	16985.57	0.07	21.64	47.69
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	11201.04	14417.54	0.04	11.92	59.60
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	15193.50	2693.43	0.04	11.96	71.56
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	10322.40	3581.30	0.02	5.20	76.77
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	0.00	3422.33	0.02	5.71	82.48
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	1979.27	3385.21	0.01	3.50	85.98
3.A Enteric Fermentation	CH <sub>4</sub>	5754.89	2895.96	0.00	1.40	87.38
3.B Manure Management	N <sub>2</sub> O	2459.33	1007.81	0.00	0.98	88.36
3.G Liming	CO <sub>2</sub>	1177.82	162.89	0.00	1.00	89.37
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	1212.44	248.99	0.00	0.90	90.26
3.B Manure Management	CH <sub>4</sub>	1752.07	771.47	0.00	0.61	90.87
2.B.2 Nitric Acid Production	N <sub>2</sub> O	1050.29	280.12	0.00	0.67	91.54
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	4210.37	2569.13	0.00	0.27	91.82
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	0.00	387.19	0.00	0.65	92.46
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	335.00	599.44	0.00	0.64	93.10
2.A.2 Lime Production	CO <sub>2</sub>	1336.65	609.75	0.00	0.43	93.53
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	0.00	269.78	0.00	0.45	93.98
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	136.73	347.53	0.00	0.43	94.41
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	1586.96	888.63	0.00	0.24	94.65
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	48.67	140.54	0.00	0.18	94.83
2.A.1 Cement Production	CO <sub>2</sub>	2489.18	1549.54	0.00	0.11	94.94
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	24.04	218.43	0.00	0.34	95.28
1.A.3.c Transport - Railways	CO <sub>2</sub>	653.86	264.11	0.00	0.27	95.55
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	109.15	249.15	0.00	0.30	95.84
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	1079.91	608.01	0.00	0.16	96.00
5.D Wastewater treatment and discharge	CH <sub>4</sub>	889.80	860.56	0.00	0.47	96.47
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	456.24	188.53	0.00	0.18	96.65
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	792.47	715.16	0.00	0.33	96.99
5.C Incineration and open burning of waste	CO <sub>2</sub>	23.15	132.43	0.00	0.20	97.18
3.H Urea application	CO <sub>2</sub>	108.53	187.10	0.00	0.19	97.38
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	68.58	146.44	0.00	0.17	97.55
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	0.00	99.07	0.00	0.17	97.71
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	482.97	246.32	0.00	0.11	97.82
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	139.44	10.23	0.00	0.13	97.96
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	206.22	223.50	0.00	0.15	98.11
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	5.42	71.04	0.00	0.11	98.22
5.D Wastewater treatment and discharge	N <sub>2</sub> O	234.18	197.23	0.00	0.08	98.29
2.B.1 Ammonia Production	CO <sub>2</sub>	990.80	741.66	0.00	0.16	98.46
2.A.3 Glass Production	CO <sub>2</sub>	123.66	125.47	0.00	0.08	98.53
2.D.1 Lubricant Use	CO <sub>2</sub>	116.13	115.54	0.00	0.07	98.60
1.A.3.d Transport - Domestic navigation	CO <sub>2</sub>	56.61	12.73	0.00	0.04	98.64
2.C.1 Iron and Steel Production	CO <sub>2</sub>	9642.54	6872.80	0.00	1.02	99.66
1.A.3.c Transport - Railways	N <sub>2</sub> O	75.21	30.38	0.00	0.03	99.69
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	0.00	22.73	0.00	0.04	99.73
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	74.50	74.50	0.00	0.04	99.77
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	21.58	0.18	0.00	0.02	99.80
2.D.3 Urea used as catalyst	CO <sub>2</sub>	0.00	18.11	0.00	0.03	99.83
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	84.10	71.08	0.00	0.03	99.86
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	36.17	36.81	0.00	0.02	99.88
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	12.79	15.11	0.00	0.01	99.89
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	0.00	6.72	0.00	0.01	99.90
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	0.00	6.66	0.00	0.01	99.91
2.C.5 Lead Production	CO <sub>2</sub>	4.04	8.81	0.00	0.01	99.92
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	0.00	5.47	0.00	0.01	99.93
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	0.00	4.24	0.00	0.01	99.94
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	0.75	4.50	0.00	0.01	99.94
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	2.20	5.39	0.00	0.01	99.95
2.C.2 Ferroalloys Production	CH <sub>4</sub>	0.18	3.67	0.00	0.01	99.96
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	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 <sub>2</sub> O	6.12	6.44	0.00	0.00	99.97
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	0.31	2.84	0.00	0.00	99.97
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	0.00	2.57	0.00	0.00	99.98
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	NF <sub>3</sub>	0.00	2.29	0.00	0.00	99.98
1.A.3 Transport - Biomass	N <sub>2</sub> O	0.00	2.22	0.00	0.00	99.98
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	PFC	0.00	1.49	0.00	0.00	99.99
5.C Incineration and open burning of waste	N <sub>2</sub> O	0.42	2.40	0.00	0.00	99.99
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	0.20	1.79	0.00	0.00	99.99
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	37.50	25.29	0.00	0.00	99.99
2.C.1 Iron and Steel Production	CH <sub>4</sub>	14.84	9.72	0.00	0.00	99.99
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	9.43	5.89	0.00	0.00	99.99
1.A.3.a Transport - Domestic Aviation	N <sub>2</sub> O	1.19	0.09	0.00	0.00	100.00
1.A.3 Transport - Biomass	CH <sub>4</sub>	0.00	0.59	0.00	0.00	100.00
2.C.2 Ferroalloys Production	CO <sub>2</sub>	0.03	0.53	0.00	0.00	100.00
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	0.00	0.51	0.00	0.00	100.00
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0.00	0.50	0.00	0.00	100.00
1.A.3.c Transport - Railways	CH <sub>4</sub>	0.92	0.37	0.00	0.00	100.00
1.A.3.d Transport - Domestic navigation	N <sub>2</sub> O	0.46	0.10	0.00	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH <sub>4</sub>	0.13	0.03	0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0.00	0.04	0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0.00	0.04	0.00	0.00	100.00
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	0.00	0.03	0.00	0.00	100.00
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	0.01	0.02	0.00	0.00	100.00
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	0.02	0.00	0.00	0.00	100.00
5.C Incineration and open burning of waste	CH <sub>4</sub>	0.00	0.00	0.00	0.00	100.00
2.B.10 Other	CO <sub>2</sub>	0.00	222.81	0.00	0.00	100.00
2.C.6 Zinc Production	CO <sub>2</sub>	0.00	0.41	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	16.25	0.00	0.00	100.00
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	0.00	100.00
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	0.00	100.00
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	0.00	0.78	0.00	0.00	100.00
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	0.00	100.00
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	3.22	0.00	0.00	100.00
5.B Biological treatment of solid waste	CH <sub>4</sub>	0.00	633.99	0.00	0.00	100.00
5.B Biological treatment of solid waste	N <sub>2</sub> O	0.00	44.59	0.00	0.00	100.00
<b>Total</b>		<b>195832.51</b>	<b>127137.81</b>	<b>0.31</b>	<b>100.00</b>	

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 <sub>2</sub>	110822.55	110822.55	54.58	54.58
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	15193.50	15193.50	7.48	62.07
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	11201.04	11201.04	5.52	67.58
2.C.1 Iron and Steel Production	CO <sub>2</sub>	9642.54	9642.54	4.75	72.33
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	10322.40	10322.40	5.08	77.42
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	6176.54	6176.54	3.04	80.46
3.A Enteric Fermentation	CH <sub>4</sub>	5754.89	5754.89	2.83	83.29
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	-4664.35	4664.35	2.30	85.59
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	4210.37	4210.37	2.07	87.66
3.B Manure Management	N <sub>2</sub> O	2459.33	2459.33	1.21	88.88
2.A.1 Cement Production	CO <sub>2</sub>	2489.18	2489.18	1.23	90.10
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	1979.27	1979.27	0.97	91.08
3.B Manure Management	CH <sub>4</sub>	1752.07	1752.07	0.86	91.94
4.G Harvested wood products	CO <sub>2</sub>	-1712.95	1712.95	0.84	92.78
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	1586.96	1586.96	0.78	93.56
2.A.2 Lime Production	CO <sub>2</sub>	1336.65	1336.65	0.66	94.22
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	1212.44	1212.44	0.60	94.82
3.G Liming	CO <sub>2</sub>	1177.82	1177.82	0.58	95.40
5.D Wastewater treatment and discharge	CH <sub>4</sub>	889.80	889.80	0.44	95.84
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	1079.91	1079.91	0.53	96.37
2.B.2 Nitric Acid Production	N <sub>2</sub> O	1050.29	1050.29	0.52	96.89
2.B.1 Ammonia Production	CO <sub>2</sub>	990.80	990.80	0.49	97.38
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	792.47	792.47	0.39	97.77
1.A.3.c Transport - Railways	CO <sub>2</sub>	653.86	653.86	0.32	98.09
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	456.24	456.24	0.22	98.31
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	482.97	482.97	0.24	98.55
4.A.2 Land converted to Forest Land	CO <sub>2</sub>	-321.25	321.25	0.16	98.71
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	335.00	335.00	0.16	98.87
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	48.67	48.67	0.02	98.90
5.D Wastewater treatment and discharge	N <sub>2</sub> O	234.18	234.18	0.12	99.01
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	206.22	206.22	0.10	99.11
4.C.2 Land converted to Grassland	CO <sub>2</sub>	-145.34	145.34	0.07	99.19
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	139.44	139.44	0.07	99.25
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	136.73	136.73	0.07	99.32
2.A.3 Glass Production	CO <sub>2</sub>	123.66	123.66	0.06	99.38
4.A.1 Forest Land remaining Forest Land	CH <sub>4</sub>	117.35	117.35	0.06	99.44
2.D.1 Lubricant Use	CO <sub>2</sub>	116.13	116.13	0.06	99.50
4.B.2 Land converted to Cropland	CO <sub>2</sub>	113.99	113.99	0.06	99.55
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	109.15	109.15	0.05	99.61
3.H Urea application	CO <sub>2</sub>	108.53	108.53	0.05	99.66
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	84.10	84.10	0.04	99.70
4.E.2 Land converted to Settlements	CO <sub>2</sub>	85.09	85.09	0.04	99.74
1.A.3.c Transport - Railways	N <sub>2</sub> O	75.21	75.21	0.04	99.78
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	74.50	74.50	0.04	99.82
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	21.58	21.58	0.01	99.83
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	68.58	68.58	0.03	99.86
1.A.3.d Transport - Domestic navigation	CO <sub>2</sub>	56.61	56.61	0.03	99.89
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	37.50	37.50	0.02	99.91
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	36.17	36.17	0.02	99.93
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	24.04	24.04	0.01	99.94
5.C Incineration and open burning of waste	CO <sub>2</sub>	23.15	23.15	0.01	99.95
4.D.2. Land converted to Wetlands	CO <sub>2</sub>	21.51	21.51	0.01	99.96
2.C.1 Iron and Steel Production	CH <sub>4</sub>	14.84	14.84	0.01	99.97
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	12.79	12.79	0.01	99.97
2.C.5 Lead Production	CO <sub>2</sub>	4.04	4.04	0.00	99.98
4.A.1 Forest Land remaining Forest Land	N <sub>2</sub> O	9.62	9.62	0.00	99.98
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	9.43	9.43	0.00	99.99
4.B.2. Land converted to Cropland	N <sub>2</sub> O	8.91	8.91	0.00	99.99
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	6.12	6.12	0.00	99.99
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	5.42	5.42	0.00	100.00
4.B.1 Cropland remaining Cropland	CO <sub>2</sub>	-2.28	2.28	0.00	100.00
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	2.20	2.20	0.00	100.00
1.A.3.a Transport - Domestic Aviation	N <sub>2</sub> O	1.19	1.19	0.00	100.00
1.A.3.c Transport - Railways	CH <sub>4</sub>	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 <sub>4</sub>	0.75	0.75	0.00	100.00
1.A.3.d Transport - Domestic navigation	N <sub>2</sub> O	0.46	0.46	0.00	100.00
5.C Incineration and open burning of waste	N <sub>2</sub> O	0.42	0.42	0.00	100.00
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	0.31	0.31	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	0.00	0.00	0.00	100.00
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	0.20	0.20	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH <sub>4</sub>	0.13	0.13	0.00	100.00
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	0.02	0.02	0.00	100.00
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	0.01	0.01	0.00	100.00
2.C.2 Ferroalloys Production	CH <sub>4</sub>	0.18	0.18	0.00	100.00
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0.00	0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0.00	0.00	0.00	100.00
2.C.2 Ferroalloys Production	CO <sub>2</sub>	0.03	0.03	0.00	100.00
5.C Incineration and open burning of waste	CH <sub>4</sub>	0.00	0.00	0.00	100.00
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	0.00	0.00	0.00	100.00
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	0.00	0.00	0.00	100.00
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	0.00	0.00	0.00	100.00
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	0.00	0.00	0.00	100.00
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0.00	0.00	0.00	100.00
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	0.00	0.00	0.00	100.00
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	0.00	0.00	0.00	100.00
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	0.00	0.00	0.00	100.00
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	0.00	0.00	0.00	100.00
2.B.10 Other	CO <sub>2</sub>	0.00	0.00	0.00	100.00
2.C.6 Zinc Production	CO <sub>2</sub>	0.00	0.00	0.00	100.00
2.D.3 Urea used as catalyst	CO <sub>2</sub>	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	NF <sub>3</sub>	0.00	0.00	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	0.00	0.00	0.00	100.00
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	0.00	0.00	0.00	100.00
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	0.00	0.00	0.00	100.00
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	0.00	0.00	0.00	100.00
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	0.00	0.00	100.00
4.C.1 Grassland remaining Grassland	CO <sub>2</sub>	0.00	0.00	0.00	100.00
4.F.2 Land converted to Other Land	CO <sub>2</sub>	0.00	0.00	0.00	100.00
5.B Biological treatment of solid waste	CH <sub>4</sub>	0.00	0.00	0.00	100.00
5.B Biological treatment of solid waste	N <sub>2</sub> O	0.00	0.00	0.00	100.00
1.A.3 Transport - Biomass	CH <sub>4</sub>	0	0	0	100
1.A.3 Transport - Biomass	N <sub>2</sub> O	0	0	0	100
<b>Total</b>		<b>189342</b>	<b>203035</b>	<b>100.00</b>	

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 <sub>2</sub>	110822.55	110822.55	56.59	56.59
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	15193.50	15193.50	7.76	64.35
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	11201.04	11201.04	5.72	70.07
2.C.1 Iron and Steel Production	CO <sub>2</sub>	9642.54	9642.54	4.92	74.99
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	10322.40	10322.40	5.27	80.26
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	6176.54	6176.54	3.15	83.42
3.A Enteric Fermentation	CH <sub>4</sub>	5754.89	5754.89	2.94	86.36
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	4210.37	4210.37	2.15	88.51
3.B Manure Management	N <sub>2</sub> O	2459.33	2459.33	1.26	89.76
2.A.1 Cement Production	CO <sub>2</sub>	2489.18	2489.18	1.27	91.03
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	1979.27	1979.27	1.01	92.04
3.B Manure Management	CH <sub>4</sub>	1752.07	1752.07	0.89	92.94
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	1586.96	1586.96	0.81	93.75
2.A.2 Lime Production	CO <sub>2</sub>	1336.65	1336.65	0.68	94.43
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	1212.44	1212.44	0.62	95.05
3.G Liming	CO <sub>2</sub>	1177.82	1177.82	0.60	95.65
5.D Wastewater treatment and discharge	CH <sub>4</sub>	889.80	889.80	0.45	96.11
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	1079.91	1079.91	0.55	96.66
2.B.2 Nitric Acid Production	N <sub>2</sub> O	1050.29	1050.29	0.54	97.19
2.B.1 Ammonia Production	CO <sub>2</sub>	990.80	990.80	0.51	97.70
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	792.47	792.47	0.40	98.10
1.A.3.c Transport - Railways	CO <sub>2</sub>	653.86	653.86	0.33	98.44
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	456.24	456.24	0.23	98.67
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	482.97	482.97	0.25	98.92
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	335.00	335.00	0.17	99.09
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	48.67	48.67	0.02	99.11
5.D Wastewater treatment and discharge	N <sub>2</sub> O	234.18	234.18	0.12	99.23
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	206.22	206.22	0.11	99.34
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	139.44	139.44	0.07	99.41
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	136.73	136.73	0.07	99.48
2.A.3 Glass Production	CO <sub>2</sub>	123.66	123.66	0.06	99.54
2.D.1 Lubricant Use	CO <sub>2</sub>	116.13	116.13	0.06	99.60
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	109.15	109.15	0.06	99.66
3.H Urea application	CO <sub>2</sub>	108.53	108.53	0.06	99.71
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	84.10	84.10	0.04	99.76
1.A.3.c Transport - Railways	N <sub>2</sub> O	75.21	75.21	0.04	99.79
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	74.50	74.50	0.04	99.83
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	21.58	21.58	0.01	99.84
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	68.58	68.58	0.04	99.88
1.A.3.d Transport - Domestic navigation	CO <sub>2</sub>	56.61	56.61	0.03	99.91
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	37.50	37.50	0.02	99.93
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	36.17	36.17	0.02	99.95
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	24.04	24.04	0.01	99.96
5.C Incineration and open burning of waste	CO <sub>2</sub>	23.15	23.15	0.01	99.97
2.C.1 Iron and Steel Production	CH <sub>4</sub>	14.84	14.84	0.01	99.98
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	12.79	12.79	0.01	99.98
2.C.5 Lead Production	CO <sub>2</sub>	4.04	4.04	0.00	99.99
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	9.43	9.43	0.00	99.99
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	6.12	6.12	0.00	99.99
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	5.42	5.42	0.00	100.00
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	2.20	2.20	0.00	100.00
1.A.3.a Transport - Domestic Aviation	N <sub>2</sub> O	1.19	1.19	0.00	100.00
1.A.3.c Transport - Railways	CH <sub>4</sub>	0.92	0.92	0.00	100.00
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	0.75	0.75	0.00	100.00
1.A.3.d Transport - Domestic navigation	N <sub>2</sub> O	0.46	0.46	0.00	100.00
5.C Incineration and open burning of waste	N <sub>2</sub> O	0.42	0.42	0.00	100.00
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	0.31	0.31	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	0.00	0.00	0.00	100.00
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	0.20	0.20	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH <sub>4</sub>	0.13	0.13	0.00	100.00
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	0.02	0.02	0.00	100.00
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	0.01	0.01	0.00	100.00
2.C.2 Ferroalloys Production	CH <sub>4</sub>	0.18	0.18	0.00	100.00
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	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 <sub>4</sub>	0.00	0.00	0.00	100.00
2.C.2 Ferroalloys Production	CO <sub>2</sub>	0.03	0.03	0.00	100.00
5.C Incineration and open burning of waste	CH <sub>4</sub>	0.00	0.00	0.00	100.00
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	0.00	0.00	0.00	100.00
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	0.00	0.00	0.00	100.00
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	0.00	0.00	0.00	100.00
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	0.00	0.00	0.00	100.00
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0.00	0.00	0.00	100.00
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	0.00	0.00	0.00	100.00
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	0.00	0.00	0.00	100.00
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	0.00	0.00	0.00	100.00
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	0.00	0.00	0.00	100.00
2.B.10 Other	CO <sub>2</sub>	0.00	0.00	0.00	100.00
2.C.6 Zinc Production	CO <sub>2</sub>	0.00	0.00	0.00	100.00
2.D.3 Urea used as catalyst	CO <sub>2</sub>	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	NF <sub>3</sub>	0.00	0.00	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	0.00	0.00	0.00	100.00
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	0.00	0.00	0.00	100.00
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	0.00	0.00	0.00	100.00
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	0.00	0.00	0.00	100.00
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	0.00	0.00	0.00	100.00
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	0.00	0.00	100.00
5.B Biological treatment of solid waste	CH <sub>4</sub>	0.00	0.00	0.00	100.00
5.B Biological treatment of solid waste	N <sub>2</sub> O	0.00	0.00	0.00	100.00
1.A.3 Transport - Biomass	CH <sub>4</sub>	0.00	0.00	0.00	100.00
1.A.3 Transport - Biomass	N <sub>2</sub> O	0.00	0.00	0.00	100.00
	<b>Total</b>	<b>195832</b>	<b>195832</b>	<b>100.00</b>	

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 <sub>2</sub>	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 <sub>2</sub>	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 <sub>2</sub>	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 <sub>2</sub>	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 <sub>2</sub>	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 <sub>2</sub>	-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 <sub>4</sub>	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 (CO <sub>2</sub> 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 <sub>4</sub>	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 <sub>2</sub> O emissions	N <sub>2</sub> O	2569.13	2569.13	52.20	1.91	1341.13	2.58	1.92	0.99	83.77
3.A Enteric Fermentation	CH <sub>4</sub>	2895.96	2895.96	20.62	2.16	597.02	2.30	2.16	0.39	86.07
2.A.1 Cement Production	CO <sub>2</sub>	1549.54	1549.54	2.83	1.15	43.83	1.05	1.16	0.05	87.12
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	888.63	888.63	53.85	0.66	478.54	0.90	0.66	1.02	88.02
3.B Manure Management	N <sub>2</sub> O	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 <sub>4</sub>	608.01	608.01	75.33	0.45	457.99	0.70	0.45	1.43	89.59
3.B Manure Management	CH <sub>4</sub>	771	771	30	1	235	0.66	0.58	0.58	90.25
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	715	715	40	1	288	0.66	0.53	0.76	90.91
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	599	599	51	0	304	0.59	0.45	0.96	91.51
2.B.1 Ammonia Production	CO <sub>2</sub>	742	742	9	1	64	0.53	0.55	0.16	92.04
5.B Biological treatment of solid waste	CH <sub>4</sub>	634	634	91	0	579	0.80	0.47	1.73	92.84
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	348	348	141	0	488	0.55	0.26	2.66	93.39
5.D Wastewater treatment and discharge	CH <sub>4</sub>	861	861	58	1	502	0.90	0.64	1.11	94.29
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	141	141	60	0	85	0.15	0.10	1.14	94.43
4.A.2 Land converted to Forest Land	CO <sub>2</sub>	-492	492	29	0	143	0.42	0.37	0.55	94.85
2.A.2 Lime Production	CO <sub>2</sub>	610	610	3	0	17	0.41	0.45	0.05	95.27
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	387	387	18	0	70	0.30	0.29	0.34	95.57
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	246	246	60	0	148	0.26	0.18	1.14	95.83
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	249	249	50	0	125	0.25	0.19	0.95	96.07
4.C.2 Land converted to Grassland	CO <sub>2</sub>	-274	274	21	0	59	0.22	0.20	0.40	96.29
2.B.2 Nitric Acid Production	N <sub>2</sub> O	280	280	16	0	43	0.21	0.21	0.29	96.51
4.C.1 Grassland remaining Grassland	CO <sub>2</sub>	-276	276	17	0	47	0.21	0.21	0.32	96.72
5.D Wastewater treatment and discharge	N <sub>2</sub> O	197	197	56	0	111	0.20	0.15	1.07	96.92
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	224	224	40	0	90	0.21	0.17	0.76	97.13
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	270	270	8	0	21	0.19	0.20	0.14	97.32
3.H Urea application	CO <sub>2</sub>	187	187	54	0	101	0.19	0.14	1.02	97.51
1.A Stationary Combustion - Other	CO <sub>2</sub>	218	218	28	0	62	0.18	0.16	0.54	97.69

fuels - MSW										
1.A.3.c Transport - Railways	CO <sub>2</sub>	264	264	5	0	14	0.18	0.20	0.10	97.88
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	249	249	11	0	28	0.18	0.19	0.21	98.06
4.G Harvested wood products	CO <sub>2</sub>	-164	164	62	0	102	0.18	0.12	1.17	98.23
3.G Liming	CO <sub>2</sub>	163	163	54	0	88	0.17	0.12	1.02	98.40
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	146	146	61	0	89	0.15	0.11	1.15	98.55
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	189	189	25	0	48	0.16	0.14	0.48	98.71
4.E.2 Land converted to Settlements	CO <sub>2</sub>	88	88	101	0	89	0.12	0.07	1.92	98.83
2.D.1 Lubricant Use	CO <sub>2</sub>	116	116	50	0	58	0.11	0.09	0.95	98.94
5.C Incineration and open burning of waste	CO <sub>2</sub>	132	132	16	0	21	0.10	0.10	0.30	99.04
2.A.3 Glass Production	CO <sub>2</sub>	125	125	11	0	14	0.09	0.09	0.21	99.13
4.B.1 Cropland remaining Cropland	CO <sub>2</sub>	-84	84	51	0	43	0.08	0.06	0.97	99.22
4.A.1 Forest Land remaining Forest Land	CH <sub>4</sub>	82	82	50	0	41	0.08	0.06	0.95	99.30
4.B.2 Land converted to Cropland	CO <sub>2</sub>	84	84	35	0	29	0.07	0.06	0.65	99.37
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	99	99	8	0	8	0.07	0.07	0.14	99.44
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	75	75	40	0	30	0.07	0.06	0.76	99.51
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	71	71	16	0	11	0.05	0.05	0.30	99.57
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	71	71	5	0	4	0.05	0.05	0.09	99.62
1.A.3.c Transport - Railways	N <sub>2</sub> O	30	30	137	0	42	0.05	0.02	2.60	99.66
5.B Biological treatment of solid waste	N <sub>2</sub> O	45	45	5	0	2	0.03	0.03	0.10	99.69
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	37	37	40	0	15	0.03	0.03	0.76	99.73
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	25	25	303	0	77	0.07	0.02	5.73	99.80
4.D.2. Land converted to Wetlands	CO <sub>2</sub>	25	25	64	0	16	0.03	0.02	1.21	99.82
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	0	0	50	0	0	0.00	0.00	0.95	99.82
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	23	23	44	0	10	0.02	0.02	0.83	99.84
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	15	15	50	0	8	0.01	0.01	0.95	99.86
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	16	16	21	0	3	0.01	0.01	0.40	99.87
1.A.3.d Transport - Domestic navigation	CO <sub>2</sub>	13	13	5	0	1	0.01	0.01	0.10	99.88
2.C.5 Lead Production	CO <sub>2</sub>	9	9	51	0	4	0.01	0.01	0.97	99.89
2.C.1 Iron and Steel Production	CH <sub>4</sub>	10	10	31	0	3	0.01	0.01	0.58	99.90
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	6	6	60	0	4	0.01	0.00	1.14	99.91
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	10	10	6	0	1	0.01	0.01	0.10	99.91
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	7	7	60	0	4	0.01	0.01	1.14	99.92
4.A.1 Forest Land remaining Forest Land	N <sub>2</sub> O	7	7	50	0	3	0.01	0.01	0.95	99.93
2.F.4 Aerosols (CO <sub>2</sub> 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 <sub>2</sub>	5	5	75	0	4	0.01	0.00	1.43	99.94
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	6	6	50	0	3	0.01	0.00	0.95	99.94
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	5	5	61	0	3	0.01	0.00	1.15	99.95
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	5	5	64	0	3	0.00	0.00	1.21	99.95
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	4	4	60	0	3	0.00	0.00	1.14	99.96
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	3	3	51	0	2	0.00	0.00	0.97	99.96
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	3	3	73	0	2	0.00	0.00	1.38	99.97
2.C.2 Ferroalloys Production	CH <sub>4</sub>	4	4	25	0	1	0.00	0.00	0.48	99.97
5.C Incineration and open burning	N <sub>2</sub> O	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 <sub>2</sub> eq.)	SF <sub>6</sub>	3	3	22	0	1	0.00	0.00	0.42	99.97
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	3	3	44	0	1	0.00	0.00	0.83	99.98
1.A.3 Transport - Biomass	N <sub>2</sub> O	2	2	61	0	1	0.00	0.00	1.15	99.98
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	PFC	1	1	44	0	1	0.00	0.00	0.83	99.98
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	NF <sub>3</sub>	2	2	21	0	0	0.00	0.00	0.40	99.98
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	2	2	54	0	1	0.00	0.00	1.02	99.98
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	1	1	44	0	0	0.00	0.00	0.83	99.98
1.A.3 Transport - Biomass	CH <sub>4</sub>	1	1	51	0	0	0.00	0.00	0.96	99.99
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	1	1	50	0	0	0.00	0.00	0.96	99.99
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0	0	50	0	0	0.00	0.00	0.96	99.99
1.A.3.c Transport - Railways	CH <sub>4</sub>	0	0	158	0	1	0.00	0.00	2.98	99.99
2.C.2 Ferroalloys Production	CO <sub>2</sub>	1	1	25	0	0	0.00	0.00	0.48	99.99
2.C.6 Zinc Production	CO <sub>2</sub>	0	0	51	0	0	0.00	0.00	0.97	99.99
1.A.3.d Transport - Domestic navigation	N <sub>2</sub> O	0	0	137	0	0	0.00	0.00	2.60	99.99
1.A.3.a Transport - Domestic Aviation	N <sub>2</sub> O	0	0	110	0	0	0.00	0.00	2.08	99.99
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0	0	60	0	0	0.00	0.00	1.14	99.99
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0	0	50	0	0	0.00	0.00	0.95	99.99
1.A.3.d Transport - Domestic navigation	CH <sub>4</sub>	0	0	158	0	0	0.00	0.00	2.98	99.99
2.F.3 Fire Protection (CO <sub>2</sub> 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 <sub>2</sub> O	0	0	75	0	0	0.00	0.00	1.43	99.99
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	0	0	79	0	0	0.00	0.00	1.49	99.99
5.C Incineration and open burning of waste	CH <sub>4</sub>	0	0	82	0	0	0.00	0.00	1.56	99.99
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0	0	44	0	0	0.00	0.00	0.83	99.99
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0	0	44	0	0	0.00	0.00	0.83	99.99
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	0	0	44	0	0	0.00	0.00	0.83	99.99
4.B.2. Land converted to Cropland	N <sub>2</sub> O	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 <sub>2</sub>	56332	56332	5	42	2817	41	44.39	0.11	41.44
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	2693	2693	6	2	157	2	2.12	0.13	43.43
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	16986	16986	4	13	631	12	13.39	0.08	55.77
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	14418	14418	4	11	563	10	11.36	0.09	66.27
2.C.1 Iron and Steel Production	CO <sub>2</sub>	6873	6873	12	5	839	5	5.42	0.27	71.67
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	3385	3385	50	3	1693	4	2.67	1.10	75.23
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	3422	3422	44	3	1491	3	2.70	0.96	78.67
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	3581	3581	14	3	487	3	2.82	0.30	81.52
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	2569	2569	52	2	1341	3	2.02	1.15	84.26
3.A Enteric Fermentation	CH <sub>4</sub>	2896	2896	21	2	597	2	2.28	0.46	86.71
2.A.1 Cement Production	CO <sub>2</sub>	1550	1550	3	1	44	1	1.22	0.06	87.82
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	889	889	54	1	479	1	0.70	1.19	88.78
3.B Manure Management	N <sub>2</sub> O	1008	1008	30	1	307	1	0.79	0.67	89.70
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	608	608	75	0	458	1	0.48	1.66	90.45
3.B Manure Management	CH <sub>4</sub>	771	771	30	1	235	1	0.61	0.67	91.15
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	715	715	40	1	288	1	0.56	0.89	91.85
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	599	599	51	0	304	1	0.47	1.12	92.49
2.B.1 Ammonia Production	CO <sub>2</sub>	742	742	9	1	64	1	0.58	0.19	93.05
5.B Biological treatment of solid waste	CH <sub>4</sub>	634	634	91	0	579	1	0.50	2.02	93.90
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	348	348	141	0	488	1	0.27	3.10	94.49
5.D Wastewater treatment and discharge	CH <sub>4</sub>	861	861	58	1	502	1	0.68	1.29	95.44
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	141	141	60	0	85	0	0.11	1.33	95.60
2.A.2 Lime Production	CO <sub>2</sub>	610	610	3	0	17	0	0.48	0.06	96.04
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	387	387	18	0	70	0	0.31	0.40	96.36
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	246	246	60	0	148	0	0.19	1.33	96.64
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	249	249	50	0	125	0	0.20	1.11	96.90
2.B.2 Nitric Acid Production	N <sub>2</sub> O	280	280	16	0	43	0	0.22	0.34	97.12
5.D Wastewater treatment and discharge	N <sub>2</sub> O	197	197	56	0	111	0	0.16	1.24	97.34
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	224	224	40	0	90	0	0.18	0.89	97.56
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	270	270	8	0	21	0	0.21	0.17	97.76
3.H Urea application	CO <sub>2</sub>	187	187	54	0	101	0	0.15	1.19	97.96
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	218	218	28	0	62	0	0.17	0.62	98.16
1.A.3.c Transport - Railways	CO <sub>2</sub>	264	264	5	0	14	0	0.21	0.12	98.36

2.A.4 Other process uses of carbonates	CO <sub>2</sub>	249	249	11	0	28	0	0.20	0.25	98.55
3.G Liming	CO <sub>2</sub>	163	163	54	0	88	0	0.13	1.19	98.73
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	146	146	61	0	89	0	0.12	1.34	98.89
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	189	189	25	0	48	0	0.15	0.56	99.06
2.D.1 Lubricant Use	CO <sub>2</sub>	116	116	50	0	58	0	0.09	1.11	99.18
5.C Incineration and open burning of waste	CO <sub>2</sub>	132	132	16	0	21	0	0.10	0.35	99.28
2.A.3 Glass Production	CO <sub>2</sub>	125	125	11	0	14	0	0.10	0.25	99.38
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	99	99	8	0	8	0	0.08	0.17	99.46
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	75	75	40	0	30	0	0.06	0.89	99.53
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	71	71	16	0	11	0	0.06	0.35	99.59
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	71	71	5	0	4	0	0.06	0.11	99.64
1.A.3.c Transport - Railways	N <sub>2</sub> O	30	30	137	0	42	0	0.02	3.03	99.69
5.B Biological treatment of solid waste	N <sub>2</sub> O	45	45	5	0	2	0	0.04	0.11	99.72
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	37	37	40	0	15	0	0.03	0.89	99.76
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	25	25	303	0	77	0	0.02	6.68	99.83
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	0	0	50	0	0	0	0.00	1.11	99.83
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	23	23	44	0	10	0	0.02	0.96	99.85
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	15	15	50	0	8	0	0.01	1.11	99.87
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	16	16	21	0	3	0	0.01	0.47	99.88
1.A.3.d Transport - Domestic navigation	CO <sub>2</sub>	13	13	5	0	1	0	0.01	0.12	99.89
2.C.5 Lead Production	CO <sub>2</sub>	9	9	51	0	4	0	0.01	1.13	99.90
2.C.1 Iron and Steel Production	CH <sub>4</sub>	10	10	31	0	3	0	0.01	0.68	99.91
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	6	6	60	0	4	0	0.01	1.33	99.92
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	10	10	6	0	1	0	0.01	0.12	99.93
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	7	7	60	0	4	0	0.01	1.33	99.93
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	7	7	44	0	3	0	0.01	0.96	99.94
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	5	5	75	0	4	0	0.00	1.66	99.95
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	6	6	50	0	3	0	0.00	1.11	99.95
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	5	5	61	0	3	0	0.00	1.34	99.96
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	5	5	64	0	3	0	0.00	1.41	99.96
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	4	4	60	0	3	0	0.00	1.33	99.97
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	3	3	51	0	2	0	0.00	1.13	99.97
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	3	3	73	0	2	0	0.00	1.61	99.98
2.C.2 Ferroalloys Production	CH <sub>4</sub>	4	4	25	0	1	0	0.00	0.56	99.98
5.C Incineration and open burning of waste	N <sub>2</sub> O	2	2	73	0	2	0	0.00	1.61	99.98
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	3	3	22	0	1	0	0.00	0.49	99.99
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	3	3	44	0	1	0	0.00	0.96	99.99
1.A.3 Transport - Biomass	N <sub>2</sub> O	2	2	61	0	1	0	0.00	1.34	99.99
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	PFC	1	1	44	0	1	0	0.00	0.96	99.99
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	NF <sub>3</sub>	2	2	21	0	0	0	0.00	0.47	99.99

1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	2	2	54	0	1	0	0.00	1.19	100.00
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	1	1	44	0	0	0	0.00	0.96	100.00
1.A.3 Transport - Biomass	CH <sub>4</sub>	1	1	51	0	0	0	0.00	1.12	100.00
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	1	1	50	0	0	0	0.00	1.11	100.00
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0	0	50	0	0	0	0.00	1.11	100.00
1.A.3.c Transport - Railways	CH <sub>4</sub>	0	0	158	0	1	0	0.00	3.48	100.00
2.C.2 Ferroalloys Production	CO <sub>2</sub>	1	1	25	0	0	0	0.00	0.56	100.00
2.C.6 Zinc Production	CO <sub>2</sub>	0	0	51	0	0	0	0.00	1.13	100.00
1.A.3.d Transport - Domestic navigation	N <sub>2</sub> O	0	0	137	0	0	0	0.00	3.03	100.00
1.A.3.a Transport - Domestic Aviation	N <sub>2</sub> O	0	0	110	0	0	0	0.00	2.43	100.00
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0	0	60	0	0	0	0.00	1.33	100.00
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0	0	50	0	0	0	0.00	1.11	100.00
1.A.3.d Transport - Domestic navigation	CH <sub>4</sub>	0	0	158	0	0	0	0.00	3.48	100.00
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	0	0	44	0	0	0	0.00	0.96	100.00
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	0	0	75	0	0	0	0.00	1.66	100.00
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	0	0	79	0	0	0	0.00	1.74	100.00
5.C Incineration and open burning of waste	CH <sub>4</sub>	0	0	82	0	0	0	0.00	1.82	100.00
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0	0	44	0	0	0	0.00	0.96	100.00
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0	0	44	0	0	0	0.00	0.96	100.00
2.F.5 Solvents (CO <sub>2</sub> 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 amount BY	Uncertain amount 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 <sub>2</sub>	110823	56332	5	23	5541	2817	116364	59149	44	17	24	19.50	24.03
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	6177	16986	4	21	230	631	6406	17617	13	16	22	23.87	46.10
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	11201	14418	4	12	437	563	11638	14981	11	9	12	27.77	58.46
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	0	3422	44	6	0	1491	0	4913	4	6	8	38.10	66.46
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	15194	2693	6	11	886	157	16079	2850	2	9	12	39.18	78.45
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	10322	3581	14	5	1404	487	11726	4068	3	4	6	42.56	83.96
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	1979	3385	50	3	990	1693	2969	5078	4	4	5	54.28	89.16
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	-4664	-5650	21	1	-997	-1208	-5661	-6858	-5	-4	-5	45.91	83.84
4.G Harvested wood products	CO <sub>2</sub>	-1713	-164	62	4	-1062	-102	-2775	-266	0	-2	-2	45.21	81.41
3.A Enteric Fermentation	CH <sub>4</sub>	5755	2896	21	1	1186	597	6941	3493	3	1	1	49.34	82.90
3.G Liming	CO <sub>2</sub>	1178	163	54	1	634	88	1812	251	0	1	1	49.95	84.36
3.B Manure Management	N <sub>2</sub> O	2459	1008	30	1	748	307	3207	1314	1	1	1	52.07	85.54
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	1212	249	50	1	608	125	1821	374	0	1	1	52.94	86.81
5.B Biological treatment of solid waste	CH <sub>4</sub>	0	634	91	0	0	579	0	1213	1	1	2	56.94	88.79
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	4210	2569	52	0	2198	1341	6408	3910	3	0	0	66.23	89.05
3.B Manure Management	CH <sub>4</sub>	1752	771	30	1	533	235	2285	1006	1	1	1	67.85	89.77
2.B.2 Nitric Acid Production	N <sub>2</sub> O	1050	280	16	1	163	43	1213	324	0	1	1	68.15	90.50
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	335	599	51	1	170	304	505	903	1	1	1	70.26	91.45
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	137	348	141	0	192	488	329	836	1	1	1	73.64	92.47
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	0	387	18	1	0	70	0	457	0	1	1	74.12	93.22
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	1587	889	54	0	855	479	2442	1367	1	0	0	77.43	93.52
2.A.2 Lime Production	CO <sub>2</sub>	1337	610	3	0	38	17	1374	627	0	0	0	77.55	93.92
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	49	141	60	0	29	85	78	225	0	0	0	78.14	94.20
4.A.2 Land converted to Forest Land	CO <sub>2</sub>	-321	-492	29	0	-93	-143	-414	-634	0	0	-1	77.15	93.60
4.C.1 Grassland remaining Grassland	CO <sub>2</sub>	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 <sub>4</sub>	1080	608	75	0	813	458	1893	1066	1	0	0	80.00	93.29
1.A.5.b Mobile	CO <sub>2</sub>	0	270	8	0	0	21	0	290	0	0	0	80.14	93.77

sources in Agriculture and Forestry														
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	24	218	28	0	7	62	31	280	0	0	0	80.57	94.19
2.A.1 Cement Production	CO <sub>2</sub>	2489	1550	3	0	70	44	2560	1593	1	0	0	80.87	94.24
5.D Wastewater treatment and discharge	CH <sub>4</sub>	890	861	58	0	519	502	1409	1363	1	1	1	84.35	95.01
1.A.3.c Transport - Railways	CO <sub>2</sub>	654	264	5	0	34	14	688	278	0	0	0	84.45	95.27
4.C.2 Land converted to Grassland	CO <sub>2</sub>	-145	-274	21	0	-31	-59	-176	-333	0	0	0	84.04	94.91
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	109	249	11	0	12	28	121	277	0	0	0	84.23	95.23
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	456	189	25	0	116	48	572	236	0	0	0	84.56	95.44
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	792	715	40	0	319	288	1112	1003	1	0	0	86.56	95.92
3.H Urea application	CO <sub>2</sub>	109	187	54	0	58	101	167	288	0	0	0	87.26	96.22
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	483	246	60	0	290	148	773	394	0	0	0	88.28	96.38
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	69	146	61	0	42	89	110	235	0	0	0	88.90	96.65
5.C Incineration and open burning of waste	CO <sub>2</sub>	23	132	16	0	4	21	27	153	0	0	0	89.04	96.87
4.B.1 Cropland remaining Cropland	CO <sub>2</sub>	-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 <sub>2</sub>	0	99	8	0	0	8	0	107	0	0	0	88.80	96.84
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	206	224	40	0	83	90	289	314	0	0	0	89.42	97.05
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	139	10	6	0	8	1	147	11	0	0	0	89.42	97.18
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	5	71	5	0	0	4	6	75	0	0	0	89.45	97.30
2.C.1 Iron and Steel Production	CO <sub>2</sub>	9643	6873	12	1	1177	839	10820	7712	6	1	1	95.26	98.67
5.D Wastewater treatment and discharge	N <sub>2</sub> O	234	197	56	0	132	111	366	308	0	0	0	96.03	98.79
4.E.2 Land converted to Settlements	CO <sub>2</sub>	85	88	101	0	86	89	171	178	0	0	0	96.65	98.90
5.B Biological treatment of solid waste	N <sub>2</sub> O	0	45	5	0	0	2	0	47	0	0	0	96.66	98.98
2.D.1 Lubricant Use	CO <sub>2</sub>	116	116	50	0	58	58	174	174	0	0	0	97.06	99.08
1.A.3.c Transport - Railways	N <sub>2</sub> O	75	30	137	0	103	42	178	72	0	0	0	97.35	99.15
2.A.3 Glass Production	CO <sub>2</sub>	124	125	11	0	14	14	137	139	0	0	0	97.45	99.23
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	0	23	44	0	0	10	0	33	0	0	0	97.52	99.29
2.B.1 Ammonia Production	CO <sub>2</sub>	991	742	9	0	85	64	1076	805	1	0	0	97.96	99.49
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	22	0	50	0	11	0	32	0	0	0	0	97.96	99.52
1.A.3.d Transport - Domestic navigation	CO <sub>2</sub>	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 <sub>2</sub> O	75	75	40	0	30	30	105	105	0	0	0	98.17	99.62
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0	16	21	0	0	3	0	20	0	0	0	98.20	99.65
4.D.2. Land converted to Wetlands	CO <sub>2</sub>	22	25	64	0	14	16	35	41	0	0	0	98.31	99.68
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	36	37	40	0	15	15	51	52	0	0	0	98.41	99.72
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	13	15	50	0	6	8	19	23	0	0	0	98.46	99.73

2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	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 <sub>2</sub> O	0	7	60	0	0	4	0	11	0	0	0	98.57	99.78
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	0	7	44	0	0	3	0	10	0	0	0	98.59	99.80
2.C.5 Lead Production	CO <sub>2</sub>	4	9	51	0	2	4	6	13	0	0	0	98.62	99.81
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	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 <sub>2</sub> O	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 <sub>2</sub>	2	5	75	0	2	4	4	9	0	0	0	98.69	99.85
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	1	5	64	0	0	3	1	7	0	0	0	98.71	99.86
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	6	6	60	0	4	4	10	10	0	0	0	98.74	99.87
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	0	3	51	0	0	2	0	5	0	0	0	98.75	99.88
4.B.2. Land converted to Cropland	N <sub>2</sub> O	9	5	250	0	22	12	31	17	0	0	0	98.83	99.88
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	0	3	73	0	0	2	1	5	0	0	0	98.85	99.89
2.C.2 Ferroalloys Production	CH <sub>4</sub>	0	4	25	0	0	1	0	5	0	0	0	98.86	99.90
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0	3	22	0	0	1	0	4	0	0	0	98.86	99.90
4.A.1 Forest Land remaining Forest Land	CH <sub>4</sub>	117	82	50	0	59	41	176	123	0	0	0	99.14	99.92
2.F.2 Foam Blowing (CO <sub>2</sub> 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 <sub>2</sub> O	0	2	73	0	0	2	1	4	0	0	0	99.16	99.93
1.A.3 Transport - Biomass	N <sub>2</sub> O	0	2	61	0	0	1	0	4	0	0	0	99.17	99.94
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	38	25	303	0	113	77	151	102	0	0	0	99.70	99.95
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> 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 <sub>2</sub> eq.)	NF <sub>3</sub>	0	2	21	0	0	0	0	3	0	0	0	99.71	99.96
4.B.2 Land converted to Cropland	CO <sub>2</sub>	114	84	35	0	39	29	153	113	0	0	0	99.91	99.98
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	0	2	54	0	0	1	0	3	0	0	0	99.92	99.99
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	9	6	50	0	5	3	14	9	0	0	0	99.94	99.99
2.C.1 Iron and Steel Production	CH <sub>4</sub>	15	10	31	0	5	3	19	13	0	0	0	99.96	99.99
2.F.5 Solvents (CO <sub>2</sub> 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 <sub>2</sub> O	1	0	110	0	1	0	2	0	0	0	0	99.96	99.99
1.A.3 Transport - Biomass	CH <sub>4</sub>	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 <sub>4</sub>	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 <sub>4</sub>	0	0	50	0	0	0	0	1	0	0	0	99.97	99.99
2.C.2 Ferroalloys Production	CO <sub>2</sub>	0	1	25	0	0	0	0	1	0	0	0	99.97	100.00
2.C.6 Zinc Production	CO <sub>2</sub>	0	0	51	0	0	0	0	1	0	0	0	99.97	100.00
1.A.3.c Transport - Railways	CH <sub>4</sub>	1	0	158	0	1	1	2	1	0	0	0	99.97	100.00
1.A.3.d Transport -	N <sub>2</sub> O	0	0	137	0	1	0	1	0	0	0	0	99.98	100.00

Domestic navigation														
4.A.1 Forest Land remaining Forest Land	N <sub>2</sub> O	10	7	50	0	5	3	14	10	0	0	0	100.00	100.00
1.A.3.d Transport - Domestic navigation	CH <sub>4</sub>	0	0	158	0	0	0	0	0	0	0	0	100.00	100.00
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0	0	60	0	0	0	0	0	0	0	0	100.00	100.00
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0	0	50	0	0	0	0	0	0	0	0	100.00	100.00
2.F.3 Fire Protection (CO <sub>2</sub> 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 <sub>2</sub> O	0	0	75	0	0	0	0	0	0	0	0	100.00	100.00
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	0	0	79	0	0	0	0	0	0	0	0	100.00	100.00
5.C Incineration and open burning of waste	CH <sub>4</sub>	0	0	82	0	0	0	0	0	0	0	0	100.00	100.00
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0	0	44	0	0	0	0	0	0	0	0	100.00	100.00
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0	0	44	0	0	0	0	0	0	0	0	100.00	100.00
2.F.5 Solvents (CO <sub>2</sub> 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 categories	GHG	Base Year Estimate (Abs)	Current Year Estimate (Abs)	Combined Uncertainty	TA_A1	Uncertain amount BY	Uncertain amount 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 <sub>2</sub>	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 <sub>2</sub>	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 <sub>2</sub>	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 <sub>2</sub> 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 <sub>2</sub>	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 <sub>4</sub>	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 <sub>4</sub>	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 <sub>4</sub>	5754.891	2895.958	30.61553	1.246789	1186.401	597.0171	6941.292	3492.975	2.446934	1.086374	1.458819	53.2159	83.22571
3.G Liming	CO <sub>2</sub>	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 <sub>2</sub> O	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 <sub>4</sub>	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 <sub>4</sub>	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 <sub>2</sub> O emissions	N <sub>2</sub> O	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 <sub>4</sub>	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 <sub>2</sub> O	1050.292	280.1217	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 <sub>4</sub>	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 <sub>2</sub> O	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 <sub>2</sub>	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 <sub>2</sub> O emissions	N <sub>2</sub> O	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 <sub>2</sub>	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 <sub>2</sub> O	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 <sub>4</sub>	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 <sub>2</sub>	0	269.7826	7.615773	0.438885	0	20.54603	0	290.3286	0.203384	0.31387	0.421476	82.47262	94.3251

1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	24.043 74	218.42 95	28.284 27	0.3304 51	6.8005 97	61.781 18	30.844 34	280.21 06	0.1962 96	0.2813 25	0.3777 72	82.862 35	94.702 87
2.A.1 Cement Production	CO <sub>2</sub>	2489.1 84	1549.5 43	2.8284 27	0.0562 08	70.404 76	43.827 69	2559.5 89	1593.3 71	1.1162 04	0.0704 97	0.0946 66	83.138 83	94.797 54
5.D Wastewater treatment and discharge	CH <sub>4</sub>	889.80 47	860.55 91	58.383 52	0.4787 63	519.49 93	502.42 47	1409.3 04	1362.9 84	0.9548 11	0.4862 44	0.6529 45	86.308 26	95.450 48
1.A.3.c Transport - Railways	CO <sub>2</sub>	653.85 84	264.11 23	5.2201 53	0.2472 7	34.132 41	13.787 07	687.99 08	277.89 94	0.1946 77	0.1815 25	0.2437 58	86.395 23	95.694 24
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	109.14 94	249.14 97	11.180 34	0.2923 18	12.203 27	27.855 79	121.35 26	277.00 55	0.1940 51	0.2144 56	0.2879 78	86.570 96	95.982 22
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	456.24 2	188.52 83	25.317 98	0.1656 42	115.51 12	47.731 54	571.75 32	236.25 98	0.1655 07	0.1451 13	0.1948 62	86.872 06	96.177 08
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	792.46 5	715.16 09	40.311 29	0.3430 02	319.45 29	288.29 06	1111.9 18	1003.4 51	0.7029 48	0.3058 86	0.4107 54	88.690 68	96.587 83
3.H Urea application	CO <sub>2</sub>	108.53 33	187.09 9	53.851 65	0.1920 11	58.446 99	100.75 59	166.98 03	287.85 49	0.2016 51	0.1942 21	0.2608 07	89.326 27	96.848 64
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	482.97 22	246.31 81	60.133 19	0.0993 02	290.42 66	148.11 89	773.39 88	394.43 71	0.2763 15	0.1153 68	0.1549 21	90.260 65	97.003 56
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	68.580 59	146.43 66	60.530 98	0.1672 24	41.512 5	88.639 54	110.09 31	235.07 62	0.1646 78	0.1770 14	0.2377 01	90.819 81	97.241 26
5.C Incineration and open burning of waste	CO <sub>2</sub>	23.148 68	132.42 8	15.811 39	0.1914 7	3.6601 27	20.938 71	26.808 8	153.36 68	0.1074 38	0.1470 22	0.1974 27	90.951 9	97.438 69
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	0	99.070 4	7.6157 73	0.1611 69	0	7.5449 77	0	106.61 54	0.0746 87	0.1152 6	0.1547 76	90.999 49	97.593 46
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	206.21 6	223.5	40.311 29	0.1500 99	83.128 33	90.095 73	289.34 43	313.59 57	0.2196 83	0.1363 3	0.1830 68	91.567 84	97.776 53
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	139.43 89	10.227 29	5.5389	0.1277 21	7.7233 82	0.5664 79	147.16 23	10.793 77	0.0075 61	0.0914 23	0.1227 65	91.571 41	97.899 3
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	5.4237 96	71.036 47	5	0.1099 48	0.2711 9	3.5518 24	5.6949 86	74.588 3	0.0522 51	0.0766 47	0.1029 24	91.593 82	98.002 22
2.C.1 Iron and Steel Production	CO <sub>2</sub>	9642.5 38	6872.7 95	12.206 56	1.1979 4	1177.0 22	838.93 16	10819. 56	7711.7 27	5.4022 95	0.7576 19	1.0173 56	96.886 03	99.019 58
5.D Wastewater treatment and discharge	N <sub>2</sub> O	234.18 06	197.23 48	56.356 01	0.0784 19	131.97 48	111.15 37	366.15 54	308.38 85	0.2160 35	0.0768 92	0.1032 53	97.587 22	99.122 83
5.B Biological treatment of solid waste	N <sub>2</sub> O	0	44.585 24	5.0358 71	0	0	2.2452 55	0	46.830 5	0.0328 06	0.0506 28	0.0679 85	97.601 38	99.190 81
2.D.1 Lubricant Use	CO <sub>2</sub>	116.13 1	115.54 15	50.249 38	0.0677 35	58.355 09	58.058 87	174.48 61	173.60 04	0.1216 12	0.0654 44	0.0878 81	97.967 64	99.278 7
1.A.3.c Transport - Railways	N <sub>2</sub> O	75.205 19	30.377 55	137.29 11	0.0284 4	103.25	41.705 67	178.45 52	72.083 22	0.0504 96	0.0470 85	0.0632 27	98.230 73	99.341 92
2.A.3 Glass Production	CO <sub>2</sub>	123.65 81	125.46 64	11.180 34	0.0760 88	13.825 4	14.027 57	137.48 35	139.49 4	0.0977 2	0.0544 94	0.0731 76	98.319 22	99.415 1
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	0	22.730 36	43.566 04	0.0369 78	0	9.9027 19	0	32.633 08	0.0228 6	0.0352 79	0.0473 74	98.381 68	99.462 47
2.B.1 Ammonia Production	CO <sub>2</sub>	990.80 21	741.66 18	8.6023 25	0.1807 78	85.232 02	63.800 16	1076.0 34	805.46 2	0.5642 5	0.1169 8	0.1570 85	98.784 15	99.619 56
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	21.578 47	0.1821 57	50.249 38	0.0220 44	10.843 04	0.0915 33	32.421 51	0.2736 9	0.0001 92	0.0224 16	0.0301 01	98.784 73	99.649 66
1.A.3.d Transport - Domestic navigation	CO <sub>2</sub>	56.612 4	12.728 31	5.2201 53	0.0379 04	2.9552 54	0.6644 37	59.567 65	13.392 74	0.0093 82	0.0272 5	0.0365 92	98.788 92	99.686 25
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	74.5	74.5	40.311 29	0.0440 68	30.031 91	30.031 91	104.53 19	104.53 19	0.0732 28	0.0397 8	0.0534 18	98.978 37	99.739 67
2.E.1 Integrated Circuit or Semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0	16.245	21.213 2	0	0	3.4460 85	0	19.691 08	0.0137 94	0.0212 88	0.0285 86	99.000 11	99.768 26
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	36.169 07	36.812 98	40.311 29	0.0224 42	14.580 22	14.839 79	50.749 29	51.652 77	0.0361 84	0.0202 9	0.0272 46	99.093 72	99.795 5
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	12.791	15.113 26	50.089 92	0.0113 44	6.4070 04	7.5702 19	19.198 01	22.683 48	0.0158 9	0.0110 74	0.0148 71	99.141 48	99.810 37
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	84.102 63	71.082 9	15.811 39	0.0285 68	13.297 79	11.239 19	97.400 43	82.322 09	0.0576 69	0.0207 65	0.0278 84	99.212 38	99.838 26
1.A.5.b Mobile sources in	N <sub>2</sub> O	0	6.7185 56	60.406 95	0.0109 3	0	4.0584 75	0	10.777 03	0.0075 5	0.0116 51	0.0156 45	99.237 98	99.853 9

Agriculture and Forestry														
2.F.4 Aerosols (CO <sub>2</sub> 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 <sub>2</sub>	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 <sub>2</sub> O	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 <sub>2</sub> O	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 <sub>2</sub>	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 <sub>4</sub>	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 <sub>2</sub> O	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 <sub>4</sub>	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 <sub>2</sub> O	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 <sub>4</sub>	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 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	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 <sub>2</sub> 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 <sub>2</sub> O	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 <sub>2</sub> O	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 <sub>4</sub>	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 <sub>2</sub> 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 <sub>2</sub> eq.)	NF <sub>3</sub>	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 <sub>4</sub>	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 <sub>2</sub>	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 <sub>4</sub>	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 <sub>2</sub> 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 <sub>2</sub> O	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 <sub>4</sub>	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 <sub>4</sub>	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 <sub>4</sub>	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 <sub>2</sub>	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 <sub>2</sub>	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 <sub>4</sub>	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 <sub>2</sub> O	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 <sub>4</sub>	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 <sub>2</sub> O	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 <sub>4</sub>	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 <sub>2</sub> 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 <sub>2</sub> O	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 <sub>4</sub>	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 <sub>4</sub>	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 <sub>2</sub> eq.)	PFC	0	0	43.56604	0	0	0	0	0	0	0	0	100	100
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0	0	43.56604	0	0	0	0	0	0	0	0	100	100
2.F.5 Solvents (CO <sub>2</sub> 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 <sub>4</sub>	265.05	417.63	8	50
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	58.65	113.88	8	60
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	11195.61	13719.29	3	3
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	12.79	17.72	3	50
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	6.12	7.39	3	60
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	22219.95	19121.96	5	3
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	60.16	22.54	5	50
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	262.57	673.47	5	60
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	0.00	301.59	10	15
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	0.00	0.81	10	50
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	0.00	1.35	10	60
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	24.04	221.01	20	20
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	0.20	1.81	20	50
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	0.31	2.87	20	70
1.A Stationary Combustion - Solid Fuels	CO <sub>2</sub>	110822.55	55609.34	4	3
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	1212.44	186.20	4	50
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	450.92	226.17	4	60
1.A.3.a Transport - Civil Aviation	CO <sub>2</sub>	139.44	7.02	4	4
1.A.3.a Transport - Civil Aviation	CH <sub>4</sub>	0.02	0.00	4	21
1.A.3.a Transport - Civil Aviation	N <sub>2</sub> O	1.19	0.06	4	40
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	6176.54	16117.13	3	2
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	37.50	23.33	3	100
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	136.73	610.49	3	100
1.A.3.c Transport - Railways	CO <sub>2</sub>	653.86	273.78	5	1
1.A.3.c Transport - Railways	CH <sub>4</sub>	0.92	0.38	5	100
1.A.3.c Transport - Railways	N <sub>2</sub> O	75.21	31.49	5	100
1.A.3.d Transport - Navigation	CO <sub>2</sub>	56.61	9.55	5	2
1.A.3.d Transport - Navigation	CH <sub>4</sub>	0.13	0.02	5	50
1.A.3.d Transport - Navigation	N <sub>2</sub> O	0.46	0.08	5	90
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	5.42	83.72	4	3
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0.00	0.04	4	50
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0.00	0.05	4	60
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	0.00	71.21	7	3
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0.00	0.36	7	50
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	0.00	3.04	7	60
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	0.00	260.37	7	3
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	0.00	0.49	7	50
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	0.00	6.72	7	60
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	456.24	196.83	4	25
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	9119.12	3129.84	4	13
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	0.75	4.93	40	50
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	2.20	0.05	7	75
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	1079.91	625.48	7	75
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	0.01	0.03	7	75
2.A.1 Cement Production	CO <sub>2</sub>	2489.18	1482.00	2	2
2.A.2 Lime Production	CO <sub>2</sub>	1336.65	629.04	2	2
2.A.3 Glass Production	CO <sub>2</sub>	123.66	111.93	5	10
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	109.15	320.51	5	10
2.B.1 Ammonia Production	CO <sub>2</sub>	990.80	689.05	5	7
2.B.2 Nitric Acid Production	N <sub>2</sub> O	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 <sub>2</sub> O	74.50	74.50	5	40
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	792.47	1080.92	5	40
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	36.17	53.22	5	40
2.B.10 Other	CO <sub>2</sub>	0.00	219.52	3	3
2.C.1 Iron and Steel Production	CH <sub>4</sub>	9642.54	6498.79	7	10
2.C.1 Iron and Steel Production	CO <sub>2</sub>	14.84	10.09	7	30
2.C.2 Ferroalloys Production	CH <sub>4</sub>	0.00	56.72	5	25
2.C.2 Ferroalloys Production	CO <sub>2</sub>	0.01	502.72	5	25
2.C.5 Lead Production	CH <sub>4</sub>	10.40	24.10	10	50
2.C.6 Zinc Production	CO <sub>2</sub>	0.00	0.29	10	50
2.D.1 Lubricant Use	CO <sub>2</sub>	116.13	92.55	5	50
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	9.43	7.07	5	50
2.D.3 Urea used as catalyst	CO <sub>2</sub>	0.00	17.02	5	5
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	CO <sub>2</sub>	0.00	17.20	15	15
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	2.35	15	15
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	NF <sub>3</sub>	0.21	2796.90	37	23
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	0.00	4.85	37	23
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0.00	2.64	37	23
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	0.00	0.00	37	23
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	0.00	20.88	37	23
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	0.00	0.03	37	23
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0.00	8.11	37	23
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	0.00	0.00	37	23
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	0.00	1.86	37	23
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	0.00	0.00	37	23
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	PFC	85.22	75.56	5	15
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	3.26	10	20
2.G.3 N <sub>2</sub> O from product uses	SF <sub>6</sub>	206.22	223.50	5	40
3.A Enteric Fermentation	N <sub>2</sub> O	5754.89	2817.27	5	20
3.B Manure Management	CH <sub>4</sub>	1772.43	768.19	5	30
3.B Manure Management	CH <sub>4</sub>	3309.60	1312.02	5	30
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	3991.85	2397.43	15	50
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	1500.79	784.92	20	50
3.G Liming	N <sub>2</sub> O	1177.82	150.29	20	50
3.H Urea application	CO <sub>2</sub>	108.53	57.03	20	50
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	-4644.62	-6907.74	0	18
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	117.30	73.31	0	50
4.A.1 Forest Land remaining Forest Land	CH <sub>4</sub>	9.61	6.01	0	50
4.A.2 Land converted to Forest Land	N <sub>2</sub> O	-321.25	-482.21	0	29
4.B.1 Cropland remaining Cropland	CO <sub>2</sub>	-2.28	-76.00	0	52
4.B.2 Land converted to Cropland	CO <sub>2</sub>	113.99	88.11	0	38
4.B.2. Land converted to Cropland	CO <sub>2</sub>	8.91	0.00	0	250
4.C.1 Grassland remaining Grassland	N <sub>2</sub> O	0.00	-273.92	0	17
4.C.2 Land converted to Grassland	CO <sub>2</sub>	-145.34	-295.18	0	20
4.D.2. Land converted to Wetlands	CO <sub>2</sub>	21.51	26.76	0	66
4.E.2 Land converted to Settlements	CO <sub>2</sub>	85.09	127.60	0	101
4.F.2 Land converted to Other Land	CO <sub>2</sub>	0.00	8.55	0	101
4.G Harvested wood products	CO <sub>2</sub>	-1712.95	-94.13	0	62
5.A Solid Waste Disposal on Land	CO <sub>2</sub>	1979.27	3330.79	30	40
5.B Biological treatment of solid waste	CH <sub>4</sub>	0.00	617.79	20	10
5.B Biological treatment of solid waste	CH <sub>4</sub>	0.00	36.50	20	1
5.C Incineration and open burning of waste	N <sub>2</sub> O	23.15	131.74	20	5
5.C Incineration and open burning of waste	CO <sub>2</sub>	0.00	0.00	20	50
5.C Incineration and open burning of waste	CH <sub>4</sub>	0.42	2.39	20	70
5.D Wastewater treatment and discharge	N <sub>2</sub> O	1138.23	731.05	21	50
5.D Wastewater treatment and discharge	CH <sub>4</sub>	234.18	204.00	26	50
1.A.3 Transport - Biomass	N <sub>2</sub> O	0.00	0.63	8	50
1.A.3 Transport - Biomass	CH <sub>4</sub>	0.00	2.37	8	60
	<b>Total</b>	<b>196142.60</b>	<b>132929.89</b>		

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 <sub>4</sub>	50.64	211.47	0.1591
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	60.53	68.93	0.0519
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	3.91	535.76	0.4030
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	50.09	8.87	0.0067
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	60.07	4.44	0.0033
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	5.83	1114.99	0.8388
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	50.25	11.33	0.0085
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	60.21	405.48	0.3050
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	18.03	54.37	0.0409
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	50.99	0.41	0.0003
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	60.83	0.82	0.0006
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	28.28	62.51	0.0470
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	53.85	0.97	0.0007
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	72.80	2.09	0.0016
1.A Stationary Combustion - Solid Fuels	CO <sub>2</sub>	5.00	2780.47	2.0917
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	50.16	93.40	0.0703
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	60.13	136.00	0.1023
1.A.3.a Transport - Civil Aviation	CO <sub>2</sub>	5.47	0.38	0.0003
1.A.3.a Transport - Civil Aviation	CH <sub>4</sub>	21.38	0.00	0.0000
1.A.3.a Transport - Civil Aviation	N <sub>2</sub> O	40.20	0.03	0.0000
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	3.82	615.19	0.4628
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	100.04	23.34	0.0176
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	100.04	610.76	0.4595
1.A.3.c Transport - Railways	CO <sub>2</sub>	5.21	14.28	0.0107
1.A.3.c Transport - Railways	CH <sub>4</sub>	100.12	0.38	0.0003
1.A.3.c Transport - Railways	N <sub>2</sub> O	100.12	31.53	0.0237
1.A.3.d Transport - Navigation	CO <sub>2</sub>	5.22	0.50	0.0004
1.A.3.d Transport - Navigation	CH <sub>4</sub>	50.25	0.01	0.0000
1.A.3.d Transport - Navigation	N <sub>2</sub> O	90.14	0.07	0.0001
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	5.00	4.19	0.0031
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	50.16	0.02	0.0000
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	60.13	0.03	0.0000
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	7.62	5.42	0.0041
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	50.49	0.18	0.0001
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	60.41	1.84	0.0014
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	7.62	19.83	0.0149
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	50.49	0.25	0.0002
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	60.41	4.06	0.0031
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	25.32	49.83	0.0375
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	13.60	425.70	0.3202
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	64.03	3.15	0.0024
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	75.33	0.04	0.0000
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	75.33	471.15	0.3544
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	75.33	0.02	0.0000
2.A.1 Cement Production	CO <sub>2</sub>	2.83	41.92	0.0315
2.A.2 Lime Production	CO <sub>2</sub>	2.83	17.79	0.0134
2.A.3 Glass Production	CO <sub>2</sub>	11.18	12.51	0.0094
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	11.18	35.83	0.0270
2.B.1 Ammonia Production	CO <sub>2</sub>	8.60	59.27	0.0446
2.B.2 Nitric Acid Production	N <sub>2</sub> O	15.52	39.68	0.0299
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	40.31	30.03	0.0226
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	40.31	435.73	0.3278
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	40.31	21.45	0.0161
2.B.10 Other	CO <sub>2</sub>	3.91	8.57	0.0064
2.C.1 Iron and Steel Production	CH <sub>4</sub>	12.21	793.28	0.5968
2.C.1 Iron and Steel Production	CO <sub>2</sub>	30.81	3.11	0.0023
2.C.2 Ferroalloys Production	CH <sub>4</sub>	25.50	14.46	0.0109
2.C.2 Ferroalloys Production	CO <sub>2</sub>	25.50	128.17	0.0964
2.C.5 Lead Production	CH <sub>4</sub>	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 <sub>2</sub>	50.99	0.15	0.0001
2.D.1 Lubricant Use	CO <sub>2</sub>	50.25	46.51	0.0350
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	50.25	3.55	0.0027
2.D.3 Urea used as catalyst	CO <sub>2</sub>	7.07	1.20	0.0009
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	CO <sub>2</sub>	21.21	3.65	0.0027
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	21.21	0.50	0.0004
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	NF <sub>3</sub>	43.57	1218.50	0.9166
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	43.57	2.12	0.0016
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	43.57	1.15	0.0009
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	43.57	0.00	0.0000
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	43.57	9.10	0.0068
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	43.57	0.01	0.0000
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	43.57	3.53	0.0027
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	43.57	0.00	0.0000
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	43.57	0.81	0.0006
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	43.57	0.00	0.0000
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	PFC	15.81	11.95	0.0090
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	22.36	0.73	0.0005
2.G.3 N <sub>2</sub> O from product uses	SF <sub>6</sub>	40.31	90.10	0.0678
3.A Enteric Fermentation	N <sub>2</sub> O	20.62	580.80	0.4369
3.B Manure Management	CH <sub>4</sub>	30.41	233.64	0.1758
3.B Manure Management	CH <sub>4</sub>	30.41	399.04	0.3002
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	52.20	1251.50	0.9415
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	53.85	422.69	0.3180
3.G Liming	N <sub>2</sub> O	53.85	80.93	0.0609
3.H Urea application	CO <sub>2</sub>	53.85	30.71	0.0231
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	18.41	-1271.82	-0.9568
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	50.00	36.65	0.0276
4.A.1 Forest Land remaining Forest Land	CH <sub>4</sub>	50.00	3.00	0.0023
4.A.2 Land converted to Forest Land	N <sub>2</sub> O	28.97	-139.68	-0.1051
4.B.1 Cropland remaining Cropland	CO <sub>2</sub>	52.31	-39.76	-0.0299
4.B.2 Land converted to Cropland	CO <sub>2</sub>	38.10	33.57	0.0253
4.B.2. Land converted to Cropland	CO <sub>2</sub>	250.00	0.00	0.0000
4.C.1 Grassland remaining Grassland	N <sub>2</sub> O	16.94	-46.41	-0.0349
4.C.2 Land converted to Grassland	CO <sub>2</sub>	19.69	-58.13	-0.0437
4.D.2. Land converted to Wetlands	CO <sub>2</sub>	65.90	17.64	0.0133
4.E.2 Land converted to Settlements	CO <sub>2</sub>	101.47	129.48	0.0974
4.F.2 Land converted to Other Land	CO <sub>2</sub>	101.47	8.67	0.0065
4.G Harvested wood products	CO <sub>2</sub>	62.00	-58.36	-0.0439
5.A Solid Waste Disposal on Land	CO <sub>2</sub>	50.00	1665.39	1.2528
5.B Biological treatment of solid waste	CH <sub>4</sub>	22.36	138.14	0.1039
5.B Biological treatment of solid waste	CH <sub>4</sub>	20.01	7.30	0.0055
5.C Incineration and open burning of waste	N <sub>2</sub> O	20.62	27.16	0.0204
5.C Incineration and open burning of waste	CO <sub>2</sub>	53.85	0.00	0.0000
5.C Incineration and open burning of waste	CH <sub>4</sub>	72.80	1.74	0.0013
5.D Wastewater treatment and discharge	N <sub>2</sub> O	54.23	396.45	0.2982
5.D Wastewater treatment and discharge	CH <sub>4</sub>	56.36	114.97	0.0865
1.A.3 Transport - Biomass	N <sub>2</sub> O	50.64	0.32	0.0002
1.A.3 Transport - Biomass	CH <sub>4</sub>	60.53	1.44	0.0011
		<b>Level uncertainty =</b>	<b>14789.24</b>	<b>3.36</b>



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 <sub>4</sub>	0.0012	0.0021	0.0607	0.0241	0.0653
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	0.0004	0.0006	0.0227	0.0066	0.0236
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	0.0312	0.0699	0.0781	0.2968	0.3069
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	0.0000	0.0001	0.0023	0.0004	0.0023
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	0.0000	0.0000	0.0010	0.0002	0.0010
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	0.0207	0.0975	0.0621	0.6894	0.6921
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	-0.0001	0.0001	-0.0046	0.0008	0.0047
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	0.0025	0.0034	0.1516	0.0243	0.1535
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	0.0015	0.0015	0.0231	0.0217	0.0317
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	0.0000	0.0000	0.0002	0.0001	0.0002
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	0.0000	0.0000	0.0004	0.0001	0.0004
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	0.0010	0.0011	0.0209	0.0319	0.0381
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	0.0000	0.0000	0.0004	0.0003	0.0005
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	0.0000	0.0000	0.0009	0.0004	0.0010
1.A Stationary Combustion - Solid Fuels	CO <sub>2</sub>	-0.0988	0.2835	-0.2965	1.6038	1.6310
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	-0.0032	0.0009	-0.1620	0.0054	0.1621
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	-0.0004	0.0012	-0.0243	0.0065	0.0252
1.A.3.a Transport - Civil Aviation	CO <sub>2</sub>	-0.0004	0.0000	-0.0017	0.0002	0.0017
1.A.3.a Transport - Civil Aviation	CH <sub>4</sub>	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Transport - Civil Aviation	N <sub>2</sub> O	0.0000	0.0000	-0.0002	0.0000	0.0002
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	0.0608	0.0822	0.1435	0.3486	0.3770
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	0.0000	0.0001	-0.0011	0.0005	0.0012
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	0.0026	0.0031	0.2640	0.0132	0.2643
1.A.3.c Transport - Railways	CO <sub>2</sub>	-0.0009	0.0014	-0.0013	0.0099	0.0100
1.A.3.c Transport - Railways	CH <sub>4</sub>	0.0000	0.0000	-0.0001	0.0000	0.0001
1.A.3.c Transport - Railways	N <sub>2</sub> O	-0.0001	0.0002	-0.0099	0.0011	0.0100
1.A.3.d Transport - Navigation	CO <sub>2</sub>	-0.0001	0.0000	-0.0002	0.0003	0.0004
1.A.3.d Transport - Navigation	CH <sub>4</sub>	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.d Transport - Navigation	N <sub>2</sub> O	0.0000	0.0000	-0.0001	0.0000	0.0001
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	0.0004	0.0004	0.0012	0.0024	0.0027
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	0.0004	0.0004	0.0011	0.0036	0.0038
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0.0000	0.0000	0.0001	0.0000	0.0001
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	0.0000	0.0000	0.0009	0.0002	0.0009
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	0.0013	0.0013	0.0040	0.0131	0.0137
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	0.0000	0.0000	0.0001	0.0000	0.0001
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	0.0000	0.0000	0.0021	0.0003	0.0021
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	-0.0006	0.0010	-0.0143	0.0057	0.0154
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	-0.0155	0.0160	-0.2021	0.0903	0.2213
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	0.0000	0.0000	0.0011	0.0014	0.0018
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	0.0000	0.0000	-0.0006	0.0000	0.0006
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	-0.0005	0.0032	-0.0407	0.0316	0.0515
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	0.0000	0.0000	0.0000	0.0000	0.0000
2.A.1 Cement Production	CO <sub>2</sub>	-0.0010	0.0076	-0.0021	0.0214	0.0215
2.A.2 Lime Production	CO <sub>2</sub>	-0.0014	0.0032	-0.0028	0.0091	0.0095
2.A.3 Glass Production	CO <sub>2</sub>	0.0001	0.0006	0.0014	0.0040	0.0043
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	0.0013	0.0016	0.0126	0.0116	0.0171
2.B.1 Ammonia Production	CO <sub>2</sub>	0.0001	0.0035	0.0006	0.0248	0.0248
2.B.2 Nitric Acid Production	N <sub>2</sub> O	-0.0023	0.0013	-0.0349	0.0074	0.0357
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	0.0001	0.0004	0.0049	0.0027	0.0056
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	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 <sub>2</sub>	0.0001	0.0003	0.0059	0.0019	0.0062
2.B.10 Other	CO <sub>2</sub>	0.0011	0.0011	0.0028	0.0047	0.0055
2.C.1 Iron and Steel Production	CH <sub>4</sub>	-0.0002	0.0331	-0.0018	0.3280	0.3280
2.C.1 Iron and Steel Production	CO <sub>2</sub>	0.0000	0.0001	0.0000	0.0005	0.0005
2.C.2 Ferroalloys Production	CH <sub>4</sub>	0.0003	0.0003	0.0072	0.0020	0.0075
2.C.2 Ferroalloys Production	CO <sub>2</sub>	0.0026	0.0026	0.0641	0.0181	0.0666
2.C.5 Lead Production	CH <sub>4</sub>	0.0001	0.0001	0.0043	0.0017	0.0047
2.C.6 Zinc Production	CO <sub>2</sub>	0.0000	0.0000	0.0001	0.0000	0.0001
2.D.1 Lubricant Use	CO <sub>2</sub>	0.0001	0.0005	0.0035	0.0033	0.0049
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	0.0000	0.0000	0.0002	0.0003	0.0003
2.D.3 Urea used as catalyst	CO <sub>2</sub>	0.0001	0.0001	0.0004	0.0006	0.0008
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	CO <sub>2</sub>	0.0001	0.0001	0.0013	0.0019	0.0023
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.0000	0.0000	0.0002	0.0003	0.0003
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	NF <sub>3</sub>	0.0143	0.0143	0.3280	0.7461	0.8150
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	0.0000	0.0000	0.0006	0.0013	0.0014
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0.0000	0.0000	0.0003	0.0007	0.0008
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	0.0000	0.0000	0.0000	0.0000	0.0000
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	0.0001	0.0001	0.0024	0.0056	0.0061
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	0.0000	0.0000	0.0000	0.0000	0.0000
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0.0000	0.0000	0.0010	0.0022	0.0024
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	0.0000	0.0000	0.0000	0.0000	0.0000
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	0.0000	0.0000	0.0002	0.0005	0.0005
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	PFC	0.0001	0.0004	0.0014	0.0027	0.0030
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.0000	0.0000	0.0003	0.0002	0.0004
2.G.3 N <sub>2</sub> O from product uses	SF <sub>6</sub>	0.0004	0.0011	0.0171	0.0081	0.0189
3.A Enteric Fermentation	N <sub>2</sub> O	-0.0055	0.0144	-0.1104	0.1016	0.1500
3.B Manure Management	CH <sub>4</sub>	-0.0022	0.0039	-0.0662	0.0277	0.0718
3.B Manure Management	CH <sub>4</sub>	-0.0047	0.0067	-0.1424	0.0473	0.1500
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	-0.0016	0.0122	-0.0785	0.2593	0.2709
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	-0.0012	0.0040	-0.0592	0.1132	0.1277
3.G Liming	N <sub>2</sub> O	-0.0033	0.0008	-0.1652	0.0217	0.1666
3.H Urea application	CO <sub>2</sub>	-0.0001	0.0003	-0.0042	0.0082	0.0092
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	-0.0192	-0.0352	-0.3530	0.0000	0.3530
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	0.0000	0.0004	-0.0016	0.0000	0.0016
4.A.1 Forest Land remaining Forest Land	CH <sub>4</sub>	0.0000	0.0000	-0.0001	0.0000	0.0001
4.A.2 Land converted to Forest Land	N <sub>2</sub> O	-0.0013	-0.0025	-0.0391	0.0000	0.0391
4.B.1 Cropland remaining Cropland	CO <sub>2</sub>	-0.0004	-0.0004	-0.0199	0.0000	0.0199
4.B.2 Land converted to Cropland	CO <sub>2</sub>	0.0001	0.0004	0.0021	0.0000	0.0021
4.B.2. Land converted to Cropland	CO <sub>2</sub>	0.0000	0.0000	-0.0077	0.0000	0.0077
4.C.1 Grassland remaining Grassland	N <sub>2</sub> O	-0.0014	-0.0014	-0.0237	0.0000	0.0237
4.C.2 Land converted to Grassland	CO <sub>2</sub>	-0.0010	-0.0015	-0.0197	0.0000	0.0197
4.D.2. Land converted to Wetlands	CO <sub>2</sub>	0.0001	0.0001	0.0041	0.0000	0.0041
4.E.2 Land converted to Settlements	CO <sub>2</sub>	0.0004	0.0007	0.0362	0.0000	0.0362
4.F.2 Land converted to Other Land	CO <sub>2</sub>	0.0000	0.0000	0.0044	0.0000	0.0044
4.G Harvested wood products	CO <sub>2</sub>	0.0054	-0.0005	0.3372	0.0000	0.3372
5.A Solid Waste Disposal on Land	CO <sub>2</sub>	0.0101	0.0170	0.4057	0.7205	0.8268
5.B Biological treatment of solid waste	CH <sub>4</sub>	0.0031	0.0031	0.0315	0.0891	0.0945
5.B Biological treatment of solid waste	CH <sub>4</sub>	0.0002	0.0002	0.0001	0.0053	0.0053
5.C Incineration and open burning of waste	N <sub>2</sub> O	0.0006	0.0007	0.0030	0.0190	0.0192
5.C Incineration and open burning of waste	CO <sub>2</sub>	0.0000	0.0000	0.0000	0.0000	0.0000
5.C Incineration and open burning of waste	CH <sub>4</sub>	0.0000	0.0000	0.0008	0.0003	0.0008
5.D Wastewater treatment and discharge	N <sub>2</sub> O	-0.0002	0.0037	-0.0103	0.1107	0.1112
5.D Wastewater treatment and discharge	CH <sub>4</sub>	0.0002	0.0010	0.0115	0.0382	0.0399
1.A.3 Transport - Biomass	N <sub>2</sub> O	0.0000	0.0000	0.0002	0.0000	0.0002
1.A.3 Transport - Biomass	CH <sub>4</sub>	0.0000	0.0000	0.0007	0.0001	0.0007
					<b>Trend</b>	<b>2.34</b>

Tab. A2 - 4 Uncertainty analysis (Tier 1), first part of Table 3.3 of IPCC 2006 GI. 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 <sub>4</sub>	335.00	599.44	8	50
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	68.58	146.44	8	60
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	11201.04	14417.54	3	3
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	12.79	15.11	3	50
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	6.12	6.44	3	60
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	15193.50	2693.43	5	3
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	21.58	0.18	5	50
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	48.67	140.54	5	60
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	0.00	387.19	10	15
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	0.00	3.44	10	50
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	0.00	5.47	10	60
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	24.04	218.43	20	20
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	0.20	1.79	20	50
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	0.31	2.84	20	70
1.A Stationary Combustion - Solid Fuels	CO <sub>2</sub>	110822.55	56332.49	4	3
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	1212.44	248.99	4	50
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	482.97	246.32	4	60
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	139.44	10.23	4	4
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	0.02	0.00	4	79
1.A.3.a Transport - Domestic Aviation	N <sub>2</sub> O	1.19	0.09	4	110
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	6176.54	16985.57	3	2
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	37.50	25.29	3	303
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	136.73	347.53	3	141
1.A.3.c Transport - Railways	CO <sub>2</sub>	653.86	264.11	5	2
1.A.3.c Transport - Railways	CH <sub>4</sub>	0.92	0.37	5	158
1.A.3.c Transport - Railways	N <sub>2</sub> O	75.21	30.38	5	137
1.A.3.d Transport - Domestic Navigation	CO <sub>2</sub>	56.61	12.73	5	2
1.A.3.d Transport - Domestic Navigation	CH <sub>4</sub>	0.13	0.03	5	158
1.A.3.d Transport - Domestic Navigation	N <sub>2</sub> O	0.46	0.10	5	137
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	5.42	71.04	4	3
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0.00	0.04	4	50
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0.00	0.04	4	60
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	0.00	99.07	7	3
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0.00	0.50	7	50
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	0.00	4.24	7	60
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	0.00	269.78	7	3
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	0.00	0.51	7	50
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	0.00	6.72	7	60
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	456.24	188.53	4	25
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	10322.40	3581.30	4	13
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	0.75	4.50	40	50
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	2.20	5.39	7	75
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	1079.91	608.01	7	75
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	0.01	0.02	7	75
2.A.1 Cement Production	CO <sub>2</sub>	2489.18	1549.54	2	2
2.A.2 Lime Production	CO <sub>2</sub>	1336.65	609.75	2	2
2.A.3 Glass Production	CO <sub>2</sub>	123.66	125.47	5	10
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	109.15	249.15	5	10
2.B.1 Ammonia Production	CO <sub>2</sub>	990.80	741.66	5	7
2.B.2 Nitric Acid Production	N <sub>2</sub> O	1050.29	280.12	4	15
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	74.50	74.50	5	40
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	792.47	715.16	5	40
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	36.17	36.81	5	40
2.B.10 Other	CO <sub>2</sub>	0.00	222.81	3	3
2.C.1 Iron and Steel Production	CO <sub>2</sub>	9642.54	6872.80	7	10
2.C.1 Iron and Steel Production	CH <sub>4</sub>	14.84	9.72	7	30
2.C.2 Ferroalloys Production	CO <sub>2</sub>	0.03	0.53	5	25

2.C.2 Ferroalloys Production	CH <sub>4</sub>	0.18	3.67	5	25
2.C.5 Lead Production	CO <sub>2</sub>	4.04	8.81	10	50
2.C.6 Zinc Production	CO <sub>2</sub>	0.00	0.41	10	50
2.D.1 Lubricant Use	CO <sub>2</sub>	116.13	115.54	5	50
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	9.43	5.89	5	50
2.D.3 Urea used as catalyst	CO <sub>2</sub>	0.00	18.11	5	5
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	16.25	15	15
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	NF <sub>3</sub>	0.00	2.29	15	15
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	0.00	3422.33	37	23
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	PFC	0.00	1.49	37	23
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	0.00	2.57	37	23
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0.00	0.00	37	23
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	0.00	22.73	37	23
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	0.00	0.03	37	23
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	0.00	6.66	37	23
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0.00	0.00	37	23
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	0.00	0.78	37	23
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	0.00	0.00	37	23
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	84.10	71.08	5	15
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.00	3.22	10	20
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	206.22	223.50	5	40
3.A Enteric Fermentation	CH <sub>4</sub>	5754.89	2895.96	5	20
3.B Manure Management	CH <sub>4</sub>	1752.07	771.47	5	30
3.B Manure Management	N <sub>2</sub> O	2459.33	1007.81	5	30
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	4210.37	2569.13	15	50
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	1586.96	888.63	20	50
3.G Liming	CO <sub>2</sub>	1177.82	162.89	20	50
3.H Urea application	CO <sub>2</sub>	108.53	187.10	20	50
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	1979.27	3385.21	30	40
5.B Biological treatment of solid waste	CH <sub>4</sub>	0.00	633.99	5	91
5.B Biological treatment of solid waste	N <sub>2</sub> O	0.00	44.59	5	1
5.C Incineration and open burning of waste	CO <sub>2</sub>	23.15	132.43	15	5
5.C Incineration and open burning of waste	CH <sub>4</sub>	0.00	0.00	20	80
5.C Incineration and open burning of waste	N <sub>2</sub> O	0.42	2.40	20	70
5.D Wastewater treatment and discharge	CH <sub>4</sub>	889.80	860.56	30	50
5.D Wastewater treatment and discharge	N <sub>2</sub> O	234.18	197.23	26	50
1.A.3 Transport - Biomass	CH <sub>4</sub>	0.00	0.59	8	50
1.A.3 Transport - Biomass	N <sub>2</sub> O	0.00	2.22	8	60
	<b>Total</b>	<b>195832.51</b>	<b>127135.00</b>		

**Tab. A2 - 5 Uncertainty analysis (Tier 1), second part of Table 3.3 of IPCC 2006 Gl. excl. LULUCF**

IPCC Source Category	Gas	Uncertainty of Emissions		
		Combined uncertainty	Uncertain amount	Combined uncertainty as % of total national emissions in year t
1.A Stationary Combustion - Biomass	CH <sub>4</sub>	50.64	303.53	0.2387
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	60.53	88.64	0.0697
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	3.91	563.02	0.4429
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	50.09	7.57	0.0060
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	60.07	3.87	0.0030
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	5.83	157.05	0.1235
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	50.25	0.09	0.0001
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	60.21	84.62	0.0666
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	18.03	69.80	0.0549
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	50.99	1.76	0.0014
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	60.83	3.33	0.0026
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	28.28	61.78	0.0486
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	53.85	0.96	0.0008
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	72.80	2.07	0.0016
1.A Stationary Combustion - Solid Fuels	CO <sub>2</sub>	5.00	2816.62	2.2155
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	50.16	124.89	0.0982
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	60.13	148.12	0.1165
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	5.54	0.57	0.0004
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	78.60	0.00	0.0000
1.A.3.a Transport - Domestic Aviation	N <sub>2</sub> O	110.07	0.10	0.0001
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	3.72	631.48	0.4967
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	302.58	76.52	0.0602
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	140.54	488.43	0.3842
1.A.3.c Transport - Railways	CO <sub>2</sub>	5.22	13.79	0.0108
1.A.3.c Transport - Railways	CH <sub>4</sub>	157.58	0.58	0.0005
1.A.3.c Transport - Railways	N <sub>2</sub> O	137.29	41.71	0.0328
1.A.3.d Transport - Domestic Navigation	CO <sub>2</sub>	5.22	0.66	0.0005
1.A.3.d Transport - Domestic Navigation	CH <sub>4</sub>	157.58	0.05	0.0000
1.A.3.d Transport - Domestic Navigation	N <sub>2</sub> O	137.29	0.14	0.0001
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	5.00	3.55	0.0028
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	50.16	0.02	0.0000
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	60.13	0.03	0.0000
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	7.62	7.54	0.0059
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	50.49	0.25	0.0002
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	60.41	2.56	0.0020
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	7.62	20.55	0.0162
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	50.49	0.26	0.0002
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	60.41	4.06	0.0032
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	25.32	47.73	0.0375
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	13.60	487.11	0.3831
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	64.03	2.88	0.0023
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	75.33	4.06	0.0032
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	75.33	457.99	0.3602
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	75.33	0.02	0.0000
2.A.1 Cement Production	CO <sub>2</sub>	2.83	43.83	0.0345
2.A.2 Lime Production	CO <sub>2</sub>	2.83	17.25	0.0136
2.A.3 Glass Production	CO <sub>2</sub>	11.18	14.03	0.0110
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	11.18	27.86	0.0219
2.B.1 Ammonia Production	CO <sub>2</sub>	8.60	63.80	0.0502
2.B.2 Nitric Acid Production	N <sub>2</sub> O	15.52	43.49	0.0342
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	40.31	30.03	0.0236
2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	40.31	288.29	0.2268
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	40.31	14.84	0.0117
2.B.10 Other	CO <sub>2</sub>	3.91	8.70	0.0068
2.C.1 Iron and Steel Production	CO <sub>2</sub>	12.21	838.93	0.6599
2.C.1 Iron and Steel Production	CH <sub>4</sub>	30.81	3.00	0.0024
2.C.2 Ferroalloys Production	CO <sub>2</sub>	25.50	0.14	0.0001
2.C.2 Ferroalloys Production	CH <sub>4</sub>	25.50	0.94	0.0007
2.C.5 Lead Production	CO <sub>2</sub>	50.99	4.49	0.0035

2.C.6 Zinc Production	CO <sub>2</sub>	50.99	0.21	0.0002
2.D.1 Lubricant Use	CO <sub>2</sub>	50.25	58.06	0.0457
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	50.25	2.96	0.0023
2.D.3 Urea used as catalyst	CO <sub>2</sub>	7.07	1.28	0.0010
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	21.21	3.45	0.0027
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	NF <sub>3</sub>	21.21	0.49	0.0004
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	43.57	1490.97	1.1727
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	PFC	43.57	0.65	0.0005
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	43.57	1.12	0.0009
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	43.57	0.00	0.0000
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	43.57	9.90	0.0078
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	43.57	0.01	0.0000
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	43.57	2.90	0.0023
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	43.57	0.00	0.0000
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	43.57	0.34	0.0003
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	43.57	0.00	0.0000
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	15.81	11.24	0.0088
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	22.36	0.72	0.0006
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	40.31	90.10	0.0709
3.A Enteric Fermentation	CH <sub>4</sub>	20.62	597.02	0.4696
3.B Manure Management	CH <sub>4</sub>	30.41	234.63	0.1846
3.B Manure Management	N <sub>2</sub> O	30.41	306.51	0.2411
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	52.20	1341.13	1.0549
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	53.85	478.54	0.3764
3.G Liming	CO <sub>2</sub>	53.85	87.72	0.0690
3.H Urea application	CO <sub>2</sub>	53.85	100.76	0.0793
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	50.00	1692.60	1.3313
5.B Biological treatment of solid waste	CH <sub>4</sub>	91.29	578.75	0.4552
5.B Biological treatment of solid waste	N <sub>2</sub> O	5.04	2.25	0.0018
5.C Incineration and open burning of waste	CO <sub>2</sub>	15.81	20.94	0.0165
5.C Incineration and open burning of waste	CH <sub>4</sub>	82.46	0.00	0.0000
5.C Incineration and open burning of waste	N <sub>2</sub> O	72.80	1.75	0.0014
5.D Wastewater treatment and discharge	CH <sub>4</sub>	58.38	502.42	0.3952
5.D Wastewater treatment and discharge	N <sub>2</sub> O	56.36	111.15	0.0874
1.A.3 Transport - Biomass	CH <sub>4</sub>	50.64	0.30	0.0002
1.A.3 Transport - Biomass	N <sub>2</sub> O	60.53	1.34	0.0011
				12.4753
		<b>Level uncertainty =</b>	<b>15860.53</b>	<b>3.39</b>

Tab. A2 - 6 Uncertainty analysis (Tier 1), third part of Table 3.3 of IPCC 2006 Gl. excl. LULUCF

IPCC Source Category	Gas	Uncertainty of Trend				
		Type sensitivity A	Type sensitivity B	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 <sub>4</sub>	0.0020	0.0031	0.0975	0.0346	0.1035
1.A Stationary Combustion - Biomass	N <sub>2</sub> O	0.0005	0.0007	0.0312	0.0085	0.0324
1.A Stationary Combustion - Gaseous Fuels	CO <sub>2</sub>	0.0365	0.0736	0.0912	0.3124	0.3254
1.A Stationary Combustion - Gaseous Fuels	CH <sub>4</sub>	0.0000	0.0001	0.0017	0.0003	0.0018
1.A Stationary Combustion - Gaseous Fuels	N <sub>2</sub> O	0.0000	0.0000	0.0008	0.0001	0.0008
1.A Stationary Combustion - Liquid Fuels	CO <sub>2</sub>	-0.0366	0.0138	-0.1098	0.0973	0.1466
1.A Stationary Combustion - Liquid Fuels	CH <sub>4</sub>	-0.0001	0.0000	-0.0035	0.0000	0.0035
1.A Stationary Combustion - Liquid Fuels	N <sub>2</sub> O	0.0006	0.0007	0.0334	0.0051	0.0338
1.A Stationary Combustion - Other fuels - 1A2	CO <sub>2</sub>	0.0020	0.0020	0.0297	0.0280	0.0408
1.A Stationary Combustion - Other fuels - 1A2	CH <sub>4</sub>	0.0000	0.0000	0.0009	0.0002	0.0009
1.A Stationary Combustion - Other fuels - 1A2	N <sub>2</sub> O	0.0000	0.0000	0.0017	0.0004	0.0017
1.A Stationary Combustion - Other fuels - MSW	CO <sub>2</sub>	0.0010	0.0011	0.0207	0.0315	0.0377
1.A Stationary Combustion - Other fuels - MSW	CH <sub>4</sub>	0.0000	0.0000	0.0004	0.0003	0.0005
1.A Stationary Combustion - Other fuels - MSW	N <sub>2</sub> O	0.0000	0.0000	0.0009	0.0004	0.0010
1.A Stationary Combustion - Solid Fuels	CO <sub>2</sub>	-0.0793	0.2877	-0.2378	1.6272	1.6445
1.A Stationary Combustion - Solid Fuels	CH <sub>4</sub>	-0.0027	0.0013	-0.1374	0.0072	0.1376
1.A Stationary Combustion - Solid Fuels	N <sub>2</sub> O	-0.0003	0.0013	-0.0206	0.0071	0.0218
1.A.3.a Transport - Domestic Aviation	CO <sub>2</sub>	-0.0004	0.0001	-0.0016	0.0003	0.0016
1.A.3.a Transport - Domestic Aviation	CH <sub>4</sub>	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Transport - Domestic Aviation	N <sub>2</sub> O	0.0000	0.0000	-0.0004	0.0000	0.0004
1.A.3.b Transport - Road Transportation	CO <sub>2</sub>	0.0662	0.0867	0.1454	0.3680	0.3957
1.A.3.b Transport - Road Transportation	CH <sub>4</sub>	0.0000	0.0001	0.0015	0.0005	0.0016
1.A.3.b Transport - Road Transportation	N <sub>2</sub> O	0.0013	0.0018	0.1857	0.0075	0.1858
1.A.3.c Transport - Railways	CO <sub>2</sub>	-0.0008	0.0013	-0.0012	0.0095	0.0096
1.A.3.c Transport - Railways	CH <sub>4</sub>	0.0000	0.0000	-0.0002	0.0000	0.0002
1.A.3.c Transport - Railways	N <sub>2</sub> O	-0.0001	0.0002	-0.0129	0.0011	0.0130
1.A.3.d Transport - Domestic Navigation	CO <sub>2</sub>	-0.0001	0.0001	-0.0002	0.0005	0.0005
1.A.3.d Transport - Domestic Navigation	CH <sub>4</sub>	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.d Transport - Domestic Navigation	N <sub>2</sub> O	0.0000	0.0000	-0.0001	0.0000	0.0001
1.A.3.e Transport - Other Transportation	CO <sub>2</sub>	0.0003	0.0004	0.0010	0.0021	0.0023
1.A.3.e Transport - Other Transportation	CH <sub>4</sub>	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Transport - Other Transportation	N <sub>2</sub> O	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Other mobile sources not included elsewhere	CO <sub>2</sub>	0.0005	0.0005	0.0015	0.0050	0.0052
1.A.5.b Other mobile sources not included elsewhere	CH <sub>4</sub>	0.0000	0.0000	0.0001	0.0000	0.0001
1.A.5.b Other mobile sources not included elsewhere	N <sub>2</sub> O	0.0000	0.0000	0.0013	0.0002	0.0013
1.A.5.b Mobile sources in Agriculture and Forestry	CO <sub>2</sub>	0.0014	0.0014	0.0041	0.0136	0.0143
1.A.5.b Mobile sources in Agriculture and Forestry	CH <sub>4</sub>	0.0000	0.0000	0.0001	0.0000	0.0001
1.A.5.b Mobile sources in Agriculture and Forestry	N <sub>2</sub> O	0.0000	0.0000	0.0021	0.0003	0.0021
1.B.1.a Coal Mining and Handling	CO <sub>2</sub>	-0.0005	0.0010	-0.0137	0.0054	0.0148
1.B.1.a Coal Mining and Handling	CH <sub>4</sub>	-0.0159	0.0183	-0.2070	0.1035	0.2314
1.B.1.b. Solid Fuel Transformation	CH <sub>4</sub>	0.0000	0.0000	0.0010	0.0013	0.0017
1.B.2 Fugitive Emission from Oil, Natural Gas	CO <sub>2</sub>	0.0000	0.0000	0.0015	0.0003	0.0015
1.B.2 Fugitive Emission from Oil, Natural Gas	CH <sub>4</sub>	-0.0005	0.0031	-0.0356	0.0307	0.0471
1.B.2 Fugitive Emission from Oil, Natural Gas	N <sub>2</sub> O	0.0000	0.0000	0.0000	0.0000	0.0000
2.A.1 Cement Production	CO <sub>2</sub>	-0.0003	0.0079	-0.0007	0.0224	0.0224
2.A.2 Lime Production	CO <sub>2</sub>	-0.0013	0.0031	-0.0026	0.0088	0.0092
2.A.3 Glass Production	CO <sub>2</sub>	0.0002	0.0006	0.0023	0.0045	0.0051
2.A.4 Other process uses of carbonates	CO <sub>2</sub>	0.0009	0.0013	0.0091	0.0090	0.0128
2.B.1 Ammonia Production	CO <sub>2</sub>	0.0005	0.0038	0.0035	0.0268	0.0270
2.B.2 Nitric Acid Production	N <sub>2</sub> O	-0.0021	0.0014	-0.0308	0.0081	0.0318
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N <sub>2</sub> O	0.0001	0.0004	0.0053	0.0027	0.0060

2.B.8 Petrochemical and carbon black production	CO <sub>2</sub>	0.0010	0.0037	0.0410	0.0258	0.0484
2.B.8 Petrochemical and carbon black production	CH <sub>4</sub>	0.0001	0.0002	0.0027	0.0013	0.0030
2.B.10 Other	CO <sub>2</sub>	0.0011	0.0011	0.0028	0.0048	0.0056
2.C.1 Iron and Steel Production	CO <sub>2</sub>	0.0031	0.0351	0.0313	0.3474	0.3488
2.C.1 Iron and Steel Production	CH <sub>4</sub>	0.0000	0.0000	0.0000	0.0005	0.0005
2.C.2 Ferroalloys Production	CO <sub>2</sub>	0.0000	0.0000	0.0001	0.0000	0.0001
2.C.2 Ferroalloys Production	CH <sub>4</sub>	0.0000	0.0000	0.0005	0.0001	0.0005
2.C.5 Lead Production	CO <sub>2</sub>	0.0000	0.0000	0.0016	0.0006	0.0017
2.C.6 Zinc Production	CO <sub>2</sub>	0.0000	0.0000	0.0001	0.0000	0.0001
2.D.1 Lubricant Use	CO <sub>2</sub>	0.0002	0.0006	0.0103	0.0042	0.0111
2.D.2 Paraffin Wax Use	CO <sub>2</sub>	0.0000	0.0000	-0.0001	0.0002	0.0002
2.D.3 Urea used as catalyst	CO <sub>2</sub>	0.0001	0.0001	0.0005	0.0007	0.0008
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.0001	0.0001	0.0012	0.0018	0.0022
2.E.1 Integrated circuit or semiconductor (CO <sub>2</sub> eq.)	NF <sub>3</sub>	0.0000	0.0000	0.0002	0.0002	0.0003
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	HFC	0.0175	0.0175	0.4019	0.9144	0.9989
2.F.1 Refrigeration and Air Conditioning Equipment (CO <sub>2</sub> eq.)	PFC	0.0000	0.0000	0.0002	0.0004	0.0004
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	HFC	0.0000	0.0000	0.0003	0.0007	0.0008
2.F.2 Foam Blowing (CO <sub>2</sub> eq.)	PFC	0.0000	0.0000	0.0000	0.0000	0.0000
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	HFC	0.0001	0.0001	0.0027	0.0061	0.0066
2.F.3 Fire Protection (CO <sub>2</sub> eq.)	PFC	0.0000	0.0000	0.0000	0.0000	0.0000
2.F.4 Aerosols (CO <sub>2</sub> eq.)	HFC	0.0000	0.0000	0.0008	0.0018	0.0019
2.F.4 Aerosols (CO <sub>2</sub> eq.)	PFC	0.0000	0.0000	0.0000	0.0000	0.0000
2.F.5 Solvents (CO <sub>2</sub> eq.)	HFC	0.0000	0.0000	0.0001	0.0002	0.0002
2.F.5 Solvents (CO <sub>2</sub> eq.)	PFC	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.1 Electrical Equipment (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.0001	0.0004	0.0013	0.0026	0.0029
2.G.2 SF <sub>6</sub> and PFC from other product use (CO <sub>2</sub> eq.)	SF <sub>6</sub>	0.0000	0.0000	0.0003	0.0002	0.0004
2.G.3 N <sub>2</sub> O from product uses	N <sub>2</sub> O	0.0005	0.0011	0.0183	0.0081	0.0200
3.A Enteric Fermentation	CH <sub>4</sub>	-0.0043	0.0148	-0.0858	0.1046	0.1352
3.B Manure Management	CH <sub>4</sub>	-0.0019	0.0039	-0.0561	0.0279	0.0626
3.B Manure Management	N <sub>2</sub> O	-0.0030	0.0051	-0.0902	0.0364	0.0973
3.D.1 Agricultural Soils, Direct N <sub>2</sub> O emissions	N <sub>2</sub> O	-0.0008	0.0131	-0.0419	0.2783	0.2814
3.D.2 Agricultural Soils, Indirect N <sub>2</sub> O emissions	N <sub>2</sub> O	-0.0007	0.0045	-0.0362	0.1283	0.1333
3.G Liming	CO <sub>2</sub>	-0.0031	0.0008	-0.1536	0.0235	0.1554
3.H Urea application	CO <sub>2</sub>	0.0006	0.0010	0.0298	0.0270	0.0402
5.A Solid Waste Disposal on Land	CH <sub>4</sub>	0.0107	0.0173	0.4289	0.7334	0.8496
5.B Biological treatment of solid waste	CH <sub>4</sub>	0.0032	0.0032	0.2951	0.0229	0.2960
5.B Biological treatment of solid waste	N <sub>2</sub> O	0.0002	0.0002	0.0001	0.0016	0.0016
5.C Incineration and open burning of waste	CO <sub>2</sub>	0.0006	0.0007	0.0030	0.0143	0.0147
5.C Incineration and open burning of waste	CH <sub>4</sub>	0.0000	0.0000	0.0000	0.0000	0.0000
5.C Incineration and open burning of waste	N <sub>2</sub> O	0.0000	0.0000	0.0008	0.0003	0.0008
5.D Wastewater treatment and discharge	CH <sub>4</sub>	0.0014	0.0044	0.0722	0.1873	0.2008
5.D Wastewater treatment and discharge	N <sub>2</sub> O	0.0002	0.0010	0.0115	0.0370	0.0388
1.A.3 Transport - Biomass	CH <sub>4</sub>	0.0000	0.0000	0.0002	0.0000	0.0002
1.A.3 Transport - Biomass	N <sub>2</sub> O	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<sub>2</sub> emissions from combustion of bituminous coal and lignite (brown coal) in the Czech Republic**

#### **1. Introduction**

Emissions of CO<sub>2</sub>, 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<sub>2</sub> 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<sub>2</sub> (t CO<sub>2</sub>/TJ) and oxidation factor. In the met

hodology for GHG inventory, IPCC provides default emission factors for CO<sub>2</sub>, 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<sub>2</sub> from combustion of solid fuels is a so called key category, to check and update the emission factors of CO<sub>2</sub> for calculation of emissions of CO<sub>2</sub> on the basis of national data. In the Czech Republic, where the main part of the CO<sub>2</sub> 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<sub>2</sub> 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  $m$

$$CC = m \cdot \frac{w_c}{m} \cdot Q_i = \frac{w_c}{Q_i} \quad (A3-1)$$

where  $w_c$  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 ( $C^r = 100 \cdot w_c$ ) and CC in t C/TJ, it is possible to rewrite the previous equation to:

$$CC \left[ t \frac{C}{TJ} \right] = \frac{10 \cdot C^r [\%]}{Q_i^r \left[ \frac{MJ}{kg} \right]} \quad (A3-2)$$

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

$$EF(CO_2) = CC \cdot 3.664 \quad (A3-3)$$

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<sub>2</sub> 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].

$$C^r = a \cdot Q_i^r + b \quad (A3-4)$$

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).

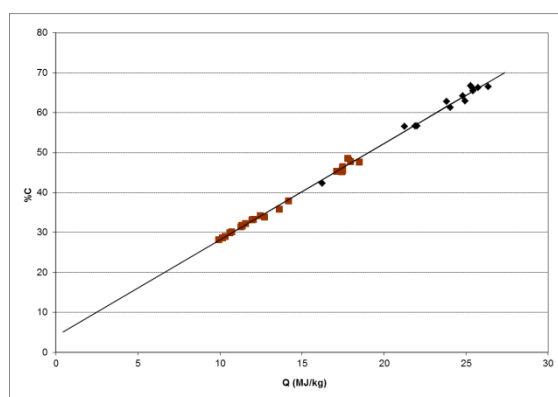
Taking into account the equation (A3-2), dependence between the carbon content CC (t C/TJ) and the calorific value  $Q_i^r$  [MJ/kg] is obtained.

$$CC = 10 \cdot \left( a + \frac{b}{Q_i^r} \right) \quad (A3-5)$$

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”.

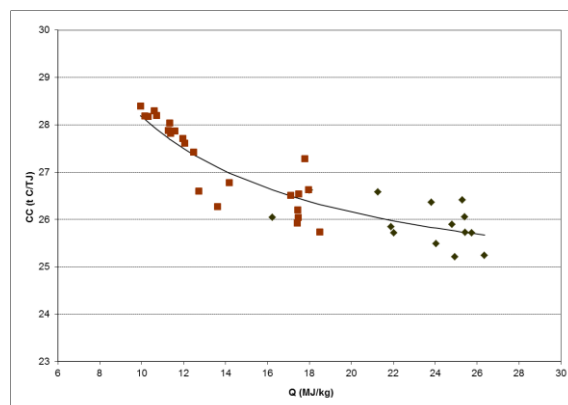
On Fig. A3 1 it can be seen, that for the combined data set “Comb” a correlation between carbon content and net calorific value can be described for both types of coal with a regression line (see equation (A3-4)) with parameters  $a = 2.4142$  and  $b = 4.0291$ , while the correlation coefficient value  $r^2 = 0.997$  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<sub>2</sub> 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-linear 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

### Set "ČEZ"

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

### Set "Dalkia"

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.

### Set "ETS"

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<sub>2</sub> (t CO<sub>2</sub>/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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>

$$27.153 \cdot 3.664 = 99.489 \frac{t CO_2}{TJ}$$

27.153 • 3.664= 99.489 t CO<sub>2</sub>/TJ. Resultant emission factor for CO<sub>2</sub> 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<sub>2</sub>

$$25.742 \cdot 3.664 = 94.317 \frac{t \text{ CO}_2}{TJ}$$

Resultant emission factor for CO<sub>2</sub> including the oxidation factor has a value of

$$94.317 \cdot 0.9707 = 91.554 \frac{t \text{ CO}_2}{TJ}$$

### A3. 2 Country specific CO<sub>2</sub> 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 <sup>-1</sup> , max.	0.2	0.2
Content of sulphur - mg.kg <sup>-1</sup> , 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

$$\frac{1000 \cdot 0.8258}{45.945} = 17.974 \frac{t C}{TJ} \quad (A3-6)$$

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<sub>2</sub> 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<sub>2</sub> and default emission factors for LPG**

	[t C/TJ]	[t CO <sub>2</sub> /TJ]
Revised 1996 Guidelines	17.2	63.07
2006 Guidelines	17.2	63.1
CO <sub>2</sub> 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<sub>2</sub> 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 of 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<sub>2</sub> emission factor from combustion of Refinery Gas. These analyses obtain the information about content of hydrogen, content of CO<sub>2</sub>, 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 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 lie within the default range 13.1 – 18.8 t C/TJ specified in the 2006 Guidelines and furthermore 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<sub>2</sub> 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<sub>2</sub> 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:

$$Q_m = \sum w_i \cdot Q_{mi} \quad (A3-8)$$

$$Q_v = Q_m \cdot d \quad (A3-9)$$

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<sup>3</sup>] is the net calorific values of Natural Gas related to its volume and  $d$  [kg/m<sup>3</sup>] 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<sub>TJ</sub> [t C/TJ]) is computed according to

$$CEF_{TJ} = CEF_m / Q_m \quad (A3-10)$$

where CEF<sub>m</sub> is carbon emission factor related to the mass.

Carbon dioxide emission factor (EF (CO<sub>2</sub>) [t CO<sub>2</sub>/TJ]) is then calculated

$$EF (CO_2) = CEF_{TJ} \cdot M_{CO_2} / M_C \quad (A3-11)$$

where  $M_{CO_2}$  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<sub>2</sub>) and Q<sub>v</sub> 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

$$EF (CO_2) = 0.269 \cdot (Q_v/3.6)^2 - 2.988 \cdot (Q_v/3.6) + 59.212 \quad (A3-12)$$

which was tightly fit to all 10 points (correlation coefficient  $R^2 = 0.999$ ). In this correlation expression Q<sub>v</sub> 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 Q<sub>v</sub>: 34.11 – 34.27 MJ/m<sup>3</sup>. The lowest net calorific value (31.31 MJ/m<sup>3</sup>) was determined for sample number 3 (Dutch field) and the highest (38.28 MJ/m<sup>3</sup>) 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 C<sub>2</sub>, C<sub>3</sub> and C<sub>4</sub> 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<sub>2</sub> emission factor. The dataset of these analyses began on 1<sup>st</sup> January 2007 and the last data are from 1<sup>st</sup> September 2011. Furthermore data for 1<sup>st</sup> 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.

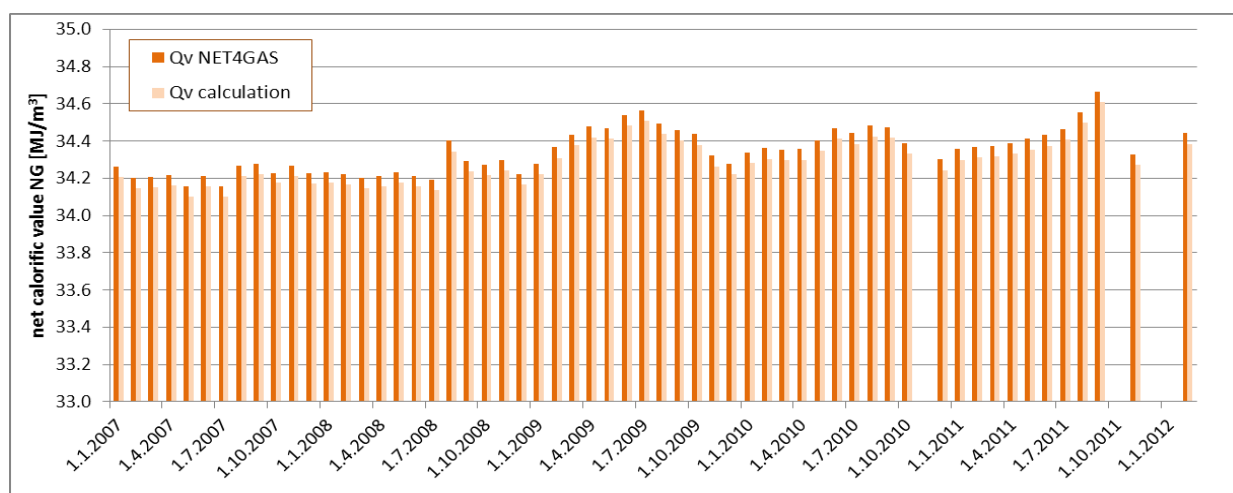


Fig. A3 3 Net calorific values given in NET4GAS Ltd. reports and net calorific values calculated on the basis of composition of Natural Gas in 1.1.2007 – 1.2.2012 (both values are given at 15°C)

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

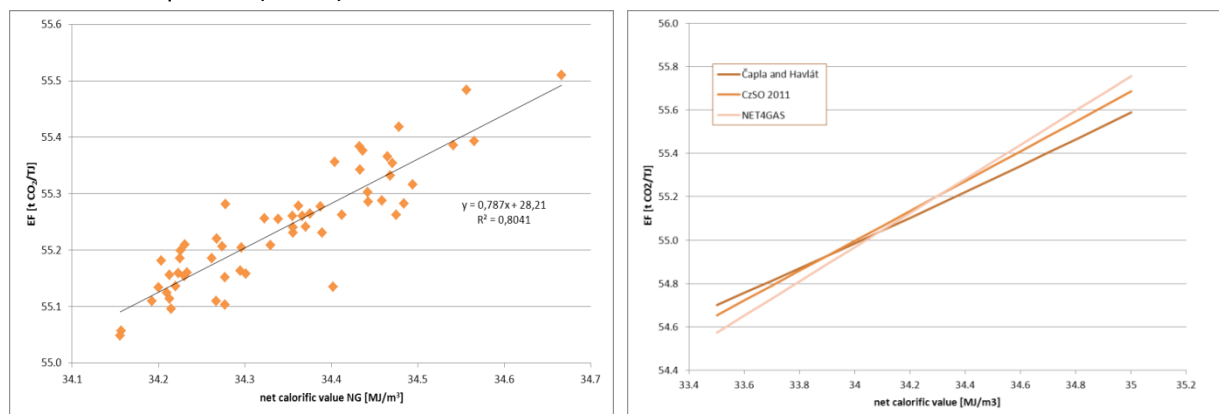
$$EF (CO_2) = 0.787 \cdot Q_v + 28.21 \quad (A3-13)$$

where  $Q_v$  [MJ/m<sup>3</sup>] 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

$$EF (CO_2) = 0.6876 \cdot Q_v + 31.619 \quad (A3-14)$$

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<sub>2</sub>/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<sup>3</sup>, 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<sup>3</sup>. 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<sup>3</sup> is depicted by the dashed line.

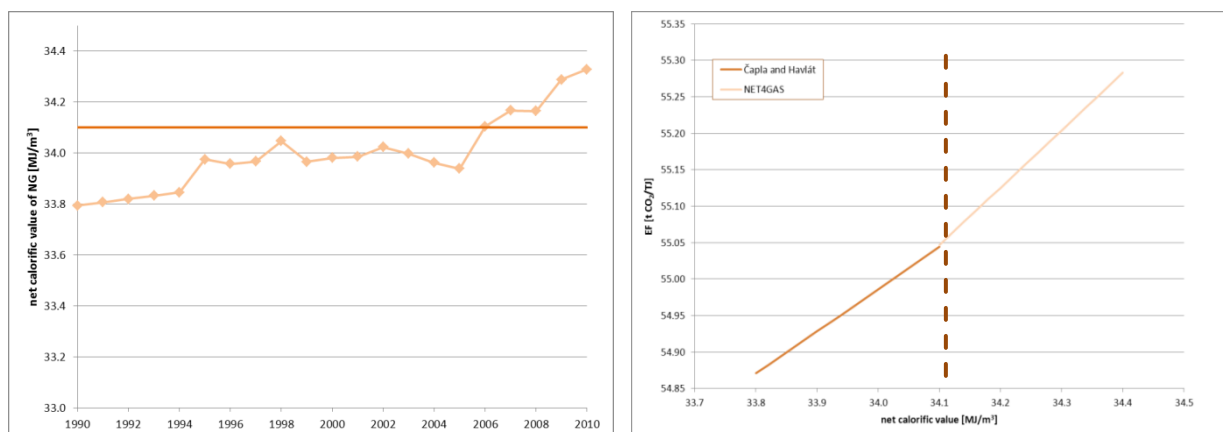


Fig. A3 5 Trend in Natural Gas NCV 1990 – 2010 and Correlation between NCV and EF combined from two approaches – Čapla and Havlát (NCV lower than 34.1 MJ/m<sup>3</sup>) and computed correlation on the basis of NET4GAS dataset (NCV higher than 34.1 MJ/m<sup>3</sup>)

Evaluation of CO<sub>2</sub> 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 <sub>2</sub> calculated on the basis of Čapla and Havlát correlation (eq. A2-5)	EF CO <sub>2</sub> calculated on the basis of NET4GAS, Ltd. dataset correlation (eq. A2-6)
	[MJ/m <sup>3</sup> ]	[t CO <sub>2</sub> /TJ]	[t CO <sub>2</sub> /TJ]
1990	33.794	<b>54.87</b>	54.81
1991	33.807	<b>54.87</b>	54.82
1992	33.820	<b>54.88</b>	54.83
1993	33.832	<b>54.89</b>	54.84
1994	33.845	<b>54.90</b>	54.85
1995	33.975	<b>54.97</b>	54.95
1996	33.957	<b>54.96</b>	54.93
1997	33.966	<b>54.97</b>	54.94
1998	34.046	<b>55.01</b>	55.00
1999	33.965	<b>54.97</b>	54.94
2000	33.980	<b>54.97</b>	54.95
2001	33.986	<b>54.98</b>	54.96
2002	34.023	<b>55.00</b>	54.99
2003	33.997	<b>54.98</b>	54.97
2004	33.962	<b>54.96</b>	54.94
2005	33.938	<b>54.95</b>	54.92
2006	34.105	<b>55.05</b>	<b>55.05</b>
2007	34.167	<b>55.08</b>	<b>55.10</b>
2008	34.164	<b>55.08</b>	<b>55.10</b>
2009	34.288	<b>55.16</b>	<b>55.19</b>
2010	34.328	<b>55.18</b>	<b>55.23</b>

The deviations between the two calculations are less than 0.15%. The values written in bold were used for recalculation of CO<sub>2</sub> 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<sub>2</sub>/TJ, which

overestimated the CO<sub>2</sub> 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):

$$EF (CO_2) = 0.787 \cdot Q_v + 28.21 \quad (A3-15)$$

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<sub>2</sub> 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<sub>2</sub>, CO, NO<sub>x</sub>, N<sub>2</sub>O, CH<sub>4</sub>, NMVOC, SO<sub>2</sub>, Pb and PM, based on the available measurements. Emission factors are expressed in g.kg<sup>-1</sup> 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<sup>-1</sup>. 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<sup>-1</sup>).

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<sub>2</sub>O production from the total amount of NO<sub>x</sub>. VOCs are separated into CH<sub>4</sub> (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<sup>-1</sup> of fuel and are processed in the MS Access database.

*Reference:*

DUFEK, J., HUŽLÍK, 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<sub>2</sub> 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 <sub>3</sub> + MgCO <sub>3</sub>	min	98.5	97.5	96.0	95.0	93.0	85.0	80.0	75.0
from which MgCO <sub>3</sub>	min	0.5	0.8	2.0	4.0	6.0	10.0	15.0	
SiO <sub>2</sub>	max	0.3	0.8	1.5	3.0	4.5	6.0	8.0	18.0
Al <sub>2</sub> O <sub>3</sub> + Fe <sub>2</sub> O <sub>3</sub>	max	0.2	0.4	0.8	2.0	3.5	5.0	6.0	6.0
from which Fe <sub>2</sub> O <sub>3</sub>	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 <sub>3</sub>	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<sub>3</sub> or MgCO<sub>3</sub> 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) No 601/2012).

Tab. A3 - 8 Emission factors for method A and B

Method	Material	EF [t CO <sub>2</sub> / t material]
A (input)	CaCO <sub>3</sub>	0.440
	MgCO <sub>3</sub>	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  $\text{MgCO}_3$  in the input material (Method A). This dependence can be observed on Fig. A3-6.

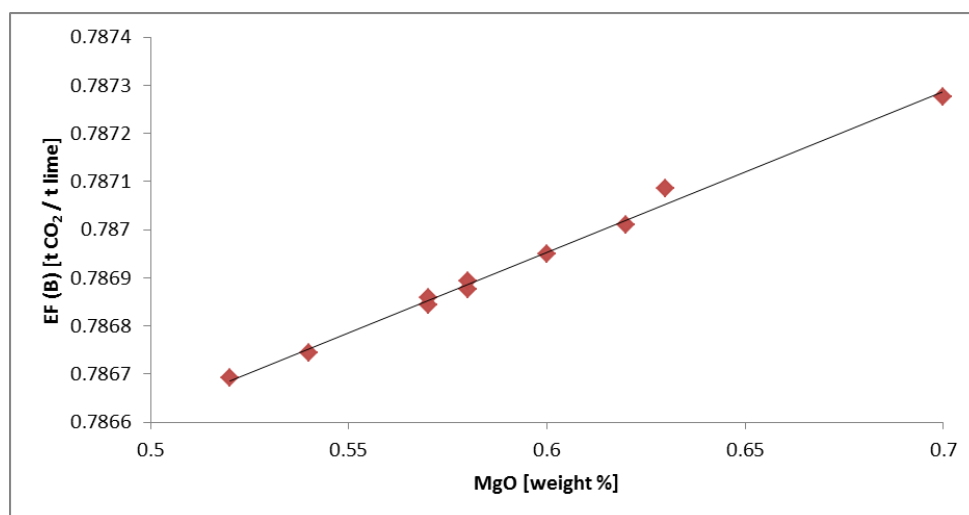


Fig. A3 6 Correlation between emission factor and mass representation of  $\text{MgCO}_3$  in input material

Dependence between emission factor and output material (weight% MgO) occurs naturally, even when using method B, as you can see on Fig. A3 - 7.

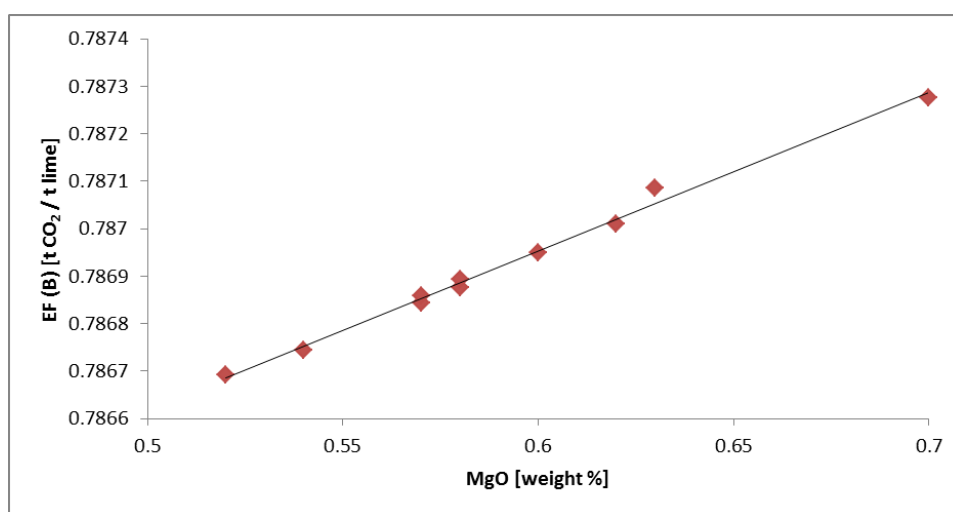


Fig. A3 7 Correlation of emission factor in mass representation of MgO in output material

As Fig. A3 - 6 and A3 - 7 shows, the emission factor varies with the amount of  $\text{MgCO}_3$  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.

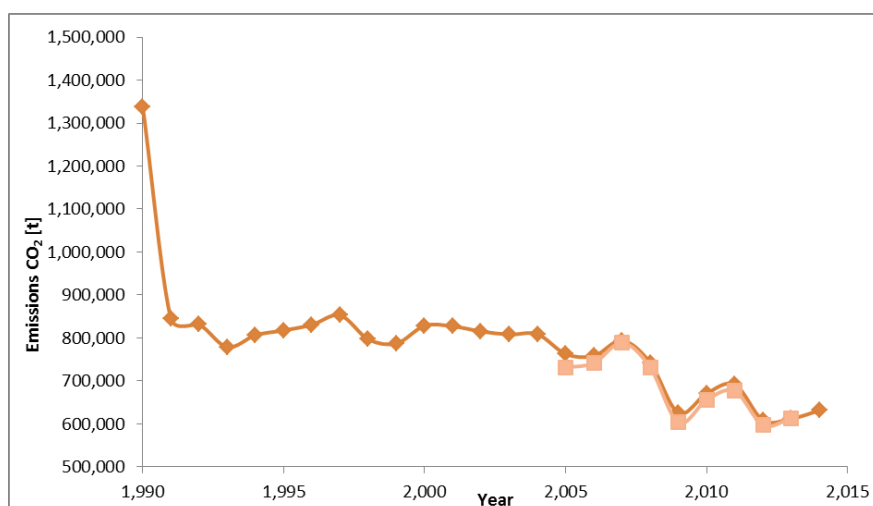


Fig. A3 8 Development of emissions of CO<sub>2</sub> from production of lime in CR for period 1990 – 2014

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<sub>2</sub>/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.

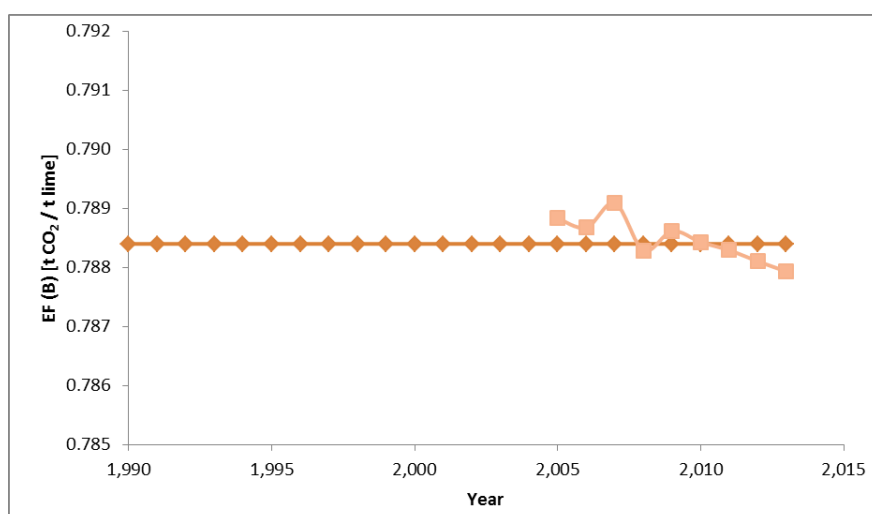


Fig. A3 9 Development of EF for production of lime in CR for period 1990 - 2014 (method B)

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<sub>2</sub>/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<sub>3</sub> 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<sub>2</sub>/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	
	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	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<sup>3</sup> 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 <sup>3</sup>	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%
$0.001011 \cdot \text{GCV} + 0.863274$ <sup>a)</sup>	0.90165	0.90168	0.90187	0.90183	0.90189			

<sup>a)</sup> 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

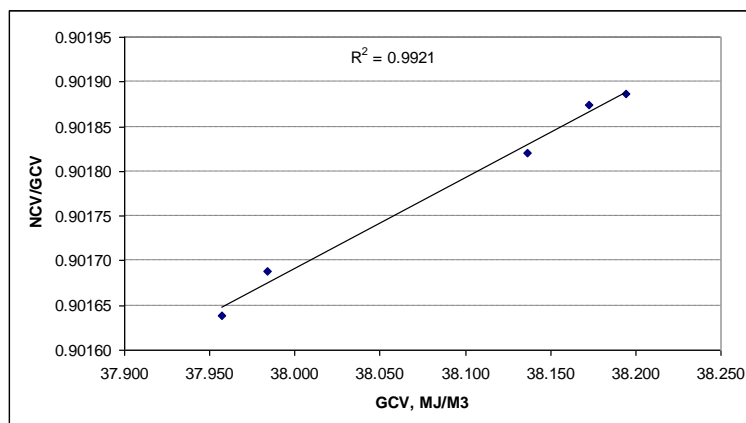


Fig. A5 1 Regression line corresponds with the data shown in Tab. A5-1.

The resulting equation for exact calculation of NCV from known values for GCV is:

$$\text{NCV} = (0.001011 * \text{GCV} + 0.863274) * \text{GCV} \quad (\text{A5} - 1)$$

where NCV and GCV are expressed in MJ/m<sup>3</sup> 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<sub>2</sub>, 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 <sup>3</sup>	16.935	17.108	16.847	16.040	16.459	17.210	17.162	
GCV, MJ/Nm <sup>3</sup>	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	%
NCV, MJ/Nm <sup>3</sup>	17.177	16.832	17.056	17.218	17.312	16.946	0.353	2.1%
GCV, MJ/Nm <sup>3</sup>	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<sup>3</sup> (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<sub>Gross</sub>), but without GCV values for individual years. Conversion to TJ related to NCV (marked as TJ<sub>Net</sub>), 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<sub>Net</sub>/TJ<sub>Gross</sub>.

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 <sup>3</sup> ]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Natural Gas <sup>**) 15 °C, 101.3 kPa</sup>	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 <sup>3</sup> ]	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Natural Gas <sup>**) 15 °C, 101.3 kPa</sup>	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 CO<sub>2</sub> estimation apply OF<sub>j</sub> – 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	EF <sub>i</sub>	OF <sub>j</sub>
Value	NA (effectively 1)	MSW: 0.95 CW: 0.95 ISW: NA HW: 0.995	MSW: 1.00 CW: 1.00 ISW: 1.00 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 facilities

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

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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](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
<b>Tables and Figures</b>		
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)		
<b>Equations</b>		
Check for consistency in equation formatting		
Check that variables used in equations are defined following the equation		
Other (specify)		
<b>References</b>		
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
<b>Input data QC</b>						
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)					
<b>Calculation</b>						
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 <u>spreadsheets</u> , <b>CRF</b> tables and <b>NIR</b>						
13	Other (please specify)						
<b>Database files</b>							
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)						
<b>Consistency</b>							
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)						
<b>Completeness</b>							
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 ( <b>NIR</b> 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)						
<b>Trend QC</b>							
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)						
<b>Data documentation (NIR + DATA)</b>							
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
<b>EMISSION DATA QUALITY CHECKS</b>						
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)						
<b>EMISSION FACTOR QUALITY CHECKS</b>						
<b>IPCC default emission factors</b>						
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						
<b>Country-specific emission factors</b>						
<b>QC on models</b>						
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						
<b>Comparisons</b>							
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)						
<b>ACTIVITY DATA QUALITY CHECKS</b>							
<b>National level activity data</b>							
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						
<b>Site-specific activity data</b>							
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)						
<b>CALCULATION RELATED QUALITY CHECKS</b>							
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.



### Standard electronic format (SEF) tables

SEF Table 1

							Party	Czech Republic
							Submission Year	2017
							Reported Year	2016
							Commitment Period	2
<b>Table 1. Total quantities of Kyoto Protocol units by account type at beginning of reported year</b>								
	Account type	Unit type						
		AAUs	ERUs	RMUs	CERs	tCERs	ICERs	
1	Party holding accounts	NO	NO	NO	NO	NO	NO	NO
2	Entity holding accounts	NO	NO	NO	NO	NO	NO	NO
3	Retirement account	NO	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	NO
8	Cancellation account for remaining units after carry-over	NO	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	ICER cancellation account for expiry							NO
13	ICER cancellation account for reversal of storage							NO
14	ICER cancellation account for non-submission of certification report							NO
15	tCER replacement account for expiry	NO	NO	NO	NO	NO		
16	ICER replacement account for expiry	NO	NO	NO	NO			
17	ICER replacement account for reversal of storage	NO	NO	NO	NO			NO
18	ICER replacement account for non-submission of certification report	NO	NO	NO	NO			NO
19	Total	NO	NO	NO	NO	NO	NO	NO

SEF Table 2A

[illegible]

SEF Table 2BC

[illegible]

SEF Table 3

[illegible]

SEF Table 4

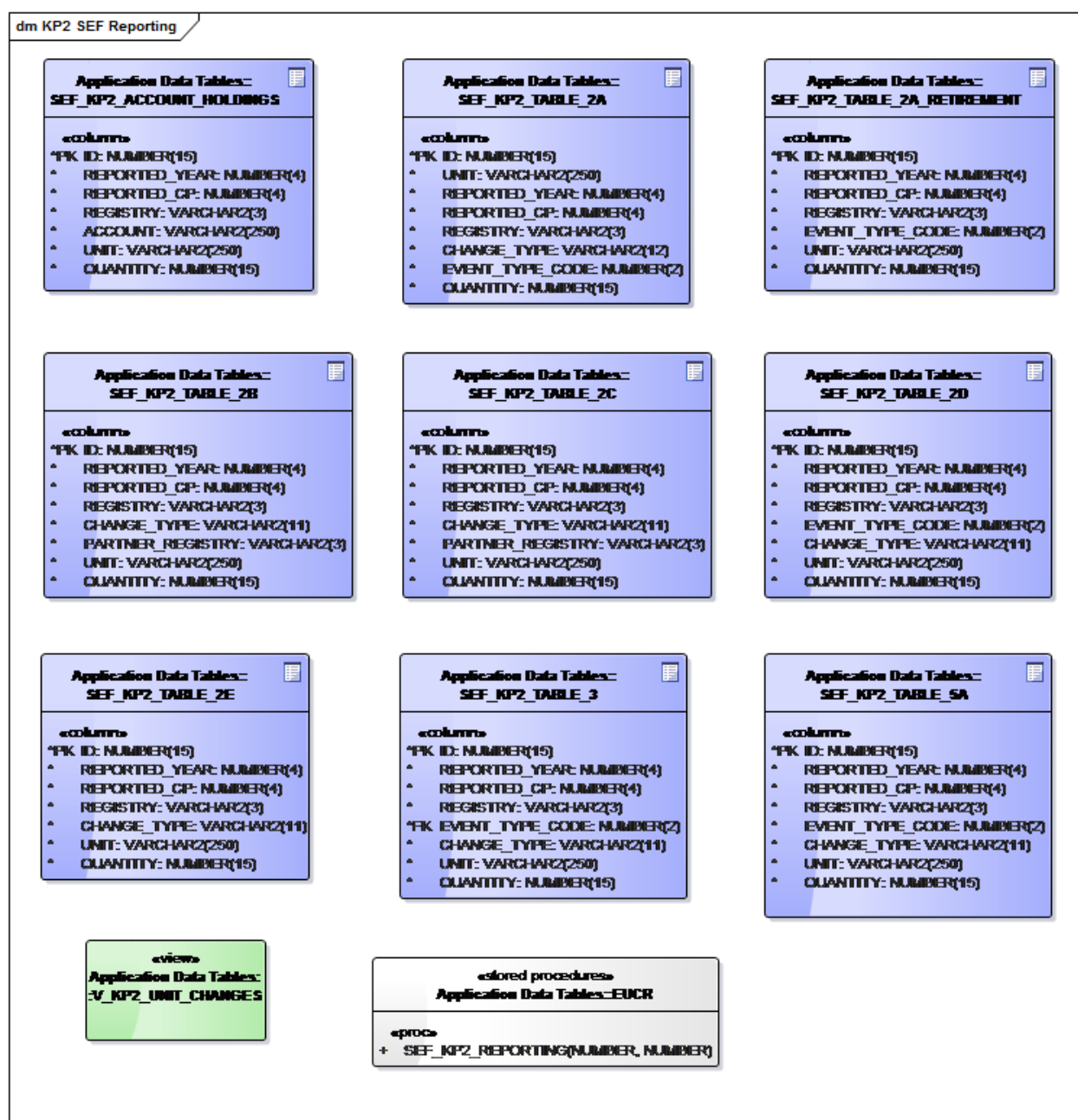
					Party	Czech Republic
					Submission Year	2017
					Reported Year	2016
					Commitment Period	2
Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year						
Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Party holding accounts	NO	NO	NO	NO	NO	NO
Entity 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	
ICER cancellation account for expiry						NO
ICER cancellation account for reversal of storage						NO
ICER cancellation account for non-submission of certification report						NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
ICER replacement account for expiry	NO	NO	NO	NO		
ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
ICER 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					ICERs	Subtractions				
	AAUs	ERUs	RMUs	CERs	tCERs		AAUs	ERUs	RMUs	CERs	ICERs
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
Non-compliance cancellation							NO	NO	NO		
Carry-over		NO		NO				NO		NO	
Carry-over to PPSR	NO						NO				
Total	NO	NO			NO		NO	NO	NO	NO	NO
Table 5b. Summary information on annual transactions											
	Additions					ICERs	Subtractions				
	AAUs	ERUs	RMUs	CERs	tCERs		AAUs	ERUs	RMUs	CERs	ICERs
Year 1 (2013)	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
Year 3 (2015)	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
Year 5 (2017)	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
Year 7 (2019)	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
2021	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2022	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2023	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Table 5c. Summary information on annual transactions between PPSR accounts											
	Additions					ICERs	Subtractions				
	AAUs	ERUs	RMUs	CERs	tCERs		AAUs	ERUs	RMUs	CERs	ICERs
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	

[illegible]

Fig. A7 1 Annex A – CP2 SEF Tables



The diagram is an Entity Relationship Diagram (ERD) titled "erd Entity Relationship Diagram". It maps the relationships between various entities in a system, organized into several main functional areas:

- Compliance:** Includes entities like "Standard", "Enrollment", "Compliance Status", "Plan 1 Allocation Plan", "Plan 2 Allocation Plan", and "Plan 3 Allocation Plan". Relationships include "VE have entries in plan" and "VE have compliance data".
- ESD Related Tables:** A large section containing numerous tables such as "ESD Allocation", "ESD Enrollment", "ESD Compliance", "ESD Endorsement", "ESD Eligibility List", "ESD Endorsement Termination", and "ESD Credits Report". It also includes "Verified Entities" (Account Operator, Institution) and "Allocation" (Account Operator, Institution).
- Secondary Tables:** Includes "Request Tables", "Reference Data Tables", "SEF Data", and "SEF Related Tables".
- Account Management:** Features "Account Group", "Account", "Account Holder", "Unit Block", and "Account Holder Representative". Relationships include "account belongs to", "account holds unit blocks", and "access on account".
- Access Control:** Includes "Task Item Access", "Access", "Profile", "User", "Role", and "Permission". Relationships include "access on account related task", "roles are granted with access", "role group permissions", and "role is specific to registry".
- Transaction and Audit:** Includes "Transaction Block", "Transaction", "Audit", and "Audit Table". Relationships include "transaction transfer transaction blocks", "auditing results in transactions", and "auction table define auction table".
- Regulatory and Reporting:** Includes "Regulatory", "Reconciliation", "Project", "Technical Data Repository", "JSTW Related Tables", "QUARTZ Related Tables", and "Logbook Log Tables". Relationships include "each account is notified and administered by registry", "notifications are addressed to registries", "reconciliations are per registry", "projects defined by registry", and "task item is linked to process".

The diagram uses standard ERD notation with rectangles for entities, ovals for relationships, and lines connecting them. Some lines are labeled with descriptive text such as "account is optionally linked to a verified entity" and "ESD data relates to ESD Compliance accounts".